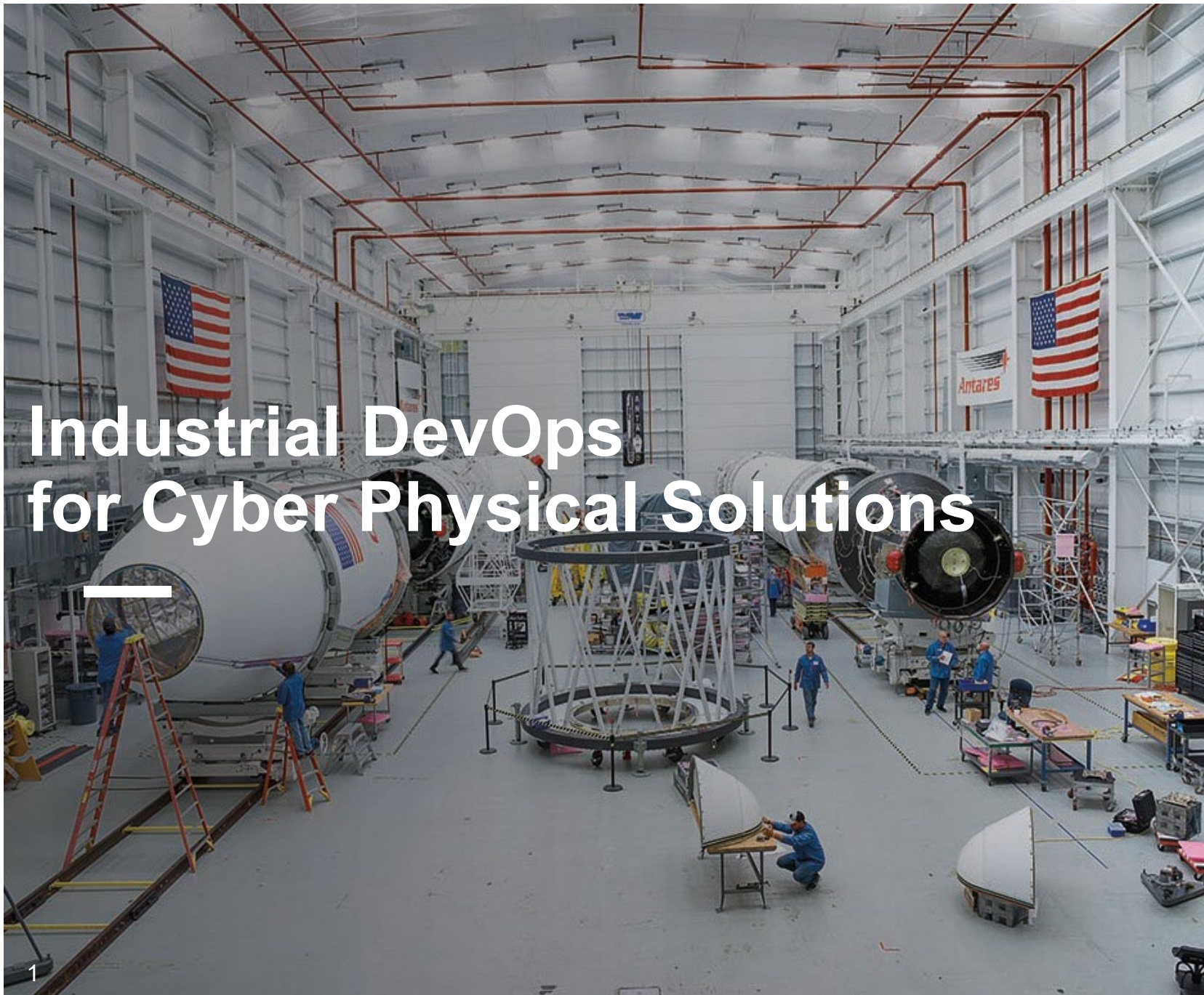# Industrial DevOps
for Cyber Physical Solutions
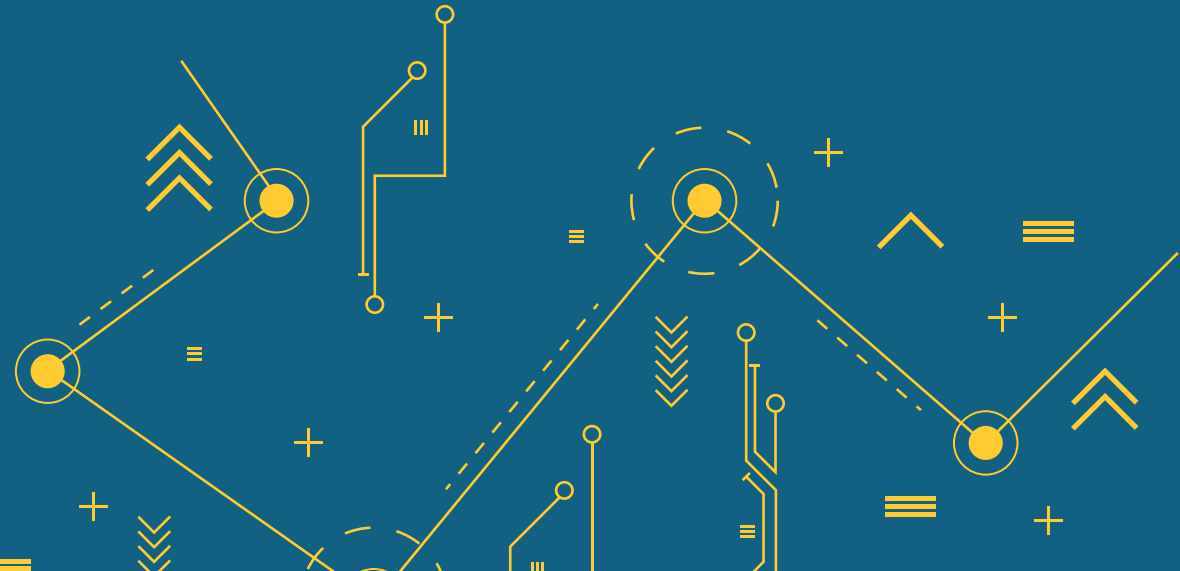
Dr. Suzette Johnson

NG Fellow, Lean-Agile

March 2024

1

build better systems faster

INDUSTRIAL DEVOPS

Dr. Suzette Johnson **and** Robin Yeman

Introduction

Dr. Suzette Johnson

Robin Yeman

We have been on a journey to improve the state of the practice in building large-scale safety-critical cyber-physical systems using Agile and DevOps

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Carnegie Mellon University
Software Engineering Institute

Innovation and Collaboration

Innovation and collaboration across all levels of the organization, are critical for a company's growth and survival in today's fast-paced working environments where new digital capabilities emerge every day

Topics

- Success Patterns through Principles

- Challenges with Implementing the Success Patterns

Success Patterns
Industrial DevOps Principles

A common disease that afflicts management the world over is the impression that
"Our problems are different". They are different to be sure, but the principles that will help to improve quality of product and service are universal in nature.

—W. Edwards Deming

What is Industrial DevOps?

► The application of continuous delivery principles to the *development, manufacturing, deployment, and serviceability of significant cyber-physical systems to enable these programs to be more responsive to changing needs while reducing lead times.*

► Focuses on building a continuous delivery pipeline that provides a multi-domain flow of value to the users and stakeholders of those deployed systems.

► Based on DevOps, Lean manufacturing, Lean product development, Lean startup, systems thinking, and scaled Agile development.

Industrial DevOps Applied

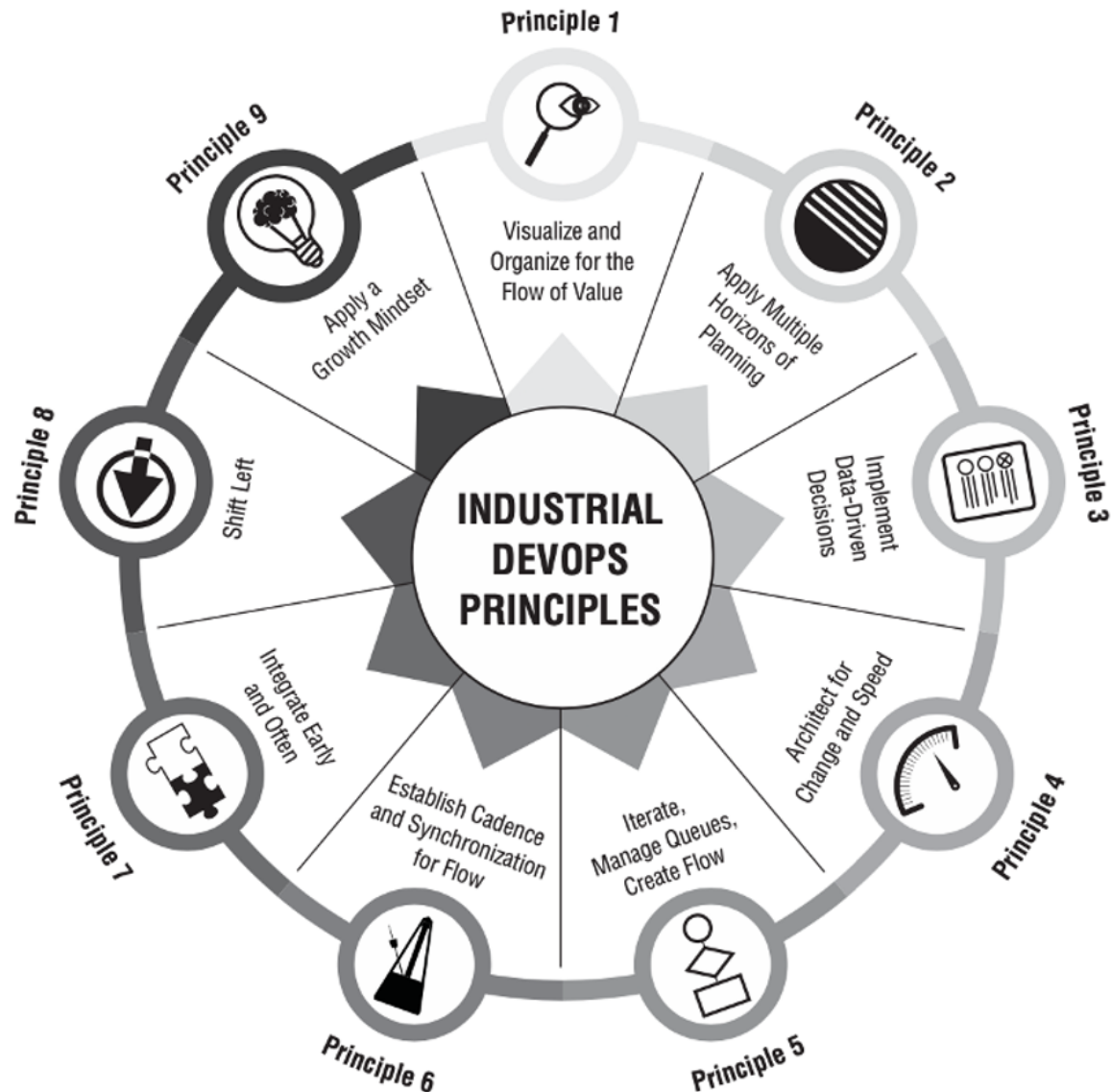## Cyber-physical systems include critical human-safety requirements

F-35

B-2

8

Industrial DevOps

The application of Lean, Agile, and DevSecOps principles to the planning, development, manufacturing, deployment, and serviceability of significant cyber-physical systems.

Reference: Johnson and Yeman. Industrial DevOps. 2023. IT Revolution.

Poll: Experience with Agile?

- None

- 0-3 years

- 5-10 years

- >10 years

Common Problems

- Lack of alignment among stakeholders on practices used to engineer, develop, integrate, test, certify

- Lack of alignment among stakeholders on tools used to engineer, develop, integrate test, certify

- Lack of transparency – data, measures, decisions – among stakeholders

- "Nothing is done until everything is done"—large batch processes and mindset

- Delays due to bureaucracy and outdated practices

- Long lead time for hardware procurement

Reference: Carnegie Mellon/SEI, Hasan Yasar

Benefits of Industrial DevOps

• Delivery of value in the shortest, sustainable lead time

• Improved collaboration and knowledge sharing across functional areas

• Build competitive advantage through rapid learning and experiments

• Improved quality

• Improved customer happiness

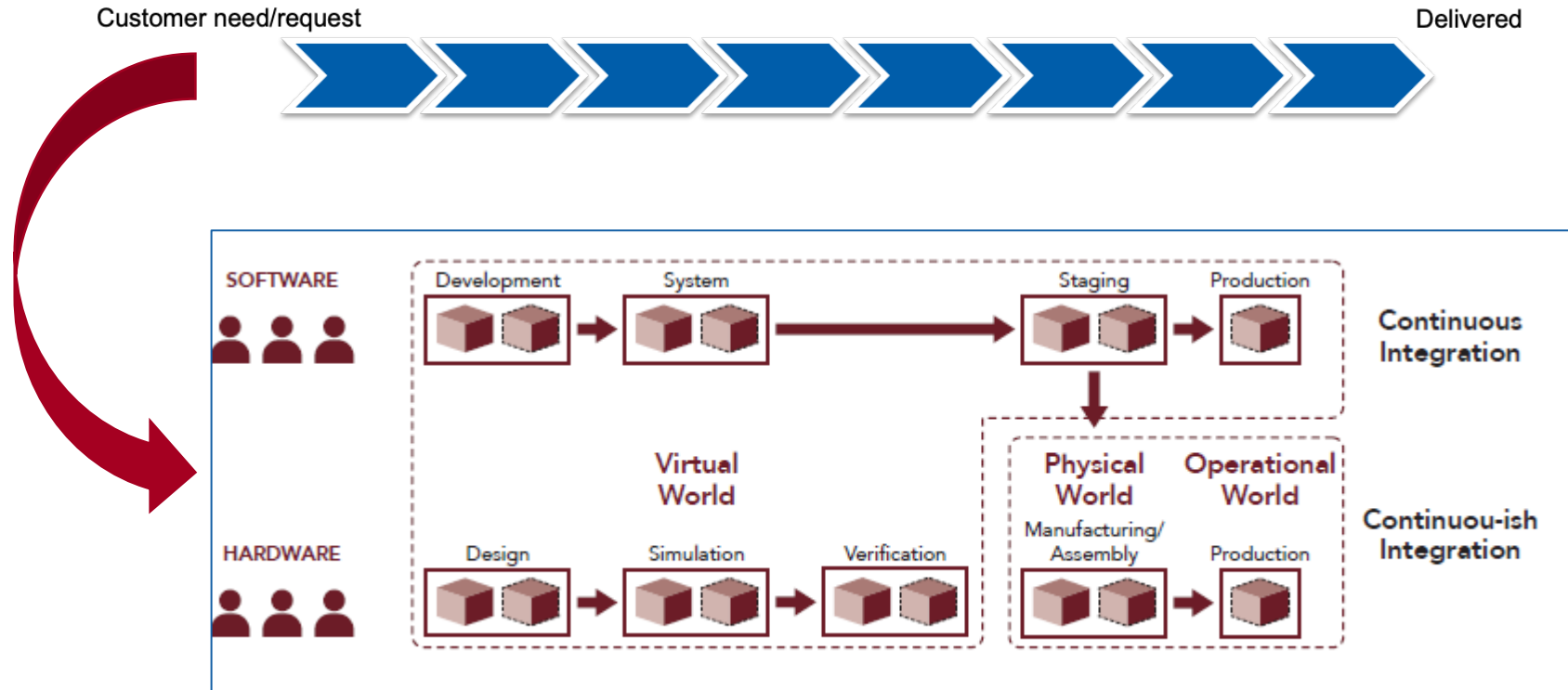• Happier, more engaged employees

Agile is a Lifecycle

Waterfall is a predictive lifecycle based on phase gates, Agile is an empirical lifecycle based on objective data.
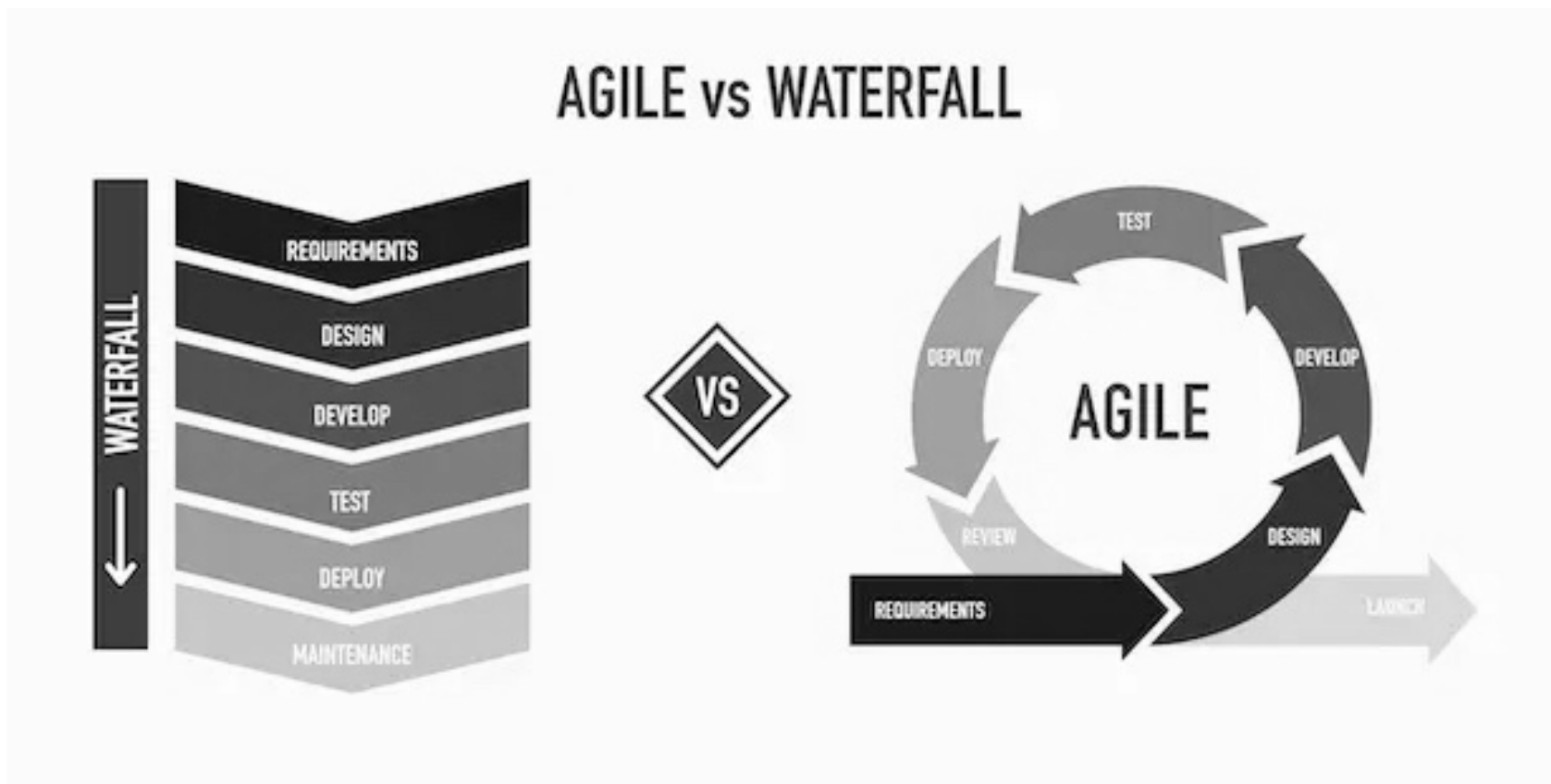
Poll: What word comes to mind when you hear the word "DevOps"?

- Free form in the chat

Principle 1: Organize for Flow of Value

Reference: Johnson ,et. al Applied Industrial DevOps. 2020. IT Revolution.

- Organization Structure
- Information Flows
- Heterogenous Subcultures
- Mental Models
- Multiple relationships
- Varying language

Principle 2: Multiple Horizons of Planning

Moving from predictive planning to empirical planning requires multiple planning horizons that are regularly updated based on objective evidence.

Epic	Q1 Features	Q2 Features	Q3 Features	Q4 Features
Add new camera, associated technology, and hardware updates	Interoperability camera (spike) New sensor Lidar enhancement Recording playback	Procure camera's ongoing traffic surveillance Obstacle-detection system enhancement	Enhanced communications with braking-system sensors Seat belt–sensor coordination Camera prototype on vehicle	Camera instantiation Full regulatory compliance

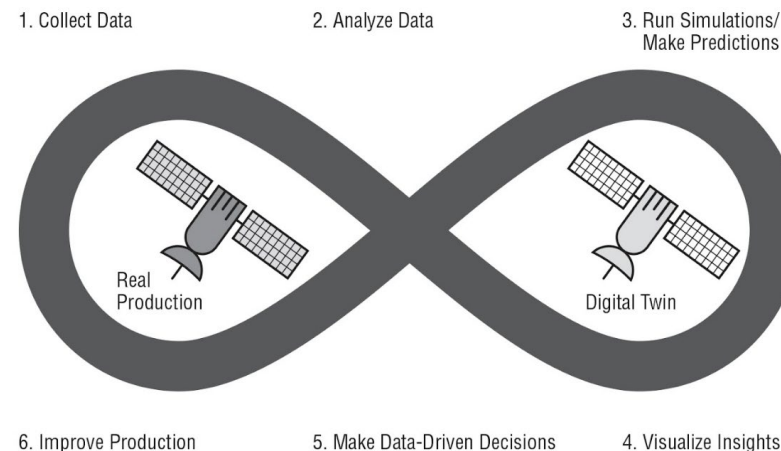*Table 3: Epic 2 Example: Decomposed Work across the Quarter*

Short Term Minimal Viable Product To Long Lead Items

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Principle 3: Data Driven Decisions

A

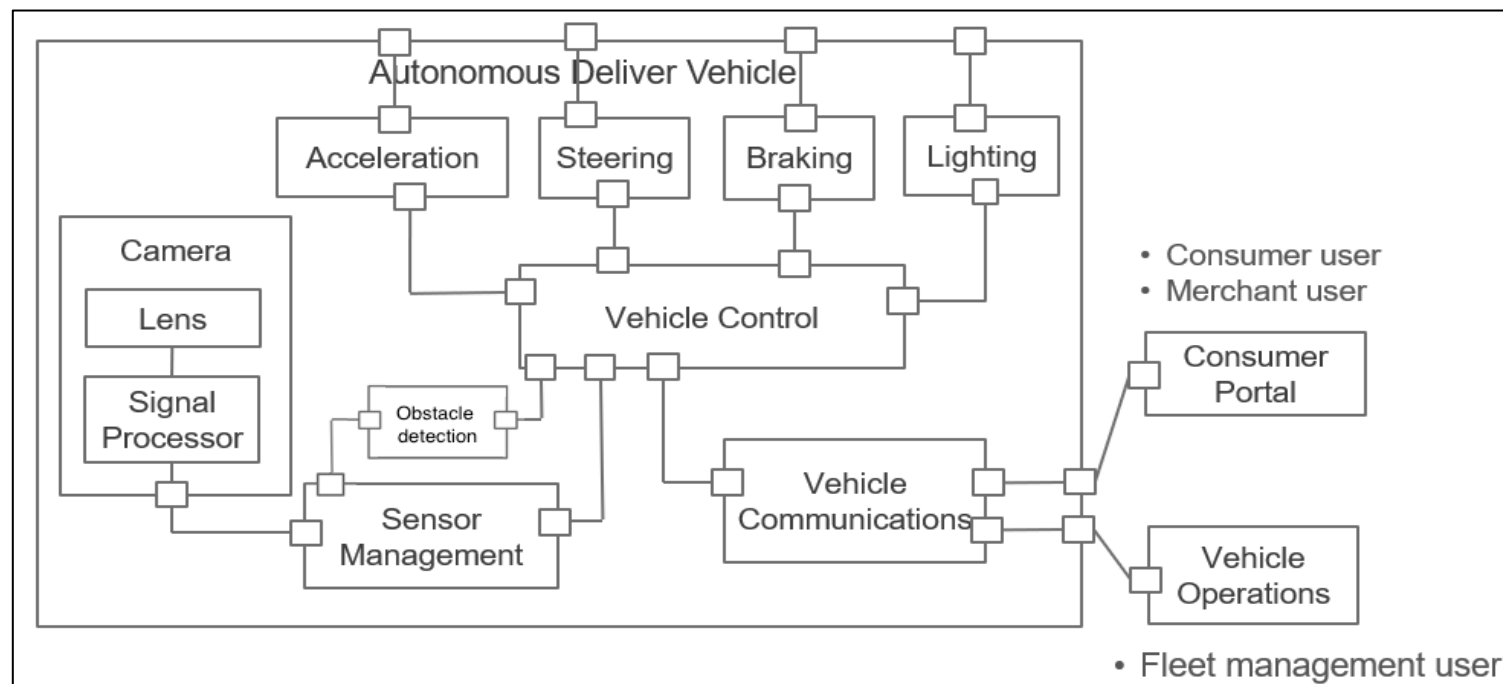|	Time Horizon	Capability	Evidence
epic	Annual	Enhance obstacle detection through updates to sensor types; refactoring architecture	Drive vehicle through multiple scenarios to validate sensor types; Evaluate deployment rate for new updates
feature	Quarterly	Enhanced Lidar sensor color profile	View colors in simulator to verify improvement
User story	Iteration	Split Lidar by component value	Validate demonstration of Lidar split by through test of
task	Day	Update cloud point extents in ESRI	CI/CD Pipeline has identified no errors with change

Backlog

Continuously improve with real-time data

B

1. Collect Data   2. Analyze Data   3. Run Simulations/ Make Predictions

Real Production   Digital Twin

6. Improve Production   5. Make Data-Driven Decisions   4. Visualize Insights

Measures when driving toward a desired business outcome

A Objectives and Key Results

B Flow Measures Feature Progress

Business Outcomes

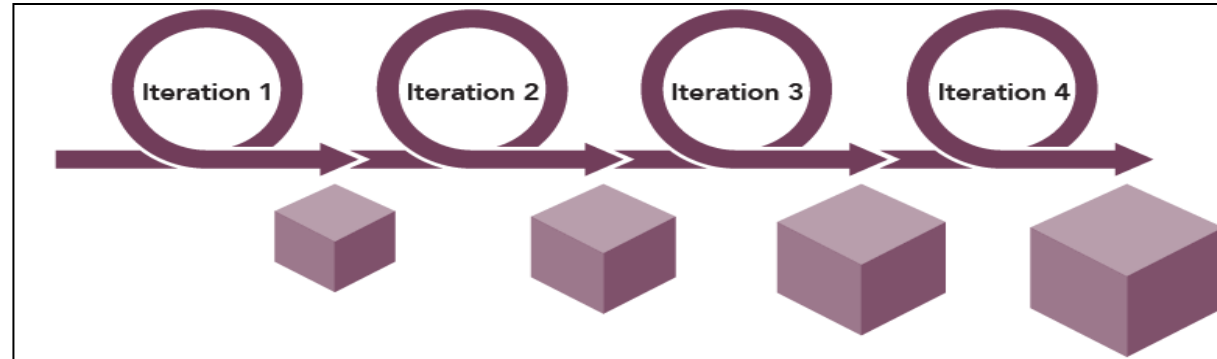*Johnson and Yeman. Industrial DevOps. 2023. IT Revolution.*

Principle 4: Architecture for Speed and Change

Modularity enables continuous flow in software, hardware, and manufacturing

Principle 5: Iterate, Reduce Batch Size, Improve Flow

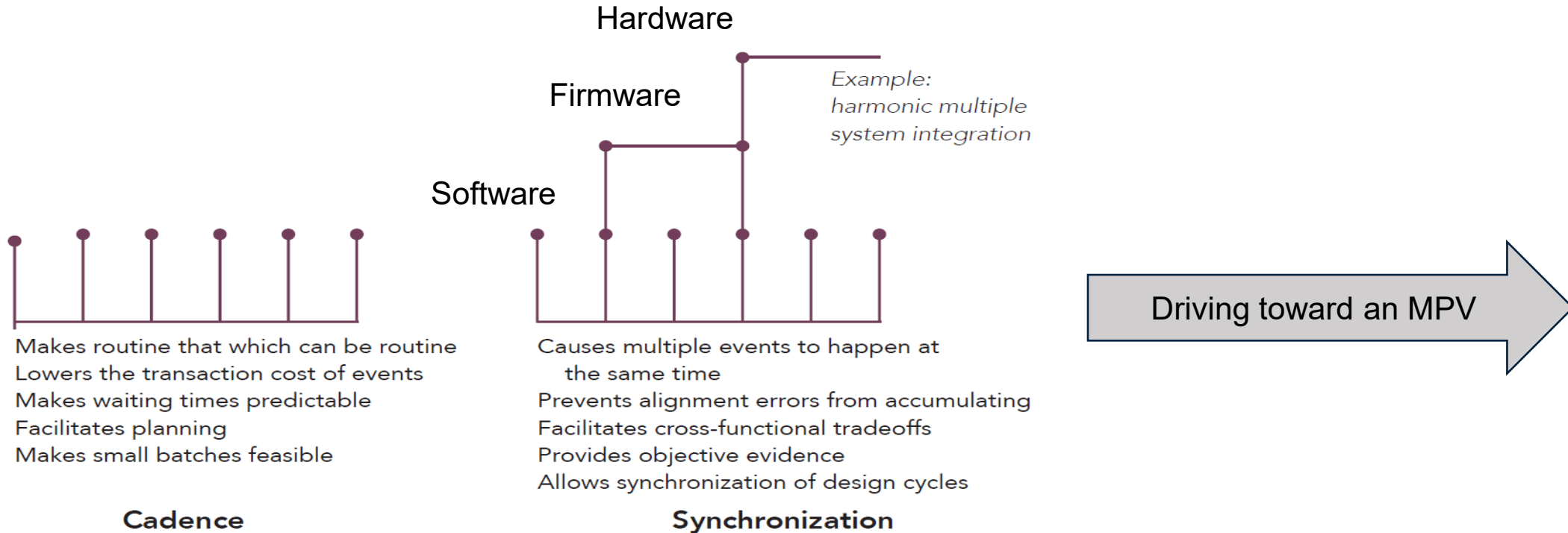## Epic 1: Software-Only Updates to Existing Fleet Vehicles

- Sensor system with an available test environment
- Simulated environment and small, code-based sensors, such as a forward and backup camera.
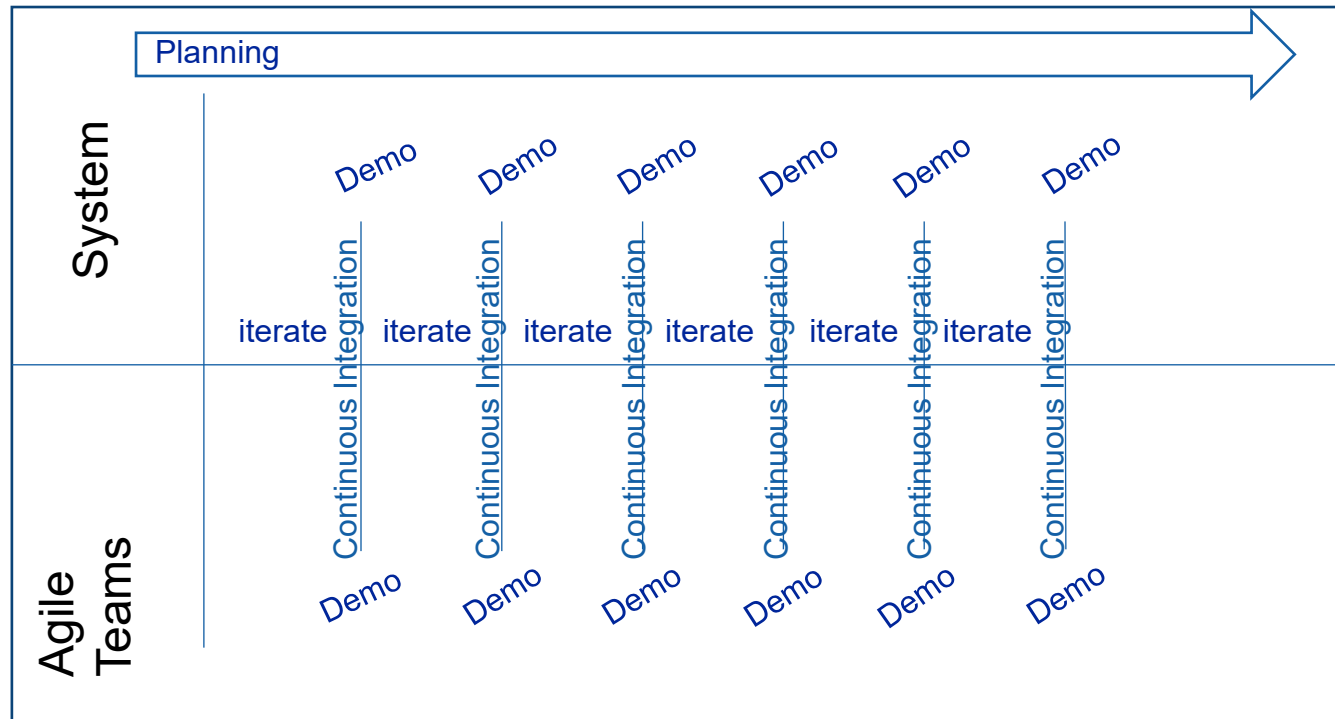
Epic 2: New Camera

- New functionality for radar sensors and using previously generated tests on a radar simulator to check the new code deployment.
- Code integration with the camera and radar system and resolve any integration errors.
- Upon successful demonstrations in the simulated environment, the team tests the firmware and software updates on a couple production cars.

Principle 6: Applying Cadence and Synchronization

Teams established a cadence of regular quarterly planning for alignment and short iterations for execution. Regular synchronization occurs by conducting demonstrations at the end of each iteration for fast feedback.
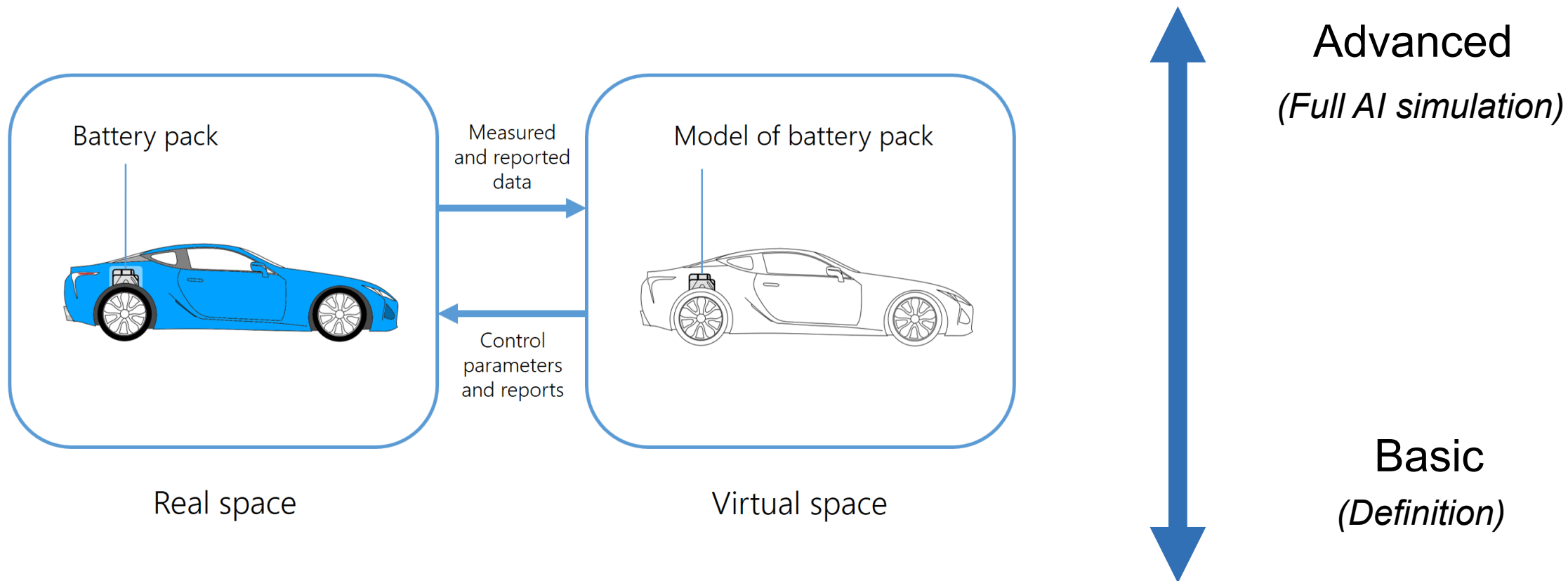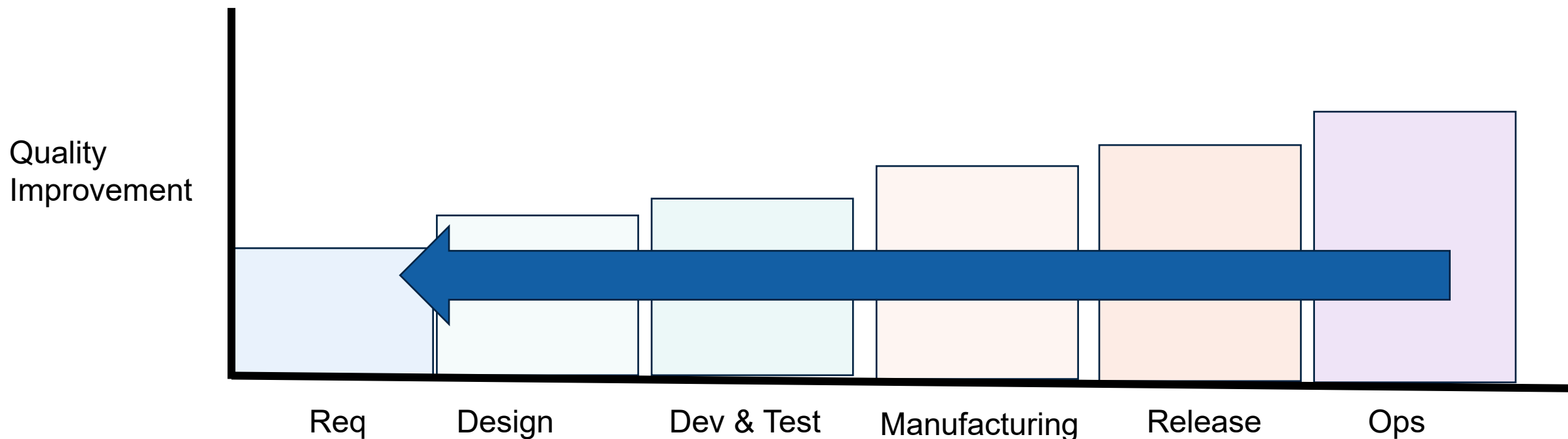
Hardware

Firmware

Example: harmonic multiple system integration

Software

Makes routine that which can be routine
Lowers the transaction cost of events
Makes waiting times predictable
Facilitates planning
Makes small batches feasible

Cadence

Causes multiple events to happen at the same time
Prevents alignment errors from accumulating
Facilitates cross-functional tradeoffs
Provides objective evidence
Allows synchronization of design cycles

Synchronization

Driving toward an MPV

Principle 7: Integrate Early and Often

Planning

System

Demo   Demo   Demo   Demo   Demo   Demo

Continuous Integration   Continuous Integration   Continuous Integration   Continuous Integration   Continuous Integration   Continuous Integration

iterate   iterate   iterate   iterate   iterate   iterate

Agile Teams

Demo   Demo   Demo   Demo   Demo   Demo

Innovations span many functional areas and require teams to reduce risk by planning together exploring ways to integrate frequently and testing early and often.

Complete/Partial Digital Thread Enabler

Battery pack

Real space

Measured and reported data

Control parameters and reports

Model of battery pack

Virtual space

Advanced

(Full AI simulation)

Basic

(Definition)

(8) Shift-Left

Quality Improvement

Req Design Dev & Test Manufacturing Release Ops

- *Test First Mindset: Test-driven development applies to software and hardware development.*
- *Design for manufacturability, reduce rework and late discoveries.*
- *Integrate small batches from product development to manufacturing for learning and feedback.*
- *Emerging digital capabilities and virtual environments are enablers for shift-left*

(9) Apply a Growth Mindset

Fixed Mindset

Are we fixed?

Growth Mindset

Are we open to new ideas?

SpaceX ✔ @SpaceX · 5h

With a test like this, success comes from what we learn, and today's test will help us improve Starship's reliability as SpaceX seeks to make life multi-planetary
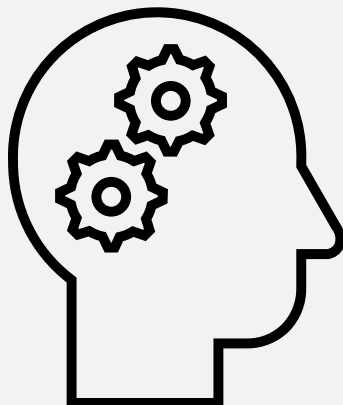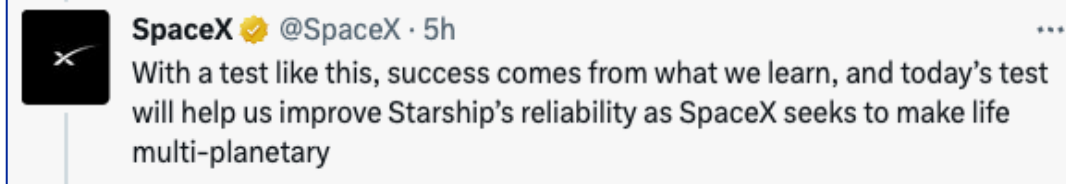
It is the ability each of us has that enables us to continuously grow our behavior, skills, performance, talents, or thinking….

A learning organization applies the same growth mindset."

Johnson and Yeman. Industrial DevOps. 2023. IT Revolution

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Six Challenges

1. Existing organizational structures

2. Lack of common language in the new way of working

3. Not understanding the Value Stream

4. Access to patterns to break down the system

5. Valuing exclusivity over inclusivity

6. Lack of Psychological Safety

Poll: What is the greatest barrier to adopting modern ways of working in your organization?

- Communication

- Knowledge/skills

- Investment

- Culture/Mindset

- Lack of leadership support

Create an Intentional Culture

Often many of the barriers to implementation stem from the organization's culture.

Reference: Johnson ,et. al Applied Industrial DevOps. 2020. IT Revolution.
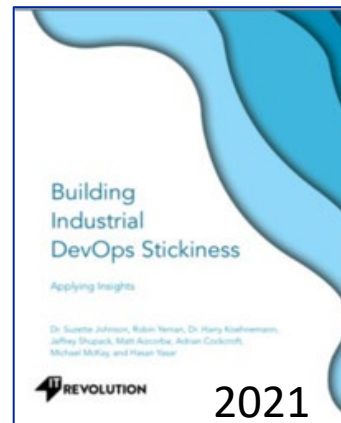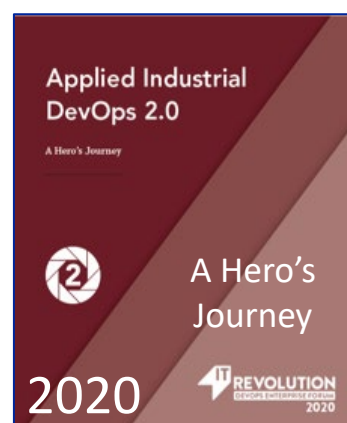
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Summary

Leveraging the power of Industrial DevOps is an industry step change.

Companies that solution this problem first will increase transparency, reduce lead time, increase value for money, and innovate faster.

Industrial DevOps

Industrial DevOps expands the definition of DevOps beyond software to enable significant cyber-physical systems development programs to be more responsive to changing needs while reducing lead times. It is the application of continuous delivery and DevOps principles to the development, manufacturing, deployment, and serviceability of significant cyber-physical systems.
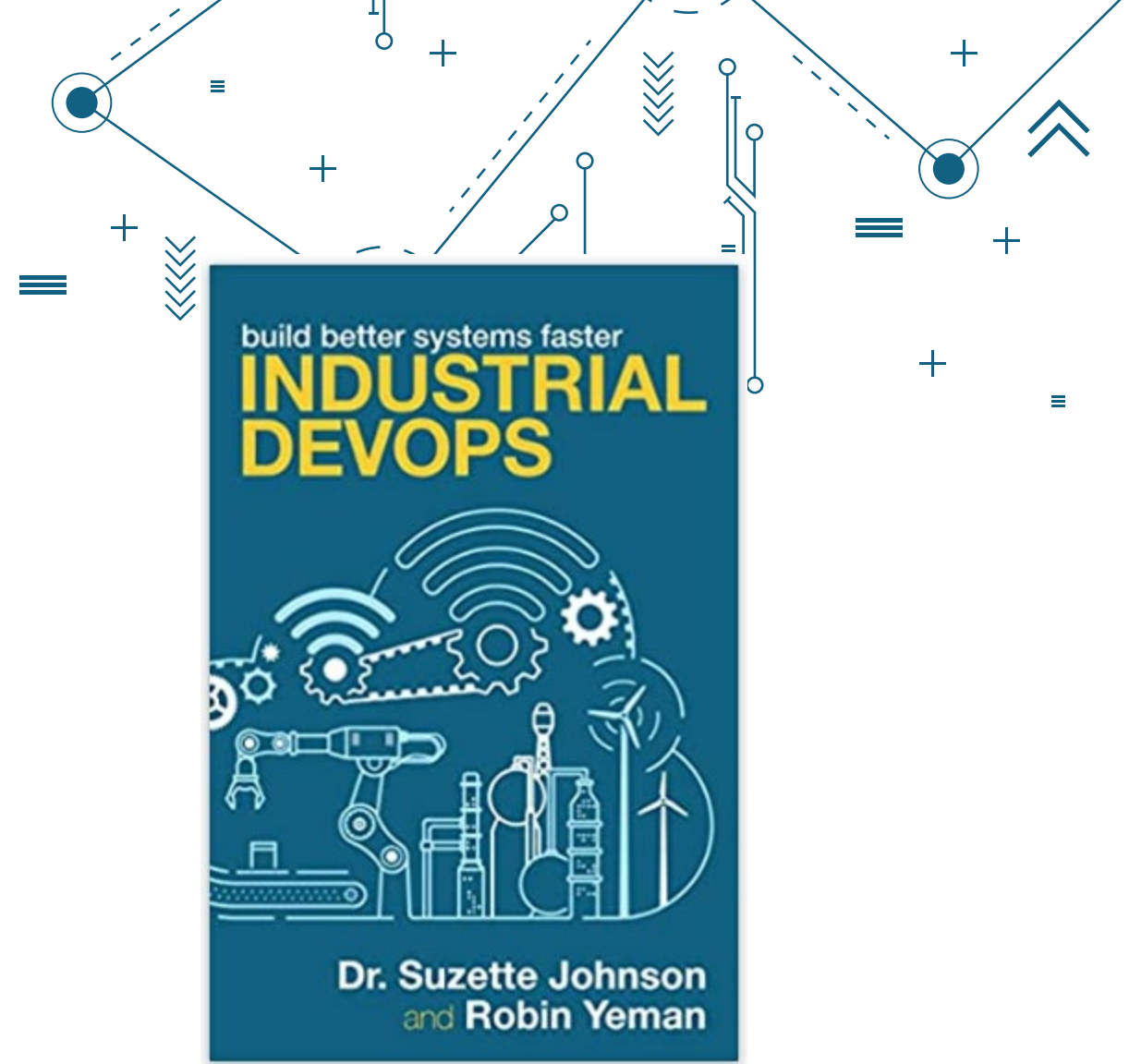

2018

2019

2020

2021

2022
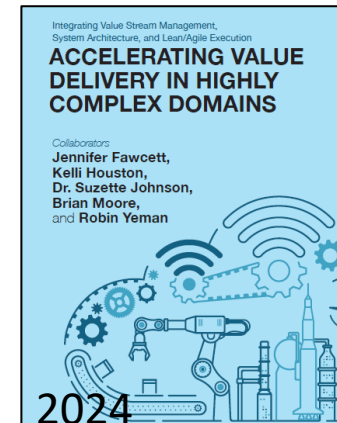
A letter to the Hardware Engineering community

2024

The Application of Industrial DevOps Using Digital Twins (coming soon)

https://itrevolution.com/book/industrial-devops//
https://itrevolution.com/book/applied-industrial-devops/
Building Industrial DevOps Stickiness (itrevolution.com)

Free and publicly available

(Free chapters)

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Q & A

ASK AWAY!