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Essential Autonomous Documentation Sensing Inputs: Lessons Learned from a Systematic Assessment

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Introduction

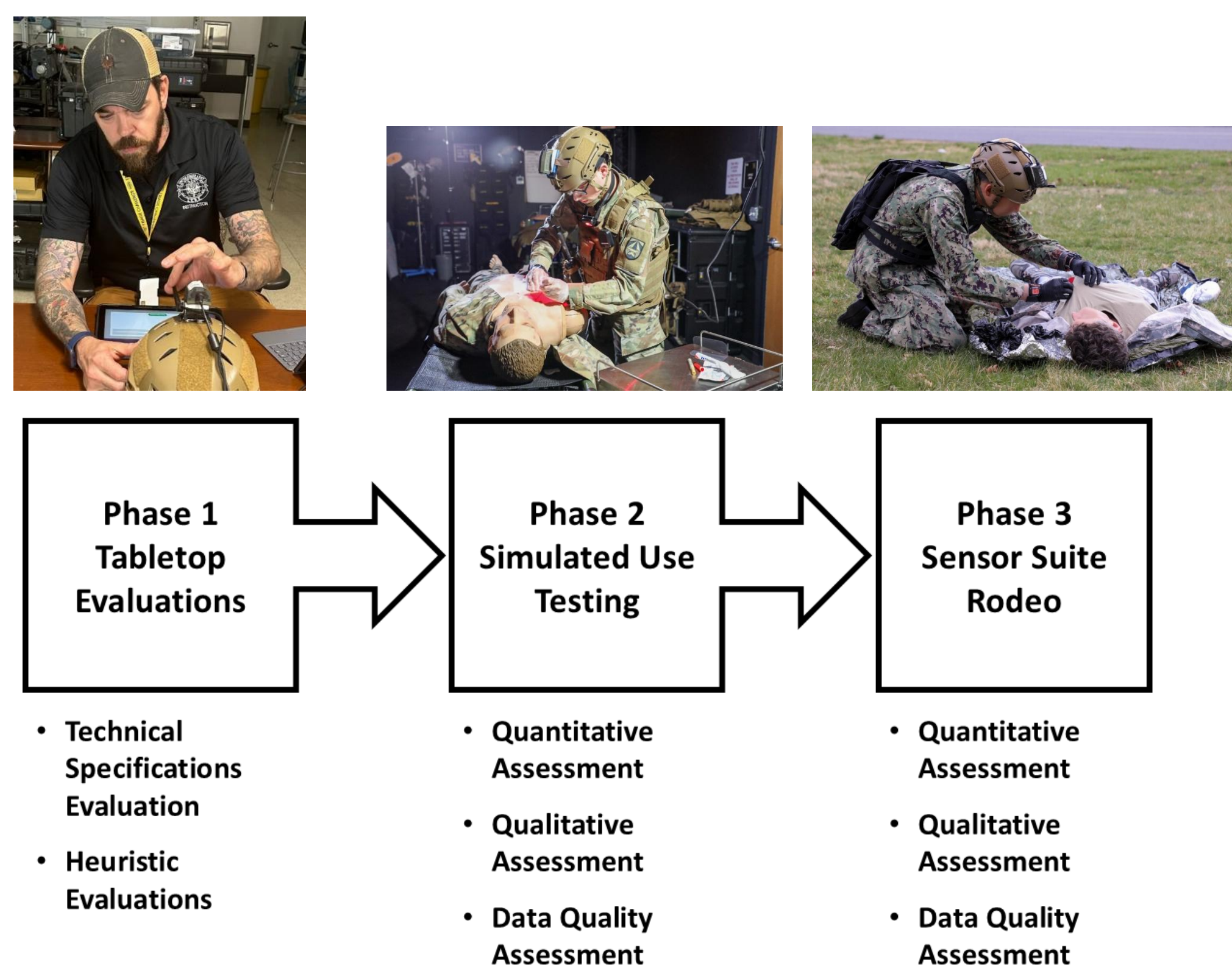
The Military Healthcare System (MHS) faces a persistent challenge: while medical documentation is mandated at all echelons, providers in high-intensity combat situations must prioritize lifesaving measures over record-keeping, often leading to significant data gaps. Manual paper-based documentation is not only burdensome, but also prone to result-interpretation errors due to varying environmental factors. To address this challenge, the United States Army Institute for Surgical Research (USAISR) conducted an analysis of prototype sensor suites designed to passively document care delivery in tactical combat casualty care (TCCC) environments.

Sensor Suite Prototype Configurations

	Medical Wearable Audio Video Entry (M-WAVE)	Autonomous Communication Medical Ecosystem (ACME)	Point of Treatment Aggregator (PoTAg)
Audio/Video (AV) Component(s)	• PatrolEyes visible (VIS)/near infrared (NIR) Camera	• GoPro Hero 13 Black Action Camera	• MOHOC M2 Camera • Sennheiser Lapel Microphone
Patient Vital Sign Monitor (VSM) Component(s)	• Vivalink Electrocardiogram (ECG) Patch • Vivalink Pulse Oximeter	• Masimo MightySat Pulse Oximeter	
Provider Activity Tracking Component	• Electromyography (EMG) Armband	• Movella Dots	• Movella Dots
Consumable Medical Supply Use Tracking Component		• Near Field Communication (NFC) Tags	
Edge Computing Device (ECD)	• NVIDIA Jetson Orin Nano		
End User Device (EUD)	• Samsung Galaxy S23 FE Smartphone	• Samsung Galaxy S21 Smartphone	• Dell Latitude 7230 Rugged Extreme Tablet

Methods

The assessment methodology prioritized functionality, usability and performance. The assessment consisted of three phases:



During the assessment, human subject participants leveraging the technology prototypes in hyper-realistic TCCC simulation environments, including a range of operational environmental lighting conditions.

Results

During simulated user testing, all three sensor suites achieved passing quantitative scores (> 60); the system usability scores (SUS) ranged from 60 to 86.7 on a 100-point scale. More complex technology configurations received higher usability scores.

Results of Sensor Suite System Wide Technical Specifications Assessment

	M-WAVE Average Score	ACME Average Score	PoTAg Average Score
Form Factor	1.7	2.0	1.8
Power Requirements	1.7	1.8	2
Interface	1.50	1.6	1.3
Data Capture & Storage	1.8	1.6	2
Device Flexibility	1.8	1.8	2
Data Transfer	1.8	1.8	1.8

The evaluation used a 3-point scale (0=lowest and 2=highest) for scoring each attribute where a score of ≥ 1 is considered acceptable/passing. Two research team evaluators (n=2) conducted this tabletop assessment separately; their individual scores were averaged

Results of Heuristic Analysis

M-WAVE	ACME	PoTAg
44.9	87	67.5
22.9	87.5	75

Due to the varied number of sensor suite components, scores were adjusted to a 100-point scale (0=lowest and 100=highest) Two research team evaluators (n=2) conducted this tabletop assessment separately; their individual scores were averaged

Simulated Use Testing: Quantitative SUS Scores

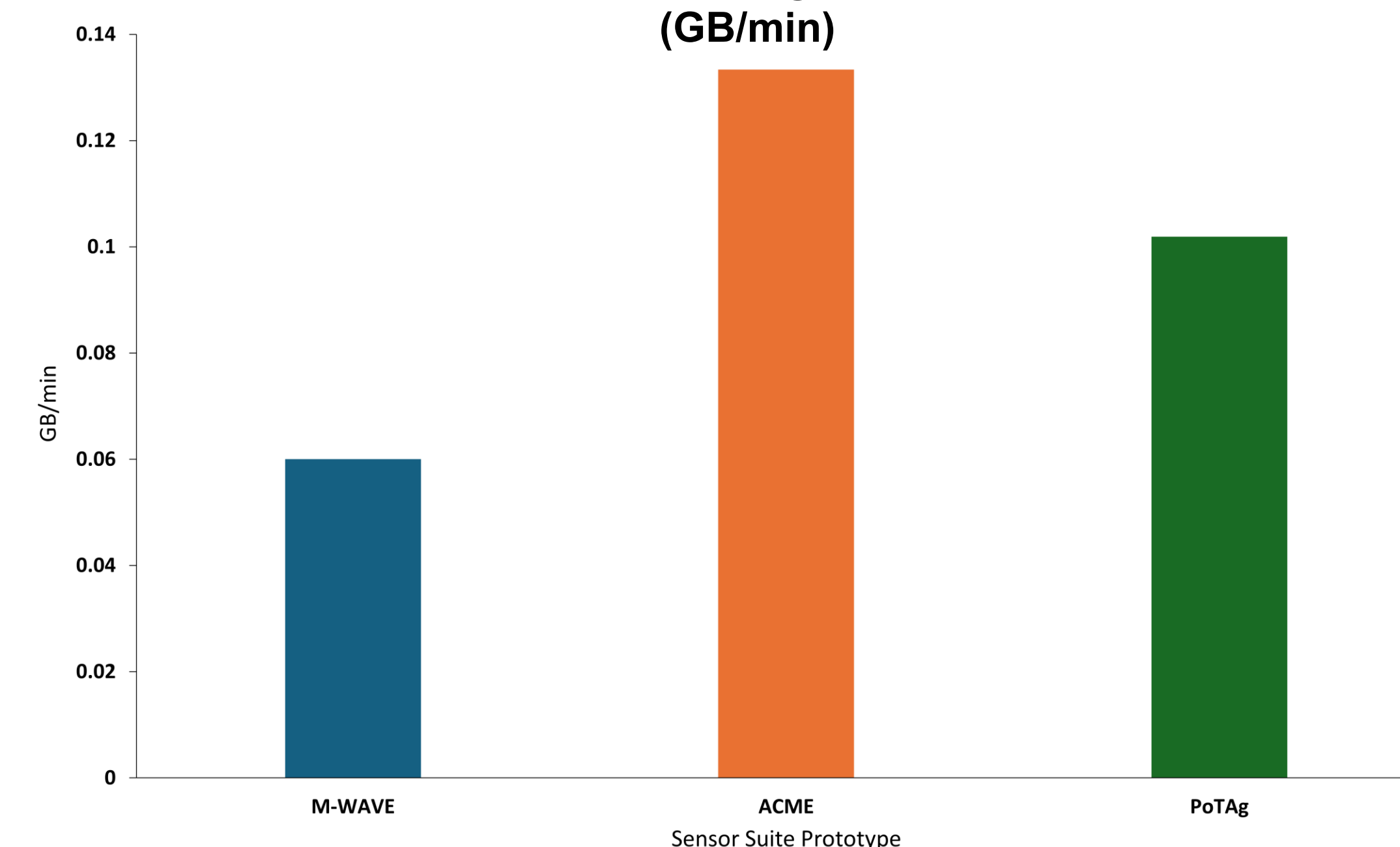
	M-WAVE	ACME	PoTAg
Total Score	85	60	80

SUS scores are based on a 100-point scale (0=lowest and 100=highest), where a score of ≥ 60 is considered passing. Two (n=2) simulation participant evaluators/TCCC providers conducted this assessment; their individual scores were averaged

All three prototypes successfully generated raw data; the individual outputs ranged from 0.12 to 0.24 gigabytes per minute (GB/min) based on the environmental lighting conditions (full sun, indoor lighting and low light).

However, from a data quality perspective, only the multi-modal camera component produced viable video data in all three environments.

Simulated Use Testing: Data File Sizes (GB/min)



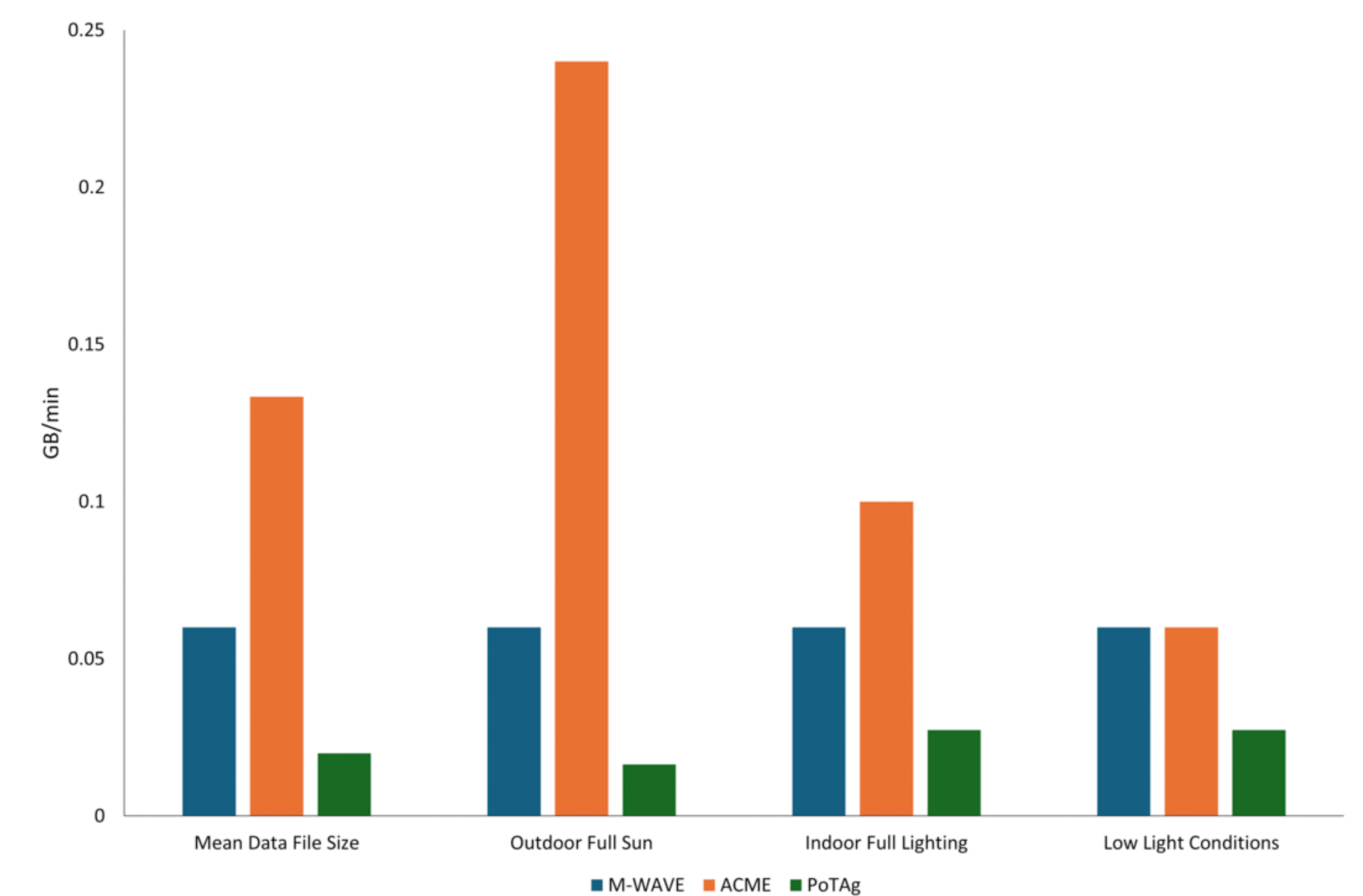
Sensor Suite Rodeo Simulation Quantitative Assessment: SUS Scores

	M-WAVE	ACME	PoTAg
Total Score	86.67	66.67	76.67

SUS scores are based on a 100-point scale (0=lowest and 100=highest), where a score of ≥ 60 is considered passing. Three (n=3) simulation participant evaluators/TCCC providers conducted this assessment; their individual scores were averaged

Results, continued

Sensor Suite Rodeo Simulation: Data File Sizes (GB/min)



Discussion

The outcomes of this comparative assessment revealed opportunities to blend the strengths of each approach into a next generation implementation, specifically the need for a multimedia camera inputs, a refined activity tracker configurations that will capture synchronized, bilateral inputs to effectively recognized medic actions (tourniquet applications et al), and improvements for localized data storage and processing for edge computing.

VIS/NIR Camera



EMG Armband for Activity Tracking



Acknowledgements: The following individuals are acknowledged for their direct and indirect support to this effort: Dr. Omar Badawi, Ms. LeNiqua Ballou, Mr. Joe Barrick, SSG Lam Bui, Dr. Jonathan Chambers, Mr. Valmik Desai, Ms. Alix Donnelly, MAJ Clarence Duccommon, Dr. Dion Edwards, Ms. Stephanie Edwards, Mr. Evan Feuer, Mr. Nate Fisher, Dr. Stephanie Fonda, Ms. Bethzaida Gonzalez-Lanham, Ms. Ollie Gray, Mr. Todd Hall, Ms. Tina Hamrick, Ms. Airi JungRhee, Mr. Daniel Kalala, Ms. Courtney Kentrus, Dr. Ben Knisley, Ms. Buffy Krall, Mr. Zach Lattimore, Dr. Jaeyeon Lee, Mr. Carl Manemeit, Mr. Larry Markins, LTC Rachel Morgans, Ms. Moriah Newman, COL Jeremy Pamplin, Ms. Yema Pizzuto, Ms. Tiffany Quach, Mr. Matt Quinn, Mr. Ethan Quist, CPT Tamara Richardson, Mr. Tyler Ring, Ms. Triana Rivera-Nichols, Mr. Jeff Robbins, Ms. Kerri Root, COL Sharon Rosser, Taylor Somers, Mr. Mark Spears, Mr. Jesse Steffens, Dr. Ericka Stoor-Burning, SPC Dustin Turner, Ms. Ann Trout, Mr. Nick Williams, and Mr. Chevas Yeoman



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