Warfighter-Machine Interface Considerations for Future Combat Systems

Terrance M. Tierney
Crewstation Technology Team

Email: tierneyt@tacom.army.mil

(586) 574-8678 / DSN 786-8678

Fax (586) 574-8684

U.S. Army Tank-Automotive RD&E Center (TARDEC)
Vetronics Technology Area
(AMSTA-TR-R, Mailstop 264)
Warren, MI 48397-5000

11 June 2003

UNCLASSIFIED

Tank-Automotive Research, Development & Engineering Center

- Background

  – Vetronics Technology Integration (VTI) Program

  – CAT Technologies

- Multi-modal Testing

  – Keyboard/Track Ball

  – Touchscreen

  – Voice Activation

  – Bump Cursor

- Technology Comparison

- Results

- Improvements

- Considerations

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

CAT Technologies
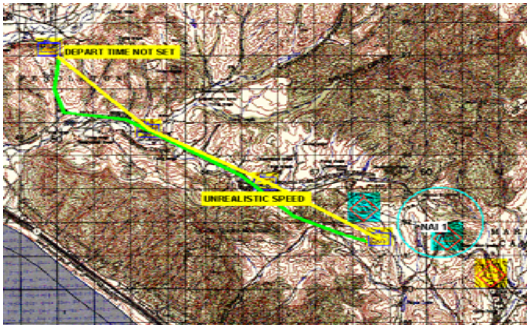
Decision Aids

- Cognitive Aids
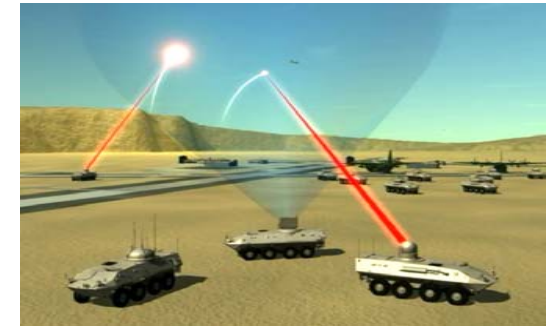- Route Planning
- Auto Driving

Soldier-Machine Interface

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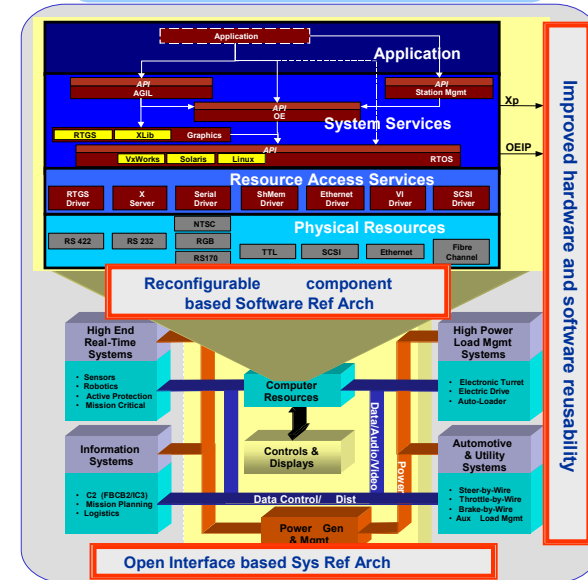- Control Multiple Unmanned Assets

NLOS/BLOS Fire

2003 Field Experiments, Ft. Bliss, TX

Embedded Simulation

- Mission Planning
- Mission Training
- Battlefield Visualization

Electronics Architecture

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

FORT BLISS SOUTH

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

SER: VMAP1 | N UP | HDG: 315° | POS:42 S 0516882E 3823011N| CUR:42 S 0519120E 3820193N

Sample of infantry unit for each type of affiliation

Unknown units

Friendly units

Neutral units

Enemy units

MINI MAP OVERVIEW

OVERVIEW BACKGD

OVERVIEW UNITS

OVERVIEW GRAPHICS

ASSET PLANNING

E-ORDERS

REPORTS

ADD UNIT

MAP INFO

CURSOR CENTER

TRACK VEHICLE

VEHICLE UP

MAP TYPES

ECHELON OVERLAY

DE-CLUTTER

MAP ANALYSIS

AGGRE-

MAP OVERLAP

Add Unit – Affiliation & Echelon

Affiliation

FRIENDLY | NEUTRAL | UNKNOWN | ENEMY

Selected unit is shown.

Affiliation classification both color and shape coded.

Echelon

TEAM | SQUAD | SECTION | PLATOON

COMPANY | BATTALN | REGIMNT | NONE

DONE | CANCEL

x miles

UGV3M

UGV4R

25 mph

WMI Considerations for FCS
Multi-modal Testing

Select SPOT Report

	Incoming Reports		Report Summary	
	Report Name	Precedence		

Incoming Reports

	Report Name	Precedence
1.	Spot Report 04:00:11	Priority 1/25/2002
2.	Bridge Report 03:59:11	Routine 1/25/2002
3.	Free Text 03:56:11	Routine 1/25/2002
4.	Spot Report 04:01:11	Priority 1/25/2002
5.	Spot Report 03:55:11	Priority 1/25/2002
6.	Spot Report 03:40:11	Priority 1/25/2002
7.	Spot Report 04:00:11	Priority 1/25/2002
6.	Spot Report 03:40:11	Priority 1/25/2002
7.	Spot Report 04:00:11	Priority 1/25/2002

Buttons (left): VIEW, EDIT, DELETE, PAGE UP, PAGE DOWN

Report Summary

Bridge R...

- Bridge Typ...
- Control:
- Condition:
- Traffic Flo...
- Location:
- Bypass Location:
- Bypass Difficulty:

Combat

- MOPP
- OBSTCL
- OPORD/ FRAGO
- OVERLAY
- POSITION REQUEST
- REDCON
- SIT-UATION
- SPOT/ SALT
- UNIT REF. QRY./RES.
- PREV. PAGE
- CANCEL

Right side buttons:
- INCMG. REPT. (15)
- OUTGNG. REPT. (2)
- HELD REPT. (1)
- COMBAT
- FIRE SUPPORT
- ALERTS/ WARNING
- MISSION PLAN

WMI Considerations for FCS
Multi-modal Testing

Main SPOT Report Screen

UNIT	Tank <Map Coordinates>
SIZE	<Unknown>
NATION-ALITY	<Unknown>
ENEMY ACTIVITY	<Unknown>
ACTION TAKEN	No Activity
MOVE-MENT	45 deg.
SPEED	100 kmph

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

SEND   SAVE   CANCEL   SEND OPTIONS   PREV. PAGE   NEXT PAGE

SPOT Report Size Sub-Screen

UNIT

SIZE

NATION-ALITY

ENEMY ACTIVITY

ACTION TAKEN

MOVE-MENT

SPEED

Size Indicator

nates>

BAT-TALION

COMPANY

PLATOON

SECTION

SQUAD

CANCEL

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

SEND

SAVE

CANCEL

SEND OPTIONS

PREV. PAGE

NEXT PAGE

SPOT Report Nationality Sub-Screen

UNIT — Tank

SIZE

NATION-ALITY

ENEMY ACTIVITY

ACTION TAKEN

MOVE-MENT

SPEED — 100 kmph

Nationality
- HOSTILE
- FRIENDLY
- NEUTRAL
- UN-KNOWN
- CANCEL

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

SEND

SAVE

CANCEL

SEND OPTIONS

PREV. PAGE

NEXT PAGE

SPOT Report Enemy Activity Sub-Screen

UNIT
SIZE
NATION-ALITY
ENEMY ACTIVITY
ACTION TAKEN
MOVE-MENT
SPEED

Tank

Enemy Activity

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

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

SEND
SAVE
CANCEL
SEND OPTIONS
PREV. PAGE
NEXT PAGE

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SPOT Report Action Taken Sub-Screen

UNIT	
SIZE	
NATION-ALITY	
ACTION TAKEN	
ACTION TAKEN	
MOVE-MENT	
SPEED	

Friendly Action Taken

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

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

SEND
SAVE
CANCEL
SEND OPTIONS
PREV. PAGE
NEXT PAGE

Tank

SPOT Report Movement Sub-Screen

UNIT

Tank
<Map Coordinates>

SIZE

Platoon

NATION-ALITY

Hostile

ACTION TAKEN

ACTION TAKEN

MOVE-MENT

SPEED

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

SEND

SAVE

CANCEL

SEND OPTIONS

PREV. PAGE

NEXT PAGE

Movement

Enter the angle of movement:

_45 deg.

DONE

RESET

CANCEL

SPOT Report Speed Sub-Screen

UNIT

Tank
<Map Coordinates>

SIZE

Platoon

NATION-
ALITY

Hostile

ACTION
TAKEN

ACTION
TAKEN

MOVE-
MENT

SPEED

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

Speed

Enter the speed of movement:

_100 km/h

DONE

RESET

CANCEL

SEND

SAVE

CANCEL

SEND
OPTIONS

PREV.
PAGE

NEXT
PAGE

FORT BLISS SOUTH.

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

Map Screen

Bumpcursor

Reports Screen

Voice PTT

Keyboard Setup
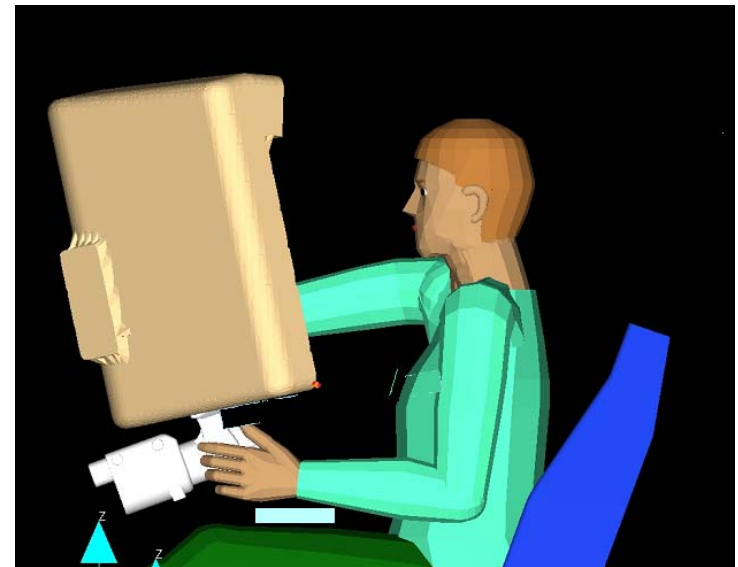
- General
    - Total of 23+ commands
    - 17 Spot Report specific commands
    - 5 Map specific commands
    - Placement of target location on map
    - 2 administrative commands for voice, keyboard and bumpcursor (setting screen display of interest)
- Keyboard/trackball
    - Trackball moves cursor 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

WMI Considerations for FCS
General Test Results

Technology	Strength	Weakness
Touch	Fast Intuitive Is faster, even after correcting errors	Least accurate No hand anchor More difficult on the move Lacks tactile feel
Trackball	Finest placement Can anchor hand to keyboard Worked well on all terrains	Slower execution time Tedious to manipulate
Voice	Eyes free for scanning Same across all terrains Effective at rest or on the move Permits multi-tasking	Slowest, waited for feedback Often repeated command Commands audible over intercom Required PTT action Premature release may cause error
Bump Cursor	Hand anchor Analog movement and selection	Poor implementation Not tested

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

- 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...