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MHSRS 2026

Precision Automated Critical Care Management (PACC-MAN): A Unified Closed-Loop Platform for Autonomous Prolonged Field Care.

Reducing manpower, extending the Golden Hour, and enabling unmanned en-route care

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Devices · Algorithms · Interface

Contributors

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- Cardiovascular Research Laboratory, Wake Forest Baptist Health
- Acute Care Translational Research Laboratory, University of Utah
- Certus Critical Care, Inc.

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Conflicts of Interest

- Austin Johnson MD, PhD is a cofounder of Certus Critical Care and sits on the board of TitinKM Biomedical.
- Luke Neff MD is a cofounder of Certus Critical Care.
- Timothy Williams MD is a cofounder of Certus Critical Care.

THE OPERATIONAL PROBLEM

Combat casualty care doctrine assumes resources we won't have.

Near-peer conflict, A2AD environments, and unmanned platforms break the assumptions behind the Golden Hour, prolonged field care, and forward surgical teams.

60 min

The Golden Hour.

Designed for permissive evacuation. In a contested theater, transit takes hours to days in current conflicts, far beyond the trauma window.

1:1

Provider ratio at the bedside.

Combat medics are not ICU-trained. Forward surgical teams don't scale to mass-casualty events under fire.

30%

NCTH mortality.

Non-compressible torso hemorrhage remains the largest source of preventable death in trauma.

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Autonomous resuscitation and critical care from POI to Role 3.

An ICU-class life-support platform sensing, deciding, and actuating for the entire en-route window will require temporary hemorrhage control, blood transfusion, fluids, and vasopressors.

Three pillars of autonomous resuscitation and critical care.

Each pillar is being engineered against operational constraints, SWaP, ruggedization, denied coms, usability, non just lab-bench feasibility.

01

DEVICES

Ruggedized, SWaP-conscious hardware.

Lab-grade → Field-ready

Battery-backed, vibration-tolerant pumps; solid-state arterial sensing; single-use endovascular catheter. Built for the helicopter, the drone, and the dirt.

02

ALGORITHMS

Local autonomy under denied comms.

In → On → Near the loop

Adaptive, multi-parameter control runs entirely on the platform with no cloud, no backhaul required. Provider stays on-the-loop or near-the-loop.

03

INTERFACE

Intuitive, simple, effective.

Engineer console → Heads-up UI

Color-coded zones, transparent rationale, two-second readability. Designed for task-saturated providers under stress.

PILLAR 01

Securely Connected Devices. From lab to field-ready.

IoT of the ICU: Integrated Devices Working Within A Secure Network

Endovascular Hemorrhage Control

Automated endovascular catheter with on catheter solid state sensing.

Small, portable, blood warmer and transfusion

Right time, right volume precision blood transfusion to optimize blood use

High volume infusion pump and syringe pump

High volume rapid transfusion and precision medication delivery

Solid state arterial blood pressure monitoring

Solid state to decrease inaccuracies to provide immediate ground truth in any shock state

PILLAR 02

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Algorithms. From binary rules to adaptive control.

Era 1-> Era 2 · Human-in-the-loop to Human-on-the-loop

Binary, threshold-driven. The system says "bolus required"; the provider presses the button. Capped by human reaction time but minimizes bias within the studies.

ERA 1 · 2015 – 2018

Wait for consent.

The algorithm detects a need and recommends an action. The provider reviews and approves. Nothing happens without the button press.

Sense | Recommend | Wait | Execute

Bottleneck: human reaction time on every cycle.

ERA 2 · 2018 onward

Manage by exception.

PACCMAN titrates within clinical guardrails. The provider intervenes only when the algorithm's logic contradicts clinical intuition.

Sense | Decide | Act | Supervise

Provider exits the loop. Stays in a supervisory role.

Era 2 · Inputs Beyond Hemodynamics

AAST PODIUM 2022

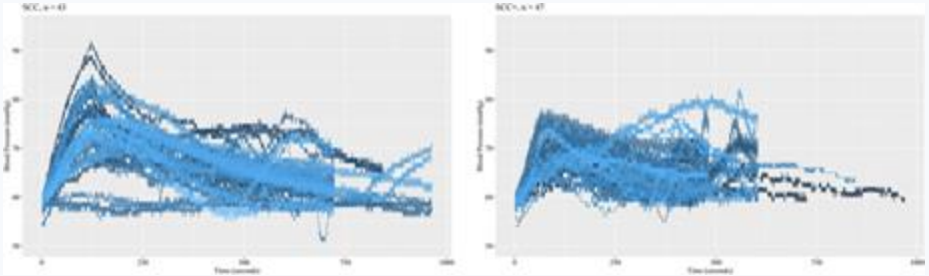
Precision Automated Critical Care Management: Closed-loop critical care for the treatment of distributive shock in a swine model of ischemia-reperfusion

Ganapathy, Aravindh S. MD; Patel, Nathan T.P. MD; Wiley, Aidan P. BA; Lane, Magan R. BS; Jordan, James E. PhD; Johnson, M. Austin MD, PhD; Adams, Jason Y. MD, MS; Neff, Lucas P. MD; Williams, Timothy K. MD

ALGORITHM CHANGES

INPUTS	Addition of lactate and urine output
FLUID RESPONSE	Graded fluid response instead of all or none
VASOPRESSORS	Addition of vasopressin at high NE doses
FLUID BOLUSES	Small volume per bolus over shorter time period

Hemodynamic response to fluid boluses



45% Reduction in Crystalloid Volume

67.5 mL/kg versus 37.5 mL/kg

Era 2 · Man Versus Machine

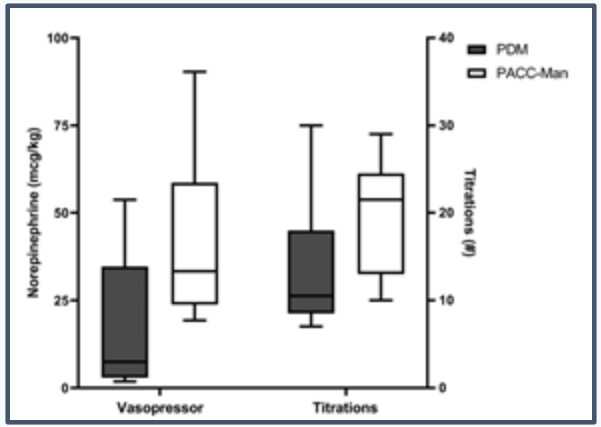
SHOCK, Vol. 61, No. 5, pp. 758–765, 2024

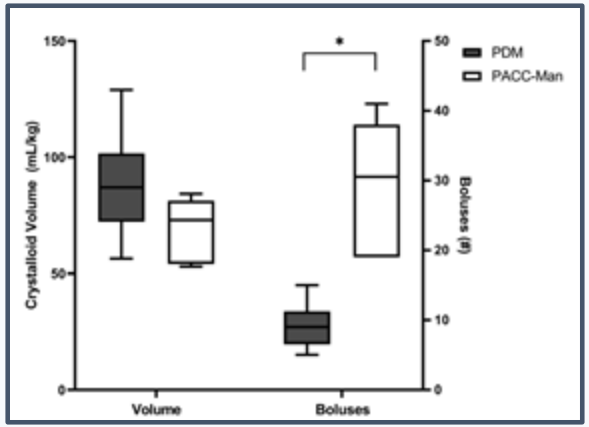
OPEN

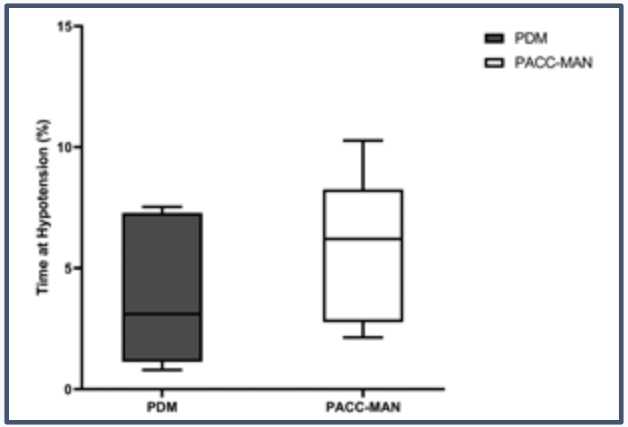
MAN VERSUS MACHINE: PROVIDER DIRECTED VERSUS PRECISION AUTOMATED CRITICAL CARE MANAGEMENT IN A PORCINE MODEL OF DISTRIBUTIVE SHOCK

Gloria D. Sanin,[1] Gabriel E. Cambronero,[1] Elizabeth C. Wood,[1] James W. Patterson,[2] Magan R. Lane,[2] Antonio C. Renaldo,[3] Bonnie E. Laingen,[1] Elaheh Rahbar,[3] Jason Y. Adams,[4] Austin Johnson,[5] Lucas P. Neff,[1] and Timothy K. Williams[2]

Hemorrhagic shock and ischemia reperfusion injury over 6 hours.

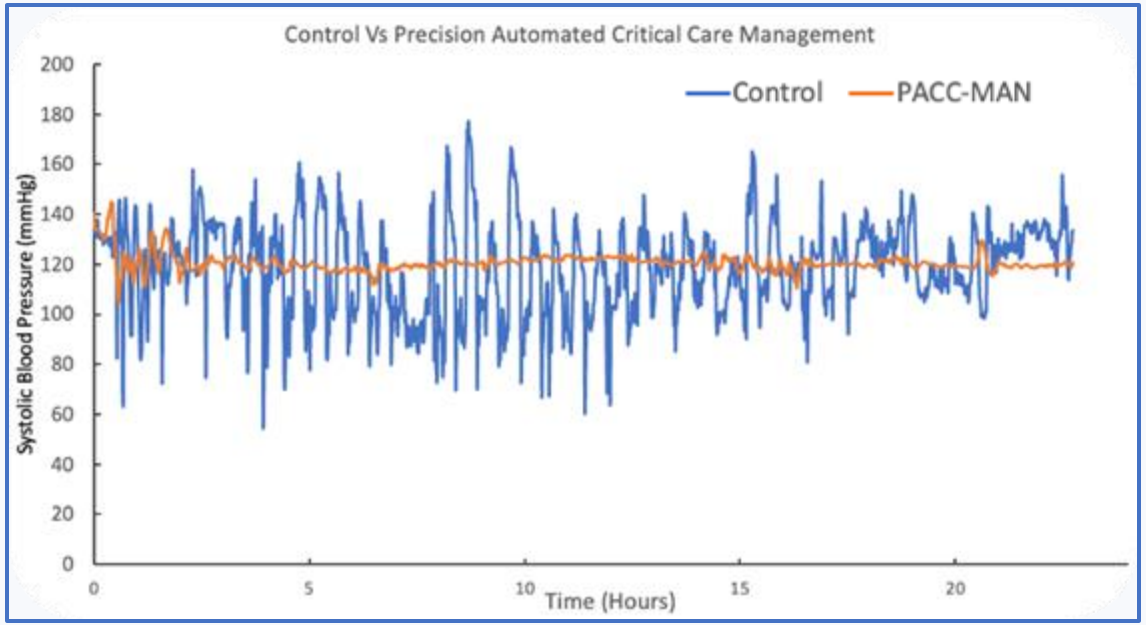


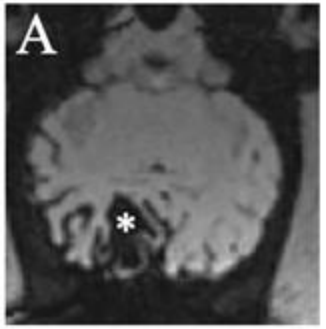


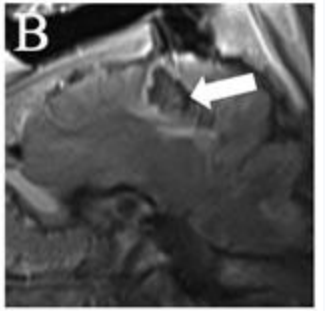


Era 2 · Not all critical care is hypotension

24 hour study of intraparenchymal hemorrhage with consistent hemodynamic instability controlled with 3+ vasopressors with an adaptive algorithm capable of running on the edge.







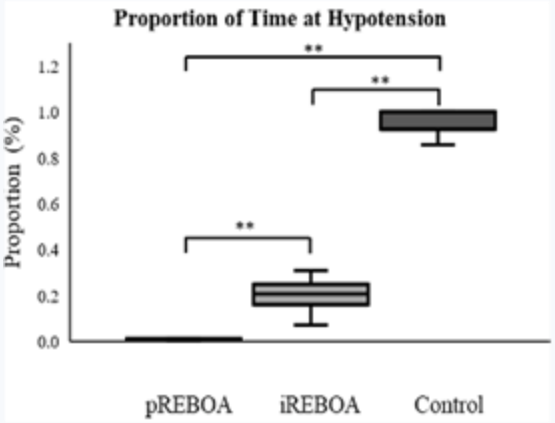
Era 2 · Catheters and Blood

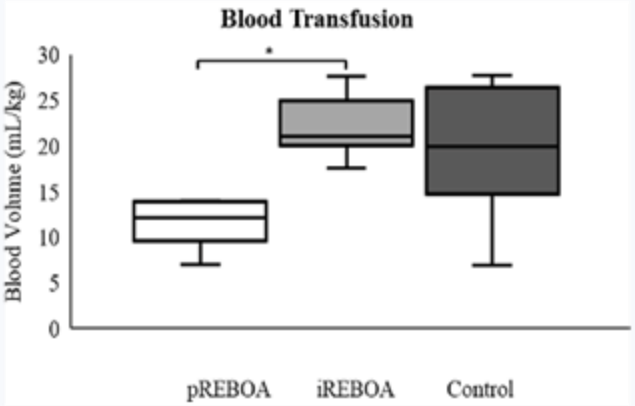
EAST Quick Shot 2023

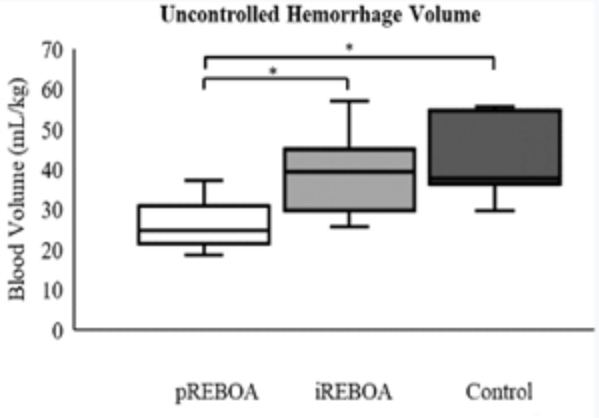
Automated partial resuscitative endovascular balloon occlusion of the aorta reduces blood loss and hypotension in a highly lethal porcine liver injury model

Gabriel E. Cambronero, MD, Gloria D. Sanin, MD, Nathan T.P. Patel, MD, Aravindh S. Ganapathy, MD, Magan R. Lane, BS, James W. Patterson, MS, Jacob A.P. Niebler, BS, M. Austin Johnson, MD, PhD, Elaheh Rahbar, PhD, James E. Jordan, PhD, Lucas P. Neff, MD, *and* Timothy K. Williams, MD
Winston-Salem, North Carolina

Blood transfusion timing and amount triggered by catheter algorithms balancing hemorrhage control and distal ischemia.







Era 2 · ARCHER: Three algorithms. One platform.

Each algorithm is tuned to physiology. They run together when the patient needs all of them, but each can run independently as modular units based on patient needs.

Endovascular control

Closed-loop balloon volume from proximal/distal pressure feedback.

Johnson et al. Shock 2019; Gupta et al. Sci Rep 2024

Transfusion control

Variable-rate, variable-volume blood delivery. Reduces hypertension overshoot.

Cambronero et al. JTACS 2023; Patel et al. Shock 2022

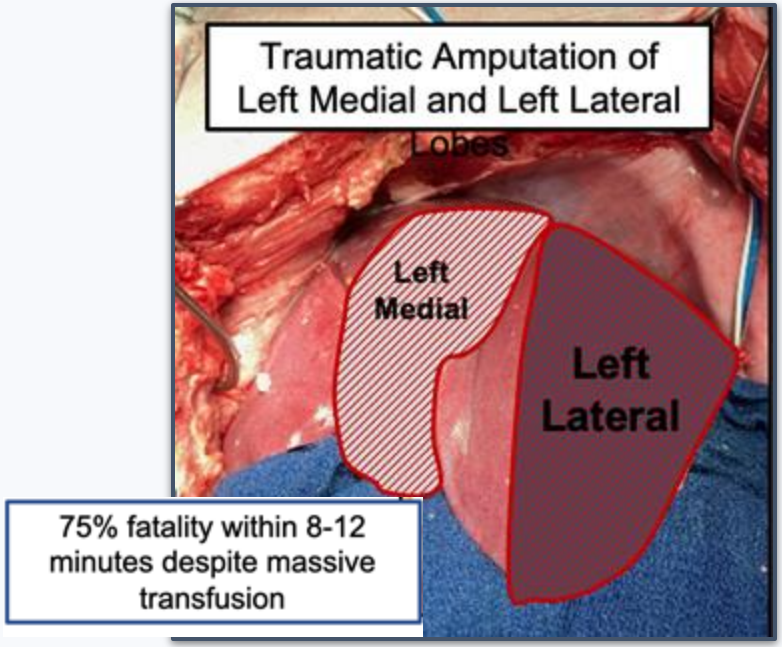
Hemodynamic resuscitation (PACCMAN)

Core PACCMAN. Fluid and vasopressor titration.

Ganapathy et al. JTACS 2023; Sanin et al. Mil Med 2025

Era 2 · ARCHER: Everything together.

Each algorithm is tuned to physiology. They run together when the patient needs all of them, but each can run independently as modular units based on patient needs.



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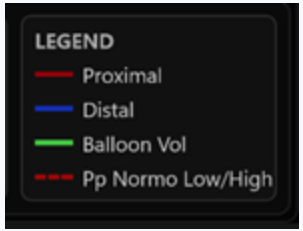

Validated across 200+ large-animal studies.

Cross-institutional. Peer-reviewed. Spanning major trauma physiology relevant to en-route and prolonged field care.

MODEL COVERAGE

- Hemorrhagic shock — controlled and uncontrolled
- Polytrauma — amputation + delayed care
- Traumatic brain injury — intraparenchymal hemorrhage
- Cardiac arrest + post-resuscitation
- Ischemia-reperfusion injury
- Sustained 24+ hour critical care

VALIDATION DATA

Blood Utilization
50% decrease in blood utilization with EVAC + LifeFlow Pro

Hemodynamics
7x decrease in blood pressure fluctuations from goal over 24 hours in in model of intraparenchymal hemorrhage

Cognitive Load
Equivalent resuscitation endpoints when compared to bedside surgeons with completely closed loop in large animal studies

Gupta et al., Sci Rep 2024 · Sanin et al., Mil Med 2025 · Ganapathy et al., JTACS 2023 · Cambronero et al., JTACS 2023 · Johnson et al., Shock 2019 · Patel et al., Shock 2022

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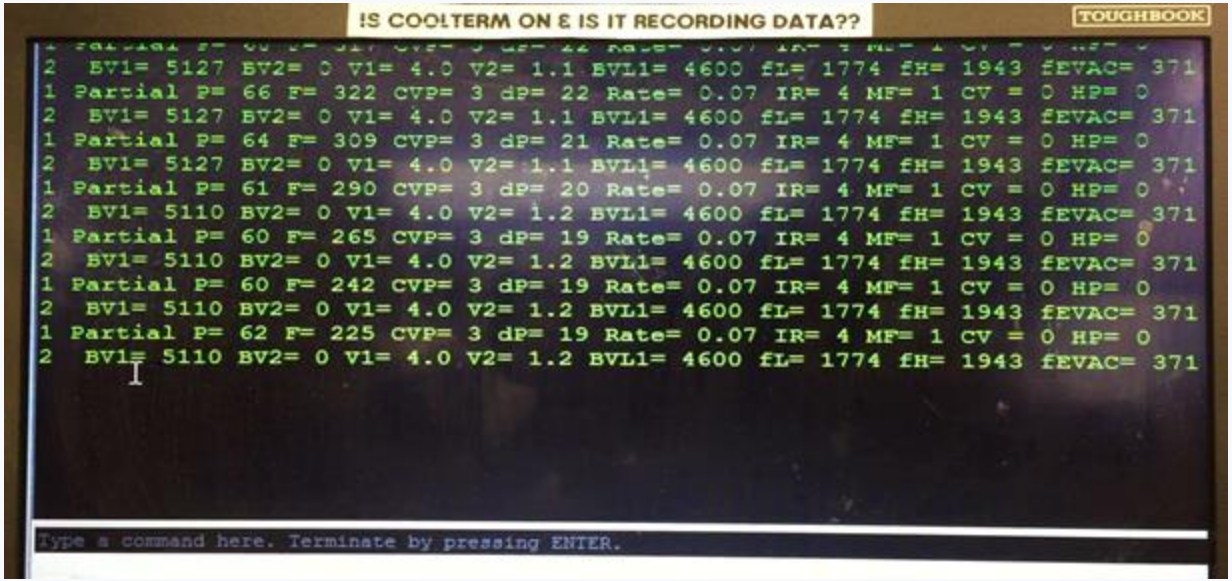
PILLAR 03

Interface. Where early automation failed.

Yes, this was our UI.

Streaming numbers on a black terminal. Unintelligible without an engineer at the console. This is what early autonomy looks like and why early autonomy doesn't deploy. We can’t all read the Matrix.



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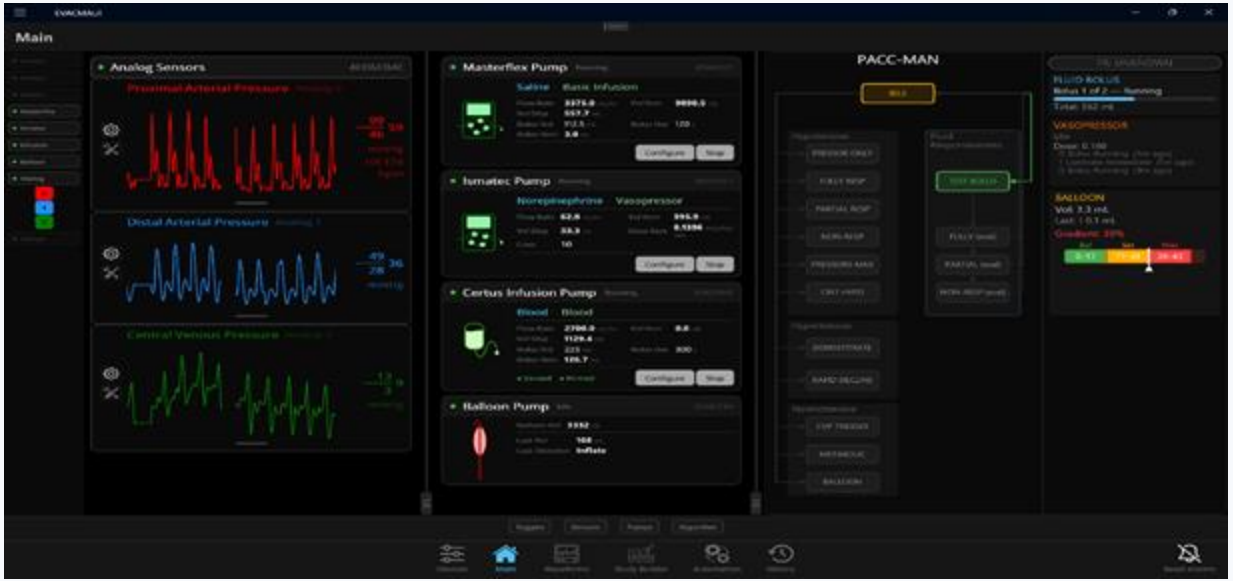
And this is what replaced it.

A heads-up dashboard built around the questions a provider actually asks: where is the patient now, what is the algorithm doing, and do I need to override?



WHAT IT DOES NOW

- Color-coded zones: green / yellow / red at a glance
- Algorithm rationale: not just numbers, but why
- Trend continuity: last 30 minutes always visible
- Action log: every autonomous action time-stamped
- Override one-tap from any view

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THANK YOU

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ICU-level care from POI to Role 3 autonomously.

01 DEVICES	02 ALGORITHMS	03 INTERFACE

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