



REVOLUTIONIZING THE WAY THE WORLD MOVES™

PME Overview

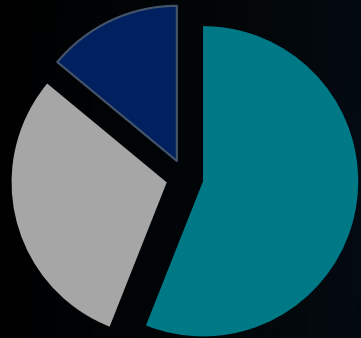
Celyn Evans – Technical Director

Tom Waligora – Chief Robotics Engineer

May 2019

Who We Are

- ESTABLISHED 1989
- PRIVATELY OWNED S-CORPORATION
- NON-TRADITIONAL QUALIFICATION
- FACILITY SECURITY CLEARANCE



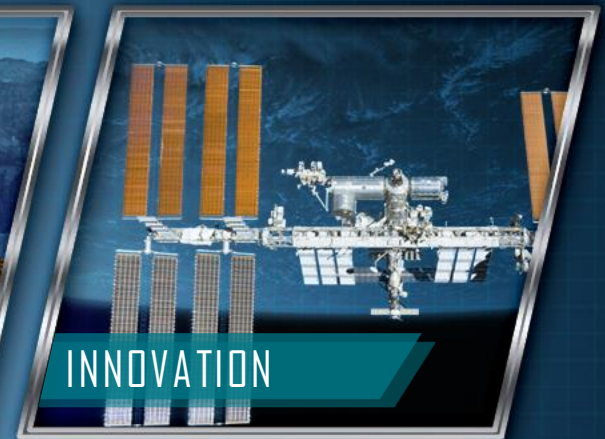
- Engineers
- Technicians
- Staff



Pratt & Miller uses a proven formula of attracting and retaining talented people, developing robust processes, and investing in advanced technology to achieve the highest level of customer and employee satisfaction.



REVOLUTIONIZING THE WAY THE WORLD MOVES™



RESEARCH & INNOVATION | ENGINEERING & DESIGN | PROTOTYPE BUILD | TEST & DEVELOPMENT | PRODUCTION

Customers

Motorsports



Exclusive to General Motors since 2005

Defense



Mobility



Innovation



Design and Build Winning Ground Vehicle Solutions

Mobility

- Wheeled & Tracked Vehicles
- Chassis & Suspension
- Mobility Analysis
- Testing and Development
- Hybrid/Electric Systems
- Software Development

Survivability

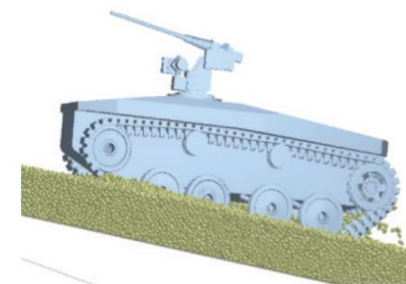
- Lightweight Systems
- Blast Analysis
- Occupant Protection

Robotics

- Autonomous Systems
- Robotic Mobility Platforms
- Software Development – Controls

Complete Vehicle Integration

- Prototype Builds
- Concept Development
- Trade Studies
- Requirements Management



Discrete Soft Soil Modelling



Building the Best Ground Robotic and Autonomy Platforms

Robotic Platform Development

- Vehicle Design Prioritizing Performance, Modularity & Affordability
- Early Co-Simulation for Architecture Determination (tool chains)
- Custom High Voltage System Design
- High Mobility Tracked & Wheeled Systems
- Drive-by-wire design & integration
- In-Wheel & Shaft Coupled Drive Motor Configurations
- Hybrid & Electric Propulsion Systems
- Full Vehicle Build & Test



Mobility Controls and Software Development

- Dynamic & Kinematic Model-Based Control
- Advanced Traction & Force Control Design
- Bimodal Enabling Actuation System Design



Autonomy Integration

- Integration of Partner Autonomy Applique
- Electrical Architecture Design
- Sensor and Perception Layer
- Path Planning Integration



Relevant Robotic Platforms

Expeditionary Modular Autonomous Vehicle

Customer

Marine Corps Warfighting Laboratory

Specifications

- TRL 7
- Diesel Electric Series Hybrid (JP8, zero oxygen, silent)
- 7,000 lbs GVW /14,000 lbs GVWR
- 30 MPH with upgrade to 55 mph
- 3 kW (Driving); 6 kW (Generator Mode)
- Overall Size: 12'7" x 5'0" x 3'0" (with CROWS II)
- Supervised autonomy, tele-op, follow me, obstacle avoidance
- GPS way-point following, Follow-me capability
- GPS denied environments

Links

<https://vimeo.com/298432618/9608b909d8>



Trackless Moving Targets (TMT-V and TMT-I)

Customer

US Army/PEO STRI

Specifications

- TRL 9 for “TMT-V” and TRL 7 for “TMT-I”
- Full electric with 4-wheel steer and independent drive
- 5,400 lbs GVW /11,200 lbs GVWR and 820 lbs/ 1300 lbs
- Top Speed TMT-V 35 MPH / TMT-I 12 mph
- “V” 181 in x 80 in x 32 in
- “I” 49.6 in x 42.8 in x 19.6 in
- GPS way-point following, reactive behavior, automated-emergency-braking



Links

<http://www.tracklessmovingtargets.com/>

<https://vimeo.com/301915160>

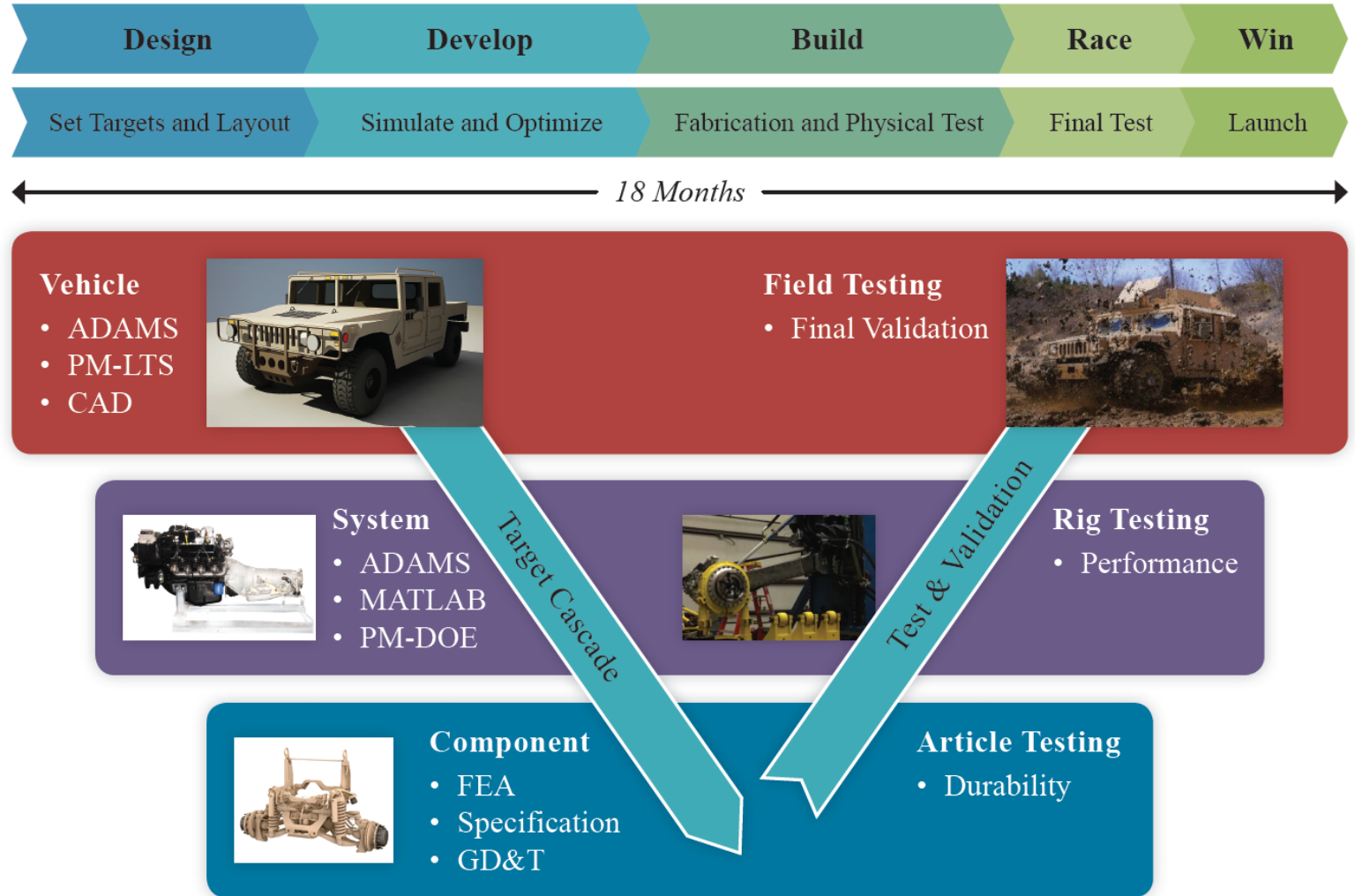


Development Process: Enabling Success

System Development Process

Product Development V-Model:

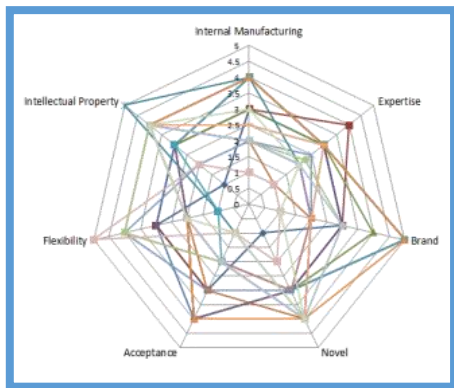
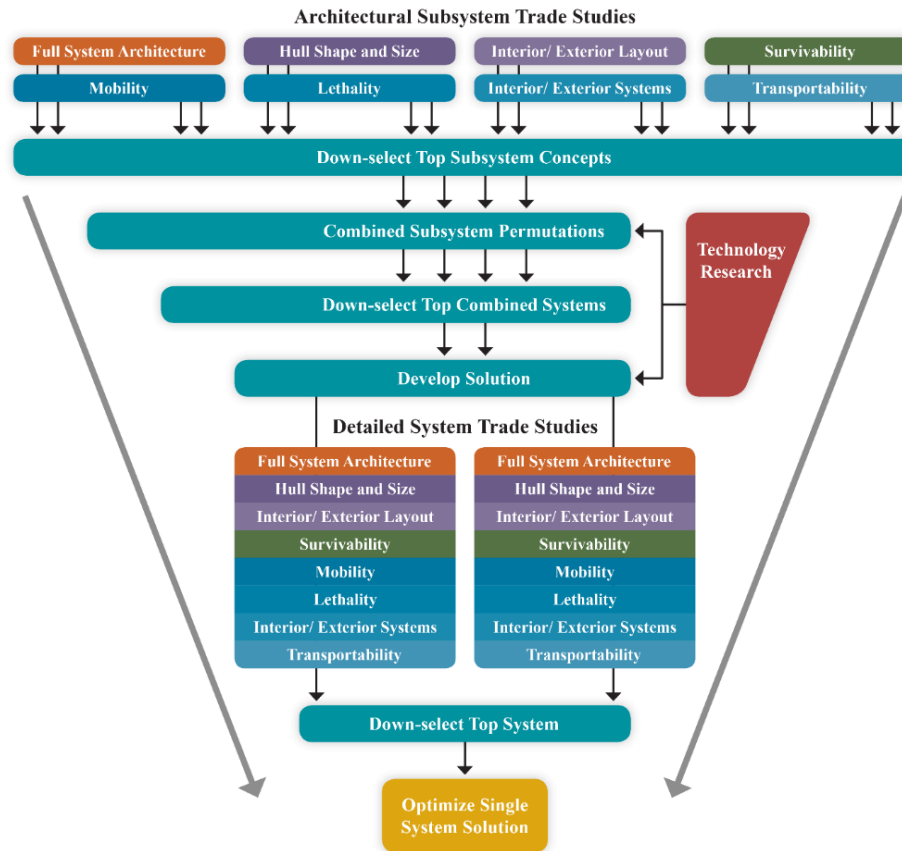
- Translating the broad vision
- Decomposing requirements/interdependencies
- Creating analysis and model driven designs
- Trading features, modularity and cost
- Architecture trades have lasting effect
- Validation of assumptions
- Concept to production



System Development Process

Analytical Hierarchy Trade Study Process

- Decompose what customer wants
- Features/Capability
- Subjective/Objective
- Creates non-intuitive solutions
- Custom



Input - Concepts

Category	Weight	Value	Score
Full System Architecture	0.25	0.10	0.25
Hull Shape and Size	0.25	0.10	0.25
Interior/ Exterior Layout	0.25	0.10	0.25
Survivability	0.25	0.10	0.25
Mobility	0.25	0.10	0.25
Lethality	0.25	0.10	0.25
Interior/ Exterior Systems	0.25	0.10	0.25
Transportability	0.25	0.10	0.25

Ranking Concept System Performance

Rank	Concept	Weighted Score	Rank
1	Concept 1	0.10	1
2	Concept 2	0.08	2
3	Concept 3	0.06	3
4	Concept 4	0.04	4
5	Concept 5	0.02	5

↓

Output - Overall System Performance and Relative Rank

Category	Weight	Value	Score
Full System Architecture	0.25	0.10	0.25
Hull Shape and Size	0.25	0.10	0.25
Interior/ Exterior Layout	0.25	0.10	0.25
Survivability	0.25	0.10	0.25
Mobility	0.25	0.10	0.25
Lethality	0.25	0.10	0.25
Interior/ Exterior Systems	0.25	0.10	0.25
Transportability	0.25	0.10	0.25

System Performance

↑

Input - Categories/Subcategories

Category/Subcategory Weighting

↓

Category/Subcategory Relative Weighting

Category	Weight	Value	Score
Full System Architecture	0.25	0.10	0.25
Hull Shape and Size	0.25	0.10	0.25
Interior/ Exterior Layout	0.25	0.10	0.25
Survivability	0.25	0.10	0.25
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Modular Architecture

Modularity Concept to Execution

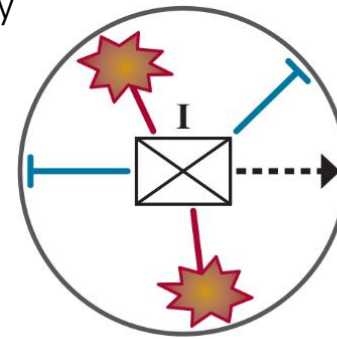
Enable combined capabilities to expand area of influence

Realization of Modular Design:

- Idea of modularity is limited in the ability to get to the future capability desired
- Full mission asset management to solve a problem
- Combining modular capabilities payload, interface, operability

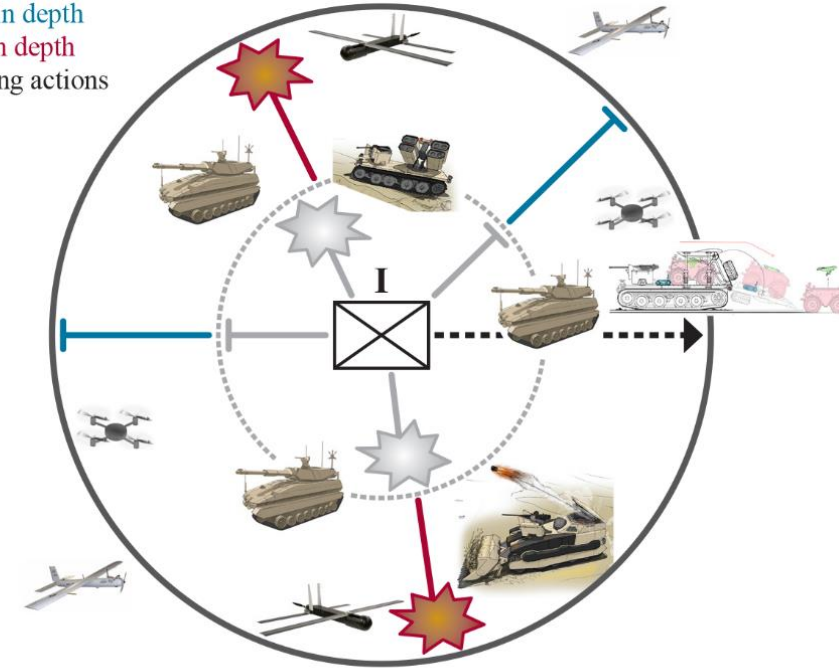


Limited View



Area of Influence - Today

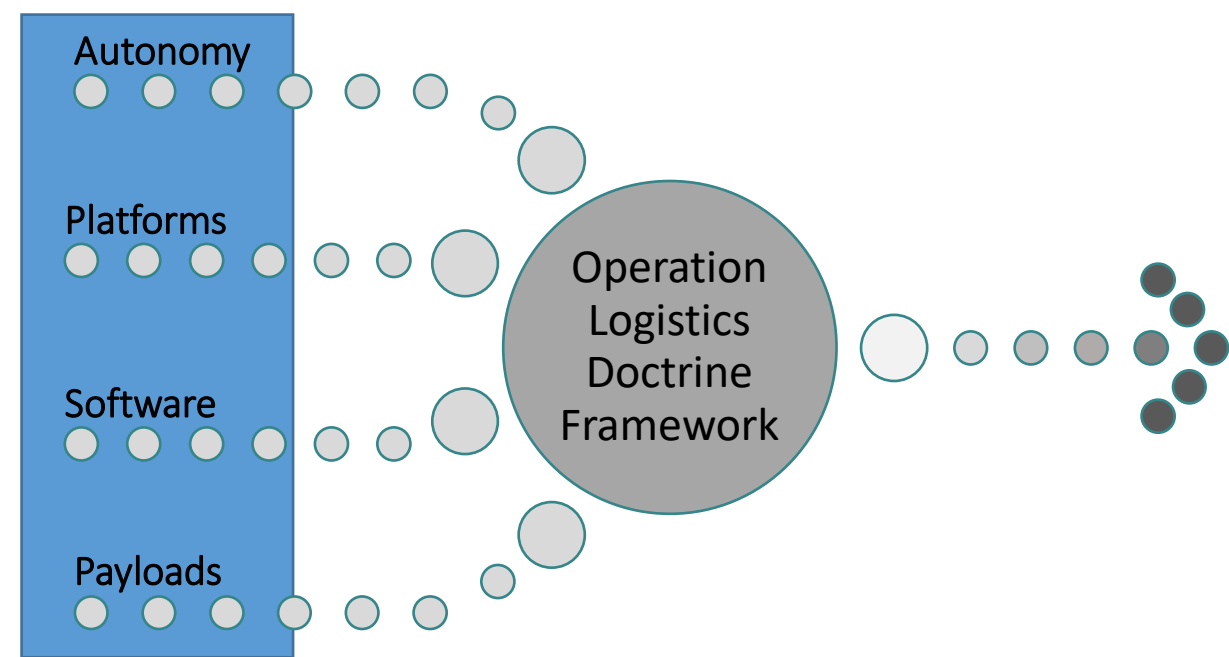
- » Sensors in depth
- » Effects in depth
- » Supporting actions



Future Area of Influence

Capability Modularity

Combined levels of modularity and operational context to meet future needs



Require modularity

Multi-Domain Asset Management

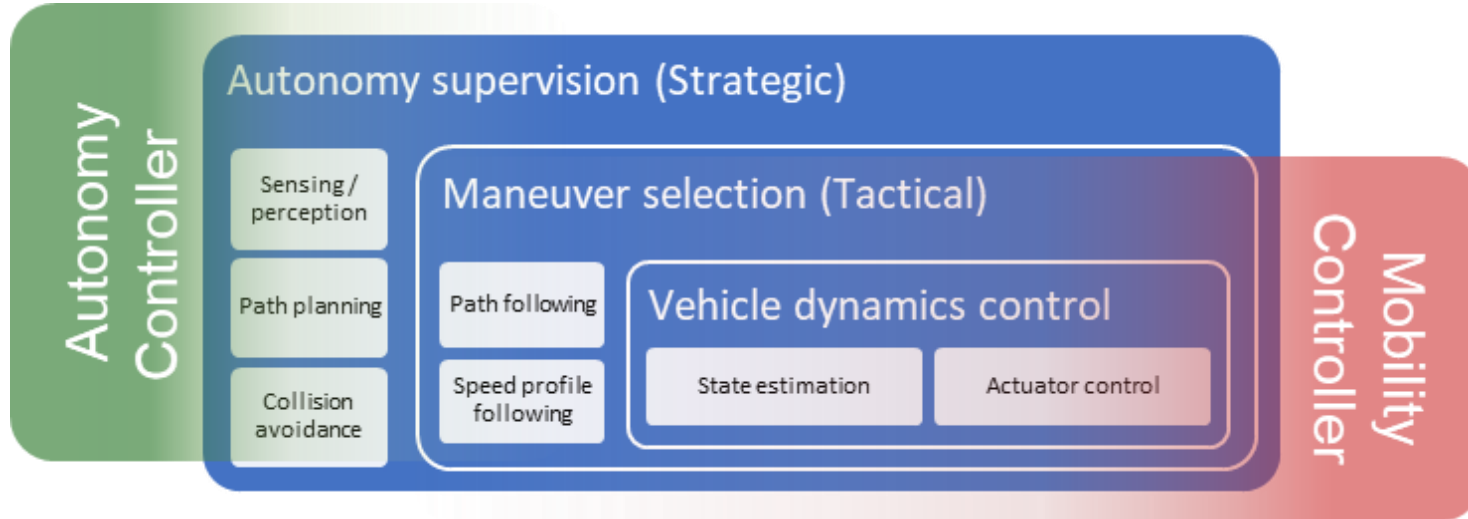


The country needs and, unless I mistake its temper, the country demands bold, persistent experimentation. It is common sense to take a method and try it: If it fails, admit it frankly and try another. But above all, try something.

- Franklin D. Roosevelt

Spectrum of Modularity: Autonomy

Autonomy stack and mobility stack are part of the solution



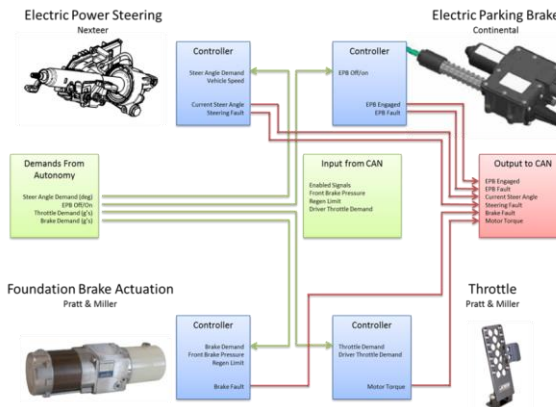
Demonstrators: Test the Theory



Human Machine Interface



Actuation System Enabling



Spectrum of Modularity: Platforms

Vehicle definition of modularity can enable or hinder success

Vehicle Modular Design:

- Simple to complicated
- Evaluate based on speed of change
- Move beyond “flat deck”
- Powertrains, size, power adaptable
- Wheels and tracks
- Armor and sensors

Rebuild

- Essential all new



Modules

- Swap key components



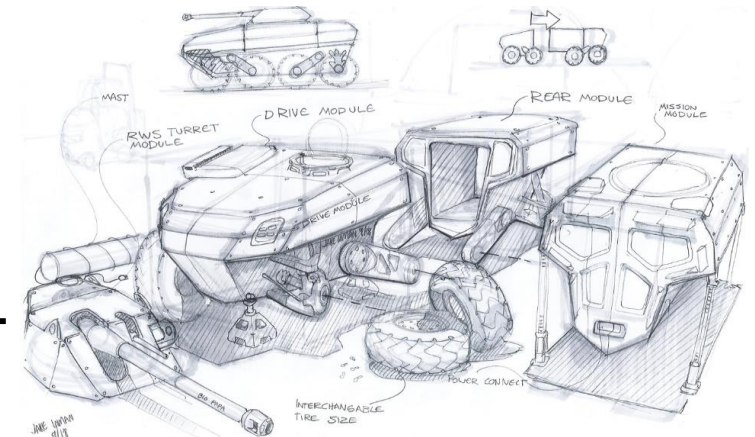
Rolling Chassis

- Separated “cabs”



Infinite

- “Lego” blocks

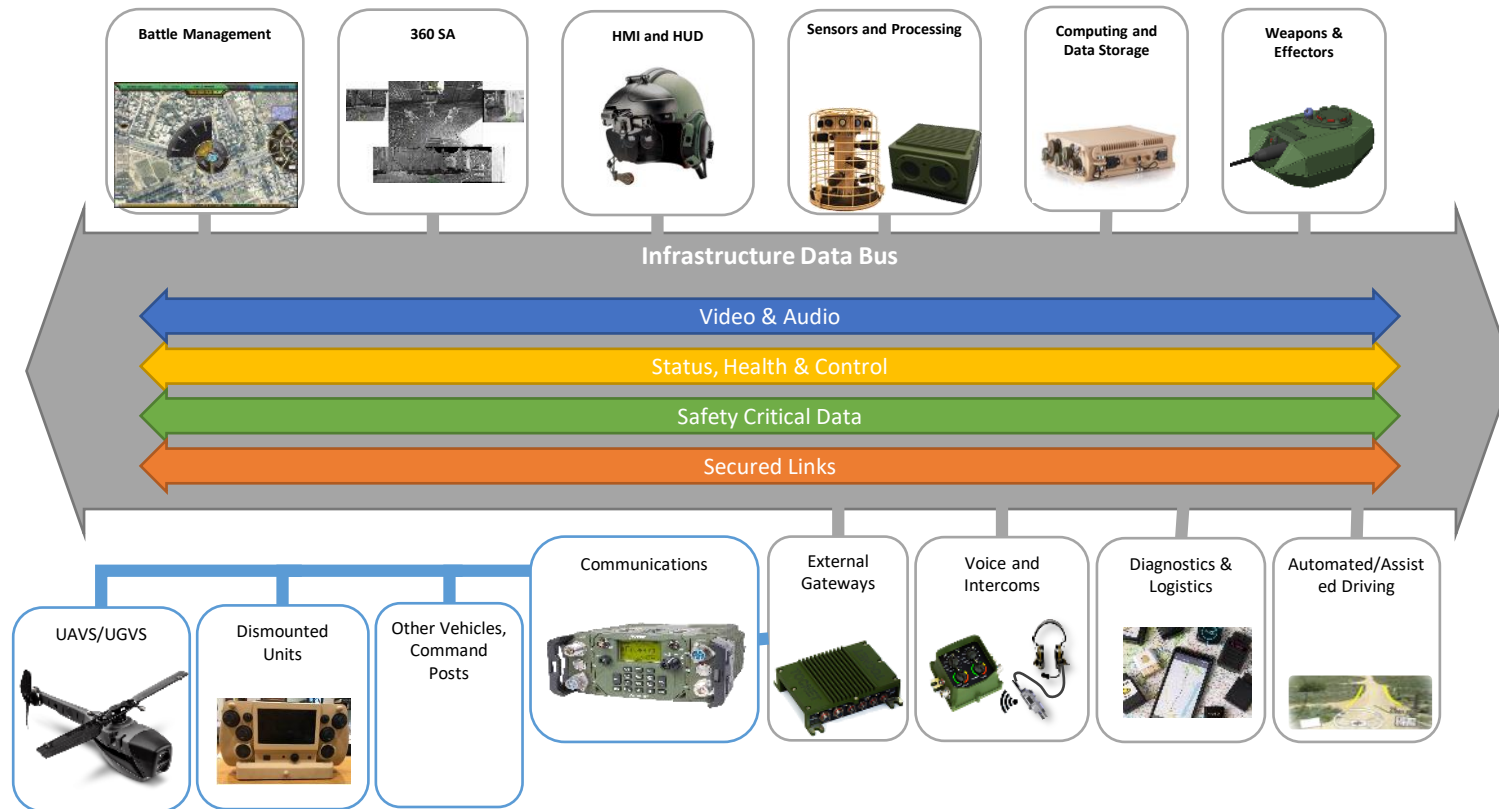
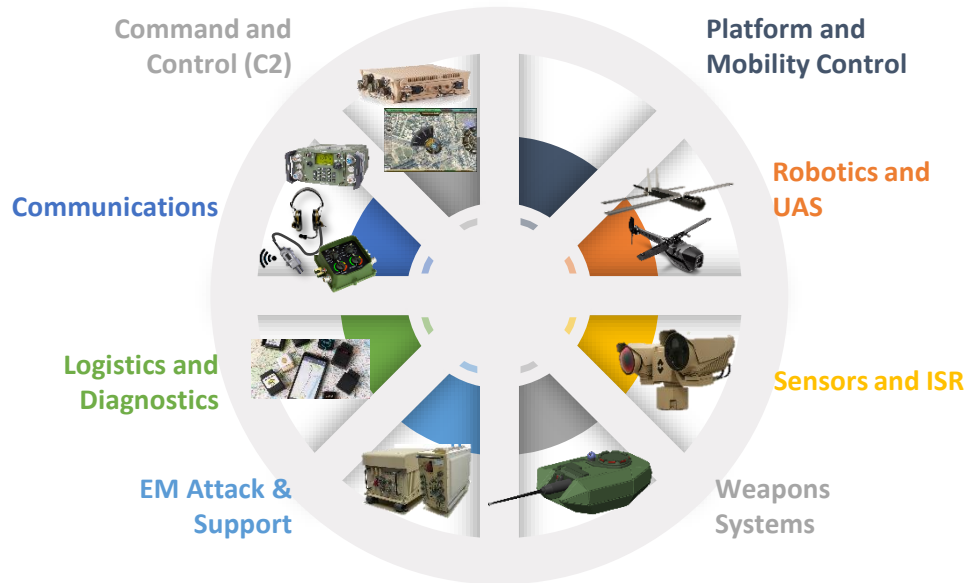


Modular Software & Payloads

Operational effectiveness involves many disparate systems

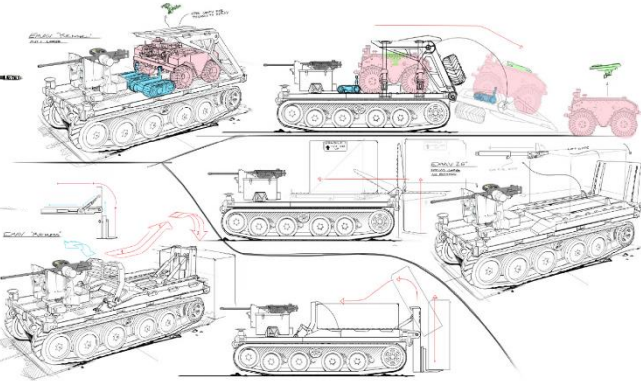
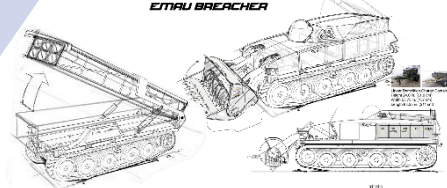
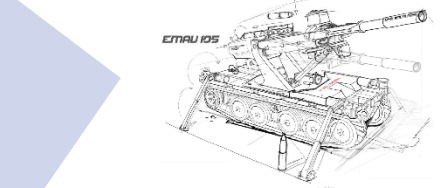
Defense is complicated:

- Mission planning, Battle Management Systems
- C4ISR, Communication
- Payload controls and cyber hardening
- Soldier information systems



Development Arc

View of Defense development path



Technology Development

Experimental Prototypes

Modular and Adaptable Platforms

Combined Capabilities
Family of Vehicles
Multi-Domain
Modularity & Speed

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PORTFOLIO



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