SURGE: Smart Ultrasound Remote Guidance Experiment
Preliminary Findings

NASA-JSC / Wyle
Aerospace Medicine Clerkship

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Presentation outline

- Ultrasound in space
- SURGE introduction
- SURGE design
- Results
- Next steps
<table>
<thead>
<tr>
<th>Team members</th>
<th>Funding</th>
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<tr>
<td>Scott Dulchavsky (PI)</td>
<td>Part of Phase 3 of the Bracelet Investigation Grant</td>
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<td>Victor Hurst</td>
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<tr>
<td>Kathleen Garcia</td>
<td>Henry Ford/NSBRI</td>
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<td>Ashot Sargsyan</td>
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<td>Doug Ebert</td>
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<td>David Ham</td>
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<td>Mary Carvalho</td>
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<td>Sean Peterson</td>
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Why SURGE?

- Exploration-class missions lead to longer communication delays with mission control
- May not always have communication capability to stream real-time ultrasound images
- SURGE explores use of a “just-in-time” learning tool, called OPEL = On-Board Proficiency Enhancer Light as an aid to a hypothetical crew medical officer working autonomously
• Inexperienced ultrasound operators
• Autonomous operation
• Investigate necessary requirements to collect useful ultrasound images
  • Level of experience
  • Amount of training
  • Human factors
• Compare to real-time, remote guidance with a communication time delay relating to a lunar mission (5 seconds)
Participants

- No formal ultrasound training
- Less than 2 hours total time using an ultrasound machine
- Mix of medical and non-medical individuals
  - Physicians
  - Biomedical engineers
  - Administrative duties
  - 1 physician astronaut
Study design – 3 groups

A  Remote Guidance
B  Autonomous OPEL
C  Remote Guidance & OPEL

OPEL refers to On-orbit proficiency enhancer light, a computer-based learning tool
### Comparison metrics

#### Fracture assessment
- Task completion time
- Correctly diagnose fractured limb
- Confidence in diagnosis
- Image quality

#### FAST abdomen assessment
- Task completion time
- Image quality

#### Post-experiment questionnaire
- Assessment of training, cue card, computer-based training, remote guidance, difficulty & frustration
Ultimately, captured ultrasound images will be reviewed and rated by two blinded and independent expert radiologists.

Preliminary assessment performed by un-blinded, non-expert, yet FAST certified family medicine physician.

Not validated.

Rating identical for both the fracture assessment and the FAST abdomen assessment.

- Each view assigned a rating
  - “1” if diagnostic
  - “0” if non-diagnostic

- Ratings from 4 views summed to give an “Image Quality” rating out of four.
What did we find?
Subjects were able to correctly identify fractured limb

- Remote Guidance: 86% *
- Autonomous (OPEL): 88% *
- Remote Guidance & OPEL: 100%

* 2 out 22 subjects identified a fracture, but in the wrong limb
OPEL refers to On-orbit proficiency enhancer light, a computer-based learning tool.

Analyzed using ANOVA: Tukey’s Honest Significant Difference (HSD) Test.
Wide variation on FAST abdomen results

OPEL refers to on-orbit proficiency enhancer light, a computer-based learning tool.

Analysed using ANOVA: Tukey’s Honest Significant Difference (HSD) Test
No perceived difference in difficulty or frustration

Initial scales for Difficulty and Frustration were a Likert scale out of 7 with 1 being “very difficult” and 7 being “not difficult at all.”

Graphs above represent 7 minus the average of each group.

None of the differences were significant.
Medically trained subjects obtained better quality FAST images

- No significant difference in FAST task completion times
- No significant difference in either fracture assessment completion times or quality of images
No correlation between FAST ultrasound task completion time and image quality
### Great ideas for improvement obtained by post-experiment questionnaire

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<thead>
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<th>Overall</th>
<th>Pre-experiment training</th>
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<td>• Maintain consistent, plain language</td>
<td>• Include a “tour” through the human body showing specific organs</td>
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<td>• Reinforce firmer pressure to improve image quality</td>
<td>• Describe how to get gel out of bottle by shaking it down to the dispersing end</td>
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<tr>
<td>• Have automatic recognition of internal body structures by ultrasound</td>
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<tr>
<th>Cue card</th>
<th>Remote guidance</th>
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<td>• Add instructions on how to capture a STILL and a VIDEO LOOP</td>
<td>• Limit instructions to 3 steps so as to not get ahead of ultrasound operator</td>
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<td>• Include a description of “SWEEP” = tilting probe one way and then the</td>
<td>• Provide positive feedback when proper images obtained to aid ultrasound operator confidence</td>
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<td>other to visualize an organ or interface</td>
<td>• Share with ultrasound operator what a “positive” scan would show</td>
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<tr>
<td>• Change position of A4 to be more posterior in mid-axillary line</td>
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Many suggestions for improving the FAST component of OPEL

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<tr>
<th>FAST abdomen procedure</th>
<th>FAST abdomen video</th>
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<tr>
<td>• Remove medical language</td>
<td>• Expand video to include more still pictures of the desired views with labels describing the target organs and where “free fluid” would appear</td>
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<tr>
<td>• Better describe orientation of probe and include pictures of orientation</td>
<td>• Better describe how to do a SWEEP or “tilt” to visualize an interface</td>
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<td>• Better describe how to locate the kidney</td>
<td>• Emphasize need to have probe nearly parallel with abdomen and tucked under ribs with firm pressure to visualize heart</td>
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<tr>
<td>• Describe how to manage with rib shadows</td>
<td>• Provide examples of “positive” free fluid ultrasound images in video</td>
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<td>• Better describe procedure to visualize heart from sub-xyphoid approach</td>
<td>• Include a “problem-solving” section that describes potential maneuvers to attempt to gain the desired image (i.e., breath holds, bending knees, rotating probe, panning probe)</td>
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<tr>
<td>• Reset depth setting after each position to avoid missing far-field structures</td>
<td>• Include a “problem-solving” section that describes potential maneuvers to attempt to gain the desired image (i.e., breath holds, bending knees, rotating probe, panning probe)</td>
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<tr>
<td>• Include a “problem-solving” section that describes potential maneuvers to attempt to gain the desired image.</td>
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<td>• Embed videos in word document at relevant line items</td>
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Thank you!

- Corrine for providing us with an excellent month at “space camp”
- Wyle for hosting us and providing logistical support
- NASA-JSC and flight docs for excellent teaching and outstanding experiences
- Mary Carvalho, PhD for rapid statistical analysis
- David Ham for technical support
- Victor Hurst IV, PhD, Kathleen Garcia, RDCS, RVT, Ashot Sargsyan, MD, and Doug Ebert, PhD for providing me with an opportunity to participate in such a neat project!