Autonomous Casualty Evacuation: State of the Art and Beyond

Presented by:
Gregory Nichols

4695 Millennium Drive
Belcamp, MD 21017-1505
hdiac.dtic.mil

Office: 443-360-4600
Fax: 410-272-6763
Email: contact@hdiac.org

HDIAC Homeland Defense & Security Information Analysis Center

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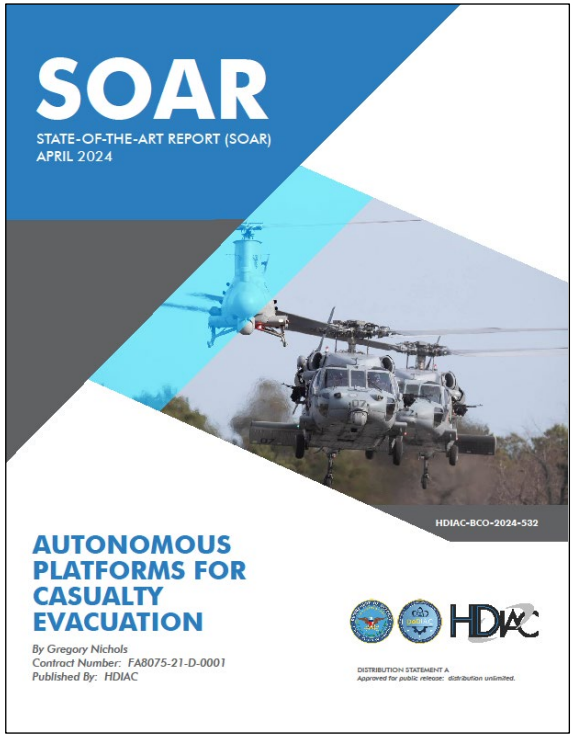
How Did We Get Here? Mostly…



MHSRS 2024

POSTER SESSION

Methodology:

1. Literature search/review
   - 2020 to the present
   - Historical documents of significance
   - Online search: Google to identify relevant, recent news, documents, and experts
   - DTIC R&E Gateway, Google Scholar, Web of Science, other relevant databases
2. Interviews
3. Demonstrations

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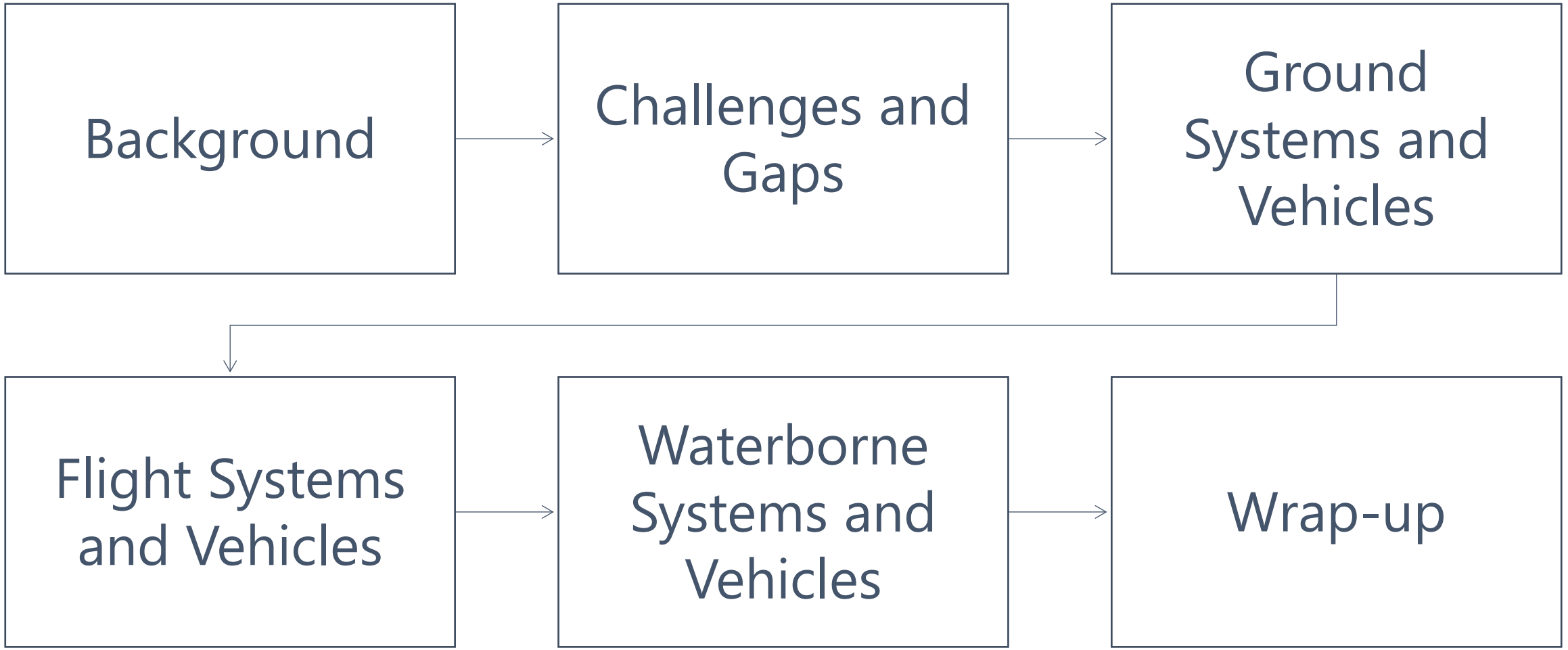
Roadmap/Agenda



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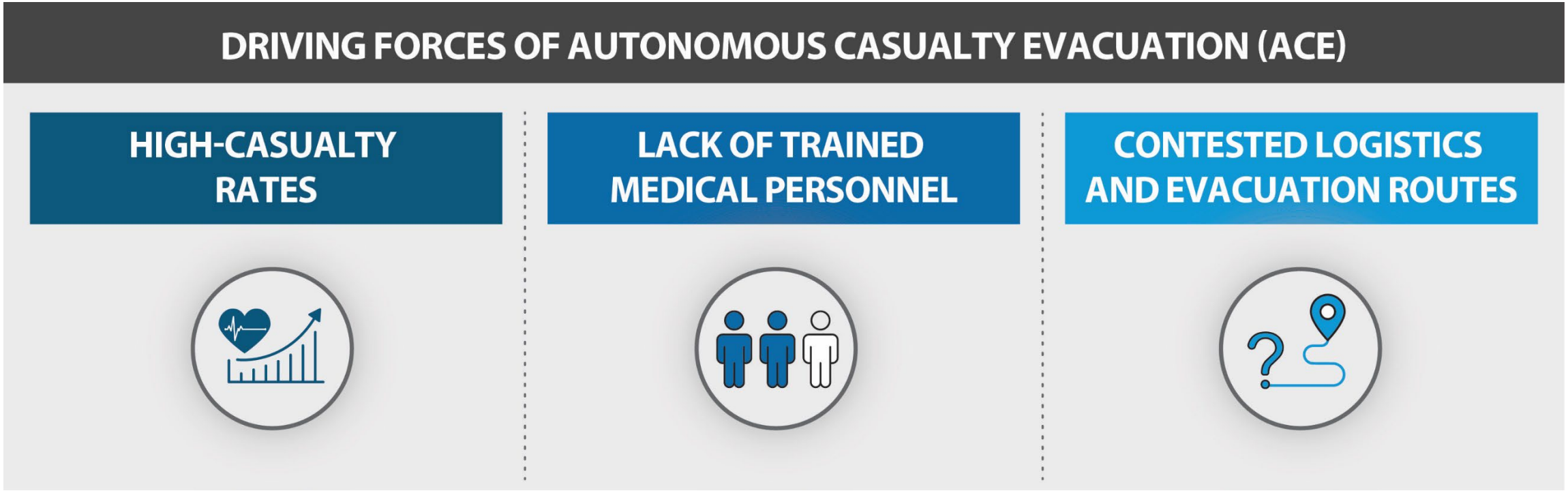
Background

"The conflict in Ukraine has demonstrated that modern warfare is unthinkable without the widespread use of unmanned vehicles." – Ruslan Pukhov, Director, Centre for Analysis of Strategies and Technologies

Key Drivers



Source: Nichols G. "State-of-the-Art Analysis of Platforms and Technical Challenges in Autonomous Casualty Evacuation." Poster presentation, 2024 Military Health System Research Symposium, Kissimmee, FL, 27 August 27 2024.

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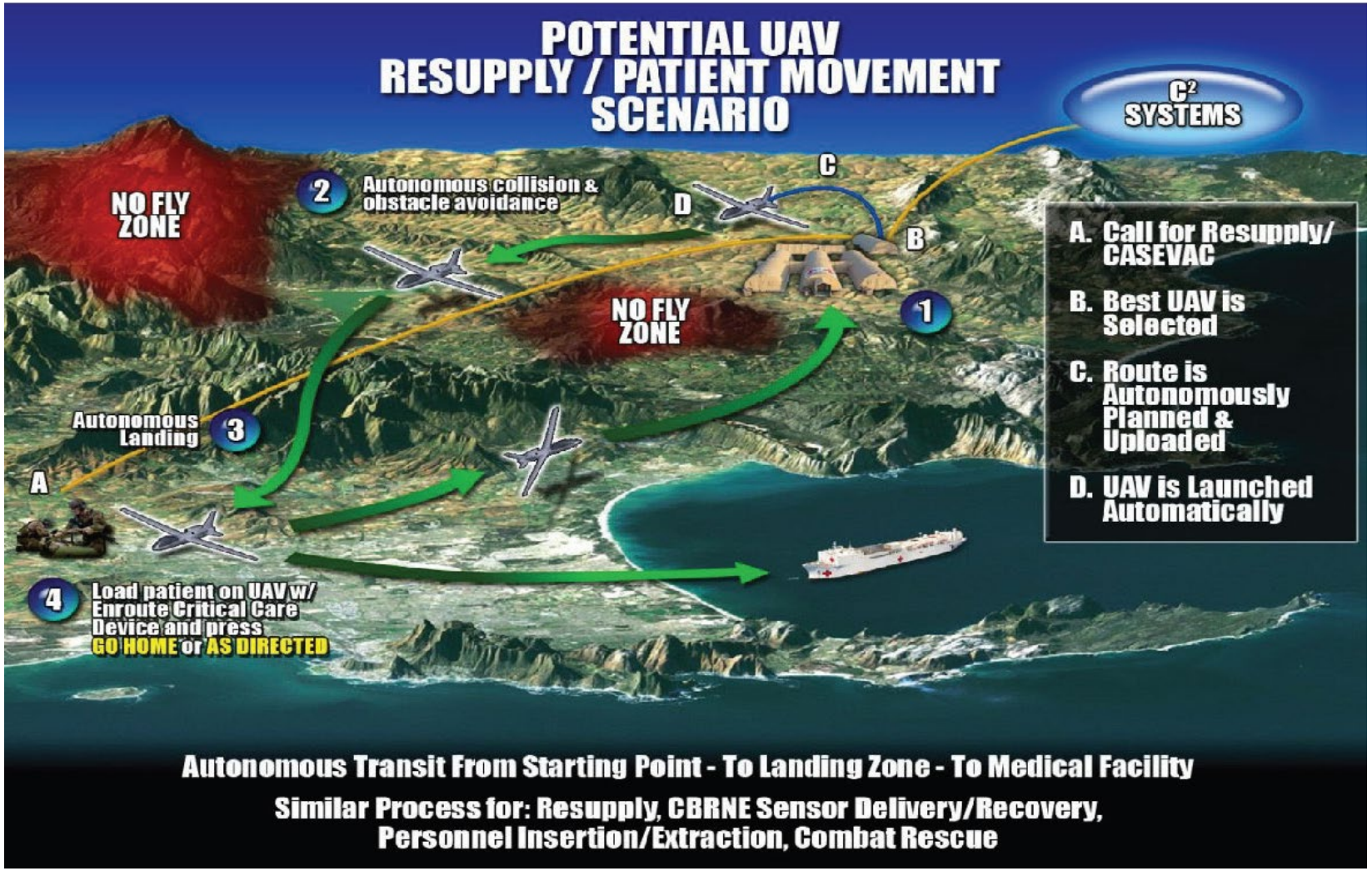
Future Battlefields?



Source: Office of the Air Force Surgeon General. "Medical Operations in Denied Environments Operational Concept." Falls Church, VA, 2 November 2015.

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War in Ukraine

- On 24 February 2022, Russian forces invaded Ukraine.
- Current estimates (Nov. 2024) of military casualties (killed and wounded) on both sides are nearly 1 M dead and wounded – not including civilians.
- Autonomy is playing a key role.

Source: https://armyrecognition.com/defense_news_december_2022_global_security_army_industry/germany_in_collaboration_with_estonia_to_deliver_14_themis_robots_to_ukraine.html
https://armyrecognition.com/ukraine_-_russia_conflict_war_2022/russian_soldiers_deploy_homemade_ugv_for_medical_evacuation_in_ukraine.html

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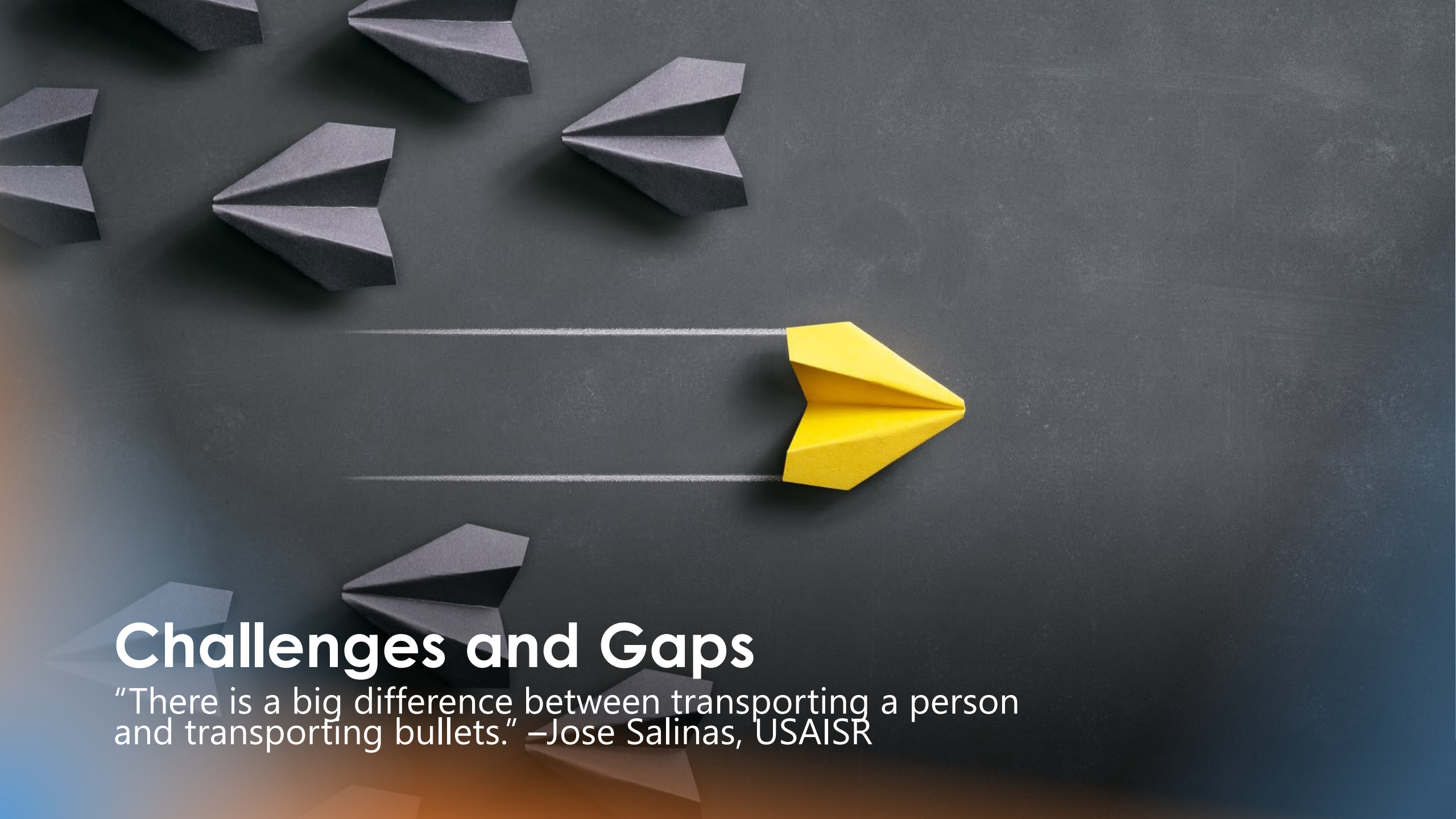

Challenges and Gaps

"There is a big difference between transporting a person and transporting bullets." –Jose Salinas, USAISR

Challenges and Gaps – Expert Interviews

Challenges	Gaps
• Strain of network • Allocation of bandwidth • Robotic combat vehicle (RCV) platform controlled by stations; lots of intricate communications • Nongovernment item platforms • Autonomous mobility and decision-making • Data curation • Ethics and policy discussion • U.S. Food and Drug Administration approval • Policy and ethical issues (autonomous systems making care decisions) • Hard-to-get wireless signal when rotor goes off • Requirements creep • Downwash • Brownouts • On the medical side, no control of platform • Question of how to make sure people develop things for bullets and can still have requirements for casualty care	• Continuation of perception sensors • Computing at the edge • Procurement • Quantitative assessment of new concepts and how they affect outcomes • Test outcomes—mapping back • Keeping a human in the loop • No communications or wide open • Communication with vehicle transport and casualty health • Data-training models (prehospital)

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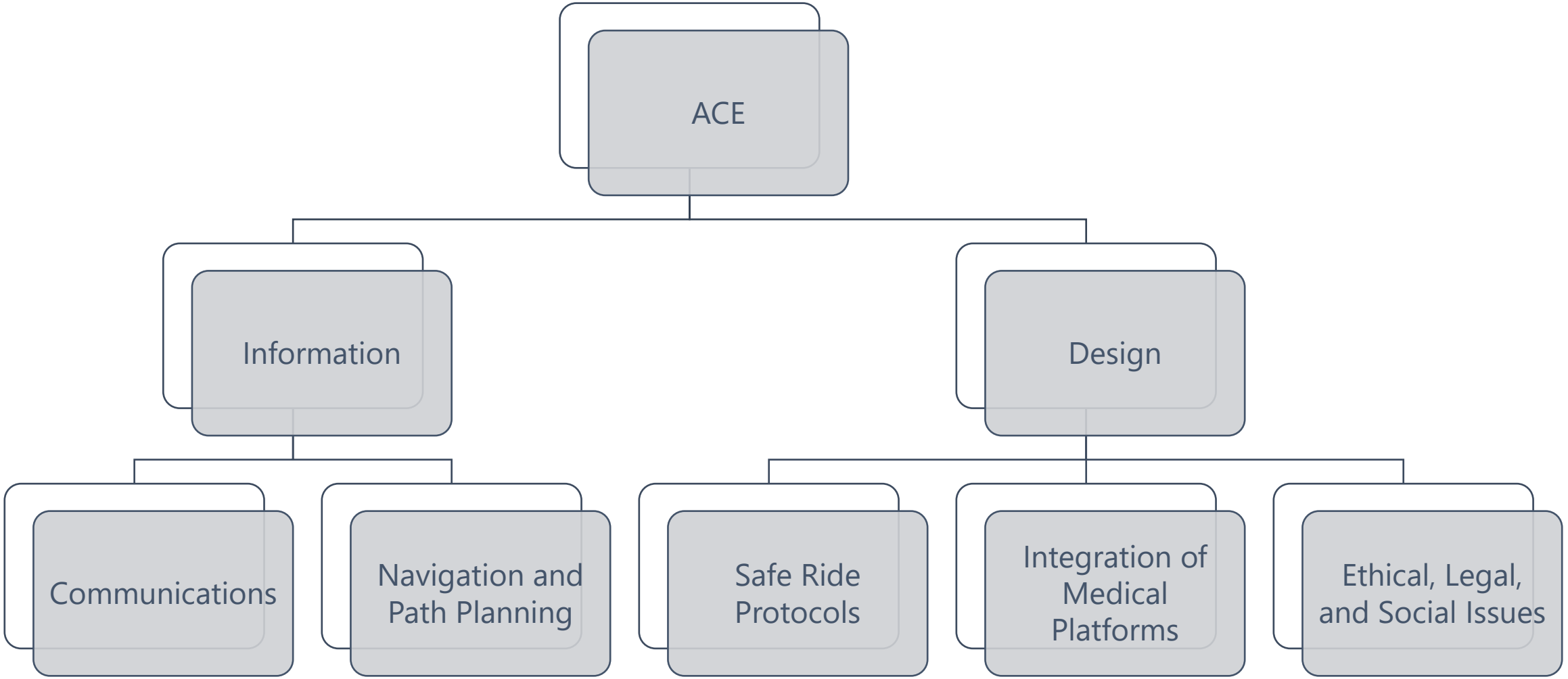
Challenges and Gaps – Decision Tree



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Design Considerations for ACE Platforms

"We don't pick the vehicle."

Base Vehicle Platform

1. Existing system—add autonomy (autonomous module)

   or

2. Design from scratch:
   - Some range of autonomy

     or

   - Autonomous-ready (capable)

Outfit for CASEVAC

1. Remove unnecessary features/existing systems (e.g., weapons)
2. Add safety features to vehicle (safe ride)
3. Integrate connectedness between autonomous vehicle control and change in patient status
4. Add patient monitoring/autonomous or semi-autonomous medical care systems (telemedicine or remote med capabilities)

Source: Nichols

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Ground Systems and Vehicles

"While theoretically very appealing, the practicalities of retrieving a potentially incapacitated or unconscious casualty pose real difficulties yet to be entirely overcome." - Pilgrim and Fitzgerald

Crawling/Walking Systems

Big Dog

(Source: https://www.darpa.mil/about-us/timeline/big-dog)

LS3 Pack Mule

(Source: https://www.darpa.mil/about-us/timeline/legged-squad-support-system)

FDNY's Robotic Dog (Boston Dynamics)

(Source: https://www.smithsonianmag.com/smart-news/robot-dog-surveys-collapsed-new-york-parking-garage-180982028/)

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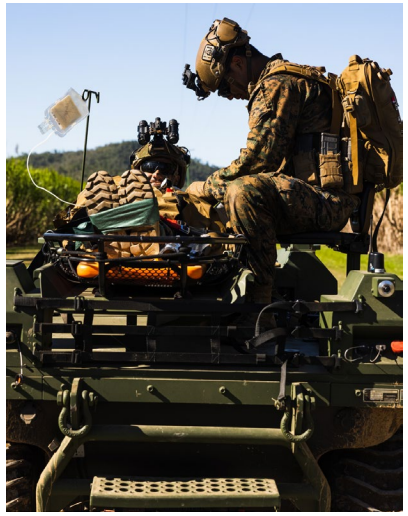
Traditional Rolling Systems

Expeditionary Modular Autonomous Vehicle (EMAV) [1]

Tracked Hybrid Modular Infantry System THeMIS Cargo CASEVAC (Milrem Robotics) [4]



Mission Master (Rheinmetal) [2]

Robotic Combat Vehicle (RCV) (General Dynamics Land Systems; Oshkosh Defense; HDT Global; Textron Systems) [3]

Soldiers Conduct Urban Assault with Human Machine Integration at Project Convergence Capstone 4 [5]

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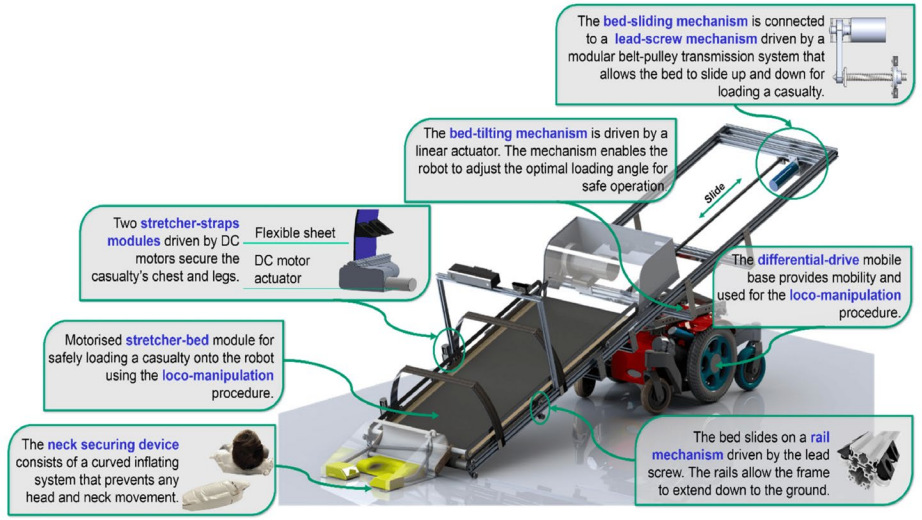
Other Things?

Representation only; not Marom-Dolphin Wild Goose

"Wild Goose"
Marom-Dolphin

"Rocky"
SuperDroid Robots

(Source: https://www.superdroidrobots.com/product/humanoid-robot-biped/)



ResQbot 2.0
Robotics and Mechatronics Lab - VT

(Source: Saputra, R. P., Rakicevic, N., Kuder, I., Bilsdorfer, J., Gough, A., Dakin, A., de Cocker, E., Rock, S., Harpin, R., & Kormushev, P. (2021). ResQbot 2.0: An Improved Design of a Mobile Rescue Robot with an Inflatable Neck Securing Device for Safe Casualty Extraction. Applied Sciences, 11(12), 5414. https://doi.org/10.3390/app11125414)

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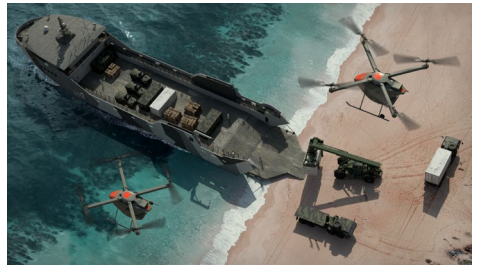
Flight Systems and Vehicles

"Lack of air superiority coupled with anti-access/area denial will foster a dependence on ground-based evacuation systems, both manned and autonomous. However, these too will be degraded." - Wissemann

Traditional-Design/Conversion

Aircrew Labor In-cockpit Automation System (ALIAS) - Sikorsky Aircraft
(Source: https://dustoff.org/dustoffer-newsletter/casualty-evacuation-and-the-army-of-2030-2040-army-aviations-vital-role/)

K-MAX
Kaman Air Vehicles
[6]



KARGO
Kaman Air Vehicles /
Near-Earth
Autonomy [7]

V-280 Valor – Bell
Helicopter [8]

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VTOL and Unconventional Systems

ALIA - BETA Technologies [9]

Cormorant - Tactical Robotics [10]

T400 - Malloy Aeronautics [11]

Aerial Reconfigurable Embedded System (ARES) – Piasecki Aircraft Corporation [12]

DP-14 - DPI UAV Systems [13]

MERT-R MEDEVAC UAV – Pulse Science [14]

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Waterborne Systems and Vehicles

"[CASEVAC] and MEDEVAC are complimentary capabilities, and when used efficiently and effectively reduce Soldier mortality." - Army Techniques Publication 4-02.2

Forerunners and Future Options

Integrated Battle Problem 23.2

Source: https://seapowermagazine.org/u-s-navy-deployment-putsleidos-autonomy-on-display/

Expeditionary Medical Ship (EMS)

Source: https://www.navalnews.com/naval-news/2023/12/austal-usa-wins-u-s-navy-contract-for-expeditionary-medical-ship/

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Example Platforms

Common Unmanned Surface Vehicle (CUSV) – Textron Systems
Source:
https://www.usni.org/magazines/proceedings/2021/february/drones-canspeed-medical-care-search-and-rescue

USNS Apalachicola (EPF 13) - Austal USA, L3 Harris, and General Dynamics Mission Systems
(Source:
https://news.usni.org/2023/02/16/crew-optional)

T38 Devil Ray – MARTAC
(Source:
https://martacsystems.com/products/t38/)

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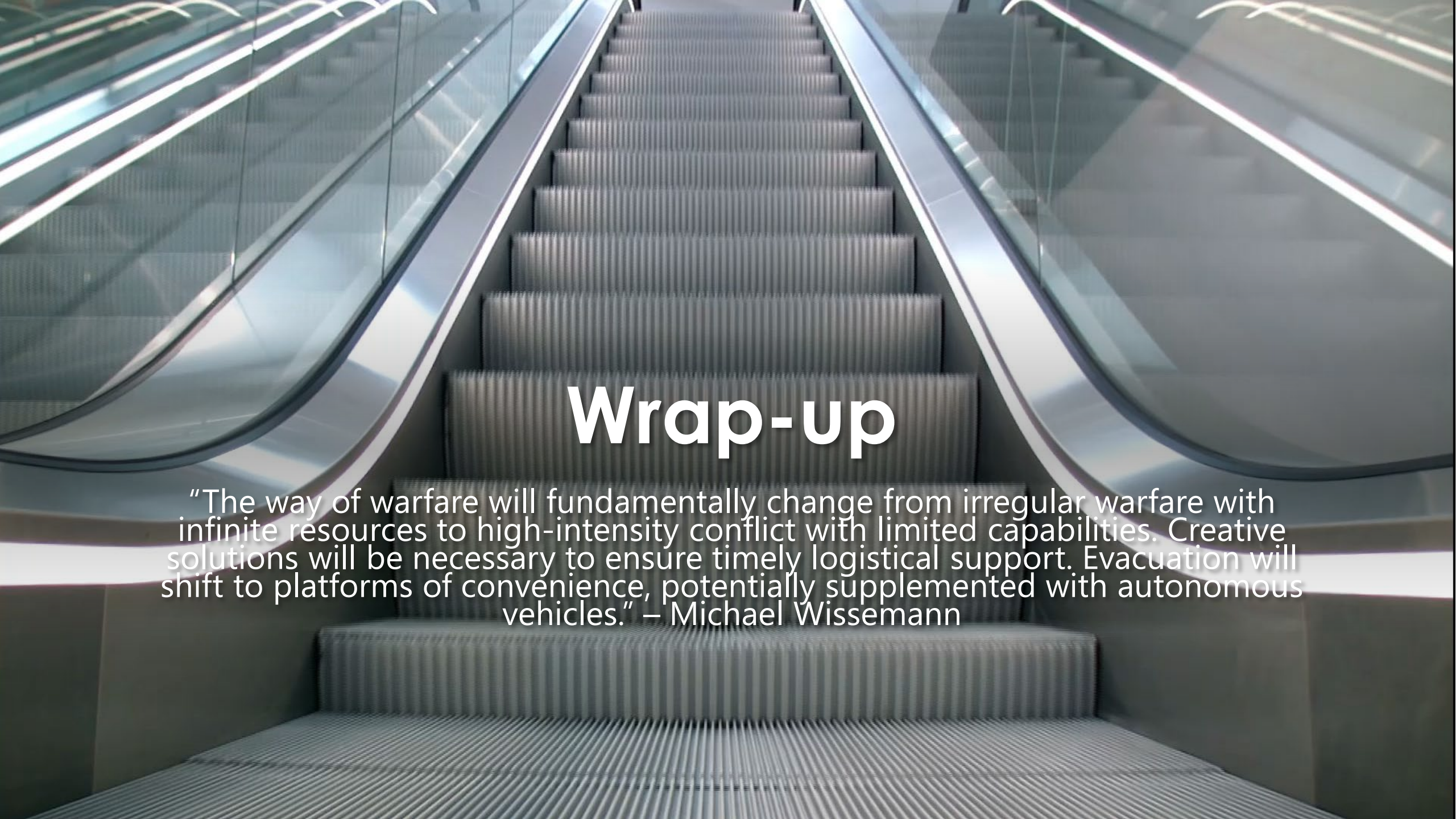

Wrap-up

"The way of warfare will fundamentally change from irregular warfare with infinite resources to high-intensity conflict with limited capabilities. Creative solutions will be necessary to ensure timely logistical support. Evacuation will shift to platforms of convenience, potentially supplemented with autonomous vehicles." – Michael Wissemann

ACE – A Deadly Business?

Russian Ministry of Defence – 2020

https://en.wikipedia.org/wiki/Ministry_of_Defence_(Russia)#/media/File:Middle_emblem_of_the_Ministry_of_Defence_of_the_Russian_Federation_(21.07.2003-present).svg

THeMIS, Milrem Robotics – 2022/2023

https://www.businessinsider.com/russian-researchers-offer-bounty-for-capture-of-themis-robot-ukraine-2022-9

Ruslan Pukhov, Director of CAST – 2022-2024

https://www.abc.net.au/news/2016-07-08/natos-warsaw-summit-underway-in-the-glare-of-the-russian-bear/7579098

Armin Papperger, CEO Rheinmetal - 2024

https://www.rheinmetall.com/en/company/management/executive-board/executive-board-overview

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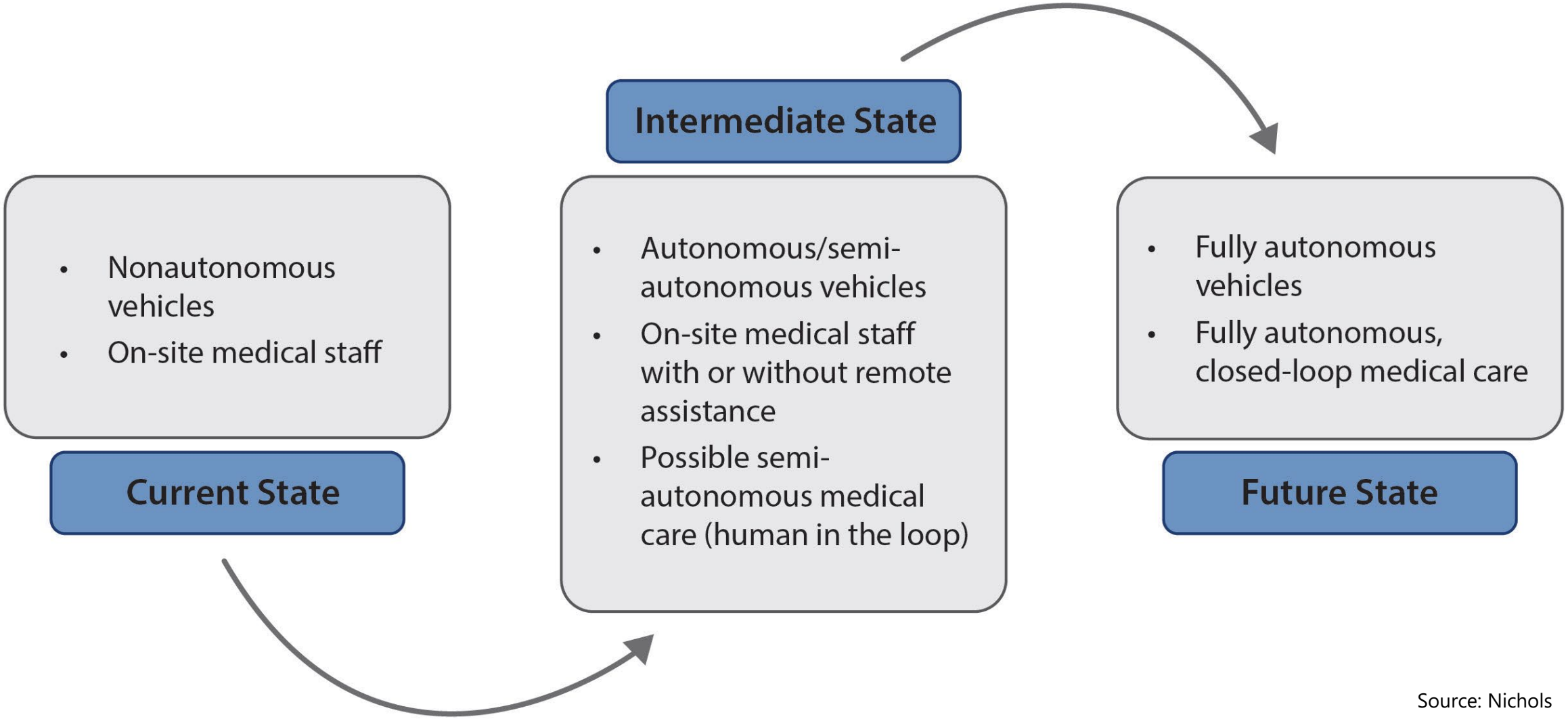
As a Reminder – Where Are We Heading?



Source: Nichols

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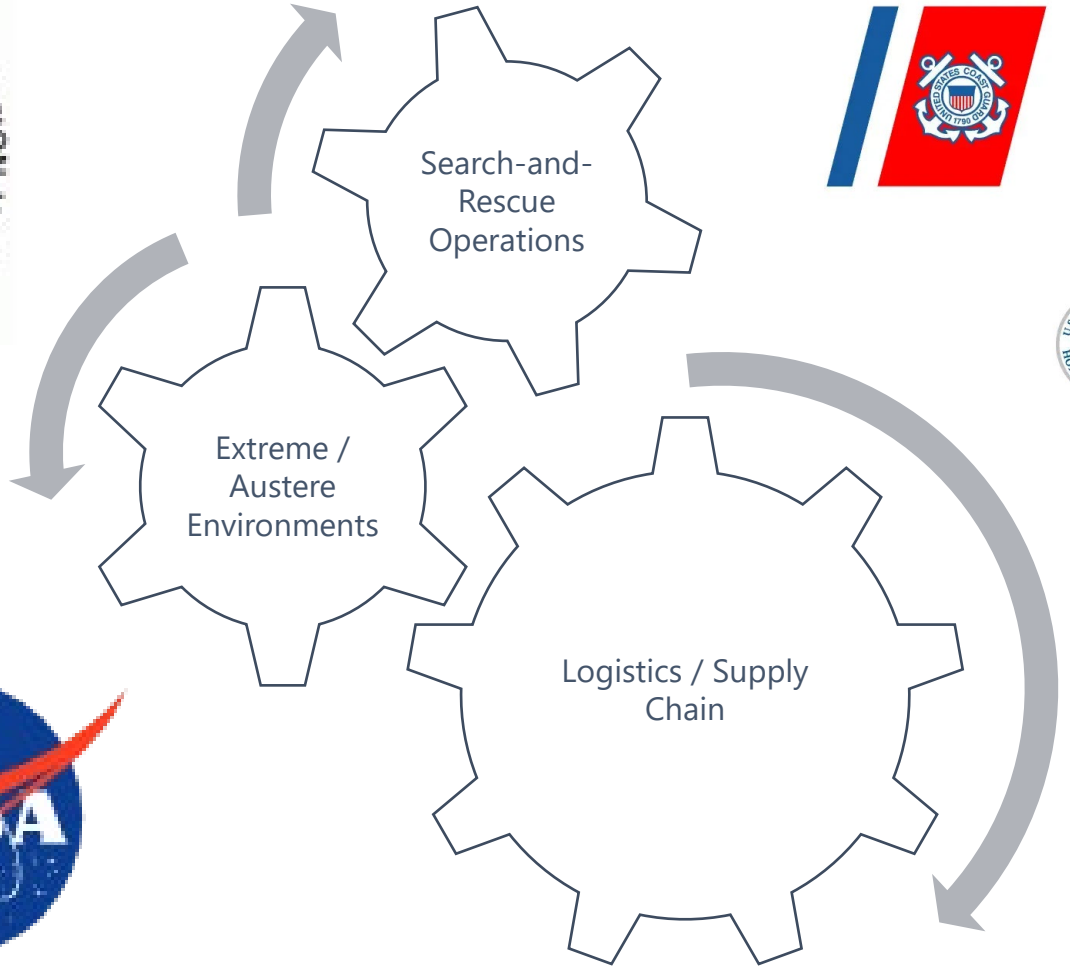
More Cross-Sector Research Collaboration?



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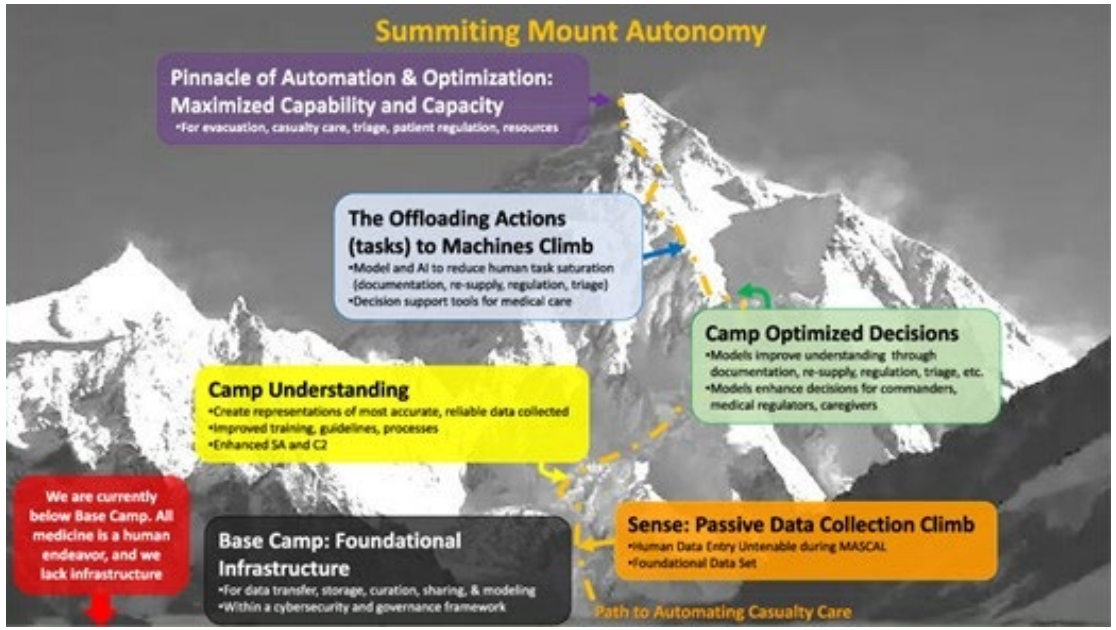
What's Next?

- A state-of-the-art report: Part 2?
  - More aspects of ACE?
  - Autonomous CBRNE response?
  - Autonomous medical care?
  - Autonomy in disaster response?
- Community of practice?
- Workshop or symposium?
- All of these or some portion?
- Something else?

(Source: https://www.auvsi.org/us-army-selects-near-earth-autonomy-lift-life-saving-autonomous-blood-and-casevac-transportation)

Jeremy C Pamplin, Mason H Remondelli, Nathan Fisher, Matthew T Quinn, Fully Autonomous Casualty Care on the Future Battlefield, Military Medicine, 2024;, usae377, https://doi.org/10.1093/milmed/usae377



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Questions / Contact / Work With Us

Gregory Nichols
greg.nichols@orau.org
(865) 223-8625

John Clements
john.clements@hdiac.org

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References/Image Sources (1/2)

Unless otherwise noted, images/graphics are sourced from:
Nichols, G. State-of-the-Art Report: "Autonomous Platforms for Casualty Evacuation." Homeland Defense and Security Information Analysis Center, April 2024.

Slide 13: Big Dog - Big Dog. DARPA . (n.d.-a). https://www.darpa.mil/about-us/timeline/big-dog; LS3 Pack Mule - LS3 Pack Mule. DARPA . (n.d.-b). https://www.darpa.mil/about-us/timeline/legged-squad-support-system

Slide 14: [1] EMAV - https://www.defense.gov/Multimedia/Photos/igphoto/2002750986/; [2] Mission Master - https://www.rheinmetall.com/en/products/unmanned-vehicles/unmanned-vehicles/mission-master-a-ugv; [3] RCV - https://www.nationaldefensemagazine.org/articles/2023/12/12/army-lays-out-plans-for-obotic-combat-vehicles; [4] THeMIS - https://armyrecognition.com/defense_news_december_2022_global_security_army_industry/germany_in_collaboration_with_estonia_to_deliver_14_themis_robots_to_ukraine.html; [5] https://www.dvidshub.net/image/8297194/soldiers-conduct-urban-assault-with-human-machine-integration-project-convergence-capstone-4

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Slide 17: [6] KARGO – KMAX - https://nextpittsburgh.com/latest-news/near-earthautonomy-creates-a-self-driving-helicopter-nowhiring/; [7] KARGO - https://kaman.com/brands/kaman-air-vehicles/kargo/defense/; [8] V-280 Valor - https://www.airmedandrescue.com/latest/news/power-fvl-how-will-bell-v280-impact-csarand-military-medevac-operations

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Slide 23: Russian MoD - https://commons.wikimedia.org/wiki/File:Middle_emblem_of_the_Ministry_of_Defence_of_the_Russian_Federation_(21.07.2003-present).svg?uselang=en#Licensing; Ruslan Pukhov - ABC News. (8 July 2016). NATO summit in Warsaw underway in glare of Russian bear. https://www.abc.net.au/news/2016-07-08/natos-warsaw-summit-underway-in-the-glare-of-the-russian-bear/7579098; Armin Papperger - Executive Board of Rheinmetall AG. Rheinmetall. (n.d.). https://www.rheinmetall.com/en/company/management/executive-board/executive-board-overview

Slide 25: US Army selects Near Earth Autonomy & Lift for Life Saving Autonomous Blood and Casevac Transportation System. (1 October 2024). AUVSI. https://www.auvsi.org/us-army-selects-near-earth-autonomy-lift-life-savin-autonomous-blood-and-casevac-transportation; Summitting Mount Autonomy - Jeremy C Pamplin, Mason H Remondelli, Nathan Fisher, Matthew T Quinn, Fully Autonomous Casualty Care on the Future Battlefield, Military Medicine, 2024. usae377, https://doi.org/10.1093/milmed/usae377

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