Tactical Decision Making Under Stress (TADMUS)

http://www-tadmus.spawar.navy.mil

Space and Naval Warfare Systems Center - San Diego (SPAWARSYSCENSD)

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Presentation Overview

◆ TADMUS Project History
  – Decision Support System 1
  – DEFTT Laboratory
  – DSS1 (Video)
  – Structured Interview / Fleet Perspective (Video)
  – DSS2 Description (Demonstration)

◆ Future Directions
  – TADMUS 2
  – Response Planner and Manager (RPM)
  – TADMUS to SEA (formerly Combat Enhancement through Integrated Decision Support)
  – Decision Centered Design
DEFTT TADMUS Laboratory Layout

Control/Observation Room

Main Room

Projector Room

TV

VCR

Building A33, Room 0418  Scale: 1" = ~4'

Unused Console
DEFTT Laboratory Resources

- Macintosh II fx
  - 14 inch monitor

- 486 Clone computer
  - 14 inch monitor

- HP 9000/835
  - 19 inch monitor

- 4 Channel Comm System

- Macintosh 840AV
  - 19 inch monitor

- 4 Channel Audio Communications Recording system

- 386 Clone computer
  - Macintosh 840AV
  - 17 inch monitor

- 386 Clone computer
  - Macintosh 860AV
  - 17 inch monitor

- 386 Clone computer
  - Macintosh 660AV
  - 17 inch monitor

- Macintosh PowerPC 8100
  - Two 19 inch monitors (touch screen)

- Macintosh PowerPC 8100
  - Two 19 inch monitors

- Pentium Clone

- AMPRO 3600 LSD System

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- Television/VHS VCR/8mm VCR

- 386 Clone computer
  - Macintosh 660AV
  - 17 inch monitor

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What TADMUS is ...

- An Office of Naval Research (ONR) 6.2 funded research program.
- A bridge between emerging cognitive theories / models and Navy C⁴I requirements.
- Development of Decision Support (SPAWARSYSCEN) and Training (NAWC-TSD) interventions to supplement & improve command decision making.
- Owned by the Navy - concepts available to transition at any time & at minimal cost.
- Transitioning to advanced development (6.3) and to hardware projects, e.g. Aegis Combat System.
What TADMUS is NOT …

◆ A program to reduce combat stress.

◆ Criticism of Aegis (or any other system).

◆ Decision making by computer.
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**Current Project Organization**

**ONR**
Gerald Malecki  
*maleckg@onr.navy.mil*

**SPAWARSYSCEN, San Diego**
Jeffrey Morrison  
*jmorris@spawar.navy.mil*

**Decision Support Products**
- Decision Support System (version 1)
- Decision Support System (version 2)
- Notional Threat Assessment displays
- Notional Threat Intent displays
- Notional Multi-platform decision support

**NAWC-TSD, Orlando**
Joan Johnston  
*joan_johnston@ntsc.navy.mil*

**Training Improvements**
- Team Dimensional Training
- Shipboard Instructor Training
- Team Leadership
- Stress Adaptation
- Critical Thinking
- Team Adaptation
Study command decision making & effects of environmental stressors: time compression & ambiguity.

Apply “Naturalistic” Decision Making Theory to CO & TAO team in CIC.

Develop interface & decision support concepts.

Develop a prototype interface & decision support system.
  - “Decision Support System” (DSS)

Test/validate principles experimentally in a tactical environment.
Project Team Expertise

◆ Operational Expertise
  – CO, NTU Cruiser; CO, Tactical Training Group Pacific; Commander & Chief of Staff, Carrier Group ONE
  – CO, Aegis Cruiser; CO, Tactical Training Group Pacific; Project Officer CINCPACFLT Littoral Study
  – CO, Fleet Combat Systems Training Unit Pacific; Officer In Charge, COMNAVSURFPAC Combat Systems Assessment Team; Combat Systems Officer, Afloat Training Group Pacific
  – Senior Electronic Warfare Operator/Technician; Master Training Specialist

◆ Research Expertise
  – Engineering Psychologist, 10+ Yrs experience: aviation, advanced automation, decision aiding, cognition, system engineering.
  – Engineering Psychologist, 20+ Yrs. experience: C4I, RDT&E, personnel selection & training, display design, cognition.

◆ Fleet Participation
Naturalistic Decision Making

- Experts make decisions differently from novices.
  - Experts use heuristics as decision making shortcuts.
    - Recognition-Primed Decision Making
    - Explanation-Based Reasoning
  - Heuristics lead to biases & can cause error.
    - Framing
    - Anchoring
    - Confirmation

- Stress Affects Performance.
  - Hypervigilance (Impulsive action)
  - Intolerance of ambiguity
  - Fixation on primary task / Tunnel vision
  - Less communicative
  - Short-term memory degradation
Decision Support System 1
Requirements & Features

- Designed as a flexible research tool.
  - Based on Cognitive Strategies used in tactical decision making.
  - Simple to learn & use.
  - Flexible Interface - Easy to modify.
  - Code readily transitionable.
  - Not intended for direct transition to shipboard applications.

- Designed to map identified decision making needs and cognitive theories to specific display modules.

- CO/TAO experimental support coordinated through CNSP staff (N812).
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DSS 1 Used as Supplement to Traditional Geo-Plot Display

Character Read Out (CRO) Display

Provides text track data on a single track

Numerous multi-function display controls

Track Priority List

<table>
<thead>
<tr>
<th>Track Type</th>
<th>Assessment</th>
<th>Big/Reg</th>
<th>Status</th>
<th>Next action</th>
<th>Last Alert</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>7013</td>
<td>La Combatte</td>
<td>Threat</td>
<td>070 / 15</td>
<td>CWS to Auto</td>
<td>Inside enemy weapon's range</td>
<td>04:40</td>
</tr>
<tr>
<td>7023</td>
<td>F-3</td>
<td>Threat</td>
<td>065 / 17</td>
<td>CWS to Auto</td>
<td>Inside enemy weapon's range</td>
<td>05:13</td>
</tr>
<tr>
<td>7001</td>
<td>Unknown</td>
<td>Threat</td>
<td>107 / 9</td>
<td>3rd Warning</td>
<td>Inside 35 km RFE limit</td>
<td>05:10</td>
</tr>
<tr>
<td>7020</td>
<td>Helicopter/Lt Air</td>
<td>Threat</td>
<td>045 / 3</td>
<td>2nd Warning</td>
<td>Change in DSS assessment</td>
<td>05:14</td>
</tr>
</tbody>
</table>
Traditional Geo-Plot Display

Character Read Out (CRO) Display Provides text-based kinematic & I.D. data on a single track

Numerous multi-function display controls
DSS1 Study

Are we on the right track with DSS?

◆ Objectives
  – Determine overall effects of DSS
  – Examine the use of DSS modules

◆ Research Questions
  – Situation Awareness
  – Communications
  – DSS Utility
  – DSS Usability
Do teams recognize more critical contacts when using DSS?

- More tracks of interest were reported at early and at middle probes.
- No difference at late. End-game more obvious.
- Most felt a positive effect of DSS. (5.78 of 7-points)
  
  "more confident of my grasp of the overall tactical picture and priority threats"

![Graph showing mean % Tracks of Interest](attachment:image.png)
Do teams take more of the required actions against threat tracks with DSS?

- Significantly more likely to take timely defensive measures.
  - Track Profile
  - Response Manager
- No difference in warnings and illuminations (provocative actions).

Note: Improved SA is reflected by taking less provocative actions earlier and more provocative actions later for a track.
When do teams take required actions against threat tracks?

First Warnings – Scenario D

<table>
<thead>
<tr>
<th>Aircraft</th>
<th>DSS</th>
<th>NoD</th>
<th>Time in Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-4 7012</td>
<td>*</td>
<td>*</td>
<td>14 12 10 8 6 4 2 0</td>
</tr>
<tr>
<td>Pumas 7013-5</td>
<td>*</td>
<td>*</td>
<td>14 12 10 8 6 4 2 0</td>
</tr>
<tr>
<td>Frelon 7016</td>
<td>*</td>
<td>*</td>
<td>14 12 10 8 6 4 2 0</td>
</tr>
<tr>
<td>Cessna 7022</td>
<td>*</td>
<td>*</td>
<td>14 12 10 8 6 4 2 0</td>
</tr>
</tbody>
</table>

* Team response

SME optimal response

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Would the DSS help prevent engagements with friendly and neutral tracks?

“More information would certainly help.”

“You can at least think about assumptions to check confidence in your assessment.”

“I’m reluctant to trust computers with these kinds of judgments.”

“You could ‘play with’ the evidence and assumptions to help reach a decision.”
Does DSS reduce workload?

- Significant reduction in workload for CO when using the DSS.
- Non-significant increase in workload for TAO with DSS.
- Large differences between teams.

![Bar chart showing mean % weighted TLX workload for CO and TAO with and without DSS.]
Analysis of transcribed voice communications required re-coding in terms of type and source.

<table>
<thead>
<tr>
<th>Message Type</th>
<th>Request</th>
<th>Reply</th>
<th>Provide</th>
<th>Acknowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Status</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clarification</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correlation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decision</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Order</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Did not code acknowledgments, problem control, reverberating orders, incomplete comms, and comms not involving CO / TAO.

Coded communications (52% of total comms) entered into MacSHAPA to support sequential communication analyses.
Does the rate of communications change when using DSS?

- Significantly fewer communications / min. overall with DSS (7.3 vs. 6.3).
  - Less need to exchange or verify data verbally

- Consistent effect for all originators of messages.

![Chart showing mean communication rate with and without DSS for different originators of communication (CO, TAO, Team, Ext).]
Does the team’s communication pattern change when using DSS?

- No significant change in team communication pattern with DSS.
  - 40% between CO & TAO
  - 35% between TAO & Team
  - less than 5% on other links

- Note well defined and highly practiced roles of team members.
Content Coding Categories

- **Information** – exchange of sensor-based data
- **Status** – exchange of procedure-based data
- **Correlation** – association of two or more data
- **Assessment** – discussion of expected track behavior, likely intent, or future actions
- **Orders** – commands to perform an action
- **Clarification** – efforts to elucidate, interpret, or correct other communications

Inter-rater reliability (3 raters): \( \kappa = .92 \)
A Glimpse Into DEFTT Lab Team Communications

- Most comms (30%) involve exchange of sensor data.
- About 20% of comms involve Clarifications.
- Remaining comms involve other issues related to track management.
- Results are relatively consistent across teams and scenarios.
How does DSS affect clarifying communications?

Mean % by Clarification Type

- Trk Location
- Kinematics
- EW Emitter
- Tactical Pic
- Track Status
- Ambiguous

[Bar chart showing comparison between No DSS and DSS for each clarification type]
Do more of the communications concern critical tracks when using DSS?

- Non-significant increase in comms about critical tracks with DSS.
  
  *However...*
  - expert tactical decision makers
  - limited DSS practice
  - highly structured roles of team members

- Notable differences across scenarios.
Other Analyses

- Timelines showing communication density.
- Duration / dwell sequences for tracks.
- Transition matrices of communication content and type for particular tracks and events.
- Sequential analysis of event-based communications.
DSS1 Study - Conclusions

- CO and TAO use the DSS frequently.
- DSS is considered useful and adds value.
- Fewer communications and fewer of certain types of clarifications with DSS.
- More of the critical contacts recognized earlier.
- More likely to take defensive measures.
- DSS is easy to understand and use.
- Many valuable suggestions for revising DSS.
CO/TAO Feedback

- DSS evaluation questionnaire.
  - Usage, utility, and usability ratings of modules
  - Overall assessment of DSS utility & usability

- Structured interview.
  - Comments about pros / cons of DSS overall
  - Suggestions for changes to the display & information
  - Reactions to incorporating DSS into ship CIC
Decision Support System (DSS-2)

- Revised display concepts based on the results from on-going research with DSS-1.
- Integrates Geo-plot from existing CIC into the DSS.
- Incorporates new concepts derived from emerging cognitive theories / models and needs expressed by Fleet operators.
- Currently working software.
- To be evaluated in simulations with revised scenarios.
- Potential application to TFCC.
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TADMUS DSS-2: CIC Conceptual Design

For additional information:

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E-Mail: jmorriso@spawar.navy.mil  E-Mail: ramoore@nosc.mil
Flag Briefings

- VADM Fargo, COMFIFTHFLT
- VADM Hancock, OPNAV(N4)
- VADM Krekich, COMNAVSURFPAC
- VADM Browne, COMTHIRDFLT
- VADM Lautenbacher, COMTHIRDFLT
- ADM Hogg, Director Strategic Studies Group
- RADM Wagner, SPAWAR
- RADM Nutwell, Deputy SPAWAR
- RADM Long, COMCRUDESGRU FIVE
- RADM Marfiak, COMCRUDESGRU FIVE
- RADM McGinn, OPNAV N88
ONR approved a 3-year 6.2 follow-on project starting FY97.

- Develop integrated training & decision support interventions (e.g. Wizards, Tutorials, embedded scenarios)
- Support SWOS PCO/PXO/Department Head tactical decision making requirements
  » Delivering DSS for scenario support and staff/student evaluation
- Extend DSS to other AW positions within CIC (AWC, TIC, EW)
- Extend DSS to other warfare areas in CIC (SUW, USW)
- Apply emerging Decision making theories to CIC problems
- Develop improved metrics / methodologies for measuring tactical decision making (e.g. real-time performance assessment, eye movement, communication analyses, etc.)
Response Planner & Manager Project (RPM)

- Customer: U.S. Navy (Battlegroup)
- Objectives:
  - Analyze and develop cognitive models of military tactical planners & planning process.
  - Develop customized interfaces to:
    - perform pre-deployment planning and real-time re-planning of battle force assets (*author and tailor specific action plans*)
    - perform tactical resource/response management based on established plans (*plan execution and monitoring*)
- Status: Funded as FY97, 3-Yr., 6.2 HF Task.
- P.O.C.: George E. Seymour; Code D44210, (619) 553-8008
- Relationship:
  - Inspired by TADMUS DSS Response Manager & Collaborative planning needs. Marines looking for similar tools.
  - Planning *and* Execution decision modeling.
TADMUS to SEA

◆ Customer: U.S. Navy (COMTHIRDFLT, PMS 400/AEGIS)

◆ Objectives:
  – Develop Tactical Fleet Command Center DSS application.
  – Mature underlying DSS algorithms / databases.
  – “DSS@Sea” shipboard evaluation.
  – Integrate decision support concepts into JMCIS

◆ Status: Funded as FY97, 4-Yr., 6.3 Human Factors Task

  – Develop mature components of TADMUS DSS & build into Aegis.

◆ Relationship:
  – Responding to Fleet requests to implement DSS onboard ship & extend DSS to battle group command level.
  – Leveraged off on-going TADMUS 6.2.
Command 21 - Decision Centered Design (DCD) Initiative

- **Sponsor:** U.S. Navy (N6M) - 6.4 funded.

- **Objectives:**
  - Develop DCD process for use across Fleet.
  - Develop DCD laboratory and expertise.
  - Perform Cognitive Task Analyses on AADC, CJTF, CVBF.
  - Develop decision support concepts for various Joint / Fleet Applications.
  - Integrate decision support concepts with C4I architecture.

- **Status:** Funded as FY98, 4-Yr., 6.4 Task

- **P.O.C.:** J.Morrison, Ph.D.; SPAWARSYSCEN Code D44210.
  (619) 553-9070

- **Relationship:**
  - Responding to Fleet reduced manning initiatives.
  - Leveraged off on-going TADMUS 6.2 / 6.3.
Conclusion

TADMUS

Decision support concepts for tactical decision makers which are:

Theoretically derived,
Empirically tested,
Fleet Validated.