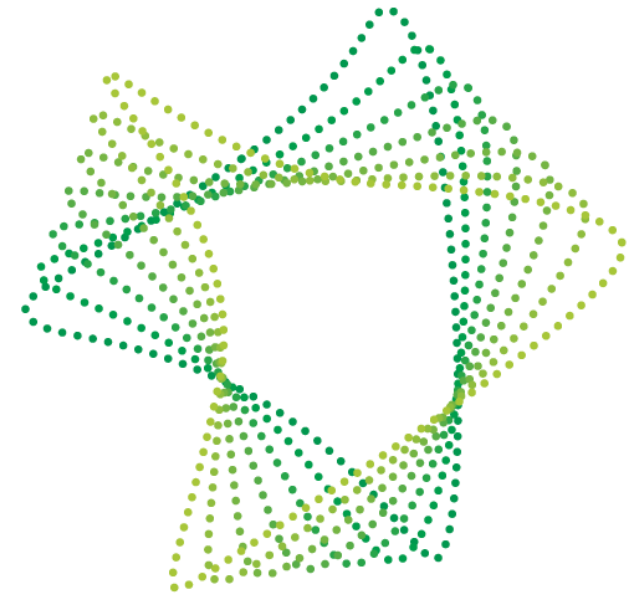# Robotics Adoption and RMF

ROS-I Asia Pacific Workshop 2021
Timothy-Joe Tan, Robotics Functional Lead
Sensors & IoT / Robotics

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CONTENTS

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Robotics Adoption – Introduction

Need for Robotics Adoption

Increasing manpower costs, scarcity of man power – ***Productivity issues***

Aging population, loss of elderly workers, young educated workforce – ***No replacement workers***

Fast changing landscape (ie: pandemic) – ***Shift away from monolithic developments, how to develop "lego" solutions***

Challenges to Robotics adoption today

Cost of adoption

Challenges to Scale

Interoperability
- Intra-systems interoperability
- Intra-premise interoperability

Robotics Adoption can be tough..!
1. Users caught in a dilemma – Need to digitize, but not sure how to scale, what to automate
2. Unclear innovation strategy – Piecemeal solutioning, may not play well with overall solutioning in the future
3. How can we scale robotics, to same levels of adoption as the car..? internet..?

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Robotics Adoption Problem - Jigsaw puzzle...
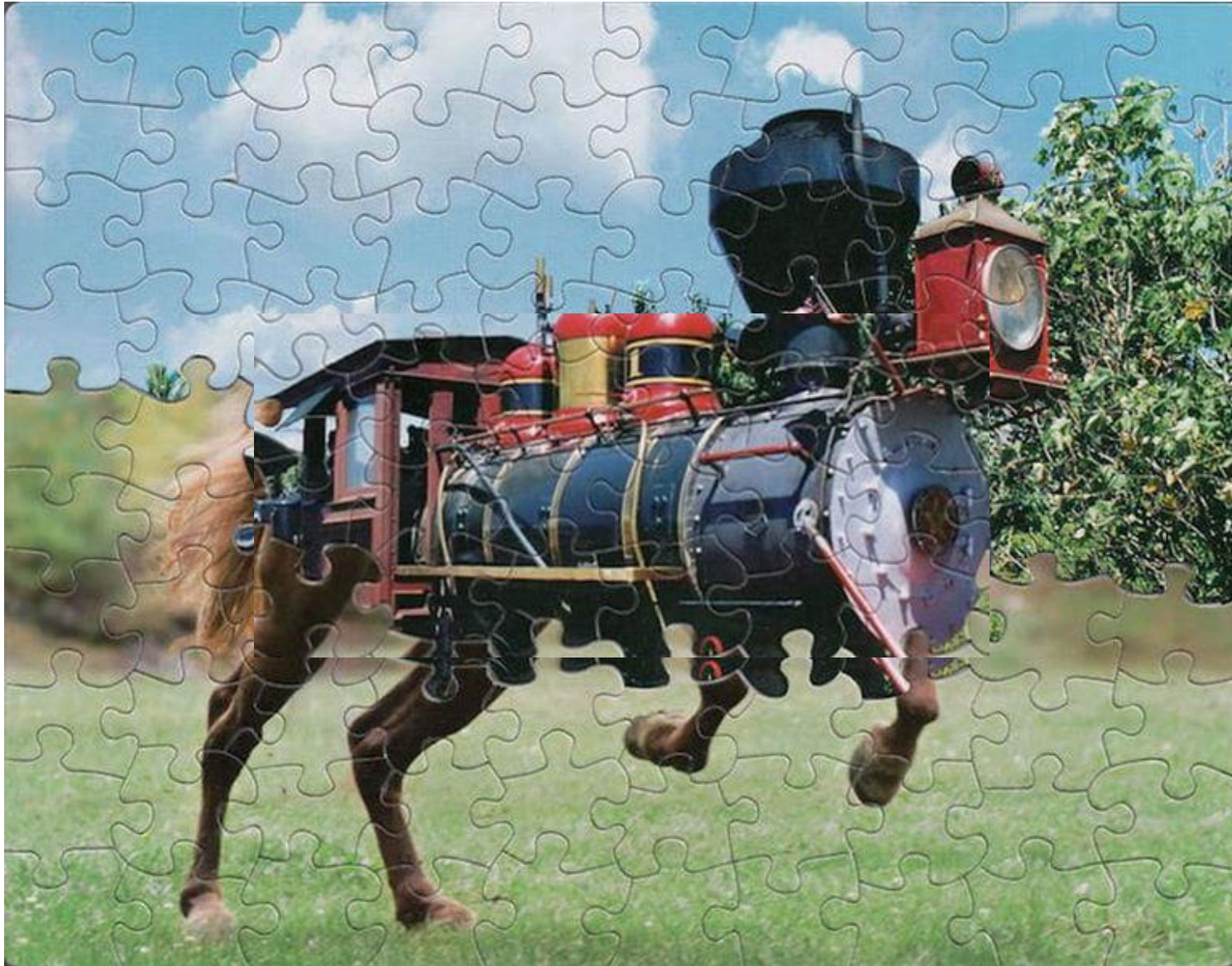
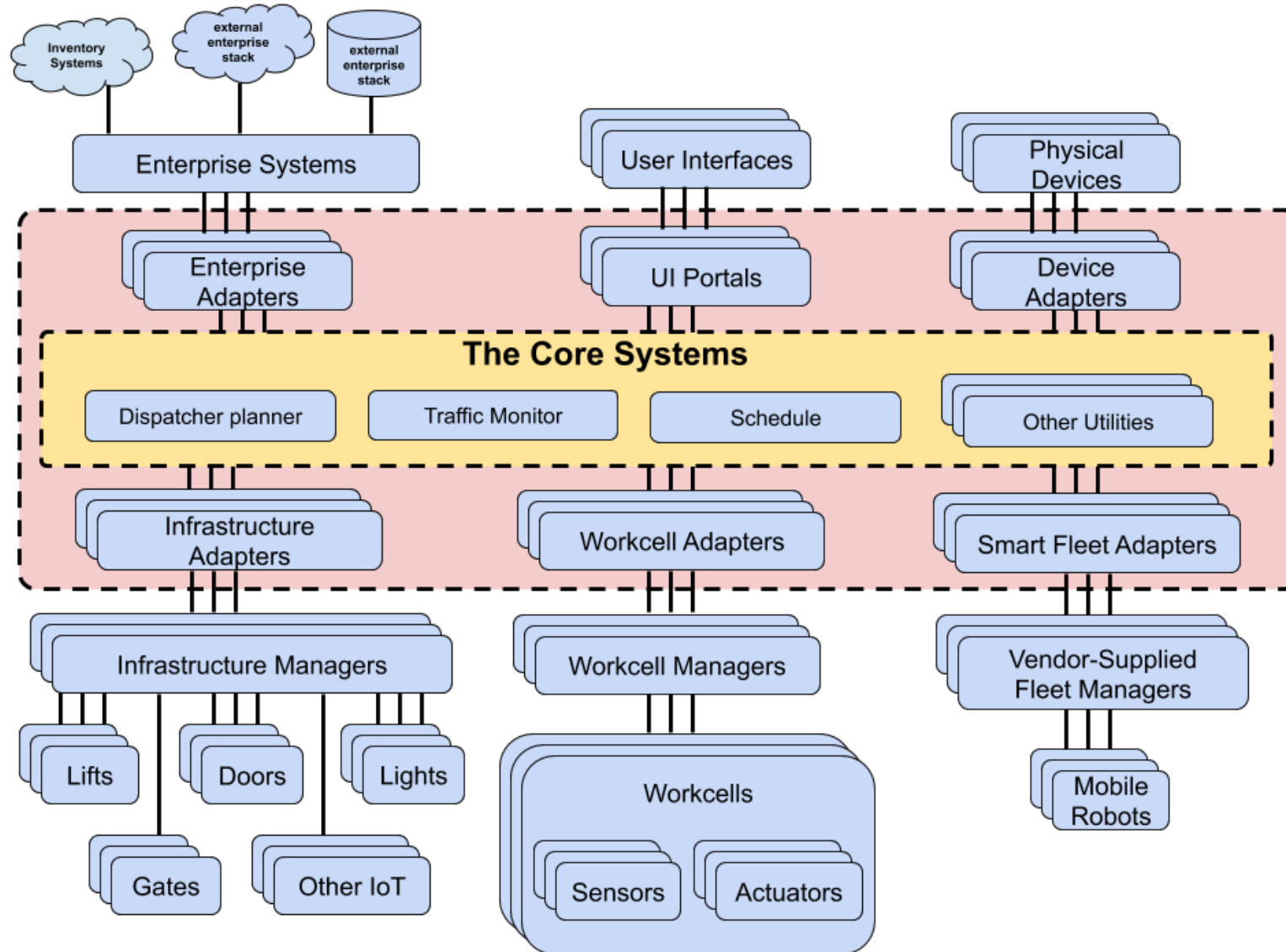Robotics adoption is like a jigsaw puzzle:
1) Aim of the game is to grow the picture...
   - Ensure the pieces fit
   - Each "jigsaw" piece takes [X]years, $[Y] million to develop (different TRLs)
   - Pieces come from different vendors
2) Challenge is to get all the pieces working together
   - Often customer doesn't know what he needs, how end picture will look like
   - *Value network* vs *Network effect*
   - New piece(s) that come along, could disrupt overall picture...

References: https://www.treehugger.com/recycled-puzzle-montage-art-tim-klein-4857103

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… to *architected* Jigsaw (Current RMF)

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… to "*Mosaic*" systems (DARPA future systems concept)

C2 Cell (CONUS)

References:
Mosaic Warfare: Busting Monoliths – Dr Timothy Grayson, DARPA/STO

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Planning and Composition

- What is the objective? What effects do we want?
- How do we know what is available?
- How do we decide what to use and how we are going to use it?
- Can I trust the plan?

Interoperability

- How do things connect (new links)?
- How can we connect the right things (adaptive networks)?
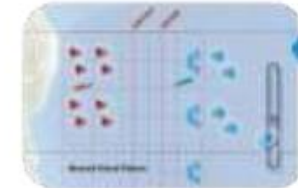- Can information drive the network? How can we discover nodes and links?
- How do we work across security domains?
- How do we synchronize?
- How do machines understand each other?
- How do we get new capabilities into existing systems?
- How do we improve speed and reliability of testing?

Execution

- How do we re-allocate capabilities at combat speed?
- How do humans and machines manage tasks at the edge
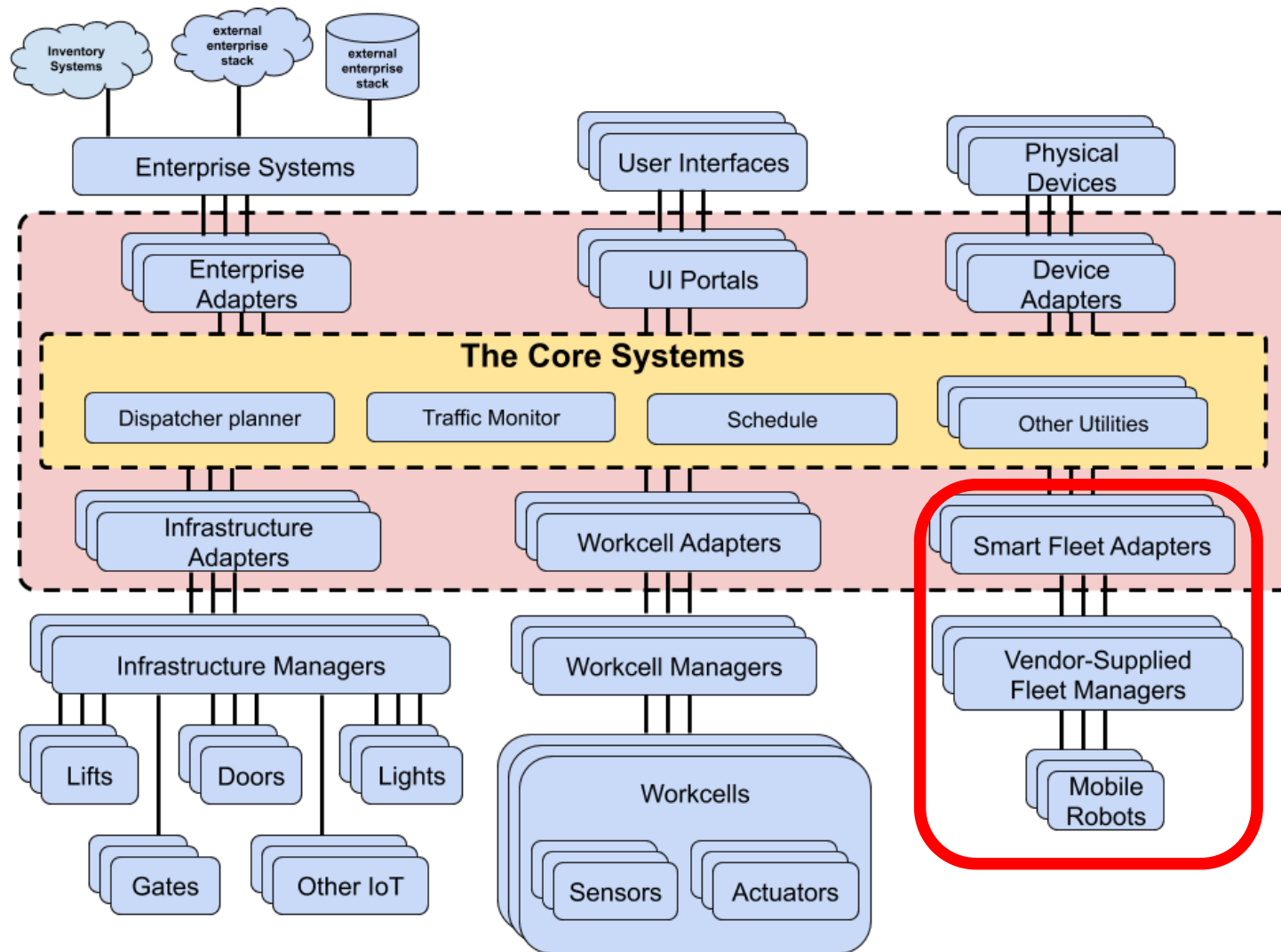- How do we automatically adapt tactics at varying scales?
- How can we train human operators fast and minimize burden?

References:
Mosaic Warfare: Busting Monoliths – Dr Timothy Grayson, DARPA/STO

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Current RMF robots architecture (in a nutshell)

Vendor-neutral, open-source software

The Schedule

Fleet Adapters customized for each vendor

Read-Only	Traffic-Light	Full-Control	Full-Control
Fleet Adapter Library	Fleet Adapter Library	Fleet Adapter Library	Fleet Adapter Library
Integration Layer specific to Vendor A	Integration Layer specific to Vendor B	Integration Layer specific to Vendor C	Integration Layer specific to FreeFleet
Vendor A API Client	Vendor B API Client	Vendor C API Client	FreeFleet API Client

Vendor-supplied proprietary hardware and software systems

Vendor A Fleet Manager

Vendor B Fleet Manager

Vendor C Fleet Manager

Free Fleet Fleet Manager

custom robot, custom robot, custom robot, custom robot, custom robot, custom robot

- Backroom
- Scheduled
- "Train" like

- People centric robots
- Ad-Hoc
- Different (higher) levels of autonomy

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RMF of the future – Moving towards "Mosaic" systems

No RMF

With RMF (Today)

Possible RMF (Future)
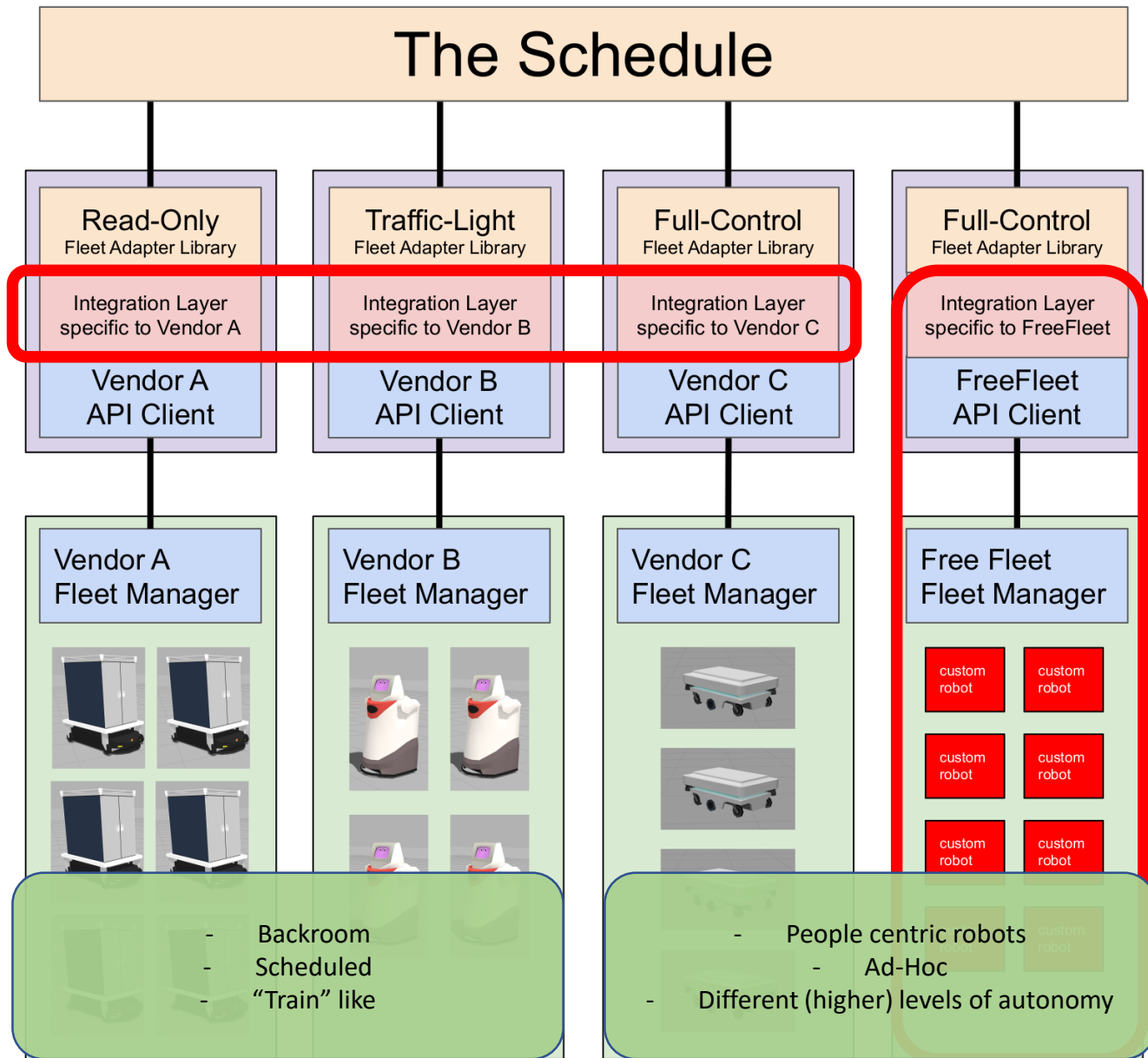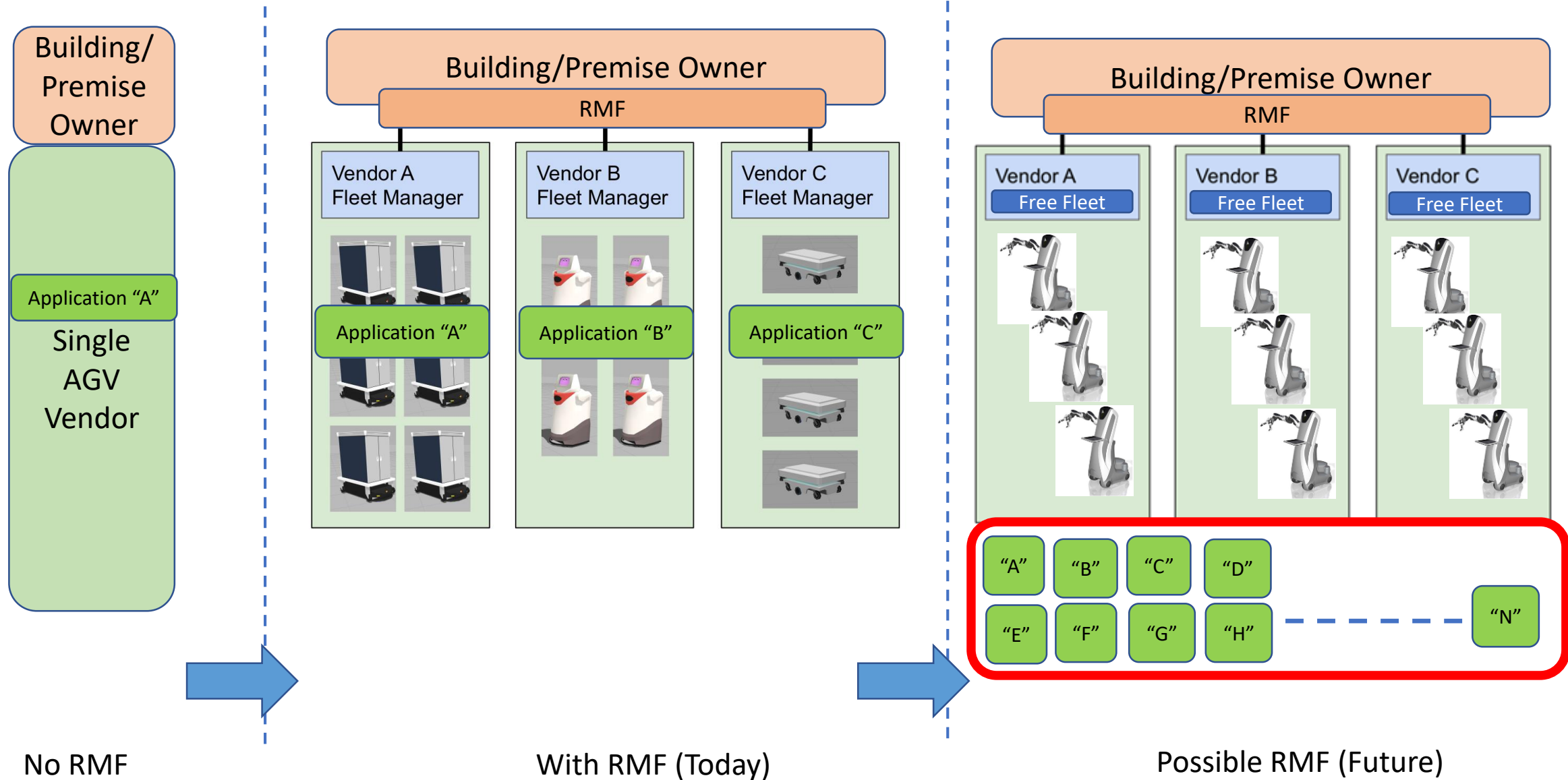
RMF of the future – Creating an army

1) Application specific robots
2) Heterogenous robots co-exist (*peacefully*)

3) Monolithic developments (non standard hardware, long lead times)

VS

1) Multi-role robots
2) (Almost) homogeneous robot working together *harmoniously*
   - 2 or more *Robots* can work together to do a task
   (ie: coordinated manipulation)
   - 2 or more *Fleets* can work together to do a task
   (ie: sensor-shooter)

3) Rapid (software + mission payload) *application* rollouts – fail often, fail fast

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RMF of the future – Moving towards "Mosaic" systems

- Mosaic contrasted to Monolithic platforms – Small, scalable, low cost
  - **Challenge to design and deploy _hardware & software_ systems like application "micro-services"**
- Improve diversity of options
- Improved speed and scalability of deployment

What *is* new is the speed of deployment that the mosaic concept allows
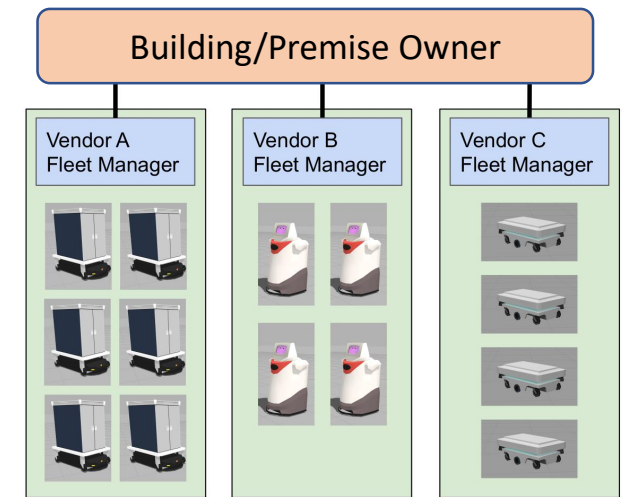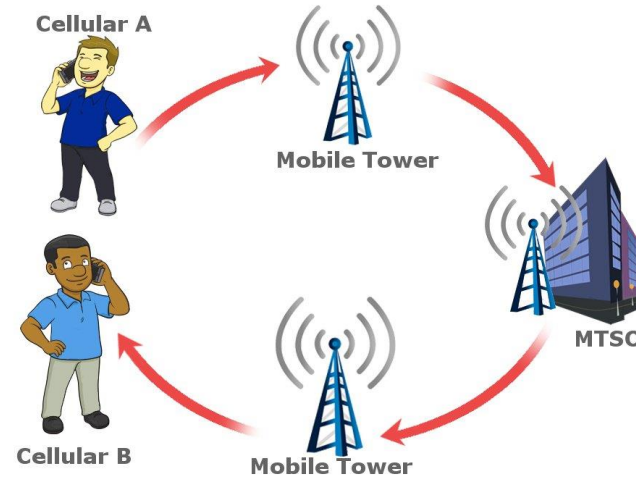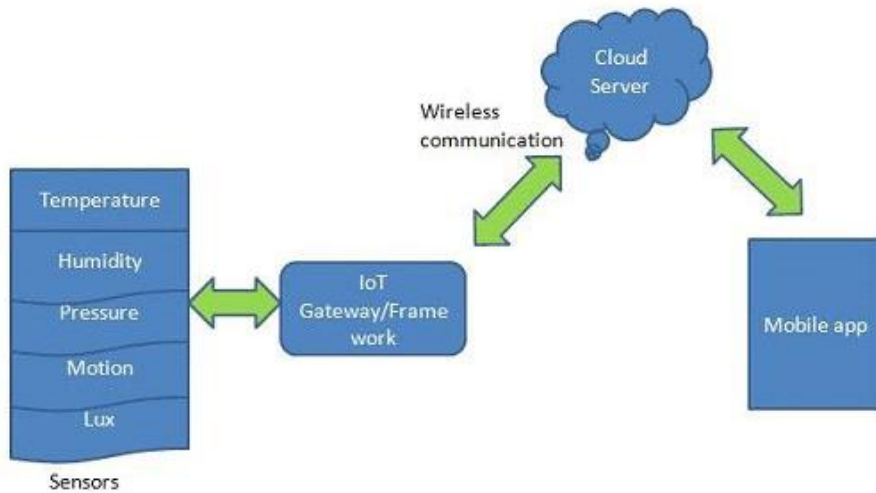
Enablers:
- Generic interfaces
- Reference design. ie:
  - Standardized interfaces & hardware
  - Mission specific payloads
Will allow for proliferation via Cloud and software applications

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Roles & Responsibilities: Across technology types

Internet of Things

	IoT	4G/5G	Robotics (today)
End user count	~1	Many (civilian consumers)	~1
Developer count	~1 (assuming closed data)	Many (app developers)	~1-3 (robot brand)
Premise Owner count	~1	Abstracted (telcos)	~1
Product (ie:Sensor) count	x00,000	x000,000	~6 – 18 (today, practical limitations)
Product complexity & cost	Simple, standardized	Handphones, fairly complex, standardized	Complex, non-standardized
Product comms reqs.	One way, low bandwidth (MQTT), non critical	2-way, high bandwidth (4/5G, wifi) User experience QoS	2-way, high bandwidth (4/5G, wifi) Biz/safety critical, need redundancy/failover
Availability of App market place	Yes / brand specific (ie: Adafruit IO)	Yes (iOS, Android)	No / Brand specific

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Challenges facing adoption

o How to encourage vendors to move towards "application" development that cuts across verticals, rather than "end to end"

→Modular vs Integrated approaches

o (?) as a service - unclear

o Cost & complexity

ie: how would robotics delivery, be cheaper than PMD deliveries?

o Premise and application *abstraction*

o Identify how to commoditize Robotics, yet preserve the Service characteristics

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Q&A

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