



A human-centered approach for the optimization of human-system-interaction in future naval C2 systems

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New challenges

- Participation in international operations for precaution of and coping with crises
- Presence of neutral, friendly, and hostile objects necessitates non-ambiguous identifications
- Fast changing situations in modern warfare demand decisions be made and actions be taken quickly
- Wrong decisions can have serious consequences
- Optical reconnaissance is of special importance in typical 21st century missions like Operation Active Endeavor
- Task is not trivial
 - Many different classes / frequently modified
 - Image material varies concerning its quality
- Easy-to-use and easy-to-learn user support systems desirable

Inherent complexity

- Ill-structured problems
- Uncertain dynamic environments
- Shifting, ill-defined, or competing goals
- Action/feedback loops
- Time stress
- High stakes
- Multiple players
- Organizational goals and norms

Degrees of automation according to Sheridan

Degree of automation	System features
1	The computer offers no assistance, human must do it all.
2	The computer offers a complete set of action alternatives, and
3	narrows the selection down to a few, or
4	suggests one, and
5	executes that suggestion if the human approves, or
6	allows the human a restricted time to veto before automatic execution, or
7	executes automatically, then necessarily informs the human, or
8	informs him after execution only if he asks, or
9	informs him after execution if it, the computer, decides to.
10	The computer decides everything and acts autonomously, ignoring the human.

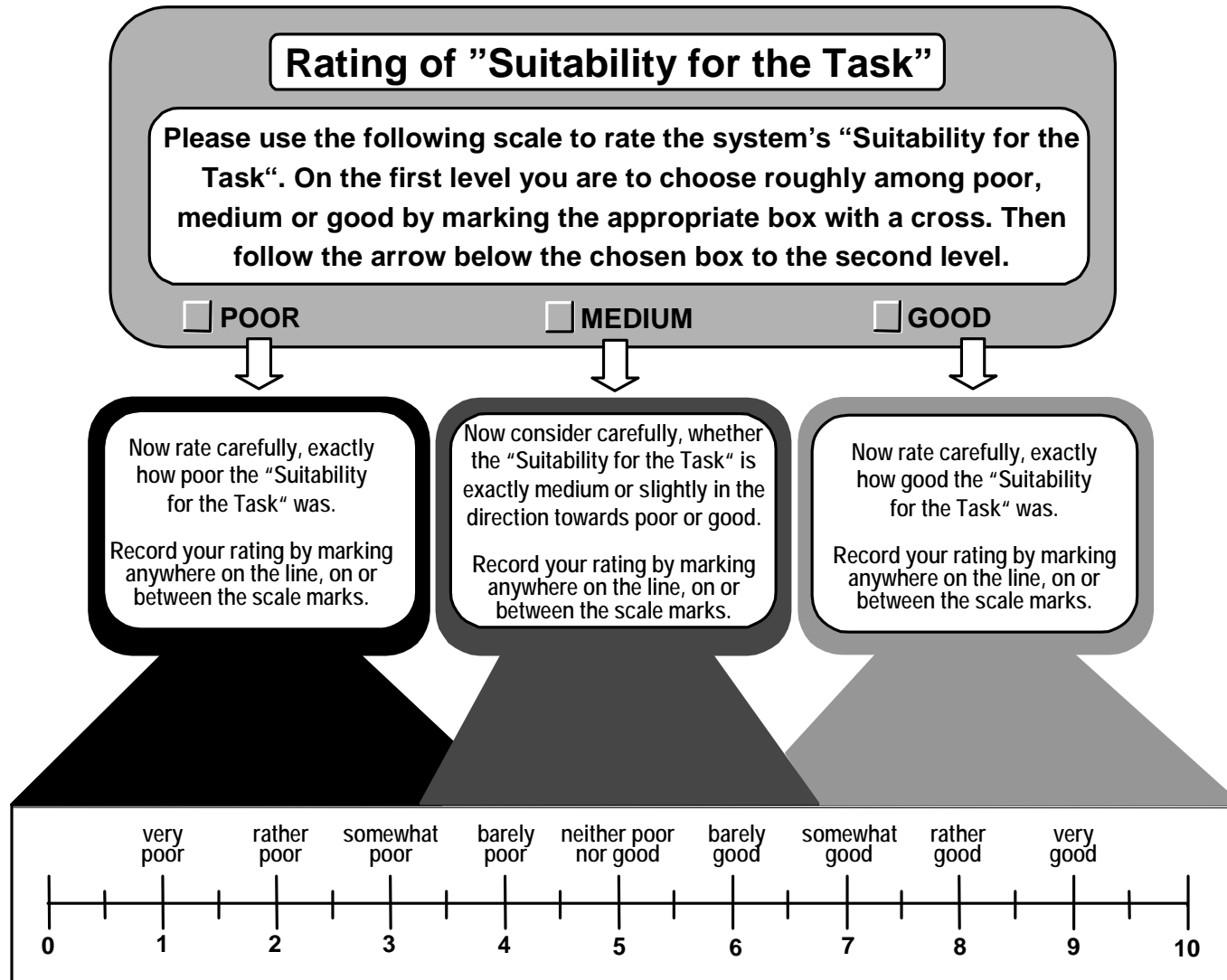
Support system development

- Demonstration facility with two workplaces
 - User support for overall C2 tasks (prototypical)
 - Operational support system for surface vessel classification based on electro-optical imagery (KEOD)
- Rapid prototyping with graphical development environment
- Subject matter experts are frequently asked to examine systems and give feedback
 - Expert talks with officers and sailors take place at Naval C2 Systems Command (KdoMFüSys) in Wilhelmshaven
 - Evaluation on naval vessels under realistic circumstances
- Optimization and enhancement based on advice

Empirical evaluation

- Onboard naval vessels under realistic service conditions
- All subjects are experienced operators
- Standardized personal introduction with exemplary scenario
- Subjects have to accomplish challenging scenarios with the system
- ISO 9241, part 10 qualities rated with 2-level rating scale ZEIS directly afterwards
- Additional text questions on what displeases and what appeals to operators

Two level rating scale (ZEIS)

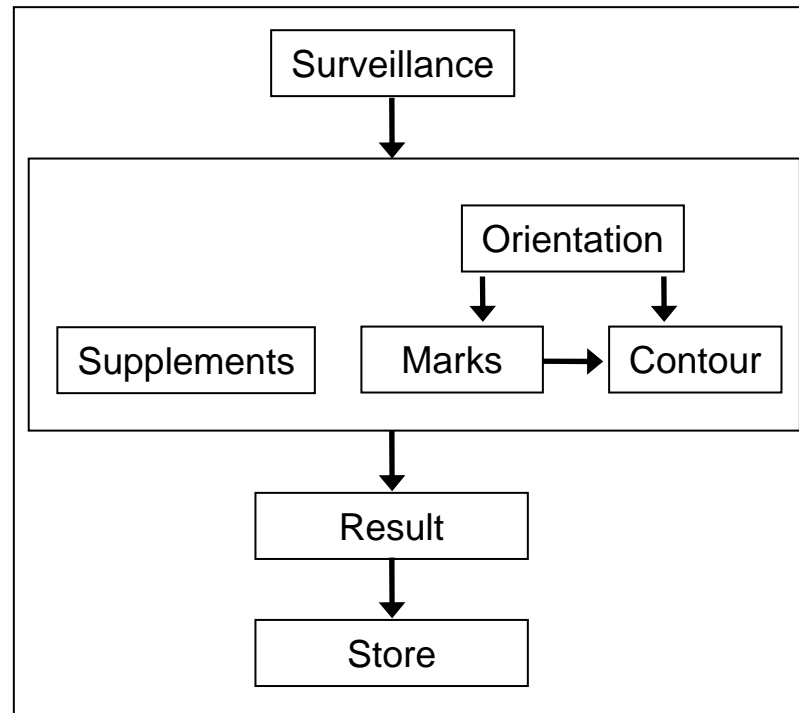


KEOD: Algorithms

- Contour classifier
 - Input: Silhouette, spatial orientation
 - Processing: Standardized OTBC is compared with reference silhouettes of all known ship classes in the database
- Marks classifier
 - Input: Visible marks with position, position independent marks, spatial orientation
 - Processing: Distances between OTBC and DB mark positions are calculated
- Supplements classifier
 - Input: Marks without position, size, flag, hull form, ...
 - Processing: Filter like comparison of equality

KEOD: Overall design

- Sequence of clear cut process states to guide users through steps necessary to feed algorithms with data and to interpret results
- Developed in cooperation with subject matter experts



KEOD: Screen layout (Surveillance)

4th quadrant

Complete database | Choose DB | Info | 2D | 3D

- Bay
- Belgica
- Berlin
- Blue-Ridge
- Bougainville
- Brandenburg
- Bremen
- Carlskrona
- Cassand
- Castle
- Ceza Yik-Hasen-Pass
- Charles-de-Gaulle
- Clemenceau
- Comandante_Joao_Delta
- D-Etienne-D-Orves
- De-La-Pierre
- De-Zeven-Provincien
- Delta
- Dergach
- Descubierta
- Duke
- Durance-1
- Durance-2
- Edinck
- Elbe
- Elis
- Ensdorf
- Falster
- Farahillah
- Fink-8
- Floreal

1st quadrant

MSC | TU | LAUER | HONG 1 | TRACKER | PLATFORM | HONG 2

EIM | EIM | REC | SCHWBY | STAB

Schiff ID: 37
 37
 2
 2
 7
 20

Ph: 3
 Ph: 314

0 60 90
 0 30 60
 0 30 60
 0 30 60

11.09.2008 05:20:13

2nd quadrant

Stop result | Delete sspic/bkm | Save picture

12:04:45

3rd quadrant

Imagery | Objects

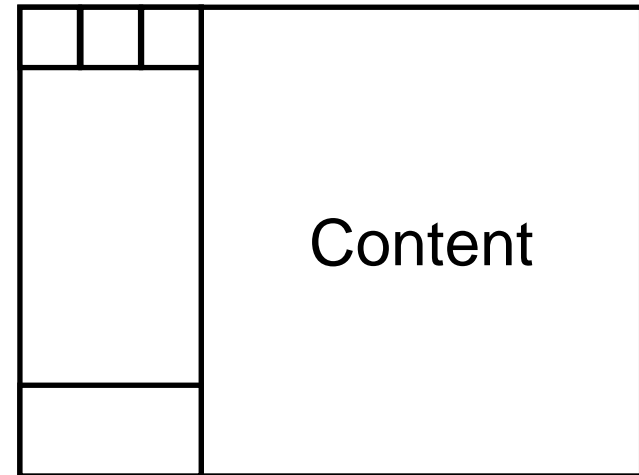
Surveillance

- 150454-2-SEP05_1 PIC
- 150455-2-SEP05_1 PIC
- 150531-2-SEP05_1 PIC
- 150728-2-SEP05_1 SEQ
- 150730-2-SEP05_1 PIC
- 150735-2-SEP05_1 PIC
- 150808-2-SEP05_1 PIC
- 150828-2-SEP05_1 PIC
- 150843-2-SEP05_1 PIC
- 151013-2-SEP05_1 PIC
- 151041-2-SEP05_1 PIC
- 151445-2-SEP05_1 BKM
- 152046-2-SEP05_1 PIC
- 180011-2-SEP05_1 PIC
- 180044-2-SEP05_2 PIC
- 180046-2-SEP05_1 PIC
- 180196-2-SEP05_1 PIC
- 181020-2-SEP05_1 PIC
- 181051-2-SEP05_1 PIC
- 181057-2-SEP05_1 PIC
- 181136-2-SEP05_1 PIC

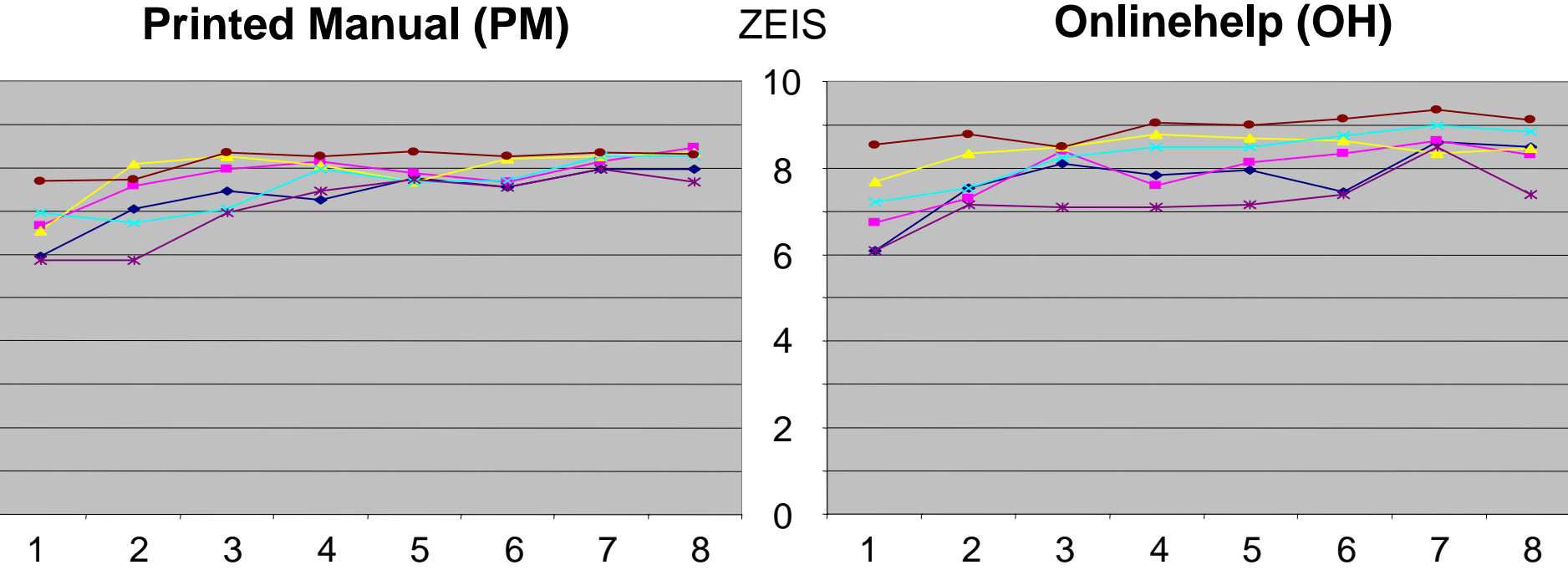
Dark room | English
 Bright room | German

Online help for KEOD

- Allows accessing all help topics without leaving the system
- Access at previously opened page using F1 key
- Context sensitive access via F2 key
- Additional tool tips as minimal invasive support
- Clear navigation concept
 - Table of contents
 - Index
 - Search function
 - Browser functions
- Special help pages



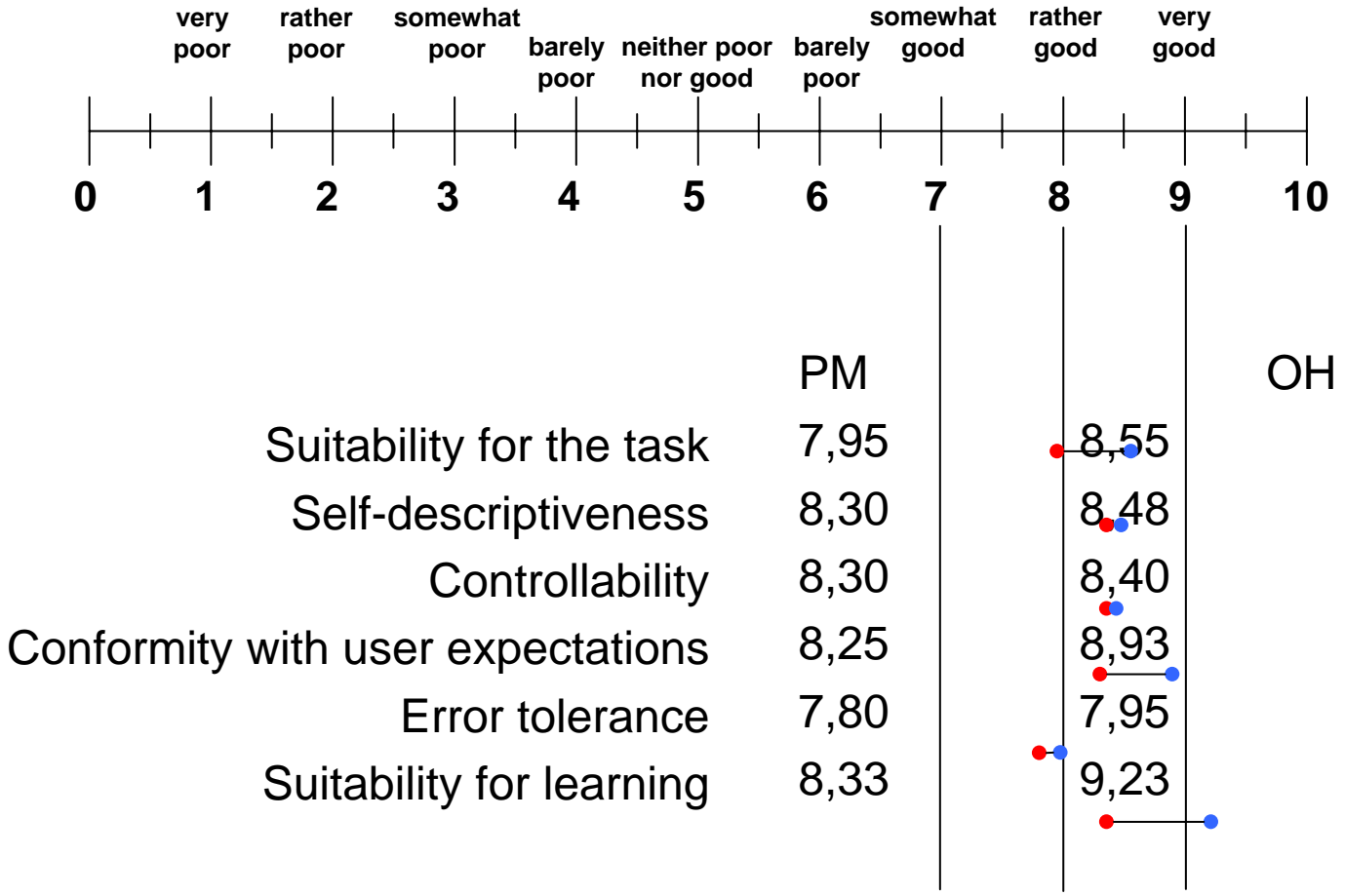
Arithmetic means of the two groups



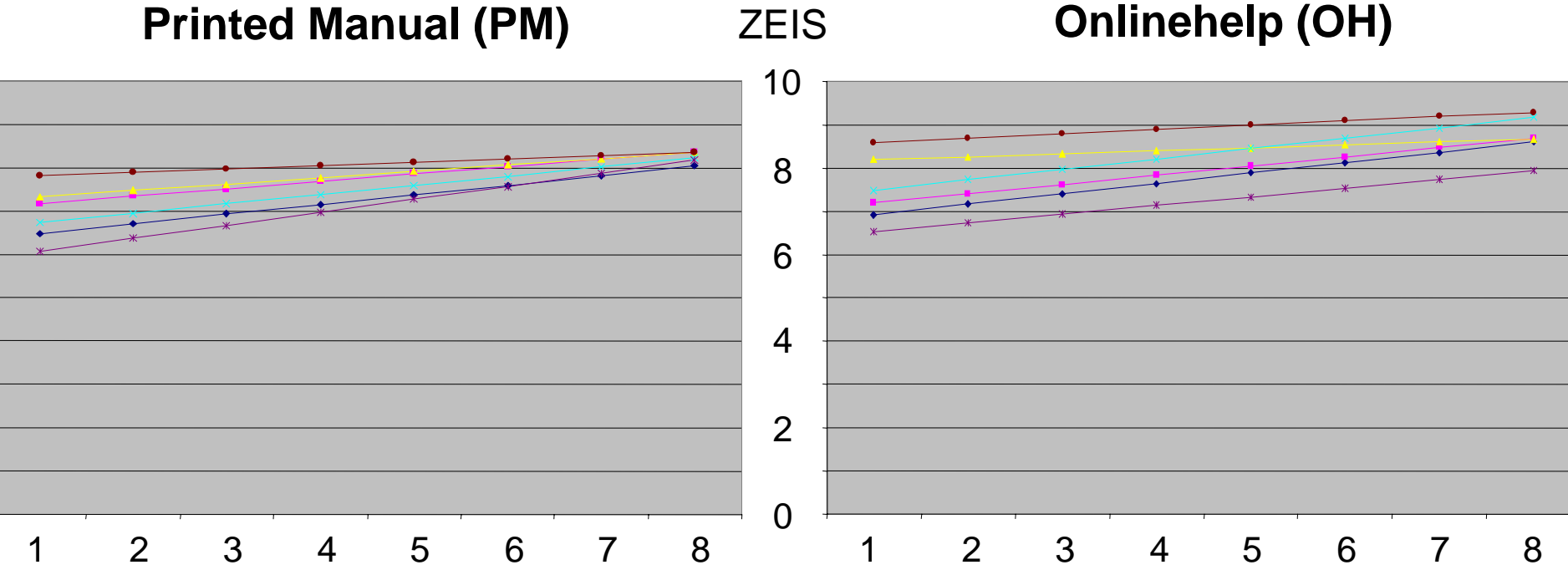
Day →

- ◆ Suitability for the task
- Self-descriptiveness
- ▲ Controllability
- ✕ Conformity with user expectations
- ✱ Error tolerance
- Suitability for learning

Arithmetic means of last two runs



Linear regression of arithmetic means



Day →

- ◆ Suitability for the task
- Self-descriptiveness
- ▲ Controllability
- ✕ Conformity with user expectations
- * Error tolerance
- Suitability for learning

Lessons learned from UNIFIL NAVOPS

- Naval component to assist Lebanese navy in securing coast and to prevent arms smuggling
- All German vessels with electro-optical sensors got support system KEOD 2.0 provisionally
 - Frigates Mecklenburg-Vorpommern, Karlsruhe and Brandenburg
 - Fast patrol boats S74 Nerz, S77 Dachs, S78 Ozelot, and S80 Hyäne
 - Task group tender Frankfurt am Main
- Despite incomplete briefings, operators managed to handle the system easily
- Operators got adequate and helpful results from the support system
- Feedback was predominantly positive

Conclusion & Outlook

- Providing operators with adequate support is an essential for 21st century naval C2
- Experimentation has proved that systems developed following a human-centered approach are highly accepted and appreciated
- Graphical representations make data and coherences more comprehensible
- Deployment of KEOD user support system to about 70 units will be supported
- Further optimization of the user support system based on lessons learned on deployment

QUESTIONS

