Warfighter-Machine Interface Considerations for Future Combat Systems

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Tank-Automotive Research, Development & Engineering Center
WMI Considerations for FCS

Agenda

• Background
  – Vetronics Technology Integration (VTI) Program
  – CAT Technologies

• Multi-modal Testing
  – Keyboard/Track Ball
  – Touchscreen
  – Voice Activation
  – Bump Cursor

• Technology Comparison

• Results

• Improvements

• Considerations
WMI Considerations for FCS
VTI Program

Crew integration & Automation Testbed (CAT) ATD

- Stryker Chassis
- Fight & Scout MOS
- Surrogate control vehicle for up to 5 robotic assets
- Driving performed via indirect vision sensors on flat-panel displays
- Local sensors for automated driving
- Target acquisition, scenario capabilities simulated with embedded B-Kit
Decision Aids
- Cognitive Aids
- Route Planning
- Auto Driving

Soldier-Machine Interface
- 3-D Audio
- Speech Recognition
- Indirect Vision Driving
- Control Multiple Unmanned Assets

CAT Technologies

2003 Field Experiments, Ft. Bliss, TX

Embedded Simulation
- Mission Planning
- Mission Training
- Battlefield Visualization

Electronics Architecture

Improved hardware and software reusability

Reconfigurable component based Software Ref Arch

Open Interface based Sys Ref Arch
Crew integration & Automation Testbed (CAT) ATD

- 2 reconfigurable crewstations
  - front-back/side-side
  - identical functionality
- 20” touchscreen displays
  - portrait orientation
  - suite/screen selection buttons in bezel
  - touch buttons on display
- Multifunction yoke
  - Driving
  - Target acquisition/engagement
  - Sensor control (SA)
  - Robotic teleoperations
  - PTT for voice activation
  - Embedded simulation
- Keyboard w/ trackball
Objective:
Compare the advantages of various multi-modal SMI(s) to minimize the time to complete a task and/or reduce the crew workload.

Procedure:

- CAT vehicle is driven on paved, secondary, and cross-country at constant speed (test coordinator begins data collection)
- Each of 4 test subjects to scan for targets via indirect vision sensors
- Upon detection, subject enters target location via map screen
- Subject then generates spot report (REPORTS, COMBAT, SPOT/SALT, UNIT, SIZE, NATIONALITY, ENEMY ACTIVITY, ACTION TAKEN, MOVEMENT, SPEED, SEND)
- 3 targets per run, 1 run per terrain type, 1 stationary run
- Repeated for Touchscreen, bumpcursor, keyboard/trackball, and voice activation
Add Units - Weapon

- The operator selects a weapon type (assuming the unit is unknown)

- The weapon graphic will appear in the upper left corner of the submenu after the type has been selected

- Weapon types are from Crewman’s Associate ATD

- Weapons are selected when information is known about the system (often from RSTA), but no organizational information is known
Add Units
Affiliation & Echelon

- Affiliation classification
  - Friendly
  - Neutral
  - Unknown
  - Enemy

- Echelon classification
  - Team
  - Squad
  - Section
  - Platoon
  - Company
  - Battalion
  - Regiment

- Echelon classification is only available for units and not weapons

Sample of infantry unit for each type of affiliation

Selected unit is shown.

Affiliation classification both color and shape coded.
Select SPOT Report

Incoming Reports

<table>
<thead>
<tr>
<th>Report Name</th>
<th>Precedence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spot Report</td>
<td>Priority</td>
</tr>
<tr>
<td>04:00:11 1/25/2002</td>
<td></td>
</tr>
<tr>
<td>Bridge Report</td>
<td>Routine</td>
</tr>
<tr>
<td>03:59:11 1/25/2002</td>
<td></td>
</tr>
<tr>
<td>Free Text</td>
<td>Routine</td>
</tr>
<tr>
<td>03:56:11 1/25/2002</td>
<td></td>
</tr>
<tr>
<td>Spot Report</td>
<td>Priority</td>
</tr>
<tr>
<td>04:01:11 1/25/2002</td>
<td></td>
</tr>
<tr>
<td>Spot Report</td>
<td>Priority</td>
</tr>
<tr>
<td>03:55:11 1/25/2002</td>
<td></td>
</tr>
<tr>
<td>Spot Report</td>
<td>Priority</td>
</tr>
<tr>
<td>03:40:11 1/25/2002</td>
<td></td>
</tr>
<tr>
<td>Spot Report</td>
<td>Priority</td>
</tr>
<tr>
<td>04:00:11 1/25/2002</td>
<td></td>
</tr>
<tr>
<td>Spot Report</td>
<td>Priority</td>
</tr>
<tr>
<td>03:40:11 1/25/2002</td>
<td></td>
</tr>
<tr>
<td>Spot Report</td>
<td>Priority</td>
</tr>
<tr>
<td>04:00:11 1/25/2002</td>
<td></td>
</tr>
</tbody>
</table>

Report Summary

<table>
<thead>
<tr>
<th>Bridge Report</th>
<th>Combat</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOPP</td>
<td>OBSTCL</td>
</tr>
<tr>
<td>OPORD/FRAGO</td>
<td>OVERLAY</td>
</tr>
<tr>
<td>POSITION REQUEST</td>
<td>REDCON</td>
</tr>
<tr>
<td>SITUATION</td>
<td>SPOT/SALT</td>
</tr>
<tr>
<td>PREV. PAGE</td>
<td>CANCEL</td>
</tr>
<tr>
<td>UNIT REF. QRY./RES.</td>
<td></td>
</tr>
<tr>
<td>COMBAT</td>
<td></td>
</tr>
<tr>
<td>FIRE SUPPORT</td>
<td></td>
</tr>
<tr>
<td>ALERTS/WARNING</td>
<td></td>
</tr>
<tr>
<td>MISSION PLAN</td>
<td></td>
</tr>
<tr>
<td>HELD REPT. (1)</td>
<td></td>
</tr>
<tr>
<td>OUTGNG. REPT. (2)</td>
<td></td>
</tr>
<tr>
<td>INCMG. REPT. (15)</td>
<td></td>
</tr>
</tbody>
</table>
### WMI Considerations for FCS

*Multi-modal Testing*

#### Main SPOT Report Screen

<table>
<thead>
<tr>
<th>UNIT</th>
<th>Tank</th>
<th>&lt;Map Coordinates&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIZE</td>
<td>&lt;Unknown&gt;</td>
<td></td>
</tr>
<tr>
<td>NATIONALITY</td>
<td>&lt;Unknown&gt;</td>
<td></td>
</tr>
<tr>
<td>ENEMY ACTIVITY</td>
<td>&lt;Unknown&gt;</td>
<td></td>
</tr>
<tr>
<td>ACTION TAKEN</td>
<td>No Activity</td>
<td></td>
</tr>
<tr>
<td>MOVEMENT</td>
<td>45 deg.</td>
<td></td>
</tr>
<tr>
<td>SPEED</td>
<td>100 kmph</td>
<td></td>
</tr>
</tbody>
</table>

**SPOT Report**

- **Page 1 of 1**
- **04:30**

- **Precedence:** Priority
- **Acknowledgment Required:** Machine Ack.
- **Security Level:** Unclassified
- **Destination Levels:** SOP List
- **Send Time:** No Delay
**WMI Considerations for FCS**

*Multi-modal Testing*

**SPOT Report Size Sub-Screen**

**SPOT Report**

Page 1 of 1 04:30

- Precedence: Priority
- Security Level: Unclassified
- Destination Levels: SOP List
- Send Time: No Delay
SPOT Report Nationality Sub-Screen

UNIT
SIZE
NATIONALITY
ENEMY ACTIVITY
ACTION TAKEN
MOVE-MENT
SPEED

- Tank
- Nationality

SPOT Report
Page 1 of 1 04:30

Precedence: Priority
Acknowledgment: Hostile
Required: Machine Ack.
Security Level: Unclassified
Destination Levels: SOP List
Send Time: No Delay

UNIT
- HOSTILE
- FRIENDLY
- NEUTRAL
- UN-KNOWN
- CANCEL

100 kmph
WMI Considerations for FCS
Multi-modal Testing

SPOT Report Enemy Activity Sub-Screen

**SPOT Report**

- Precedence: Priority
- Acknowledgment Required: Machine Ack.
- Security Level: Unclassified
- Destination Levels: SOP List
- Send Time: No Delay

**Tank**

**Enemy Activity**

- ACQUIRE/TRACK
- ADJUST-ING
- ASSEMBLING
- ATTACK-ING
- BOMBING
- BYPASS-ING
- CHAFF LAYING
- CONTIN. MISSION
- COVER-ING
- CROSS. LN. DEP.
- CANCEL
- NEXT PAGE

**Movement**

**SPEED**

**Action Taken**

**Size**

**Nationality**

**Enemy Activity**

**Movement**

**Speed**

**Action Taken**

**Size**

**Nationality**

**Enemy Activity**
WMI Considerations for FCS
Multi-modal Testing

SPOT Report Action Taken Sub-Screen

SPOT Report
Page 1 of 1 04:30

Precedence: Priority
Acknowledgment Required: Machine Ack.
Security Level: Unclassified
Destination Levels: SOP List
Send Time: No Delay

Friendly Action Taken

- ACQUIRE/TRACK
- ADJUSTING
- ASSEMBLING
- ATTACKING
- BOMBING
- BYPASSING
- CHAFF LAYING
- CONTIN. MISSION
- COVERING
- CROSS. LN. DEP.
- CANCEL
- NEXT PAGE

UNIT
SIZE
NATIONALITY
ACTION TAKEN
ACTION TAKEN
ACTION TAKEN
MOVEMENT
SPEED

SEND
SAVE
CANCEL
SEND OPTIONS
PREV. PAGE
NEXT PAGE
SPOT Report Movement Sub-Screen

- Tank: <Map Coordinates>
- Platoon: 
- Hostile: 
- Precedence: Priority
- Acknowledgment Required: Machine Ack.
- Security Level: Unclassified
- Destination Levels: SOP List
- Send Time: No Delay

Movement

Enter the angle of movement:

45 deg.
SPOT Report Speed Sub-Screen

Enter the speed of movement:

100 km/h
Test Considerations:

- Crewstation testing is begun with button push, which time stamps activities.
- Event log captures hardware events, like screen touch, bumpcursor press, keyboard entry, and push to talk button press.
- 2 driving camera inputs and over-the-shoulder camera input is recorded on data recorder.
- Vehicle information is recorded (speed, location, yaw, etc.).
- Questionnaires issued after testing to capture subjective data.
- Safety driver operates vehicle.
- Subject provided with map location upon sighting, or after target has been passed without sighting.
- 3 attempts for voice permitted, then override with touch.
- Touch used to place target on map for voice.
- Bump cursor calibration not accurate due to compressed schedule, not used in this test.
WMI Considerations for FCS
Multi-modal Testing
WMI Considerations for FCS
Multi-modal Testing

• General
  • Total of 23+ commands
  • 17 Spot Report specific commands
  • 5 Map specific commands
  • Placement of target location on map
  • 2 administrative commands for voice, keyboard and bumpcursor (setting screen display of interest)

• Keyboard/trackball
  • Trackball moves cursor on given screen, analog
  • Enter key and left key above trackball are equivalent to “Done”
  • Hot keys for moving display of interest from screen to screen

• Touchscreen
  • A touch event triggers a display of interest event
  • Touch is based on a press event, will explore release event in future
  • Stylus attached to crewstation for more accurate placement
Voice Activation

- Commands are grammar specific (wrong word results in error)
- No training required, natural language
- Stanford Research Institute (SRI) International algorithm
- Use Bose noise cancellation headset, tied into intercom system
- Feedback provided as popup on screen (remains on for 3 seconds)
  - accepted command (displays words in green banner)
  - did not hear or recognize (displayed Pardon Me? in yellow banner)
  - Rejected command (displays reject in red banner)

- Bump Cursor
  - DOI button on yoke for moving display of interest
  - Sensitivity set too high, would shoot past buttons in analog
  - Cursor position often moved when button was depressed
  - Left, right, up, and down movement with wrap-around, select with depression of button
<table>
<thead>
<tr>
<th>Technology</th>
<th>Strength</th>
<th>Weakness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Touch</td>
<td>Fast</td>
<td>Least accurate</td>
</tr>
<tr>
<td></td>
<td>Intuitive</td>
<td>No hand anchor</td>
</tr>
<tr>
<td></td>
<td>Is faster, even after correcting errors</td>
<td>More difficult on the move</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lacks tactile feel</td>
</tr>
<tr>
<td>Trackball</td>
<td>Finest placement</td>
<td>Slower execution time</td>
</tr>
<tr>
<td></td>
<td>Can anchor hand to keyboard</td>
<td>Tedious to manipulate</td>
</tr>
<tr>
<td></td>
<td>Worked well on all terrains</td>
<td></td>
</tr>
<tr>
<td>Voice</td>
<td>Eyes free for scanning</td>
<td>Slowest, waited for feedback</td>
</tr>
<tr>
<td></td>
<td>Same across all terrains</td>
<td>Often repeated command</td>
</tr>
<tr>
<td></td>
<td>Effective at rest or on the move</td>
<td>Commands audible over intercom</td>
</tr>
<tr>
<td></td>
<td>Permits multi-tasking</td>
<td>Required PTT action</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Premature release may cause error</td>
</tr>
<tr>
<td>Bump Cursor</td>
<td>Hand anchor</td>
<td>Poor implementation</td>
</tr>
<tr>
<td></td>
<td>Analog movement and selection</td>
<td>Not tested</td>
</tr>
</tbody>
</table>
WMI Considerations for FCS

Potential Improvements

Touch
- Set action on release, then finger can be positioned (dragged) before event
- Tactile feedback is missing, however, current technology is more difficult to integrate and cost prohibitive
- Optimize button size for error reduction
- Provide anchor point to stabilize hand
- Stylus too difficult to use on the move
- Permit map zoom of target area for more accurate placement

Keyboard/trackball
- Calibrate movement for quicker placement across displays
- Anchor keyboard for more stability, stowage when not in use

Voice Activation
- Debug recognition problem requiring multiple attempts
- Decrease dependency on feedback (visual)
- Expand natural language to interpret user input (instead of exact phrase)
- Mute speech over intercom, may cause communication problems

Bump Cursor
- Improve implementation, test against other input devices
- Delineate analog movement (ex. map placement) vs. button activation
WMI Considerations for FCS

Considerations

• All inputs require little additional vehicle space or weight to implement; in line with goals of FCS
• May be possible to blend devices for best fit implementation
  • Each has distinct advantages over other input types
  • Redundancy allows for backup if individual system fails
  • Auditory queuing may be helpful to ease visual burden
• Explore other complimentary technologies to ease workload burden
  • Eye tracker (SMI enabler)
  • Lip tracker (Voice)
  • Microphones - multiple, noise cancellation, bone conduction
  • 3D audio, w/ head tracker (Communication)
  • Helmet mounted display (driving, reconnaissance)
  • Autostereoscopy (driving, reconnaissance)
  • Intelligent agents (anticipate/prompt behaviors)
  • Autonomous driving (multi-tasking)
  • Virtual keyboard (space savings)
  • Thought reading, interpretation...