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| 4. TITLE AND SUBTITLE<br><br>DOD Training Technology Technical Group (T2TG)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                 |                                                                | 5. FUNDING NUMBERS<br><br>PE- 62717A<br>PR- A791<br>TA- 3103<br>WU- M01 |  |
| 6. AUTHOR(S)<br><br>Dr. Robert J. Seidel                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                 |                                                                |                                                                         |  |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)<br>U.S. Army Research Institute<br>5001 Eisenhower Avenue<br>ATTN: PERI-II<br>Alexandria, VA 22333-5600                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                 |                                                                | 8. PERFORMING ORGANIZATION<br>REPORT NUMBER<br><br>N/A                  |  |
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| 13. ABSTRACT (Maximum 200 words)<br>The sixth meeting of T2TG was held on 24-25 Mar 92, at Phoenix AZ. It was hosted by Armstrong Laboratory Williams AFB. Dr. William Howell, AL/HRD spoke about situational awareness as it relates to aircrew performance. Mr. Denis Breglia, NTSC, described issues surrounding development and use of virtual environments as training technologies. Dr. Michael Drillings, USARI, discussed findings of ARI sponsored National Research Council reports on value of "non-mainstream" training techniques for US Army training. Training Technology demonstrations at Williams Air Force Base, Armstrong Laboratory included night vision devices, MULTIRAD (simulator) and visual color modeling. During the Steering Committee meeting it was decided that we should encourage our respective laboratories to view T2TG as a mechanism for implementing TAPSTEM. Changes in the chairmanships of subgroups will take place next year: the Navy taking over Advanced Technologies, and the Army assuming chairmanship of the Crew, Group and Unit subgroups. In addition, the chair of the Steering Committee will rotate from the Army to the Navy following next year's meeting. |                                                                 |                                                                |                                                                         |  |
| 14. SUBJECT TERMS<br><br>Situational awareness, development and use of virtual environments, non-mainstream training techniques                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                 |                                                                | 15. NUMBER OF PAGES<br>362                                              |  |
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## DOD Training Technology Technical Group (T2TG) Minutes

The sixth meeting of the DOD Training Technology Technical Group (T2TG) was held on 24-25 March 1992, at Phoenix Arizona. It was hosted by Armstrong Laboratory, Williams Air Force Base.

There were three keynote presenters. Dr. William Howell, AL/HRD spoke about situational awareness as it relates to aircrew performance. Mr. Denis Breglia, NTSC, described the issues surrounding the development and use of virtual environments as training technologies. Dr. Michael Drillings, of the Basic Research Office, USARI, discussed the findings of ARI sponsored National Research Council reports on the value of "non-mainstream" training techniques for U.S. Army training. Training Technology demonstrations at Williams Air Force Base, Armstrong Laboratory included night vision devices, MULTIRAD (simulator), and visual color modeling.

During the Steering Committee meeting, it was decided that we should encourage our respective laboratories to view T2TG as a mechanism for implementing TAPSTEM. Changes in the chairmanships of subgroups will take place next year: the Navy taking over Advanced Technologies, and the Army assuming chairmanship of the Crew, Group, and Unit subgroups. In addition, the chair of the Steering Committee will rotate from the Army to the Navy following next year's meeting.

The next meeting is scheduled for 4-5 May 1993. It will be hosted by the Army Research Institute in Orlando, Florida.

The following pages provide the agenda, subgroup summaries, hardcopies of the viewgraphs, and the list of attendees.



**ROBERT J. SEIDEL, Ph.D.**  
Chief, Automated Instructional Systems,  
U.S. Army Research Institute  
Chair, T2TG

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## **AGENDA**

### **6th DoD TRAINING TECHNOLOGY TECHNICAL GROUP**

**24-25 March 1992**

#### **TUESDAY, 24 MARCH 1992**

**0700 - 0800 Registration/Fees**

#### **PLENARY SESSION I**

**0800 - 0810 Commander's Welcome  
(Lt Col Lynn Carroll)**

**0810 Aircrew Training Research Division Overview**

**0830 Administrative Support Announcements  
(Ms Linda Swan)**

**0845 - 0900 Introduction of Invited Speakers  
(Dr Bob Seidel, ARI)**

**0900 - 0940 Situational Awareness  
(Dr William Howell, HR Directorate Armstrong Laboratory)**

**0940 - 1020 Enhancing Human Performance  
(Dr Michael Drillings, ARI)**

**1020 - 1050 Coffee Break**

**1050 - 1130 Virtual Environments  
(Mr. Denis Breglia, NTSC)**

**1130 - 1300 LUNCH**

#### **SUBGROUP SESSION I**

##### **Advanced Training Technology**

**Introduction and Administrative Issues Subgroup Theme:  
Simulator, Simulations and "Virtual Reality"**

**Enhancing Aircrew Training Through Virtual Environment  
Research (Dr. Richard Thurman, USAF AL/HRAU)**

**Research on the Use of Virtual Environments in Crisis  
Management in the Navy (Ms. Janet Dickieson, NPRDC)**

**Behavioral Requirements for Training in Virtual  
Environments (Dr Bruce Knerr, USARI)**



**Crew, Group, Team, and Unit Technology Sub-Group**

**Opening Remarks**

**Joint Collective Training R&D Effort**

- Dr Frank Moses, ARI
- Dr Eduardo Salas, NTSC
- Discussion (All)

**Training Design & Evaluation**

**Welcome and Administrative Issues**

**Training Needs and Evaluation Issues**

- Identifying Over-and-Under-Trained Tasks (Ms Morales)
- Opportunities to Perform Trained Tasks (Dr Mark Teachout)

**Roundtable Discussion (ALL)**

1600 Adjourn from Subgroup Location

1700 - 1900 No Host Bar with Heavy Hors d'Oeuvres - Resort's Lounge

**WEDNESDAY, 25 MARCH 1992**

**SUBGROUP SESSION II**

**Advanced Training Technology**

**Visual Learning in Virtual Environment (Dr J. Psotka, ARI)**

**Summary and Conclusions of Virtual Reality in Training Research in the Services or "What are the Research Issues in the use of Virtual Reality in Training?"**

**Roundtable Discussion**

**Crew, Group and Unit Training**

**Aircrew Coordination Training R&D**

- Dr David Baker, NTSC
- Mr Randall Oser, NTSC
- Major Wes Woodruff, USAF, NTSC
- Discussion (All)

**Training Design and Evaluation**

**Instructional, Planning and Evaluation Issues**

- Modeling Skill Acquisition (Dr Sabol)
- Retention of Knowledge Learned in College (Dr Ellis)

**Roundtable Discussion (ALL)**

0945 - 1000 BREAK

**SUBGROUP SESSION III**

**Advanced Training Technology**

Basic Job Skills Job Family Tutor  
(Dr Ellen Hall, USAF-AL/HRMJC)

Issues in Designing and Intelligent, NLP-based Tutor for  
Foreign Languages (Dr Michelle Sams, USARI)

Summary and Conclusions

**Crew, Group and Unit Training**

Update of AF ISD Process  
- Major Conrad Bills, ASD/YTEE

Team Decision-Making Training (Update)  
- Eduardo Salas

Discussion (All)  
- Next Meeting  
- Topics  
- Format  
- Product(s)

**Training Design and Evaluation**

Instructional, Planning and Evaluation Issues  
- Instructional Strategies for Logistic Command and  
Control (Captain Hioki)  
- Distance Learning (Mr Gettman)

Roundtable Discussion (ALL)

1145 - 1245 LUNCH

1245 Bus departs Conference Center

1300 Arrival Williams Air Force Base, Armstrong Laboratory

1300 - 1500 DEMONSTRATIONS

| <u>GROUP 1</u> | <u>DEMOS</u>                                  | <u>GROUP 2</u> |
|----------------|-----------------------------------------------|----------------|
| 1305 - 1325    | Night Vision Devices & Training<br>(Bldg 558) | 1435 - 1500    |
| 1335 - 1400    | MULTIRAD<br>(Bldg 561)                        | 1405 - 1425    |
| 1435 - 1500    | Visual Systems Color Modeling<br>(Bldg 558)   | 1305 - 1325    |
| 1510           | Bus departs Williams Air Force Base           |                |
| 1525           | Arrival Conference Center                     |                |
| 1530 - 1630    | Wrap-Up                                       |                |

**PLENARY SESSION I**

DR. WILLIAM HOWELL

HR Directorate Armstrong Laboratory

# SITUATIONAL AWARENESS



DR WILLIAM C. HOWELL  
HUMAN RESOURCES DIRECTORATE  
ARMSTRONG LABORATORY

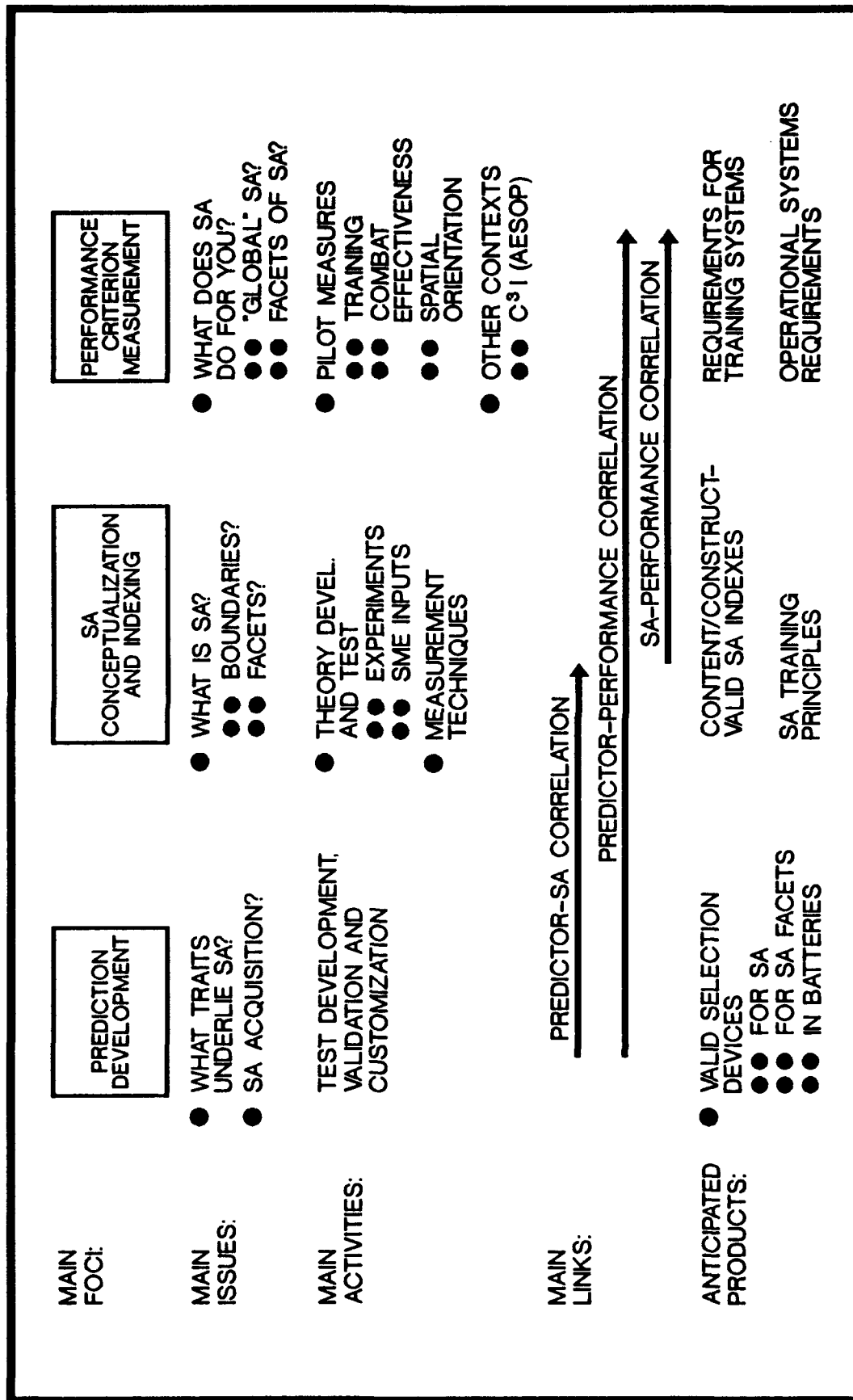


# OVERVIEW

- WHY SA BECOME HOT ISSUE
  - WHY DON'T HAVE HANDLE ON IT
  - WHY COULD BE USEFUL IF DID
- WHAT THE LITERATURE TELLS US
  - THEORETICAL ISSUES
  - MEASUREMENT ISSUES
  - RESEARCH ISSUES
- WHAT AF IS DOING
  - SAINT INITIATIVE (NOW)
  - AFOSR 6.1 INITIATIVE (FY94)
- SUMMARY



# COORDINATED ATTACK ON SA



HOWELL



## BACKGROUND

DEFINITION OF SA:  
"MILITARY OPERATORS' KNOWLEDGE OF IMMEDIATE  
TACTICAL SITUATION."

--Sarter & Woods, 1991

### OPERATIONAL PROBLEM

- INCREASING INFORMATION-PROCESSING DEMANDS  
(COCKPIT & ELSEWHERE)
- MISHAP ATTRIBUTION (80% OF OPS CLASS A)
- AIR STAFF CONCERNS (PAT)
- FRAGMENTATION OF KNOWLEDGE; LIMITED  
SUCCESS OF INTERVENTIONS

CONCLUSION: NEED EXISTS, AS DOES POTENTIAL  
FOR SIGNIFICANT R&D CONTRIBUTION





## BACKGROUND (Cont.)

### RESEARCH PROBLEM

- HARD TO DEFINE SA PRECISELY
  - STRONG, YET DIFFERENT OPINIONS ON MEANING
  - EVIDENCE SUGGESTS MULTIFACETED CONSTRUCT
- HARD TO MEASURE RELIABLY
  - 3 MAIN APPROACHES, EACH LIMITED
    1. EXPLICIT KNOWLEDGE PROBES
    2. IMPLICIT MEASURES
    3. SUBJECTIVE RATINGS
- R&D EFFORTS TEND TO BE FRACTIONATED

CONCLUSION: NEED FOR AN INTEGRATED ATTACK AT  
SEVERAL LEVELS (BASIC SCIENCE --  
APPLICATION)

**Table 1**  
**Characteristics of Pilot Situation Awareness**

| Situation          | Situation Components              | Benefits of Awareness                                        | Mission Categories                                               | External Information Sources                                   | Novice                                                   | Expert                                    |
|--------------------|-----------------------------------|--------------------------------------------------------------|------------------------------------------------------------------|----------------------------------------------------------------|----------------------------------------------------------|-------------------------------------------|
| <b>Routine</b>     | Spatial orientation               | Mid-air collision avoidance                                  | Local navigation, guidance and control                           | Sensory information from the environment                       | Expending unnecessary effort                             | Utilizing non-competing resources         |
|                    | Environment                       | Terrain avoidance                                            |                                                                  |                                                                | Not perceiving patterns                                  | Multiplexing                              |
|                    | Routine goals                     | Robust decision making in the face of:                       | Communication outside the cockpit                                | Cockpit visual and auditory displays                           |                                                          | Shortening transmissions                  |
|                    | Procedures for attaining goals    |                                                              | Flight crew resource management                                  | Extra- and intra-aircraft communication                        |                                                          | Converting interference                   |
|                    | Aircraft system status            | Turbulence<br>Cross winds<br>Windshear<br>Loss of visibility | Cabin management                                                 | Recorded flight plans                                          |                                                          | Chunking                                  |
|                    | Aircraft performance              |                                                              | Routine management of physical equipment, resources, and systems | Flight management computer                                     |                                                          |                                           |
|                    | Crew responsibilities & knowledge |                                                              | Routine management of FMC and related crew aiding systems        | Flight manuals and checklists<br><br>Future 3D navigation aids |                                                          |                                           |
|                    |                                   |                                                              | Bridging activities                                              |                                                                |                                                          |                                           |
| <b>Non-Routine</b> | Special constraints               | Improved decision making in the face of:                     | Macro-planning & navigation                                      | Future route diversion aids                                    | Making last minute plans during high workload            | Shedding, delaying, and pre-loading tasks |
|                    | Contingency plans                 | Go around<br>Weather rerouting                               |                                                                  |                                                                |                                                          |                                           |
| <b>Emergency</b>   | Unusual symptoms                  | Improved fault management                                    | Diagnosis of physical equipment, resources, and systems          | Future fault finding aids                                      | Fixating on one or two salient possibilities             | Letting go of high workload strategies    |
|                    | Trouble-shooting techniques       |                                                              |                                                                  |                                                                | Ignoring vital flight information while trouble-shooting |                                           |
|                    | Emergency procedures              |                                                              | Diagnosis of FMC & related crew-aiding systems                   |                                                                |                                                          |                                           |

**Note:** The rows are cumulative. In other words, the entries for emergency situations include all the entries for routine and non-routine situations.

# CURRENT PERSPECTIVES





# THEORETICAL ISSUES

- 1 CONSTRUCT OR MANY? (SARTER & WOODS, OTHERS)
  - SPATIAL ORIENTATION
  - GEOGRAPHICAL SA
  - TACTICAL SA
    - IDENTITY (THREATS)
    - RESPONSIBILITY
    - TEMPORAL



## THEORETICAL ISSUES (CONT.)

- PROCESS (ENDSLEY)
  - LEVEL I (PERCEPTION OF SIT ELEMENTS)
  - LEVEL II (INFORMATION INTEGRATION)
  - LEVEL III (PROJECTION OF FUTURE STATES)
- COGNITIVE UNDERPINNINGS? (FRACKER, BBN)
  - RELATION TO COGNITIVE MODELS, CONSTRUCTS
    - TOP-DOWN (KNOWLEDGE, RULE, SKILL DRIVEN)
    - BOTTOM-UP (DATA DRIVEN)
- INDIVIDUAL DIFFERENCES? TRAINABILITY?



# MEASUREMENT ISSUES

## (FRACKER, SARTER & WOODS)

- KINDS OF MEASURES
  - EXPLICIT (SELF-REPORT) -- MEMORY, CONSCIOUS
    - REFLECTIVE
    - IMMEDIATE (SAGAT)
  - SUBJECTIVE (RATING) -- DEFINED BY SCALES
  - IMPLICIT (INFERRED) -- PERFORMANCE BASED
    - TSD (ENVELOPE SENSITIVITY)
    - EXPERT SYSTEMS (MODEL COMPARISON)
- QUALITY OF MEASURES (PSYCHOMETRIC)
  - FRACKER'S WORK

# Tentative Conclusions

**RELIABILITY**      **CONTENT**      **CRITERION**      **CONSTRUCT**  
 ..... **VALIDITY**

| <b>EXPLICIT</b>      |           |         |          |           |
|----------------------|-----------|---------|----------|-----------|
| <b>Memory Probes</b> | Variable  | Limited | Moderate | Uncertain |
| <b>IMPLICIT</b>      |           |         |          |           |
| <b>Sensitivity</b>   | Moderate  | Limited | Unknown  | Moderate  |
| <b>SUBJECTIVE</b>    |           |         |          |           |
| <b>HiRes</b>         | Uncertain | Limited | Poor     | Uncertain |



# RESEARCH STRATEGIES

- MEASURE EXPLICITLY AS F OF SYSTEM MANIPULATION
  - NARROW FOCUS (STATIC, CONSCIOUS CONTENT)
- APPLY PRINCIPLES IN SELECTION, TRAINING ETC. AND MEASURE PERFORMANCE (IMPLICIT)
  - IS SA RESPONSIBLE?
- USE EXPERTS TO DEVELOP MODELS OF COMPLEX SCENARIOS (e.g. AIR COMBAT); TEST VS PERFORMANCE; REFINE.
  - SITUATION SPECIFIC?
- MULTIPLE MEASURES; CONVERGE ON CONSTRUCTS
  - PRIMARILY SUGGESTION



# AF INITIATIVES





# AL-WIDE CRASH PROGRAM (1 YEAR)

- "SAINT" TEAM FORMED
- WORKING DEFINITION

"A PILOT'S CONTINUOUS PERCEPTION OF SELF AND A1C IN RELATION TO THE DYNAMIC ENVIRONMENT OF FLIGHT, THREATS, AND MISSION, AND THE ABILITY TO FORECAST, THEN EXECUTE TASKS BASED ON THE PERCEPTION"

- OBJECTIVES
  - DEVELOP MEASURES FOR VISUALLY-GUIDED AIR-AIR COMBAT
  - IDENTIFY PRELIM. SELECTION TOOLS (ASSUMES APTITUDE/SKILL)
  - IDENTIFY PRELIM. TRAINING TOOLS (ASSUMES TRAINABLE SKILL)

**3.1.1 Dr Grant McMillan (AL/CFIIP). Serves as project leader and responsible for overall execution of the study.**

**3.1.2 Lt Col Jim Bushman (AL/CCE). Assists Dr McMillan in management and execution of the study.**

**3.1.3 Maj David Perry (AL/IIRMAA). Responsible for development, test, and evaluation of the SAAB. Responsible for overall analyses of the study.**

**3.1.4 Dr Wayne Waag (AL/IIRAT). Responsible for development, test, and evaluation of the SA Rating Scale. Assists in overall study analyses.**

**3.1.5 Dr Mike Vidulich (AL/CFIIP). Responsible for identification of the cognitive and performance components of SA. Advises on the development of the SAAB and the SA Rating Scale.**

**3.1.6 Dr Sam Schiflett (AL/CFTO). Advises on the development of the SAAB and SA Rating Scale.**

**3.1.7 Maj Glen Larsen (USAFSAM/FP). Consultant to overall study.**

**3.1.8 Lt Col Tim Kinney (WL/FIP). Joint Cockpit Office representative. Serves as consultant to overall study.**



# RESEARCH PLAN

- CONCURRENT DEVELOPMENT OF
  - THEORY-DRIVEN (COGNITIVE) SA APTITUDE TEST BATTERY
  - EXPERT-DRIVEN (BEHAVIORAL) CRITERION--BARS
- VALIDATION IN AIR-COMBAT SIMULATOR USING SELECTED SCENARIOS AND PILOTS

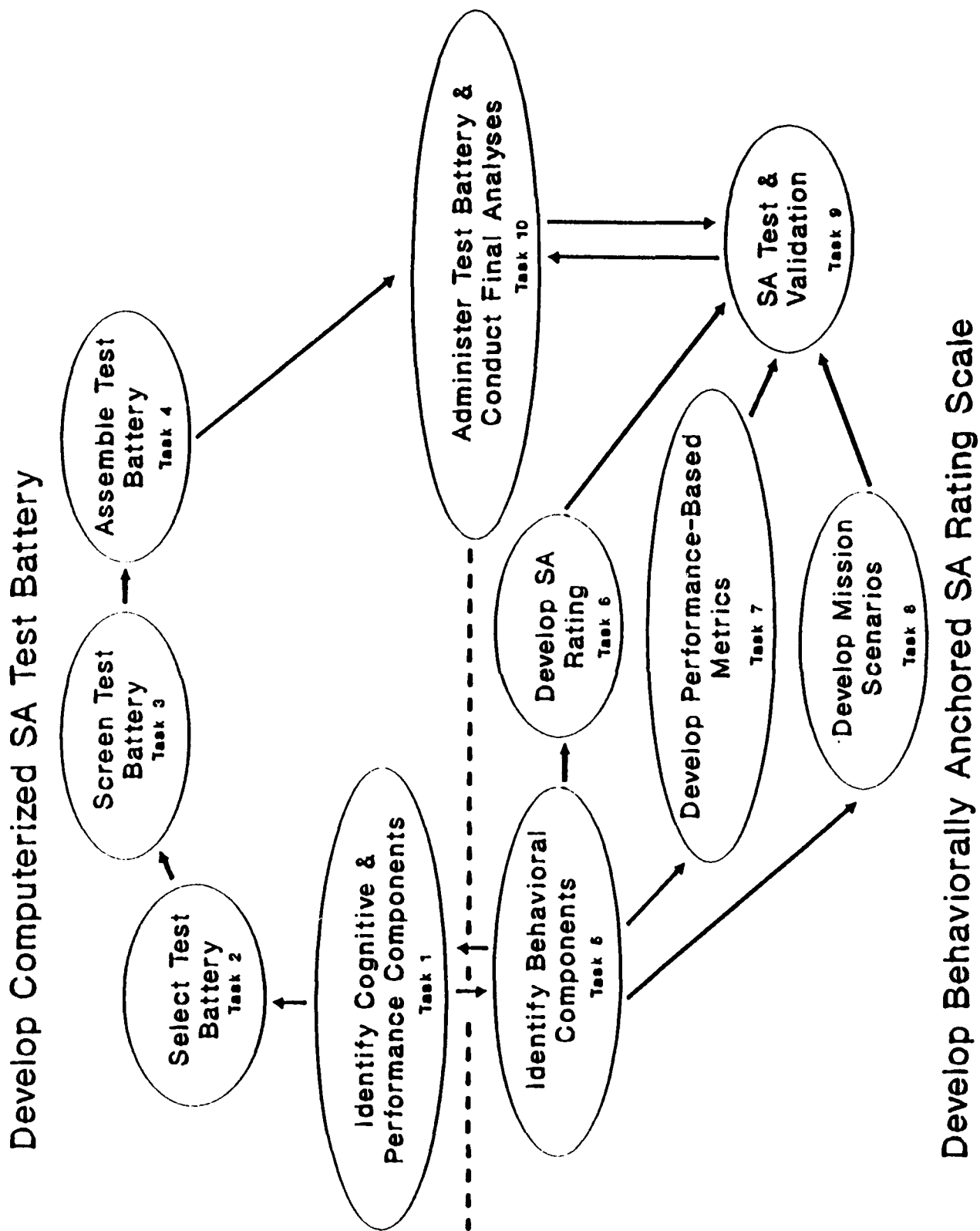


Figure 1. SAINT Research Plan



## AFOSR 6.1 TEAM SA INITIATIVE

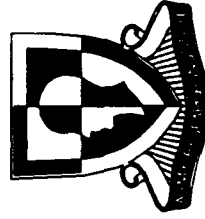
- EXPLORE GROUP PROCESSES IN TEAM PERFORMANCE
  - SHARED AND INDIVIDUAL SA
  - HOW DO YOU PROMOTE?
    - COMMUNICATION ISSUES
    - "GROUPWARE" ISSUES
    - GROUP STRUCTURE/PROCESS ISSUES
    - LEADERSHIP, TRAINING ISSUES

DR. MICHAEL DRILLINGS

U.S. Army Basic Research Office  
5001 Eisenhower Ave, Alexandria, VA

**REPORTS OF THE  
COMMITTEE ON TECHNIQUES FOR THE  
ENHANCEMENT OF HUMAN PERFORMANCE**

**U.S. Army Research Institute  
Basic Research Office**



**Michael Drillings**  
*(703) 274-5572; DSN 284-5572*



# ENHANCING HUMAN PERFORMANCE

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- Commissioned by the Army Research Institute
- Performed by the National Research Council
- Major Reports of Phases I & II are:

Druckman, D. & Swets, J. A., eds. 1988. Enhancing Human Performance: Issues, Theories, and Techniques. Washington: National Academy Press.

Druckman, D. & Bjork, R. A., eds. 1991. In the Mind's Eye: Enhancing Human Performance. Washington: National Academy Press.

# **ENHANCING HUMAN PERFORMANCE**

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## **PHASE I OBJECTIVES:**

- **Evaluate Selected, Non-Mainstream Techniques**
- **Provide an Authoritative Assessment of These Techniques for Policymakers in R&D**
- **Consider the Use of the Techniques in Army Training**
- **Develop Appropriate Criteria for Evaluating Claims**
- **Recommend Research to Better Understand Performance Enhancement**

# ENHANCING HUMAN PERFORMANCE

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## **"EVALUATING HUMAN TECHNOLOGIES..."**

**HEGGE, TYNER, AND GENSER (1983)**

- **Effects of Technique**
- **Evidence for Claims**
- **Theoretical Support**
- **Who will be able to use**
- **Implications for Army Operations**
- **Army Philosophy**
- **Cost — Benefit Factors**

# **ENHANCING HUMAN PERFORMANCE**

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## **Learning During Sleep**

- **No Evidence During Verified Sleep**
- **May be Some Effects During Light Sleep**
- **May be Relevant to State-Dependent Learning and Retention**
- **May be Cost-Effective for Additive Training**
- **Deserves More Research**

# **ENHANCING HUMAN PERFORMANCE**

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## **Accelerated Learning**

- **Systems Approach is Warranted**
- **No evidence of "Non-Mainstream" effects**
- **Greater Application Possible in Army**

## **Mental Practice**

- **Is Effective, But Not in Place of Physical Practice**
- **Attentional Control & Visual Concentration Training not Proven**
- **Sybervision™ Not Proven**
- **Biofeedback Not Proven**

# **ENHANCING HUMAN PERFORMANCE**

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## **Altering Mental States**

- **No Evidence for Hemispheric Effects on Performance**
- **No Evidence for Hemi-Sync<sup>tm</sup>**
- **Is There an Optimal Level of Arousal?**
- **Hypnosis and Meditation Should be Investigated**
- **No Validated Measures of Hemisphericity**

# ENHANCING HUMAN PERFORMANCE

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## Stress Management

- Relaxation Training — Effective
- Biofeedback — Limited Utility
- Cognitive Restructuring — Effective
- Behavioral Skills Training — Effective
- Relevance to Military Situation
- Societal Issues

# **ENHANCING HUMAN PERFORMANCE**

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## **Influence Strategies**

- **No Evidence for Effect of Neurolinguistic Programming**
- **Social Psych Literature Could be Basis for Techniques for Training to Influence Soldiers**

## **Group Cohesion**

- **Lack of Studies Linking Cohesion & Performance**
- **There may be some Negative Effects**



# **ENHANCING HUMAN PERFORMANCE**

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## **Parapsychology**

- **Evidence does not Justify Optimism**
- **Remote Viewing and Ganzeld Experiments are Flawed**
- **Psychokinesis Effects are Extremely Small and the Research is also Flawed**
- **Recommends a Common Protocol for Experimentation**

# **ENHANCING HUMAN PERFORMANCE**

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## **PHASE II OBJECTIVES:**

- **Address Broad Theoretical Principles Underlying Training Program**
- **More Basic Issues of Performance**

# ENHANCING HUMAN PERFORMANCE

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## Long-Term Retention & Transfer

- **Maximum Performance at End of Training May be Sub-Optimal for Long-Term Performance**
- **Increased Retention:**
  - **Increased Original Learning, Varying Learning Conditions, Develop Automaticity, Build in Environmental Cues, Mnemonics, Elaboration, Distributing Practice, Cooperative Learning, Doing, Testing, Part-Task Training**
- **Increased Transfer:**
  - **Contextual Interference During Training, Variety in Training, Reducing Feedback**

# **ENHANCING HUMAN PERFORMANCE**

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## **Modeling Expertise**

- **Is the Expert-Modeling Component the Most Critical?**
- **Problem for Modeler**
- **Problem for Learner**
- **Role of Explanation**
- **Role of Domain Knowledge**
- **Unproven, Except for Basic Skills**

# ENHANCING HUMAN PERFORMANCE

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## Developing Careers

### Myers-Briggs Type Indicator:

- Unsited for Self-Assessment
  - Reliability
  - Construct Validity
  - Predicting Validity
  - Discrimination Between Occupations

# **ENHANCING HUMAN PERFORMANCE**

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## **Subliminal Self-Help**

- **No Evidence that it is Effective**
- **No Reason to Believe That it could be**

## **Meditation**

- **No "Special" Effect**
- **Epistemological Note**
- **Other Evidence**

# **ENHANCING HUMAN PERFORMANCE**

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## **Optimizing Individual Performance**

- **Relaxation, Imagery, Mental Preparation Strategies, Skill Development Strategies, and Coping Produce Small to Moderate Improvements in Motor Performance in Less than Elite Performers.**
- **Preperformance Routines Seem to be Effective.**
- **Aerobic Exercise Helps People to Cope Better with Psychosocial Stressors.**
- **Neuropsychological Advances are Promising.**

# **ENHANCING HUMAN PERFORMANCE**

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## **Team Performance**

- **Research on Group Structure and Functions is Lacking**
- **Groups Should be Stratified for Military Relevance**
- **Difficult to Generalize Results from Real Groups**
- **What is Optimal Division of Training Between Team and Individual Skills?**



# **ENHANCING HUMAN PERFORMANCE**

---

## **PHASE III OBJECTIVE:**

- **Look More at Army Training Environment**

## **Candidate Topics:**

- **Hypnotic Augmentation of Performance**
- **Situated Learning**
- **Motivation**
- **Sensory Transformation**

**MR. DENIS BREGLIA**

**Naval Training Systems Center, Code 251  
Orlando, Florida**

# **VIRTUAL ENVIRONMENT TRAINING TECHNOLOGY**

# **VET**

**Denis R. Breglia  
Simulation Imagery Branch  
Naval Training Systems Center**



# VE TECHNOLOGY

A communication medium which facilitates natural, high efficiency interaction between a user and a computer generated environment

# VE FEATURES

**Efficient**

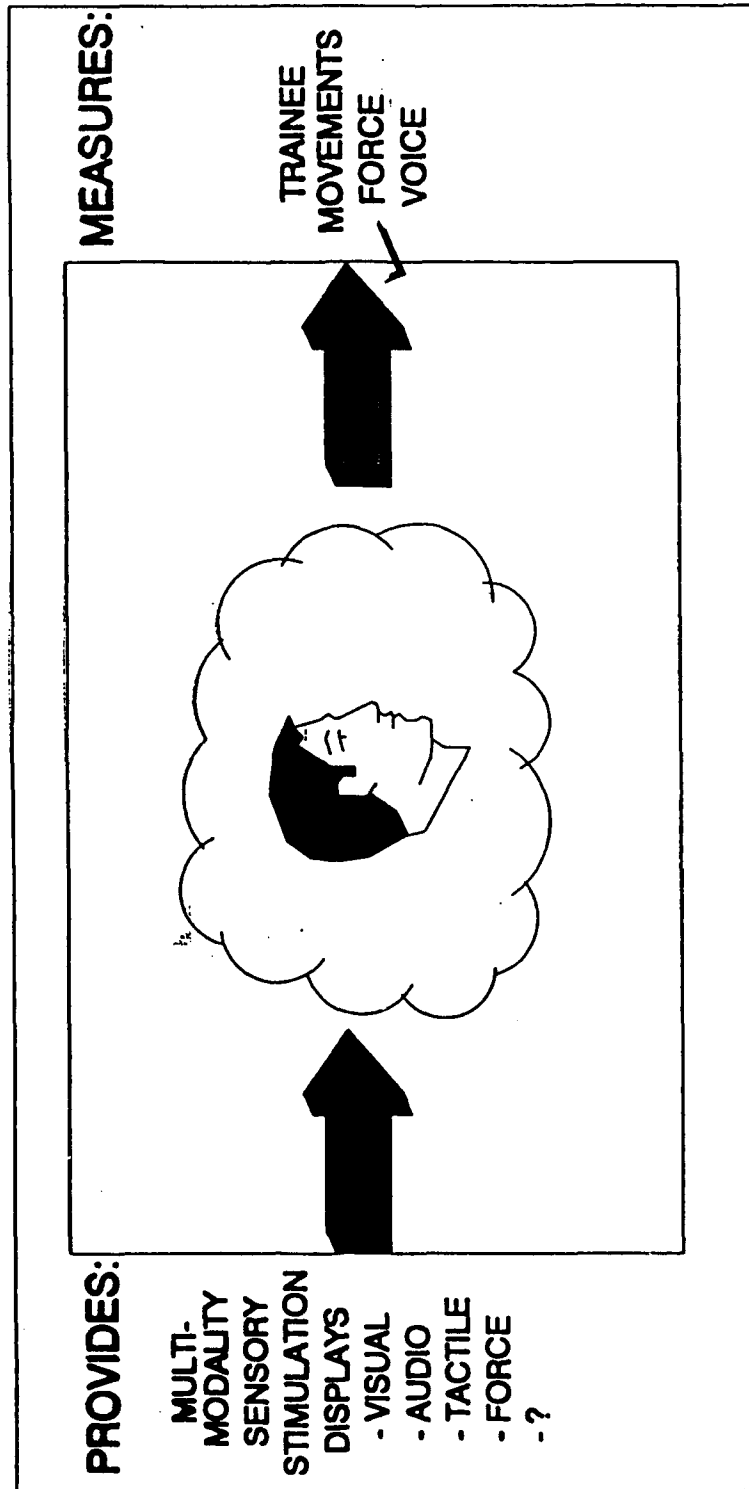
**Flexible**

**Multimodal**

**Three-dimensional**

**Interactive**

# VIRTUAL ENVIRONMENT



# VE APPLICATIONS

COMMUNICATION

TELEOPERATION

EDUCATION

RECREATION

DESIGN

VISUALIZATION

PROGRAMMING

DECORATING

SHOPPING

ENTERTAINMENT

MEDICAL

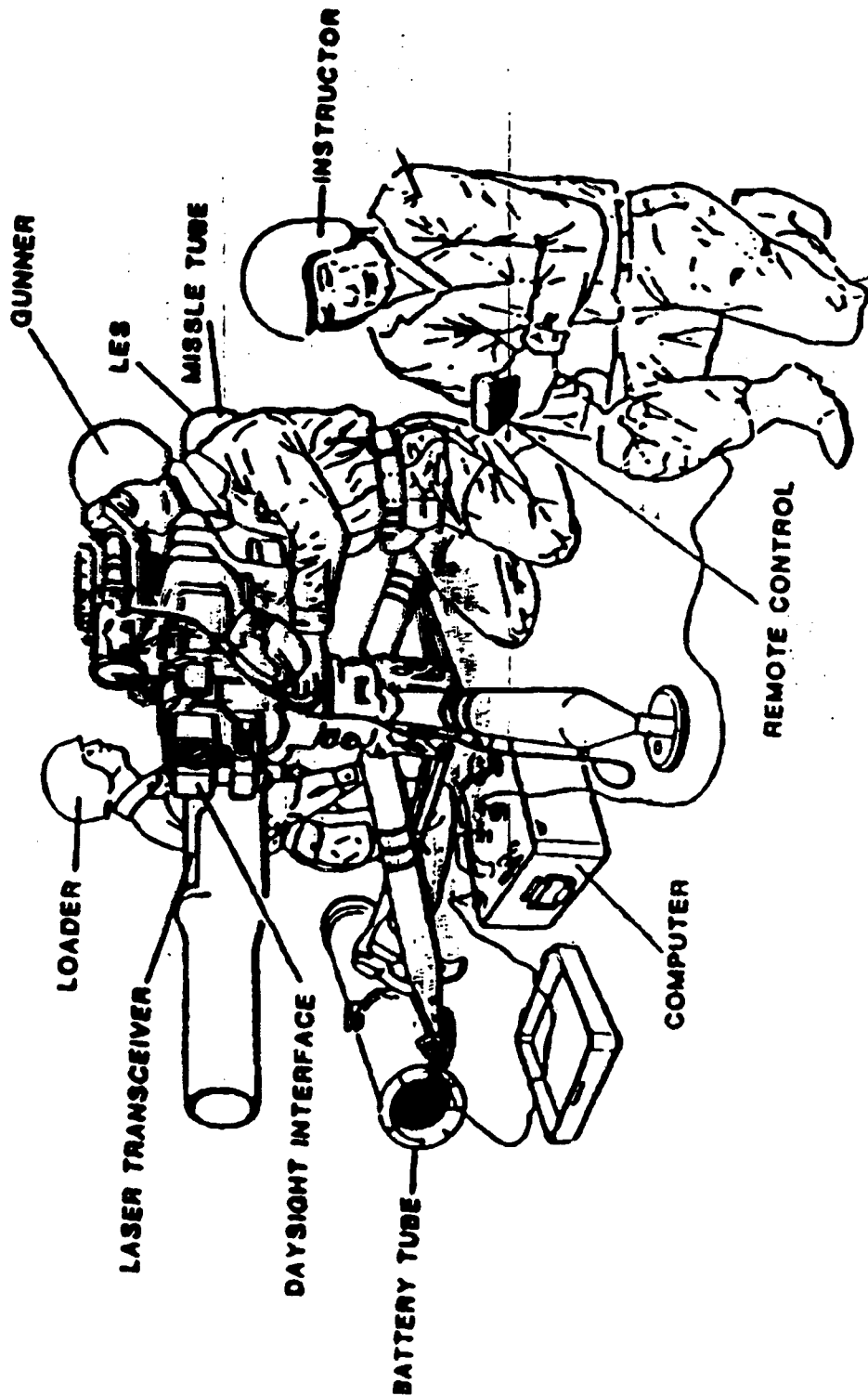
& TRAINING !



# **CHALLENGES FACING MILITARY TRAINING**

- **DECREASING ECONOMIC RESOURCES**
- **INCREASING COMPLEXITY OF TASKS**
- **INCREASING COSTS OF INSTRUCTIONAL PERSONNEL**
- **DECREASING AVAILABILITY OF RANGES**
- **INCREASING UTILIZATION OF RESERVES** ✓
- **INCREASING COSTS OF TRAINING TDY**
- **DECREASING AVAILABILITY OF SCHOOLHOUSES**
- **INCREASING NEED FOR TEAM TRAINING**
- **CHANGING ROLE OF MILITARY**

Anti-Tank Weapon  
Precision Gunnery Training  
System (PGTS)

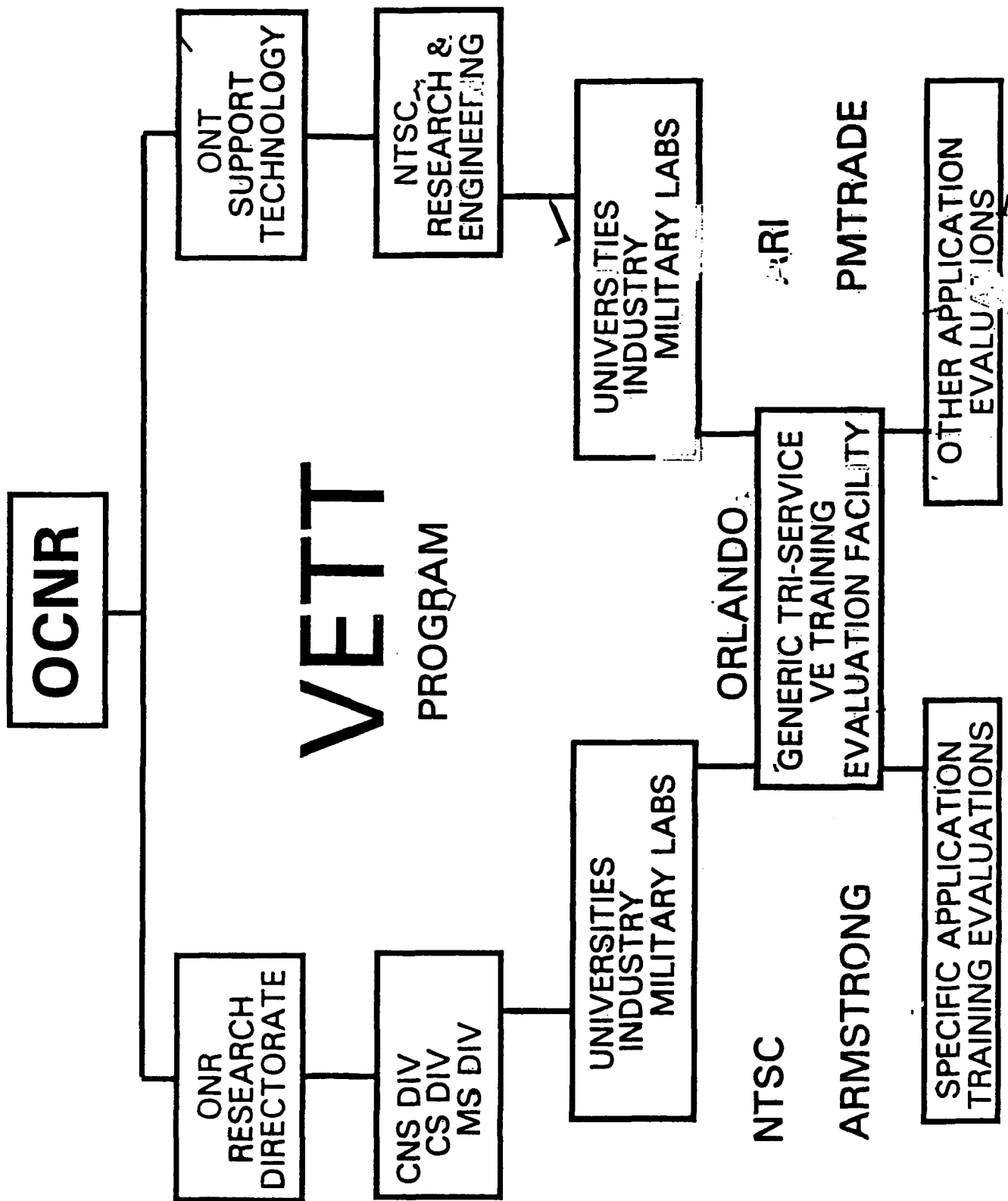




# VETT

## POTENTIAL PAYOFFS

- DECREASED TRAINER DEVELOPMENT & ACQUISITION COSTS
- DECREASED TRAINER OPERATION & MAINTENANCE COSTS ✓
- REDUCED PHYSICAL REQUIREMENTS: WEIGHT, SIZE, ENERGY
- DEPLOYABLE, AVAILABLE
- ENHANCED TRAINING



# RELIANCE STRUCTURE FOR VETT

| R&D FOCUS                                    |                                                                                                   |           |
|----------------------------------------------|---------------------------------------------------------------------------------------------------|-----------|
| ARMY                                         | NAVY                                                                                              | AIR FORCE |
| RELIANCE<br>CATEGORY                         | PERCEPTUAL AND COGNITIVE REQUIREMENTS<br>INTEGRATION SOFTWARE<br>SOLID MODELING SOLUTIONS<br>ETC. |           |
|                                              | BASIC RESEARCH                                                                                    |           |
| TRAINING<br>DEVICES<br>AND<br>FEATURES       | DISPLAYS AND TRANSDUCERS<br>MCRTS<br>INSTRUCTIONAL FEATURES<br>HUMAN PERFORMANCE EFFECTS<br>ETC.  |           |
|                                              | DEVELOPMENT<br>INTEGRATION<br>AND GENERIC<br>EVALUATION                                           |           |
| UNIT COLLECTIVE<br>TRAINING                  | ✓                                                                                                 |           |
| LAND WARFARE/<br>ROTARY WING<br>TRAINING     |                                                                                                   |           |
| SEA WARFARE<br>TRAINING                      |                                                                                                   |           |
| CLASSROOM<br>INSTRUCTION                     |                                                                                                   |           |
| AIRCREW TRNG<br>EFFECTIVENESS                |                                                                                                   |           |
| INTELLIGENT<br>COMPUTER-AIDED<br>INSTRUCTION |                                                                                                   |           |
|                                              | SPECIFIC<br>TRAINING<br>APPLICATIONS                                                              |           |

# VIRTUAL ENVIRONMENT TRAINING



# SIMULATOR VS VE

## TRAINING SIMULATOR

HMI SPECIFIC TO EQUIPMENT BEING  
SIMULATED - 1000'S OF DESIGNS  
ENVIRONMENT MODELED TO REAL  
WORLD PHYSICS



## VE TRAINING

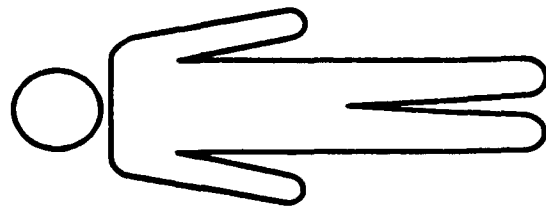
ONE OR FEW HMI HARDWARE DESIGNS  
ENVIRONMENT DESIGNED FOR "LEARNING



# VE TRAINING

VS

# SIMULATOR TRAINING



USER

SIMULATOR



HUMAN MACHINE INTERFACE



VE



DIS  
WORLD

# VETT PROJECT

**OBJECTIVE:** Improve affordability and effectiveness of training through application of VE.



**APPROACH:** Develop, demonstrate, and evaluate VE-based training system concepts.

# VE TRAINING APPLICATIONS

CONCEPT APPLIES TO ALL TRAINING



BUT

NOW LIMITED BY TECHNOLOGY SOA

# VETT APPROACH

## 3 PARALLEL EFFORTS

DEVELOP COMPONENT TECHNOLOGIES



DESIGN AND INTEGRATE CANDIDATE  
TRAINING APPLICATIONS

EVALUATE POTENTIAL COST AND  
TRAINING EFFECTIVENESS

# VE DISPLAYS

VISUAL, AUDITORY & HAPTIC



AND, EVENTUALLY

VESTIBULAR, OLFACTORY & GUSTATORY

# VISUAL DISPLAYS

## ISSUES

✓

AFFORDABILITY  
FIELD OF VIEW  
RESOLUTION

FULL COLOR  
COMFORT  
CONVENIENCE

# AUDITORY DISPLAYS

## ISSUES



## 3-D CALIBRATION

## EFFECTIVE UTILIZATION

# HAPTIC DISPLAYS

## ISSUES

GROUNDING FORCES



TACTILE ICONS

WHOLE BODY ACCELERATION

NTSC 251 1105 03/92



# VE TRANSDUCERS

POSITION

ORIENTATION



FORCE

SPEECH

# POSITION AND ORIENTATION TRANSDUCERS ISSUES

## FREEDOM OF MOVEMENT ABSOLUTE/RELATIVE INTERFERENCE

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# FORCE TRANSDUCERS

## ISSUES

69

INTIMATE WITH FORCE DISPLAY

REACTIVE AND PROACTIVE

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# SPEECH TRANSDUCERS

## ISSUES

SPEAKER INDEPENDENT

CONTEXT INDEPENDENT

CONTINUOUS SPEECH

# TRAINING ENVIRONMENTS

## ISSUES

Multimodal cue substitution and/or enhancement

Departures from the physics of  
the real world ✓

Visualization of the invisible

Behavior of virtual actors

# BEHAVIORAL RESEARCH ISSUES

- \* PERFORMANCE EFFECTIVENESS
  - CAN THE JOB BE DONE IN A VE
- \* TRAINING EFFECTIVENESS
  - IS VETT THE BEST WAY TO TRAIN
- \* SIDE EFFECTS
  - DISORIENTATION, VERTIGO, ETC.
- \* EFFECT OF IMMERSION
  - IS IMMERSION CRITICAL TO TRAINING

# VETT COMPLEXITY LEVELS

1. SEATED OPERATOR, CONSOLE,  
3-D VISUALIZATION

2. PLATFORM OPERATOR,  
WORKBENCH

3. SEATED TEAM, NETWORK

4. AREA OPERATOR

5. AREA TEAM

# SEATED OPERATOR

VE - 1 MONITOR, BUTTONS, SWITCHES,  
KNOBS, INSTRUMENT DISPLAYS,  
KEYBOARD, AUDIO

74

VE - 2 WRAP AROUND, DYNAMIC, 3-D

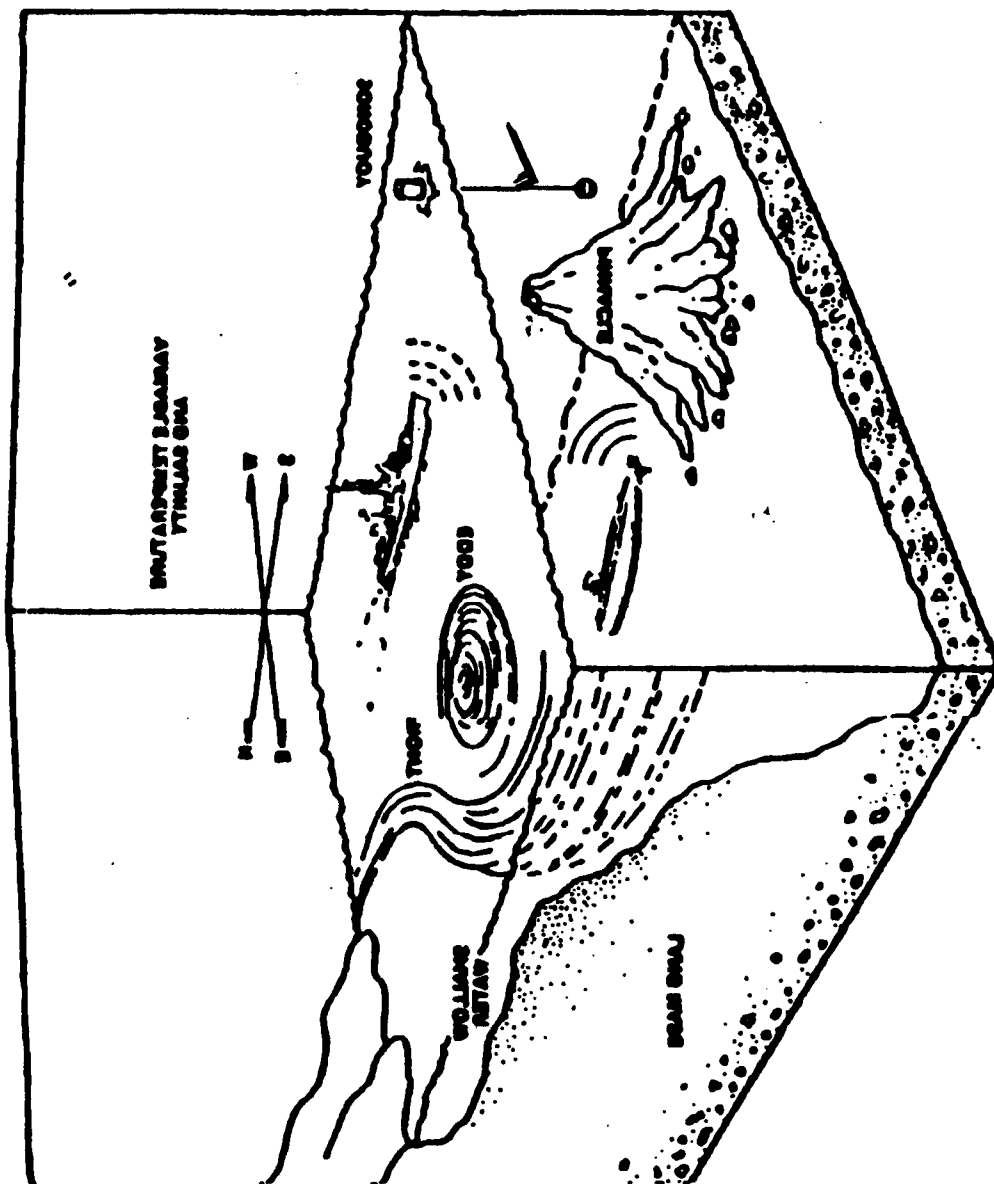
## VE HARDWARE

DISPLAYS - HMD, HEADPHONES, GLOVES

TRANSDUCERS - HEAD, HAND, FINGER P & O







# PLATFORM OPERATOR

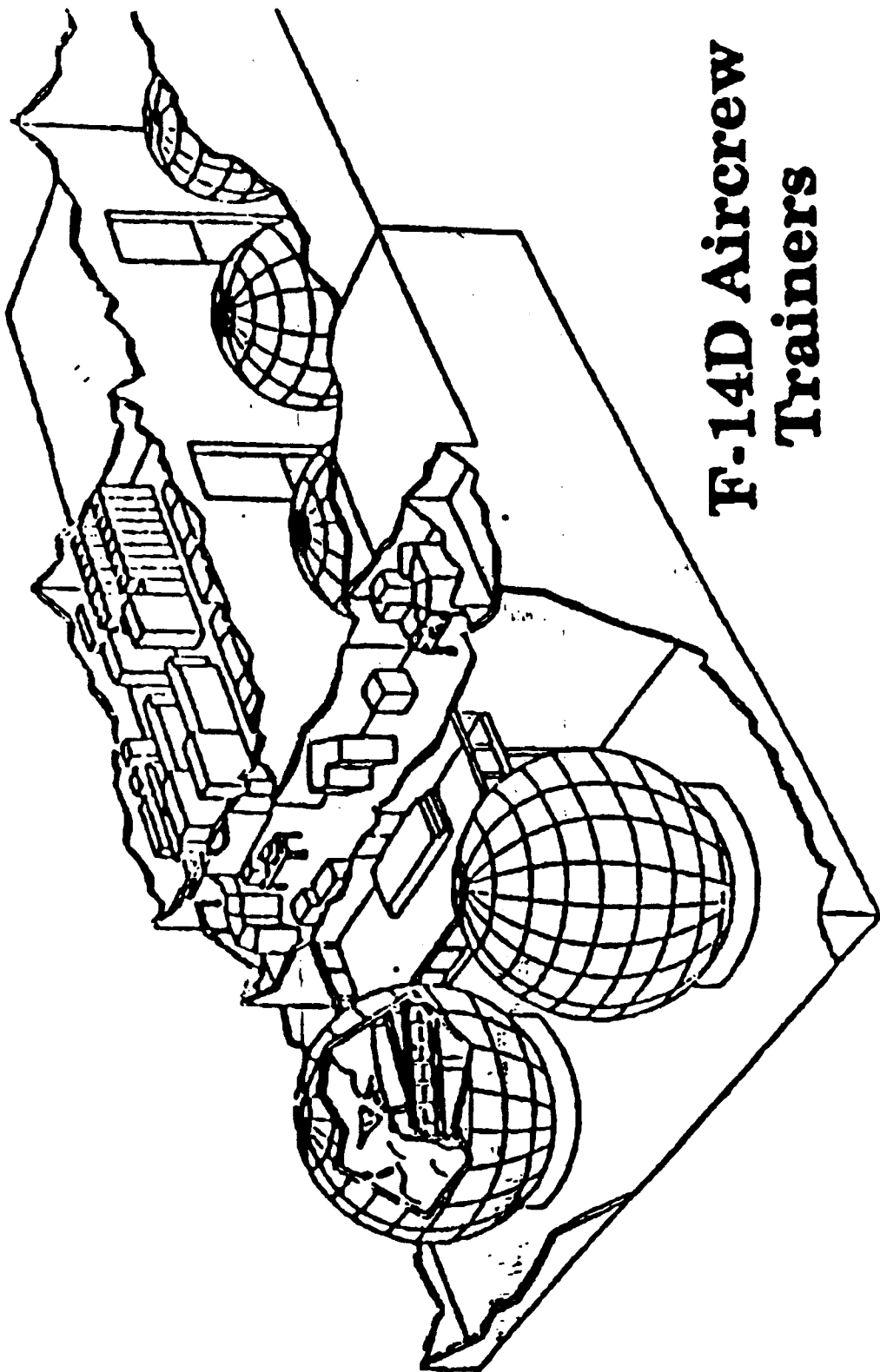
VE - 1    MANUAL CONTROLS AND  
          DISPLAYS, AUDIO, FORCES

VE - 2    WORKBENCH, HANDTOOLS

## VE HARDWARE

DISPLAYS -    LEVEL 1 PLUS FORCE

TRANSDUCERS - LEVEL 1 PLUS FORCE



## F-14D Aircrew Trainers



# SEATED TEAM

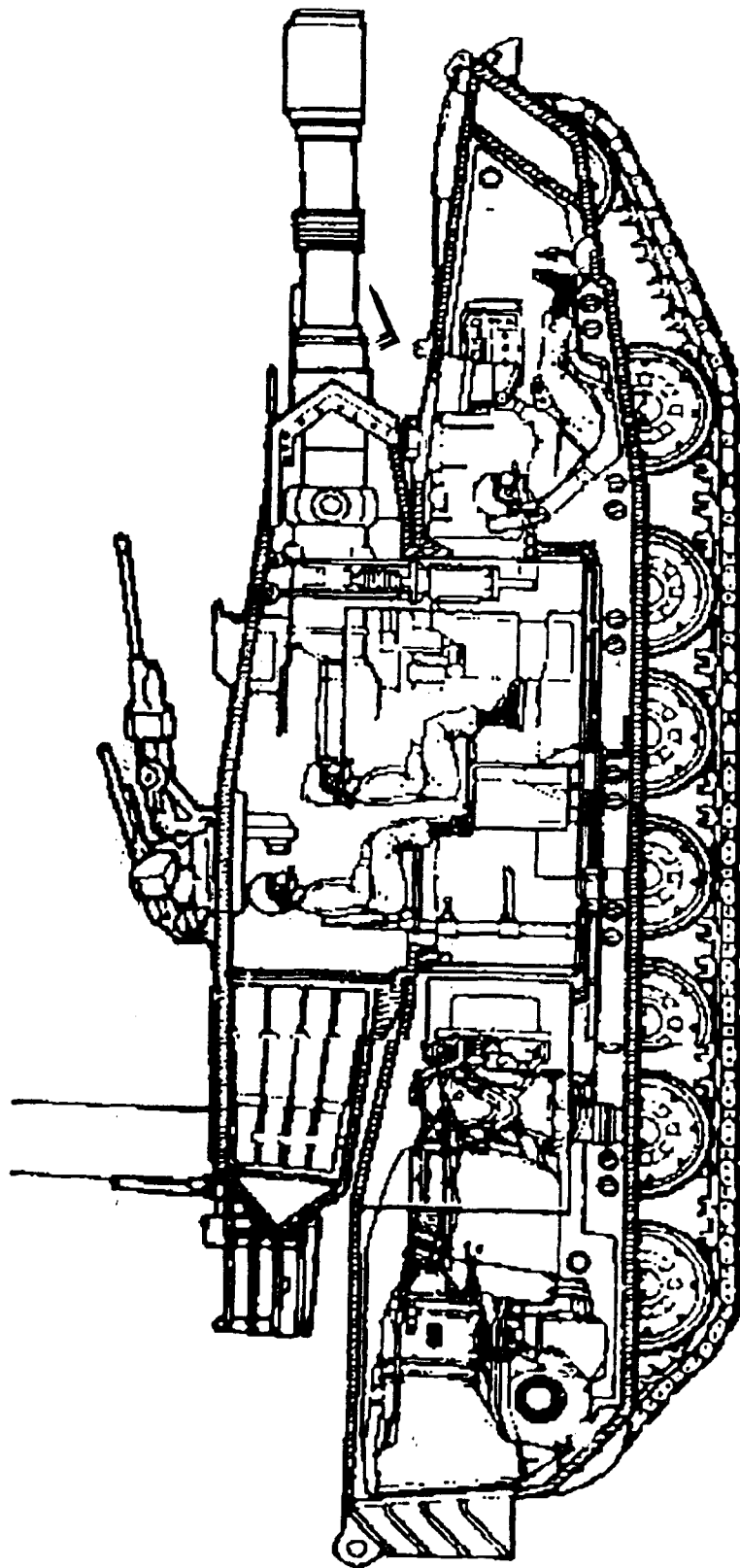
VE - 1 AUDIBLE TEAM / INSTRUCTOR

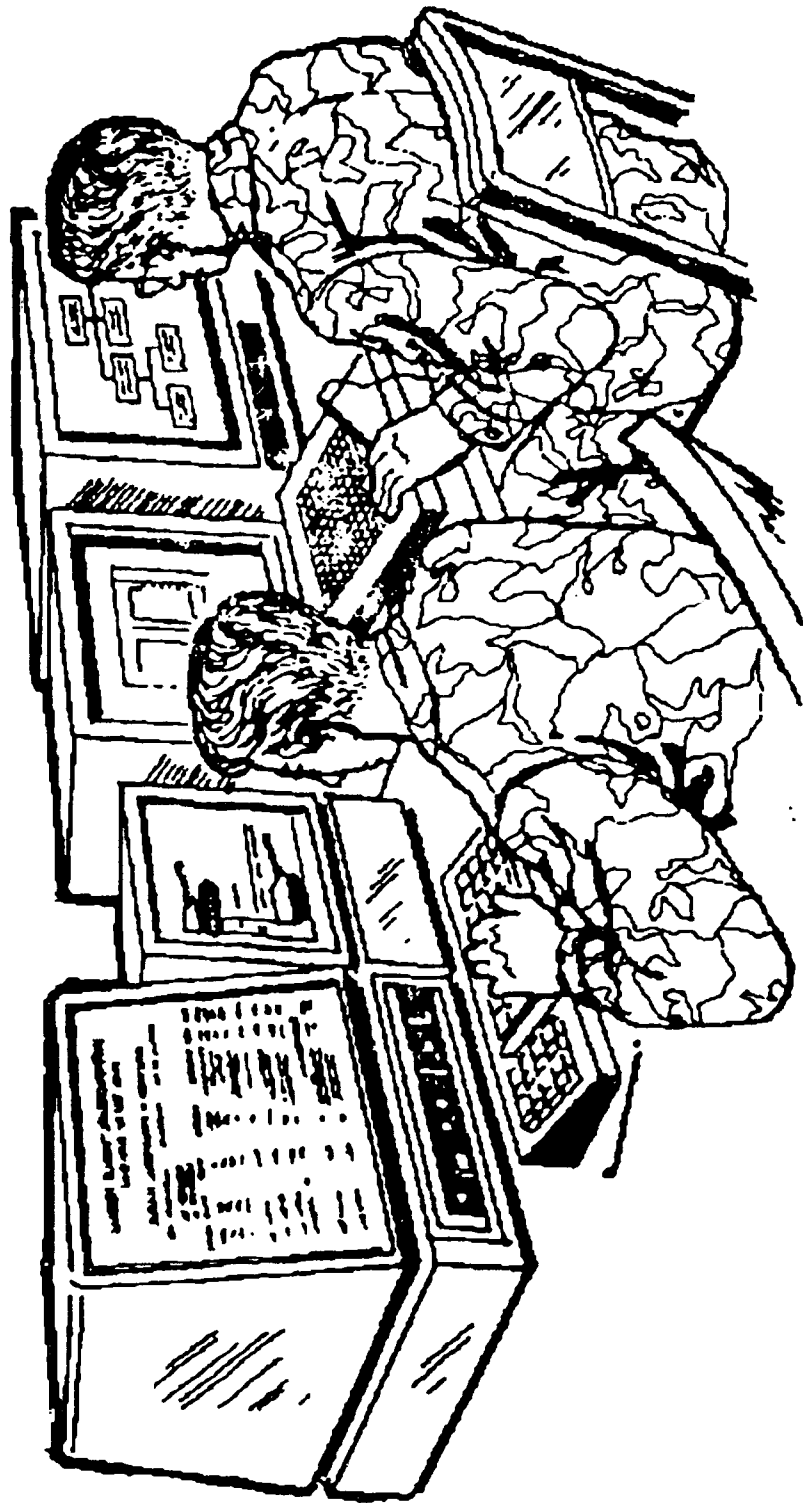
VE - 2 VISIBLE TEAM / INSTRUCTOR

# VE HARDWARE

DISPLAYS - LEVEL 2 PLUS PEOPLE

TRANSDUCERS - LEVEL 2 PLUS SPEECH







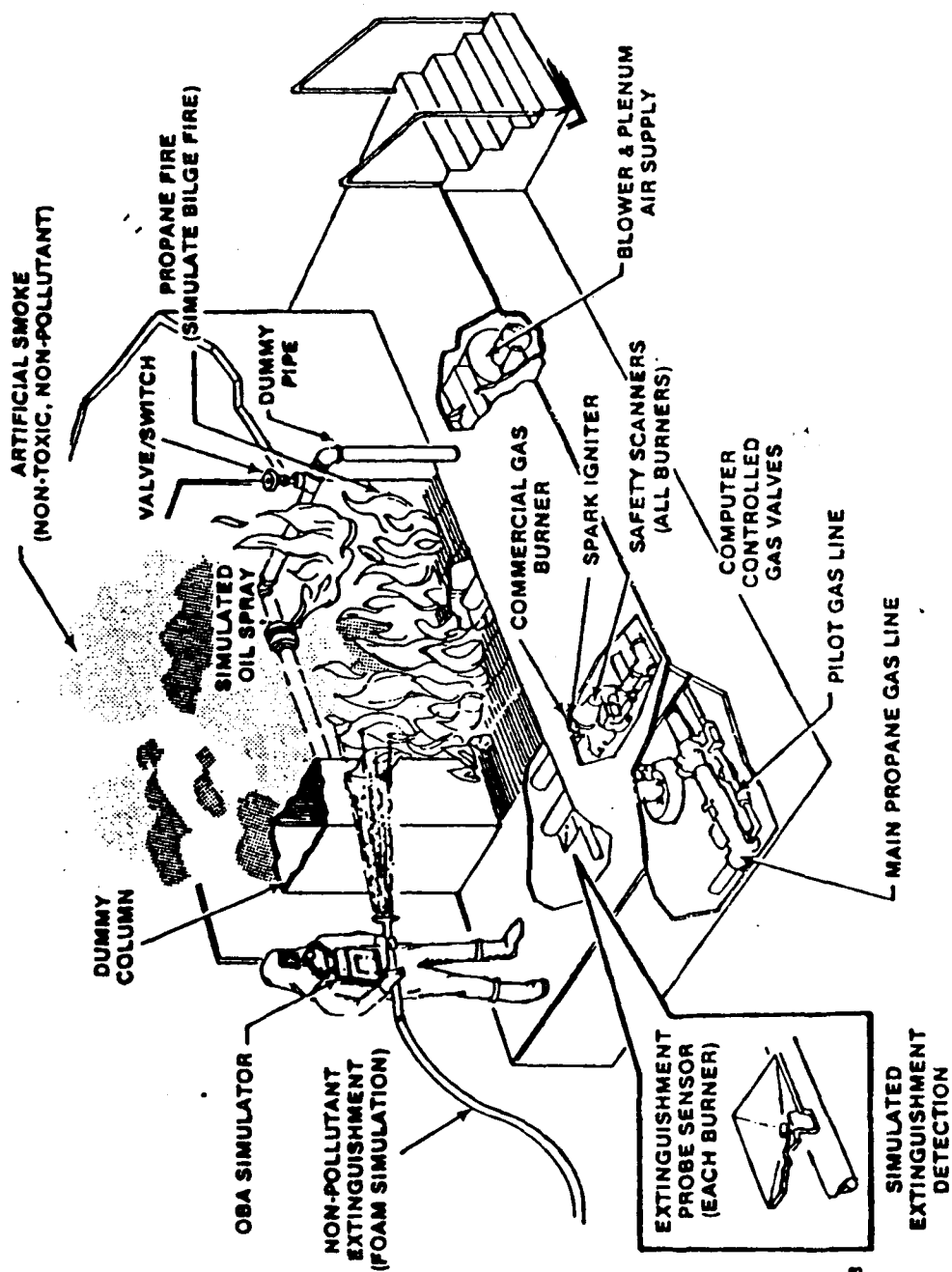
# AREA OPERATOR

VE STAND, WALK, BEND

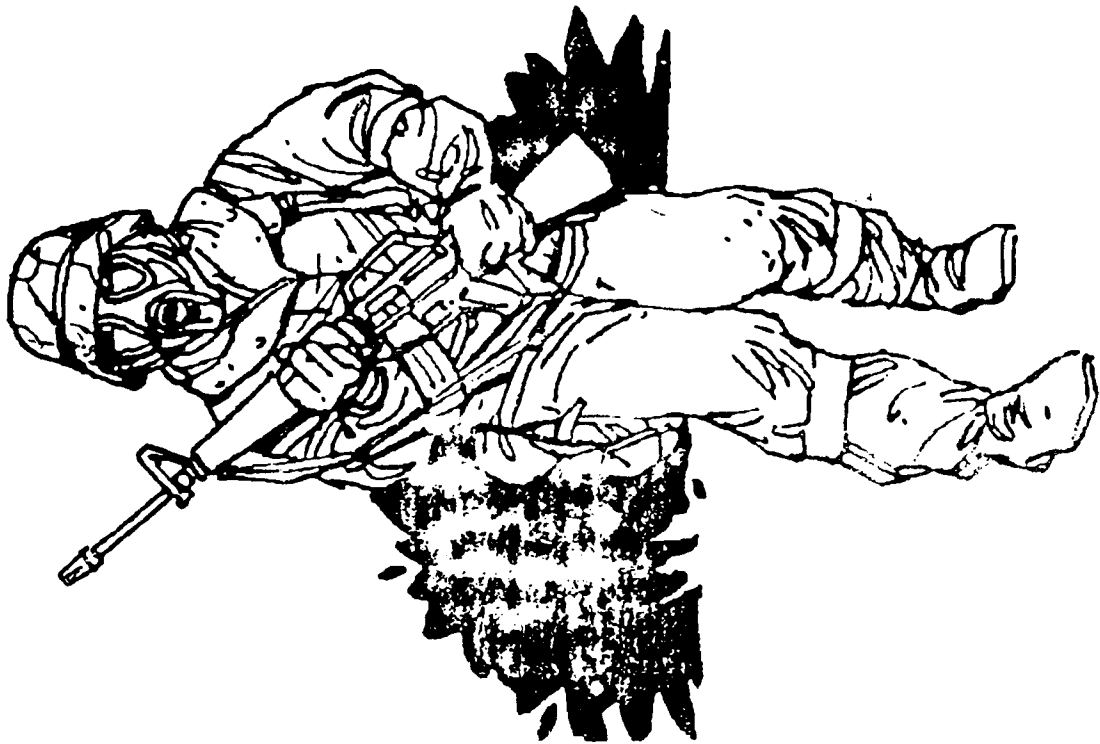
## VE HARDWARE

DISPLAYS - LEVEL 3 PLUS GROUNDED  
FORCE

TRANSDUCERS - LEVEL 3 PLUS WHOLE  
BODY P & O & FORCE



28



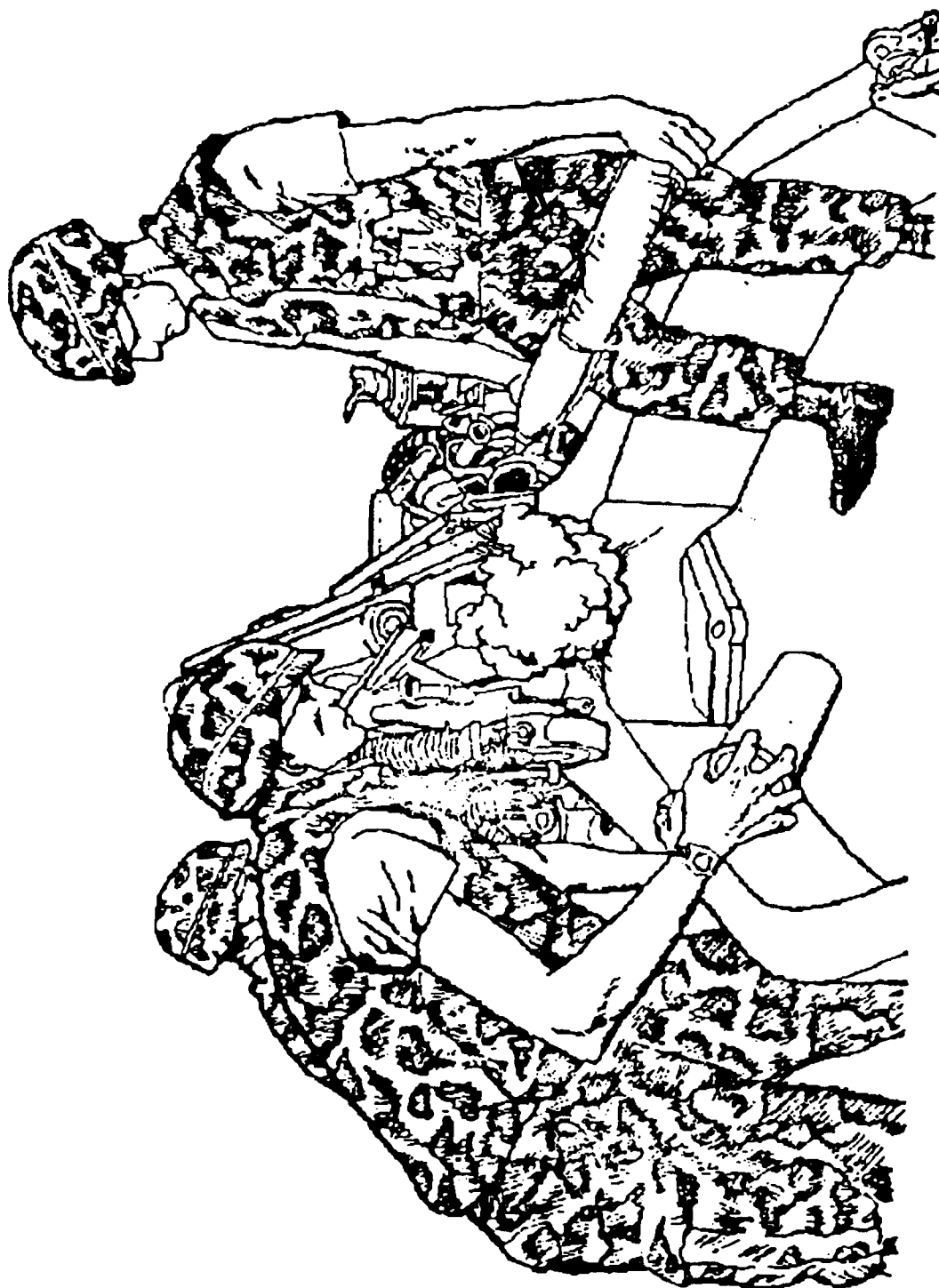
# **AREA TEAM**

**VE      MULTI - PERSONNEL MANUAL  
TASKS**

## **VE HARDWARE**

**DISPLAYS - LEVEL 4 PLUS PEOPLE**

**TRANSDUCERS - LEVEL 4**



**SUBGROUP SESSION I**

**ADVANCED TRAINING TECHNOLOGY**

Introduction and Administrative Issues Subgroup Theme:  
Simulator, Simulations and "Virtual Reality"

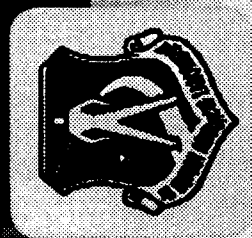
Enhancing Aircrew Training Through Virtual  
Environment Research:  
Dr. Richard Thurman

Research on the Use of Virtual Environment in  
Crisis Management in the Navy:  
Ms. Janet Dickieson  
(no hard copies available)

Behavioral Requirements for Training  
in Virtual Environments:  
Dr. Bruce Knerr

# Virtual Environments

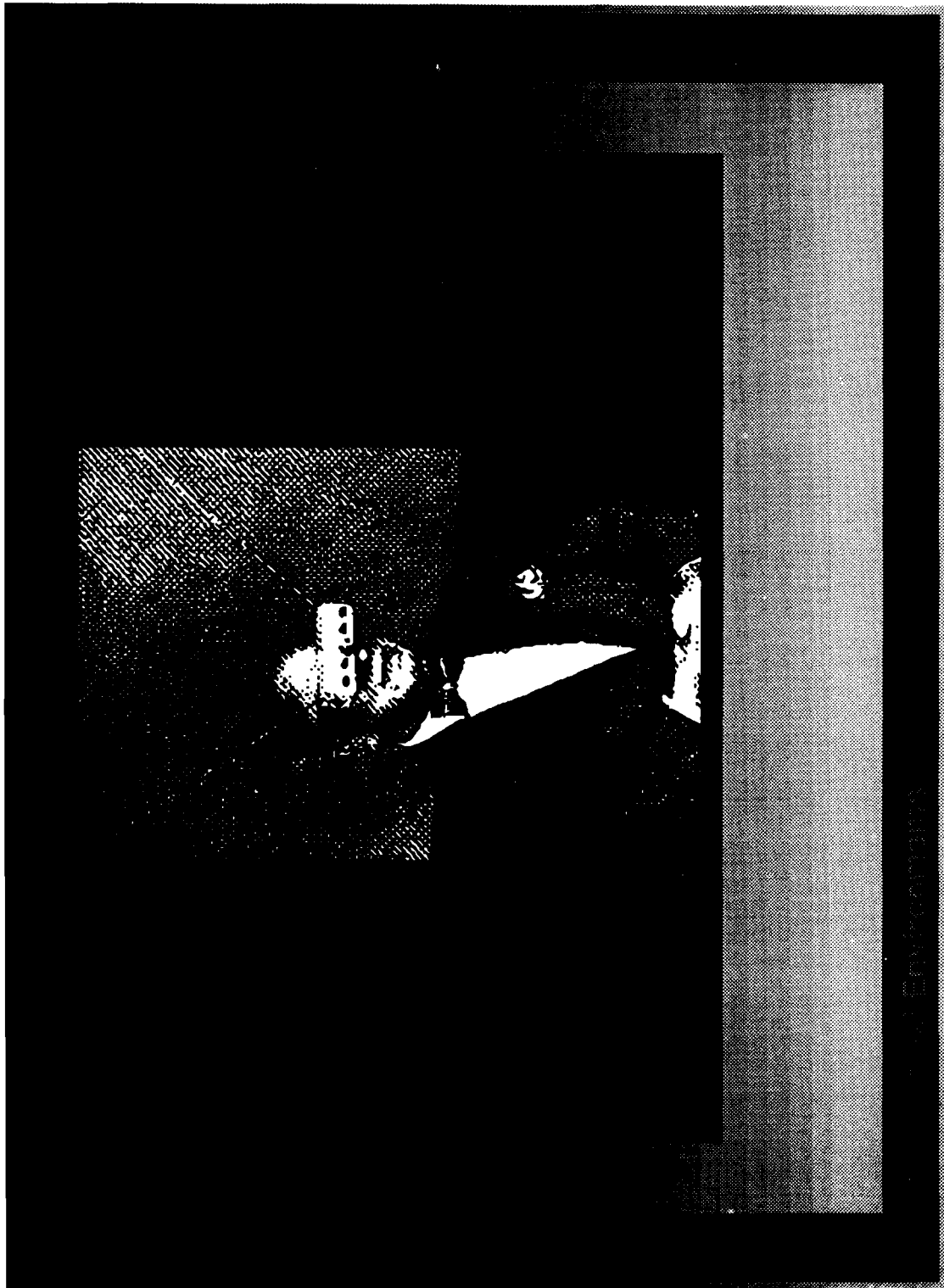
## ENHANCING AIRCREW TRAINING



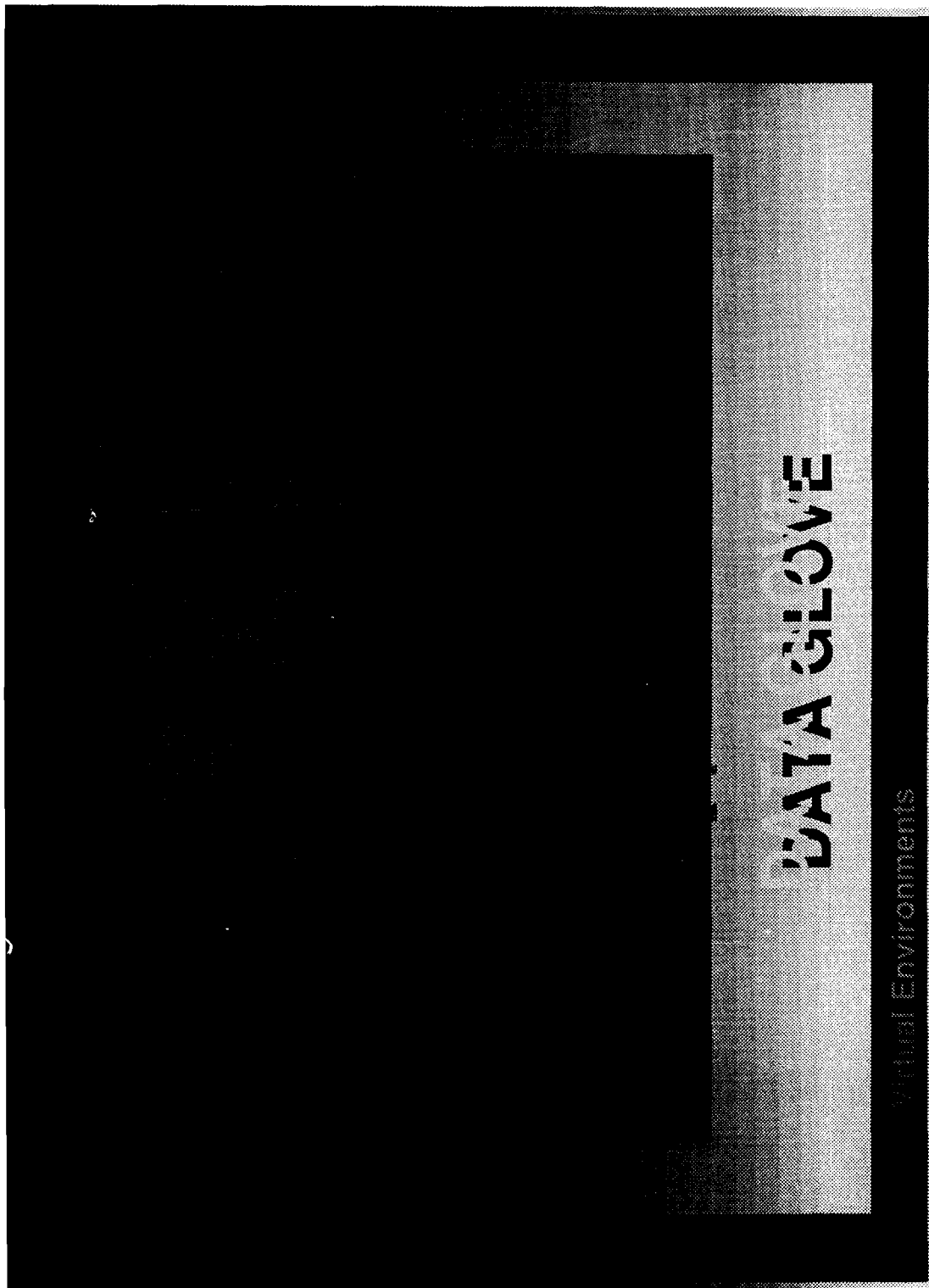
Air Force  
Armstrong Lab  
Aircrew Training Research Division  
Williams AFB  
Arizona

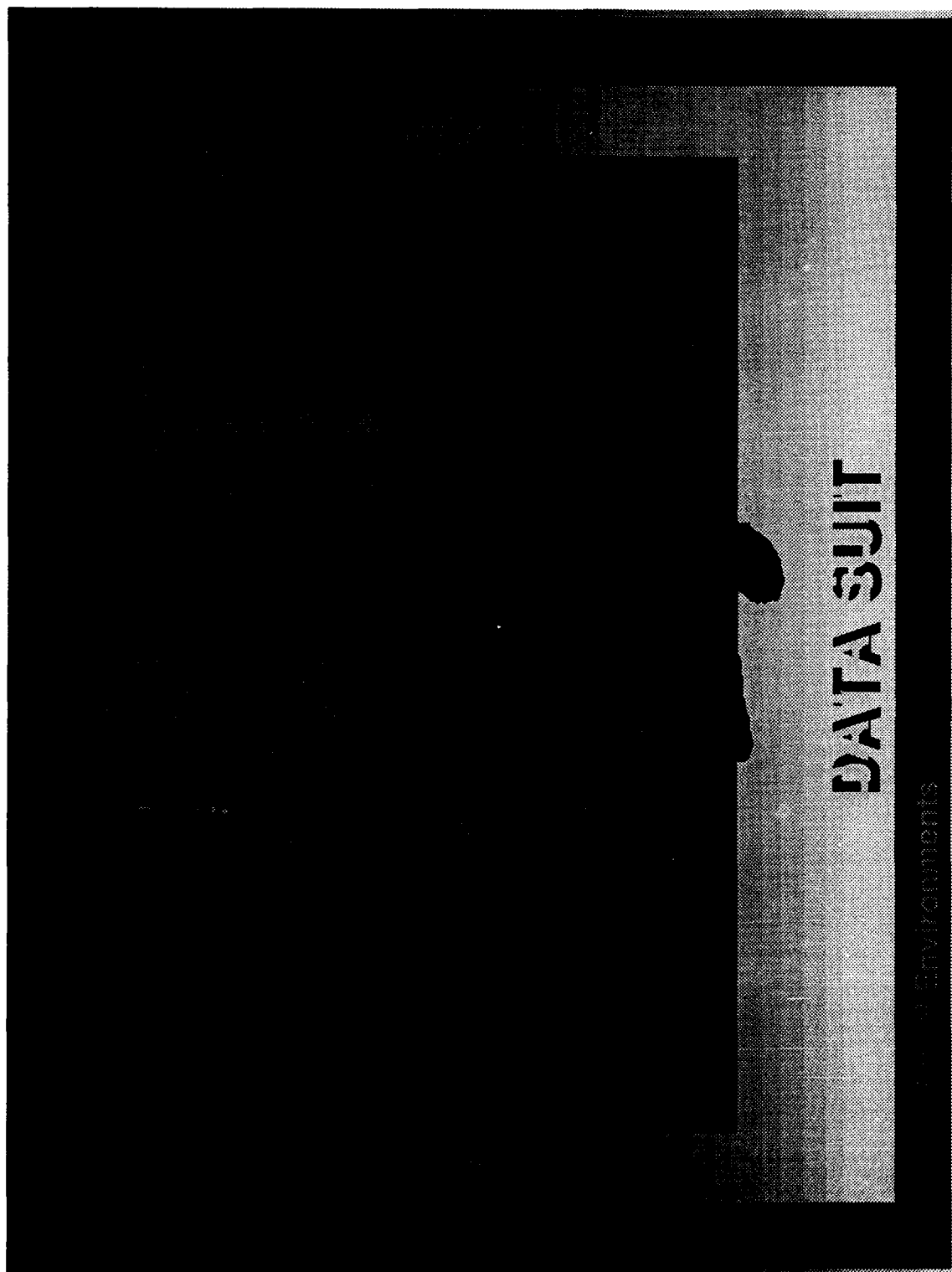
Richard Thurman

Virtual Environments









DATA SUIT

and Environments

# VERITY SCALE

Complete  
Correspondence  
To "Natural Laws"

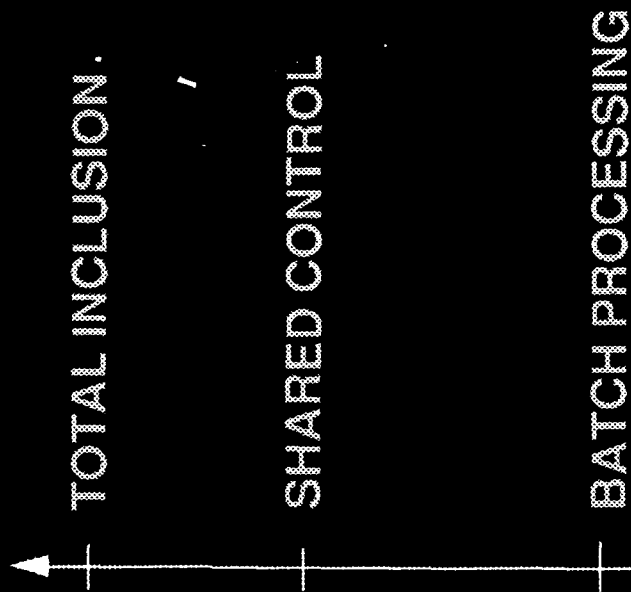
Tele-  
presence

Alternative  
Realities

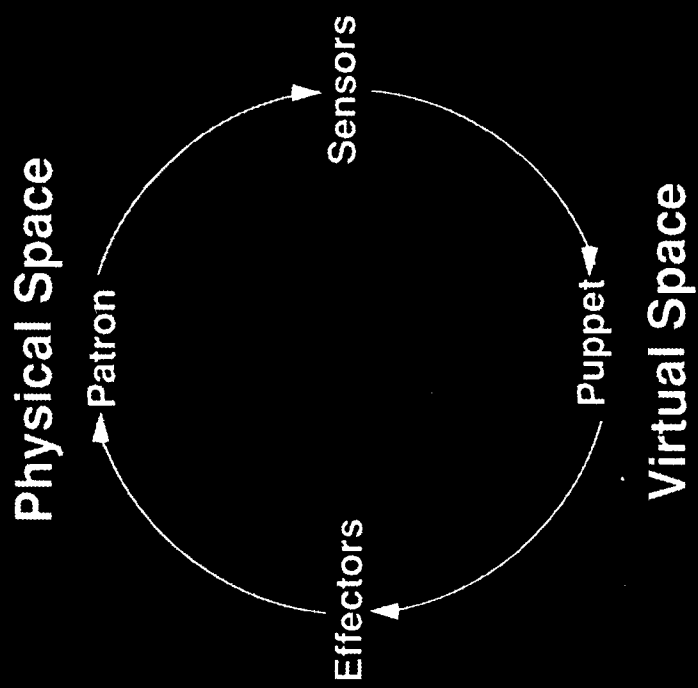
Novel  
Environments

Virtual Environments

# INTEGRATION SCALE



Virtual Environments



## CYBERNETIC FEEDBACK LOOP

(Washar, 1991)

Virtual Environments

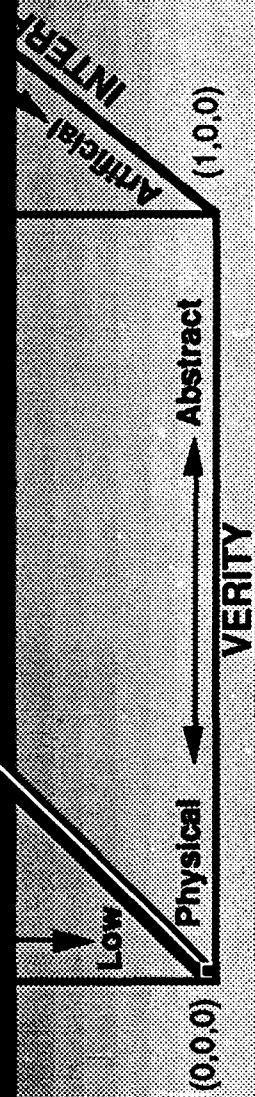
# INTERFACE SCALE

NATURAL  
INTERFACE

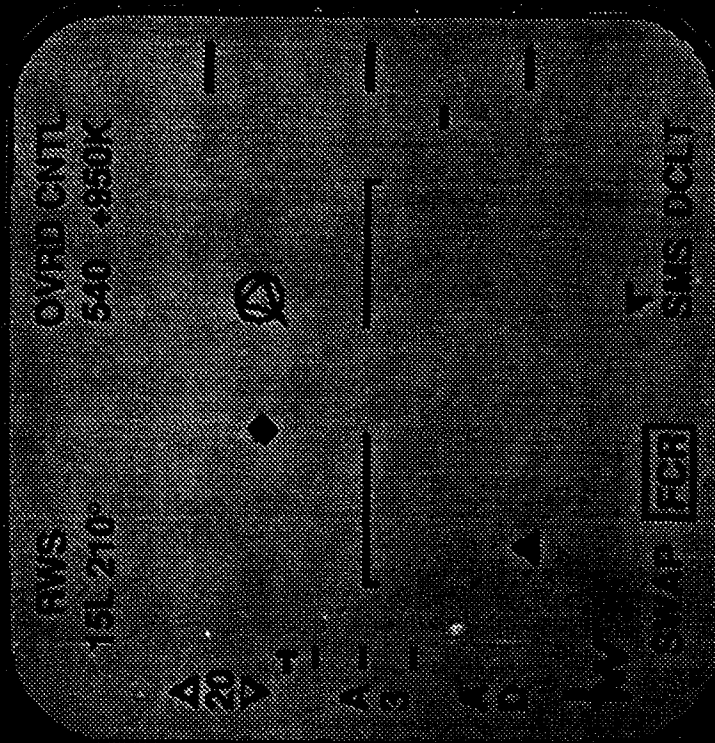
ARTIFICIAL  
INTERFACE

Virtual Environments

# VIRTUAL REALITY



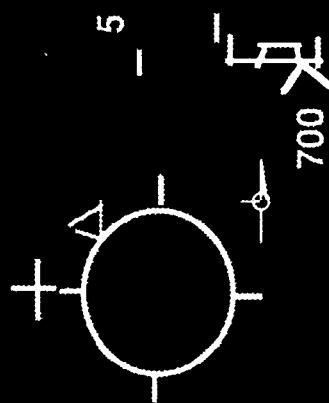
Virtual Environments



# HEAD DISPLAY

Virtual Environments





ARM  
0.89

12

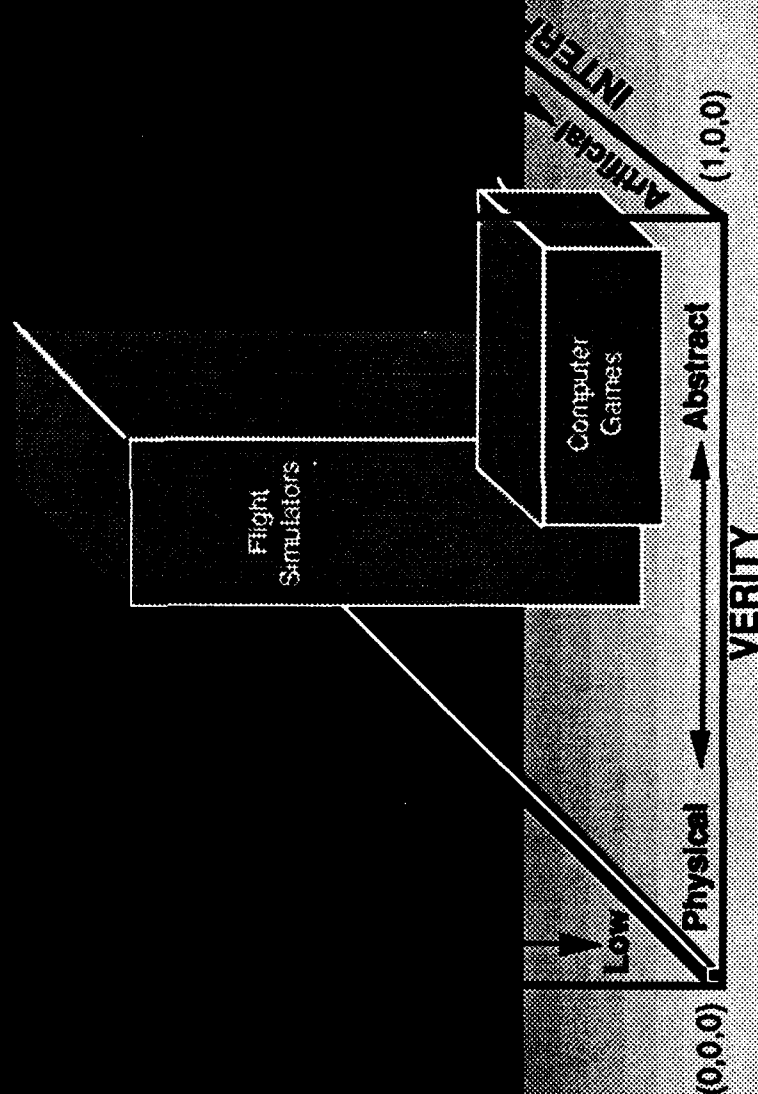
90  
MSL

045  
700  
115>03

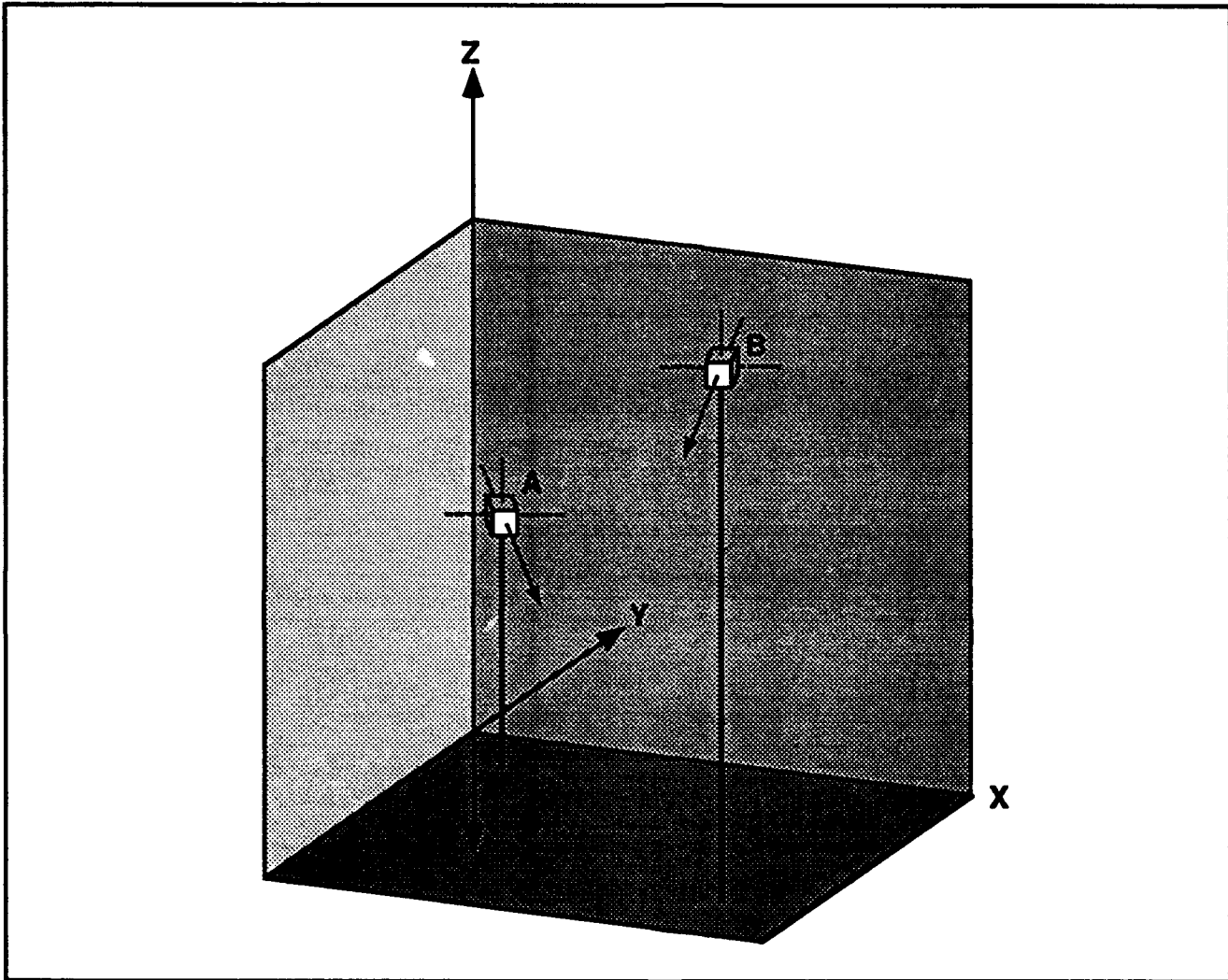
# HUD DISPLAY

Harsh Environments

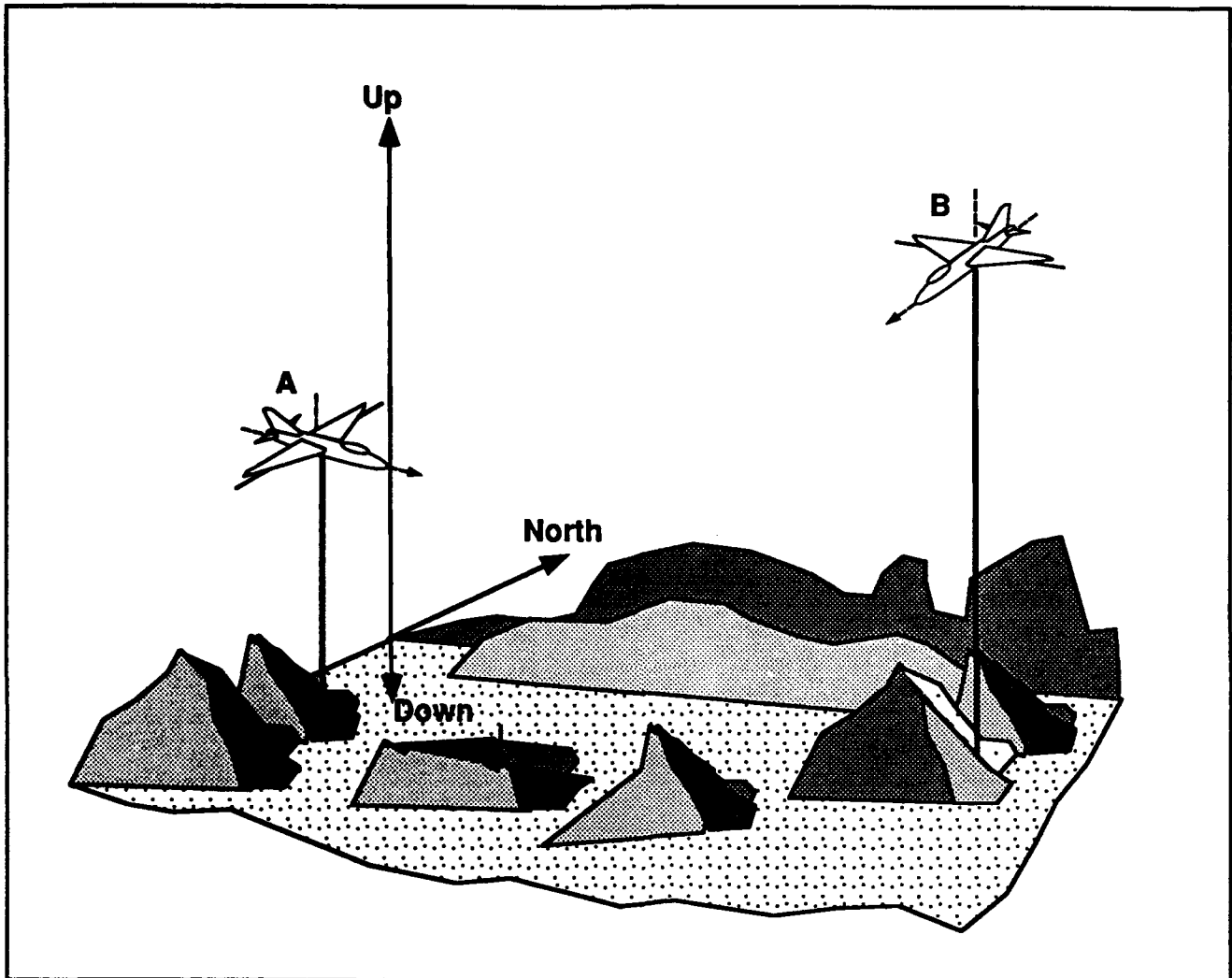
# VIRTUAL REALITY



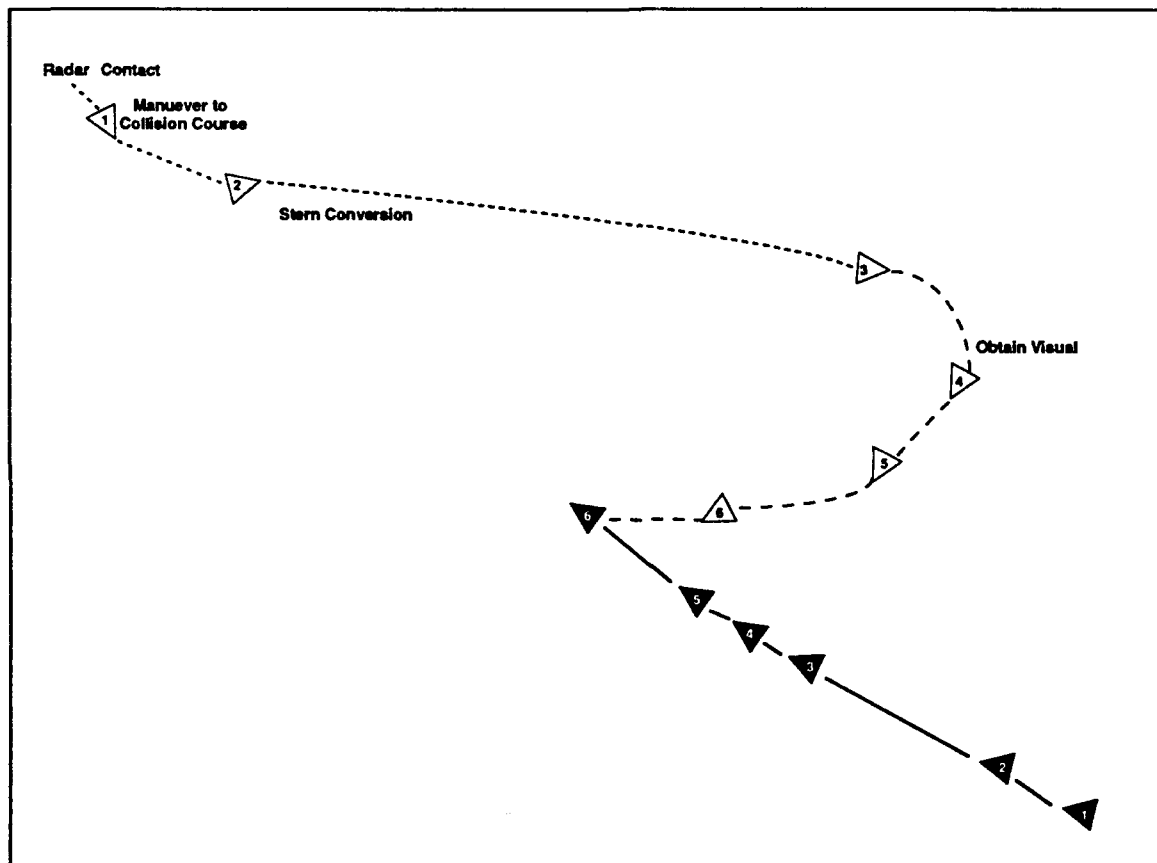
Virtual Environments



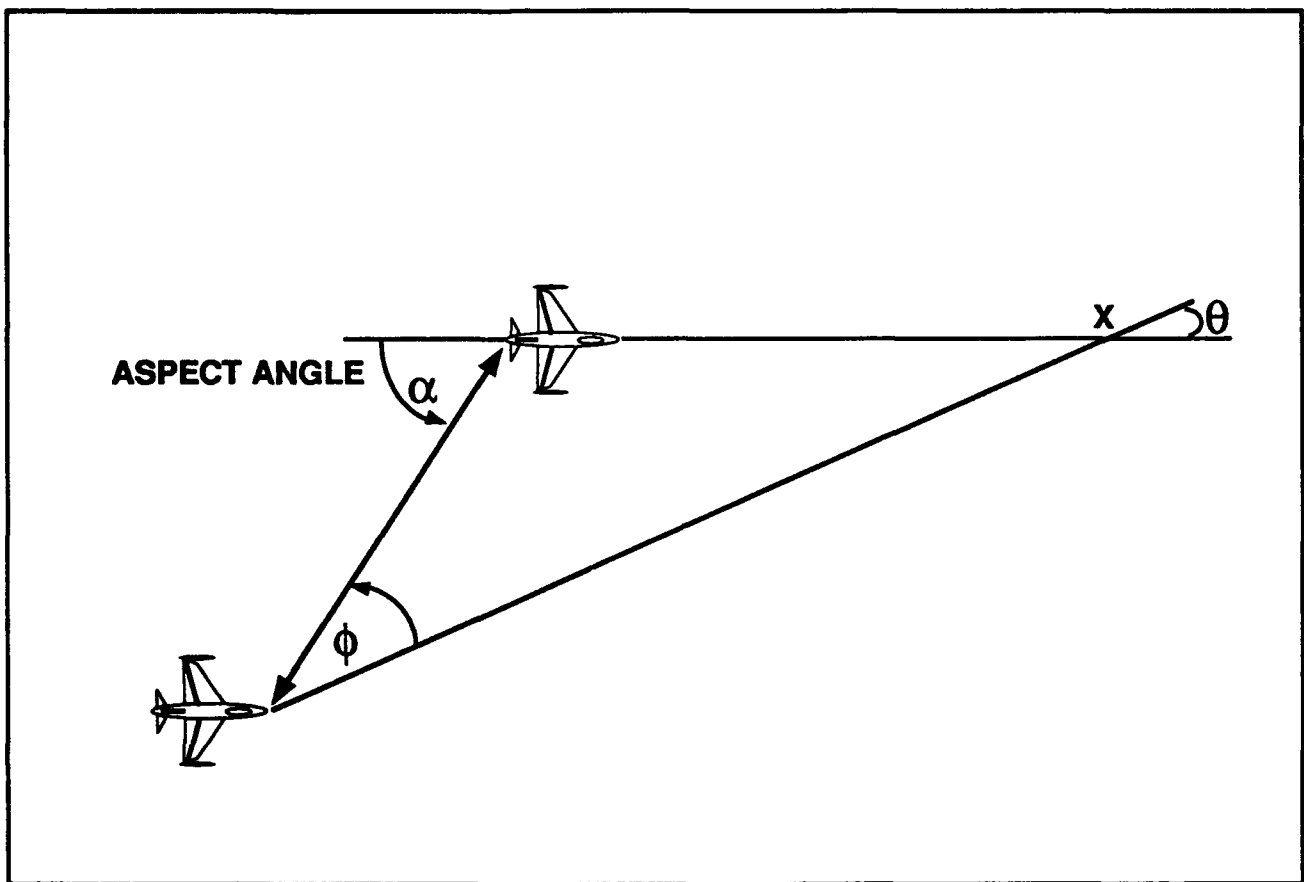
**Spatial awareness consists of a description of each object's 3 coordinates of location, 3 coordinates of orientation and a motion velocity vector.**



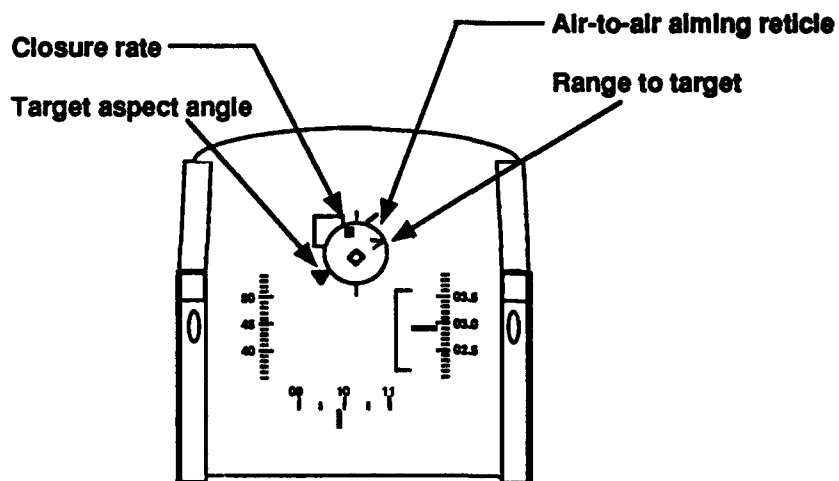
**The air-to-air intercept as a spatial awareness problem.**



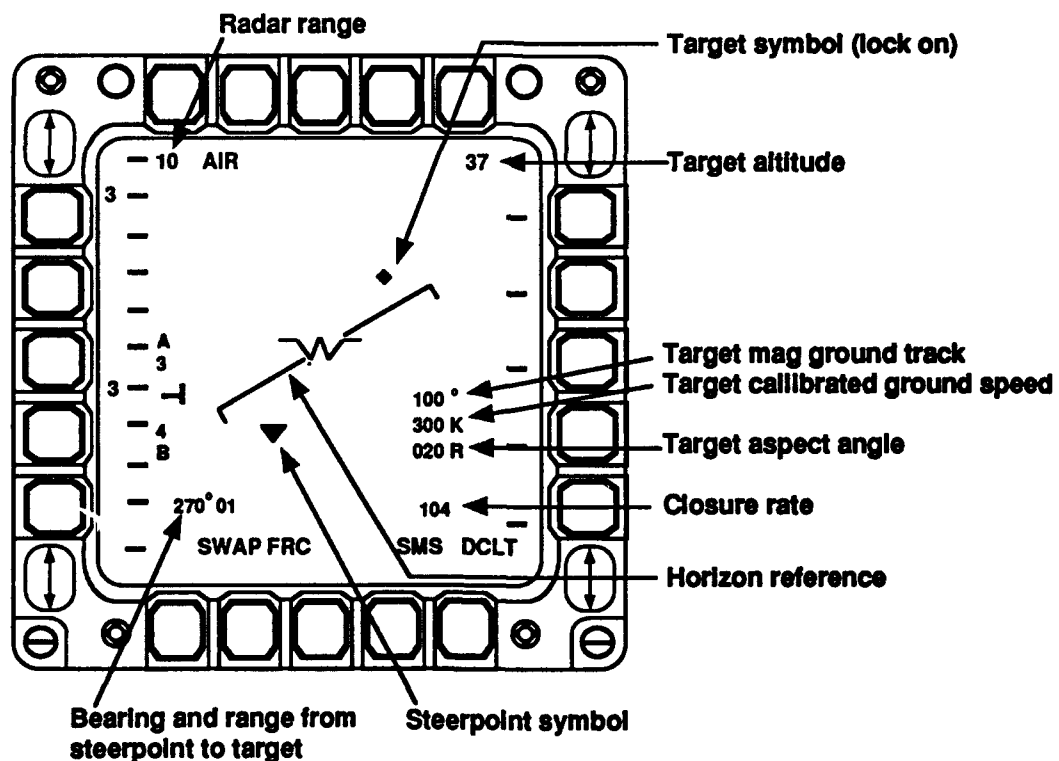
## The Basic Air-to-Air Intercept



**The geometry of the air-to-air intercept.**

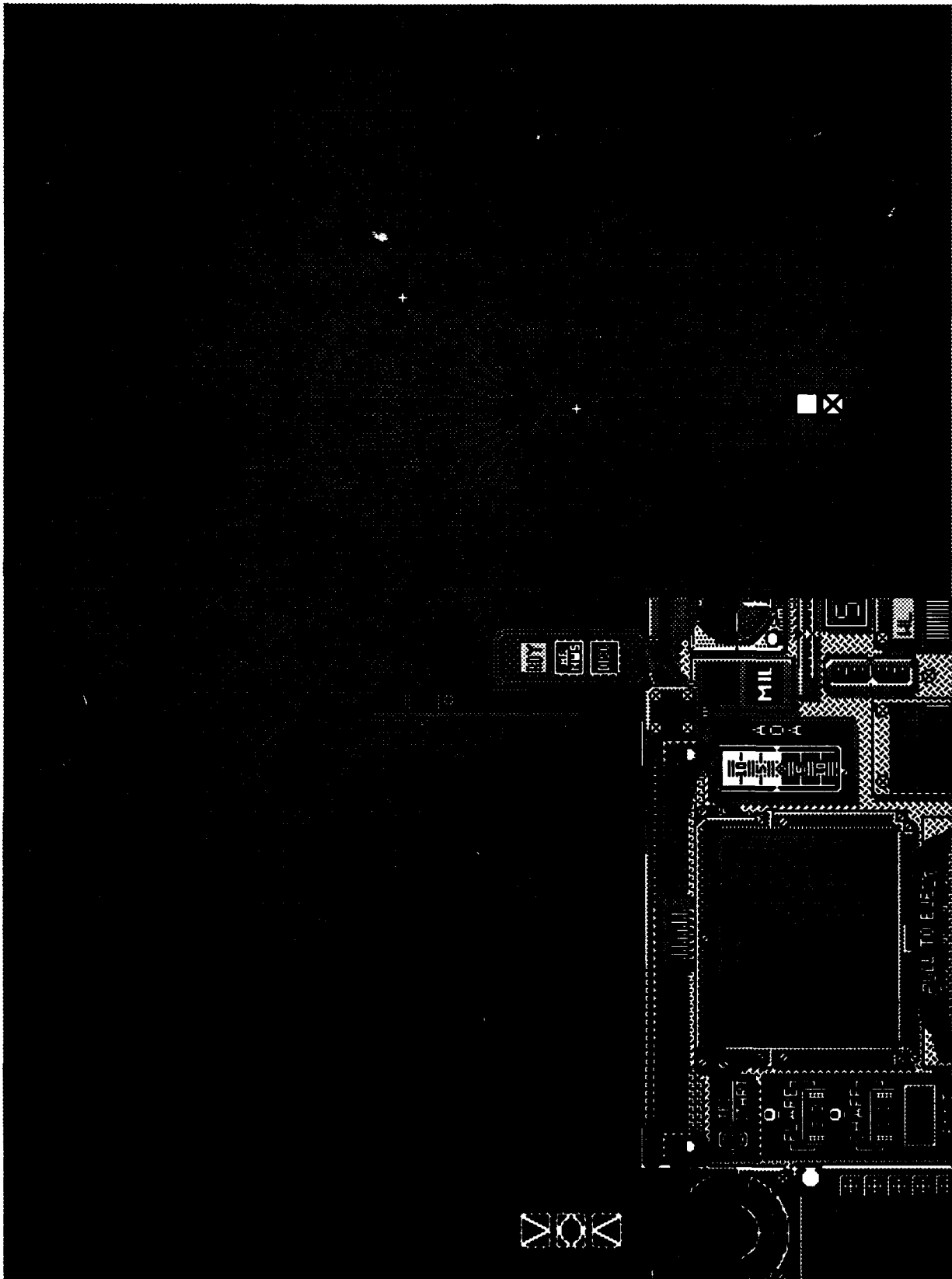


**Head Up Display (HUD) in Air-to-Air Mode**

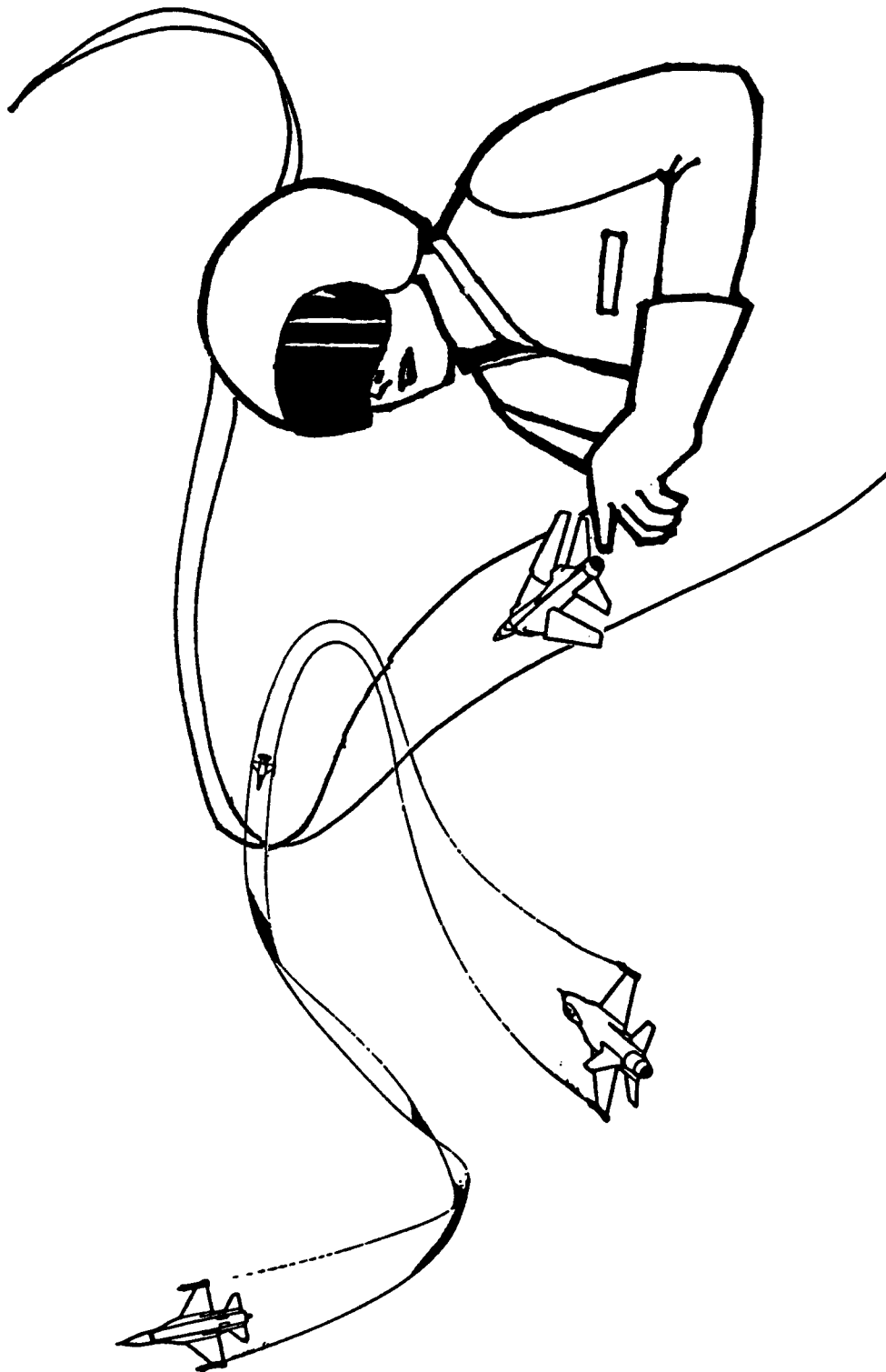


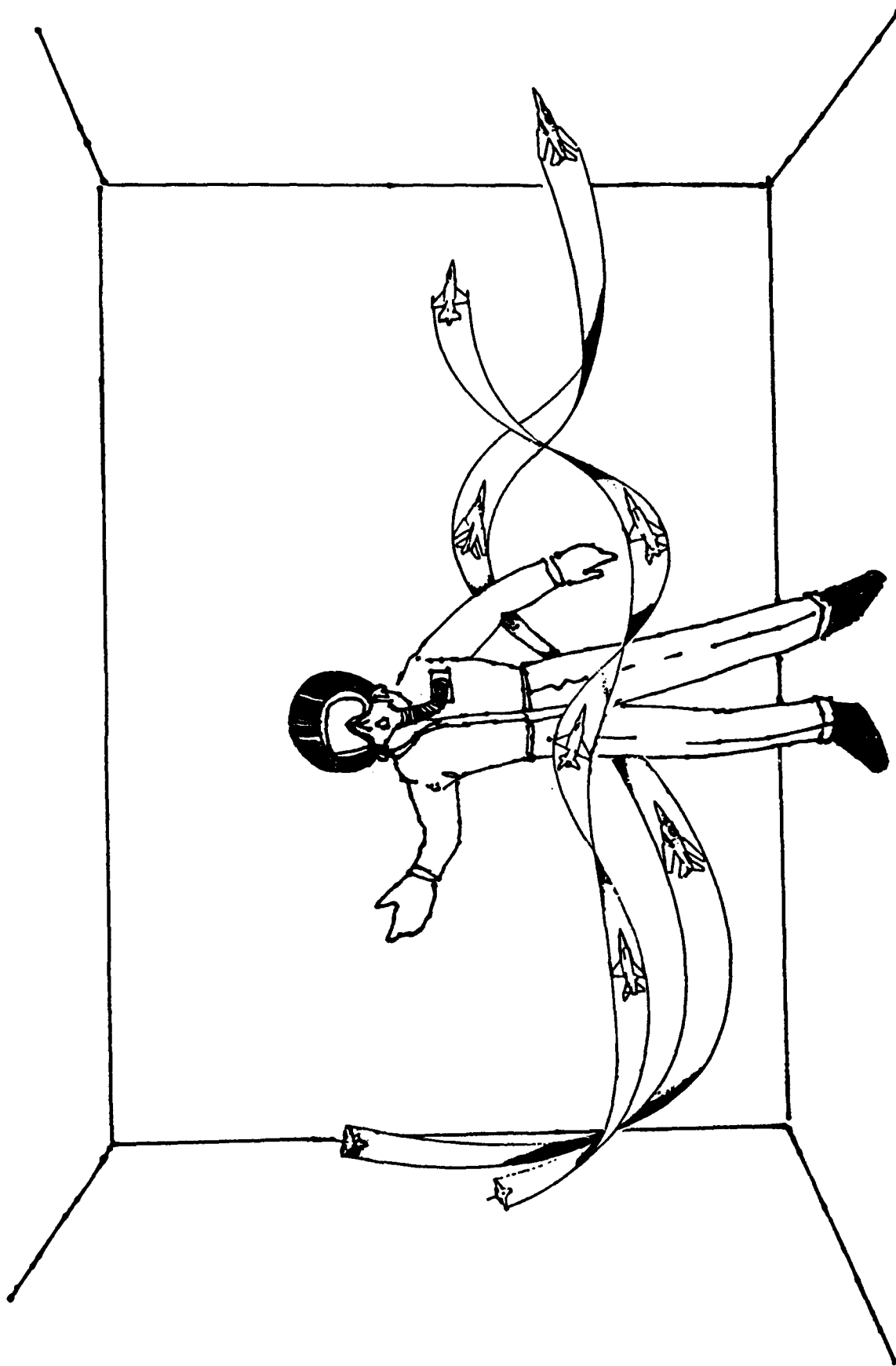
**Radar Display (REO) in Single Target Track Submode**

## **Spatial Instruments Representing the Air Space During the Intercept**

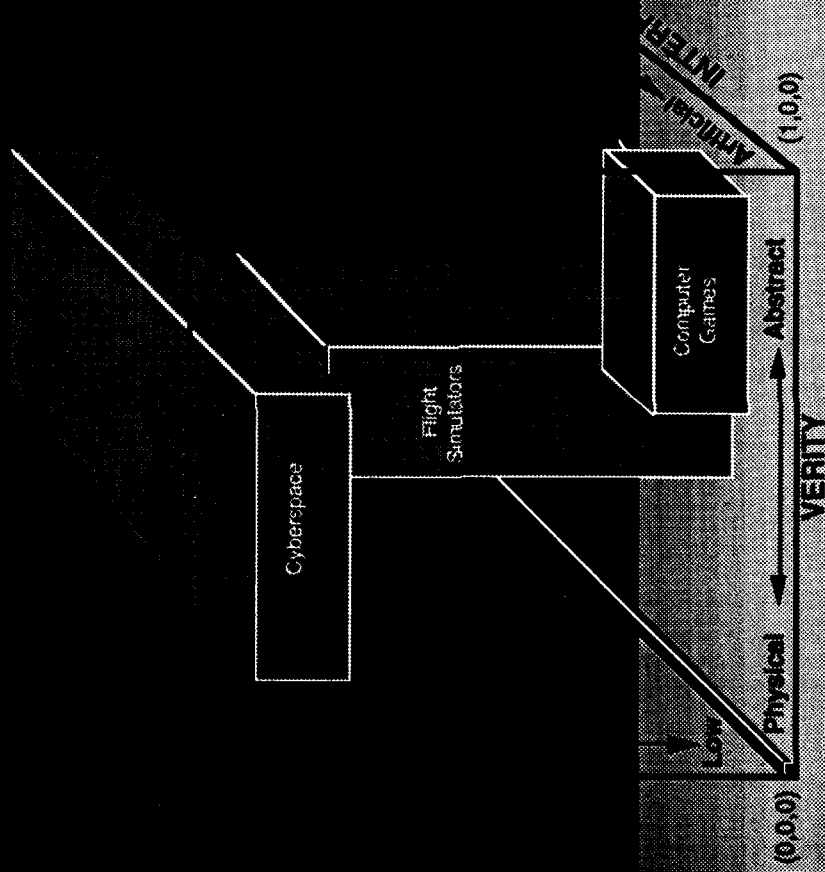








# VIRTUAL REALITY



# BEHAVIORAL REQUIREMENTS FOR TRAINING & REHEARSAL IN VIRTUAL ENVIRONMENTS

A R M Y R E S E A R C H I N S T I T U T E



Dr. Bruce W. Knerr  
Army Research Institute  
PM TRADE Field Unit  
Orlando, FL



PM TRADE FIELD UNIT

OUR CONTEXT FOR VIRTUAL ENVIRONMENT RESEARCH

TRAINING DEVICES AND SIMULATORS

DISTRIBUTED INTERACTIVE SIMULATION (DIS)

SIMNET -> CCTT

BDS-D

UPAS

111

SUPERTROOP & I-PORT

SOLDIER INTEGRATED PERFORMANCE ENSEMBLE (SIPE)

SNOWBIRD CONFERENCE

ASB 91 SUMMER STUDY ON ARMY SIMULATION STRATEGY

NTSC VIRTUAL ENVIRONMENT TRAINING TECHNOLOGY (VETT)

ARMY SCIENCE BOARD 1991 SUMMER STUDY

THE MEMBERS OF THE STUDY TEAM BELIEVE THAT THE APPROACH WE HAVE CALLED THE ELECTRONIC BATTLEFIELD CAN MAKE MAJOR IMPROVEMENTS IN THE WAY THE ARMY DOES DEVELOPMENT, TESTING AND TRAINING. IT CAN EITHER REDUCE COST OVER TIME, OR IMPROVE PERFORMANCE, OR RESULT IN A COMBINATION OF LESSER AMOUNTS OF BOTH.

RECOMMENDATION: AGGRESSIVELY ADOPT THE ELECTRONIC BATTLEFIELD TECHNOLOGY FOR COLLECTIVE COMBINED ARMS TRAINING.

ARMY SCIENCE BOARD 1991 SUMMER  
STUDY ON SIMULATION STRATEGY

## **VIRTUAL ENVIRONMENTS RESEARCH GOALS**

**IDENTIFY VIRTUAL ENVIRONMENT INTERFACE REQUIREMENTS FOR MISSION PLANNING & REHEARSAL, MISSION-SPECIFIC TRAINING, AND COMBAT PROFICIENCY TRAINING FOR THE DISMOUNTED SOLDIER**

**EXAMINE FEASIBILITY OF VIRTUAL ENVIRONMENT TECHNOLOGY TO SUPPORT MISSION PLANNING AND POST-MISSION FEEDBACK FOR THE UNIT COMMANDER**

**DEVELOP SUPPORTING TRAINING TECHNOLOGY**

**VALIDATION OF TRAINING AND PERFORMANCE TRANSFER**

**METHODOLOGY FOR PERFORMANCE MEASUREMENT AND FEEDBACK**

**METHODOLOGY FOR TRAINING PROGRAM DEVELOPMENT**





**SCENARIOS FOR USING VIRTUAL ENVIRONMENTS**

**MISSION PLANNING & REHEARSAL**

**MISSION-SPECIFIC TRAINING**

**COMBAT PROFICIENCY TRAINING**

**COMBAT PROFICIENCY TRAINING**

---

**IMPROVE UNIT PROFICIENCY IN A VARIETY OF SITUATIONS**

**SOLDIERS ARE QUALIFIED IN INDIVIDUAL SKILLS**

**GENERIC MISSION, TERRAIN, & OPFOR**

**USUALLY REAL TIME**

## MISSION PLANNING & REHEARSAL

SUPPORT PLAN DEVELOPMENT & TRYOUT FOR SPECIFIC OPERATION

FAMILIARIZE SOLDIERS WITH THEIR ROLES (CRAWL & WALK)

COGNITIVE EMPHASIS (WHAT, WHEN, & WHERE)

INVOLVES UNIT & INDIVIDUAL TASKS

SOLDIERS ARE QUALIFIED IN INDIVIDUAL SKILLS

SPECIFIC MISSION, TERRAIN, & OPFOR

MAY DIFFER FROM REAL TIME (FASTER OR SLOWER)

FEEDBACK DIRECTED TOWARD IMPROVING THE PLAN

## MISSION-SPECIFIC TRAINING

IMPROVE CAPABILITY TO CARRY OUT A PLAN FOR A SPECIFIC  
OPERATION SUCCESSFULLY

INVOLVES UNIT & INDIVIDUAL TASKS

SOLDIERS ARE QUALIFIED IN INDIVIDUAL SKILLS

SPECIFIC MISSION, TERRAIN, & OPFOR

SOLDIERS PRACTICE THEIR ROLES (RUN)

COGNITIVE & PSYCHOMOTOR (WHAT, WHEN, WHERE, & HOW)

REAL TIME

## WHAT IS A VIRTUAL ENVIRONMENT ?

A SIMULATED SPACE WITH WHICH THE VIEWER DIRECTLY INTERACTS VIA HEAD-MOUNTED DISPLAYS, SENSOR-EQUIPPED GLOVES, AND SPECIAL EQUIPMENT. IT IS DISTINGUISHED FROM MOST VISUAL SIMULATIONS IN THAT THE 'VEHICLE' IS THE PARTICIPANT'S OWN BODY, RATHER THAN AN AIRCRAFT, TANK, ETC.

A VIRTUAL ENVIRONMENT REQUIRES

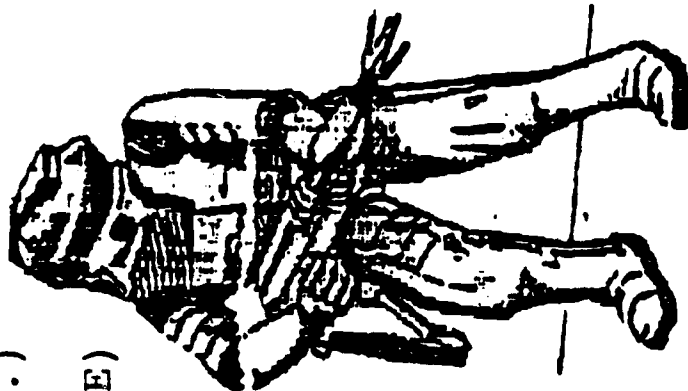
3-D REAL-TIME INTERACTIVE GRAPHICS (STEREOPSIS IF  
NEEDED)

MULTIPLE SENSES BEYOND GRAPHICS (SOUND, TOUCH...)

DIRECT MANIPULATION OF OBJECTS (E.G., BY A GLOVE)

FREE MOTION OF THE EYEPOINT WITHIN THE SPACE

MULTIPLE INTERACTING, MUTUALLY VISIBLE HUMANS





*"Is that you, or am I experiencing Artificial Reality?"*

"SATISFACTORY SEX, IN A FORM THAT COULD BE TRANSMITTED  
LONG-DISTANCE, BY COMPUTER, COULD BE AVAILABLE AS EARLY  
AS THE YEAR 2050."

JOEL GARREAU  
WASHINGTON POST SUNDAY MAGAZINE  
DECEMBER 30, 1990

ARI OPTION TO NTSC VETT CONTRACT

OBJECTIVES

EXAMINE VE CAPABILITIES AND TRENDS VIS A VIS INDIVIDUAL  
COMBAT SIMULATIONS (ICS)

CONSIDER CAPABILITIES OF THREE LEVELS OF ICS TO SUPPORT  
DISMOUNTED INFANTRY FUNCTIONS

LEVEL 1 (SIMNET/CCTT EQUIVALENT)

MULTI-SCREEN VISUAL DISPLAYS  
SPEAKERS FOR BATTLEFIELD SOUNDS  
JOYSTICKS & SIMILAR DEVICES  
DI ICONS

LEVEL 2 (3-5 YEARS)

LOW RESOLUTION HMD  
SENSING OF LIMB & BODY POSITION  
MOVEMENT IN PLACE  
HEADPHONES FOR LOCALIZED SOUND  
LIMITED SPEECH RECOGNITION (SD)  
SPECIALIZED CONTROL & SENSING DEVICES  
LOW-FIDELITY ARTICULATED DI ICONS

LEVEL 3 (>5 YEARS)

HIGH RESOLUTION HMD  
EYE TRACKING  
SENSORY STIMULATION OF WHOLE BODY MOVEMENT  
ADVANCED SPEECH RECOGNITION (SI)  
PROGRAMMABLE GENERAL-PURPOSE CONTROL &  
SENSING DEVICES  
FULLY ANIMATED DI ICONS



**ARI OPTION TO NTSC VETT CONTRACT**

---

**CONCLUSIONS**

ICS IS A LOGICAL PROGRESSION OF DIS CAPABILITIES  
THERE ARE POTENTIAL TRAINING & MISSION REHEARSAL  
BENEFITS TO BE OBTAINED FROM THE TECHNOLOGY AVAILABLE  
NOW

**DIFFICULT PROBLEMS**

MISSION-SPECIFIC TRAINING  
URBAN OR CLOSE-IN OPERATIONS  
CONTROL AND MANIPULATION OF WEAPONS AND EQUIPMENT  
WHOLE BODY MOVEMENT

## **MAKING VIRTUAL ENVIRONMENTS A REALITY**

### **ENGINEERING/COMPUTER SCIENCE ISSUES**

**VISUAL DISPLAYS**

**REAL-TIME IMAGERY CONSTRUCTION**

**HEAD & BODY TRACKING**

**TACTILE & FORCE SENSING & FEEDBACK**

**DATABASE GENERATION**

### **BEHAVIORAL ISSUES**

**INTERFACE REQUIREMENTS**

**PERFORMANCE MEASUREMENT & FEEDBACK**

**PERFORMANCE & TRAINING TRANSFER**

**TRAINING STRATEGIES**

AN EXAMPLE OF WHAT WE DON'T KNOW

WHAT VISUAL DISPLAY UPDATE RATE IS REQUIRED FOR A PERCEPTION  
OF CONTINUOUS MOVEMENT?

| <u>SOURCE</u>                      | <u>UPDATES/SEC</u> |
|------------------------------------|--------------------|
| FLIGHT SIMULATORS                  | 60                 |
| ENTERTAINMENT INDUSTRY             | 30                 |
| THRU SIMULATED BUILDING (UNC)      | 20                 |
| DRIVER SIMULATOR (STI)             | 20                 |
| PARACHUTE MANEUVER SIMULATOR (STI) | 10                 |

## PRELIMINARY VIRTUAL ENVIRONMENT INTERFACE ISSUES

### INPUT (SOLDIER -> COMPUTER) REQUIREMENTS

#### MOVEMENT TRACKING

GROSS

FINE

HEAD/EYE

HAND/FINGER

#### VOICE RECOGNITION

### OUTPUT (COMPUTER -> SOLDIER) REQUIREMENTS

#### VISUAL DISPLAYS

BRIGHTNESS

RESOLUTION

NEAR OBJECTS

FAR OBJECTS

UPDATE RATE

MOVEMENT RATE & LAG

HEAD MOVEMENT COMPENSATION

FIELD OF VIEW

STEREOSCOPIC VS MONOCULAR DISPLAYS

COLOR

#### TERRAIN REPRESENTATION

AREA

LEVEL OF DETAIL (GRANULARITY)

FUNCTIONAL VS PHYSICAL FIDELITY

ENVIRONMENT

WEAPONS & EQUIPMENT

TACTILE FEEDBACK

FORCE FEEDBACK

AUDITORY CUES/VOICE SYNTHESIS

LOCALIZATION

LIBRARY

### HUMAN FACTORS ISSUES

**BEHAVIORAL REQUIREMENTS FOR TRAINING AND REHEARSAL IN VIRTUAL ENVIRONMENTS (ILLUSION ENGINEERING, INC)**

**DEVELOP PRACTICAL USAGE SCENARIOS AND TASKS TO BE PERFORMED FOR**

**COMBAT PROFICIENCY TRAINING  
MISSION PLANNING & REHEARSAL  
MISSION-SPECIFIC TRAINING**

**DEVELOP TAXONOMY OF SIGNIFICANT VIRTUAL ENVIRONMENT  
INTERFACE CHARACTERISTICS**

**DETERMINE INTERFACE REQUIREMENTS FOR EACH TYPE OF TASK**

**SUMMARIZE LITERATURE**

**IDENTIFY KNOWLEDGE GAPS**

**DEVELOP RESEARCH PLAN TO FILL GAPS**

**IDENTIFY REQUIREMENTS & COST FOR RESEARCH TEST BED**

## **VIRTUAL ENVIRONMENTS RESEARCH GOALS**

**IDENTIFY VIRTUAL ENVIRONMENT INTERFACE REQUIREMENTS FOR MISSION PLANNING & REHEARSAL, MISSION-SPECIFIC TRAINING, AND COMBAT PROFICIENCY TRAINING FOR THE DISMOUNTED SOLDIER**

**EXAMINE FEASIBILITY OF VIRTUAL ENVIRONMENT TECHNOLOGY TO SUPPORT MISSION PLANNING AND POST-MISSION FEEDBACK FOR THE UNIT COMMANDER**

**DEVELOP SUPPORTING TRAINING TECHNOLOGY**

**VALIDATION OF TRAINING AND PERFORMANCE TRANSFER**

**METHODOLOGY FOR PERFORMANCE MEASUREMENT AND FEEDBACK**

**METHODOLOGY FOR TRAINING PROGRAM DEVELOPMENT**

**CREW, GROUP, TEAM, AND UNIT TECHNOLOGY SUB-GROUP**

**Opening Remarks**

**Joint Collective Training R&D Effort:**

**Dr. Frank Moses, ARI**

**Dr. Eduardo Salas, NTSC**

**(No hard copies available)**

# **ASSESSMENT OF JOINT TRAINING STRATEGIES FOR INCREASING WARFIGHTING EFFECTIVENESS**

## **Participating Organizations:**

**ARI**

**NTSC**

**ALHR & ASD/XR**

**Dr. Frank Moses  
POC @ ARI  
Tel: 274-8293)**



## **ASSESSMENT OF JOINT TRAINING STRATEGIES**

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### **GOAL**

#### **DEVELOP TECHNOLOGIES FOR --**

- **TRAINING JOINT SERVICE TASKS -- MIXES OF GROUND, ROTARY, FIXED-WING, BEACHHEAD ASSAULT, AND SUPPORTING NAVAL FORCES**
- **ASSESSING JOINT TRAINING STRATEGIES -- SCHEDULES OF TRAINING EVENTS AND DISTRIBUTION OF RESOURCES**

### **NEED**

- **INCREASE JOINT TRAINING EFFECTIVENESS THROUGH BEST USE OF DISTRIBUTED INTERACTIVE SIMULATION**

- **DEVELOP OR ADAPT A TRAINING TESTBED\***
- **DEVELOP PROTOTYPE METHODS FOR AFTER ACTION REVIEWS (AARs) AND OTHER FEEDBACK TECHNIQUES**
- **DEMONSTRATE TRAINING PRINCIPLES/PROCEDURES, AARs, AND OTHER TRAINING AND PERFORMANCE FEEDBACK TECHNIQUES**
- **ANALYTICALLY ESTIMATE THE TRADEOFFS AMONG ALTERNATIVE TRAINING PRINCIPLES/PROCEDURES**

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\* A DATABASE WITH (A) GENERIC WARTIME SCENARIOS REQUIRING JOINT OPERATIONS AND (B) METHODS/TECHNOLOGIES FOR SELECTIVE REPLAY AND MEASUREMENT OF COLLECTIVE TRAINING PERFORMANCE

## **R & D SCOPE**

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- **ADDRESS MULTI-SERVICE COMBAT TRAINING RE:  
BATTLE PLANNING, PREPARATION, AND EXECUTION**
  - - **CLOSE AIR SUPPORT, SAFE PASSAGE**
  - - **COMBINED AMPHIBIOUS AND LAND ASSAULT**
- **FORCE-LEVEL TRAINING**
  - - **BOTH HORIZONTAL AND VERTICAL ORGANIZATIONS**
  - - **COMBINATIONS OF ANY TWO-OR-MORE ECHELONS**

## **COLLECT CRITICAL DATA**

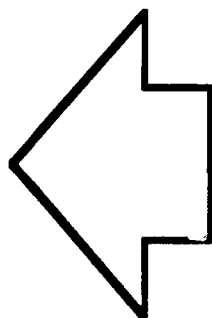
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- **FROM OBSERVATIONS OF TRAINING WITH SIMULATOR NETWORKS**
  - - **IDENTIFY CRITICAL TASKS FOR COMBAT SCENARIOS**
  - - **IDENTIFY MEASUREMENT ISSUES AND METHODS**
- **ANALYZE OBSERVATIONS/DATA IN TERMS OF**
  - - **PERFORMANCE REVIEW**
  - - **CROSS-TRAINING**
  - - **FREQUENCY OF TRAINING**
  - - **GUIDED PRACTICE**
  - - **ETC**

*HOW TO GET THERE*

## ENHANCED TRAINING STRATEGIES

(FTX .. DEPLEX .. LFX .. CPX ...)



### MEASURES

Assessment Data

### RESOURCES

Logistics  
Spaces  
Ranges

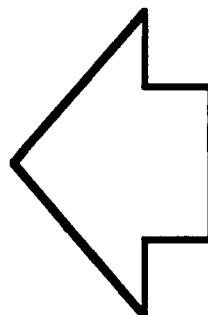


R & D



### SCENARIOS

Objectives  
Conditions  
Tasks-Functions

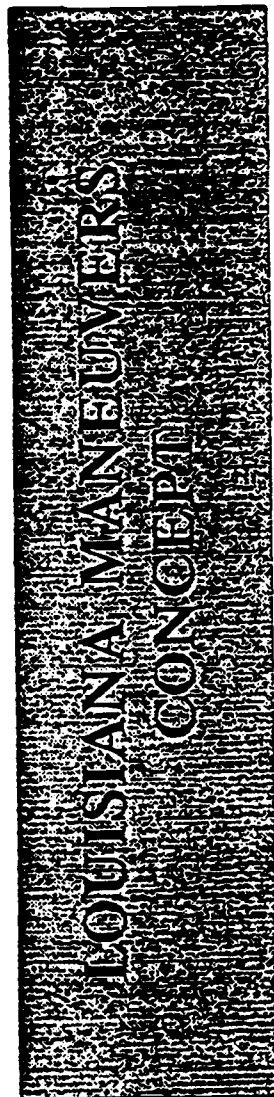


### EMERGING TECHNOLOGIES \*

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\* Models, Simulations, Distributed Interactive Simulations/Networks, Virtual Reality, etc.

## RELATED INITIATIVES



REALISTIC (LG UNIT) EXERCISES  
"ACHIEVE WARTIME REALISM"

☆☆☆ Commanders Conference

# HISTORICALLY: ARMY-AIR

## LOUISIANA MANEUVERS

1941

### CONCEPT

- GOAL: BATTLEFIELD REALISM; VALIDATE TRAINING, ORGANIZATION AND DOCTRINE
- RED/BLUE FIELD ARMY WITH AIR TASK FORCE
- OFFENSIVE MISSION FOR BOTH SIDES
- FREE PLAY, FIRE MARKERS AND UMPIRES
- NO SCRIPTED SCENARIOS AND <sup>MINIMAL</sup> ~~MANUAL~~ CONTROL MEASURES
- STRESS C2, MANEUVER, MOVEMENT AND LOGISTICS
- UMPIRE MANUAL USED TO RESOLVE ENGAGEMENTS
- FIRST USE OF AFTER ACTION CRITIQUE

### LARGE SCALE MEETING ENGAGEMENTS

☆☆☆ Commanders Conference —

## LOUISIANA MANEUVERS

1941

### LESSONS LEARNED

- LARGE SCALE EXERCISES ARE EFFECTIVE
  - TRAINS SR CDR'S & STAFF OFFICERS
  - COUNTERPRODUCTIVE FOR GROUND TROOPS
- UMPIRE MANUAL VALID MEANS OF RESOLVING COMBAT
  - REVISION OF SOME TABLES REQUIRED
  - DIDN'T REFLECT ACTUAL CAPABILITY OF ALL UNITS AND WEAPONS
- FOLLOW ON TRAINING PROGRAM FOCUSED AT SMALL UNIT LEVEL
  - STANDARDIZED PERFORMANCE MEASURES
  - CENTRALIZED EVALUATION
- AFTER ACTION CRITIQUE - EFFECTIVE TOOL

EFFECTIVE TRAINING TOOL FOR TARGET AUDIENCES

☆☆☆ Commanders Conference



*MODERN: Army ++ → JONT*

## LOUISIANA MANEUVERS

1994

### - TNG AUDIENCE

- THEATRE ARMY
- ARMY GROUP
- FIELD ARMY
- CORPS
- DIVISION (EXERCISE CELL/FIELD LOCATIONS?)

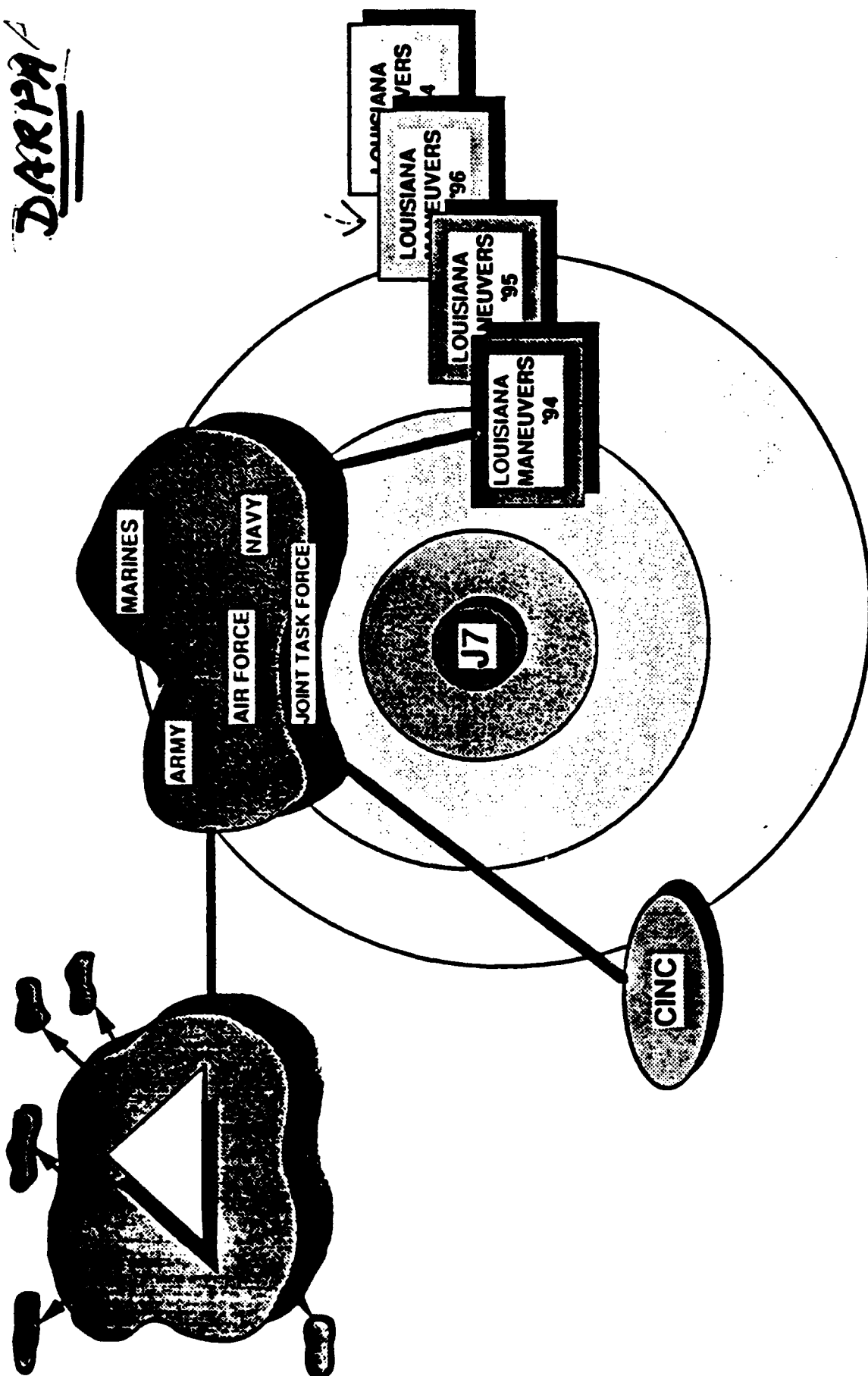
### - AREAS OF EMPHASIS:

- SR CDR & STAFF OFFICER TNG
- JOINT/COMBINED OPERATIONS
- CAMPAIGN PLANNING
- COMMAND & CONTROL
- FORCE PACKAGING
- FORCE PROJECTION
- LARGE SCALE MANEUVER
- LARGE SCALE MOVEMENT
- SUSTAINMENT
- INTELLIGENCE
- REDEPLOYMENT

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# SYNTHETIC BATTLEFIELDS ON DEMAND

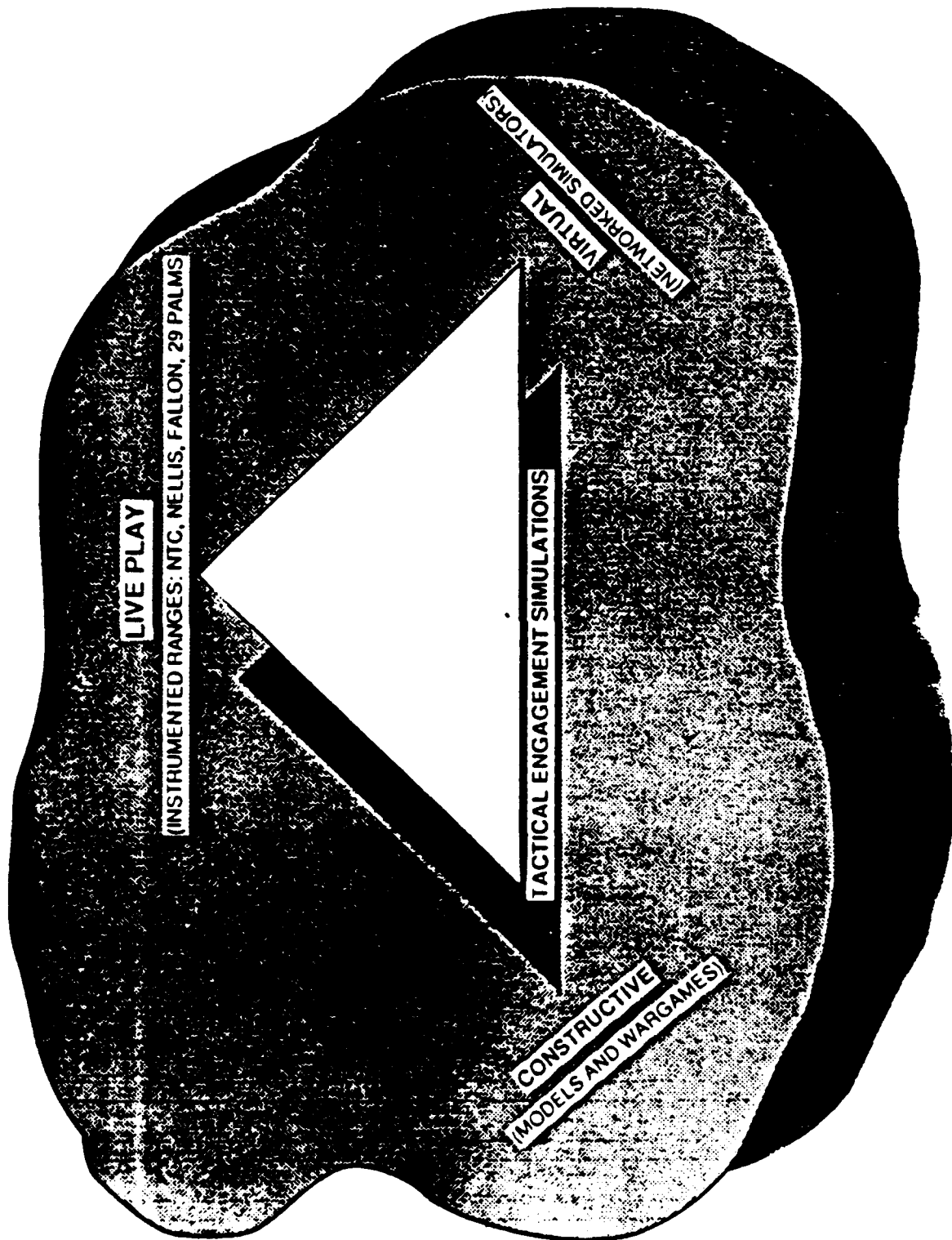
**DARPA**

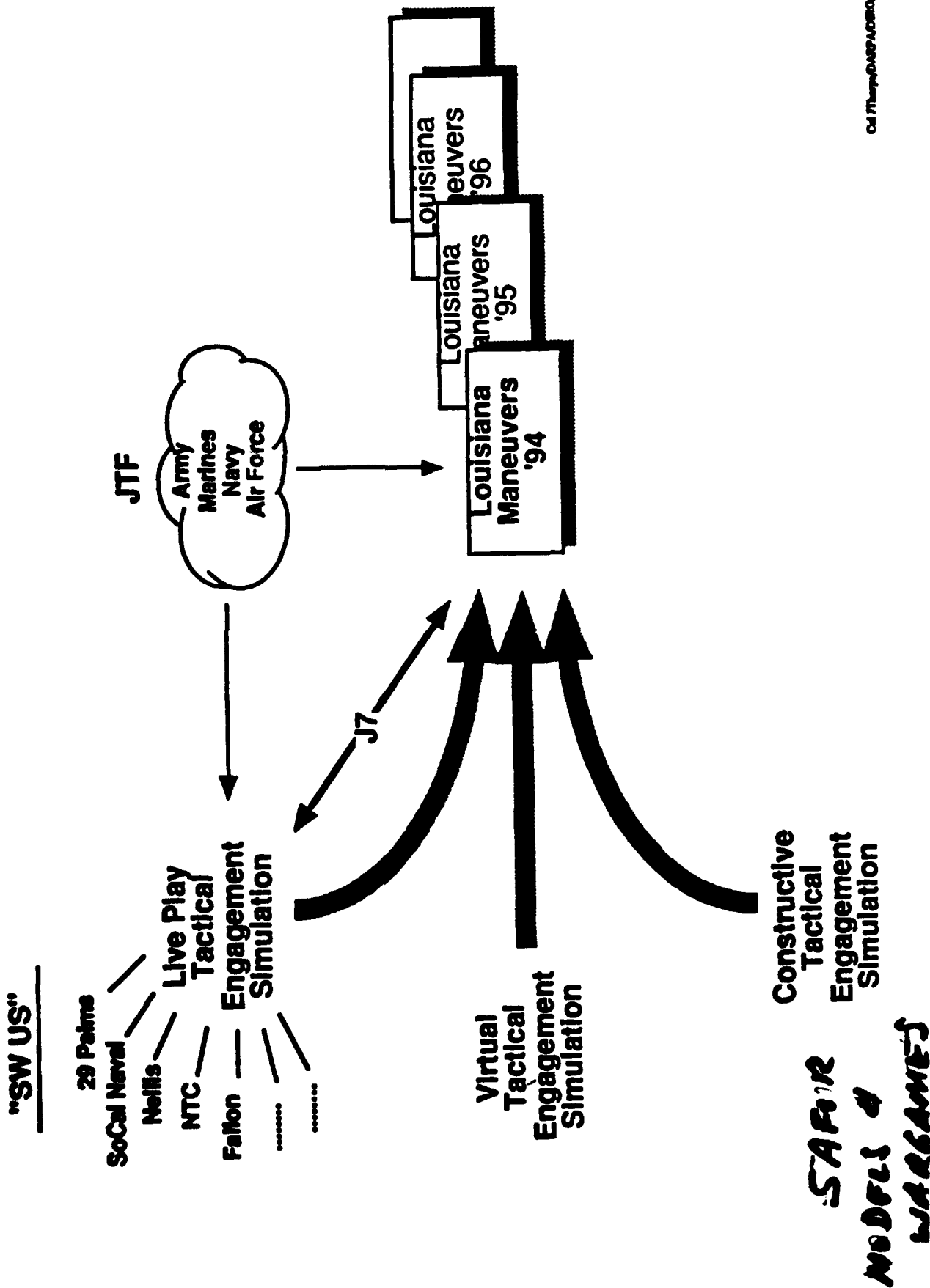




Advanced Systems  
Technology Office

## SIMULATION TECHNOLOGY FOR THE SYNTHETIC BATTLEFIELD





# SYNTHETIC BATTLEFIELDS ON DEMAND

CONCEPT

KOREAN  
3D SIMULATION  
TEST BED

NTC 3D  
SIMULATION TEST  
BED

OTHER S/W USA  
3D SIMULATION  
TEST BEDS

CENTCOM  
SIM  
TEST BED

THEATER - SCALE SIMULATION  
LINKED LAND, SEA, AIR FIELD EXERCISES AND SIMULATIONS  
MULTIPLE SIMULTANEOUS SCALABLE AGGREGATION LEVELS  
WORLD -WIDE MANEUVER AREA  
MULTIPLE WAR GAMES

DSINET

**TRAINING DESIGN & EVALUATION**

**Training Needs and Evaluation Issues**

**Identifying Over-and-Under Trained Tasks:  
Ms. Michele Morales**

**Opportunities to Perform Trained Tasks  
Dr. Mark Teachout**

# **AN INVESTIGATION OF TRAINING EFFICIENCY**

**MICHELE M. MORALES  
ARMSTRONG LABORATORY**

**MARCH 1992**

# TRAINING EFFICIENCY RESEARCH

## OUTLINE

- RESEARCH OBJECTIVES
- 4 PHASES OF PROJECT
  - TRAINING CONTENT IDENTIFICATION
  - TRAINING EMPHASIS IDENTIFICATION
  - MATCHING TECHNIQUE APPLICATION
  - TASK PERFORMANCE LINKED WITH MATCHING TECHNIQUE
- CURRENT RESEARCH



# RESEARCH OBJECTIVES

TO DEVELOP METHODOLOGIES TO EXAMINE:

1. TRAINING CONTENT VALIDITY
  - IS TRAINING CONTENT JOB RELEVANT?
2. TRAINING EFFICIENCY
  - ARE TASKS OVER OR UNDERTRAINED?

FOR THE AGE ABR COURSE

# **STEP 1**

## **IDENTIFICATION OF TRAINING CONTENT DOMAIN**

**PURPOSE: IDENTIFY TRAINING CONTENT DOMAIN  
IN TERMS OF OSR TASK STATEMENTS**

**METHOD: SMES LINKED OSR TO POI  
SMES LINKED TASKS TO INSTRUCTIONAL  
AREAS**

**INSTRUCTORS VERIFIED LINKS**

**OUTCOME: TRAINING DOMAIN IDENTIFIED  
AS CONSISTING OF 99 TASKS**

## **STEP 2**

### **IDENTIFICATION OF TRAINING EMPHASIS**

**PURPOSE: IDENTIFY EMPHASIS INSTRUCTORS  
PLACE ON EACH TASK TRAINED**

**METHOD: SURVEYS DEVELOPED FOR THE FIVE  
INSTRUCTIONAL AREAS**

**53 INSTRUCTORS SURVEYED  
ESTIMATED TOTAL TIME DEVOTED TO  
EACH TASK**

**OUTCOME: TIME ESTIMATES FOR THE  
99 TASKS TRAINED**

# **STEP 3**

## **APPLICATION OF THE MATCHING TECHNIQUE**

**PURPOSE:** APPLY MATCHING TECHNIQUE  
TO AGE ABR COURSE

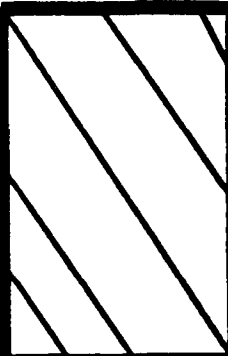
**METHOD:** COMPARE OSR EMPHASIS RATINGS  
TO INSTRUCTOR TIME ESTIMATES  
RATINGS AND TIME ESTIMATES  
TRANSFORMED TO Z-SCORES

COMPUTER SOFTWARE DEVELOPED TO  
DISPLAY RESULTS

**OUTCOMES:** IDENTIFICATION OF POTENTIALLY OVER  
OR UNDERTRAINED TASKS

# MATCHING TECHNIQUE TO EXAMINE TRAINING EFFICIENCY

TRAINING  
EMPHASIS  
FROM  
OSR  
RATINGS

|                                    | HI                                                                                | MED               | LOW                              |
|------------------------------------|-----------------------------------------------------------------------------------|-------------------|----------------------------------|
| POSSIBLE<br>TRAINING<br>DEFICIENCY |  |                   |                                  |
|                                    |                                                                                   | TRAINING<br>MATCH |                                  |
|                                    |                                                                                   |                   | POSSIBLE<br>TRAINING<br>EXCESSES |
|                                    | LOW                                                                               | MED               | HI                               |
| ACTUAL TRAINING EMPHASIS           |                                                                                   |                   |                                  |

### TASK 441 ADJUST PNEUMATIC SYSTEM CLUTCHES

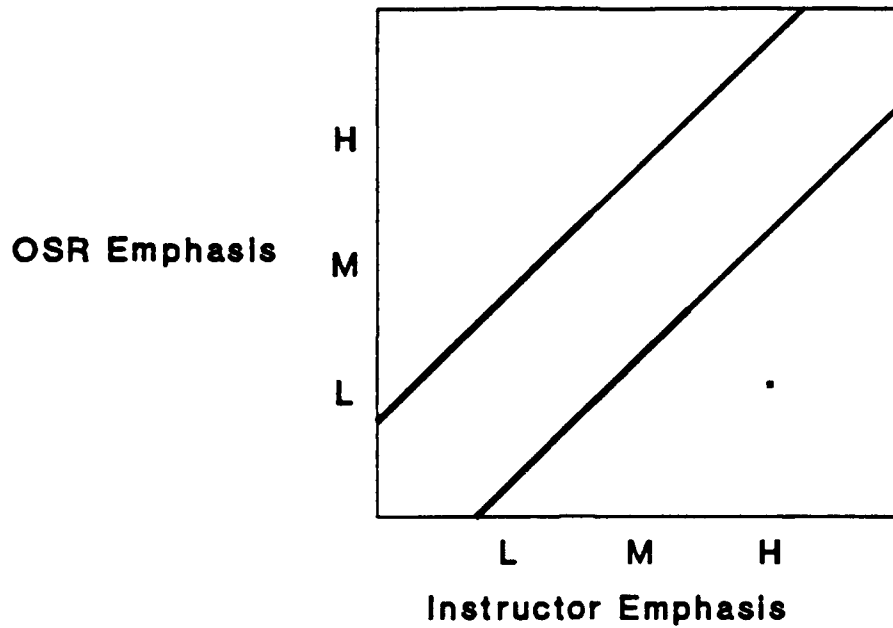


Figure 1a: Possible overtrained task

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### TASK 246 ADJUST GAS TURBINE ENGINE GOVERNORS

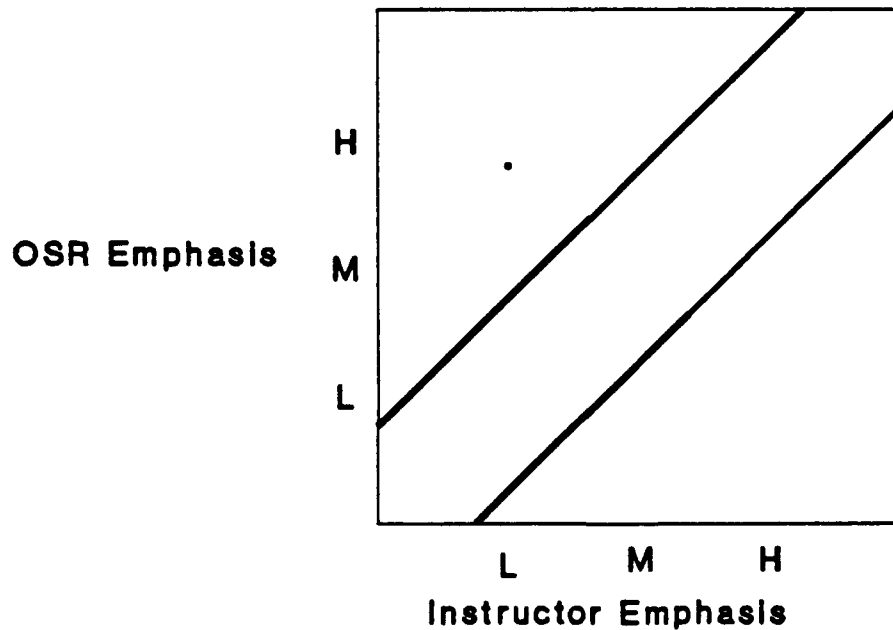


Figure 1b: Possible undertrained task

FIGURE 1. Examples of Possible Over and Undertrained Tasks.

**TASK 264: ISOLATE ENGINE OR MOTOR MECH. MALF.**

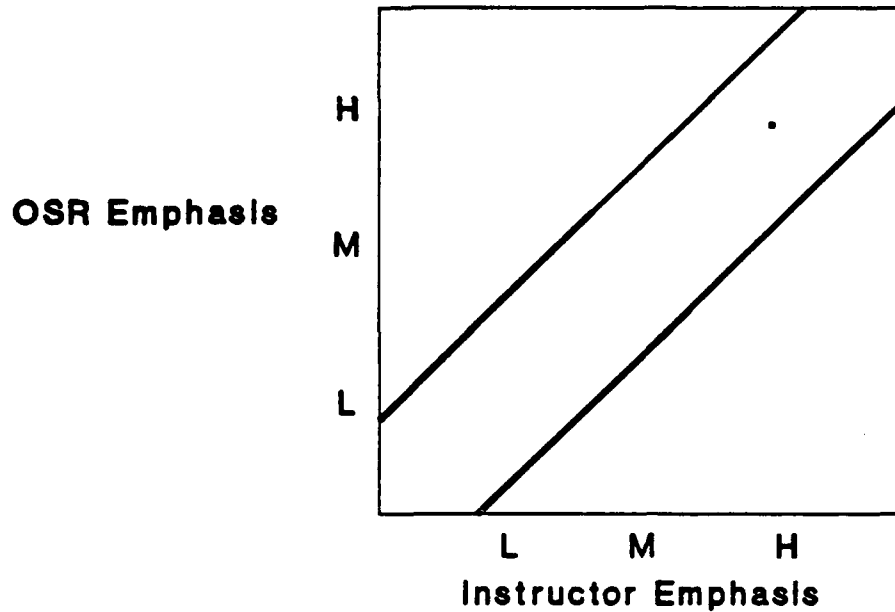


**Figure 2a: Training hit, high emphasis**

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**TASK 226: REMOVE OR INSTALL CANNON PLUG PARTS**

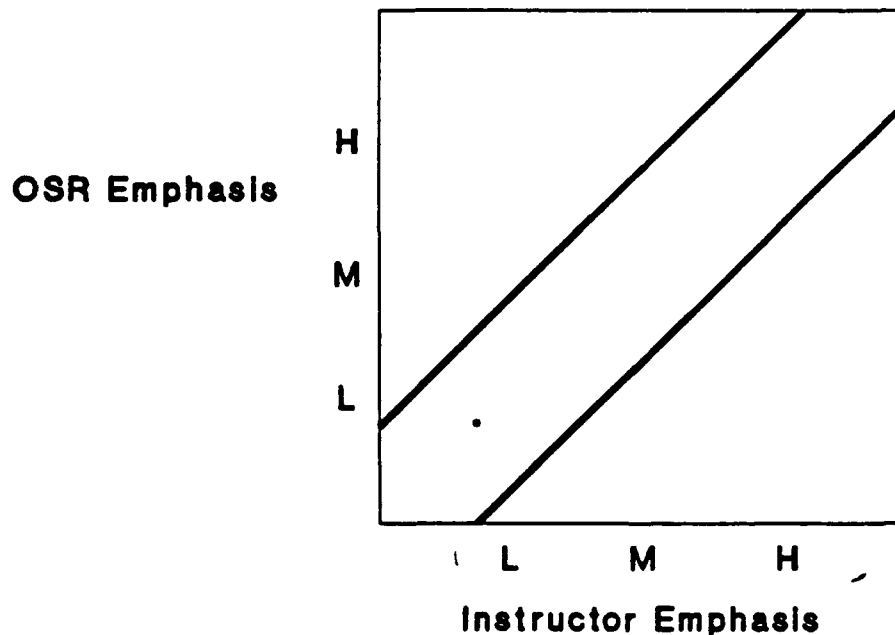


**Figure 2b: Training hit, low emphasis**

**FIGURE 2. Examples of Tasks that are Training Hits.**

## **STEP 4**

### **LINKING MATCHING OUTCOMES & PERFORMANCE**

**PURPOSE:** RELATE MATCHING OUTCOMES WITH TASK  
PERFORMANCE OF AGE AIRMEN

**METHOD:** DEVELOPMENT OF CONCEPTUAL MODEL  
USE OF JPMS HANDS ON PERFORMANCE DATA  
FOR THE 11 TASKS TRAINED IN ABR COURSE  
PERFORMANCE OF 52 OF 286 AIRMEN EXAMINED  
WEIGHTED COMPOSITE SCORES ABOVE 5  
CONSIDERED "PERFORMED WELL"

**OUTCOMES:** TASKS FOUND IN ALL SIX CELLS OF MODEL



# JOB PERFORMANCE LEVEL

Not Performed Well      Performed Well  
(Few People can Perform      (Most People can Perform  
the Task Well)      the Task Well)

|                                                        |                                         |
|--------------------------------------------------------|-----------------------------------------|
| Eliminate from Training<br>and Find Other Options      | Reduce or Maintain<br>Training Emphasis |
| Increase Training<br>Emphasis                          | Maintain Current<br>Emphasis            |
| Increase Training<br>Emphasis or Find<br>Other Options | Maintain Current<br>Emphasis            |

Training  
Excesses

Training  
Deficiencies

Training  
Hits

## RESULTS OF MATCHING TECHNIQUE

FIGURE 3. Model of Matching Outcomes and Task Performance.

# JOB PERFORMANCE LEVEL

Not Performed Well      Performed Well  
(Few People can Perform      (Most People can Perform  
the Task Well)      the Task Well)

|            |                   |
|------------|-------------------|
| 446        | 209               |
| 251<br>503 | 154<br>155<br>162 |
| 179<br>264 | 215<br>238        |

Training  
Excesses

Training  
Deficiencies

Training  
Hits

## RESULTS OF MATCHING TECHNIQUE

FIGURE 4. Results of Linking Matching Outcomes to Performance.

# **CURRENT RESEARCH**

- **GOAL OF TRAINING**
- **COLLECTION OF KNOWLEDGE AND PERFORMANCE DATA**
- **STUDY OF VARIABLES THAT INFLUENCE TRAINING**

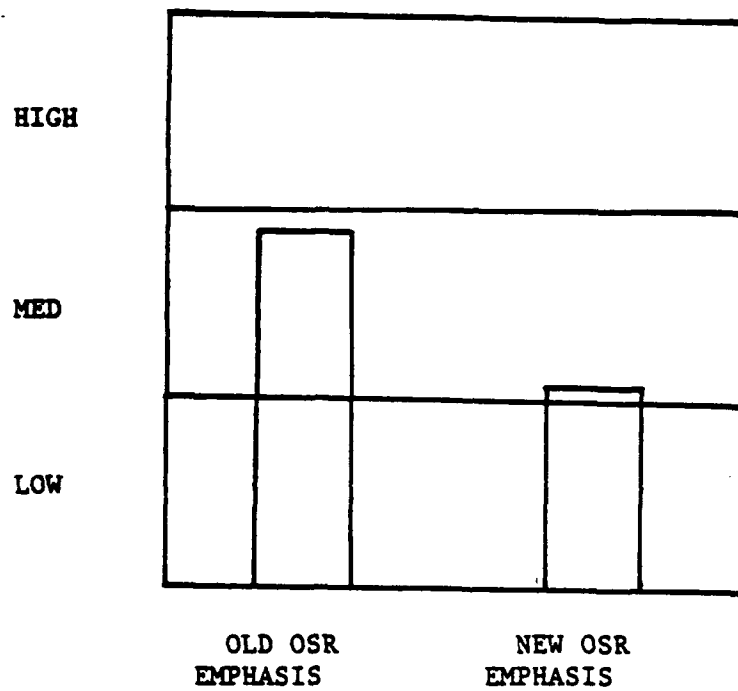
Cluster by equipment  
Cluster by function  
Rank order by % performing first term  
Rank-order by difficulty rating  
Rank order by % performing 1st 12 mo.  
Rank order by ATI  
Return to main menu

Use the UP and DOWN ARROWS to highlight an option

Press RETURN to select the highlighted option

Screen 11

Task: 381 Isolate electrical circuitry malfunctions



Press any key to continue

Screen 17

# FACTORS AFFECTING THE OPPORTUNITY TO PERFORM TRAINED TASKS

MARK S. TEACHOUT  
23 MARCH 1992

**PART I:** For each task statement listed below, answer the following questions in the appropriate column. When completing these questions, only consider the first twelve months since graduation from Chanute AFB regardless of how long you have been at your present duty station.

1. In the first 12 months since completion of training at Chanute AFB, have you **PERFORMED** this task either with or without supervision? Completely fill in the circle "Y" if you have performed the task or fill in the circle "N" if you have not performed the task.

For every item that you answer yes, please answer the following two questions:

2. **WHEN** was the first time you performed the task? Fill in "Y" if you first performed the task in the first eight months after graduation. Otherwise, fill in the number corresponding to the month in which you first performed the task.

3. **HOW MANY TIMES** have you performed the task since graduating from Chanute AFB? Use the boxes to mark your answer. For example, if you have performed "Adjust contactor points" two times in the first twelve months since graduating from Chanute, you would write in the boxes **0 0 2**

|     |                                                                                 | PERFORMED?                         |                         | WHEN?      | HOW MANY                                                       |
|-----|---------------------------------------------------------------------------------|------------------------------------|-------------------------|------------|----------------------------------------------------------------|
|     |                                                                                 | YES                                | NO                      | (MONTH)    | OF TIMES?                                                      |
| 1.  | Fill out AFTO Forms 244 .....                                                   | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 2.  | Make entries on AFTO Forms 350 (item processing tag) .....                      | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 3.  | Perform generator inspections .....                                             | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 4.  | Measure resistance in electrical circuits .....                                 | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 5.  | Perform electrical system operational checks .....                              | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 6.  | Solder electrical wiring .....                                                  | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 7.  | Splice electrical wiring. ....                                                  | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 8.  | Adjust engine fuel system components .....                                      | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 9.  | Isolate engine, motor, or generator mechanical malfunctions .....               | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 10. | Perform compression tests .....                                                 | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 11. | Perform engine, motor, or generator operational checks .....                    | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 12. | Remove or install AGE tire, tube, or wheel assemblies .....                     | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 13. | Perform air conditioner visual or service inspections .....                     | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 14. | Perform hydraulic test stand service inspections .....                          | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 15. | Perform hydraulic test stand periodic inspections .....                         | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 16. | Clean motor or generator armatures .....                                        | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 17. | Charge refrigerant systems .....                                                | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 18. | Perform air conditioner leakage tests .....                                     | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 19. | Perform air conditioner operational checks .....                                | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 20. | Purge refrigerant systems .....                                                 | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 21. | Adjust hydraulic high pressure system components .....                          | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 22. | Isolate hydraulic system malfunctions .....                                     | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 23. | Perform hydraulic system operational checks .....                               | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 24. | Pack wheel bearings .....                                                       | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 25. | Perform load bank inspections .....                                             | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 26. | Remove or install engine fan belts .....                                        | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 27. | Perform generator periodic inspections .....                                    | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 28. | Perform gas turbine compressor periodic inspections .....                       | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 29. | Adjust turbine engine bleed air systems .....                                   | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 30. | Adjust turbine engine fuel systems .....                                        | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 31. | Load test generator sets .....                                                  | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 32. | Perform air compressor periodic inspections .....                               | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 33. | Isolate heating system malfunctions .....                                       | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 34. | Perform heating system operational checks .....                                 | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 35. | Isolate air compressor system malfunctions .....                                | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 36. | Remove or install air compressor filtering system components. ....              | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 37. | Remove or install fuel lines or fittings other than diesel .....                | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 38. | Remove or install hydraulic lines or fittings .....                             | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 39. | Research TO's, charts, or diagrams for AGE enclosures, chassis, or drives ..... | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |
| 40. | Inspect vehicles for safety of operation .....                                  | <input checked="" type="radio"/> Y | <input type="radio"/> N | 9 10 11 12 | <input type="text"/> <input type="text"/> <input type="text"/> |

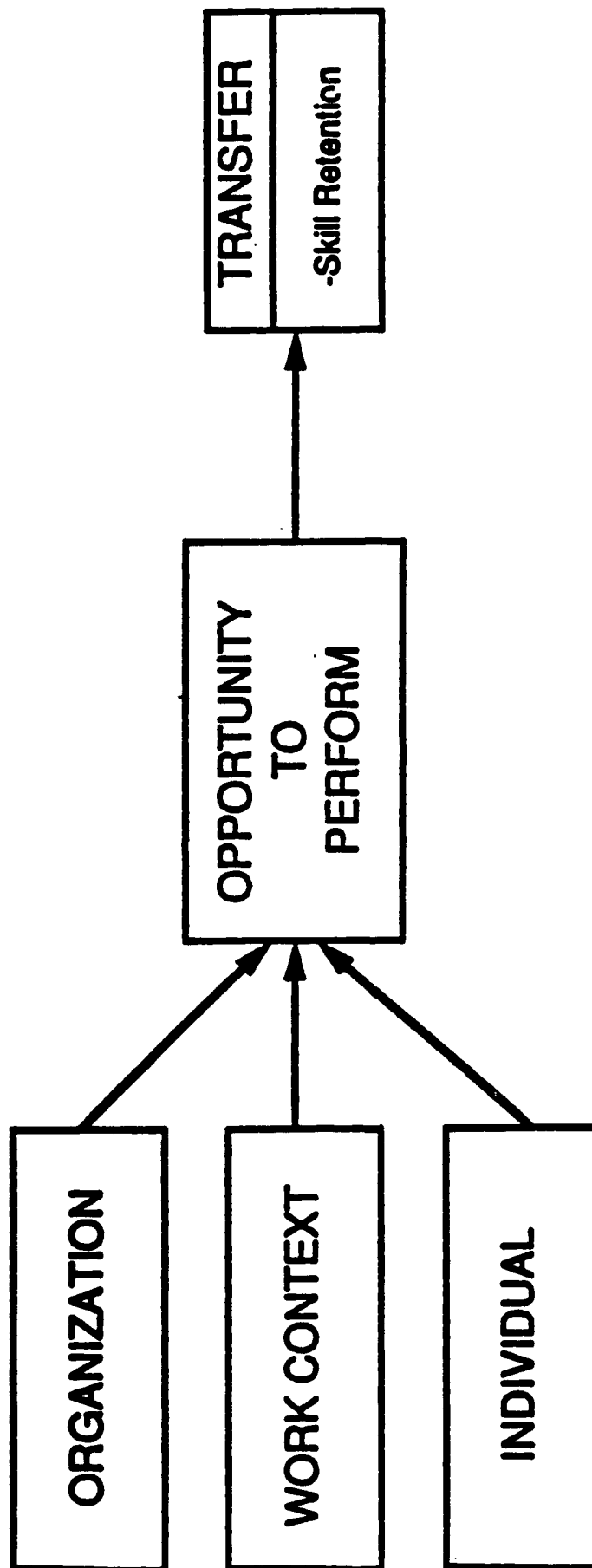
**% PERFORMING TASK BY MONTH**  
**After 4 Months**

| TASK # | MONTH |      |      |      | TOTAL |
|--------|-------|------|------|------|-------|
|        | 1     | 2    | 3    | 4    |       |
| 1      | 62.4  | 27.5 | 4.2  | .5   | 94.6  |
| 2      | 47.6  | 27.8 | 11.8 | 3.2  | 90.4  |
| 3      | 22.2  | 33.3 | 16.4 | 4.2  | 76.1  |
| 4      | 17.5  | 35.4 | 12.7 | 5.3  | 70.9  |
| 5      | 29.8  | 29.8 | 17.6 | 3.7  | 80.9  |
| 6      | 13.6  | 19.4 | 17.3 | 4.7  | 55.0  |
| 7      | 24.1  | 35.6 | 16.2 | 2.6  | 78.5  |
| 8      | 8.9   | 25.8 | 20.0 | 4.7  | 59.4  |
| 9      | 12.2  | 21.7 | 20.1 | 5.8  | 59.8  |
| 10     | 1.6   | 5.3  | 7.4  | 1.6  | 15.9  |
| 11     | 41.0  | 37.8 | 12.8 | 2.7  | 94.3  |
| 12     | 21.6  | 35.8 | 24.2 | 2.6  | 84.2  |
| 13     | 7.4   | 22.6 | 12.6 | 11.6 | 54.2  |
| 14     | 3.7   | 12.6 | 15.3 | 6.8  | 38.4  |
| 15     | 2.6   | 5.2  | 9.9  | 3.7  | 21.4  |
| 16*    | 4.2   | 12.1 | 7.9  | 3.2  | 27.4  |
| 17     | 0.0   | 4.7  | 3.2  | 1.6  | 9.5   |
| 18     | 0.0   | 2.6  | 3.7  | 1.0  | 7.3   |
| 19     | 5.2   | 18.8 | 16.8 | 5.2  | 46.0  |
| 20     | 0.0   | 2.6  | 3.1  | 0.0  | 5.7   |



**Times Performing Task**  
**After 4 Months**

| <b>TASK</b> | <b>MEAN</b> | <b>RANGE</b> | <b>SD</b> |
|-------------|-------------|--------------|-----------|
| 1           | 20.8        | 1-125        | 22.7      |
| 2           | 10.1        | 1-75         | 10.1      |
| 3           | 7.6         | 1-75         | 10.6      |
| 4           | 5.3         | 1-25         | 5.3       |
| 5           | 12.0        | 1-75         | 12.9      |
| 6           | 3.3         | 1-20         | 3.4       |
| 7           | 8.7         | 1-50         | 9.7       |
| 8           | 4.2         | 1-15         | 3.4       |
| 9           | 5.6         | 1-25         | 4.8       |
| 10          | 3.3         | 1-20         | 4.0       |
| 11          | 20.3        | 1-104        | 20.8      |
| 12          | 6.8         | 1-30         | 6.5       |
| 13          | 6.0         | 1-35         | 7.3       |
| 14          | 4.9         | 1-30         | 5.8       |
| 15          | 2.3         | 1-8          | 2.1       |
| 16*         | 3.8         | 1-20         | 3.9       |
| 17          | 3.8         | 1-15         | 4.4       |
| 18          | 2.5         | 1-10         | 2.5       |
| 19          | 6.0         | 1-35         | 6.9       |
| 20          | 2.9         | 1-10         | 3.0       |



## **OPPORTUNITY TO PERFORM CONSTRUCT**

| <b>DIMENSION</b>      | <b>DEFINITION</b>             |
|-----------------------|-------------------------------|
| <b>Breadth</b>        | <b># of Tasks</b>             |
| <b>Activity Level</b> | <b># Times</b>                |
| <b>Task Type</b>      | <b>Difficulty/Criticality</b> |

# **METHOD**

## **TRAINING COURSE**

**Aerospace Ground Equipment**

**18 Weeks**

**99 Tasks Taught**

## **SAMPLE**

**180 Recent Graduates**

**34 Tasks Sampled**

## **DATA COLLECTION**

**Survey Methodology**

**Measures gathered 4 months after training**

# MEASURES

## SUPERVISOR

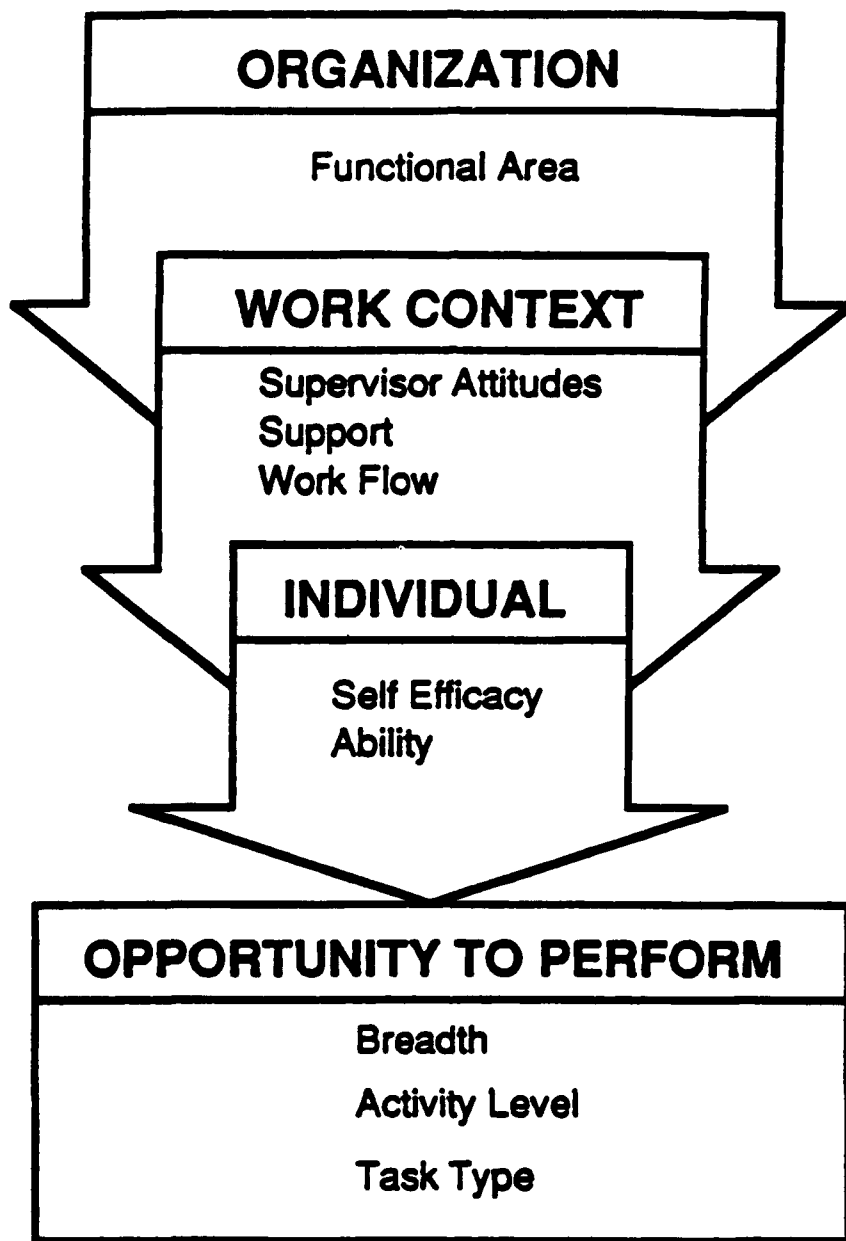
Attitudes Toward Airman  
Work Flow

## AIRMAN

Opportunity to Perform  
Support  
Self Efficacy

## OTHER

MAJCOM  
Ability (ASVAB)



# Hierarchical Block Regression Results

## For Breadth

| STEP  | VARIABLES                                          | R <sup>2</sup> | ΔR <sup>2</sup> |
|-------|----------------------------------------------------|----------------|-----------------|
| 1     | MAJCOM                                             | .04            | .04             |
| ----- |                                                    |                |                 |
| 2     | Sup Attitudes <sup>a</sup><br>Support<br>Work Flow | .10*           | .06*            |
| ----- |                                                    |                |                 |
| 3     | Self Efficacy <sup>a</sup><br>Ability (AFQT)       | .20*           | .10*            |

NOTE: \* p<.05

<sup>a</sup> Beta for this variable was significant (P<.05) at this step

# Hierarchical Block Regression Results

## For Activity Level

| STEP | VARIABLES                                    | R <sup>2</sup> | ΔR <sup>2</sup> |
|------|----------------------------------------------|----------------|-----------------|
| 1    | MAJCOM <sup>a</sup>                          | .07*           | .07*            |
| 2    | Sup Attitudes<br>Support<br>Work Flow        | .09*           | .02             |
| 3    | Self Efficacy<br>Ability (AFQT) <sup>a</sup> | .13*           | .04*            |

NOTE: \*  $p < .05$

<sup>a</sup> Beta for this variable was significant ( $P < .05$ ) at this step



# Hierarchical Block Regression Results

## For Task Type

| STEP | VARIABLES                                                       | R <sup>2</sup> | ΔR <sup>2</sup> |
|------|-----------------------------------------------------------------|----------------|-----------------|
| 1    | MAJCOM                                                          | .03            | .03             |
| 2    | Sup Attitudes <sup>a</sup><br>Support <sup>a</sup><br>Work Flow | .50*           | .47*            |
| 3    | Self Efficacy <sup>a</sup><br>Ability (AFQT)                    | .55*           | .05*            |

NOTE: \* p<.05

<sup>a</sup> Beta for this variable was significant (P<.05) at this step

# Findings

- **Opportunity to perform is a multidimensional construct**
- **There are individual differences in opportunities to perform trained tasks**
- **These differences are predictable**

## SUBGROUP SESSION II

### ADVANCED TRAINING TECHNOLOGY

Visual Learning in Virtual Environment:  
Dr. J. Psotka

Summary and Conclusions of Virtual Reality in Training  
Research in the Services or "What are the Research  
Issues in the use of Virtual Reality in Training?"

## **Visual Communication in Multi-Media Virtual Realities.**

This basic research project in visual communication examines how visual knowledge should be structured to take full advantage of advanced computer environments for training, especially hypertext and virtual reality. A Visual Aircraft Recognition (VACR) Training hypertext has been built and tested. Virtual Reality workstations have been explored and will be used for future experiments. A theory of visual concept learning is under development.

### **6.1 RESEARCH**

Our first experiments examined the interface, architecture, and training strategy issues for combining images and text in multimedia systems. An Army Field Manual (FM 44-30) was completely digitized, and redesigned to take advantage of several powerful hypertext features: search, browsing, "hot" words or buttons, apparent motion, and colored contrasts. A series of experiments determined the training advantages of these features. These results were integrated into a theoretical framework that combined "ecological perception" with "apparent motion" as a basis for visual concept learning. The theory is continuing to be refined and tested in ongoing work.

The hypertext and digitized images are being transferred from our experimental multimedia platform to a state-of-the-art Virtual Reality Platform for research. This work will examine the value of virtual "immersion" into a 3-D environment for memory of spatial orientation, over 2-D spatial interfaces. In addition, the Virtual Reality workstation will allow us to extend our theoretical framework to begin to analyze the comparative strengths of speech communication versus visual communication in the exchange of shared mental models among crew and group members. Interactions between people and simulated crew members will use detailed models of animated agents and faces developed at the Army Center for AI at the University of Pennsylvania.

### **THEORY**

Basic theories about visual communication need to be developed in detail if the rapid progress in computer technologies is to be fully leveraged in future Army training. Recent synthetic reality and hypermedia computer technologies, combined with Artificial Intelligence (AI) knowledge representation techniques, offer unprecedented opportunities for digitizing, displaying, transforming, and transmitting pictures as easily as words and sentences.

### **POTENTIAL MILITARY RELEVANCE**

The Army is increasingly turning to large scale simulator networking for cost effective training of warfighting skills. This research advances several core technologies that will be transferred to 6.2 research in AISTA, PM-TRADE Field Unit, and Ft. Bliss Field Unit. The VACR training hypertext is being transferred to Ft. Bliss currently. Future work will have direct bearing on distributed simulator design for "popped hatch" tank simulators, and effective crew communication and spatial navigation training.

ARI POC: Dr. Joseph Psotka, AV 284-5540; Comm (703) 274-5540.

# Visual Concept Training

## Basic Research



### Research Problem

#### What are the best

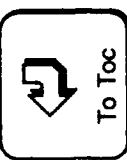
- o Technological opportunities for Visual Communication?
- o Interfaces to complex visual knowledge spaces?
- o Training designs in advanced technology environments?

### Research Approach

Hypothesis: Use Ecological Perception to Structure Knowledge

- o Digitize a multimedia HyperBook for training
- o Conduct experiments to determine principles of training design in multimedia environments

# Visual Concept Training Basic Research



## Technological Opportunity

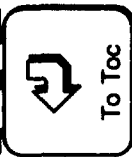
- o Visual Communication
- o Hypertext and Multimedia
- o AI and Semantic Networks
- o Cyberspace

## Army Relevance

- o Training and Command/Control
  - o Protect SHORAD Lethality
  - o VACR -- Visual Aircraft Recognitor
  - o HQDA -- FM 44-30

# Visual Concept Training

## Basic Research



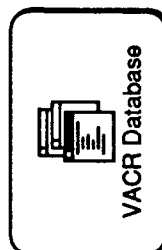
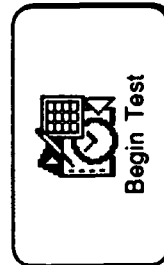
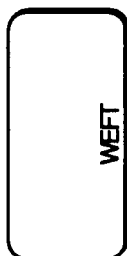
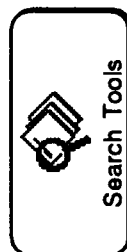
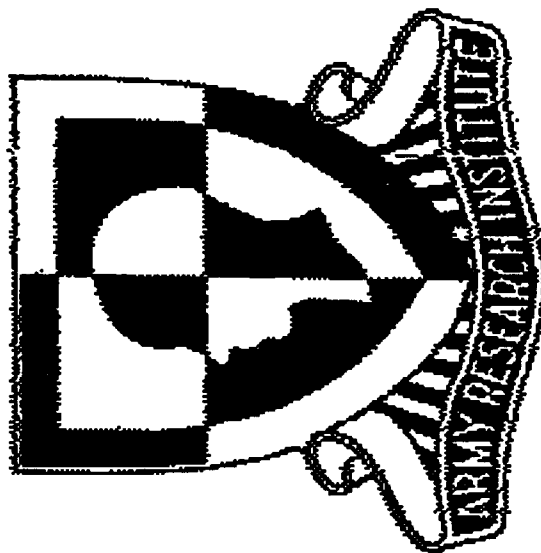
### Expected Outcomes

- o Exploration of Technological Possibilities
- o Cognitive Theory of Visual Concept Training
- o Experiments Verifying Principles of Hypertext Design for Combining Text and Image Media in Training

### Research Accomplishments

- o FM 44-30 Digitized Hypertext
- o Technologies for Comparison and Contrast of Visual
- o CyberSpace Interface to AirPlane Pictorial Browser

# ARI Multimedia Aircraft Recognition Trainer



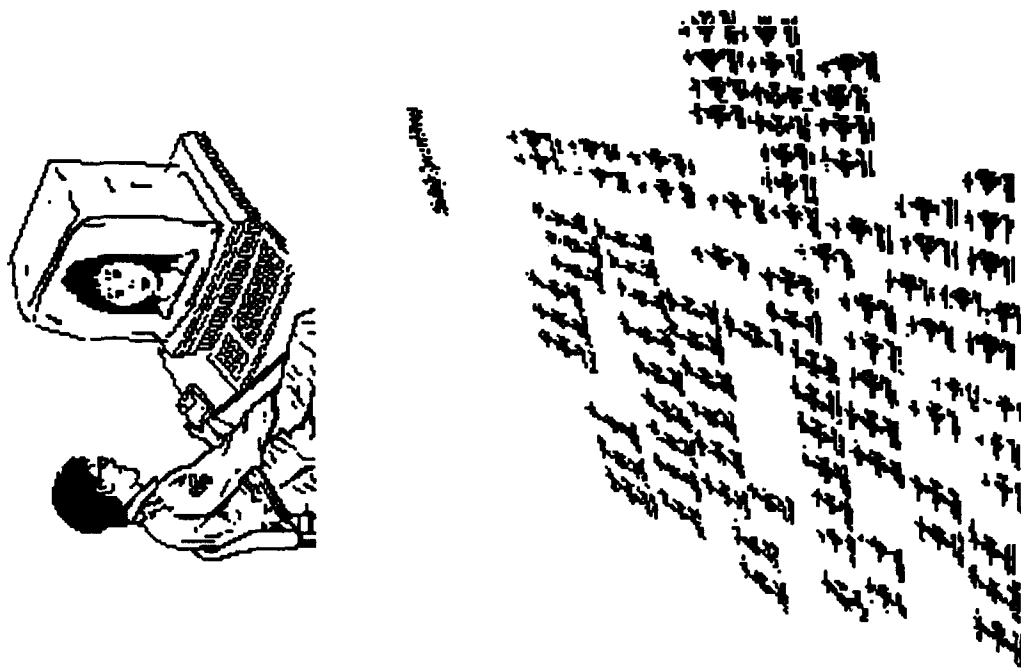
Basic Research Briefing



# ☐ Table of Contents

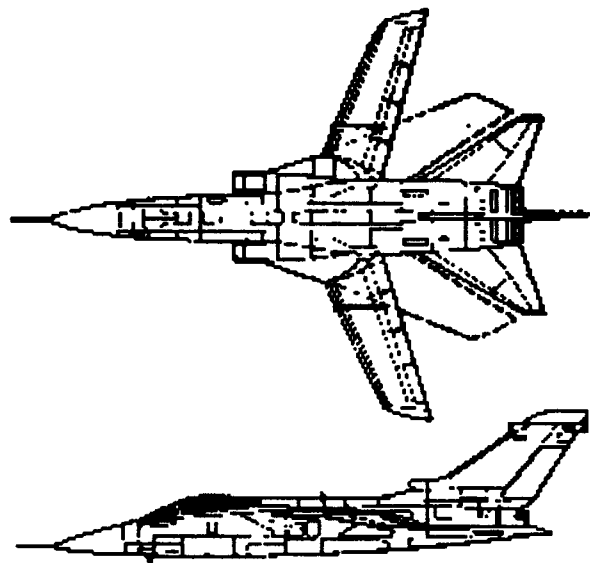
- ☐ 1. ARMY OPPORTUNITY AND NEED
  - ☐ US Army Research Institute
- ☒ 2. RESEARCH OBJECTIVES AND APPROACH
- ☐ 3. RESOURCES
- ☐ 4. MILESTONES
- ☐ 5. PRODUCTS AND DEMO
- ☒ 6. Experimental Results
  - ☐ 7. Future Directions
  - ☐ 8. 6.2 CONNECTIONS

\*





## EXAMPLE



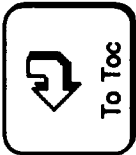
☐ MILLARD FILLMORE

☐ JOHN ADAMS

☐ TORNADO

☐ GEORGE MASON

# FIRST EXPERIMENT



## FM 44-30 VERSUS HYPERBOOK

Learn names of 20 planes in half an hour

Unpaired t-Test X<sub>1</sub>: Condition Y<sub>1</sub>: PosTest

|     |                   |                 |
|-----|-------------------|-----------------|
| DF: | Unpaired t Value: | Prob. (1-tail): |
| 8   | -3.772            | .0028           |

| Group:    | Count: | Mean: | Std. Dev.: | Std. Error: |
|-----------|--------|-------|------------|-------------|
| Book      | 5      | 12.8  | 2.168      | .97         |
| HyperCard | 5      | 17    | 1.225      | .548        |

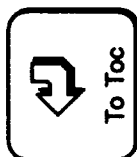
2 Standard Deviation effect with only 10 Subjects

12.8 / 20

17 / 20

Correct

## **SECOND EXPERIMENT**



### **FM 44-30 VERSUS HYPERBOOK**

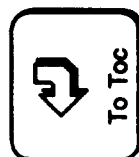
**TEST NOT JUST ON OUTLINES, BUT ON  
DIFFERENT PICTURES AND MODELS**

## **RESULTS**

- o HyperBook still superior on tests
- o Much more examination of HyperBook
  - o Similar Planes, ContraPict, WEFT

## **Third EXPERIMENT**

---



### **FM 44-30 VERSUS HYPERBOOK**

---

**TEST AGAINST SIMILAR PLANES  
TRANSFER TEST AGAINST NEW PICTURES  
TWENTY PLANES IN ONE HOUR**

## **RESULTS**

- o HyperBook superior on transfer test
- o Individual examination of HyperBook
  - o Similar Planes, ContraPict, WEFT
- o Many more complaints from FM students

**Aircraft Name**

**DIRECTIONS:**

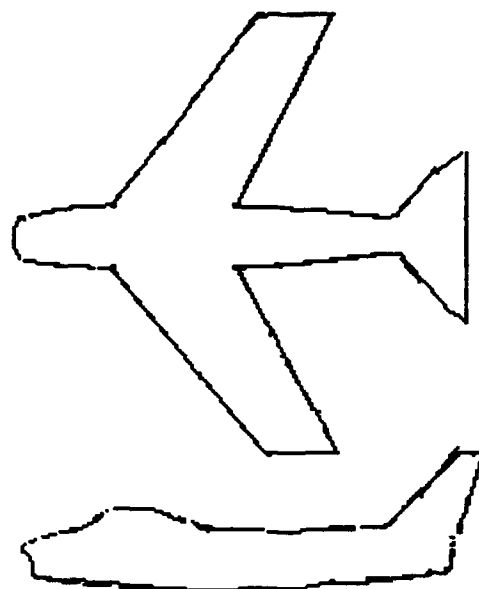
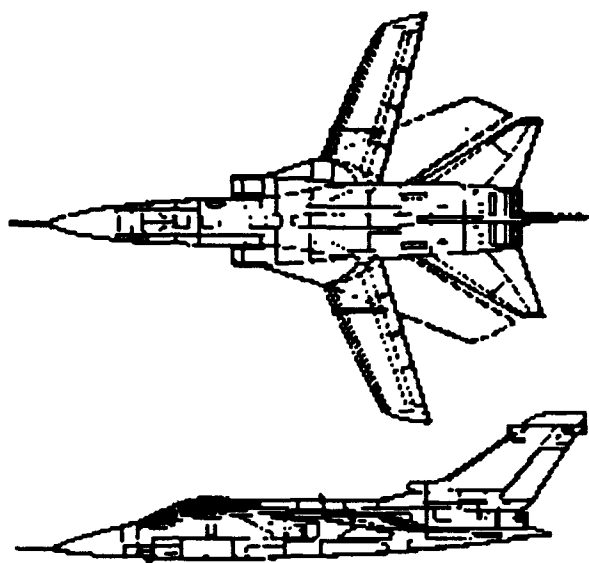
Click on the name  
of any plane to go  
to the card with  
information about  
that plane.

JAGUAR  
AV-8 HARRIER  
KING AIR U-21  
HAWK  
DRAKEN  
F-15 EAGLE  
AN-24 COKE, AN-26 CURL  
YAK-36 FORGER  
U-8F SEMINOLE, QUEEN AIR  
TU-26 BACKFIRE  
C-141B STARLIFTER  
HUNTER  
A-6 INTRUDER  
F-4 PHANTOM  
MIG-25 FOXBAT  
MIRAGE-III/5  
C-5A GALAXY  
B-1B  
An-32 CLINE  
KFIR C-2  
TORNADO

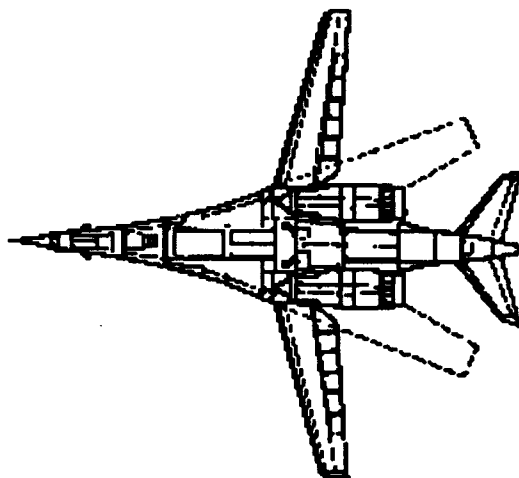
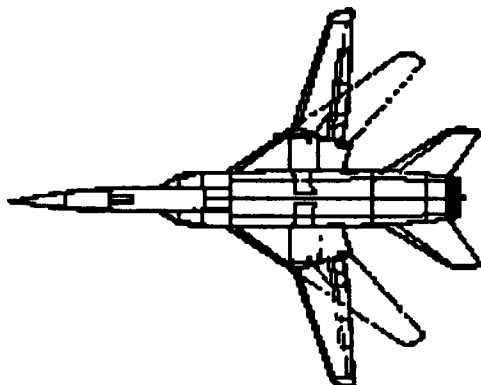
**Main Menu**

## EXAMPLE

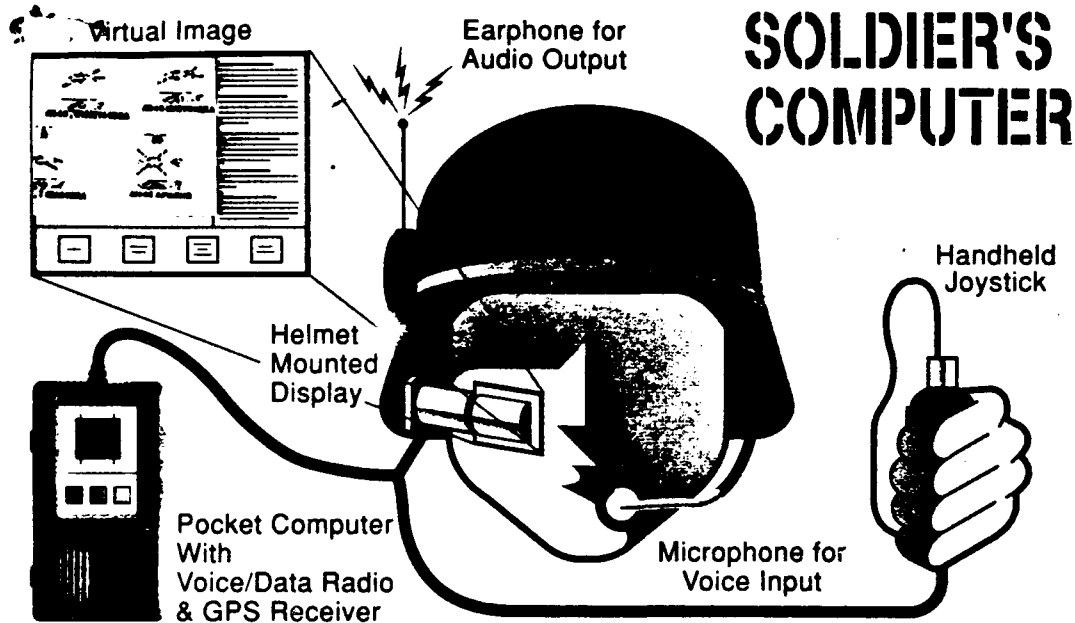
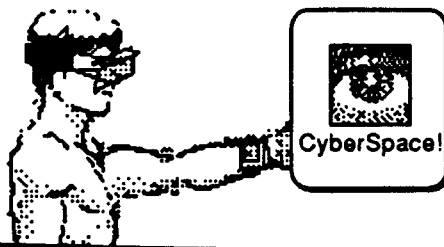
- ☐ MILLARD FILLMORE ☐
- ☐ JOHN ADAMS ☐
- ☐ TORNADO ☐
- ☐ GEORGE MASON ☐



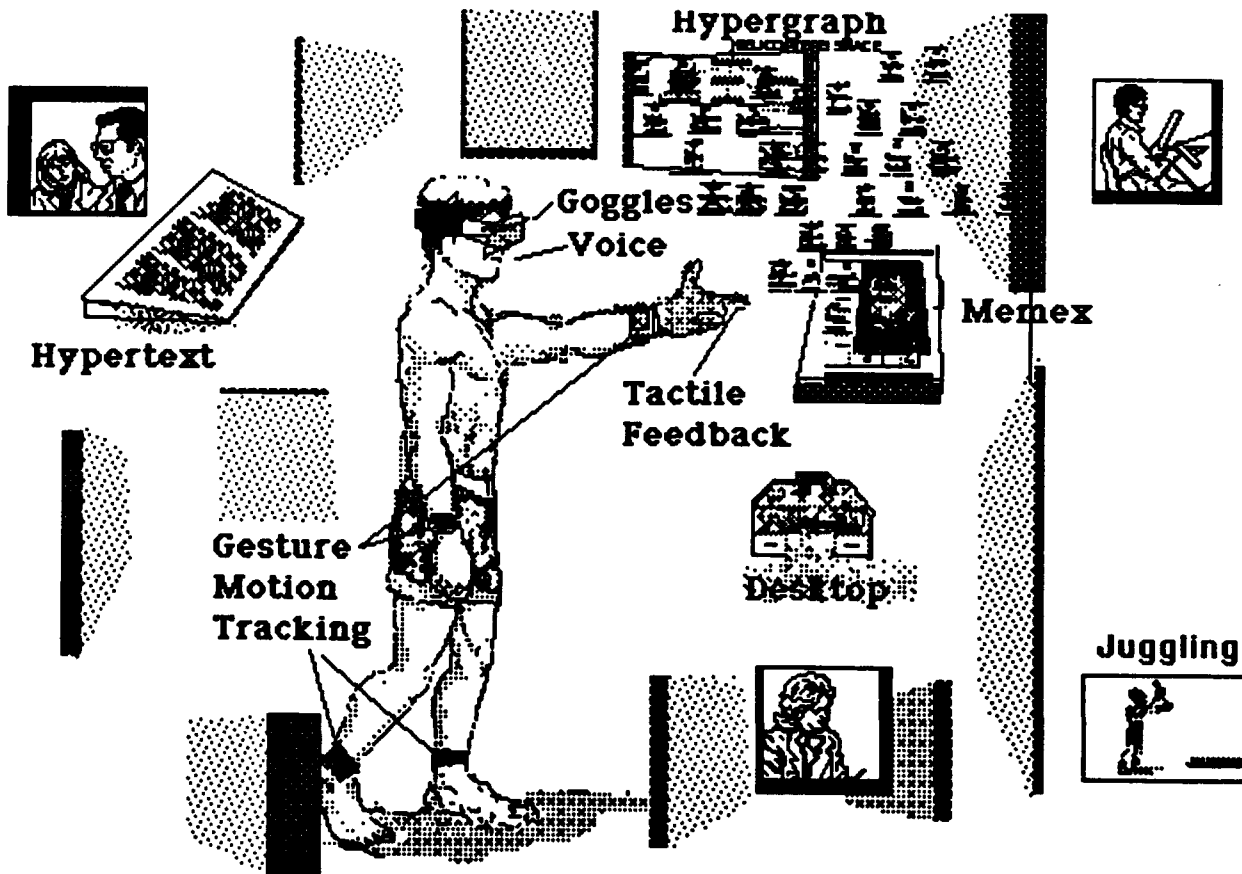
- TU-16 BADGER ○
- TU-26 BACKFIRE ○
- B-52 ○
- JAGUAR ○



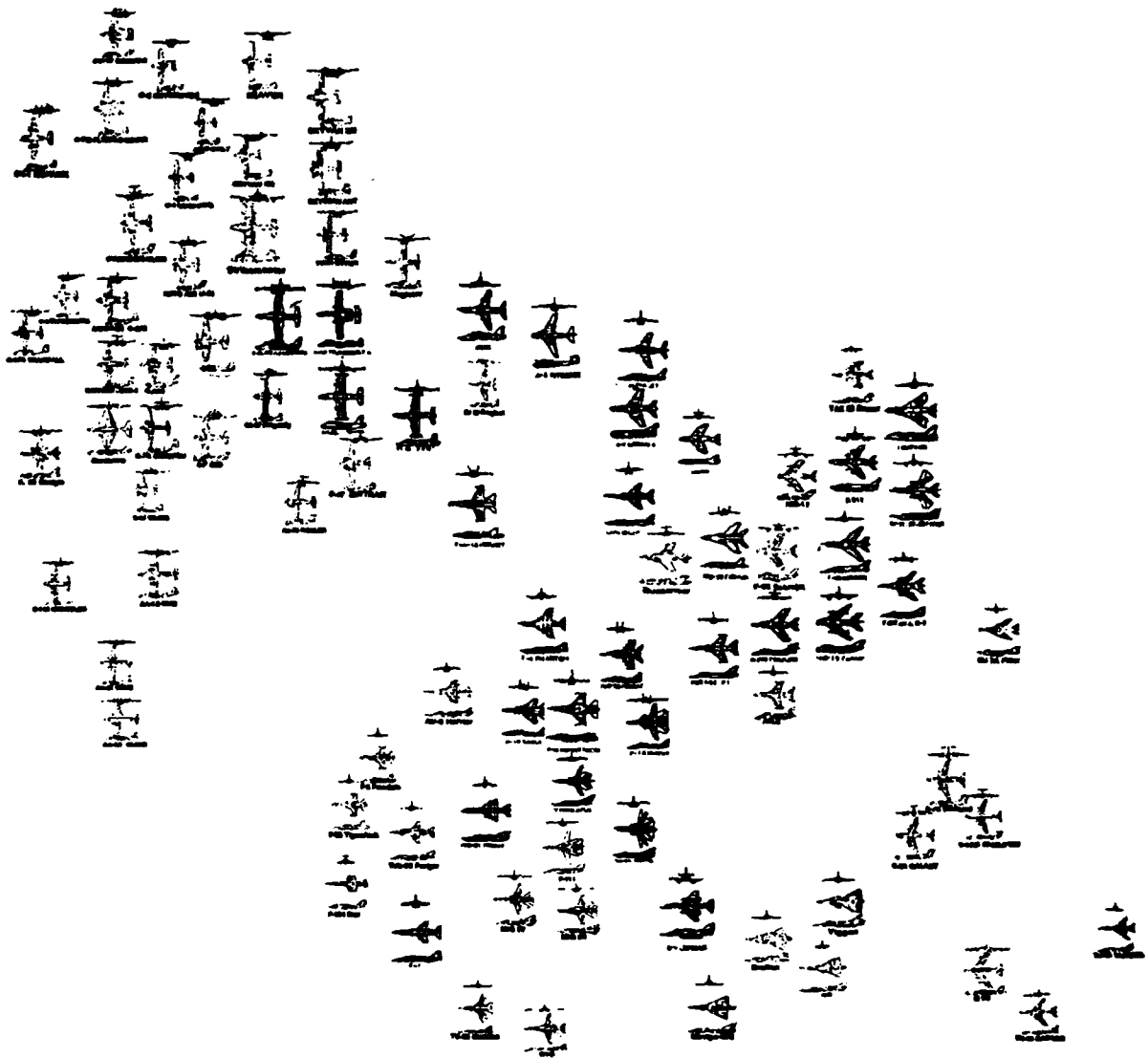




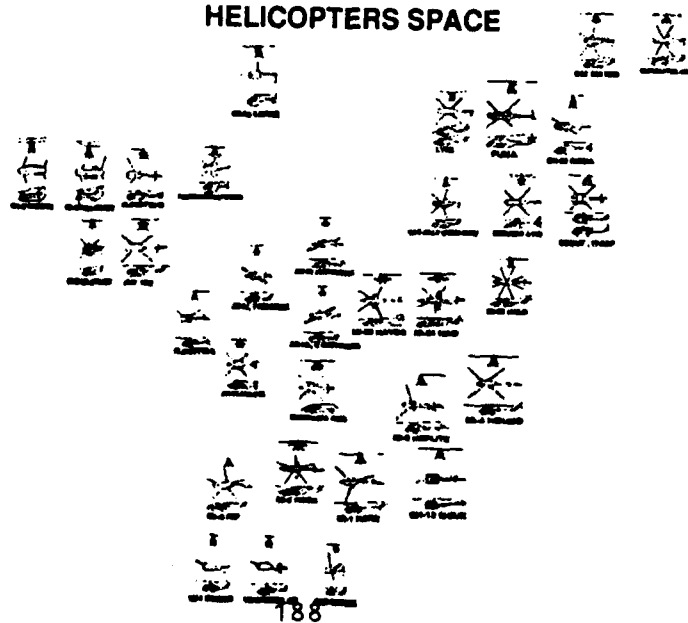
ABP V BPA



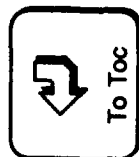
# Similarity Space of Planes



## HELICOPTERS SPACE



## Third EXPERIMENT



### FM 44-30 VERSUS HYPERBOOK

Learn names of 20 planes in an hour

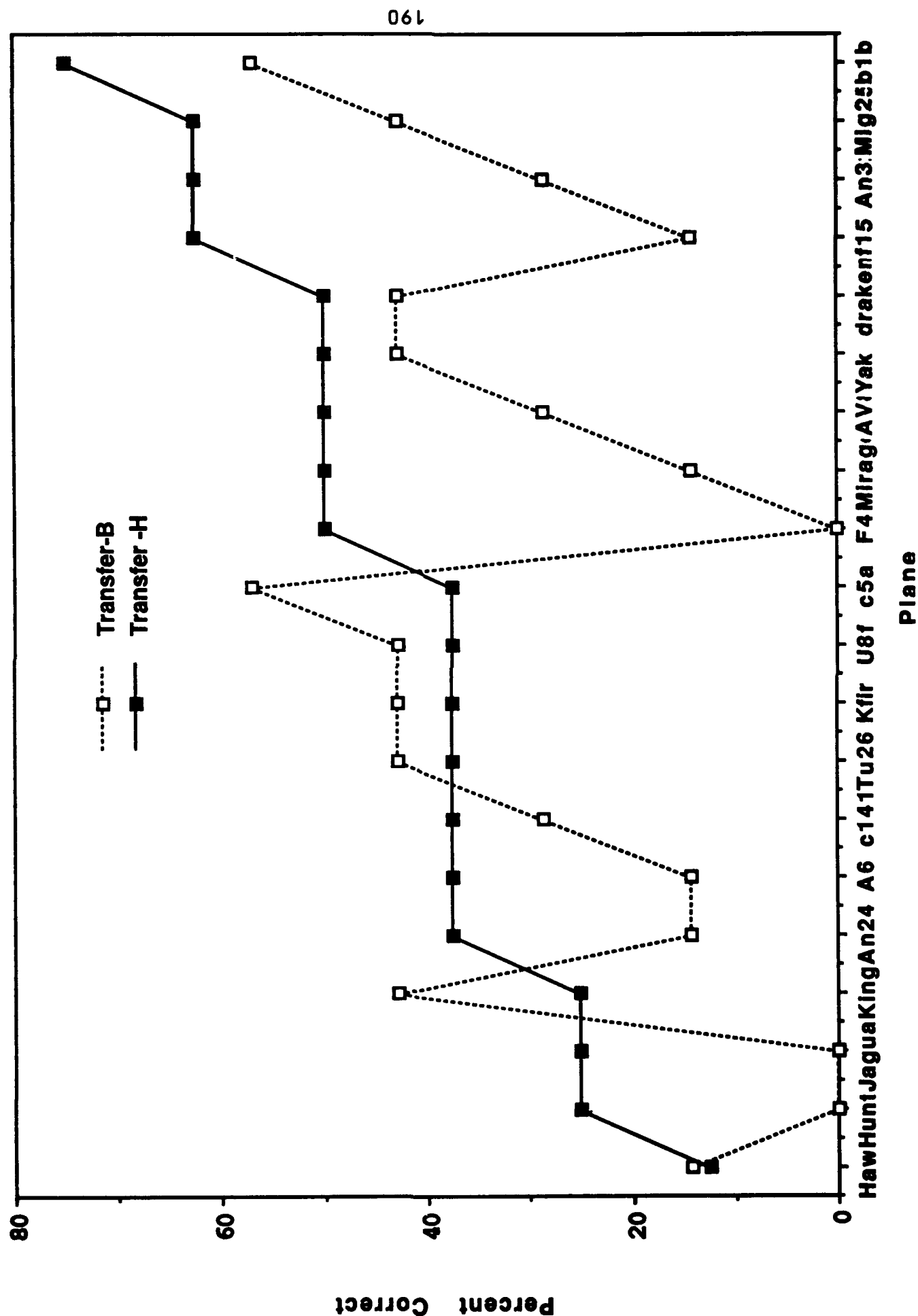
|                    | PreTest | PostTest | TransferTest |
|--------------------|---------|----------|--------------|
| HyperBook<br>(N=8) | 13.8*   | 55.0*    | 41.6**       |
| Book<br>(N=7)      | 14.6*   | 48.2*    | 30.0**       |

\*\* p.<.05 (sign test)

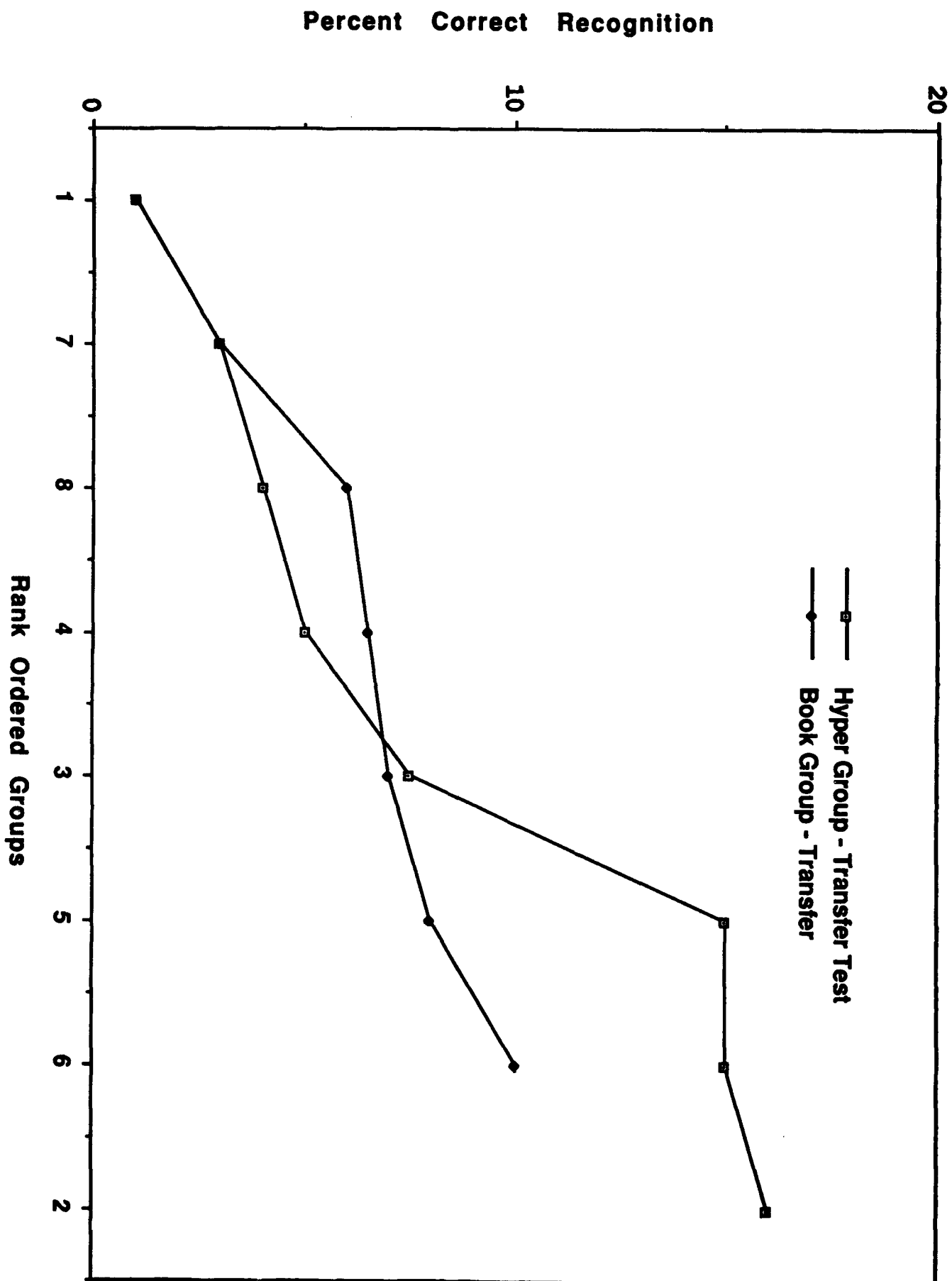
\* not sig.

Percent correct recognition after 1 hour study.

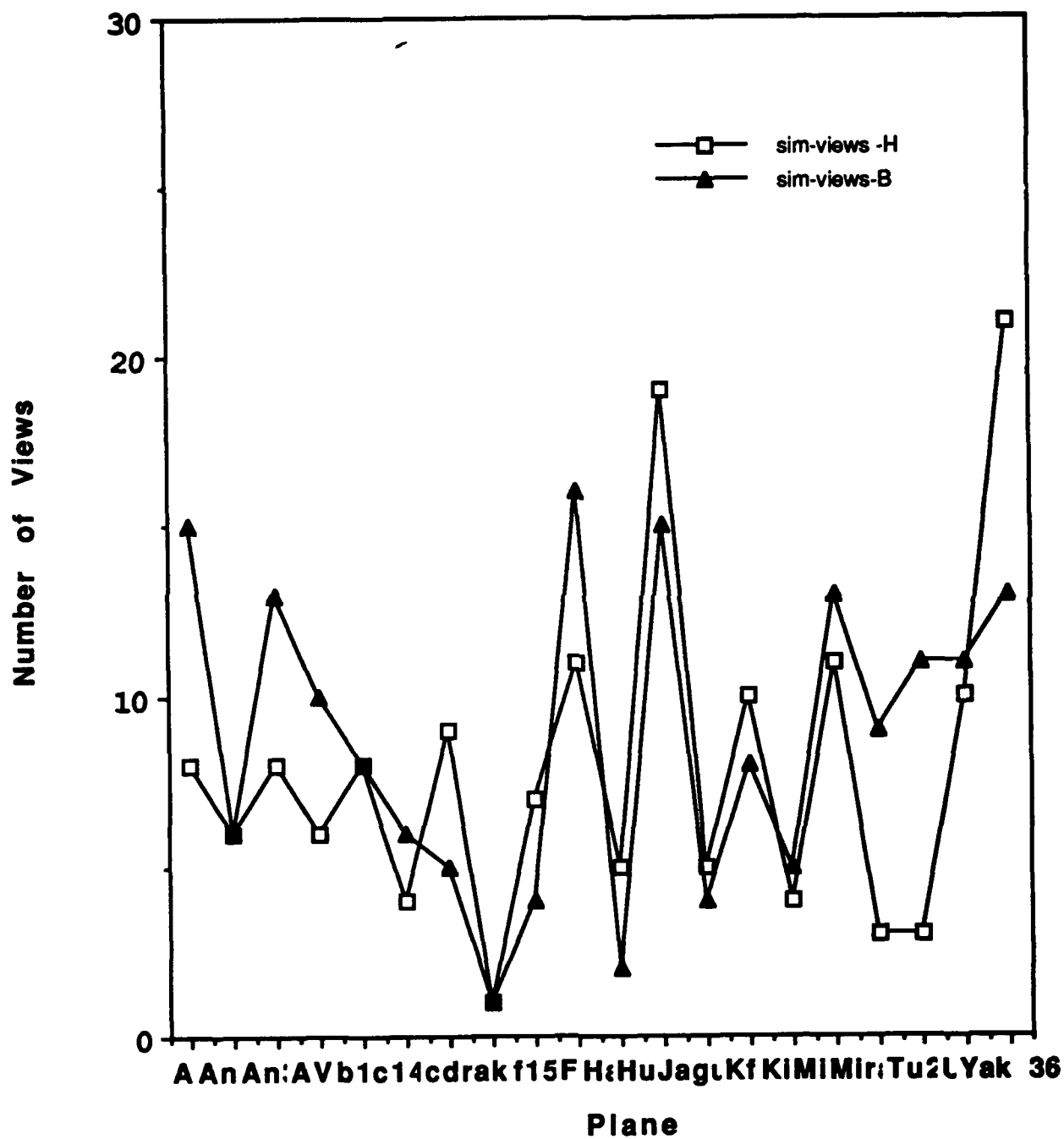
# Percent recognition for Book and Hyper Groups on Transfer Test with New Pictures



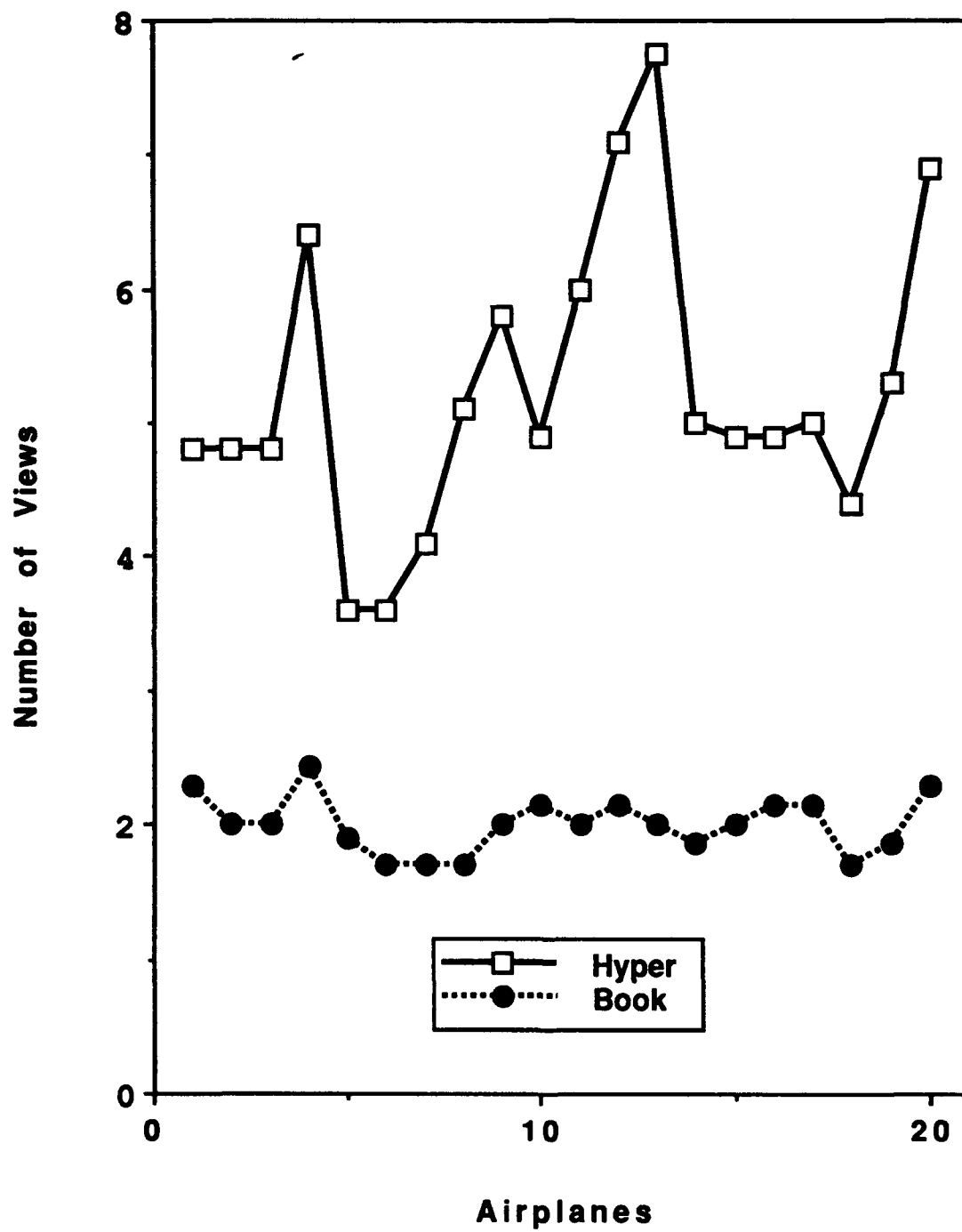
Data from "Hyper Group - Subject Measures"



Number of Similar Planes viewed by Both Groups

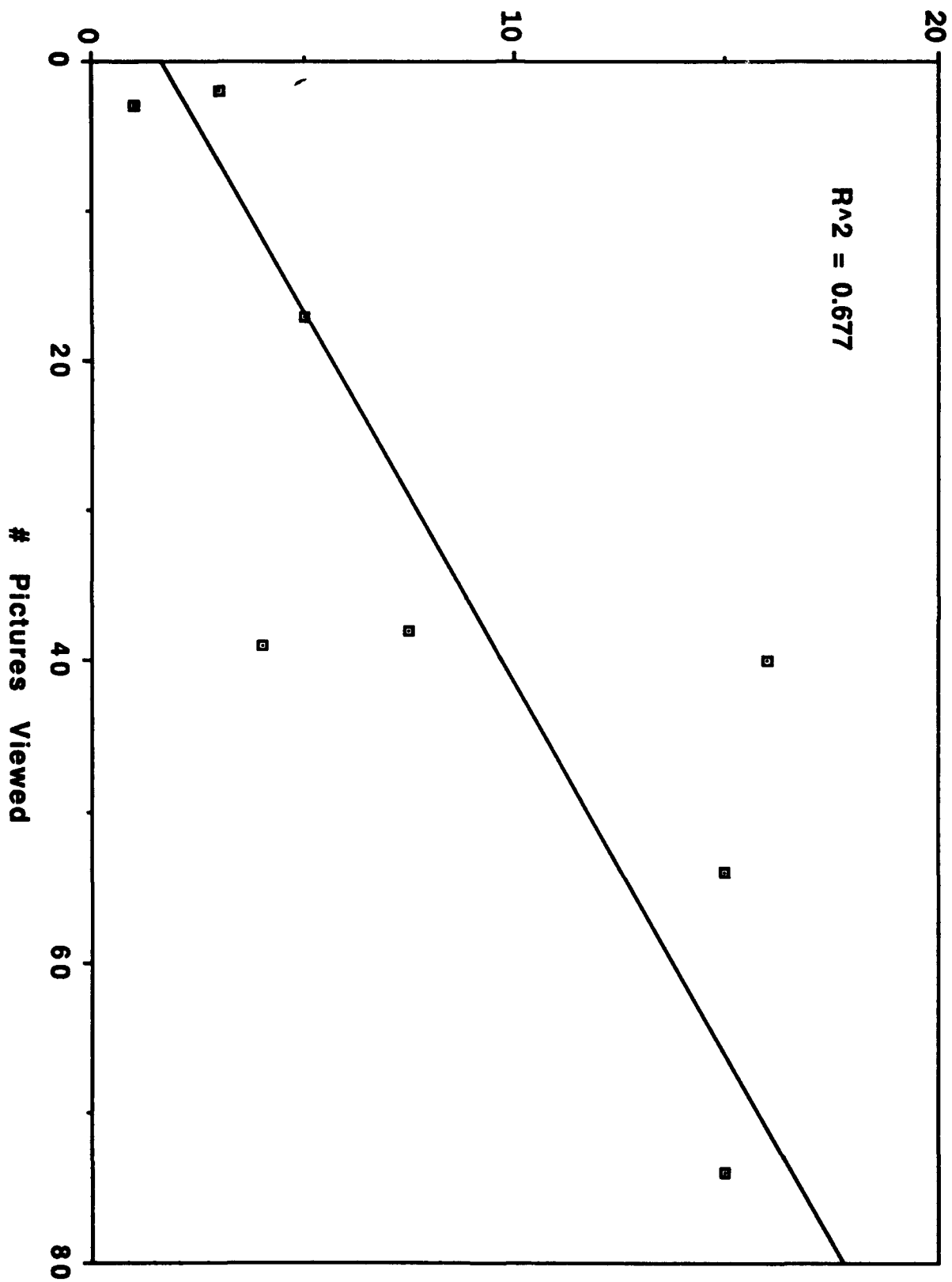


**Number of Looks at Each Plane**



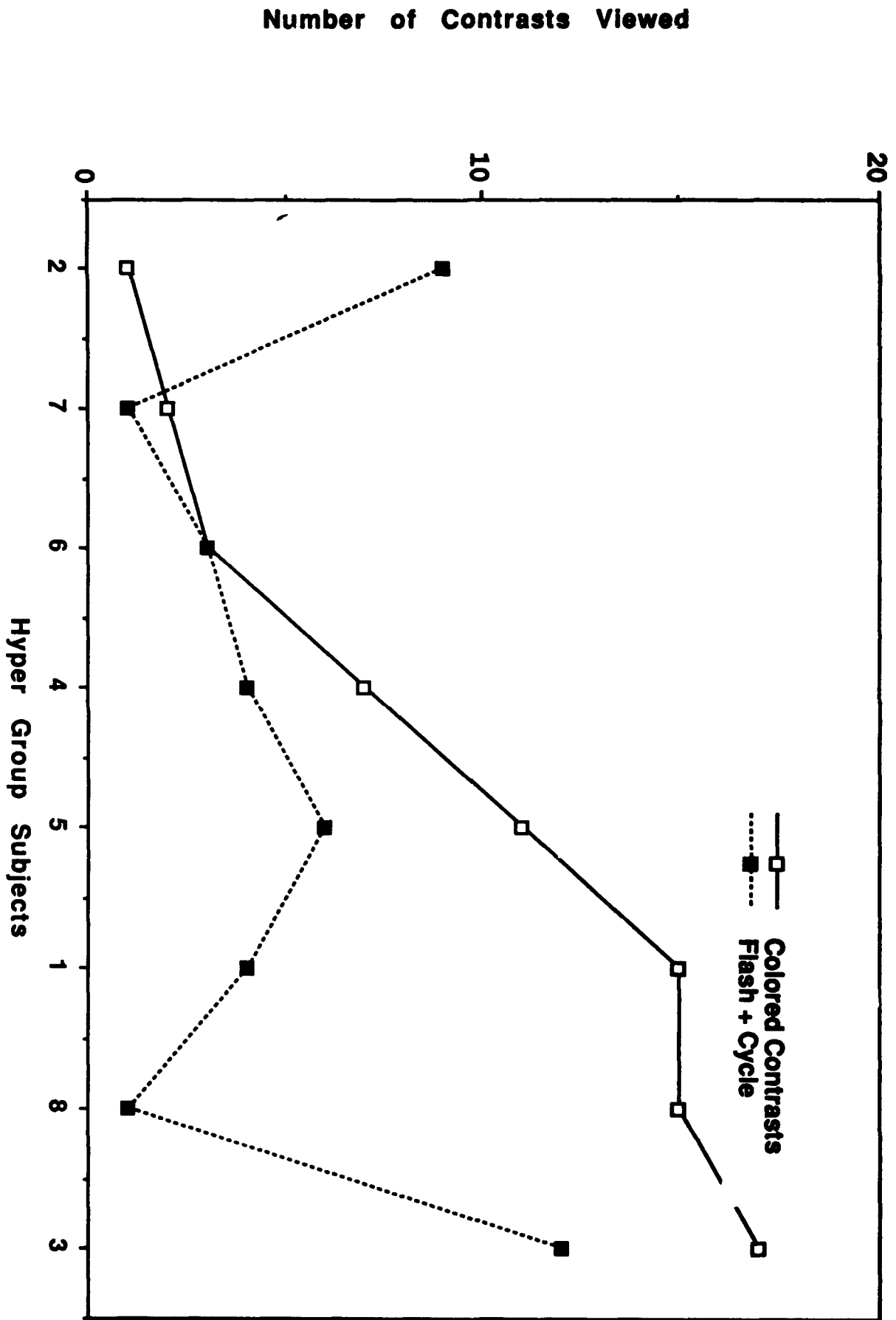
# Transfer Test

Data from "Hyper Group - Subject Measures"

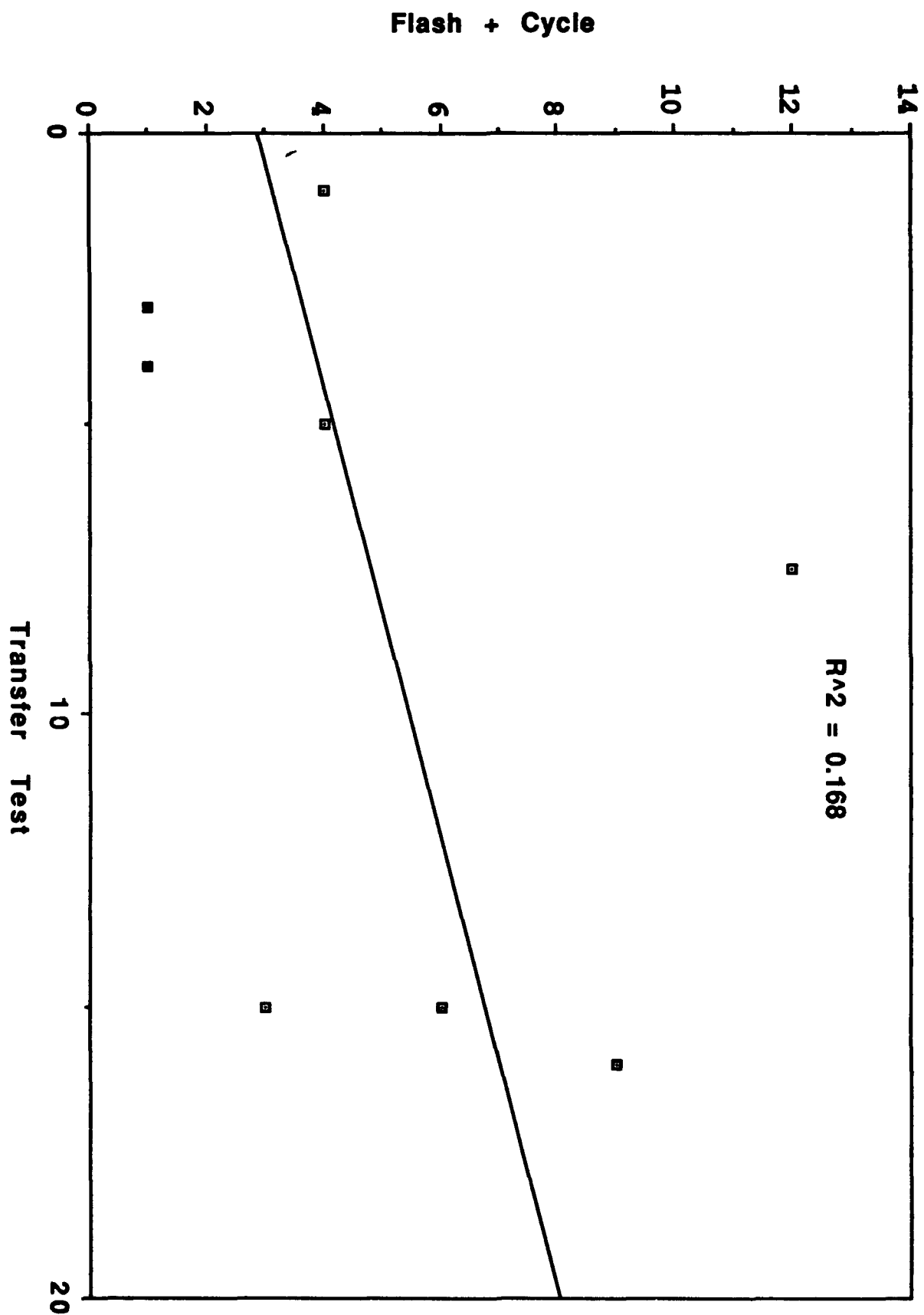




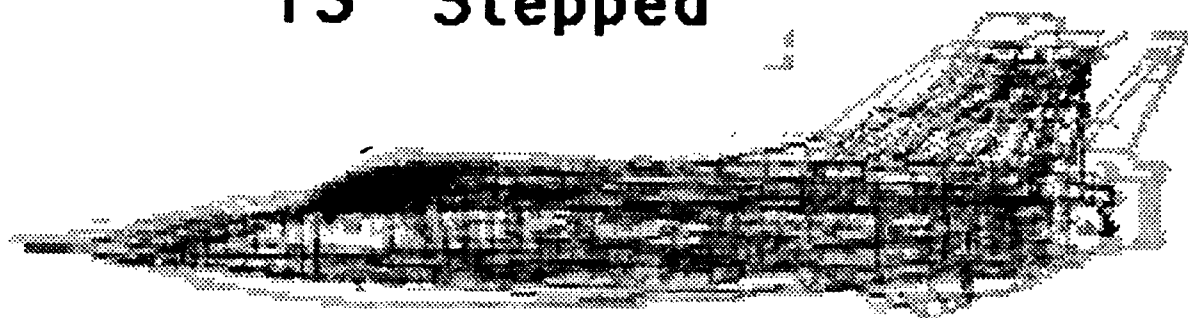
Data from "Hyper Group - Subject Measures"



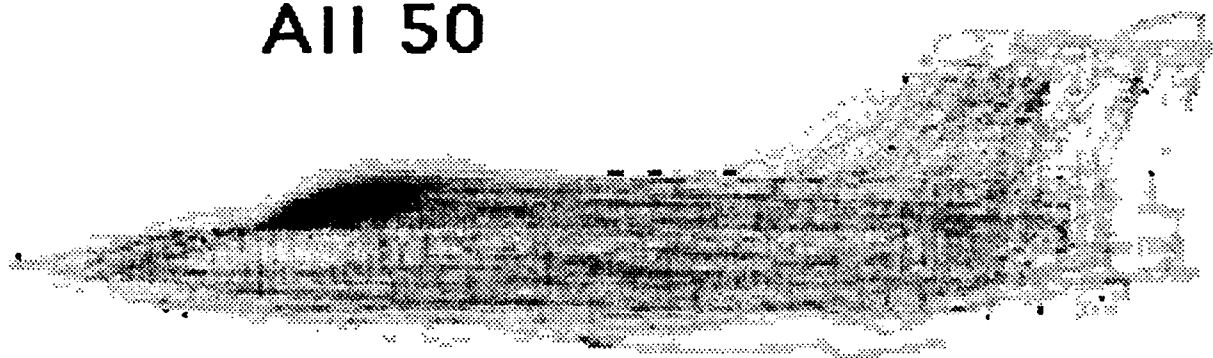
# Data from "Hyper Group - Subject Measures"



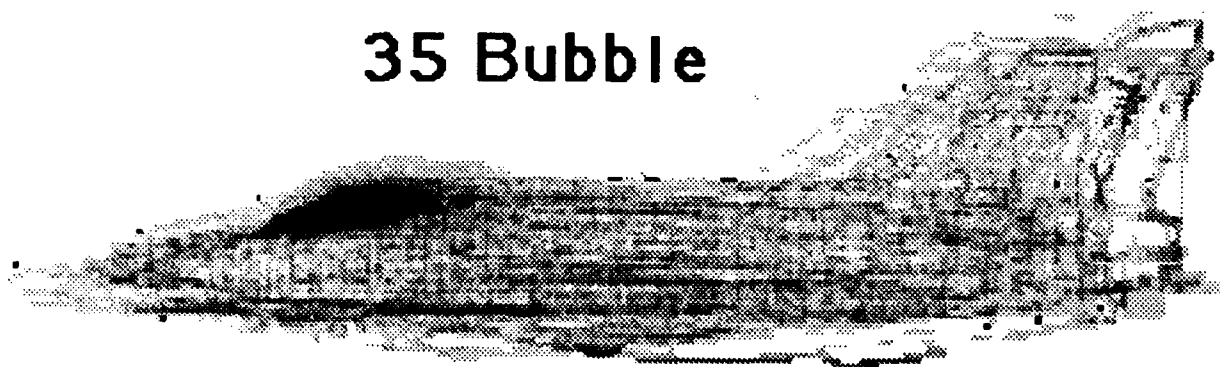
## 15 Stepped

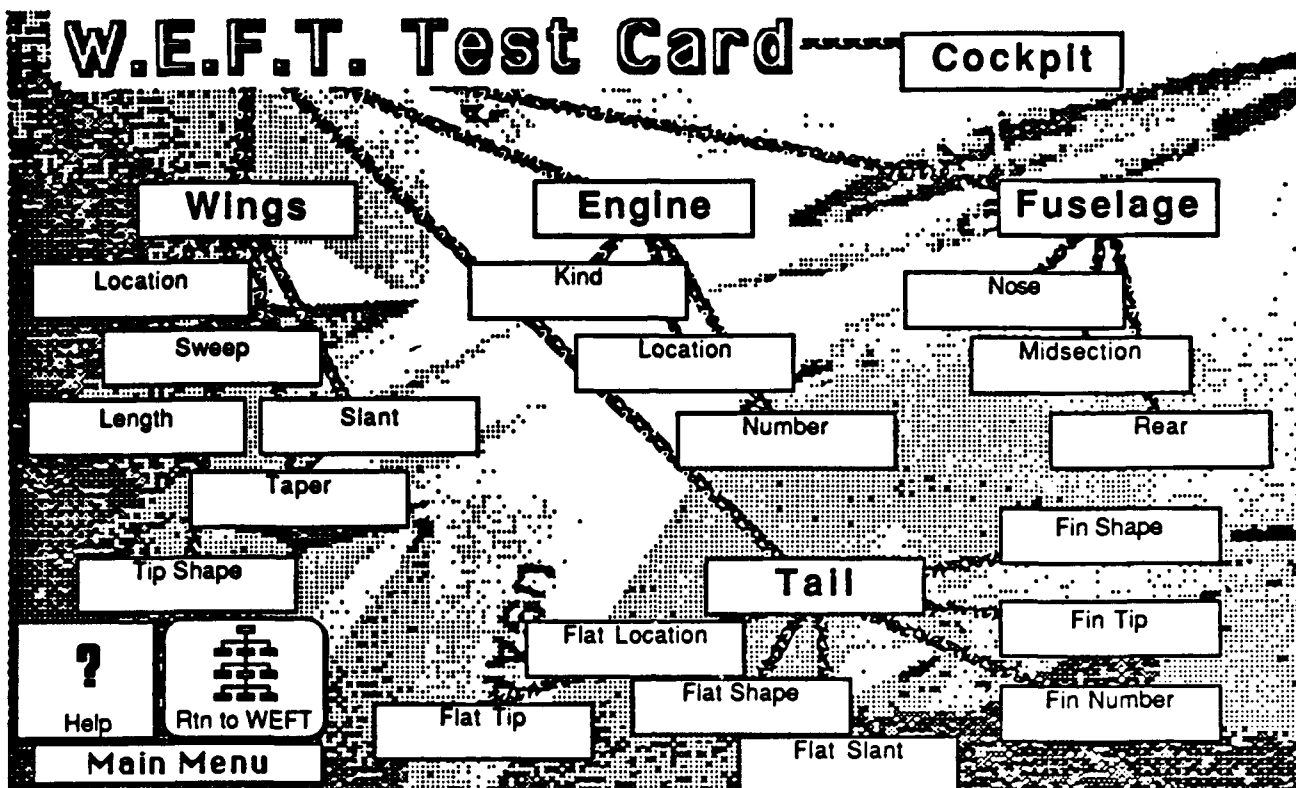


## All 50



## 35 Bubble





Test yourself on any WEFT feature by buttoning that feature and then answering all the questions that come up ...

## Aircraft Role

|                |              |             |
|----------------|--------------|-------------|
| Attack         |              |             |
| Ground Attack  |              |             |
| Interceptor    |              |             |
| Fighter        |              |             |
| Strike         |              |             |
| Fighter-bomber |              |             |
| Bomber         |              |             |
| Cargo          | Transport    |             |
| Reconnaissance | Surveillance | Observation |
| Trainer        |              |             |

[Main Menu](#)

Click on any button to see all the aircraft that have the selected Role.

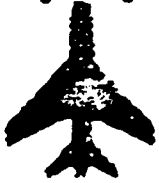
## Armament

|             |
|-------------|
| Cannon      |
| Gun         |
| Gun pods    |
| Gun packs   |
| Machine gun |
| Mini gun    |
| Bombs       |
| Missiles    |
| ALCM        |
| SRAM        |
| ASM         |
| ARM         |
| SAM         |
| Rockets     |

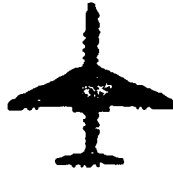
[Main Menu](#)

## Jet Aircraft

Jet, swept wing,  
fuselage engine(s)



Jet, swept wing,  
flank/root engines



Jet, swept wing,  
underwing engines



Jet, swept wing,  
rear engines



Jet, straight wing,  
fuselage engine(s)



Jet, straight wing,  
wing engines



Jet, straight wing,  
rear engines



Jet, delta wing



Jet, variable  
geometry



Stealth



Main Menu

To Propeller Aircraft and Helicopters

## Propeller Aircraft and Helicopters

Twin propellers



Amphibians



Helicopter, single  
rotor, light



Four propellers



Biplanes



Helicopter, single  
rotor, medium/heavy



Single propeller



Twin Booms



Helicopter, twin  
rotors



Main Menu

To Jet Aircraft

# Guided Tour

To get an overview of the different aircraft listed below, click the "Take Tour" button. On the tour, click anywhere to go to the next plane.

## USA

AWACS  
A-6 INTRUDER  
A-10 Thunderbolt II  
B-52  
AH-64 APACHE  
F-4 PHANTOM  
F-15 Eagle  
F-16 FIGHTING  
FALCON  
F-111  
F-117A

Take Tour

## IRAQ

MIRAGE-F1  
Mi-24 HIND  
MiG-23 Flogger B  
MIG-29 Fulcrum  
Su-24 FENCER

Take Tour

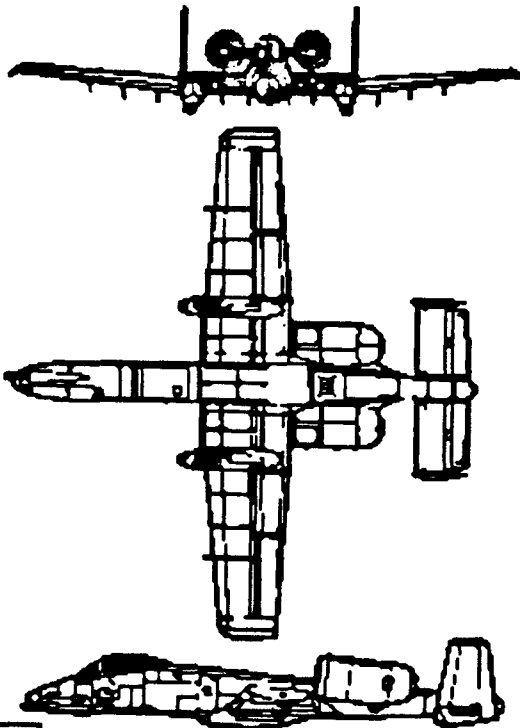
Main Menu

## A-10 THUNDERBOLT II

Country of Origin.  
Similar Aircraft.

USA.  
None.

Users



Crew. One.  
Role. Close air support, ground attack.

Armament. 30-mm cannon, bombs, rockets, HELLFIRE missiles, gun pods.

Dimensions. Length 53 feet, span 58 feet.

Wings. Wings are low mounted on the fuselage, unequally tapered, with blunt curled-under tips. Landing gear pods extend forward of the wings' leading edges.

Engine(s). Two turbofan engines in pods, high on the rear of the body between the wings and the tail section.

Fuselage. Rounded nose, tapered rear, bubble canopy. Protrusion in nose is the 30-mm GAU-8 cannon.

Tail. Two tall fins on tips of flat. Unequally tapered fins extend above and below the tail flat. Rectangular tail flat is low-mounted on fuselage.

Sound



Picture

Type



Menu

index

Shape

User



# ALPHA JET

Country of Origin. France, West Germany.

Users

Similar Aircraft. Hawk.

Crew. Two

Role. Light attack, advanced trainer.

Armament. Gun pods, bombs, rockets, missiles.

Dimensions. Length 40 feet, span 30 feet.

Wings. High-mounted, swept-back, and tapered with curved tips, slight negative slant.

Sound

Engine(s). Two alongside body under the wings, oval shaped air intakes forward of the wings' leading edges. Exhausts at the rear of wings' trailing edges.

Fuselage. Slender, pointed nose and tail. Two-seat bubble cockpit.

Tail. One Swept-back and tapered tail fin with squared tip.

Swept-back and tapered tail flats mid-mounted on body with negative slant and square tips.



Flash it

Contrast it

Type



Menu

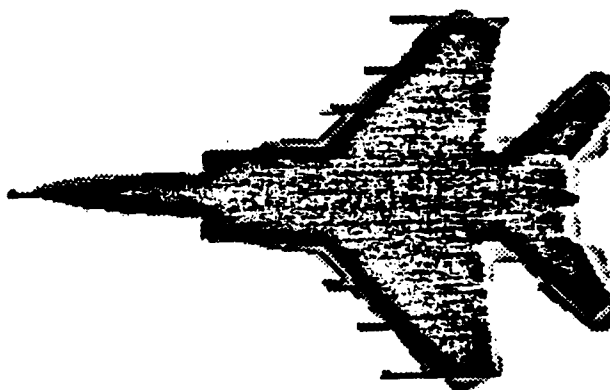
index

Shape

User



FLASHES "HAWK" SUPERIMPOSES "HAWK"





CREW, GROUP AND UNIT TRAINING

Opening Remarks

Aircrew Coordination Training R&D:

Dr. David Baker, NTSC  
Mr. Randall Oser, NTSC  
Major Wes Woodruff, USAF, NTSC

**ORGANIZATIONAL VARIABLES AND AIRCREW  
COORDINATION:  
IMPLICATIONS FOR TEAM TRAINING**

**MARY D ZALESNY  
KENT STATE UNIVERSITY**

**DAVID P. BAKER  
CAROLYN PRINCE  
EDUARDO SALAS  
NAVAL TRAINING SYSTEMS CENTER**

## **BACKGROUND**

- **HUMAN ERROR IS A LEADING CAUSE OF AVIATION MISHAPS.**
- **AIRCREW COORINATION TRAINING (ACT) HAS BEEN IDENTIFIED AS AN APPROACH FOR OFFSETTING AIR MISHAPS.**
- **ORGANIZATIONAL VARIABLES ARE LIKELY TO IMPACT ACT AND CAN NOT BE IGNORED.**

## **RESEARCH OBJECTIVES**

- **GATHER INFORMATION FROM RESERVE AVIATION SQUADRONS RELATED TO:**
  - **AIRCREW COORDINATION**
  - **TEAM PERFORMANCE**
  - **RESOURCE MANAGEMENT**
- **IDENTIFY CRITICAL ORGANIZATIONAL VARIABLES**
- **IDENTIFY FUTURE RESEARCH NEEDS**

## **MILITARY RESERVES**

- **UNIQUE ORGANIZATION TO STUDY FOR SEVERAL REASONS:**
  - **ORGANIZATIONAL MEMBERS HAVE DUAL ALLIANCES.**
  - **POSITIONS ARE SHARED BETWEEN RESERVES AND ACTIVES.**
  - **ACTUAL JOB PERFORMANCE MAY NEVER OCCUR.**

## METHOD

- INTERVIEWS WERE CONDUCTED WITH PERSONNEL FROM MARINE RESERVE SQUADRONS.
- 1715 QUESTIONNAIRES WERE ADMINISTERED TO A STRATIFIED RANDOM SAMPLE OF ALL RESERVE SQUADRONS.
- COLLECTED 3 PERFORMANCE MEASURES:
  - MCCRES
  - CRP
  - CGI

## **RESULTS**

- **3 ORGANIZATIONAL VARIABLES WERE IDENTIFIED AS CRITICAL:**

- **TRAINING**

- **LEADERSHIP**

- **COORDINATION**

## **TRAINING**

- **RESERVES RECEIVED SIGNIFICANTLY LESS MOS TRAINING AND OJT PRIOR TO JOINING A SQUADRON.**
- **THE DEGREE OF TRAINING RECEIVED WAS AFFECTED BY THE MAG/SITE/SQUADRON COMMANDERS.**



## **LEADERSHIP**

- **LEADERSHIP WAS STRONGLY RELATED TO PERCEPTIONS OF SQUADRON FUNCTIONING.**
- **COMMANDERS AND THEIR SQUADRONS VIEW THE SQUADRON DIFFERENTLY.**
- **COMMANDERS DID NOT FEEL PREPARED FOR THE LEADERSHIP RESPONSIBILITIES OF A RESERVE SQUADRON.**

## **COORDINATION**

- **COORDINATION WAS VIEWED AS CRITICAL**
  - **ESPECIALLY FOR OFFICERS.**
- **COORDINATION MUST OCCUR BETWEEN:**
  - **TEAM MEMBERS.**
  - **ACTIVES AND RESERVES IN SIMILAR POSITIONS.**
  - **VARIOUS SQUADRON FUNCTIONS (e.g., OPERATIONS, MAINTENANCE, ETC.).**

## **PERFORMANCE**

- **% OF RESERVISTS IN THE SQUADRON  
WAS RELATED TO:**
  - CRP
  - CGI
- **VARIABLES NOT RELATED INCLUDED:**
  - DRILL TIME SPENT ON INSPECTIONS
  - PREPARATION FOR RESERVE SQUADRON
  - DEGREE OF COORDINATION REQUIRED

## **SUMMARY**

- THE RESULTS SHOWED THREE ORGANIZATIONAL VARIABLES TO BE CRITICAL:
  - TRAINING
  - LEADERSHIP
  - COORDINATION
- THESE VARIABLES ARE LIKELY TO HAVE AN IMPACT ON AIRCREW COORDINATION AND TEAM PERFORMANCE IN GENERAL.

## **FUTURE RESEARCH**

- IDENTIFY OTHER IMPORTANT ORGANIZATIONAL VARIABLES THAT CAN IMPACT TEAM PERFORMANCE.
- DETERMINE SPECIFIC RELATIONSHIPS BETWEEN ORGANIZATIONAL VARIABLES AND AIRCREW COORDINATION.
- DETERMINE NEW METHODS TO OFFSET ORGANIZATIONAL VARIABLES.
  - TEAM TRAINING FOR ACTIVE DUTY AND RESERVES.

**AIRCREW COORDINATION TRAINING  
INTEGRATION**

**TRAINING TECHNOLOGY TECHNICAL GROUP  
MARCH 1992**

**RANDALL L. OSER**

**NAVAL TRAINING SYSTEMS CENTER  
ORLANDO, FL**

# **AIRCREW COORDINATION TRAINING (ACT) INTEGRATION**

- **PRESENTATION OVERVIEW**
  - **ACT AND INTEGRATION**
  - **INTEGRATION RESEARCH QUESTIONS**
  - **LEVELS OF INTEGRATION**
  - **'SEAMLESS' INTEGRATION OF ACT: V-22**
  - **RESEARCH REQUIRED**
  - **CONCLUSIONS**

# AIRCREW COORDINATION TRAINING

## INTEGRATION

- RESEARCH QUESTIONS
  - WHAT IS THE MOST EFFECTIVE METHOD FOR INTEGRATING SKILL-BASED AIRCREW COORDINATION TRAINING INTO 'STICK AND RUDDER' AIRCREW TRAINING?
  - CAN AIRCREW COORDINATION SKILLS BE TRAINED IN PARALLEL WITH 'STICK AND RUDDER' AIRCREW TRAINING?
  - WHEN SHOULD AN INTEGRATED APPROACH BE USED OR NOT USED?



# **AIRCREW COORDINATION TRAINING**

## **INTEGRATION**

- **RESEARCH QUESTIONS (Cont.)**
  - **HOW SHOULD AN INTEGRATED APPROACH BE EVALUATED?**
  - **WHEN IS THE MOST APPROPRIATE TIME TO INTRODUCE AND TRAIN AIRCREW COORDINATION SKILLS?**

# 'STAND-ALONE' INTEGRATION

## KNOWLEDGE

- Provide Platform Specific Information (i.e., Modules)

## DEMONSTRATION

- Demonstrate Effective/Ineffective Behaviors

## PRACTICE/ FEEDBACK

- Develop Skills
- Reinforce

Skills

AIRCREW  
COORDINATION  
TRAINING

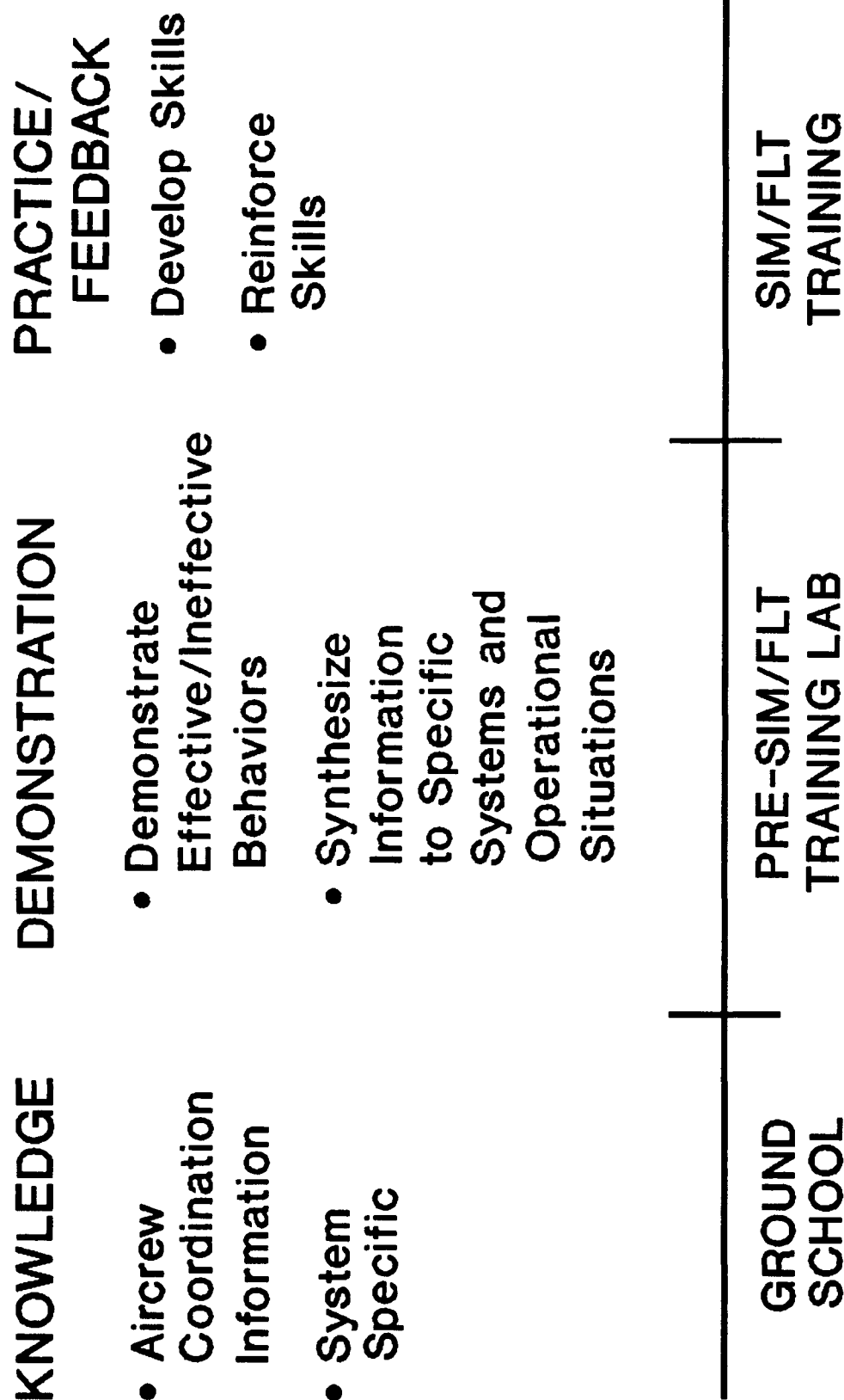
SIM/FLT  
TRAINING

GROUND  
SCHOOL

# 'EMBEDDED' INTEGRATION

| KNOWLEDGE                                                                                                                                                          | DEMONSTRATION                                                                                                                                                     | PRACTICE/<br>FEEDBACK                                                                       |   |   |   |   |   |   |   |   |   |   |                                                                                                                                                                    |   |   |   |   |   |   |   |   |   |   |   |   |  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|---|---|---|---|---|---|---|---|---|---|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|---|---|---|---|---|---|---|---|---|--|
| <ul style="list-style-type: none"><li>• Aircrew Coordination Information (i.e., Modules)</li><li>• Mission Specific</li></ul>                                      | <ul style="list-style-type: none"><li>• Demonstrate Effective/Ineffective Behaviors</li><li>• Synthesize Information to Specific Operational Situations</li></ul> | <ul style="list-style-type: none"><li>• Develop Skills</li><li>• Reinforce Skills</li></ul> |   |   |   |   |   |   |   |   |   |   |                                                                                                                                                                    |   |   |   |   |   |   |   |   |   |   |   |   |  |
| <table><tr><td>A</td><td>A</td><td>A</td><td>A</td></tr><tr><td>C</td><td>C</td><td>C</td><td>C</td></tr><tr><td>T</td><td>T</td><td>T</td><td>T</td></tr></table> | A                                                                                                                                                                 | A                                                                                           | A | A | C | C | C | C | T | T | T | T | <table><tr><td>A</td><td>A</td><td>A</td><td>A</td></tr><tr><td>C</td><td>C</td><td>C</td><td>C</td></tr><tr><td>T</td><td>T</td><td>T</td><td>T</td></tr></table> | A | A | A | A | C | C | C | C | T | T | T | T |  |
| A                                                                                                                                                                  | A                                                                                                                                                                 | A                                                                                           | A |   |   |   |   |   |   |   |   |   |                                                                                                                                                                    |   |   |   |   |   |   |   |   |   |   |   |   |  |
| C                                                                                                                                                                  | C                                                                                                                                                                 | C                                                                                           | C |   |   |   |   |   |   |   |   |   |                                                                                                                                                                    |   |   |   |   |   |   |   |   |   |   |   |   |  |
| T                                                                                                                                                                  | T                                                                                                                                                                 | T                                                                                           | T |   |   |   |   |   |   |   |   |   |                                                                                                                                                                    |   |   |   |   |   |   |   |   |   |   |   |   |  |
| A                                                                                                                                                                  | A                                                                                                                                                                 | A                                                                                           | A |   |   |   |   |   |   |   |   |   |                                                                                                                                                                    |   |   |   |   |   |   |   |   |   |   |   |   |  |
| C                                                                                                                                                                  | C                                                                                                                                                                 | C                                                                                           | C |   |   |   |   |   |   |   |   |   |                                                                                                                                                                    |   |   |   |   |   |   |   |   |   |   |   |   |  |
| T                                                                                                                                                                  | T                                                                                                                                                                 | T                                                                                           | T |   |   |   |   |   |   |   |   |   |                                                                                                                                                                    |   |   |   |   |   |   |   |   |   |   |   |   |  |
| GROUND SCHOOL                                                                                                                                                      |                                                                                                                                                                   | SIM/FLT TRAINING                                                                            |   |   |   |   |   |   |   |   |   |   |                                                                                                                                                                    |   |   |   |   |   |   |   |   |   |   |   |   |  |

# 'SEAMLESS' INTEGRATION



# **AIRCREW COORDINATION TRAINING**

## **V-22 ACT INTEGRATION**

- **IMPLICATIONS FOR 'SEAMLESS' INTEGRATION**
  - **GLASS COCKPIT**
  - **AUTOMATED SYSTEMS**
  - **TILT-ROTOR FLIGHT PROFILE**
  - **DEVELOPMENTAL PROGRAM**
  - **OPERATIONAL TRAINING ENVIRONMENT**

# AIRCREW COORDINATION TRAINING

## V-22 ACT INTEGRATION

- APPLICATION OF 'SEAMLESS' INTEGRATION
  - REVIEW OF RELEVANT LITERATURE
  - CONDUCT NEEDS ANALYSIS
  - IDENTIFICATION OF CRITICAL TASKS REQUIRING COORDINATION
  - DEVELOPMENT OF PROTOTYPE MATERIALS (i.e., INTEGRATED GROUND SCHOOL TRAINING MATERIALS, SIMULATOR EXERCISES)
  - UTILIZATION AND EVALUATION OF TRAINING MATERIALS

## Outline of Instruction

After selecting the ILS key, the pilot will be prompted to tune the desired ILS frequency and select the desired ILS front course bearing, final decision height, final approach speed and the intercept track (heading) under the VOR/ILS COURSE, ILS FS/DH and TRACK CDU legend/keys. Pilots should decide on all parameters to be entered prior to selecting the ILS key. When the front course bearing is entered, the heading for a 30° intercept will appear under the REF HEADING legend. The reference heading can be changed by the pilot provided the intercept angle is less than 90°.

When data entry is complete, the TRK mode will be activated and the ILS armed, causing the TRK legend to update to TRK\* and the ILS legend to ILS ARM. The system heading reference will be automatically set to magnetic.

NOTE: Arming the ILS mode will also cause the filters for the localizer and glideslope signals to be initialized. These filters provide smoothed estimates of the variables required for the ILS guidance processing.

### a) Localizer Geometry

Once the ILS mode is armed, the aircraft will turn to the entered ground track angle to intercept the ILS localizer angle. Pilots should monitor aircraft performance against expected aircraft performance.

## Instructor Activity

State that it is important to ensure that the entire crew is aware that an ILS approach will be performed.

Stress the importance of pilots anticipating and communicating all legend updates during ILS approaches to ensure the system is functioning properly and to maintain situational awareness.

28. Show transparency V-22-PLTFDS-0020 and direct students to the Student Workbook, 2.11.3.

## GROUND OPERATIONS

NOTE: IC at TAKEOFF POSITIONILS Exercise:

Call waveoff prior to DECISION HEIGHT alert, requiring pilot to quickly assume manual control of the aircraft.

- ☐ Perform - Normal Instrument Pretakeoff Checks

## FLIGHT OPERATIONS

- ☐ Perform - Short Instrument Takeoff
- ☐ Perform - Instrument Conversion and Climbout, Flight Director
- ☐ Perform - Flight using VOR, TACAN - Airplane Mode/Conversion Mode, Flight Director - Commanded
- ☐ Perform - Missed Approach/Wave Off - Flight Director - Commanded

NOTE: IC at TAKEOFF POSITION

- ☐ Perform - Normal Instrument Takeoff
- ☐ Perform - Instrument Conversion and Climbout
- ☐ Perform - Instrument Approach: VOR, Flight Director - Commanded
- ☐ Perform - Landings from Instrument Approach - Short Landing

NOTE: IC at Final Instrument Approach Position

- ☐ Perform - Instrument Approach: ILS, Flight Director

ILS Approach:

- ☐ Pilots announce to crew/ensure crew aware that ILS approach will be conducted
- ☐ Prior to selecting ILS key, pilots have decided on all parameters to be entered (i.e., ILS front course bearing, final decision height, final approach speed, and intercept track (heading)).



Pilot not flying:

- ☐ Enters and checks data
- ☐ Communicates TRK legend update to TRK\* and ILS legend update to ILS ARM
- ☐ Pilots monitor aircraft turn to ground track angle
- ☐ Pilots note LOC CAPTURE annunciator, TRK\* mode update to TRK, and ILS ARM update to ILS\*
- ☐ Pilots monitor aircraft pitchover/descent to glideslope
- ☐ Pilot flying communicates readiness to assume aircraft control
- ☐ Pilots note DECISION HEIGHT alert
- ☐ Pilot flying announces he is assuming control of the aircraft
- ☐ Pilot flying assumes control of the aircraft and announces when he has control of the aircraft

227

☐ Perform - Landings from Instrument Approach - Hover Vertical Landing

☐ Perform - Normal Shutdown

#### POST FLIGHT OPERATIONS

☐ Review - Problem areas

☐ Preview next flight

# **AIRCREW COORDINATION TRAINING INTEGRATION**

- **RESEARCH REQUIRED**
  - **LABORATORY STUDIES**
  - **OPERATIONAL/FIELD STUDIES**
  - **SKILL RETENTION**
  - **TRAINING OPTIMIZATION**
  - **PERFORMANCE MEASUREMENT**

# AIRCREW COORDINATION TRAINING INTEGRATION

- CONCLUSIONS
  - IMPLICATIONS OF RESEARCH
  - CONSTRAINTS OF THE OPERATIONAL ENVIRONMENT
  - INTRODUCTION OF NEW TECHNOLOGIES
  - APPLICATION OF INTEGRATED ACT IN MILITARY AND CIVILIAN AVIATION ENVIRONMENTS

# TABLE TOP AIRCREW COORDINATION TRAINING SYSTEM

(T-TACTS)

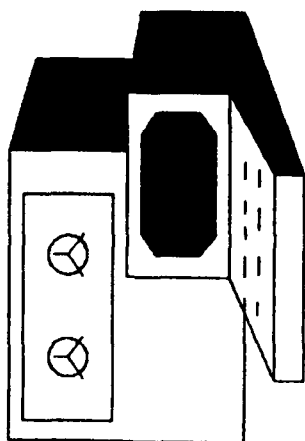
MAJ WES WOODRUFF  
NTSC AIR FORCE LIAISON OFFICER

# OVERVIEW

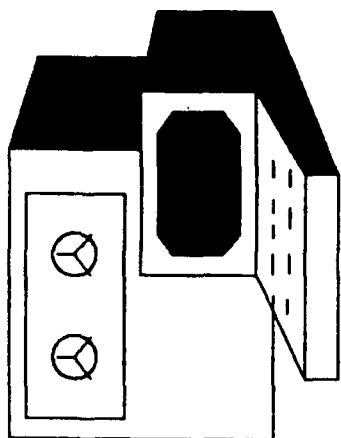
- EQUIPMENT
- SOFTWARE
- SCENARIO DEVELOPMENT
- FUTURE ENHANCEMENTS/PROGRAMS

# **EQUIPMENT**

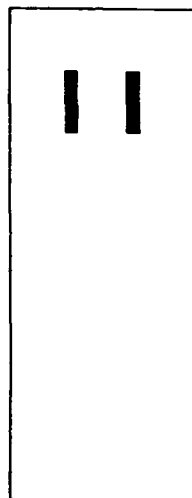
- IBM 286 OR 386 PC
  - MICROSOFT FLIGHT SIMULATOR
- AIRCRAFT AND SCENERY DESIGN**
- SCENERY DISKS**
- VGA UPGRADE**
- FLIGHT CONTROLS
  - HEADSETS AND SPLITTER BOXES



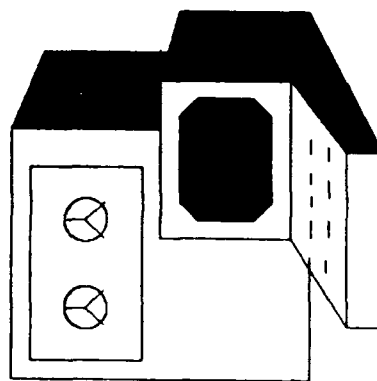
PILOT



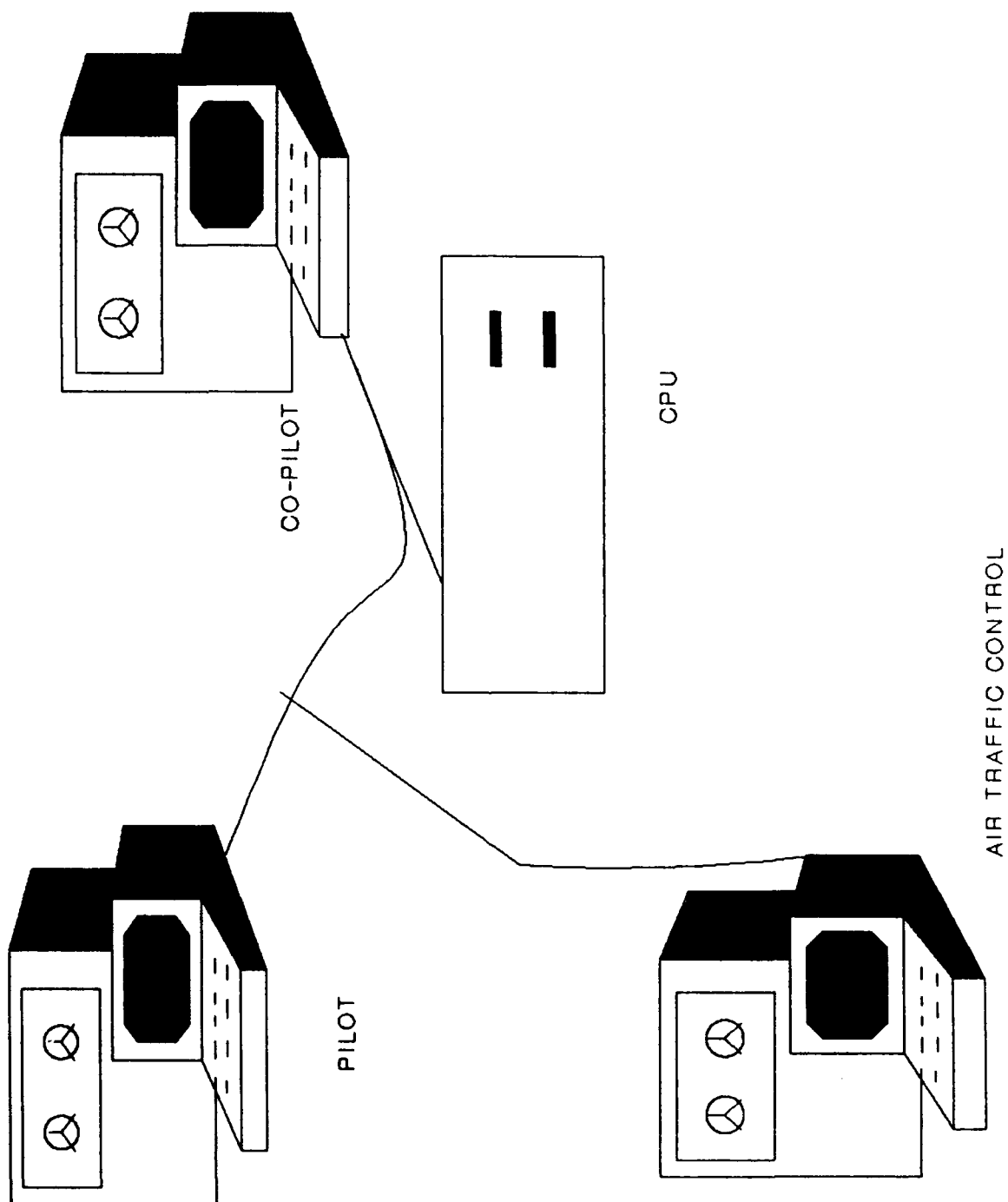
CO-PILOT



CPU



AIR TRAFFIC CONTROL





# SOFTWARE

- INEXPENSIVE

TOTAL COST \$ 130.00

- REAL WORLD

- EASY TO LEARN

15 MINUTE ORIENTATION

- NOT A FLIGHT TRAINER

# SCENARIO DEVELOPMENT

- LOCATIONS IN FS DATA BASE
- USE FLIGHT PUBLICATIONS
- UNFAMILIAR AREA TO SUBJECTS
- 20 MINUTES LONG
- NO EQUIPMENT FAILURES
- NOT MAKING SUBJECTS EXPERTS ON FS
- HIGH DEGREE OF REALISM
- ATC COMM
- AIRCREWMAN, PAX ON BOARD

# **SCENARIO DEVELOPMENT (cont)**

- **SCENARIOS**

- C-12 TYPE AIRCRAFT**

- TRANSPORTING AN ADMIRAL FROM A TO B**

- **CREW PROBLEMS TO SOLVE**

- LOST COMMUNICATION**

- PASSENGER HAS HEART ATTACK**

# **FUTURE ENHANCEMENTS/PROGRAMS**

## **EQUIPMENT**

- SOUND BOARD
- MORE AND VARIED ATC COMMUNICATIONS
- LARGER TEAMS
- ELIMINATION OF KEYBOARD
- THROTTLE, GEAR AND FLAP HANDLE

## **PROGRAMS**

- T-34                      - F-18                      - T-44
- A-6                      - USMC RESERVES

TRAINING DESIGN AND EVALUATION

Instructional, Planning and Evaluation Issues

Modeling Skill Acquisition:  
Dr. Mark Sabol

Retention of Knowledge Learned in College:  
Dr. John Ellis

MODELS OF SKILL ACQUISITION

MARK SABOL  
ARMY RESEARCH INSTITUTE  
ALEXANDRIA, VIRGINIA

PRESENTATION AT T2TG MEETING  
PHOENIX, ARIZONA  
MARCH 25, 1992

**TOPICS TO BE DISCUSSED:**

- COMPLETED RESEARCH ON PERCEPTUAL-MOTOR SKILL TRAINING
  - MODELS
  - FINAL ISSUES
- FUTURE RESEARCH
  - COLLECTIVE SKILLS
  - RETRAINING

**PRELIMINARY CONFUSION MATRIX RESULTS - SEP 90**  
(Data from 10 subjects at each speed)

All errors that occurred  $\geq 5\%$  of the time each stimulus was presented  
(4-element stimuli, only):

Speed = 10 Groups per Minute

Speed = 20 Groups per Minute

Stimulus      H    . . . .  
Response      S    . . .      (38%)

Stimulus      B    - . . .  
Response      D    - . .      (19%)

Stimulus  
Response

Stimulus      V    . . . -  
Response      U    . . .      (10%)

Stimulus      F    . . . .  
Response      L    . . . .      ( 8%)

Stimulus      L    . . . .  
Response      R    . . .      ( 7%)

Stimulus      F    . . . .  
Response      U    . . .      ( 6%)

Stimulus      Y    - . . -  
Response      C    - . . .      ( 6%)

Stimulus  
Response

Stimulus      Z    - . . .  
Response      G    - . .      ( 6%)

Stimulus  
Response

Stimulus  
Response

Stimulus  
Response

Stimulus  
Response

H    . . . .  
S    . . .      (21%)

B    - . . .  
X    - . . -      ( 6%)

V    . . . -  
U    . . .      ( 7%)

L    . . . .  
R    . . .      (16%)

F    . . . .  
U    . . .      (15%)

Y    - . . -  
C    - . . .      ( 5%)

C    - . . .  
Y    - . . -      (6%)

Z    - . . .  
Q    - . . -      ( 6%)

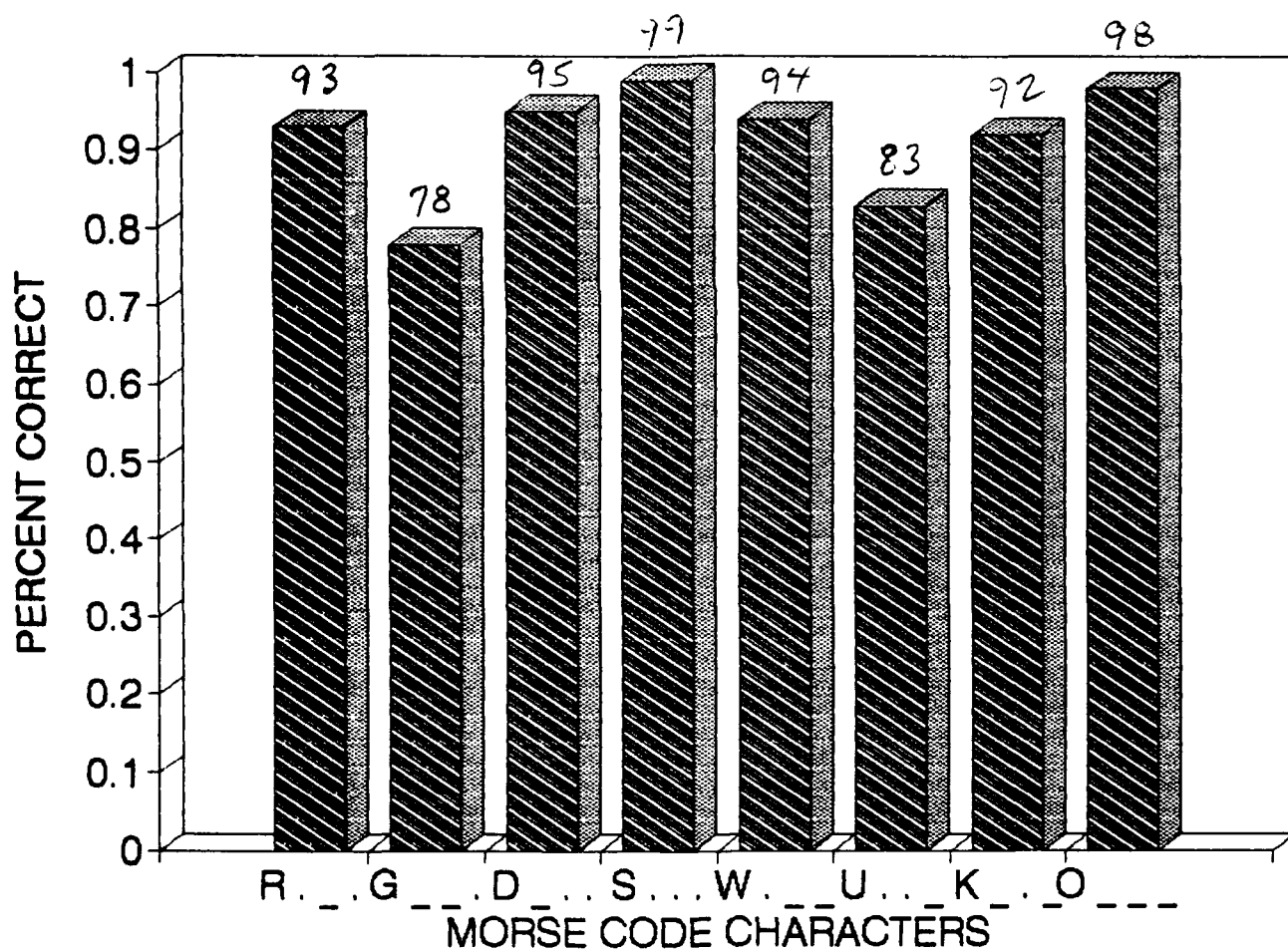
P    . . . .  
W    . . .      ( 9%)

J    . . . -  
W    . . .      ( 8%)

P    . . . .  
J    . . . -      ( 7%)

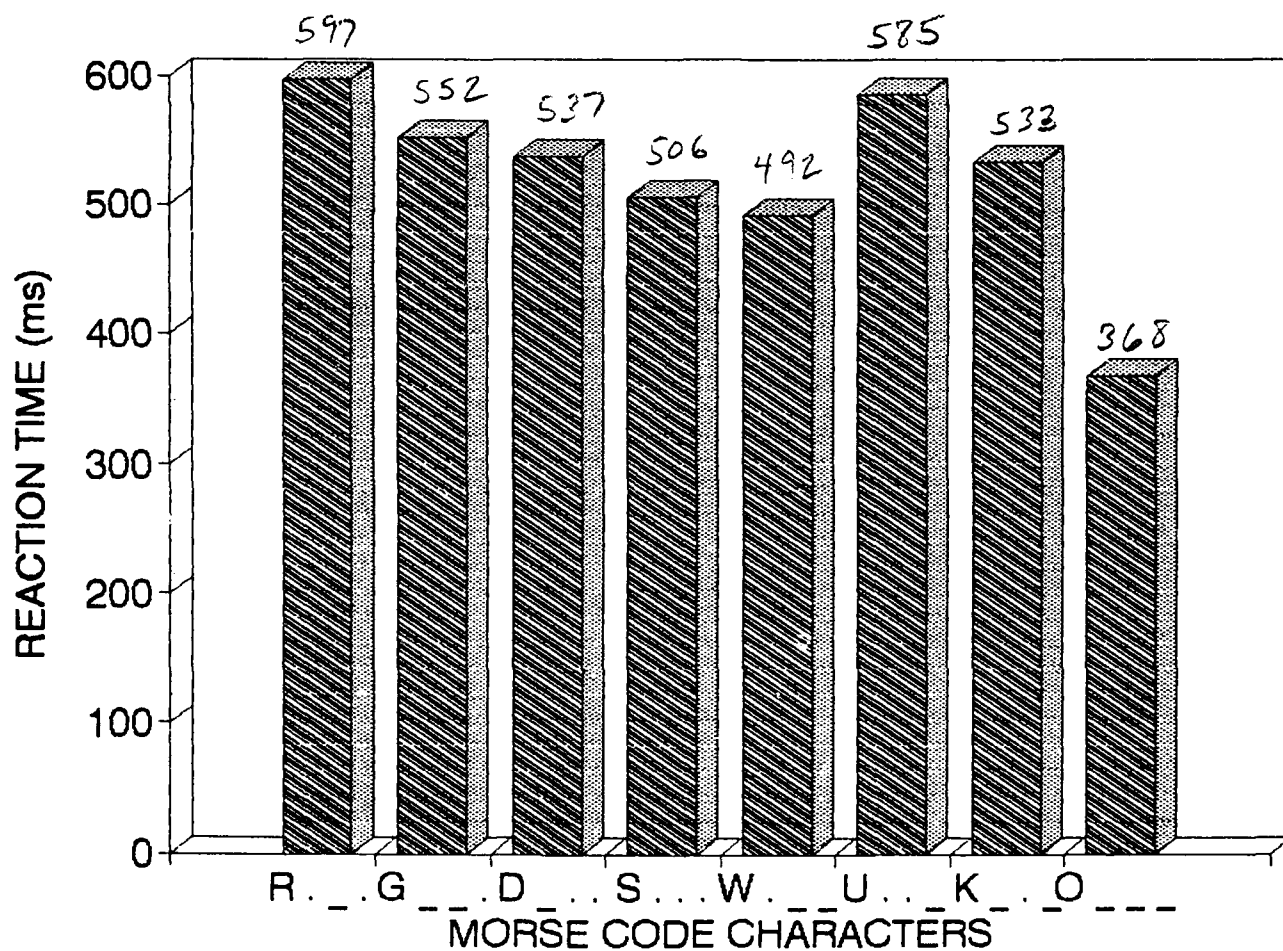


# THREE-ELEMENT CHARACTERS

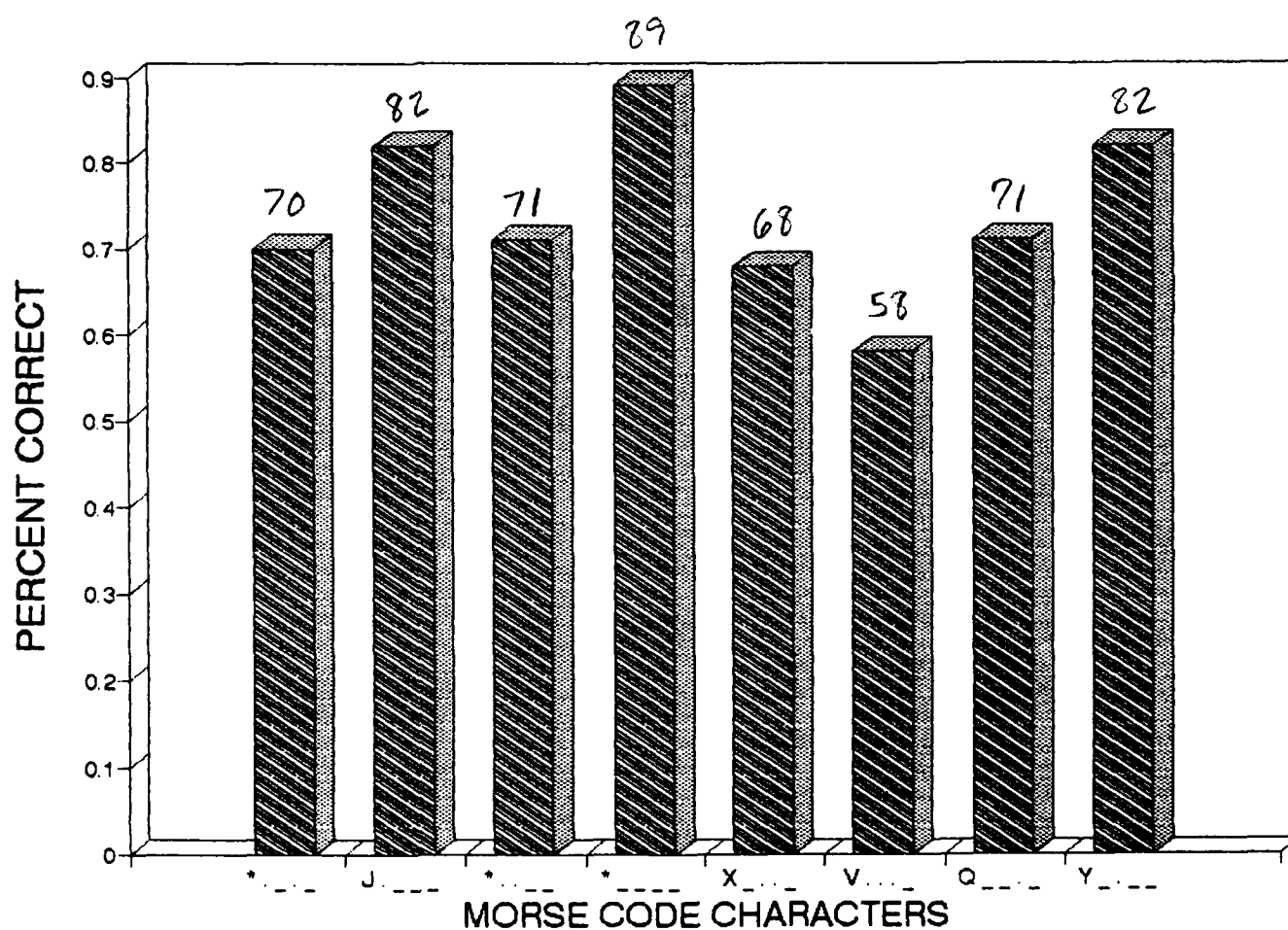


8 Ss, 400 trials/5

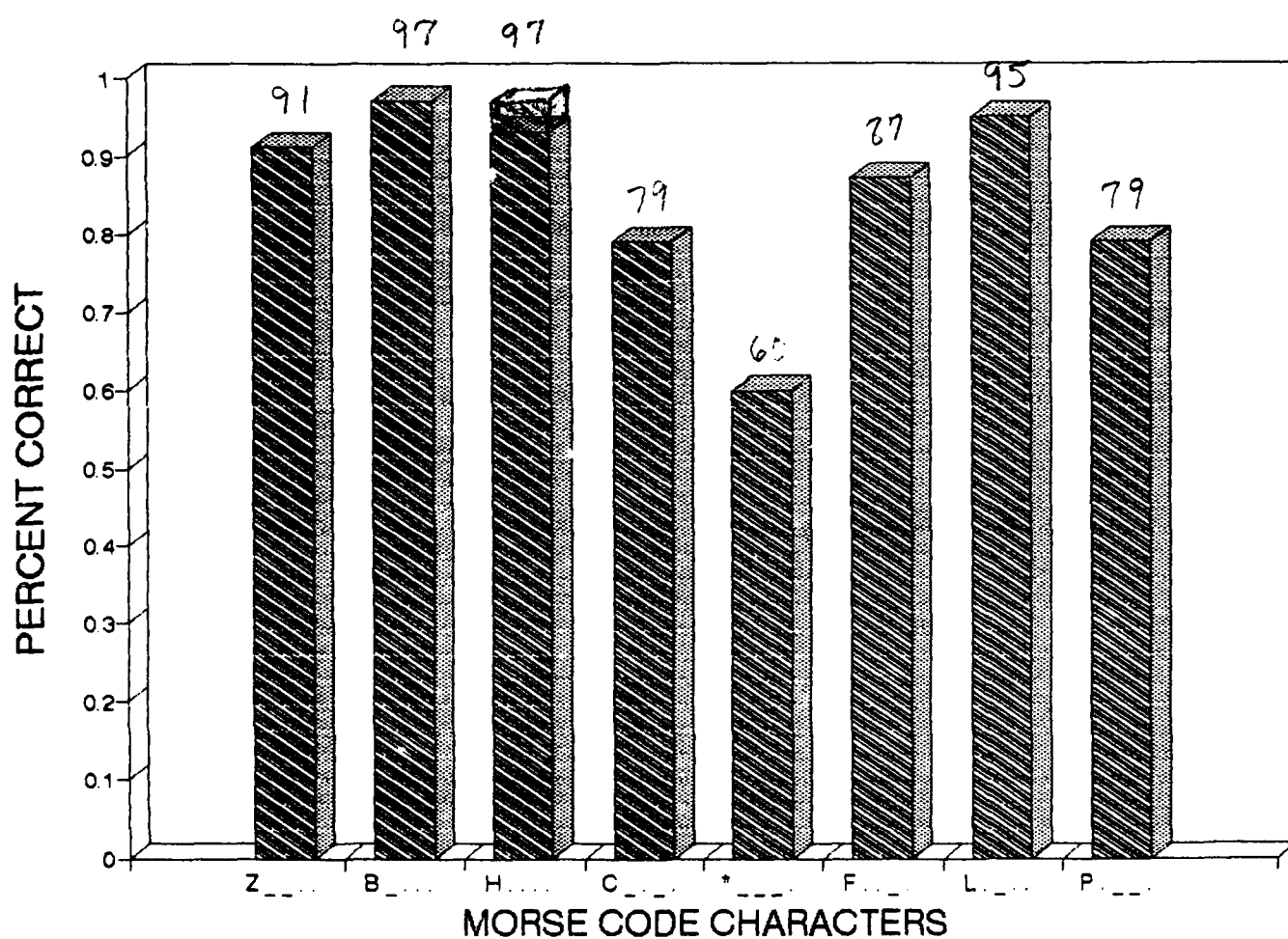
# THREE-ELEMENT CHARACTERS



# FOUR-ELEMENT CHARACTERS

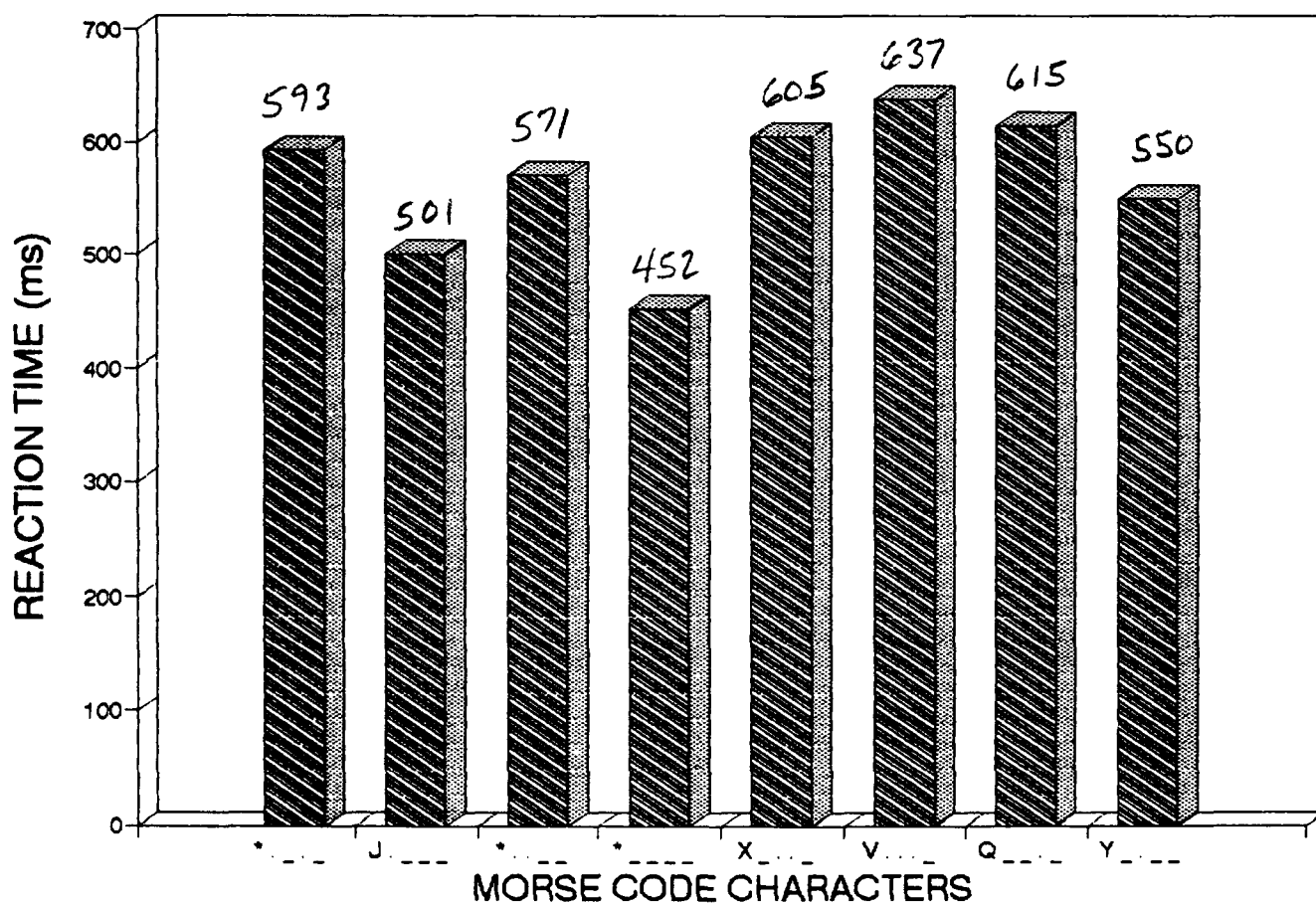


# FOUR-ELEMENT CHARACTERS

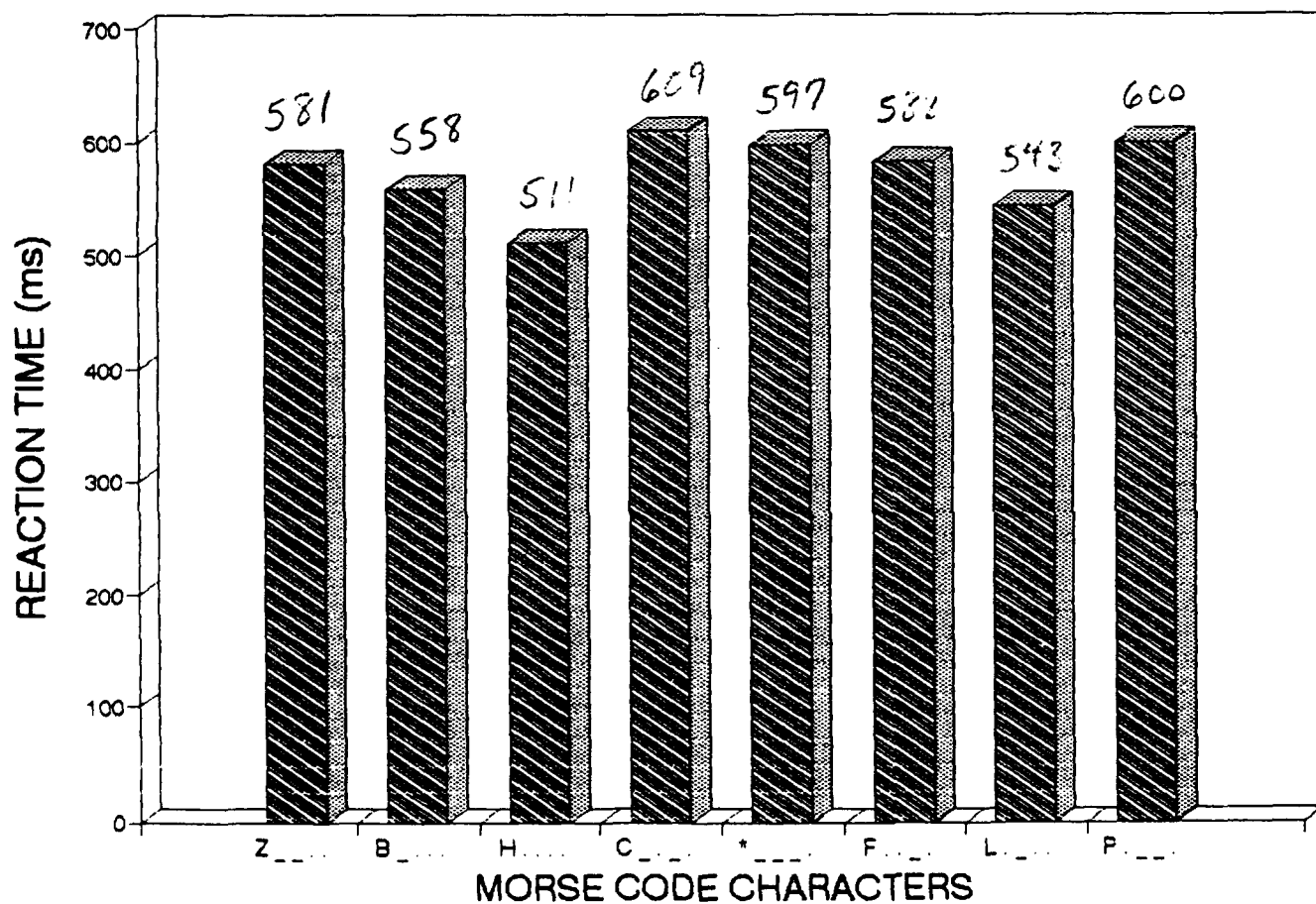


18 ss, 240 trials/s

# FOUR-ELEMENT CHARACTERS



# FOUR-ELEMENT CHARACTERS

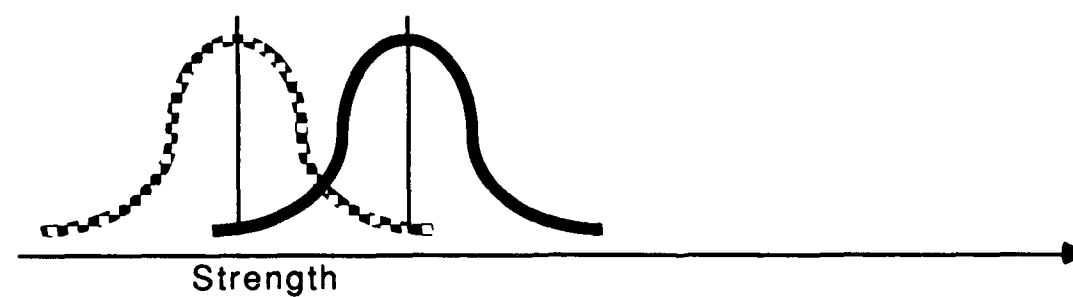
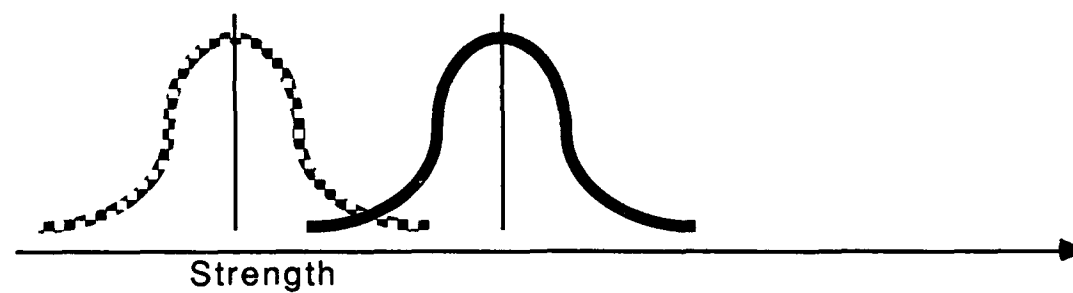
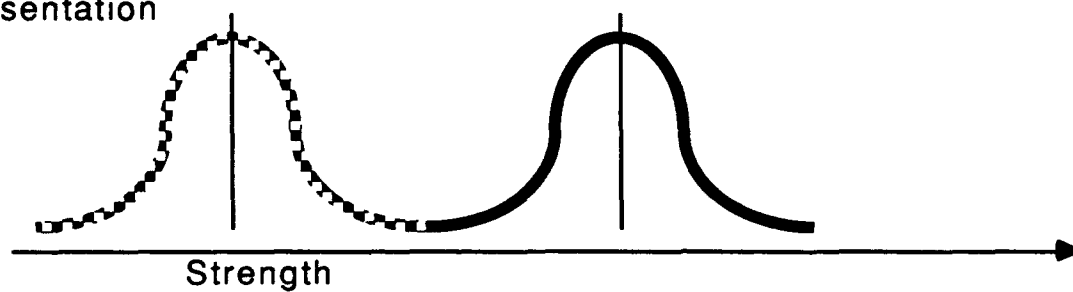


# Stimulation and Decay of Trace Strength Register Single Presentation

Rest  
(Noise)



Stimulus  
Presentation



Rest  
(Noise)



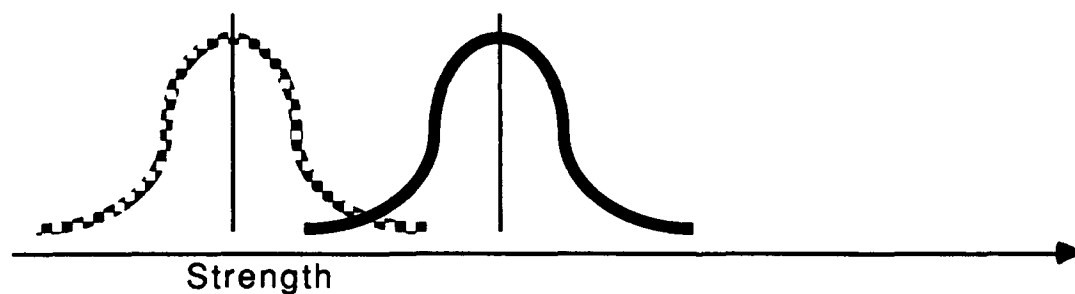
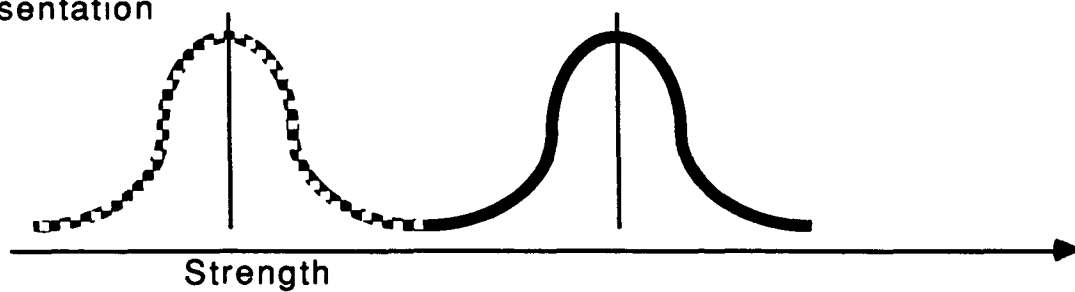
T  
I  
M  
E

# Stimulation and Decay of Trace Strength Register Double Presentation

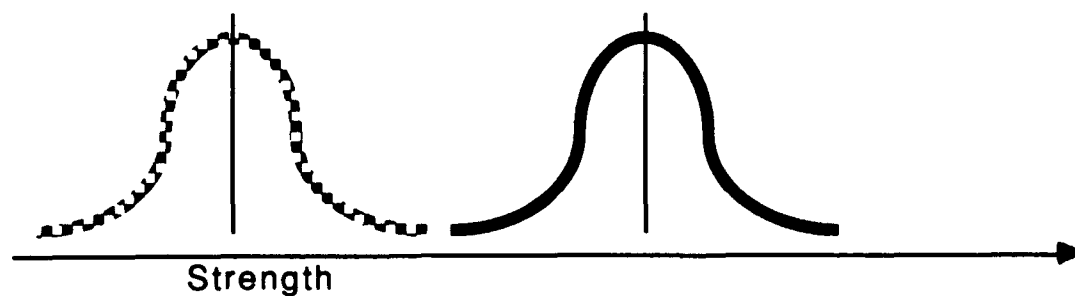
Rest  
(Noise)



Stimulus  
Presentation



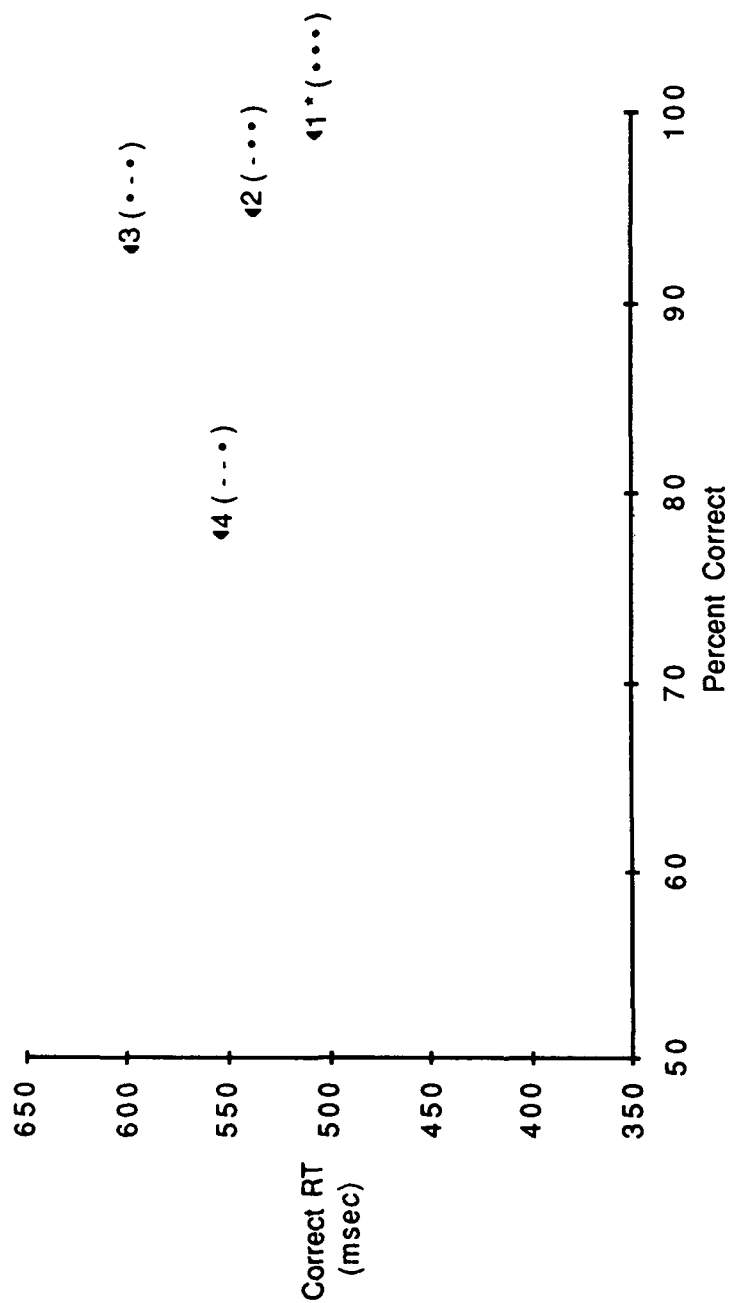
Stimulus  
Presentation



T  
I  
M  
E

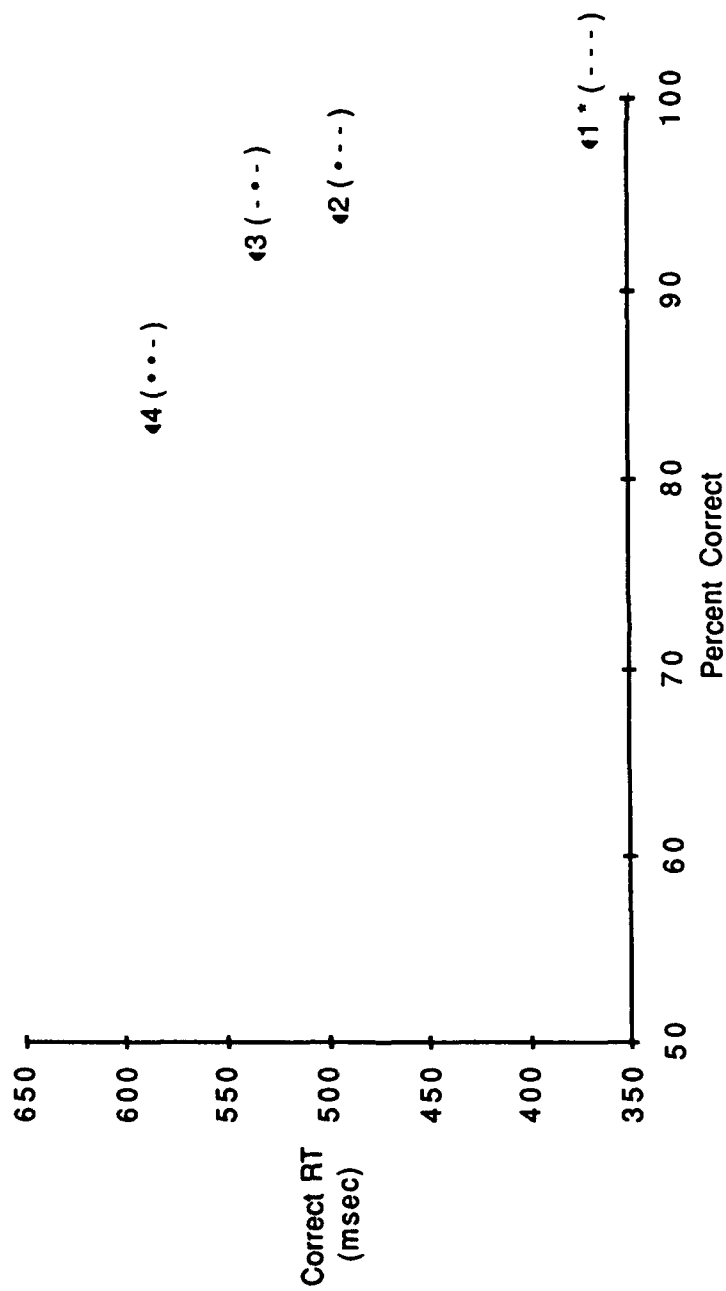


### 3-Element Characters with a Final "dit"



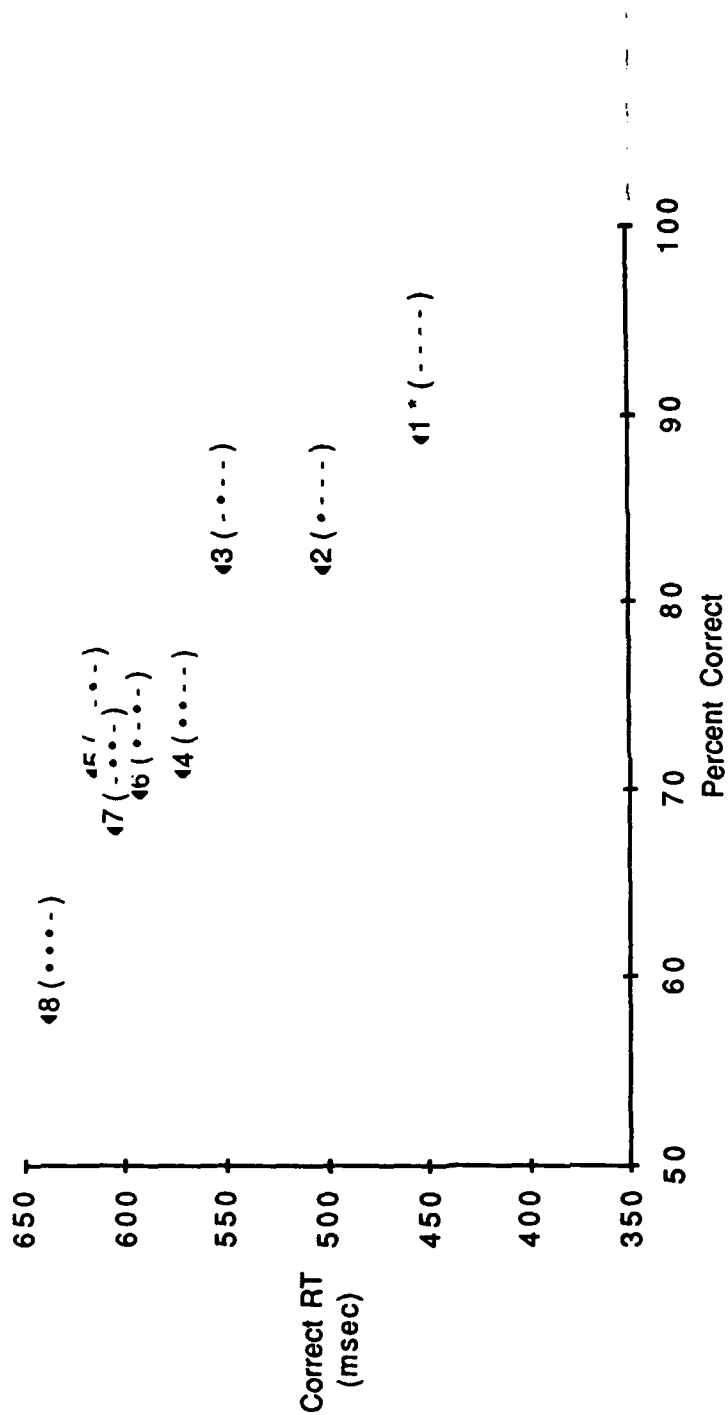
\* Character rank predicted from trace strength model

### 3-Element Characters with a Final "dah"



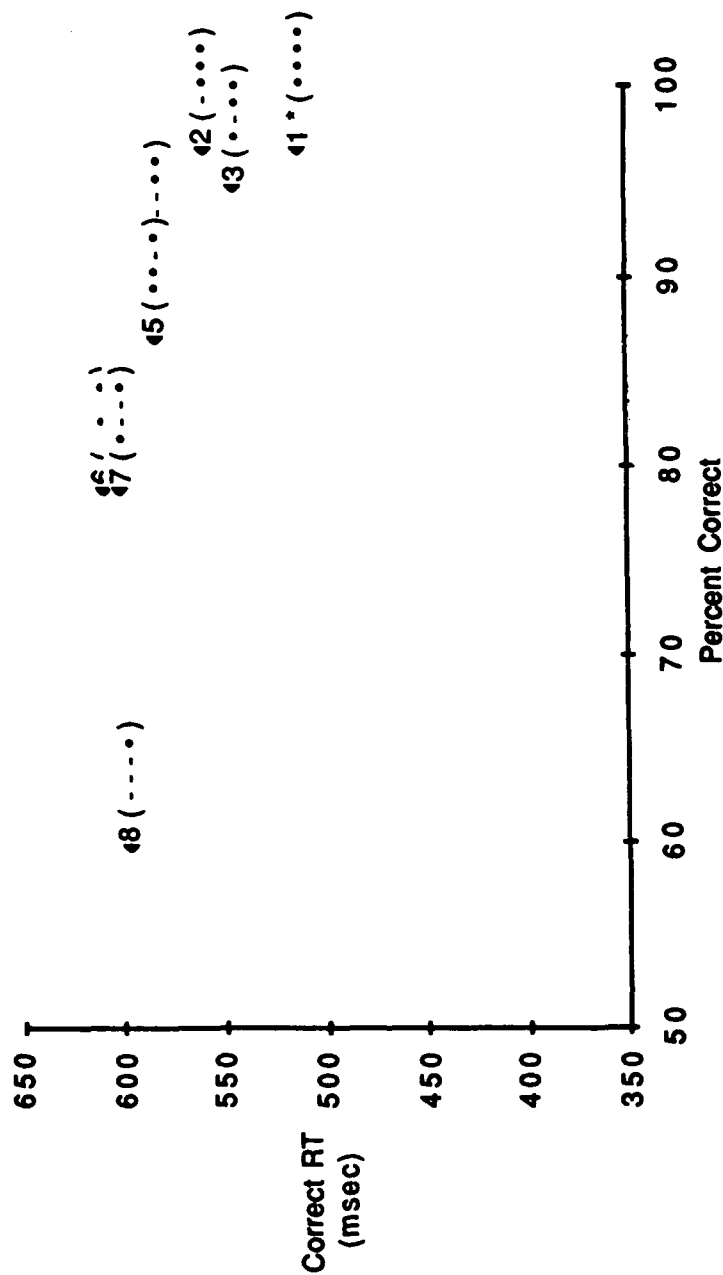
\* Character rank predicted from trace strength model

# 4-Element Characters with a Final "dah"



\* Character rank predicted from trace strength model

# 4-Element Characters with a Final "dit"



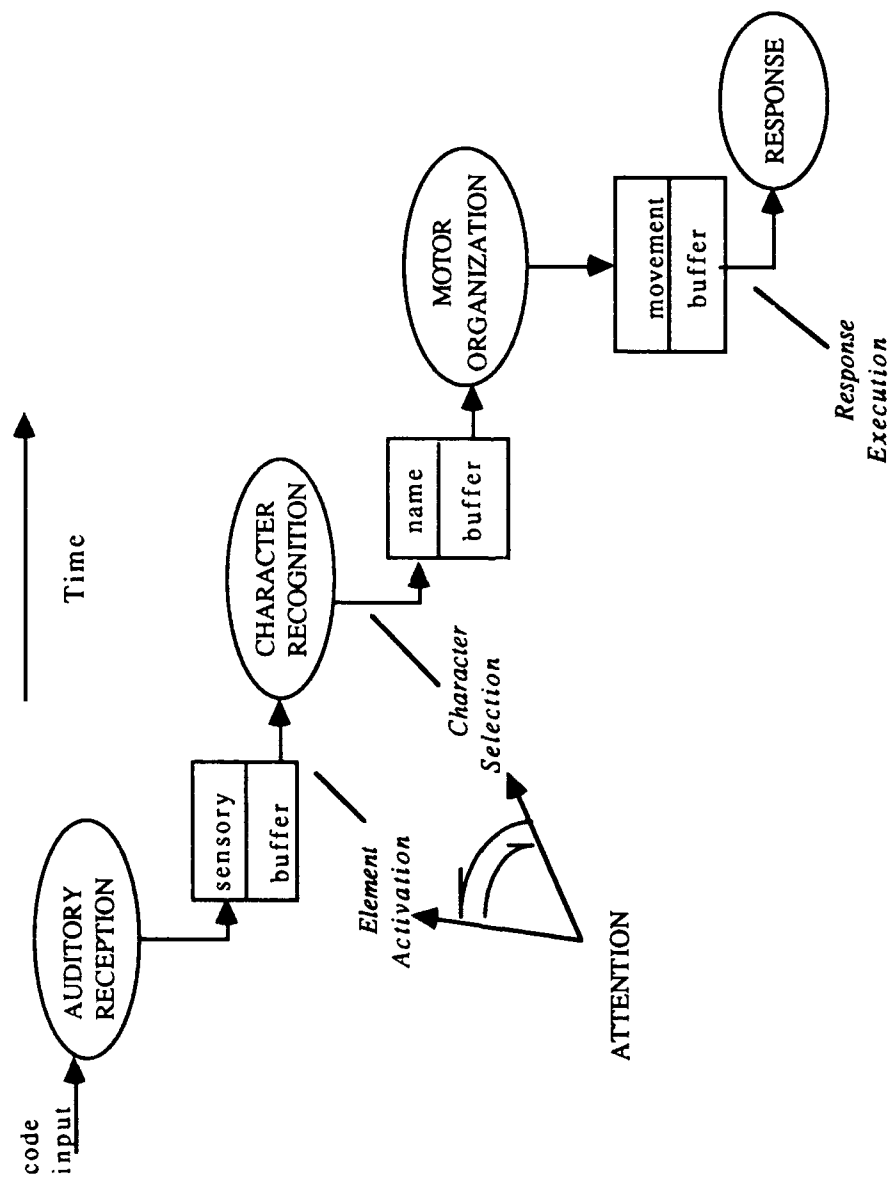
\* Character rank predicted from trace strength model

## MODEL DEVELOPMENT

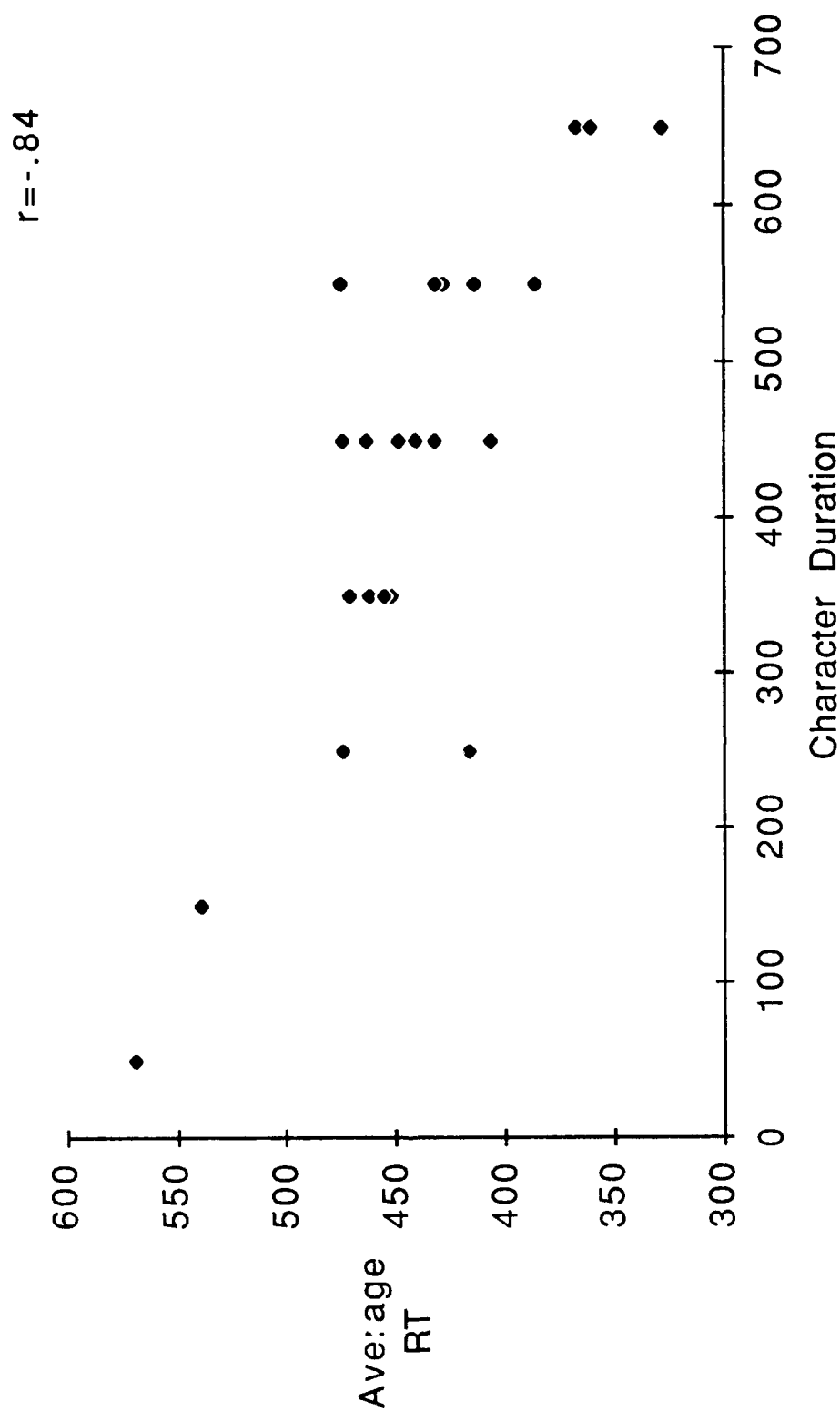
### FEATURES OF MODEL:

- attention shifts from previous character recognition to auditory buffer
- *Element Activation*
  - feeds information from sensory store to character recognition system
  - starts once response to previous stimulus is decided upon
  - stops after a fixed period of time (for a given speed, subject)
  - for novices, elements activated serially, earliest first (to avoid further decay)
  - for experts, all elements activated in parallel
- *Character Selection*
  - decides on character identity based upon activated information only
  - initiates response execution
- *Response Execution*
  - autonomous, proceeds without need for attention
  - attention can shift to auditory buffer for activation of next stimulus

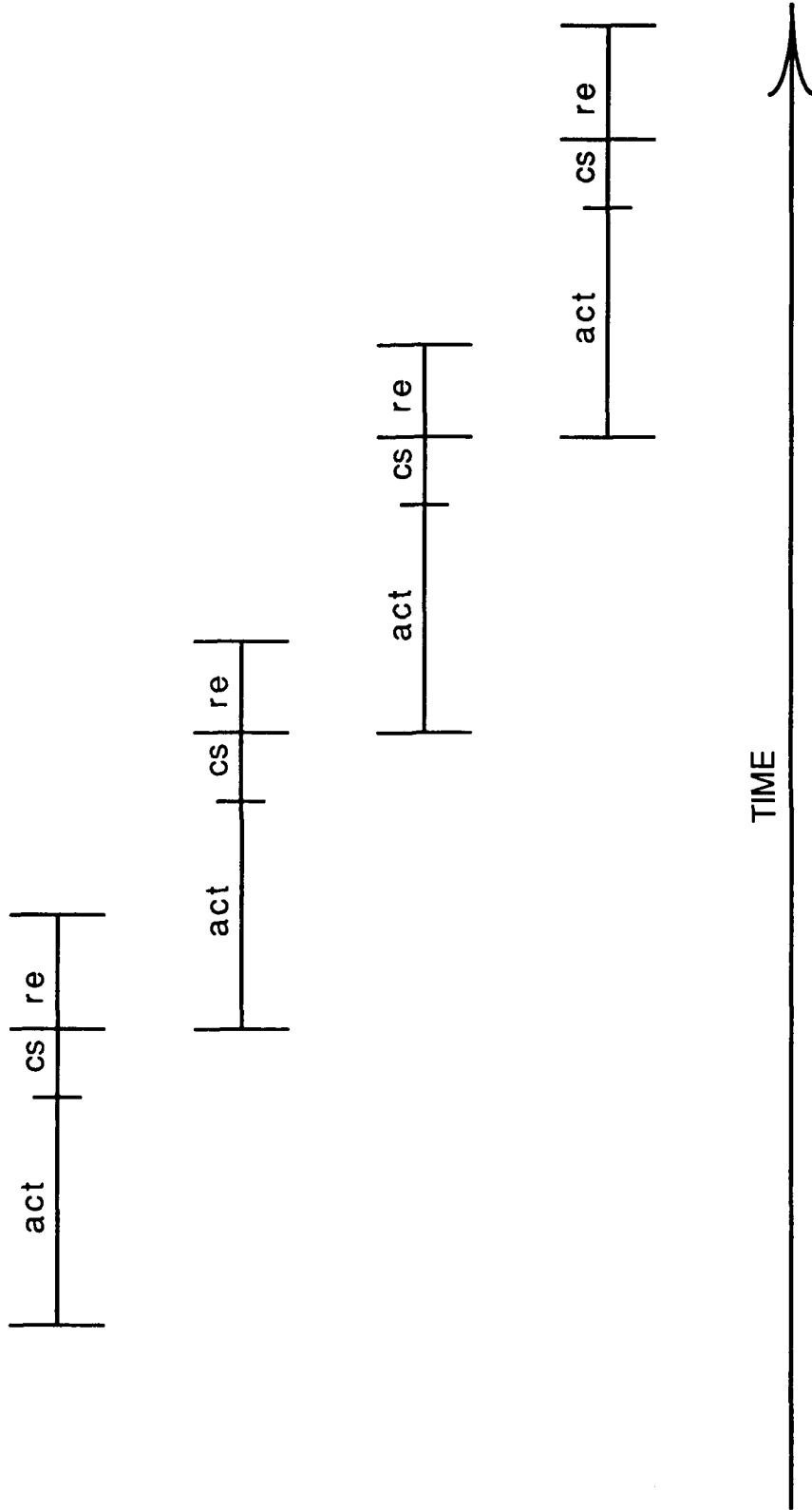
Figure 4. Cognitive process model for skilled Morse code copying.



# 15 Subjects, Last 18 GPM Session



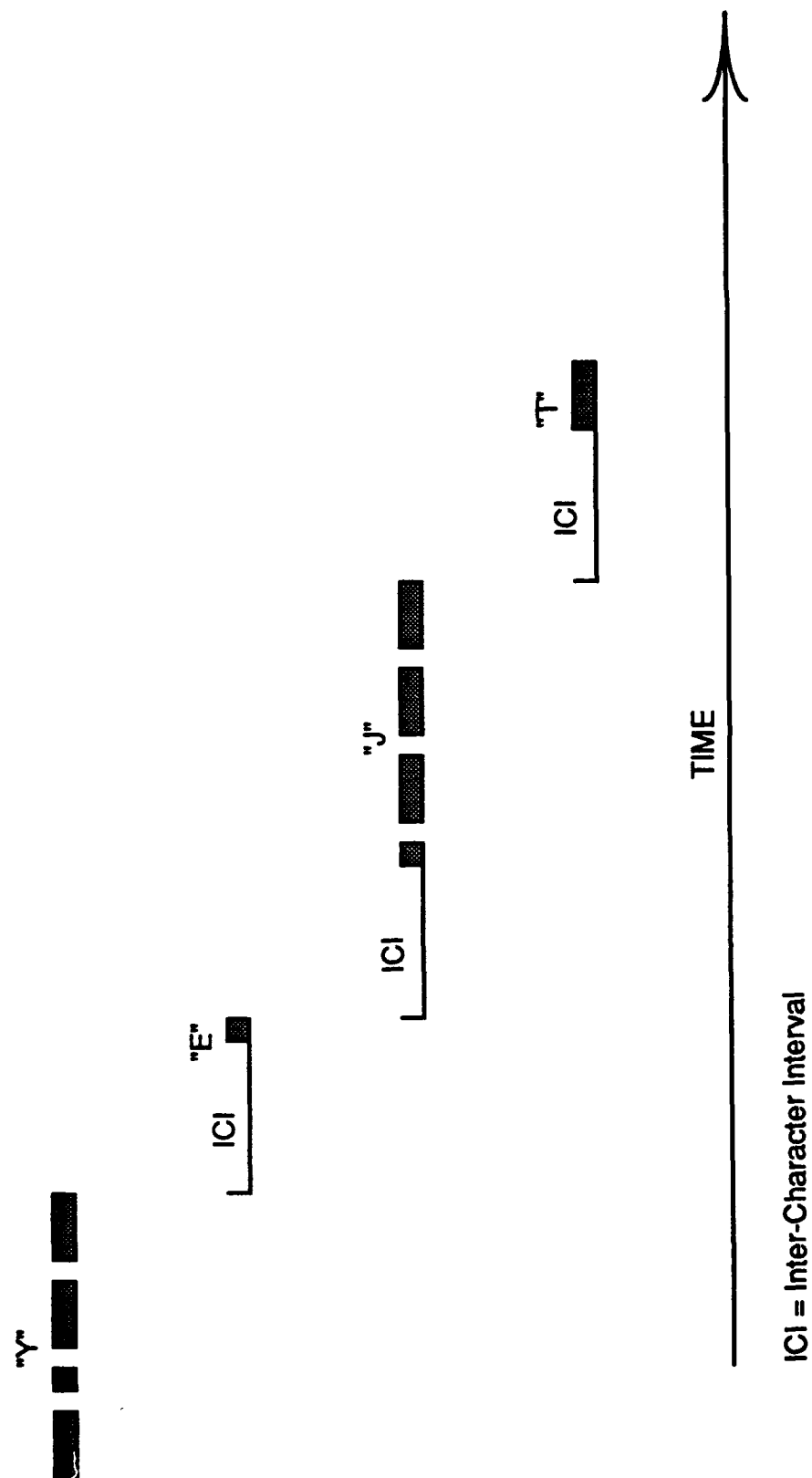
# PROCESSING SEQUENCE EXAMPLE



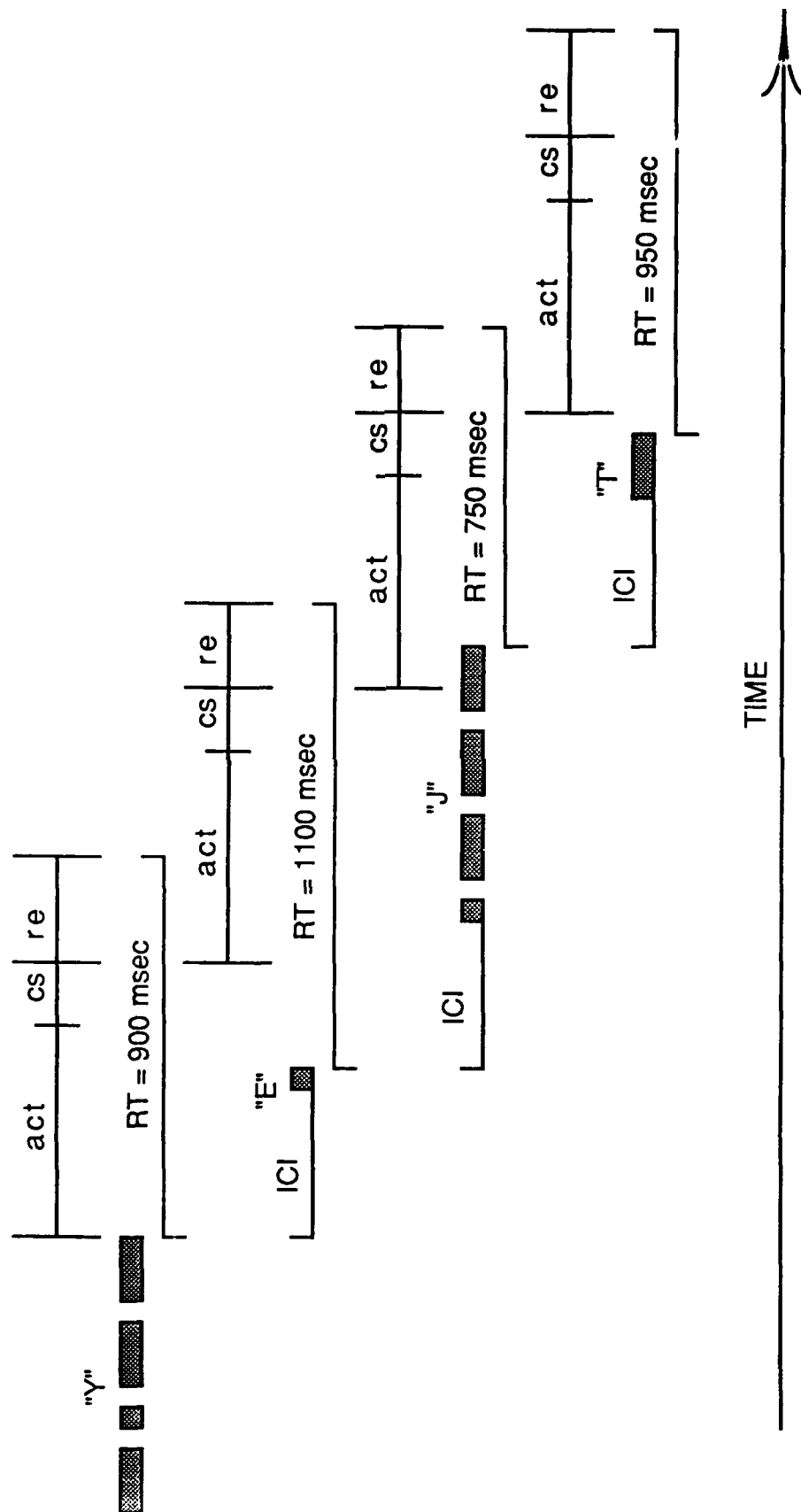
act = activation time (constant for given speed and subject, internally clocked, starts when previous cs finishes)  
cs = character selection time (nearly constant, decreases with practice)  
re = response execution time (variable)



# STIMULUS SEQUENCE EXAMPLE



# RESULTANT REACTION TIME SEQUENCE



ICI = Inter-Character Interval

act = activation time (constant, internally clocked, starts when previous cs finishes)

cs = character selection time (nearly constant)

re = response execution time (variable)

Figure 1. Mean Reaction Time for Each Group of Subjects  
at Different Presentation Speeds

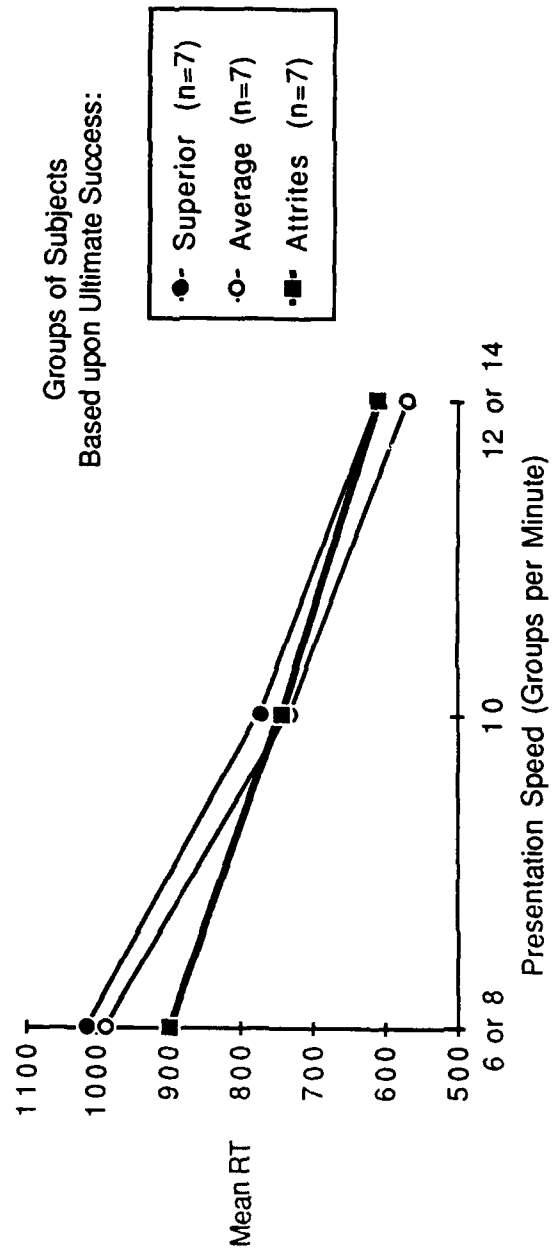
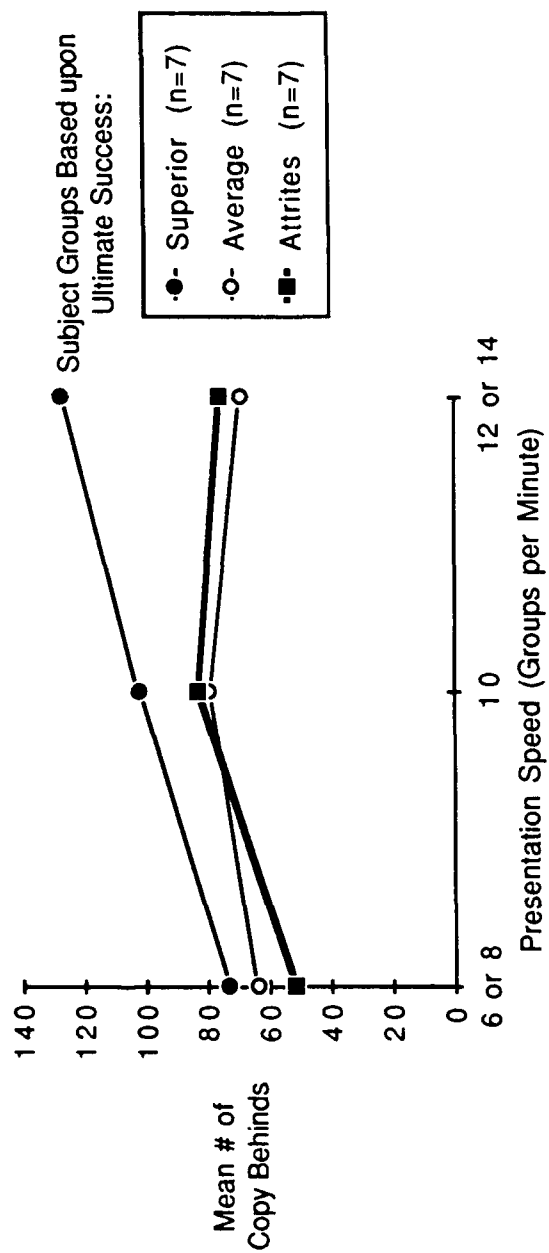


Figure 2. Mean Number of Instances of "Copying Behind" by Each Group of Subjects at Different Presentation Speeds



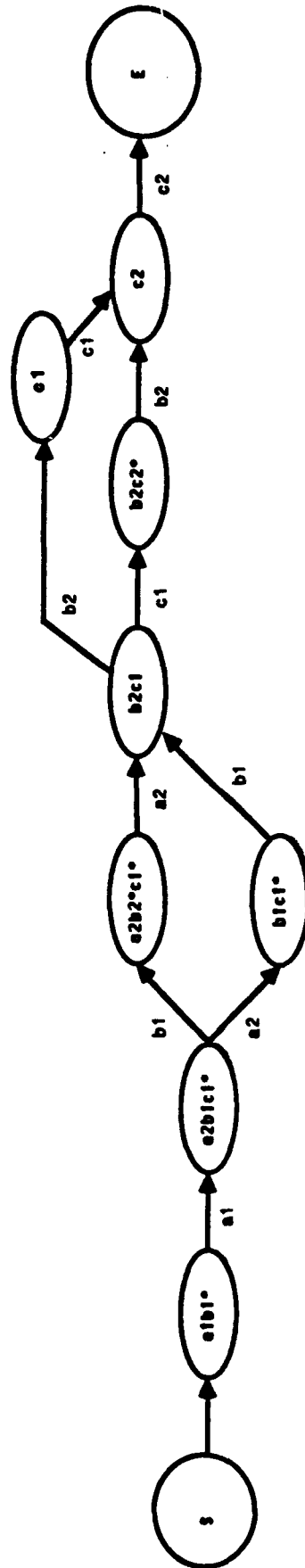


Figure 1. Diagram of the Large Start-Buffer, Upstream Blocking Model for three items.

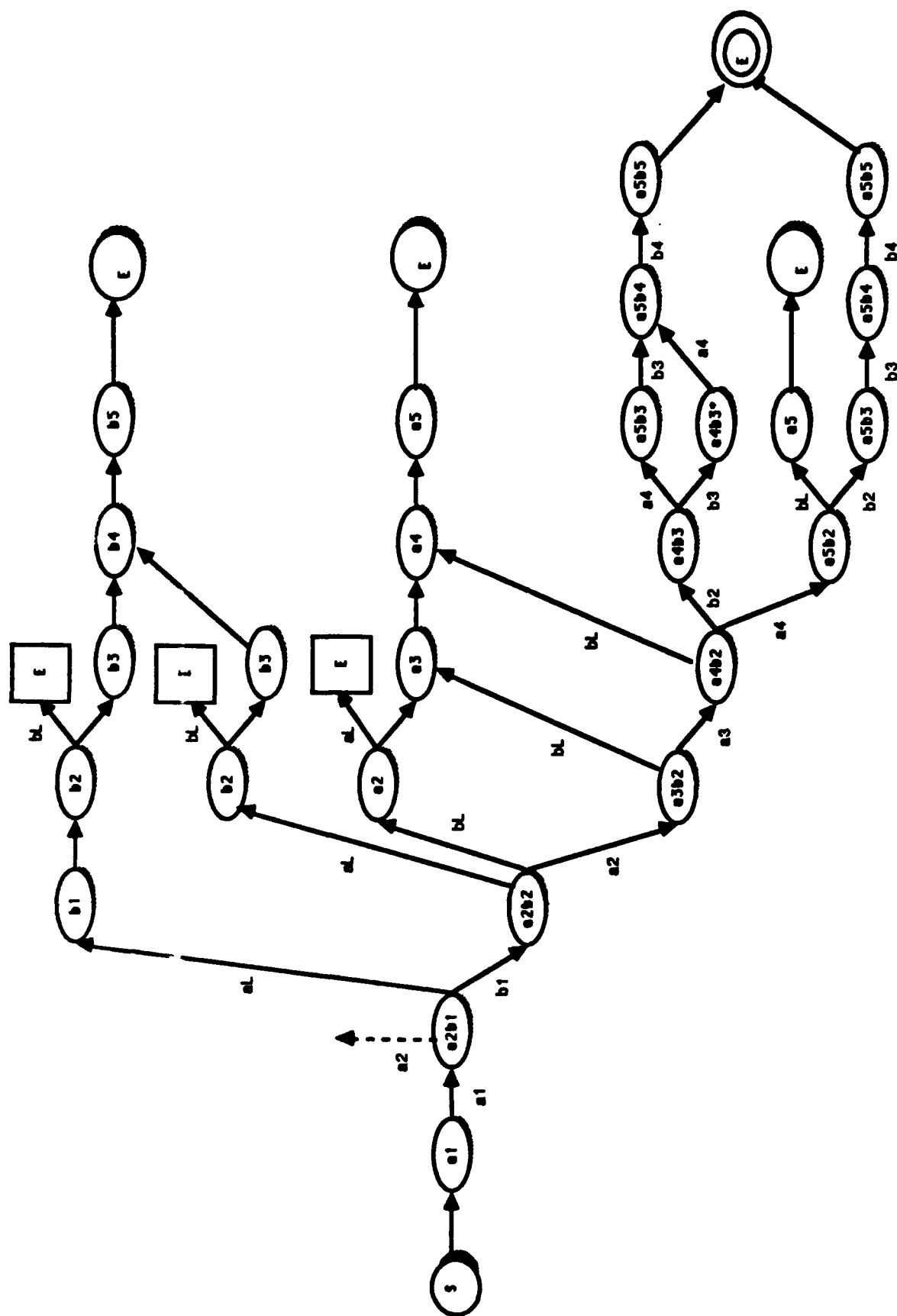


Figure 3b. Diagram of the Four Stage Model with Simultaneous Buffer Decay.

## FUTURE RESEARCH IN SKILL ACQUISITION AND RETENTION

### MODELS OF COLLECTIVE SKILL ACQUISITION AND RETENTION (WORK UNDERWAY)

- SYNTHETIC TRAINING ENVIRONMENTS (E.G., SIMNET)
- COGNITIVE TASK ANALYSIS OF CREWS
- GROWTH AND DECAY IN CREW PROFICIENCY

### RETRAINING TIME FOR THE INDIVIDUAL READY RESERVE (WORK IN PLANNING)

- TIME TO REGAIN PROFICIENCY AFTER SEPARATION PERIODS OF 9 TO 36 MONTHS
- EMPIRICAL APPROACH THAT REQUIRES "MINI-MOBILIZATION" OF UP TO 1,000 SOLDIERS
- PREVIOUS RESEARCH ON IRR SKILL DECAY WAS UNABLE TO ASSESS RETRAINING DUE TO WAR CONTINGENCIES

## **RESEARCH QUESTIONS**

- **How much do we remember of what we learned in secondary and post secondary classroom?**
- **What variables affect long-term retention for knowledge learned in schools?**
- **What cognitive structures and processes account for long-term retention?**



## **TYPES OF KNOWLEDGE AND SKILL**

- **Declaritive**
- **Procedural**
- **Conceptual/Contextual/Causal**

## **RESEARCH QUESTIONS - KANSAS STUDIES**

- **Will PSI students learn and retain more than LFM students?**
- **Will retention for both groups decline over time?**
- **If PSI do learn more and retention does decline, will the rate of decline differ for the two groups?**
- **Will performance on a retention test that is the same as the end-of-course test be better than performance on a different but parallel form of the test?**
- **Does the amount of forgetting differ for different learning tasks?**
- **Does proctoring has the same effect as overlearning?**

## **VARIABLES AFFECTING RETENTION**

- **Original Learning**
- **Task Requirements**
- **Overlearning**
- **Test Conditions**
- **Retention Interval**
- **Individual Differences**

**Data from PE School Study - Late 1970's**

| <b>Test<br/>Version</b> | <b>Immediate</b> | <b>4 Weeks<br/>Later</b> | <b>6-8 Months<br/>Later</b> | <b>Percent<br/>Loss</b> |
|-------------------------|------------------|--------------------------|-----------------------------|-------------------------|
| <b>I</b>                | <b>89.28</b>     | <b>87.61</b>             | <b>73.08</b>                | <b>18%</b>              |
| <b>II</b>               | <b>87.22</b>     | <b>75.28</b>             | <b>68.93</b>                | <b>21%</b>              |
| <b>III</b>              | <b>89.64</b>     | <b>79.53</b>             | <b>70.73</b>                | <b>21%</b>              |

**N= 83**

Data from ASW Study - 1983

| Condition           | Percent Correct<br>End of Course | Percent Correct<br>25 Days Later | Percent<br>Loss |
|---------------------|----------------------------------|----------------------------------|-----------------|
| Fact                | 86%                              | 78%                              | 8%              |
| Computation         | 80%                              | 56%                              | 24%             |
| Gram Analysis       | 87%                              | 76%                              | 11%             |
| Gram Classification | 85%                              | 74%                              | 11%             |
| Systematic Analysis | 77%                              | 61%                              | 16%             |

**Data from Kansas Study - 1989**

| <b>Condition</b> | <b>Percent Correct<br/>End of Course</b> | <b>Percent Correct<br/>3 Months Later</b> | <b>Percent<br/>Loss</b> |
|------------------|------------------------------------------|-------------------------------------------|-------------------------|
| <b>PSI-S</b>     | <b>87%</b>                               | <b>78%</b>                                | <b>10%</b>              |
| <b>PSI-D</b>     |                                          | <b>73%</b>                                | <b>16%</b>              |
| <b>LD-S</b>      | <b>76%</b>                               | <b>68%</b>                                | <b>10%</b>              |
| <b>LD-D</b>      |                                          | <b>62%</b>                                | <b>17.5%</b>            |

### Item Category Results from the Kansas Study - 1991

| Gains from Pretest to End of Course |               |      |                |    |
|-------------------------------------|---------------|------|----------------|----|
| Item Category                       | 4-month Group |      | 11-month Group |    |
|                                     | X             | SD   | X              | SD |
| Recognition                         | 32.1          | 13.6 |                |    |
| Recall                              | 48.9          | 21.2 |                |    |
| Comprehension                       | 30.7          | 20.8 |                |    |
| Mental Skills                       | 31.0          | 22.1 |                |    |

| Same Form Loss - End-of-Course to End-of-Interval |               |      |                |      |
|---------------------------------------------------|---------------|------|----------------|------|
| Item Category                                     | 4-month Group |      | 11-month Group |      |
|                                                   | X             | SD   | X              | SD   |
| Recognition                                       | -13.7         | 12.7 | -18.7          | 11.7 |
| Recall                                            | -25.0         | 20.6 | -28.3          | 19.2 |
| Comprehension                                     | -12.7         | 16.6 | -15.3          | 17.1 |
| Mental Skills                                     | -13.7         | 18.1 | -18.7          | 15.8 |

| Different Form Loss - End-of-Course to End-of-Interval |               |      |                |      |
|--------------------------------------------------------|---------------|------|----------------|------|
| Item Category                                          | 4-month Group |      | 11-month Group |      |
|                                                        | X             | SD   | X              | SD   |
| Recognition                                            | -16.9         | 14.2 | -20.2          | 10.8 |
| Recall                                                 | -27.9         | 25.4 | -36.2          | 20.8 |
| Comprehension                                          | -18.6         | 18.9 | -16.9          | 18.8 |
| Mental Skills                                          | -17.9         | 21.0 | -21.3          | 23.4 |

**SUBGROUP SESSION III**

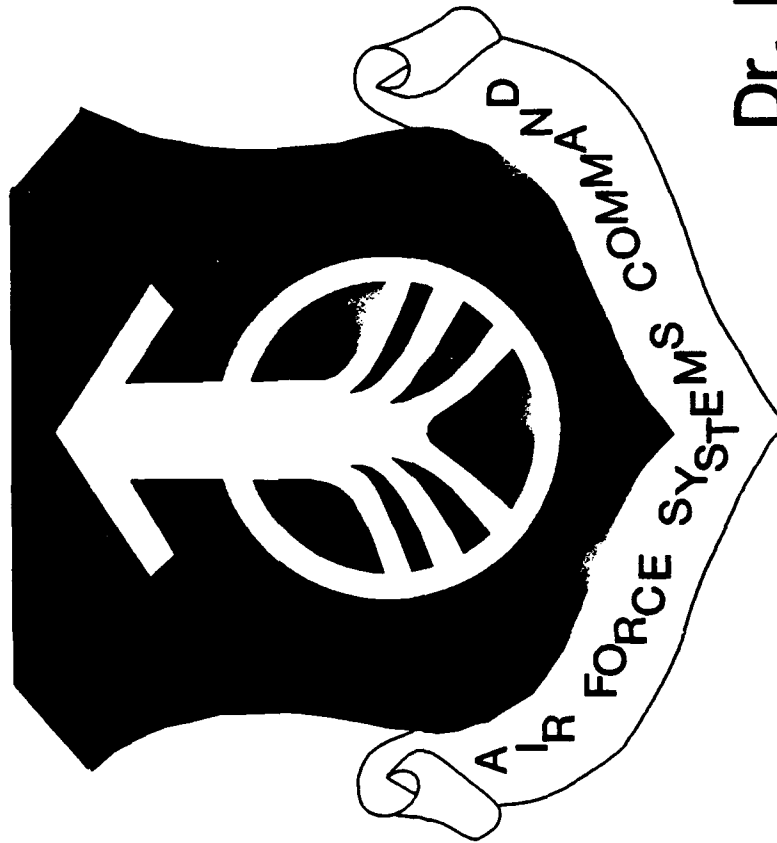
**ADVANCED TRAINING TECHNOLOGY**

Basic Job Skills Job Family Tutor:  
Dr. Ellen Hall

Issues in Designing and Intelligent,  
NLP-based Tutor for Foreign Languages:  
Dr. Michelle Sams



# Basic Job Skills Job Family Tutor



Dr. Ellen Hall  
AL/HRMJC



## OVERVIEW

History of BJS Program

Research Problem

BJS Goals

Approach

Tutoring Single Jobs vs. Job Families

Job Family Tutor Learning Study

Illustration of JFT Instruction

Payoffs



## CHRONICLE OF SIGNIFICANT EVENTS

- CY 88: Successful field test of prototype Avionics Troubleshooting Tutor
- Mar 88: Request from TAC/LG (MGen Vicellio) to AFSC/XT (BGen Stebbins) to accelerate BJS effort
- CY 89: TAC Day briefing to AFSC/CC (Gen Randolph) and TAC/CC (Gen Russ) and staff
- Dec 89: MOU signed by TAC/LG (MGen Logeman) and AFSC/XT (MGen Ferguson) for continued support of BJS R&D
  - included authorizations for two F15 avionics technicians for BJS in-house team
  - allows access to maintenance personnel at F15/16/111 flying units



## ADVOCACY FOR BJS PROGRAM

**"We consider this a crucial research project with tremendous payback potential in the aircraft maintenance training area."**

**MGen Henry Viccelio, Jr TAC/LG**

**to**

**BGen Charles Stebbins AFSC/XT**

**March, 1988**

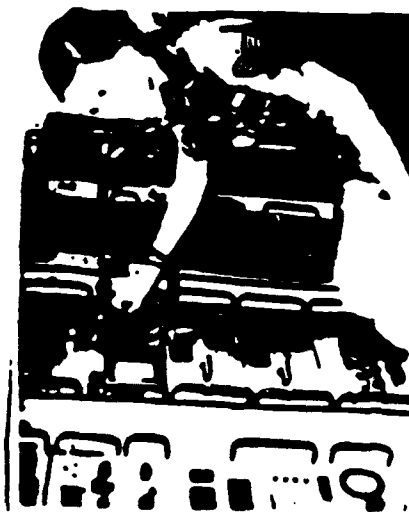


## CHRONICLE OF SIGNIFICANT EVENTS (Cont'd)

- CY 89-90: TAC funded \$26.1M FY92 initiative for FSD of F15 and F16 troubleshooting tutors
  - OPR: HSD/YA and XR
- Dec 90: Demo of refined tutor given to CSAF (Gen McPeak) and AFSC/CC (Gen Yates) as part of new CSAF's orientation to AFSC
- Jan 91: TAC Day demo of refined tutor given to TAC/CC (Gen Russ) and AFSC/CC (Gen Yates), Andrews AFB MD



# THE PROBLEM



- Becoming competent in technologically complex environment

- Countering the negative effects of machine capabilities

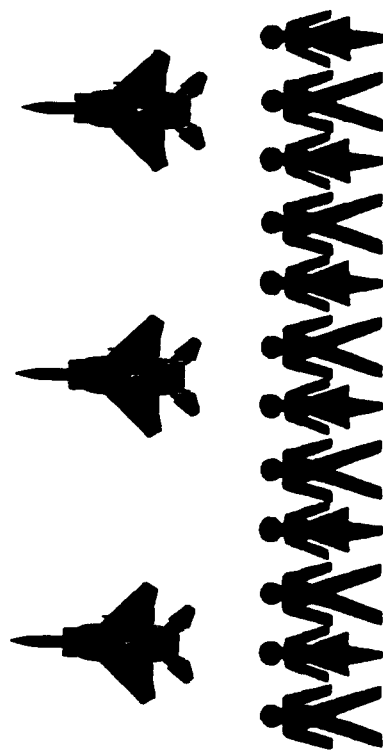
... lost

**apprenticeship**



## THE PROBLEM

### CURRENT WING STRUCTURE



- Becoming competent in technologically diverse environments

### COMPOSITE WING STRUCTURE

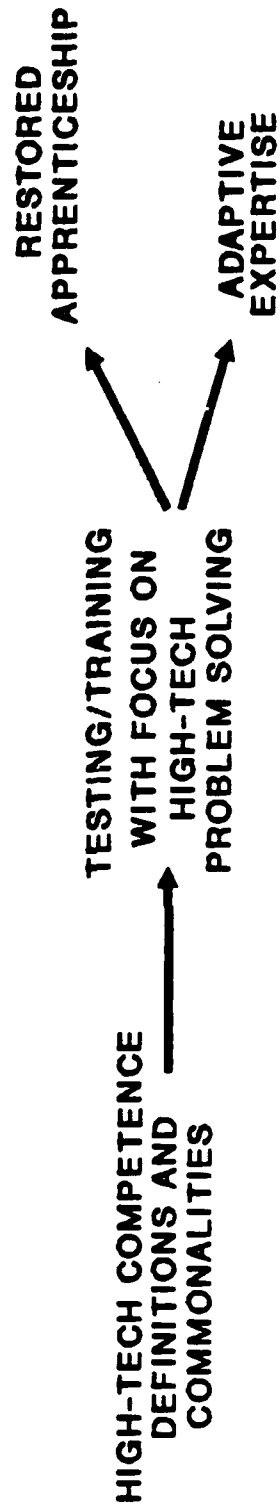


- Accommodating new force structure and force downsizing

... Fostering Adaptive Expertise



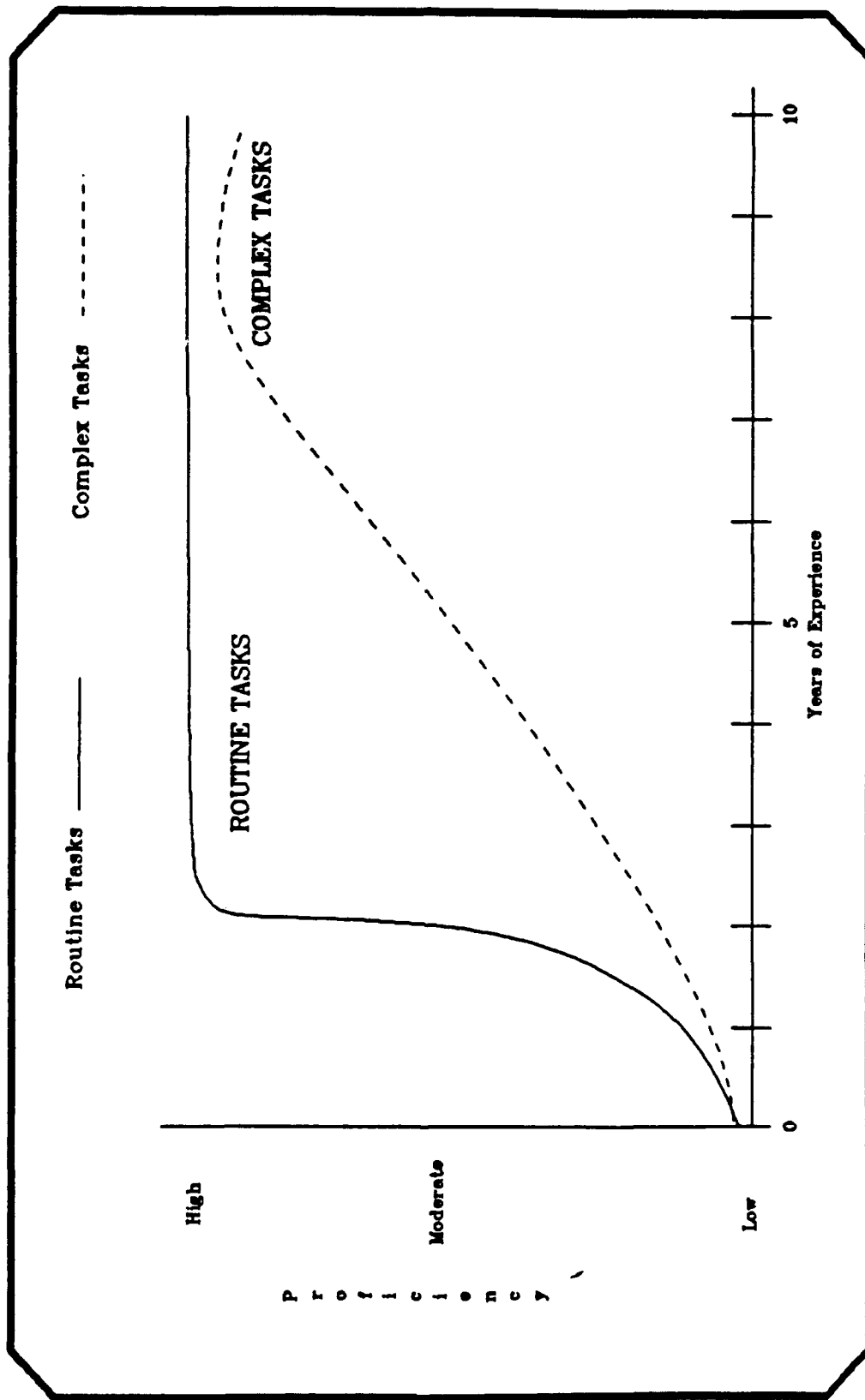
## BASIC JOB SKILLS GOALS:





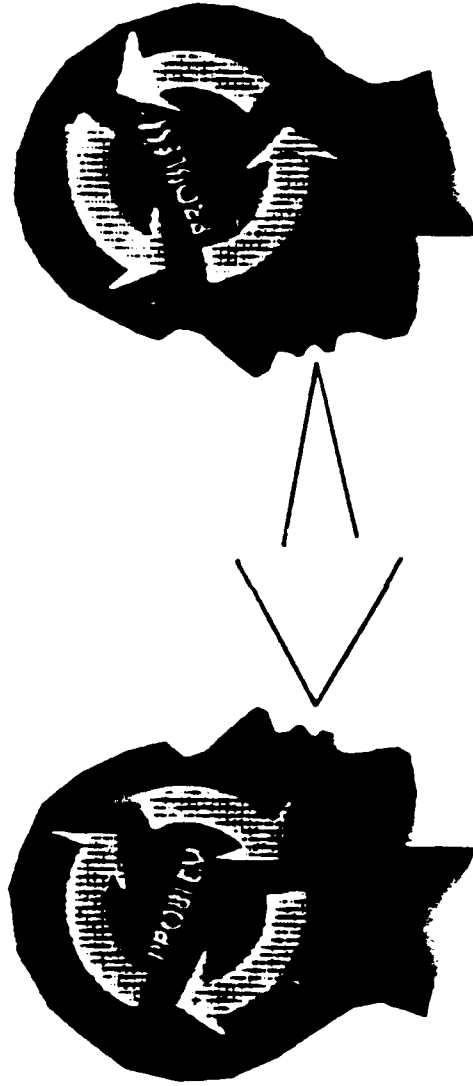


# COMPLEX SKILLS





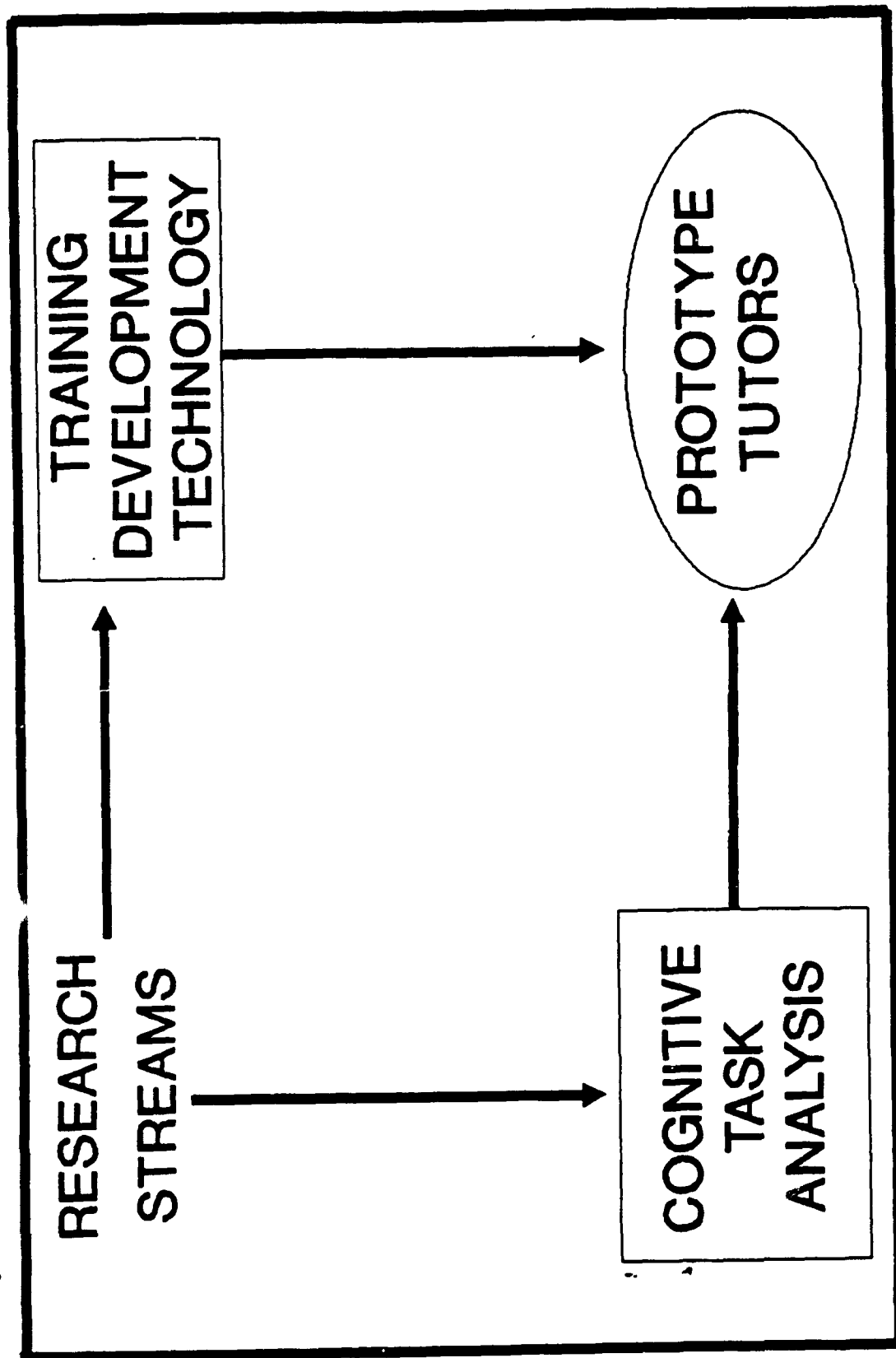
# APPROACH



- THEORIES OF EXPERT PROBLEM SOLVING
  - PROCEDURES BASED ON ADVANCES IN ARTIFICIAL INTELLIGENCE TO SPECIFY HOW EXPERTS SOLVE PROBLEMS
  - PROCEDURES BASED ON PRINCIPLES OF APPRENTICESHIP TRAINING TO TURN EXPERT KNOWLEDGE INTO LEARNABLE CONTENT FOR TRAINING
- COGNITIVE TASK ANALYSIS TECHNOLOGY
- TRAINING DEVELOPMENT TECHNOLOGY



# R&D APPROACH



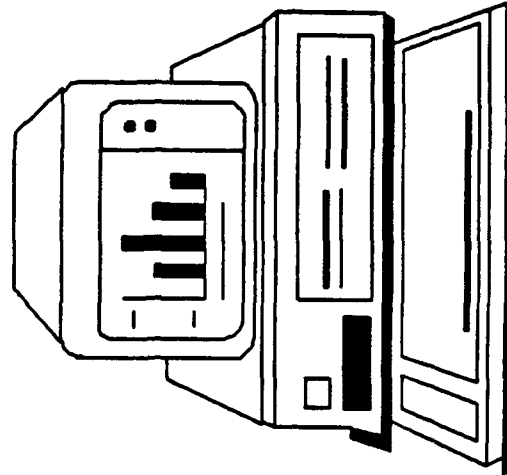
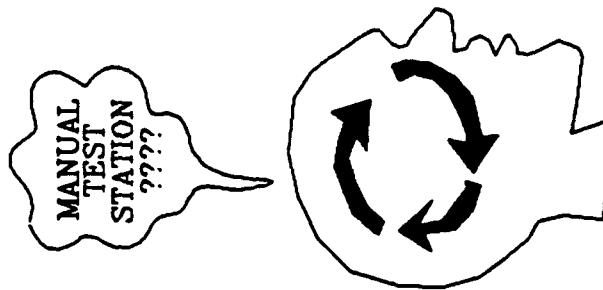


## **BJS TECHNOLOGIES**

- **Cognitive Task Analysis (CTA) Technology**
- **Training Development Technology (TDT)**
- **Prototype Troubleshooting Tutors**
  - **Single Job Tutors**
  - **Job Family Tutors**



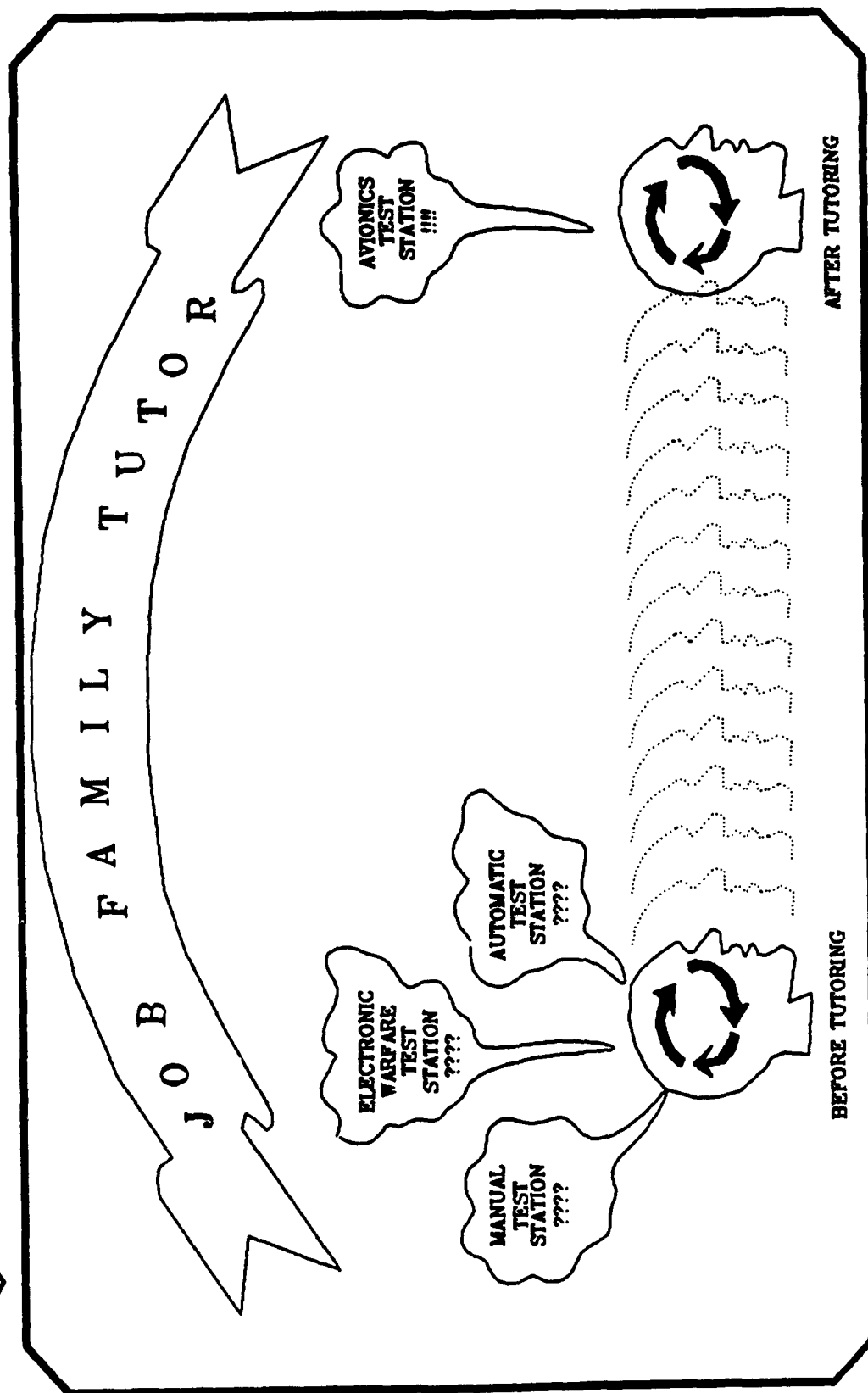
# SINGLE JOB TUTOR



- TROUBLESHOOTING  
SCENARIOS
- COACHING
- TRAINEE  
EVALUATION

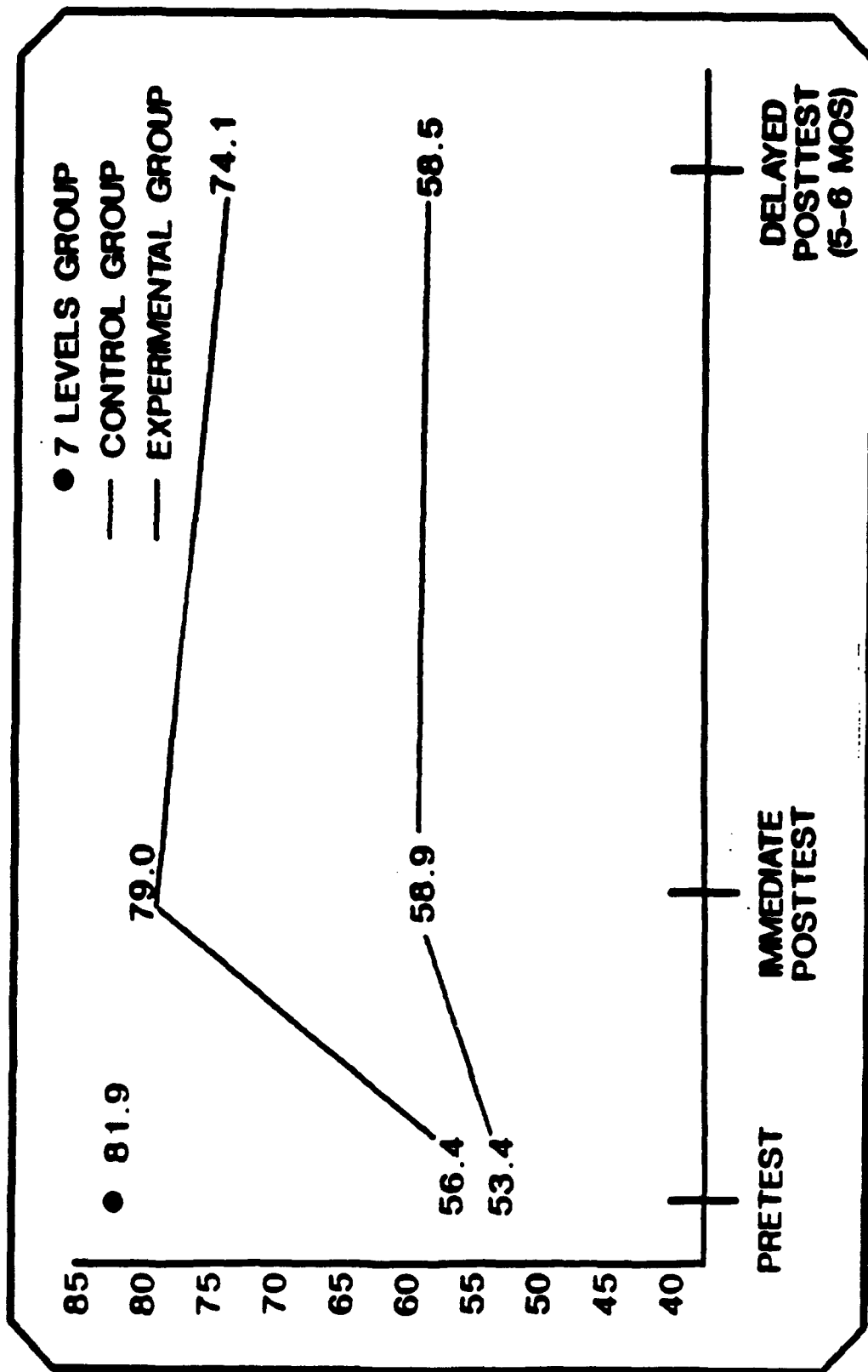


# FOSTERING ADAPTIVE EXPERTISE



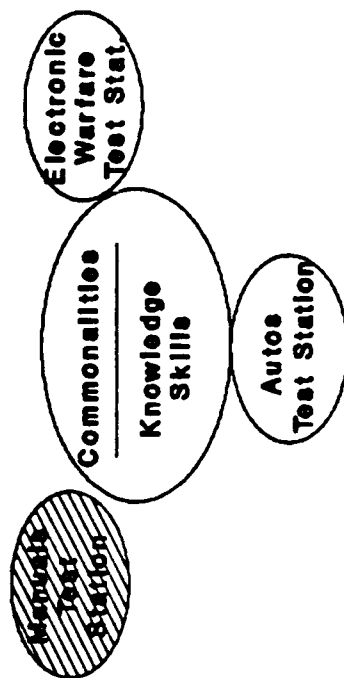


# EVALUATION RESULTS: AVIONICS TROUBLESHOOTING TUTOR (SJT)

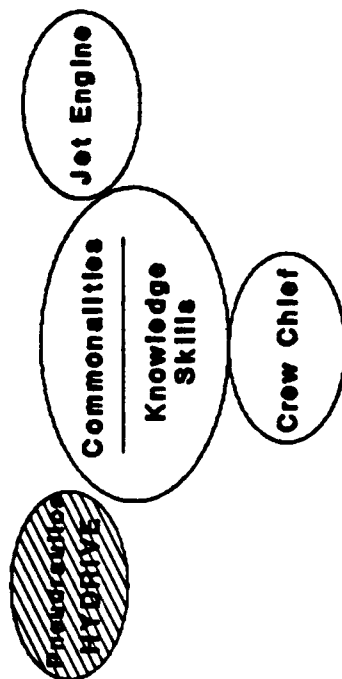




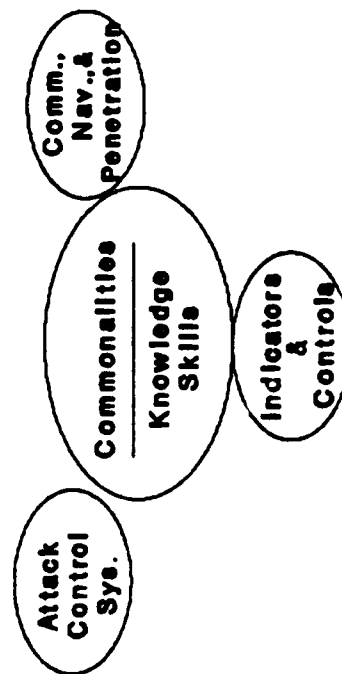
## PROPOSED JOB FAMILY TUTORS



### Original Avionics JFT (F15 AIS)



### Mechanical JFT (F15 TAMS)

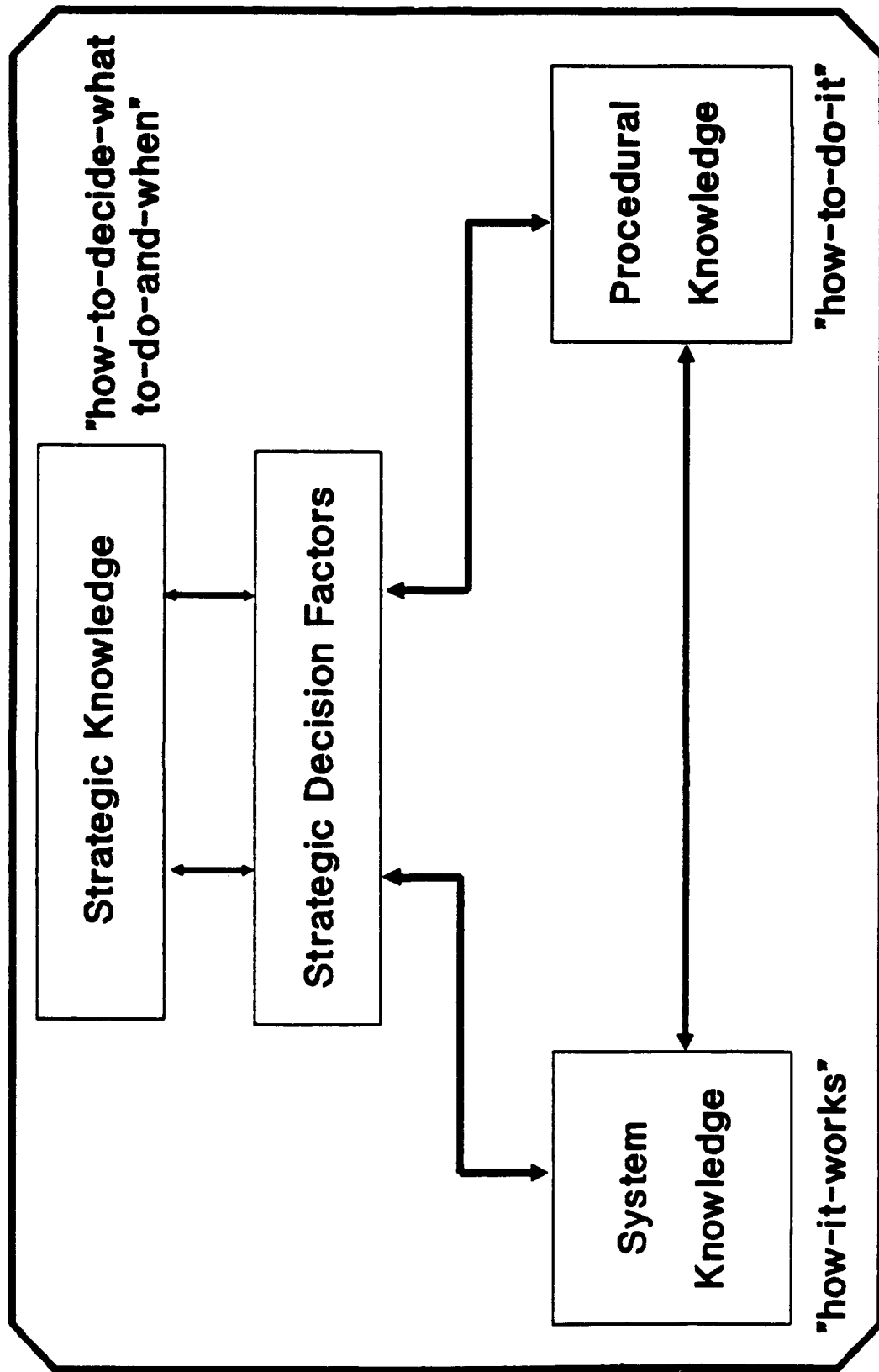


### Alternative Avionics JFT (F15 Flightline)





## COGNITIVE SKILL COMMONALITIES

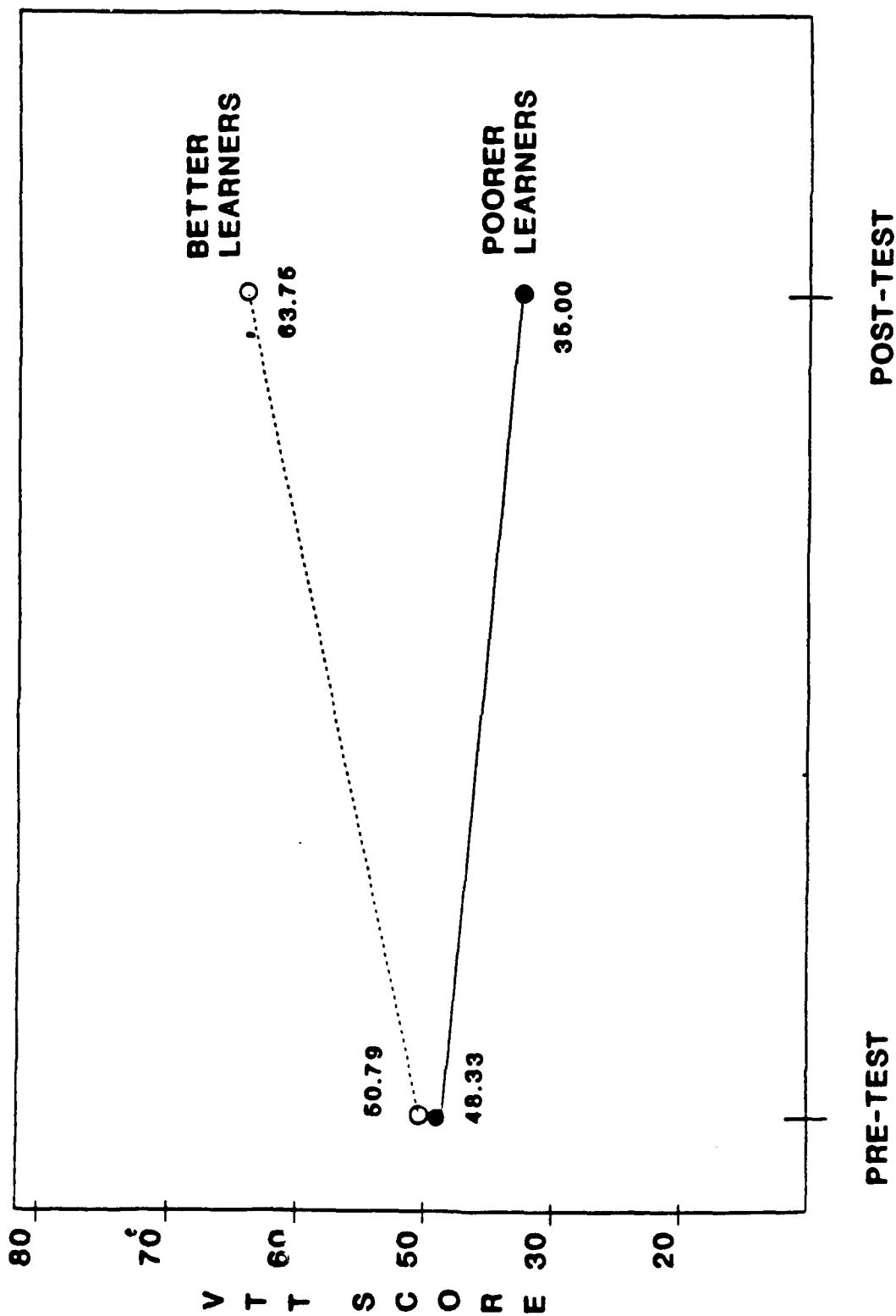




## **AVIONICS JFT LEARNING STUDY** **49TH TFW--HOLLOMAN AFB NM**

- Six Rivet trainees into EWS job participated
  - Tech School
  - OJT
  - Experience range
- Pre-posttest scored by verbal troubleshooting procedure
- Six hours of one-on-one tutoring by EWS expert
- Effect on performance
  - Four technicians improved
  - Two technicians regressed

# AVERAGE PRE- AND POST-TEST SCORES BETTER LEARNERS VS. POORER LEARNERS





## SAMPLING OF QUESTIONS

Procedural

Knowledge

"I need to find an easy spot on the Lower 16 card to pick off the signal."  
"How do you actually use the general maintenance program?"

System

Knowledge

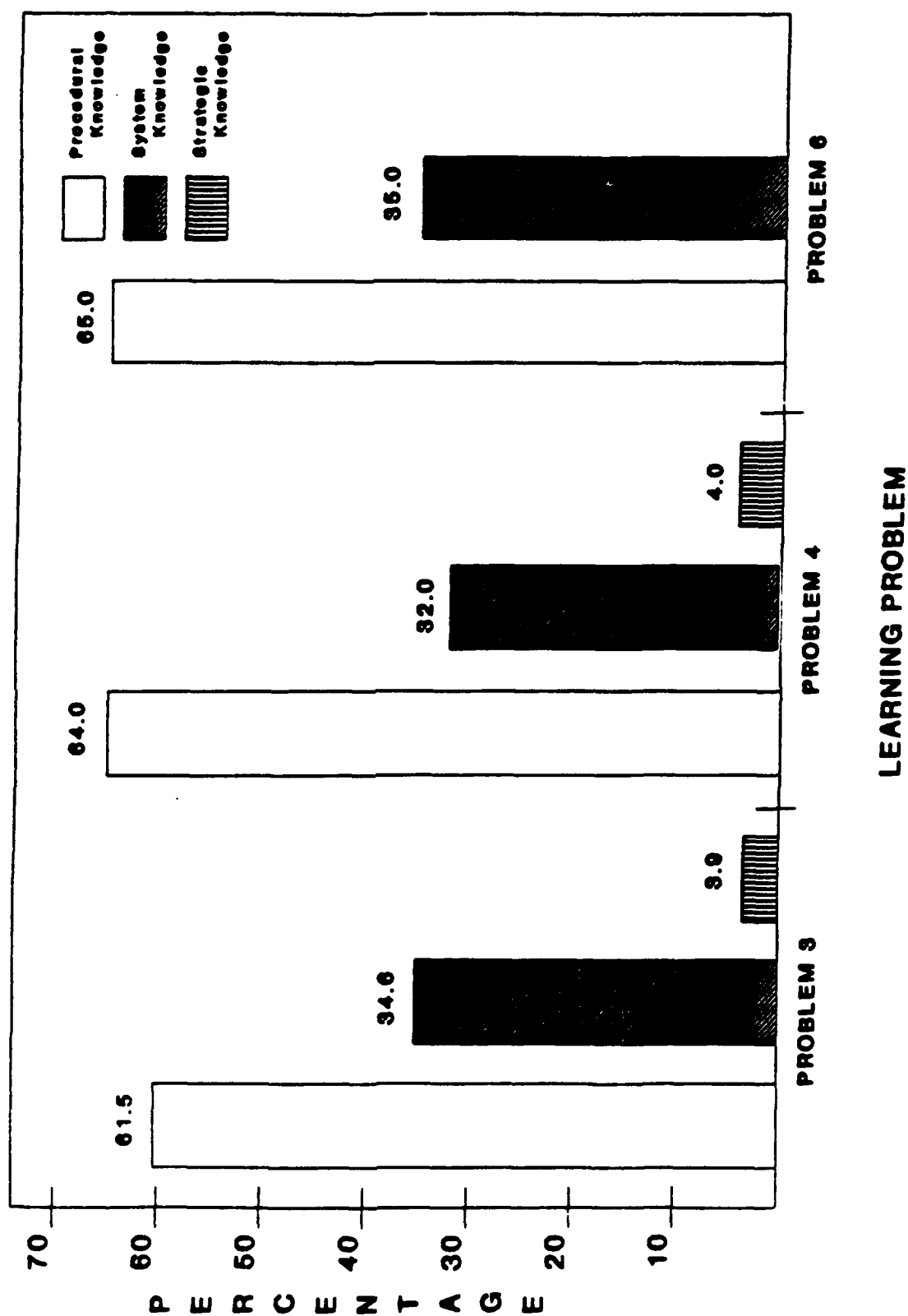
"I know all the station resources that are being used, but I don't know how."  
"Could the RF Counter be called a Microwave Frequency Counter?"

Strategic

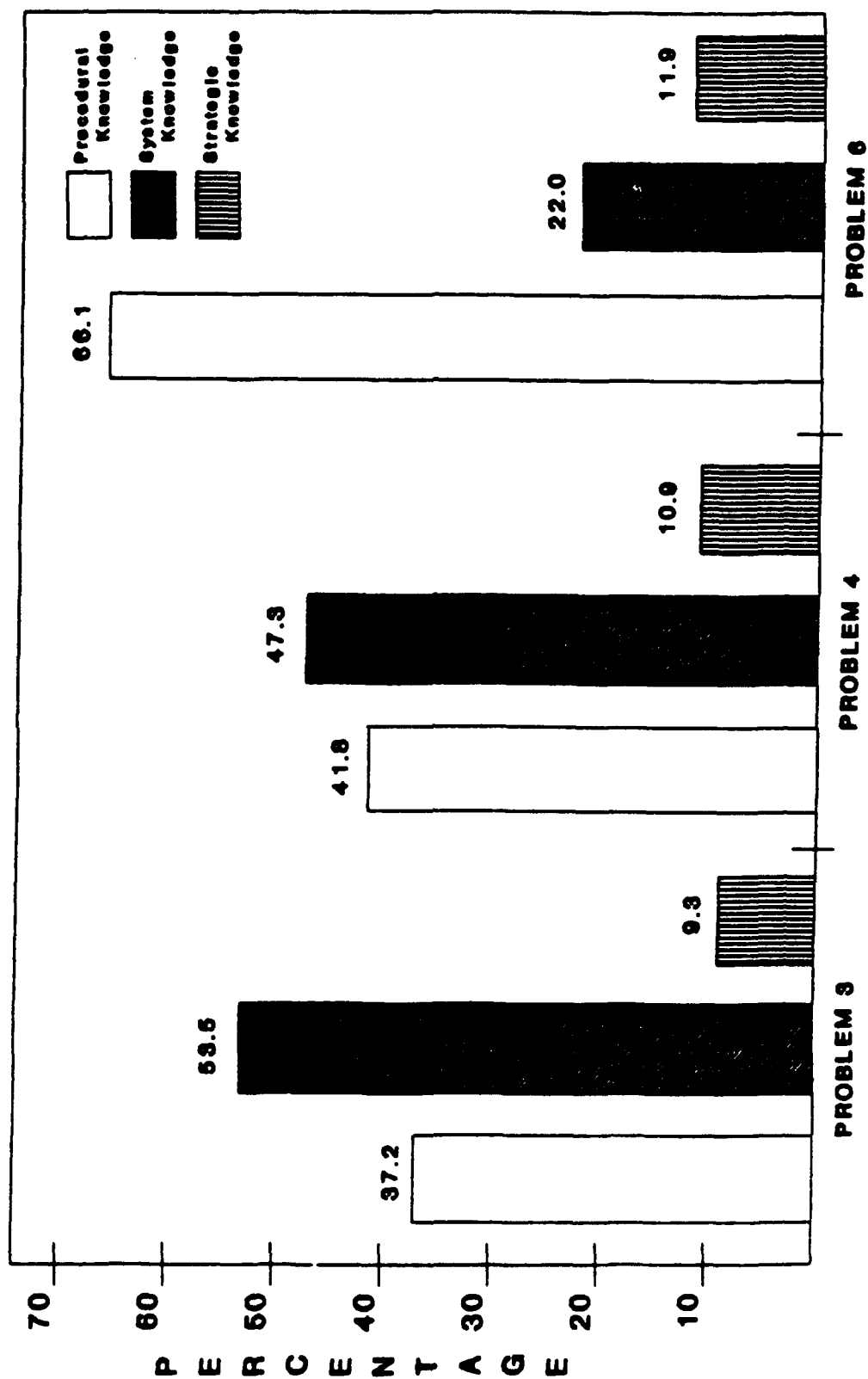
Knowledge

"Is there another way to split the path to see if I'm getting the signal, besides measuring off the relays?"  
"For practical purposes, is it generally easier to leave the LRU test set up and take a measurement off the MSS to verify the output?"

**PERCENTAGE OF QUESTION TYPE BY PROBLEM  
(POORER LEARNERS)**



**PERCENTAGE OF QUESTION TYPE BY PROBLEM  
(BETTER LEARNERS)**



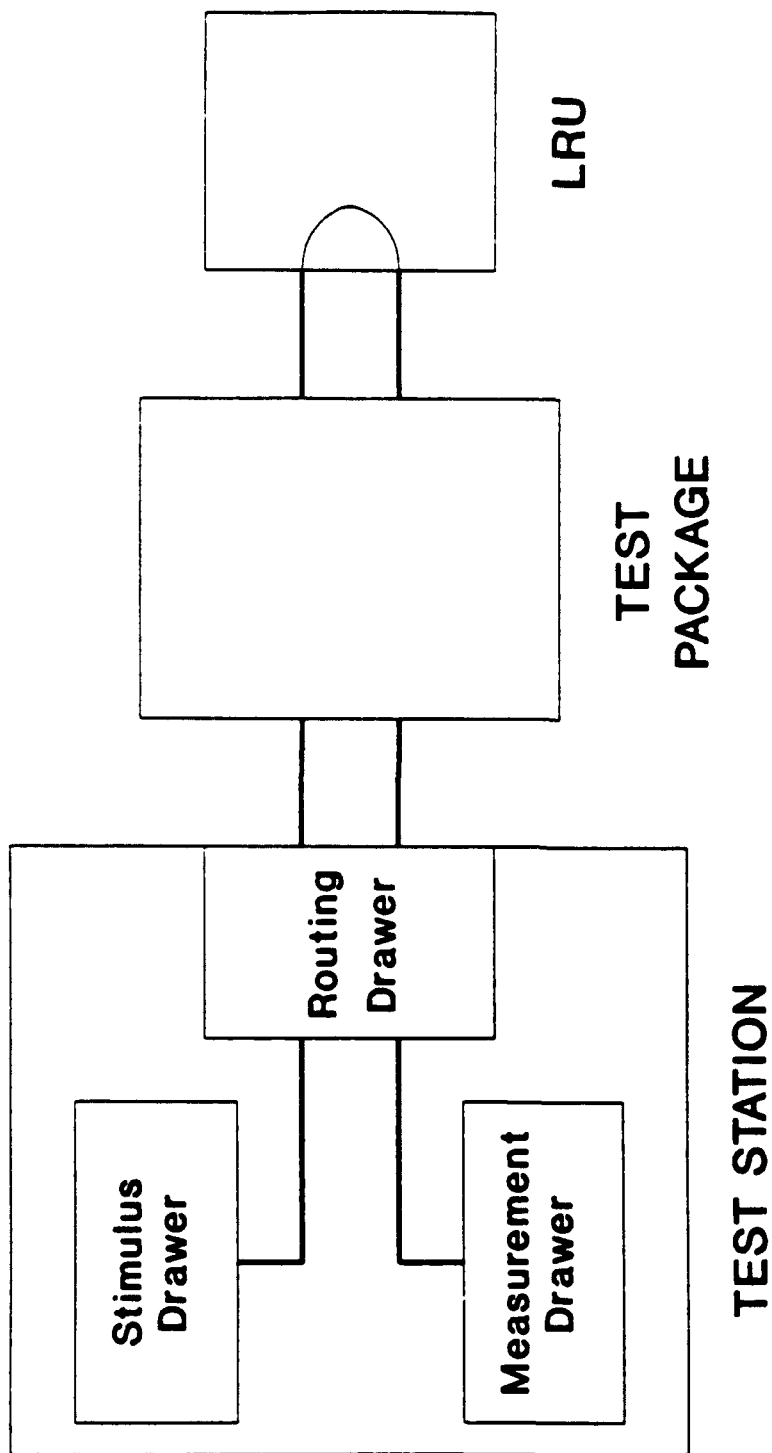


**Figure 6 . General Equipment Configuration During LRU Testing**

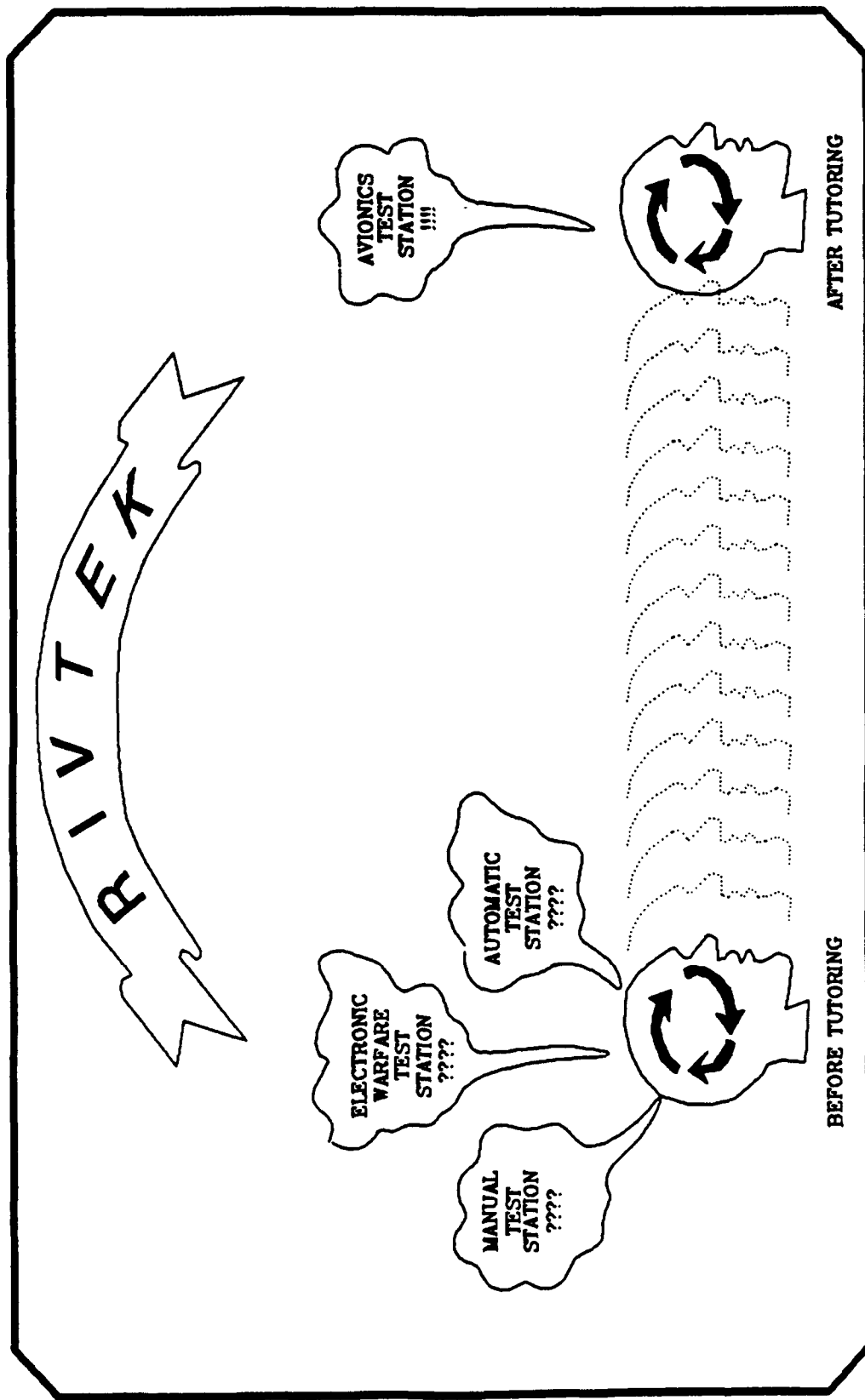


# ILLUSTRATION OF JFT INSTRUCTION





# FOSTERING ADAPTIVE EXPERTISE





## RIVTEK ADAPTIVE EXPERTISE

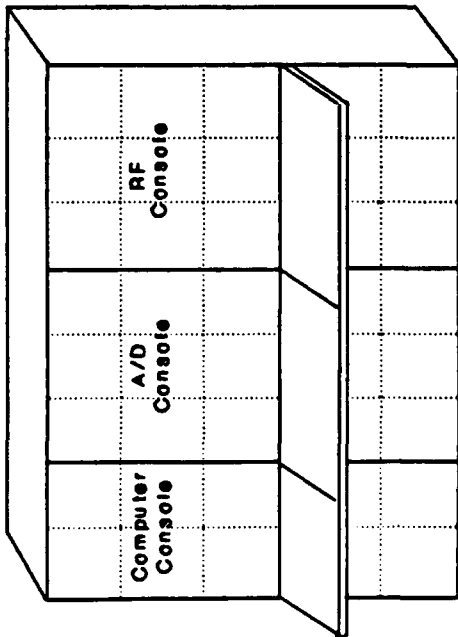
### INTRODUCTION

In RIVTEK you will be challenged to become a better troubleshooter on avionics equipment that is similar, but not identical, to the equipment on which you received your primary AF technical training. You will be presented a series of increasingly difficult troubleshooting scenarios to advance your fault isolation skills on the TEWS Intermediate Test Equipment (TITE). In addition, RIVTEK is equipped to strengthen your troubleshooting and learning skills in general. As a consequence, you can significantly increase your adaptiveness as a technician on multiple avionics systems -- even on systems that are yet to be fielded, e.g., avionics systems on the ATF.



## RIVTEK ADAPTIVE EXPERTISE

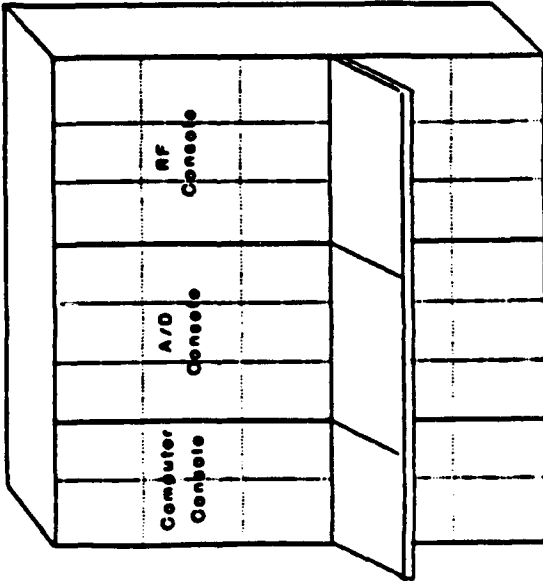
In the course of working through RIVTEK's scenarios, you will be evaluated at various points along the way. Performance indicators will gauge the following: (a) your increasing skill in troubleshooting the TITE station, (b) your growing independence from RIVTEK's coaching, and (c) your general adaptiveness across different avionics systems. Your goal is to take full advantage of RIVTEK's coaching and other explanatory resources to become a skilled, adaptive technician with improved "mental tools" for thinking about and solving hard electronic failures on any piece of equipment. As a final RIVTEK evaluation, you will be presented scenarios on a system that is entirely novel to you.

| INFORMATION BOX                                                                                                                                                                  |                       | GENERAL ACTIONS       |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------|
|                                                                                                                                                                                  |                       | Access Tech Data      |
|                                                                                                                                                                                  |                       | Activate Equipment    |
|                                                                                                                                                                                  |                       | Change Goal           |
|                                                                                                                                                                                  |                       | Show Parallel         |
|                                                                                                                                                                                  |                       | Cancel Current Action |
|                                                                                                                                                                                  |                       | Quit                  |
| EQUIPMENT ENVIRONMENT                                                                                                                                                            | TECH DATA ENVIRONMENT |                       |
| <div><div><div>Computer Console</div><div>A/D Console</div><div>RF Console</div></div></div> |                       |                       |

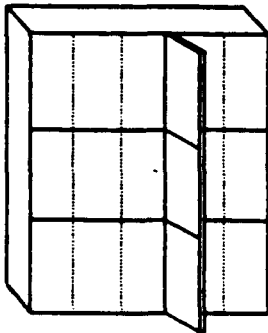
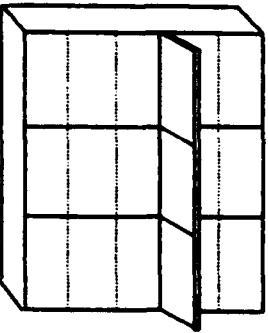
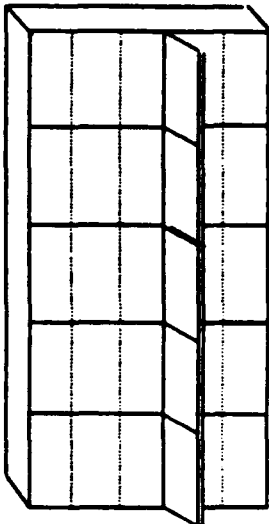


## INFORMATION BOX

The Tactical Electronic Warfare System (TEWS) Intermediate Test Equipment (TITE) is a semi-automatic test station. It is used to test components of the F-15's Electronic Countermeasures (ECM) system. It consists of three sections: (1) the Computer Console which is used to control the test station; (2) the Analog/Digital Console which processes signals below radio frequency; and (3) the Radio Frequency Console which processes RF signals. To ensure the test station is operating correctly it is tested periodically. These tests, called Operational Assurance/ Fault Isolation (OA/FI), test each device in the test station; if one fails, <sup>it</sup> must be repaired before an ECM component can be tested by the test station.

| INFORMATION BOX                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | GENERAL ACTIONS                                                                                                                    |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|
| <p>YOU ARE PERFORMING THE OPERATIONAL ASSURANCE AND FAULT ISOLATION (OAFI) TESTS ON THE TEWS INTERMEDIATE TEST EQUIPMENT (TITE) AS PART OF ITS WEEKLY MAINTENANCE INSPECTION. YOU HAVE INSTALLED THE PROPER SOFTWARE AND HAVE BEGUN TESTING. THE TEST STATION HAS REPORTED A FAIL AT OAFI SEGMENT P2 T10 S620 D1 M01 AND YOU MUST TROUBLESHOOT THE MALFUNCTION. YOUR FIRST GOAL IS TO ANALYZE INFORMATION RELEVANT TO THE FAIL. THERE ARE TWO SOURCES OF INFORMATION THAT WILL HELP YOU DO THIS. THE FIRST IS THE TITE CRT DISPLAY SHOWN BELOW AND THE SECOND IS THE OAFI TEST SUMMARY FOR THE FAILED TEST. IF YOU WANT TO KNOW MORE ABOUT THE CRT DISPLAY OR SEE THE TEST SUMMARY, SELECT ACCESS TECH DATA IN THE GENERAL ACTION MENU.</p> <p><b>TROUBLESHOOTING GOAL:</b> Analyze information relevant to the fail.</p> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <p>Access Tech Data</p> <p>Activate Equipment</p> <p>Change Goal</p> <p>Show Parallel</p> <p>Cancel Current Action</p> <p>Quit</p> |
| EQUIPMENT ENVIRONMENT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | TECH DATA ENVIRONMENT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <p>P2 T10 S620 D1 M01 DATA</p> <p>TSG 10 620<br/>H 1 1.99997+37 SEC 1.00000+00 S15-4 S14-4 S13-4</p> <p>OPERATOR ACTION</p> <p>1. USE DPO TO VERIFY 10 KHZ, 2.2 VP-P<br/>AT BOTH 50 OHM LOADS ON COUNTER/TIMER</p> <p>2. ENTER 1 IF ONE SIGNAL IS MISSING OR<br/>2 IF BOTH SIGNALS ARE MISSING</p> <p>7 2</p> <p>OPERATOR ACTION</p> <p>1. USE DPO TO VERIFY 10 KHZ, 4 VP-P AT<br/>AT PULSE GENERATOR J108</p> <p>2. ENTER 1 IF THE SIGNAL IS MISSING OR<br/>2 IF THE SIGNAL IS PRESENT</p> <p>7 2</p> <p>OPERATOR INSTRUCTION</p> <p>S15-4 FAILED TO SET. REFER TO TO 3307-38-77-<br/>28-1-2 FOR FAULT ISOLATION INSTRUCTIONS.</p> <p>STATION CLEARED</p> |                                                                                                                                    |

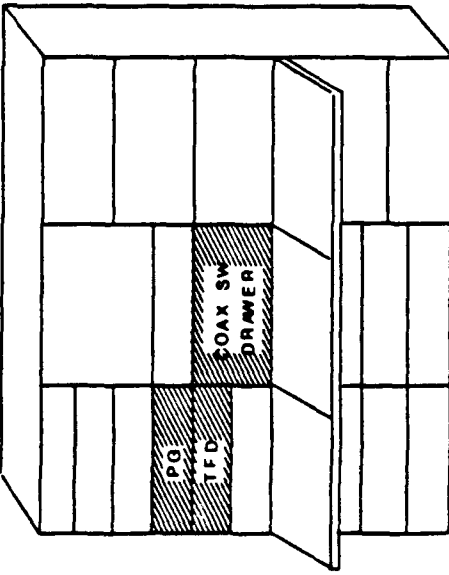
| GENERAL ACTIONS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                               |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>The Automatic test stations consists of a group of three test stations. Each test station is semi-automatic. Each test station is used to test one of three types of F-15 components: (1) Aircraft Displays; (2) Aircraft Computers; and (3) Microwave components of the Radar system. To ensure they are operating correctly, QA/FI tests can also be performed on them. These tests are performed automatically under computer control with the results being displayed to the technician.</p> | <p>Access Tech Data</p> <p>Activate Equipment</p> <p>Change Goal</p> <p>Show Parallel</p> <p>Cancel Current Action</p> <p>Quit</p> <p>Equipment Tech Data</p> |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <p>MICROWAVE TEST STATION</p> <p>COMPUTER TEST STATION</p> <p>DISPLAYS TEST STATION</p>                                                                       |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <p>Manuale</p> <p>Automatic</p>                                                                                                                               |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <p>EQUIPMENT ENVIRONMENT</p>                                                                                                                                  |

| INFORMATION BOX                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |  | GENERAL ACTIONS                                                                                                                                                                                                                                                                                                                                                                                       |                       |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| <p>The Manual test stations consist of a group of three test stations. These test stations are under complete control of the technician. Each test station is used to test components from one of three functionally unique F-15 systems: (1) the Radar system (Ant TS); (2) the Communication, Navigation and Identification systems (CNI TS); and Aircraft Indicators and Controls (I&amp;C TS). To ensure they are operating correctly, O&amp;FI tests can also be performed on them. However, the parameters of each test station device (i.e., stimulus, routing and measurement parameters) must be set up by the technician for each test.</p> <p><b>TROUBLESHOOTING GOAL:</b> Analyze information relevant to the fail.</p> |  | Access Tech Data                                                                                                                                                                                                                                                                                                                                                                                      | Activate Equipment    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |  | Change Goal                                                                                                                                                                                                                                                                                                                                                                                           | Cancel Current Action |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |  | Quit                                                                                                                                                                                                                                                                                                                                                                                                  |                       |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |  | Equipment Tech Data                                                                                                                                                                                                                                                                                                                                                                                   |                       |
| EQUIPMENT ENVIRONMENT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |  | <p>COMMUNICATION, NAVIGATION, &amp; IDENTIFICATION TEST STATION</p>  <p>INDICATORS AND CONTROLS TEST STATION</p>  <p>ANTENNA TEST STATION</p>  |                       |



| INFORMATION BOX                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                     | GENERAL ACTIONS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                    |                                |                   |                                |            |                     |                                                           |                                    |                    |                                                                                                                                                                                                                                                                                                                                                                                                       |            |         |              |        |                   |                                |      |                 |                                                   |                   |               |  |             |  |  |  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|--------------------------------|-------------------|--------------------------------|------------|---------------------|-----------------------------------------------------------|------------------------------------|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|---------|--------------|--------|-------------------|--------------------------------|------|-----------------|---------------------------------------------------|-------------------|---------------|--|-------------|--|--|--|
| <p>OA/FI tests are also performed on the Manual test stations; however, they are not part of a weekly inspection. In fact, skilled Manual technicians rarely use OA/FI tests because of the limited information they provide. Compared to the TITE OA/FI test summary shown below, the Manual station OA/FI tech data is much more general. For example, the level of detail stops at the CARD level, whereas the TITE OA/FI test summary specifies COMPONENTS (e.g., switches and jacks). To get COMPONENT information, the Manual technician must access schematics.</p> |                     | <p>Access Tech Data</p> <p>Activate Equipment</p> <p>Change Goal</p> <p>Cancel Current Action</p> <p>Quit</p> <p>Tech Data</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                    |                                |                   |                                |            |                     |                                                           |                                    |                    |                                                                                                                                                                                                                                                                                                                                                                                                       |            |         |              |        |                   |                                |      |                 |                                                   |                   |               |  |             |  |  |  |
| <p><b>TROUBLESHOOTING GOAL:</b> Analyze information relevant to the fail</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                    |                                |                   |                                |            |                     |                                                           |                                    |                    |                                                                                                                                                                                                                                                                                                                                                                                                       |            |         |              |        |                   |                                |      |                 |                                                   |                   |               |  |             |  |  |  |
| <p><b>TECH DATA PARALLEL</b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                     | <p><b>TECH DATA ENVIRONMENT</b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                    |                                |                   |                                |            |                     |                                                           |                                    |                    |                                                                                                                                                                                                                                                                                                                                                                                                       |            |         |              |        |                   |                                |      |                 |                                                   |                   |               |  |             |  |  |  |
| <p><b>Automatics</b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                     | <p><b>TO 3307-38-77-28-1-1</b></p> <p>Table 2-15. Coaxial Switching Drawer Test Summary</p> <table border="1"> <thead> <tr> <th>DEVICE</th> <th>UNDER TEST</th> <th>DRAWER</th> <th>SETUP DATA</th> <th>LIMITS</th> </tr> </thead> <tbody> <tr> <td>P2T10562001M801</td> <td>5 Vdc output</td> <td>Counter/Timer</td> <td>TI from cba 0 to 100 us</td> <td>0 to 0.01s</td> </tr> <tr> <td></td> <td>100 ns TO/TP</td> <td></td> <td>100 us range</td> <td></td> </tr> <tr> <td></td> <td>0 Vdc offset</td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td>10 kba freq</td> <td></td> <td></td> <td></td> </tr> </tbody> </table> <p>PCEN: J108</p> <p>ADCOAX: S15-C, S15-4, S10-2, S9-2, S8-1, S7-6, S8-6, S14-4</p> <p>PATN TO CH A INPUT: ADCOAX: S13-4, S13-C</p> <p>NOTE: High and low signals follow the same routing, but the low is carried on the shield.</p> |                                    | DEVICE                         | UNDER TEST        | DRAWER                         | SETUP DATA | LIMITS              | P2T10562001M801                                           | 5 Vdc output                       | Counter/Timer      | TI from cba 0 to 100 us                                                                                                                                                                                                                                                                                                                                                                               | 0 to 0.01s |         | 100 ns TO/TP |        | 100 us range      |                                |      | 0 Vdc offset    |                                                   |                   |               |  | 10 kba freq |  |  |  |
| DEVICE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | UNDER TEST          | DRAWER                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | SETUP DATA                         | LIMITS                         |                   |                                |            |                     |                                                           |                                    |                    |                                                                                                                                                                                                                                                                                                                                                                                                       |            |         |              |        |                   |                                |      |                 |                                                   |                   |               |  |             |  |  |  |
| P2T10562001M801                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 5 Vdc output        | Counter/Timer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | TI from cba 0 to 100 us            | 0 to 0.01s                     |                   |                                |            |                     |                                                           |                                    |                    |                                                                                                                                                                                                                                                                                                                                                                                                       |            |         |              |        |                   |                                |      |                 |                                                   |                   |               |  |             |  |  |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 100 ns TO/TP        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 100 us range                       |                                |                   |                                |            |                     |                                                           |                                    |                    |                                                                                                                                                                                                                                                                                                                                                                                                       |            |         |              |        |                   |                                |      |                 |                                                   |                   |               |  |             |  |  |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 0 Vdc offset        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                    |                                |                   |                                |            |                     |                                                           |                                    |                    |                                                                                                                                                                                                                                                                                                                                                                                                       |            |         |              |        |                   |                                |      |                 |                                                   |                   |               |  |             |  |  |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 10 kba freq         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                    |                                |                   |                                |            |                     |                                                           |                                    |                    |                                                                                                                                                                                                                                                                                                                                                                                                       |            |         |              |        |                   |                                |      |                 |                                                   |                   |               |  |             |  |  |  |
| <p><b>OA/FI tests</b></p> <table border="1"> <thead> <tr> <th>Step No</th> <th>Panel</th> <th>Action</th> <th>Normal Indication</th> <th>Remedy For Abnormal Indication</th> </tr> </thead> <tbody> <tr> <td>183</td> <td>2A243 UNIP CTRL PNL</td> <td>1. Press to illuminate STIMULUS SEL TEST switch indicator</td> <td>2A241 FM29 CMTR 290 MHZ to 310 MHZ</td> <td>Refer to step F137</td> </tr> </tbody> </table>                                                                                                                                                      |                     | Step No                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Panel                              | Action                         | Normal Indication | Remedy For Abnormal Indication | 183        | 2A243 UNIP CTRL PNL | 1. Press to illuminate STIMULUS SEL TEST switch indicator | 2A241 FM29 CMTR 290 MHZ to 310 MHZ | Refer to step F137 | <p><b>OA/FI Fault Isolation tests</b></p> <table border="1"> <thead> <tr> <th>Step No</th> <th>Panel</th> <th>Action</th> <th>Normal Indication</th> <th>Remedy For Abnormal Indication</th> </tr> </thead> <tbody> <tr> <td>F137</td> <td>2A242 RF/RMS VN</td> <td>a. Observe RF MILLI-VOLTMETER<br/>b. Replace A1A13</td> <td>Above -5 (-15dBm)</td> <td>Replace A1A10</td> </tr> </tbody> </table> |            | Step No | Panel        | Action | Normal Indication | Remedy For Abnormal Indication | F137 | 2A242 RF/RMS VN | a. Observe RF MILLI-VOLTMETER<br>b. Replace A1A13 | Above -5 (-15dBm) | Replace A1A10 |  |             |  |  |  |
| Step No                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Panel               | Action                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Normal Indication                  | Remedy For Abnormal Indication |                   |                                |            |                     |                                                           |                                    |                    |                                                                                                                                                                                                                                                                                                                                                                                                       |            |         |              |        |                   |                                |      |                 |                                                   |                   |               |  |             |  |  |  |
| 183                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 2A243 UNIP CTRL PNL | 1. Press to illuminate STIMULUS SEL TEST switch indicator                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 2A241 FM29 CMTR 290 MHZ to 310 MHZ | Refer to step F137             |                   |                                |            |                     |                                                           |                                    |                    |                                                                                                                                                                                                                                                                                                                                                                                                       |            |         |              |        |                   |                                |      |                 |                                                   |                   |               |  |             |  |  |  |
| Step No                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Panel               | Action                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Normal Indication                  | Remedy For Abnormal Indication |                   |                                |            |                     |                                                           |                                    |                    |                                                                                                                                                                                                                                                                                                                                                                                                       |            |         |              |        |                   |                                |      |                 |                                                   |                   |               |  |             |  |  |  |
| F137                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 2A242 RF/RMS VN     | a. Observe RF MILLI-VOLTMETER<br>b. Replace A1A13                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Above -5 (-15dBm)                  | Replace A1A10                  |                   |                                |            |                     |                                                           |                                    |                    |                                                                                                                                                                                                                                                                                                                                                                                                       |            |         |              |        |                   |                                |      |                 |                                                   |                   |               |  |             |  |  |  |



| INFORMATION BOX                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | GENERAL ACTIONS                                                                                                                    |                   |                    |                                               |                                                                                                                                                                      |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|-------------------|--------------------|-----------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Where can you find the parameters of the Pulse Generator's output signal?</p> <p>Correct! The parameters of the Pulse Generator's output signal are found in the DEVICE UNDER TEST - SETUP DATA section of the Coaxial Switching Drawer's Test Summary.</p> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <p>Access Tech Data</p> <p>Activate Equipment</p> <p>Change Goal</p> <p>Show Parallel</p> <p>Cancel Current Action</p> <p>Quit</p> |                   |                    |                                               |                                                                                                                                                                      |
| <p><b>TROUBLESHOOTING GOAL:</b> Analyze information relevant to the fail.</p>                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                    |                   |                    |                                               |                                                                                                                                                                      |
| EQUIPMENT ENVIRONMENT                                                                                                                                                                                                                                          | TECH DATA ENVIRONMENT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                    |                   |                    |                                               |                                                                                                                                                                      |
| <p>A/D CONSOLE</p>                                                                                                                                                         | <p>TO 3307-38-77-28-1-1</p> <p>Table 2-19. Coaxial Switching Drawer Test Summary</p> <table border="1"> <thead> <tr> <th>DEVICE UNDER TEST</th> <th>MEASUREMENT DEVICE</th> </tr> </thead> <tbody> <tr> <td> <p>DRIVER: P110530010001</p> <p>Pulse Gen</p> </td> <td> <p>DAUGHTER: SETUP DATA</p> <p>Counter/Timer</p> <p>TI from cha 0 to 0.01s</p> <p>Co cha 100 us range</p> <p>100 ns TA/TF</p> <p>0 Vdc offset</p> <p>10 kHz freq</p> </td> </tr> </tbody> </table> <p>-----ROUTING-----</p> <p>PCEN: J108</p> <p>ADCOAI: S15-C, S15-4, S16-2, S9-2, S6-1, S7-6, S8-6, S14-4</p> <p>PATN TO CH A INPUT:</p> <p>ADCOAI: S13-4, S13-C</p> <p>TTDI: CH A INPUT</p> <p>PATN TO CH B INPUT:</p> <p>ADCOAI: S14-C</p> <p>TTDI: CH B INPUT</p> <p>NOTE: High and low signals follow the same routing, but the low is carried on the shield.</p> |                                                                                                                                    | DEVICE UNDER TEST | MEASUREMENT DEVICE | <p>DRIVER: P110530010001</p> <p>Pulse Gen</p> | <p>DAUGHTER: SETUP DATA</p> <p>Counter/Timer</p> <p>TI from cha 0 to 0.01s</p> <p>Co cha 100 us range</p> <p>100 ns TA/TF</p> <p>0 Vdc offset</p> <p>10 kHz freq</p> |
| DEVICE UNDER TEST                                                                                                                                                                                                                                              | MEASUREMENT DEVICE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                    |                   |                    |                                               |                                                                                                                                                                      |
| <p>DRIVER: P110530010001</p> <p>Pulse Gen</p>                                                                                                                                                                                                                  | <p>DAUGHTER: SETUP DATA</p> <p>Counter/Timer</p> <p>TI from cha 0 to 0.01s</p> <p>Co cha 100 us range</p> <p>100 ns TA/TF</p> <p>0 Vdc offset</p> <p>10 kHz freq</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                    |                   |                    |                                               |                                                                                                                                                                      |

| INFORMATION BOX                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | GENERAL ACTIONS                                                                                                                    |                   |                    |                                      |                                                                              |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|-------------------|--------------------|--------------------------------------|------------------------------------------------------------------------------|
| <p>THIS TROUBLESHOOTING GOAL REQUIRES YOU TO INVESTIGATE THE SIGNAL PATH THROUGH THE ROUTING DEVICE. (DRAWER LEVEL) SINCE YOU HAVE VERIFIED THAT THE INPUTS TO THE MEASUREMENT DEVICE WERE BAD AND THE OUTPUT FROM THE STIMULUS DEVICE WAS GOOD, YOU HAVE ISOLATED THE MALFUNCTION TO THE SIGNAL ROUTING.</p> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <p>Access Tech Data</p> <p>Activate Equipment</p> <p>Change Goal</p> <p>Show Parallel</p> <p>Cancel Current Action</p> <p>Quit</p> |                   |                    |                                      |                                                                              |
| <p><b>TROUBLESHOOTING GOAL:</b> Investigate the signal path through the routing device.</p>                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                    |                   |                    |                                      |                                                                              |
| EQUIPMENT ENVIRONMENT                                                                                                                                                                                                                                                                                         | TECH DATA ENVIRONMENT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                    |                   |                    |                                      |                                                                              |
| <div style="border: 1px solid black; padding: 10px; margin: 10px;"> <div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> Remote<br/>PTDs </div> <div style="text-align: right;">Coax Sw Dwr</div> </div>                                                                                 | <p>TO 3307-38-77-28-1-1</p> <p>Table 2-19. Coaxial Switching Drawer Test Summary</p> <table border="1"> <thead> <tr> <th>DEVICE UNDER TEST</th> <th>MEASUREMENT DEVICE</th> </tr> </thead> <tbody> <tr> <td> DRAWER<br/>P21052001MB01<br/>Pulse Gen </td> <td> ROUTING DATA<br/> Counter/Timer<br/> 71 from chA to chB<br/> 100 us range<br/> 0.01s </td> </tr> </tbody> </table> <p>-----ROUTING-----</p> <p>PCEN: J108<br/> AUCOAX: S15-C, S15-4, S16-2, S9-2,<br/> S6-1, S7-4, S8-6, S14-4<br/> PATH TO CH A INPUT:<br/> ADCOAX: S13-4, S13-C</p> <p>TTD: CH A INPUT<br/> PATH TO CH B INPUT:<br/> ADCOAX: S14-C<br/> TTD: CH B INPUT</p> <p>NOTE: High and low signals follow the same routing, but the low is carried on the shield.</p> |                                                                                                                                    | DEVICE UNDER TEST | MEASUREMENT DEVICE | DRAWER<br>P21052001MB01<br>Pulse Gen | ROUTING DATA<br>Counter/Timer<br>71 from chA to chB<br>100 us range<br>0.01s |
| DEVICE UNDER TEST                                                                                                                                                                                                                                                                                             | MEASUREMENT DEVICE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                    |                   |                    |                                      |                                                                              |
| DRAWER<br>P21052001MB01<br>Pulse Gen                                                                                                                                                                                                                                                                          | ROUTING DATA<br>Counter/Timer<br>71 from chA to chB<br>100 us range<br>0.01s                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                    |                   |                    |                                      |                                                                              |

| GENERAL ACTIONS                                                                                                                | INFORMATION BOX                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|--------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Access Tech Data<br>Activate Equipment<br>Change Goal<br>Show Parallel<br>Cancel Current Action<br>Quit<br>Equipment Tech Data | <p>The UHF Control Panel is a ROUTING and CONTROL device that serves a function similar to that of the Coaxial Switching to route signals to and from the UUT and other station drawers. The Coaxial Switching Drawer is controlled by the station computer. In Manual, the technician manually sets the controls on the UHF Control Panel. The UHF Control Panel is also used as a STIMULUS and MEASURING device.</p> <p><b>TROUBLESHOOTING GOAL:</b> Investigate the signal path through the routing device.</p> |
| EQUIPMENT PARALLEL                                                                                                             | <div> <div> Remote<br/>PTDs </div> <div>Coax Sw Dwr</div> </div> <div>UHF CONTROL PANEL</div> <div> <div> Test Point Select Circuits<br/>(Circuit Card Assemblies) </div> <div> Stimulus Select Circuits<br/>(Coaxial Switches) </div> </div>                                                     |

| INFORMATION BOX                                                                                                                                                                                                                                                                                                                           |              | GENERAL ACTIONS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                  |                   |  |                    |  |        |            |        |            |                 |              |               |                                  |           |          |  |              |  |              |  |              |  |             |  |  |
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| <p>a. You have eliminated the Counter/Timer.</p> <p>b. You have eliminated the Pulse Generator.</p> <p>c. You have measured the signal at S15-4, you measured 0 Vdc.</p> <p>d. You have measured the signal at 81W32-P1, you measured 5 Vdc pulses.</p> <p>e. You have measured resistance from S15-C to S15-4, you measured an open.</p> |              | Access Tech Data                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                  |                   |  |                    |  |        |            |        |            |                 |              |               |                                  |           |          |  |              |  |              |  |              |  |             |  |  |
|                                                                                                                                                                                                                                                                                                                                           |              | Change Goal                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                  |                   |  |                    |  |        |            |        |            |                 |              |               |                                  |           |          |  |              |  |              |  |              |  |             |  |  |
|                                                                                                                                                                                                                                                                                                                                           |              | Show Parallel                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                  |                   |  |                    |  |        |            |        |            |                 |              |               |                                  |           |          |  |              |  |              |  |              |  |             |  |  |
| TROUBLESHOOTING GOAL: Investigate the signal path through the routing device.                                                                                                                                                                                                                                                             |              | Cancel Current Action                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                  |                   |  |                    |  |        |            |        |            |                 |              |               |                                  |           |          |  |              |  |              |  |              |  |             |  |  |
|                                                                                                                                                                                                                                                                                                                                           |              | Quit                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                  |                   |  |                    |  |        |            |        |            |                 |              |               |                                  |           |          |  |              |  |              |  |              |  |             |  |  |
|                                                                                                                                                                                                                                                                                                                                           |              | Troubleshooting                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                  |                   |  |                    |  |        |            |        |            |                 |              |               |                                  |           |          |  |              |  |              |  |              |  |             |  |  |
| EQUIPMENT                                                                                                                                                                                                                                                                                                                                 |              | TECH DATA ENVIRONMENT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                  |                   |  |                    |  |        |            |        |            |                 |              |               |                                  |           |          |  |              |  |              |  |              |  |             |  |  |
| <div> <div>Tests Completed</div> <div>Test Results Explained</div> <div>Options Remaining</div> <div>Preferred Next Test</div> </div>                                                                                                                                                                                                     |              | <p>TO 3387-38-77-28-1-1</p> <p>Table 3-15. Coaxial Switching Drawer Test Summary</p> <table border="1"> <thead> <tr> <th colspan="2">DEVICE UNDER TEST</th> <th colspan="2">MEASUREMENT DEVICE</th> </tr> <tr> <th>DRAWER</th> <th>SETUP DATA</th> <th>DRAWER</th> <th>SETUP DATA</th> </tr> </thead> <tbody> <tr> <td>P2T1056200LMS01</td> <td>5 Vdc output</td> <td>Counter/Timer</td> <td>TI from chA 0 to<br/>to chB 0.01s</td> </tr> <tr> <td>Pulse Gen</td> <td>10 us PW</td> <td></td> <td>100 us range</td> </tr> <tr> <td></td> <td>100 ns TR/TF</td> <td></td> <td>0 Vdc offset</td> </tr> <tr> <td></td> <td>10 KHz freq</td> <td></td> <td></td> </tr> </tbody> </table><br><p>PCEN: J108</p> <p>ADCOAX: S15-C, S15-4, S10-2, S9-2,</p> <p>S6-1, S7-6, S8-6, S14-4</p> <p>PATH TO CH A INPUT:</p> <p>ADCOAX: S13-4, S13-C</p> <p>TTD: CH A INPUT</p> <p>PATH TO CH B INPUT:</p> <p>ADCOAX: S14-C</p> <p>TTD: CH B INPUT</p> <p>NOTE: High and low signals follow the same routing, but the low is carried on the shield.</p> |                                  | DEVICE UNDER TEST |  | MEASUREMENT DEVICE |  | DRAWER | SETUP DATA | DRAWER | SETUP DATA | P2T1056200LMS01 | 5 Vdc output | Counter/Timer | TI from chA 0 to<br>to chB 0.01s | Pulse Gen | 10 us PW |  | 100 us range |  | 100 ns TR/TF |  | 0 Vdc offset |  | 10 KHz freq |  |  |
| DEVICE UNDER TEST                                                                                                                                                                                                                                                                                                                         |              | MEASUREMENT DEVICE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                  |                   |  |                    |  |        |            |        |            |                 |              |               |                                  |           |          |  |              |  |              |  |              |  |             |  |  |
| DRAWER                                                                                                                                                                                                                                                                                                                                    | SETUP DATA   | DRAWER                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | SETUP DATA                       |                   |  |                    |  |        |            |        |            |                 |              |               |                                  |           |          |  |              |  |              |  |              |  |             |  |  |
| P2T1056200LMS01                                                                                                                                                                                                                                                                                                                           | 5 Vdc output | Counter/Timer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | TI from chA 0 to<br>to chB 0.01s |                   |  |                    |  |        |            |        |            |                 |              |               |                                  |           |          |  |              |  |              |  |              |  |             |  |  |
| Pulse Gen                                                                                                                                                                                                                                                                                                                                 | 10 us PW     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 100 us range                     |                   |  |                    |  |        |            |        |            |                 |              |               |                                  |           |          |  |              |  |              |  |              |  |             |  |  |
|                                                                                                                                                                                                                                                                                                                                           | 100 ns TR/TF |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 0 Vdc offset                     |                   |  |                    |  |        |            |        |            |                 |              |               |                                  |           |          |  |              |  |              |  |              |  |             |  |  |
|                                                                                                                                                                                                                                                                                                                                           | 10 KHz freq  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                  |                   |  |                    |  |        |            |        |            |                 |              |               |                                  |           |          |  |              |  |              |  |              |  |             |  |  |
| <div> <div> <div>P</div> <div>I</div> </div> <div> <div>C</div> <div>1</div> <div>2</div> <div>3</div> <div>4</div> <div>5</div> <div>6</div> <div>7</div> </div> </div> <p>S15</p> <p>Coaxial Switch</p>                                                                                                                                 |              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                  |                   |  |                    |  |        |            |        |            |                 |              |               |                                  |           |          |  |              |  |              |  |              |  |             |  |  |

| INFORMATION BOX                                                                                                                                                                                                                                     |  | GENERAL ACTIONS                                                                                                                                                                                                                                                                                         |  |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| <div>19999.9 Kohms</div>                                                                                                                                                                                                                            |  | <div>Access Tech Data</div> <div>Activate Equipment</div> <div>Change Goal</div> <div>Show Parallel</div> <div>Cancel Current Action</div> <div>Quit</div> <div>Routing Switching</div> <div>Coaching</div>                                                                                             |  |
| <div> <b>TROUBLESHOOTING GOAL:</b> Investigate the signal path through the routing device.         </div>                                                                                                                                           |  |                                                                                                                                                                                                                                                                                                         |  |
| <div> <b>EQUIPMENT ENVIRONMENT</b> <div> <div>Take Measurement</div> <div>Run OAFI</div> <div>Swap</div> <div>Rerun Original Test</div> </div> <div> </div> <div> <b>S15 - P1</b> </div> <div> <div> </div> <div> </div> <div> </div> </div> </div> |  | <div> <b>TECH DATA ENVIRONMENT</b> <div> </div> <div> <div>NO. 1 H NO. 2 H NO. 3 H NO. 4 H NO. 5 H NO. 6 H NO. 7 H NO. 8 VDO</div> <div>1 2 3 4 5 6 7 8 P1</div> </div> <div> <div>T.O. 33D7-38-77-2-3 fig 6-65 (sh3)</div> <div>Coaxial Switching Drawer 81A1</div> <div>pg 6-406A</div> </div> </div> |  |



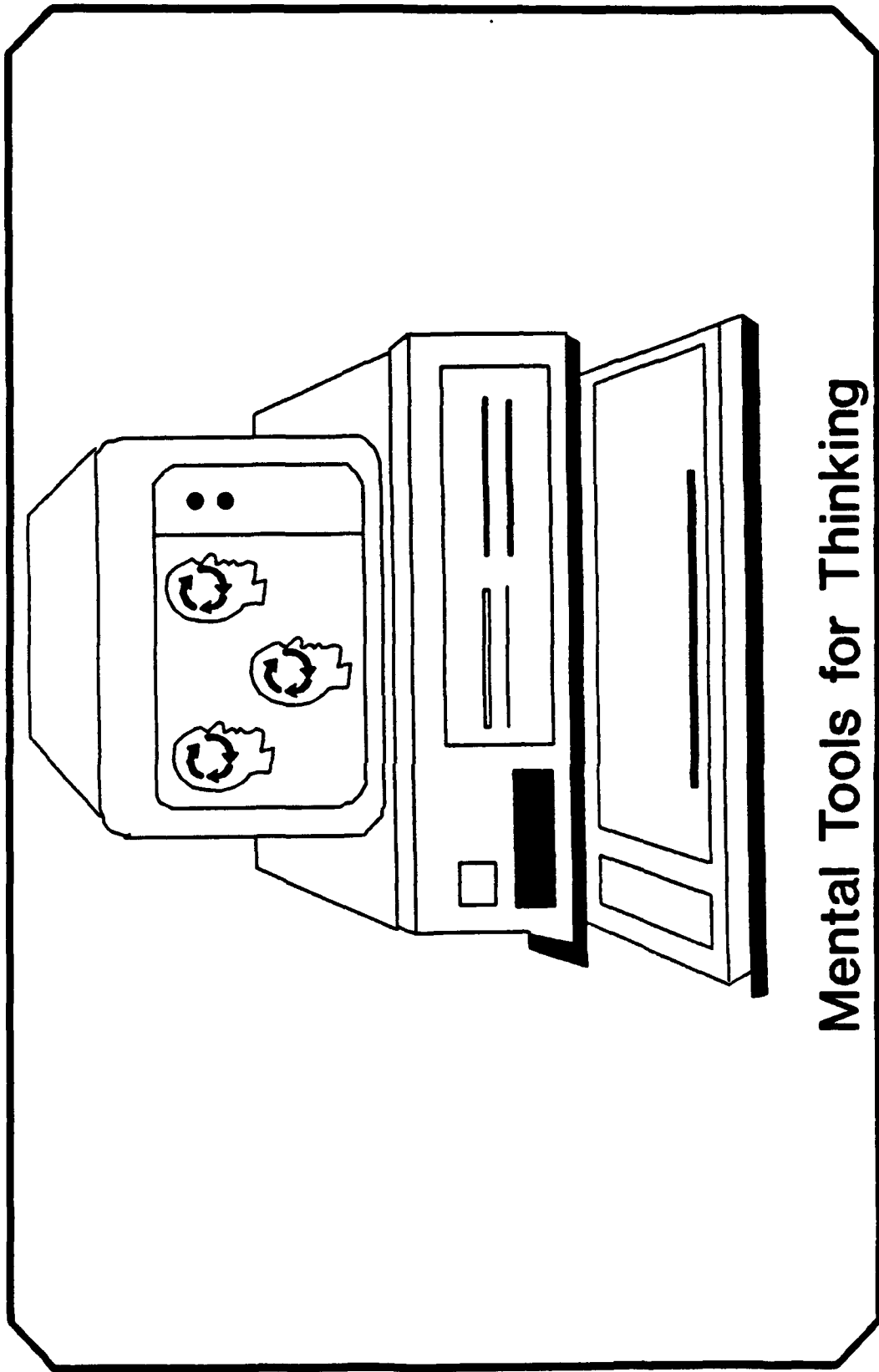
## **POST-PROBLEM ACTIVITIES IN RIVTEK**

- Critique of trainee's solution
  - Positive features of solution praised
  - Any violations of standard troubleshooting practices reported
  - General levels of proficiency estimated
    - System Knowledge
    - Procedural Knowledge
    - Strategic Knowledge
  - Adaptiveness level estimated
  - Dependence/independence of coaching: level of appropriateness estimated
- Alternative troubleshooting solutions presented and explained
- Activities to strengthen learning skills associated with adaptive expertise presented/scored





**PAYOFF**

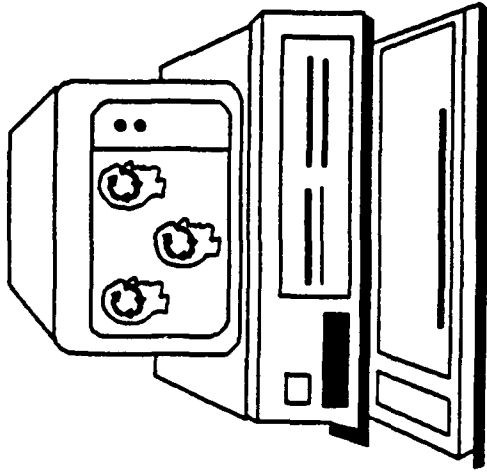


**Mental Tools for Thinking**



## PAYOFFS

- Maintenance savvy captured in tutors
  - Reasons behind decisions made explicit
  - Alternative solutions understood
- Acceleration of complex skill development
  - Restored apprenticeship learning experiences
  - Performance with understanding
  - Enhanced, stable productivity
- Performance adaptiveness
  - Flexibility under novel conditions (e.g., combat)
  - Transfer of skills to new systems, new AF organization structure
  - Reduced training demands/costs
  - Enhanced utilization of personnel



## **ARMY RESEARCH INSTITUTE (ARI) FOREIGN LANGUAGE TUTOR**

ARI has a program of research on technology applications for language learning. A current project has produced an interactive PC-based tutor to help teach military specific language skills and maintain general language proficiency for students at the intermediate level and above. The current tutor is in German.

### **INDIVIDUALIZED INSTRUCTION:**

The computer program can ask questions (written or orally) and give feedback. It can analyze and understand freely-typed input by the students in the target language using natural language processing. It can diagnose and track errors in grammar and meaning and adapt the lesson automatically to the individual student's progress.

### **FLEXIBILITY:**

The tutor includes an authoring interface which allows instructors to create new lessons. The interface is also an aid to researchers who can use the tutor to define alternative instructional strategies and test them. This interface is comprised of sample templates to be filled in and requires no programming skills.

### **EXTENDABILITY:**

The tutors under development are designed to challenge the student to communicate and learn in the target language. Most of the software in these tutors would require only minimal changes to apply to a range of foreign language (extendability to Arabic has been demonstrated). This is primarily due to two factors: 1) the natural language processor contains reusable language universal components, and 2) the lesson authoring system (a "one-time" development cost) can be used for any language application.

### **FUTURE DEVELOPMENT:**

A new 3-year development program will begin in 1992, with the goal of creating a "second generation" tutor that will immerse the student in the language environment through interactive dialogs utilizing natural language processing, speech recognition systems, and dynamic graphics. Spanish and Arabic are the target languages.

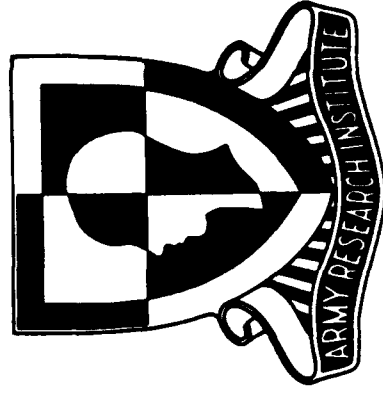
ARI POCs: Dr. Melissa Holland, Team Leader  
Dr. Jonathan Kaplan, Dr. Michelle Sams, Dr. Cathie Alderks, Mr. Rich Maisano  
(703) 274-5540 AV 284-5540

# ARMY RESEARCH INSTITUTE

## ADVANCED TECHNOLOGY FOR LANGUAGE LEARNING

### TRAINING RESEARCH LAB ADVANCED LANGUAGE LEARNING TECHNOLOGY TEAM

Dr. Melissa Holland, Team Leader  
Dr. Jonathan Kaplan, Dr. Michelle Sams, Dr. Cathie Alderks, Mr. Rich Maisano  
(703) 274-5540 AV 284-5540



# **BACKGROUND**

---

## **ARMY NEED:**

- \*\* Assist Military Intelligence & Special Forces linguists acquire and maintain language proficiency**
- \* In school, few resources to teach job specific language skills**
- \* In field, constraints exist on training time and resources for language maintenance**

## **ARI's RESPONSE:**

- \*\* Develop an interactive and adaptive computer tutor**
- \* To provide individualized instruction for MI & SOF linguists**
- \* To provide a vehicle for ARI researchers to investigate how to improve foreign language acquisition and retention**

# **ADVANCED TECHNOLOGY FOR LANGUAGE LEARNING**

---

## **PROGRAM GOALS:**

**Increase the preparedness of military linguists by developing "realistic immersion" environments through user-friendly state-of-the-art technology.**

**Conduct research on second language acquisition and retention with the aim of optimizing the tutor's pedagogical and technological approach.**

## **MAJOR PRODUCTS:**

### **FIRST GENERATION TUTOR**

**(German, available August 1992)**

### **SECOND GENERATION TUTOR**

**(Spanish & Arabic, 3 year program starts May 1992)**

# LANGUAGE SKILLS

|         |           |
|---------|-----------|
| READING | LISTENING |
| WRITING | SPEAKING  |

**COMPREHENSION**  
(Recognition)

**PRODUCTION**  
(Recall)

## Computer-assisted Language Learning

**WRITING**

natural language processing  
key word matching  
string matching

**SPEAKING**

connected speech -> action or discourse results  
speak words/short phrases -> action results  
speak words/short phrases -> pronunciation feedback  
listen -> pronounce -> repeat

**Goal is to communicate.**

# OUTSTANDING FEATURES OF TUTOR

---

## \* INDIVIDUALIZED INSTRUCTION

Capability provided by natural language processor

Parses full sentences input by students  
Analyzes grammatical errors

Capability provided by tutor program

Develops a profile of student's strengths and weaknesses  
Adapts lessons to the individual student

## \* FLEXIBILITY

Authoring system for instructors (requires no programming skills)

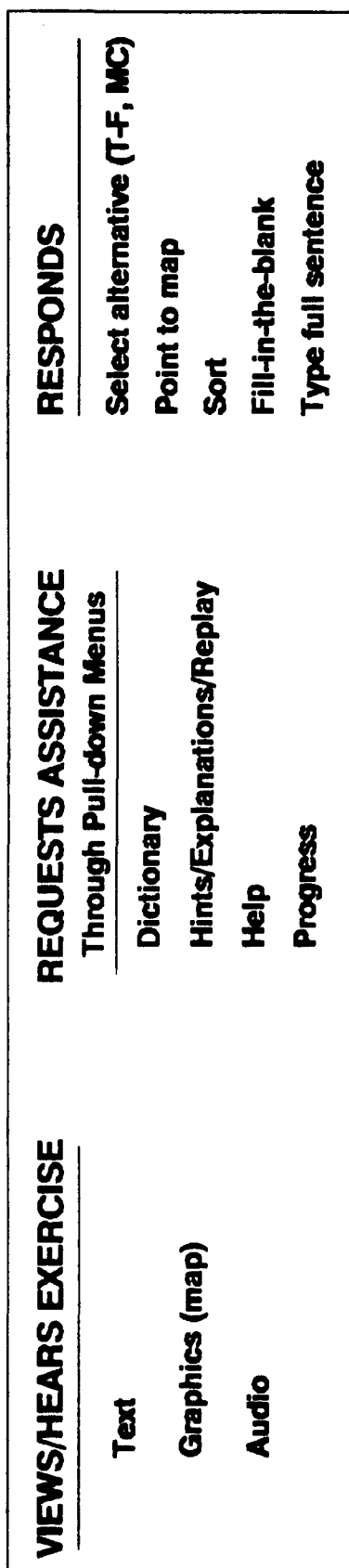
Lessons, feedback, hints, lesson progression rules

## \* EXTENDABILITY

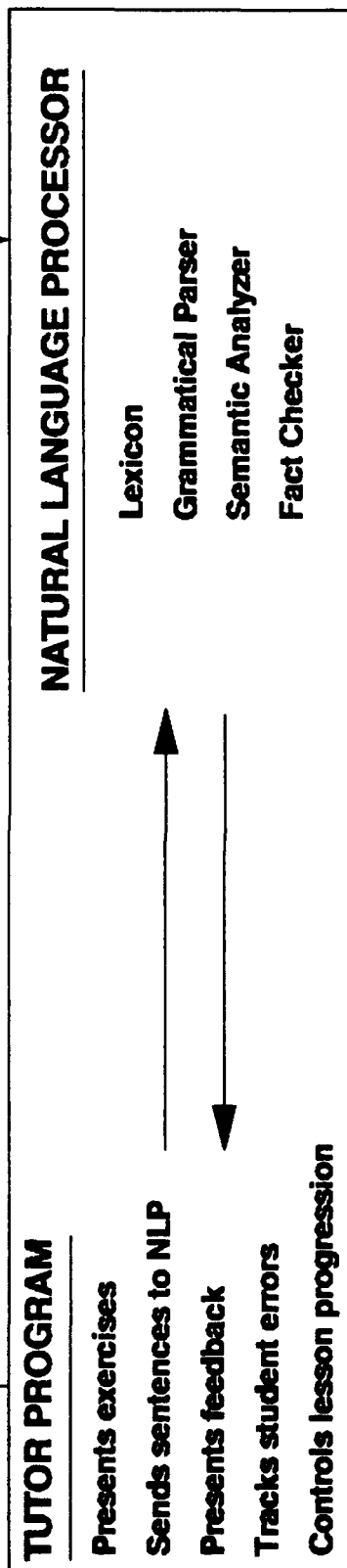
Parser is based on language universal principles with "switches"  
that change the parameters for different languages



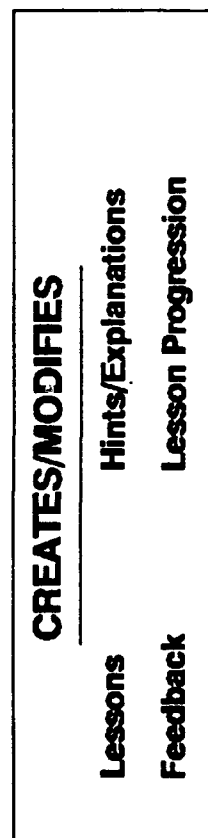
## STUDENT



## LANGUAGE TUTOR



## INSTRUCTOR/RESEARCHER



## **SECOND GENERATION ATTRIBUTES**

---

### **TECHNOLOGIES and DESIGN:**

- \* Utilize relevant technologies (e.g., voice recognition), where possible
- \* Natural language processing (NLP) integrated with ITS/ICAI
- \* Based on language universal principles for extendability
- \* Dynamic graphics and interactive dialogs simulating second language immersion
- \* Capability to alter feedback mechanisms, track student performance, and diagnose classes of errors
- \* Easy reconfiguration (by a non-programmer) along selected dimensions for research purposes and lesson alteration

# RESEARCH: POSSIBLE ISSUES TO BE EXAMINED

---

## COGNITIVE ASPECTS

- \*\* Theoretical framework and cognitive model of foreign language acquisition and retention
- \* Immersion variables (e.g., overt response to input -> dialog, graphics animation)
- \* Cognitive demands of task (e.g., production vs. comprehension)

## INSTRUCTIONAL APPROACH

- \* Construction of lessons & tests (e.g., problem solving, multiple-choice)
- \* Instructional design (e.g., presentation of linguistic rules, response dependent lesson branching)
- \* Error feedback (e.g., promote discourse & stop only on critical errors, diagnosis & prescription)

## FORMAT VARIABLES

- \* Screen layout, color, graphics
- \* Input formats
- \* Speech recognition/production

CREW, GROUP AND UNIT TRAINING

Update of AF ISD Process:  
Major Conrad Bills

Team Decision-Making Training (Update)  
Dr. Eduardo Salas  
(No hard copies available)

## **INTRODUCTION**

### **GOALS OF BASELINE ANALYSIS**

- **LOOK AT:**

#### **CURRENT EMERGING INSTRUCTIONAL DESIGN PROCESSES**

#### **ADVANCES IN LEARNING THEORY**

#### **HIGH-TECH TRAINING SYSTEMS**

#### **AUTOMATED ISD TOOLS**

- **RECOMMEND CHANGES**

---

### **REVISION OF AIR FORCE ISD**

## **SUMMARY OF APPROACH AND FINDINGS**

### **APPROACH**

- 1. SURVEY THROUGH QUESTIONNAIRE**
- 2. INTERVIEWS**
- 3. OBSERVATION**
- 4. LITERATURE REVIEW**

---

**REVISION OF AIR FORCE ISD**

## **SUMMARY OF APPROACH AND FINDINGS**

### **OVERALL RESULTS AND IMPLICATIONS**

#### **1. STRENGTHS OF CURRENT AIR FORCE PROCESS**

- a. The Process Itself**
- b. General Architecture**

---

#### **REVISION OF AIR FORCE ISD**

## **SUMMARY OF APPROACH AND FINDINGS**

### **OVERALL RESULTS AND IMPLICATIONS (Continued)**

#### **2. LIMITATIONS OF CURRENT PROCESS**

- a. Adaptability**
- b. Follow letter rather than the intent**
- c. Excessive paperwork**
- d. Information is too complex**
- e. Information is outdated**
- f. Lacks information on affective domain**
- g. Lacks detail on cognitive domain**

---

**REVISION OF AIR FORCE ISD**



## **SUMMARY OF APPROACH AND FINDINGS**

### **OVERALL RESULTS AND IMPLICATIONS (Continued)**

#### **3. SUGGESTIONS FOR IMPROVEMENTS**

- a. Reduce paperwork**
- b. Provide information in a more comprehensible manner**
- c. Provide information on affective domain**
- d. Provide information on cognitive domain**

---

#### **REVISION OF AIR FORCE ISD**

## **DETAILED RESULTS OF THE SURVEY**

### **- TARGET AUDIENCE DESCRIPTION BY APPLICATION**

### **- SUMMARY OF FINDINGS**

- ACQUISITION**
- FLYING/AIRCREW**
- EDUCATION**
- TECHNICAL/MAINTENANCE**

---

### **REVISION OF AIR FORCE ISD**

## **RECOMMENDATIONS**

- 1. ADAPT SYSTEMS APPROACH**
  - 2. ISD IS TOTAL QUALITY PROCESS**
  - 3. DEVELOP SEPARATE GUIDELINES**
    - ACQUISITION**
    - FLYING/AIRCREW**
    - TECHNICAL/MAINTENANCE**
  - 4. DEVELOP "HOW TO'S"**
  - 5. ESTABLISH TECHNOLOGY CLEARING HOUSE AND "WHAT WORKS"**
  - 6. ESTABLISH 1-800 CENTRAL FACILITY**
- 

**REVISION OF AIR FORCE ISD**

## **RECOMMENDATIONS**

### **NEEDS:**

- **ACCESSIBILITY**
- **FLEXIBILITY**
- **CURRENCY**
- **AUTOMATION**

---

**REVISION OF AIR FORCE ISD**

## **RECOMMENDATIONS**

### **MODEL FUNCTIONAL REQUIREMENTS**

#### **UNIQUE PERFORMANCE REQUIREMENTS**

- **ACQUISITION: INTERRELATE ENGINEERING AND TRAINING INFORMATION**
- **FLYING/AIRCREW: INTEGRATE PSYCHOMOTOR, PROCEDURAL, AND COGNITIVE SKILLS IN REAL TIME**
- **TECHNICAL/MAINTENANCE: DIAGNOSTIC PROBLEM SOLVING**

---

**REVISION OF AIR FORCE ISD**

## **TOP-LEVEL TRAINING SYSTEM FUNCTIONS**

- ANALYSIS/DESIGN
- DEVELOPMENT
- DELIVERY
- MANAGEMENT/ADMINISTRATION
- SUPPORT
- EVALUATION
- QUALITY ASSURANCE

---

**REVISION OF AIR FORCE ISD**

## **RECOMMENDATIONS**

### **TOTAL QUALITY MANAGEMENT PROCESS**

- **BELIEFS ABOUT RELATIONSHIP BETWEEN QUALITY AND COSTS**
- **TO IMPROVE RESULTS, FOCUS ON PROCESS, NOT OUTCOMES**

---

### **REVISION OF AIR FORCE ISD**

## **RECOMMENDATIONS**

- **INPUT FROM TOTAL QUALITY MANAGEMENT**
    - **CUSTOMER**
      - **KNOWING AND SATISFYING**
    - **QUALITY**
      - **DEFINED BY CUSTOMER, ULTIMATE MEASURE OF VALUE**
    - **CONTINUOUS PROCESS IMPROVEMENT**
      - **CUSTOMER EXPECTATIONS RISE, FOCUS ON PROCESS**
    - **PEOPLE**
      - **TEAMS, COMMON VISION. TO ACHIEVE ORGANIZATION'S OBJECTIVES, COUPLE AUTHORITY WITH RESPONSIBILITY**
- 

**REVISION OF AIR FORCE ISD**



## **RECOMMENDATIONS**

### **FORMAT:**

- AFM 50-2
- AFP 50-68

**(3 VOLUMES AND EXECUTIVE SUMMARY)**

---

**REVISION OF AIR FORCE ISD**

## **NEXT-PHASE ACTIVITIES**

### **PRODUCTS:**

- **AFM 50-2**
  - **AFP 50-68**
  - **EXECUTIVE SUMMARY**
  - **VOLUME 1 - ACQUISITION**
  - **VOLUME 2 - FLYING/AIRCREW**
  - **VOLUME 3 - TECHNICAL/MAINTENANCE**
- 

### **REVISION OF AIR FORCE ISD**

**PROCESS:**

**DESIGN/DEVELOP DRAFTS**

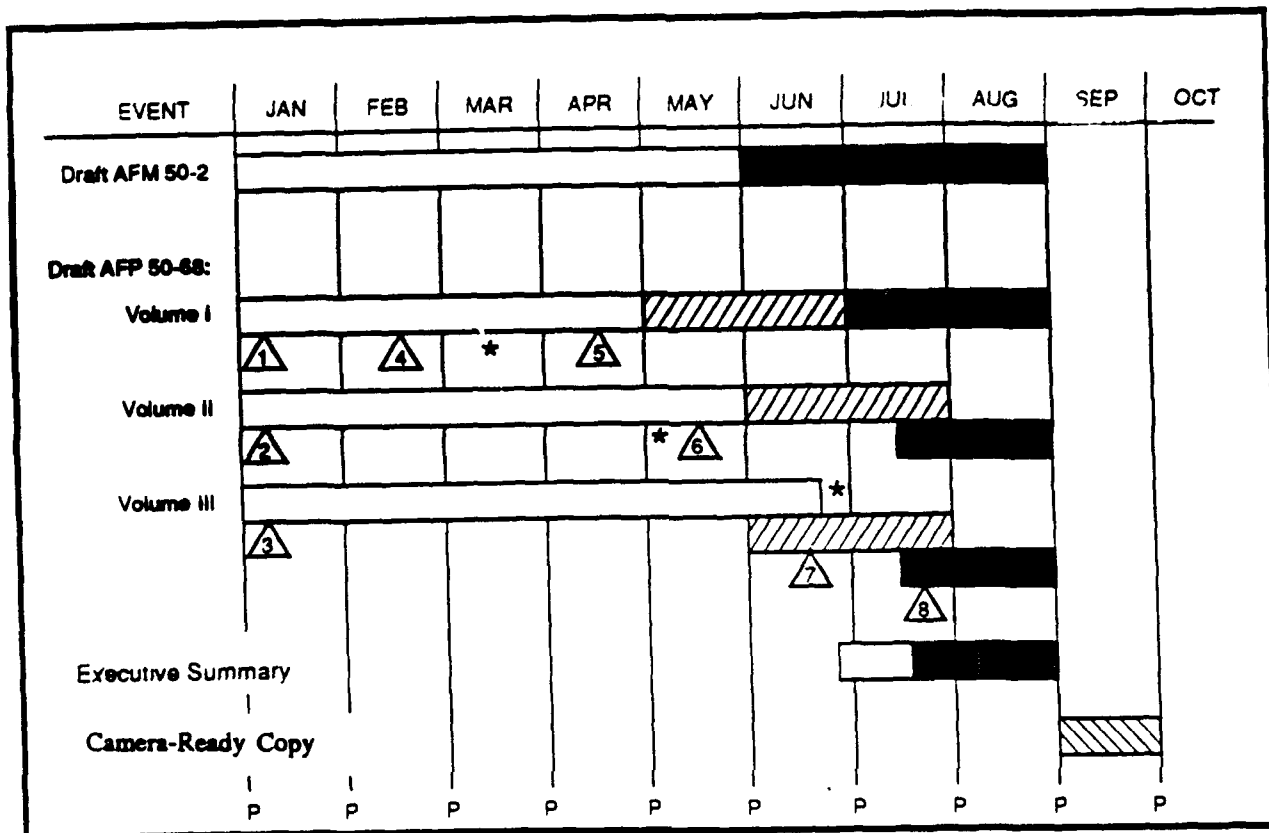
**FORMATIVE EVALUATION**

**REVISE DRAFTS**

**PREPARE CAMERA-READY COPY**

---

**REVISION OF AIR FORCE ISD**



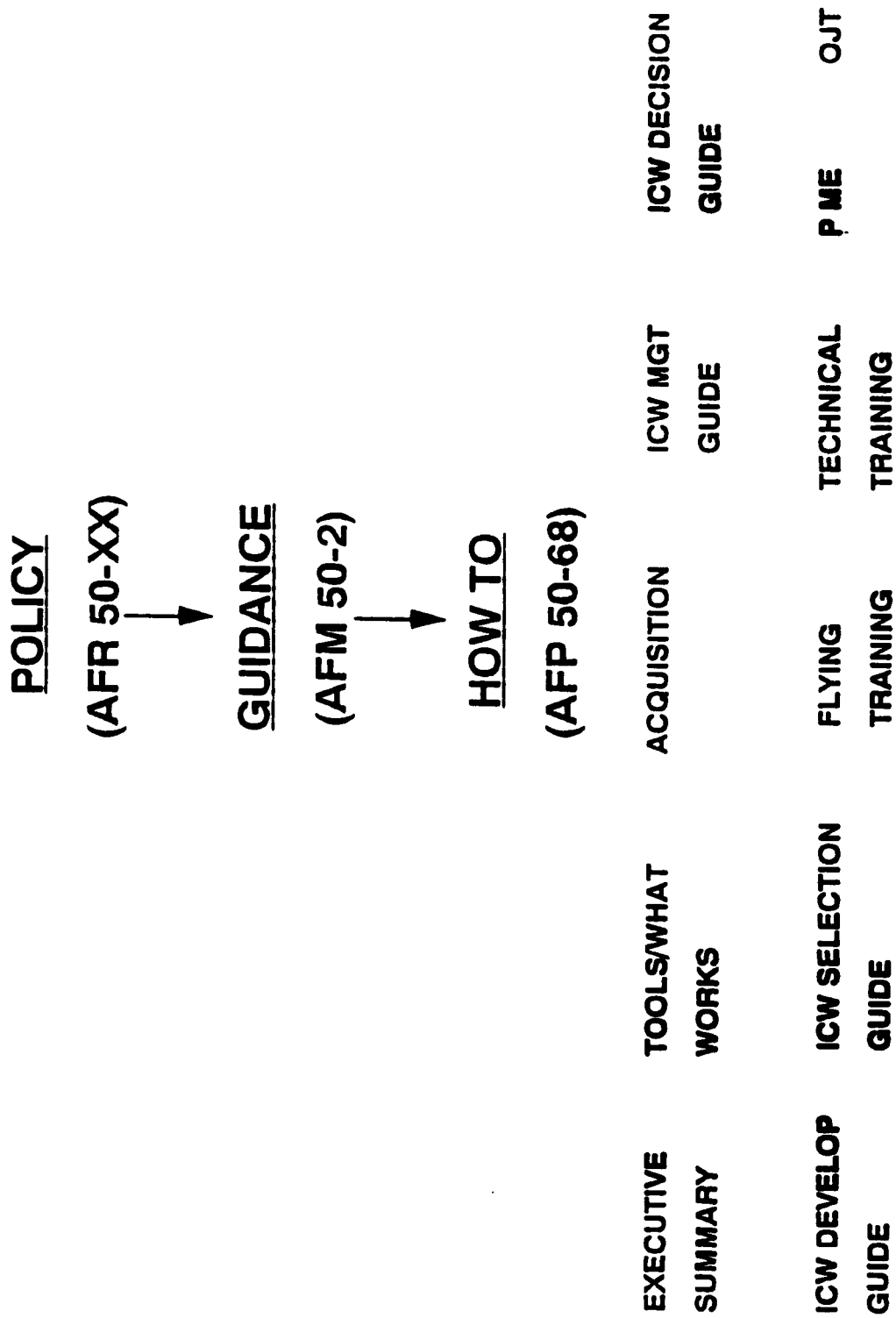
#### LEGEND

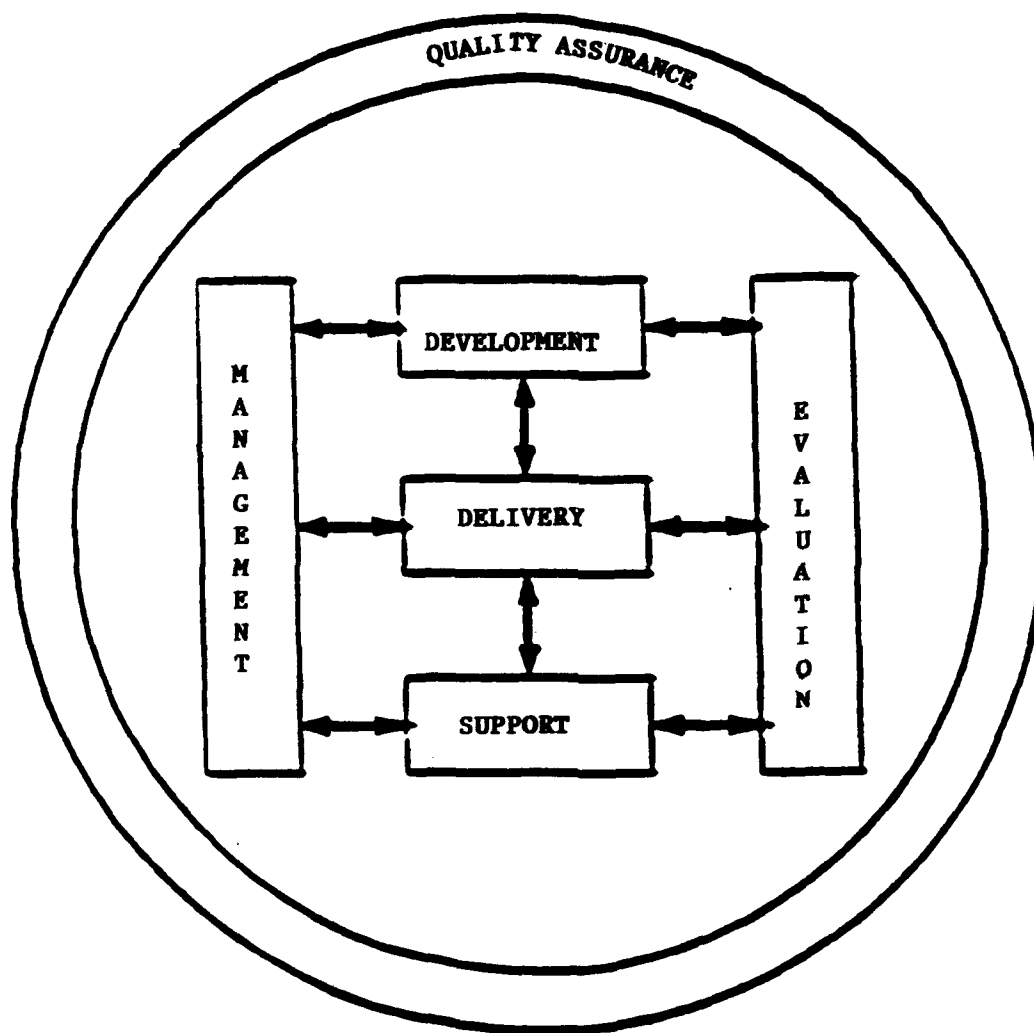
-  SwRI Work Effort
-  Government Review
-  Conduct Formative Evaluations
-  SwRI Revision Effort
-  Camera-Ready Copy
-  Technical Interchange Meeting
-  Monthly Progress Report
-  Trips

#### TRIPS:

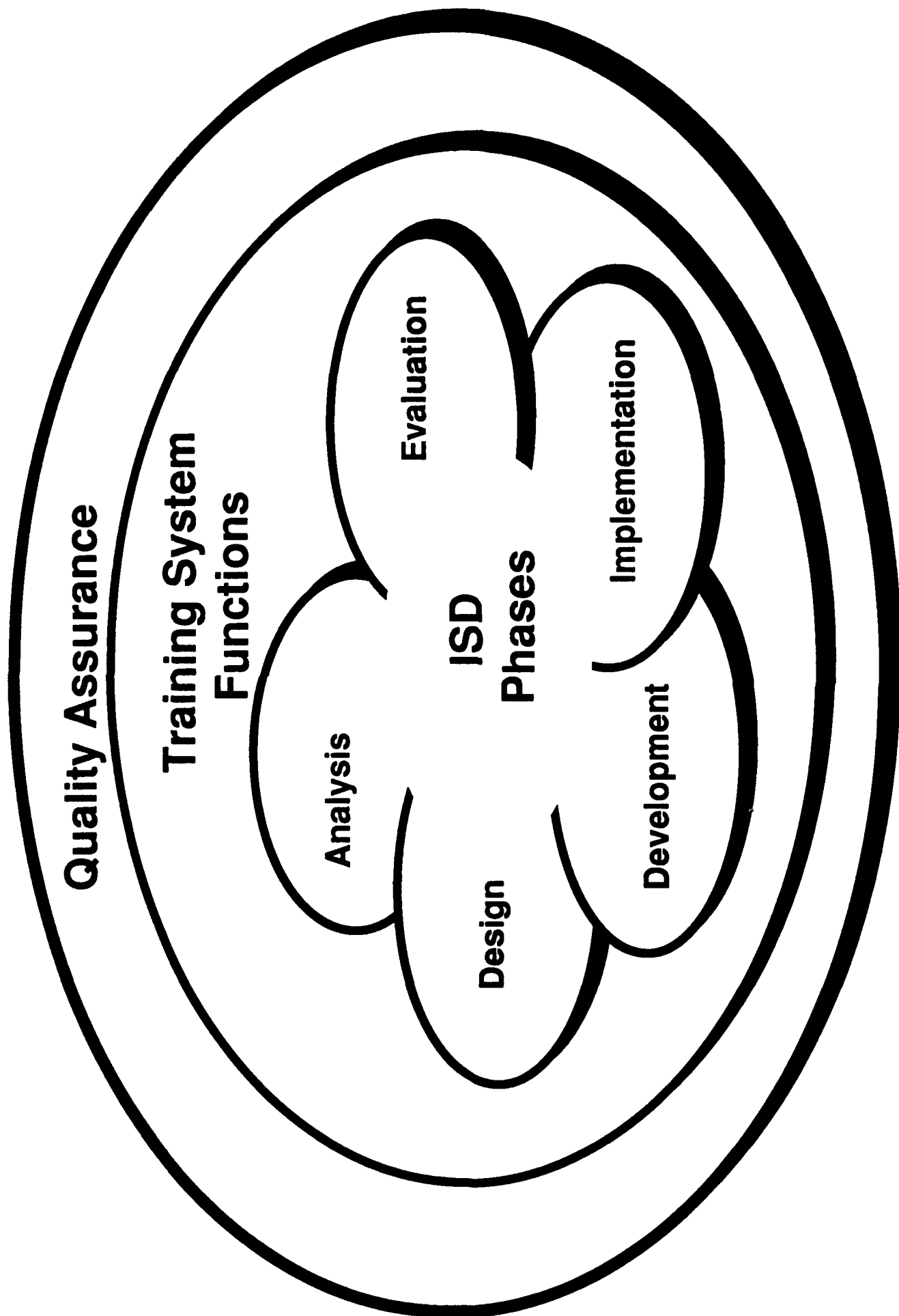
- 1. Wright-Patterson (ASD)
- 2. Luke AFB
- 3. Lowry TTC
- 4. Edwards AFB
- 5. Wright-Patterson and/or Edwards AFB
- 6. Luke AFB
- 7. Lowry TTC
- 8. Wright-Patterson

# POLICY FLOW





**Training System Functional Model**



TRAINING DESIGN AND EVALUATION

Instructional, Planning and Evaluation Issues

Instructional Strategies for Logistic  
Command and Control:  
Captain Reynold Hioki

Distance Learning:  
Mr. Dennis Gettman  
(No hard copies available)



# **Training Technology Technical Group (T2TG)**

## **Desktop Training for Logistics Command and Control**

**Capt Reynold Hioki  
AL/HRTC  
25 Mar 92**

### **PROBLEM STATEMENT**

- **Limited training opportunities for required complex, time/risk-critical decision-making.**
  - - **Expense and other limitations of exercises**
  - - **Changing threat environment**
  - - **Personnel changeover**
  - - **Use of battle staff augmentees**
  - - **Inadequate knowledge about effective instructional strategies for complex decision making**
  - - **Lack of validated training outcomes**
  
- **Sponsor: HQ USAF/LGXX**
- **User: HQ AFLC**

## **OBJECTIVE**

**Develop instructional strategies for complex decision-making domains**

**Develop Desktop Training System for training complex decision-making skills**

### **PAYOFFS**

**Effective individualized training for logistic battle staff personnel**

### **PRODUCTS**

**Validated instructional strategies**

**Desktop Training System prototype**

## **OBJECTIVE**

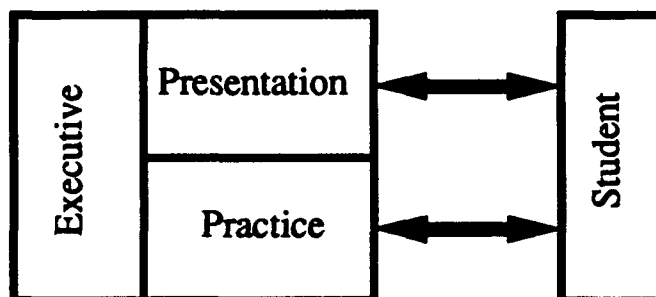
**Develop instructional strategies for complex decision-making domains designed to instruct:**

- concepts/facts**
- rules/procedures**
- principles/relations**

**Develop a desktop training system prototype for training of complex decision-making that includes:**

- presentation capability**
- simulation capability**

## SYSTEM ARCHITECTURE



## PAYOFFS

**Provide effective complex decision-making training for individual battle staff personnel:**

- when needed
- where needed
- at lower cost

## **PRODUCTS**

### **Validated instructional strategies**

- literature-based
- contractor sponsored symposium
- experimentation

### **ITS prototype**

- object-based, graphical user interface
- adaptive to individual student needs
- presentation and practice capability

## **SCIENTIFIC METHODOLOGY**

### **Instructional methodology**

- training requirements analysis
- literature review
- instructional methodology symposium
- field evaluation
- experimentation

### **ITS prototype**

- instructional methodology
- rapid-prototyping approach
- object-based
- field evaluation
- experimentation

WRAP-UP

Training Design and Evaluation  
Summary - Mark Teachout  
(No hard copies available)

CREW, GROUP, UNIT AND TEAM

Dr. Eduardo Salas

ADVANCED TRAINING TECHNOLOGY

Dr. Ray Perez

## T2TG

### Crew, Group, Team, & Unit Training Technology

Eduardo Salas & Frank Moses  
Co-Chairs

- Session I was entirely devoted to a discussion of a DMSO proposal submitted by ARI (lead), NTSC, and Armstrong Lab. The discussion was led by Frank Moses. He outlined the objectives of the project and the products. The proposed work is to exploit "SIMNET-like" technology and demonstrated the efficacy of different training strategies. He also showed a videotape recreating the Battle of 73 Easting.

- The topic for Session II was aircrew coordination training (ACT). There was a presentation given by Major Woodruff on a Tabletop Aircrew Coordination trainer. This is a low-fidelity PC based flight simulator that allows crews to practice teamwork skills. It generated lots of interest and discussion. Then, David Baker and Randy Oser from NTSC updated the group on recent advances of the ACT research. They focused their discussion on organizational issues in ACT and integration of ACT to technical skills. Finally, Judith Orasanu (NASA-Ames) gave a summary of current work that they are supporting on aircrew coordination and presented some data on her research.

- The last session was a presentation by Major Bills on the AF ISD work. He updated the group on what has been done and where the work is going.

## Summary Advanced Training Technology Subgroup of the T2TG

The Advanced Training Technology subgroup met on the 24 & 25 March 1992. The thirteen attendees for this session represented both bench scientists and users. They represented all the major laboratories in the three services (NRL, ARI, AFHRL, NTSC, NPDR, ONR). The theme of the five paper presentations of this meeting was research on "Virtual Reality Its Application to Training and Intelligent Tutors." Five papers were presented by Scientists from the service laboratories (ARI, AFHRL, NTSC, NPDR). The guest discussant for these presentations was Dr. Denis Breglia from NTSC. Each presentation was followed by a discussion led by Dr. Perez, Ms. Dickieson, and Dr. Breglia. The meeting was co-chaired by Dr. Perez and Ms. Dickieson. Ms. Dickieson is the incoming chair.

Dr. Richard Thurman (AFHRL) presented his research on the use of Virtual Reality (VR) technology to enhance pilot tactical skills. He was followed by a presentation by Dr. Bruce Knerr (ARI) on the Army's efforts to generate training requirements for the use of Virtual Reality technology in the Army's future Close Combat Tactical Trainer. Dr. Joseph Psotka (ARI) presented a paper on the use of hyper-media to enhance visual problem-solving in a Virtual Reality environment. Dr. Psotka pointed out the similarities in considerations for VR and Hypertext applications. He was followed by a paper presented by Dr. Ellen Hall (AFHRL) on the Air Force's tutor for the family of skills. This paper in turn was followed by Dr. Wisher (ARI) who described his research on cognitive modeling of the acquisition of morse code. Dr. Michelle Sams (ARI) presented the work they are doing on a Foreign Language Tutor. The objective of Dr. Hall and Dr. Sams' projects is to design, develop, and implement intelligent tutors.

The paper presentations and questions were followed by a discussion and suggestions of future topics for Advanced Training Technologies Subgroup meetings.

A summary of conclusions of the VR research and comments made by the group follow.

- o Little or no instructional design theory exists to go along with and guide the use of VR technology.

- o Hardware/software hasn't reach sufficient level of maturity for commercial or military applications.

- Commercial applications will produce the largest technical gains in the development of VR.

- No economies of scales exists for VR.

- o More research is needed to answer the following questions and issues.

- To what degree do we need this technology (what current training problem will it solve)?
  - We need a better understanding of spatial orientation before we can effectively design and use VR technology.
  - We need better theories and definitions of visual metaphors for capturing data.
- o Government needs to be more proactive in helping industry define its needs.

In general, advances in training technology, including the work on the design of Intelligent tutors, need to address the requirement for personnel to perform increasingly complex and difficult tasks and possess a wide range of skills.

Topics for next meeting:

- o Distance Learning/Distance Education
- o Virtual Environments
- o Applied Technologies

It was suggested that we invite DMSO to attend and have personnel from Disney World brief on their applications of VR. Everyone agreed that we should always have included in our sessions, various projects to be briefed that are beyond the conceptual stage and can report data.

In sum, the meeting was very successful as measured by the enthusiasms of the participants and their representativeness. At least one bench scientist from each of the services labs was in attendance.

Ray S. Perez  
 Jan Dickieson  
 Co-Chairpersons Advanced  
 Training Technologies Subgroup



# **ADVANCE TRAINING TECHNOLOGIES ATTENDEES**

| <u>NAME</u>     | <u>AGENCY/SYMBOL</u>                                  | <u>PHONE</u>                                                      |
|-----------------|-------------------------------------------------------|-------------------------------------------------------------------|
| Ray Perez       | ARI, PERI-IIB                                         | C (703) 274-8694<br>DSN 284-8694                                  |
| Jan Dickieson   | NPRDC, 132                                            | C (619) 553-9270<br>AV 553-9270                                   |
| Major Jim Mika  | TPDC                                                  | C (407) 281-3683                                                  |
| John E. Buckley | TRADOC-DCST                                           | AV 680-5535                                                       |
| Wes Regian      | AL/HRTI                                               | AV 240-2034                                                       |
| Jim Fleming     | AL/HRTI                                               | AV 240-2034                                                       |
| Richard Thurman | AL/HRAU                                               | DSN 474-6561                                                      |
| Philip Miller   | 436STS/OLED Edwards AFB                               | DSN 525-8767                                                      |
| Kevin Dixon     | HQATC/XPCR                                            | DSN 487-3390                                                      |
| Michelle Sams   | ARI, Alex VA                                          | AV 284-5540                                                       |
| Reynold Hiola   | AL/HRTC                                               | DSN 240-2981                                                      |
| Meryl Baker     | NPRDC, 01G                                            | C (619) 553-0785<br>AV 553-0785                                   |
| Joe Psotka      | ARI, Alex VA                                          | C (703) 274-5540<br>AV 284-5540<br>Psotka@ALEXANDRIA-EMH2.ARMY.ML |
| Bruce Knerr     | ARI-PM TRADE Field Unit                               | C (407) 380-4378<br>AV 960-4378                                   |
| Denis Breglia   | NTSC-CODE 251                                         | C (407) 380-8159<br>AV 960-8159                                   |
| Carl Driskell   | US Army STRICOM<br>(Formerly PM TRADE)<br>AMCPM-TND-E | C (407) 380-4348<br>DSN 960-4348                                  |

## T2TG REGISTRATION LIST

### ATTENDEES

BAKER, DAVID DR.  
BAKER, MERYL DR.  
BILLS, CONRAD G. MAJ  
BREGLIA, DENIS MR.  
BUCKLEY, JOHN MR.  
CARROLL, LYNN LTC  
CHAMBERLAIN, MARTY CAPT  
CRAWFORD, ALICE MS.  
DICKIESON, JANET MS.  
DIXON, KEVIN CAPT  
DRILLINGS, MICHAEL DR.  
DRISKELL, CARL MR.  
ELLIS, JOHN DR.  
FLEMING, JIM MR.  
GETTMAN, DENNIS MR.  
GRAY, THOMAS DR.  
HALL, ELLEN DR.  
HIOKI, REYNOLD CAPT  
HOWELL, WILLIAM DR.  
KNERR, BRUCE DR.  
MIKA, JAMES MAJ  
MILLER, PHILIP CAPT  
MITCHELL, DENNIS LTC  
MORALES, MICHELE MS.  
MOSES, FRANK DR.  
ORASANU, JUDITH  
OSER, RANDALL MR.  
THURMAN, RICHARD DR.  
PEREZ, RAY DR.  
PSOTKA, JOE DR.  
REGIAN, WES DR.  
ROMANICK, PAUL D. MAJ  
RUCK, HENDRICK DR.  
SABOL, MARK DR.  
SALAS, EDUARDO DR.  
SAMS, MICHELLE DR.  
SEIDEL, ROBERT J. DR.  
SINE, DON CDR  
TEACHOUT, MARK DR.  
UTCHEL, DONALD CAPT  
WOODRUFF, WES MAJ

NTSC, Orlando, FL  
NPR&DC, San Diego, CA  
ASD/YTEE, Wright-Patterson AFB, OH  
NTSC, CODE 251, Orlando, FL  
HQTRADOC, Ft. Monroe, VA  
ATRD, Williams AFB, AZ  
ONR, Arlington, VA  
NPS, Monterey, CA  
NPRDC, San Diego, CA  
ATC/XPCR, Randolph AFB, TX  
ARI, Alexandria, VA  
PM-TRADE, Orlando, FL  
NPRDC, San Diego, CA  
AL/HRTI, Brooks AFB, TX  
AL/HRTC, Brooks AFB, TX  
AL/HRA, Williams AFB, AZ  
AL/HRMJC, Brooks AFB, TX  
AL/HRTC, Brooks AFB, TX  
HR/CA, Brooks AFB, TX  
PM-TRADE ARI, Orlando, FL  
TPDC, Orlando, FL  
436 STS/OLED, Edwards, CA  
ASD/XRS, Wright-Patterson AFB, OH  
AL/HRTE, Brooks AFB, TX  
ARI, Alexandria, VA  
NASA-ARC, Moffett Field, CA  
NTSC, Orlando, FL  
AL/HRAU, Williams AFB, AZ  
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ARI, Alexandria, VA  
AL/HRTI, San Antonio, TX  
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AL/HRT, Brooks AFB, TX  
ARI, Alexandria, VA  
NTSC, Orlando, FL  
ARI, Alexandria, VA  
ARI, Alexandria, VA  
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