Industrial Human Augmentation System

Exoskeleton Technology Initiative for DoD Industrial Activities

Jamie Mattern, Naval Surface Warfare Center, Carderock Division
Dana Ellis, National Center for Manufacturing Sciences
David McArdle, Naval Surface Warfare Center, Carderock Division
iHAS Tool Holder Variant

• The Industrial Human Augmentation System (iHAS) Tool Holder Variant is the first known exoskeleton system devised for industrial applications.

• The prototype is comprised of two independent exoskeleton technologies that were first combined and demonstrated by the Naval Surface Warfare Center SWC-Carderock Technology Office in 2011.

  1st technology - zeroG® Exoskeleton Arm System
  • Allows operators to use heavy tools up to 40 lbs as if weightless.
  • Requires no power.

  2nd technology - MANTIS™ Lower Body Exoskeleton
  • Transfers stress and weight from the human operator to the exoskeleton frame.
  • No power, electronics or actuation required.

• The iHAS Tool Holder Variant will improve the productivity and quality of industrial work practices while reducing the likelihood of strain-related injuries to the workforce.

“We see this project as having tremendous benefit in cost savings, improved production, and, perhaps most importantly, reduction of stress related injuries.”

~ CAPT Williamson, PSNS&IMF CO
iHAS Tool Holder Variant

Arm + Body = Mobile Tool Holder

"The Navy can’t afford not to develop this technology."

~ RDML Creevy, Director of Naval Warfare Centers
Primary Objective of Current Efforts

Complete a block buy of iHAS Tool Holder Variant units for Naval Shipyards in FY15

Requirements to Support FY15 Buy

– Shipyard T&E project using production work
– Develop a Purple Procurement Specification
– Develop an acquisition strategy for FY15 procurement
– Develop business cases for representative applications
– Identify & address safety concerns and issues
– Address all Human Subjects Research requirements

“(i)HAS technology is a fundamental redefinition of the relationship between the worker and the tool where the physical strength of the worker is no longer a factor.”

~ CAPT Williamson, PSNS&IMF CO
Developmental History of Exoskeleton Technology

• 2000 DARPA’s vision for military exoskeleton development
  • $50M project known as "Exoskeletons for Human Performance Augmentation" which spawned a number of exoskeleton projects. The scope of the program included the development of actively controlled exoskeletons that not only increased strength and speed, but enable larger weapons to be carried, provided a higher level of protection from enemy fire or chemical attack, allowed wearers to stay active longer and carry more food, ammunition etc.
  • Provided 2 viable products – but not pursued further by DARPA
    • Raytheon’s XOS 2 – Powered by cord or motor – Invested ~$30M 2000-2010
    • Lockheed Martin’s Human Universal Load Carrier (HULC) – Powered by battery or fuel cell – Invested > $20M 2000-2013

• 2010 Army Pursues Soldier Support Variant
  • 2010 Army invested $2M in HULC to reduce soldier burden
  • $75K to Navy to pursue Navy applications Industrial Variant

• 2011 NSWCCD developed concept & established Team for Industrial Variant
  • Initial target: Mobile, heavy tool holder to transfer tool loads directly to the ground
    • NAVSEA 04
    • Puget Sound Naval Shipyard
    • NSWCCD
    • OSD NCMS – Commercial Technologies for Maintenance Activities (CTMA) Program
  • Demonstrated conceptual prototype at:
    • Puget Sound Naval Shipyard
    • Newport News Shipbuilding
  • 2012 NSWCCD DTL led team efforts for RDT&E of the Industrial Variant
    • 2012 Team demonstrated re-designed “Basic Prototype” at PSNS (Basic = No power & no hydraulics)
    • 2012 Funds provided for Industrial Variant
      • $75K NSWCCD
      • $100K OSD CTMA
      • >$500K PSNS labor and materials
      • >$500K Industry investments and in-kind cost share
2011 Shipyard Proof of Concept Demos

- Two days performing various tasks at both NNS and PSNSY
  - Noticeable productivity improvement
  - Noticeable quality improvement
  - Reduced fatigue

- PSNSY Demo (Aug 2011):
  - Workers performed a continuous overhead grind for 25 minutes.
  - Typical unassisted performance showed 21 breaks taken during a 25 minute period.

- NNS Demo (Sep 2011):
  - Overhead/vertical grinding - Demonstrated 30 minute overhead grind with 3 breaks for movement, total 3 minutes
  - Noticeable productivity improvement with arm alone
  - Pick and place/material handling - single person ability to lift and carry 150 lb. load with suit and lifting bracket.

- Lessons learned:
  - System needs to be optimized for industrial applications
  - Needs to be adapted to better accommodate a wide variety of height and weight of users
  - In suit training is required
  - Need to pursue technology further
2012 Shipyard Prototype Evaluation Results

Preliminary Evaluation of 2nd generation iHAS unit at PSNS, November 2012
Sponsored by National Center for Manufacturing Science (NCMS)

Demo Summary
- 5 Operators; 2 MANTIS Systems
- 10 Test Sessions Augmented vs. Un-augmented
- 25 lbs Heat Induction Tool in Various Locations
- Quantitative and Qualitative Evaluations

Results
- Team of 2 Alternating (1 Augmented + 1 Support): Productivity Equivalent to Team of 3 rotating Un-augmented Operators
- Operators Reported Significantly Reduced Fatigue
- Observed Improved Ergonomics
- Postural Analysis showed Improved Posture
Preliminary Evaluation of 2nd generation iHAS unit at PSNS, November 2012
Sponsored by National Center for Manufacturing Science (NCMS)
Quoted from the NCMS Final Report

“The evaluation produced compelling results:

1) Testing indicated a high potential for significant team productivity improvements, as the iHAS enabled a two-worker team to equal the production of a three-worker team that does not utilize a iHAS.
2) Quantitative data suggests the iHAS improves overall individual productivity by 3.4% (comparing only 2-person teams, and therefore not including any benefit of team size reduction of item #1). However, this finding needs to be verified through further testing, as the sample size of this test was not large enough to make the results statistically significant.
3) Qualitative data suggests the iHAS improves worker ergonomics and significantly reduces worker fatigue.
4) The HAS performed effectively in a wide array of work environments (unstable footing, loose impediments, rain, wind, cold, etc.).

Additionally, test participant feedback was overwhelmingly positive. Test participants were able to quickly acclimate to the system, maneuver through the entire shipyard while wearing the system, and implement the system in their typical activities. Test participants expressed a desire to implement the HAS into some aspect of their standard work.”
Technology Transition Mechanisms

Navy

• Public Shipyards – NAVSEA 04
• Private Shipyards – NSRP
• Other Naval Industrial Base Activities – NCMS
• Navy Facilities - NAVFAC

Other DoD

• Purple Organizations
  • OSD Joint Technology Exchange Group (JTEG)
  • OSD National Center for Manufacturing Sciences (NCMS)
  • NCMS Commercial Technologies for Maintenance Activities (CTMA)
• DoD ManTech
• Army NATICK Soldier RDT&E Center
Assistance from Other DoD Stakeholders

• Technology Transition to Other Services and Programs
  – Participate in iHAS DoD Quarterly Updates
  – Equipois, Inc. Website  http://www.equipoisinc.com
    » Sample Applications (all proven in production)
    » Business Case Development Tool
    » Case Study for a Grinding Application
    » Equipment Available
  – Identify applications within your workload
• Feedback on Draft Purple Procurement Specification
• Feedback on Draft Representative Business Cases
Questions?

"Bottom line for me is this is all about people, listening to our folks and putting our words and actions into alignment on something that makes a real difference to them. The feedback from the deck-plate is pretty amazing, we need to keep this moving forward!"

~ RDML Whitney, NAVSEA04