

Human Augmentation Technology

Bluejacket HULC

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Agenda

- Problem
- Opportunity
- Evaluation/Results
- Next Steps

Many jobs require human beings to perform tasks that put them at risk

- *Total Ownership Cost / Human Asset / Injury Rates*

- *Construction Cost*
- *Productivity*
- *Quality*
- *Manpower*
- *Personnel/Training*
- *Worker's Comp*



Human vs. Machine



“White Collar”

Fine Motor Control
Perception
Judgment
Creativity
Versatility

Intelligent
Manual
Labor
(Brains
Plus
Hands)

- Tool use
- Fine manipulation
- Variable tasks
- Non-uniform handling



Automation

Strength
Endurance
Precision
Repeatability

“Unskilled Labor”
(Automation not feasible
or economical)

The Opportunity... Human Augmentation



Moves in Concert with The Person

Robots Legs

Robot Supports Loads

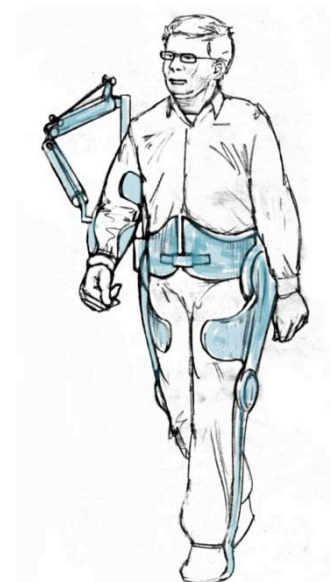
Intelligence, Adaptability

Strength, Endurance

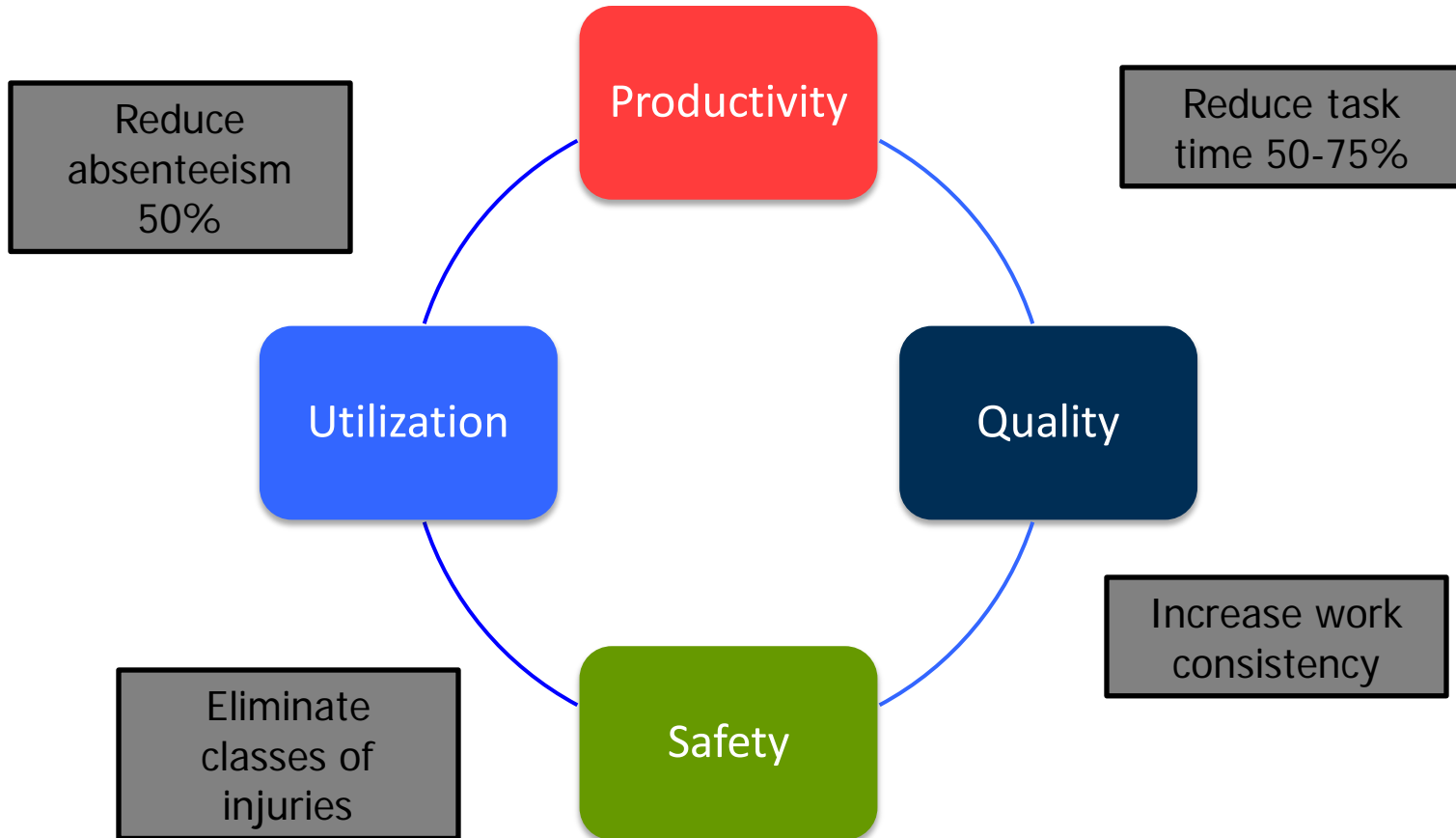
Imagine when...

...machines work alongside humans to:

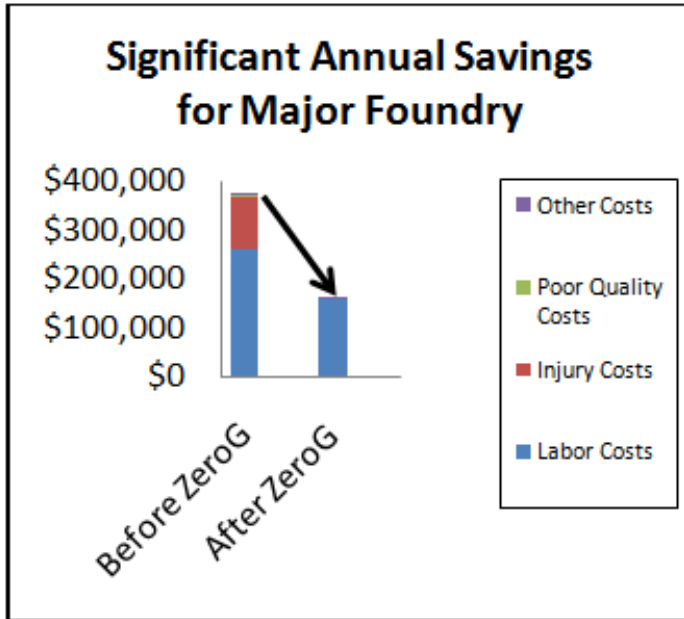
- Give them the strength, stamina and precision of a machine
- Protect them from accident and injury
- Compensate for their disabilities and old age
- Help them recover from infirmities
- Teach them to be more efficient
- Learn from them to evolve and to help others



The Potential of Human Augmentation



Economic Impact



Project ROI Summary:

Total Cost Savings	\$219,720
Less Depreciation	- \$9,000
Less Annual Maintenance	- \$750
Total Net Savings	\$ 209,970
Total zeroG Acquisition Cost	\$ 36,000
ROI	583%
Payback Period	0.17 years

Annual ROI of 393%

Annual ROI of 583%

Case Study – Automotive Manufacturer



Project ROI Summary

Injury Cost Savings	\$39,376
Other Cost Savings (i.e. tool repair costs)	\$ 3,000
Total Cost Savings	\$42,376
Less Depreciation	- \$2,500
Less Annual Maintenance	- \$250
Total Net Savings	\$ 39,256
Total zeroG Acquisition Cost - (1) zeroG System	\$ 10,000
ROI	393%
Payback Period	3.1 months

Real World Examples of successful Human Augmentation for Industrial Processes

Collaboration Team



Newport News Shipbuilding
A Division of Huntington Ingalls Industries

- **Exoskeletal Arm Systems (zeroG):**
 - zeroG arm mitigates the weight of heavy tools.
 - Arm requires no power.
 - Arm supports the tool through a wide range of motion.
 - Can reduce vibration transmission.
 - zeroG arms at TRL 9 status, TRL 5 for lifting.
 - Single arm stabilize tools to 40 lbs, dual arm to 80 lbs.
- **Lower Body Exoskeleton (HULC)**
 - Load of up to 200 lbs is transferred to the ground.
 - 20 hour charge life at expected work rates.
 - HULC at TRL 5.
 - HULC being developed for multiple applications.



PSNS - Evaluations

- Focus on viability assessment within this application
- Two days performing various tasks
- Nine Puget workers in the suit
- Suit in single arm mode overhead grinding
- Comparative testing – augmented and unaugmented
- Timed repetitive tasks





PSNS – Results/Lessons Learned

- Worker performed a continuous overhead grind for 25 minutes.
 - Typical unaugmented performance showed 21 breaks taken during 25 minute period.
- Noticeable quality improvement when augmented.
- Potential to shorten drydock period.
- Enabling technology
 - One participant had a muscular-skeletal disease.
 - Was able to perform the task in the system.

Lessons learned

- System needs to be optimized for this application
- Better anthropometric accommodation
- Training required/Order of training



- Focus on identifying optimization requirements
- Two days performing various tasks
- Nine NNS workers in the suit
- Suit in single arm mode
 - Overhead and vertical grinding
- Suit without arm
 - Pick and place/material handling
- Mobility and agility in simulated ship deck.
- Comparative testing – augmented and unaugmented
- Timed repetitive tasks





NNS – Results/Lessons Learned



- Overhead/vertical grinding
 - Results with workers supports value of human augmentation
 - Demonstrated 30 minute overhead grind with 3 breaks for movement, totaling 3 minutes
 - Noticeable productivity improvement with arm alone
- Pick and place
 - Demonstrated single person ability to lift and carry 115 lb. load with suit and lifting bracket.

Lessons learned

- Proper training and user confidence/trust are significant factors
 - Man-machine interaction is key
- Added understanding of requirements.
- Environmental variations are important
 - Surface height/distance is a factor

Next Steps...



- Study focused on safety & performance improvements of augmented workers.
- Capture and clarify requirements for the technology.
 - Identify application landscape
 - Explore new areas of use – pick and place of heavy components
 - Business case rationale
- Stakeholder support:
 - For human augmentation optimization
 - For Joint Service collaboration

Human Augmentation = Improved Total Ownership Cost / Human Asset Optimization / Reduced Injury Rates