Introduction

Science and Technology Department – Brazilian Army

Aeronautics Institute of Technology (ITA)
Brazilian Air Force

Goal

- To present a Brazilian experiment about visual automatic alerts and its effects in the situation awareness of a net-centric command and control (C2) systems operator.
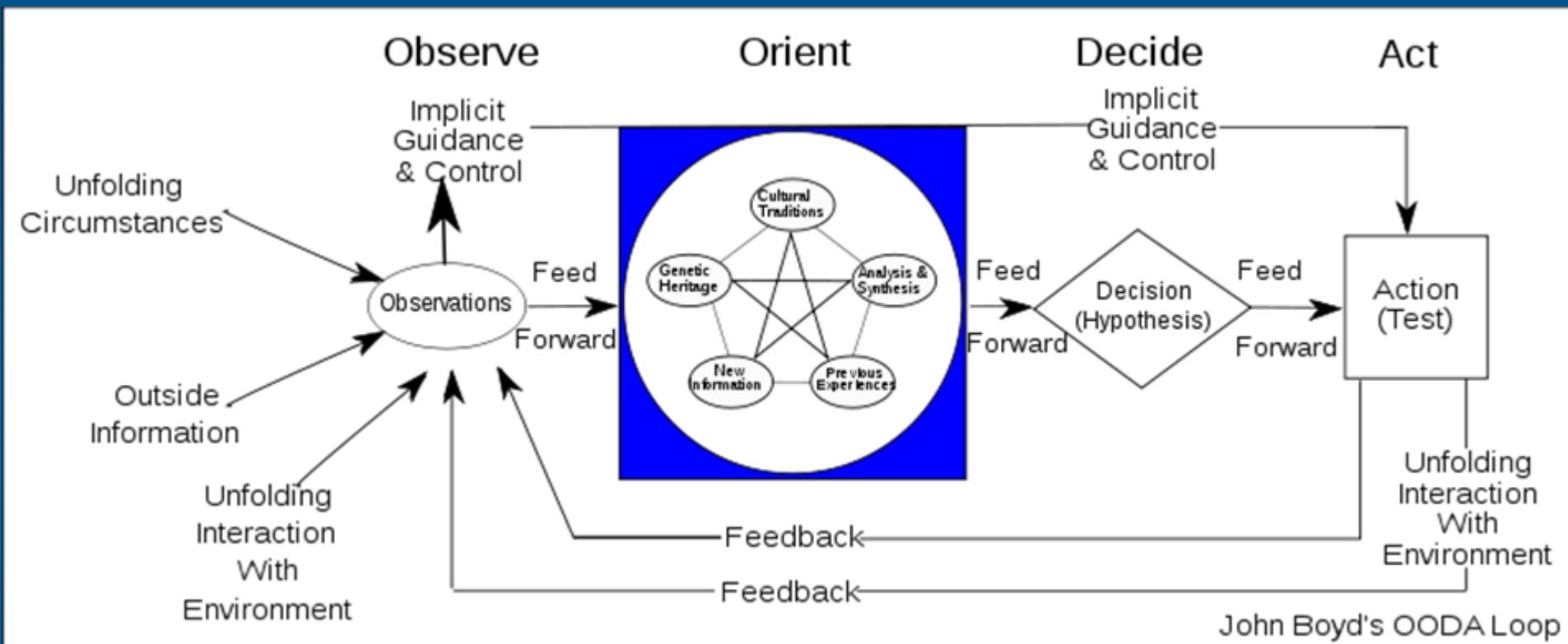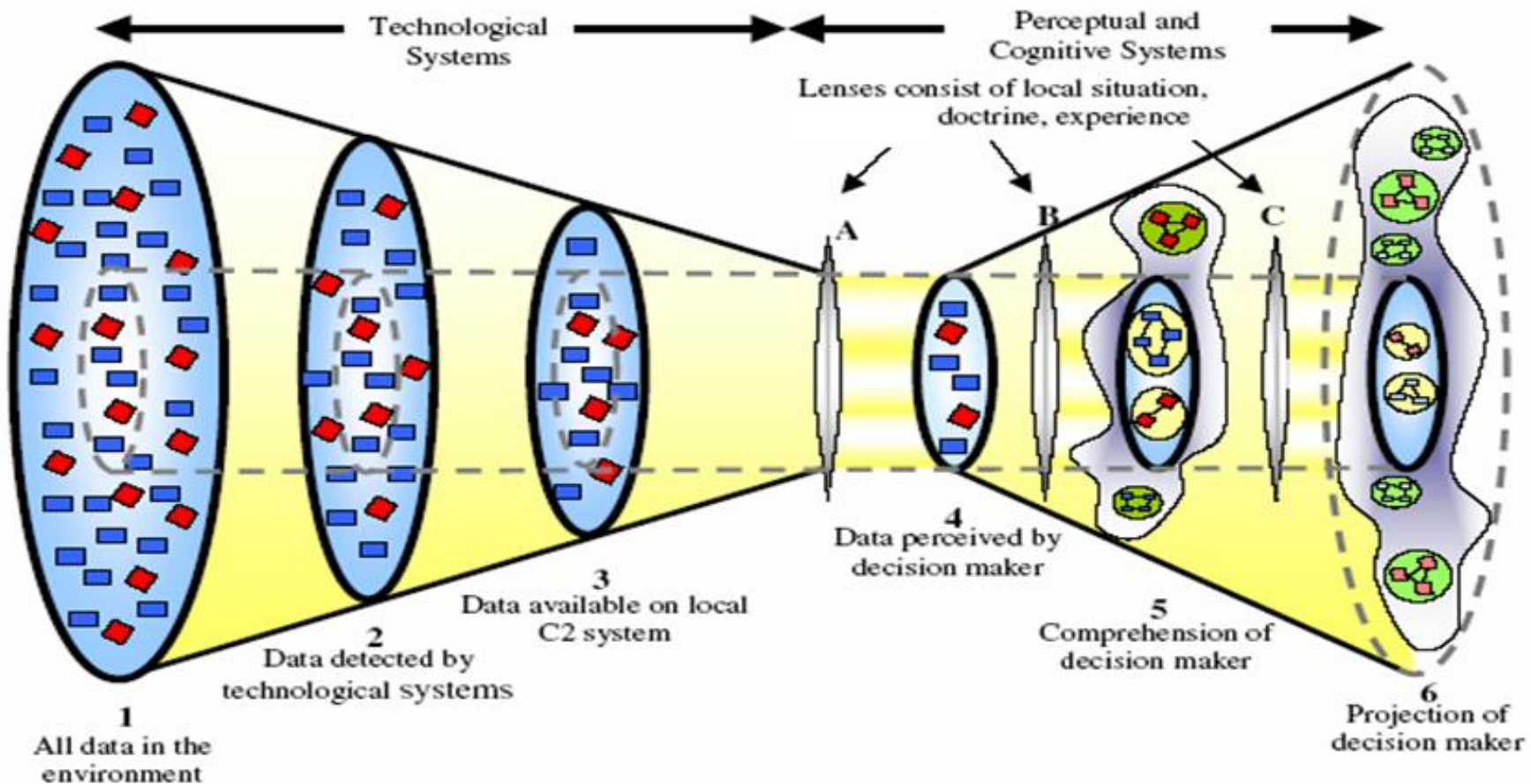
Summary

1. Introduction
   - Decision Making
2. BackGround
   - Situation Awareness (SA)
   - Situation Awareness Measures
   - Net-centric Command and Control (C2) Systems
   - Automated Alerting System
3. Experiment
   - Procedures
   - Results
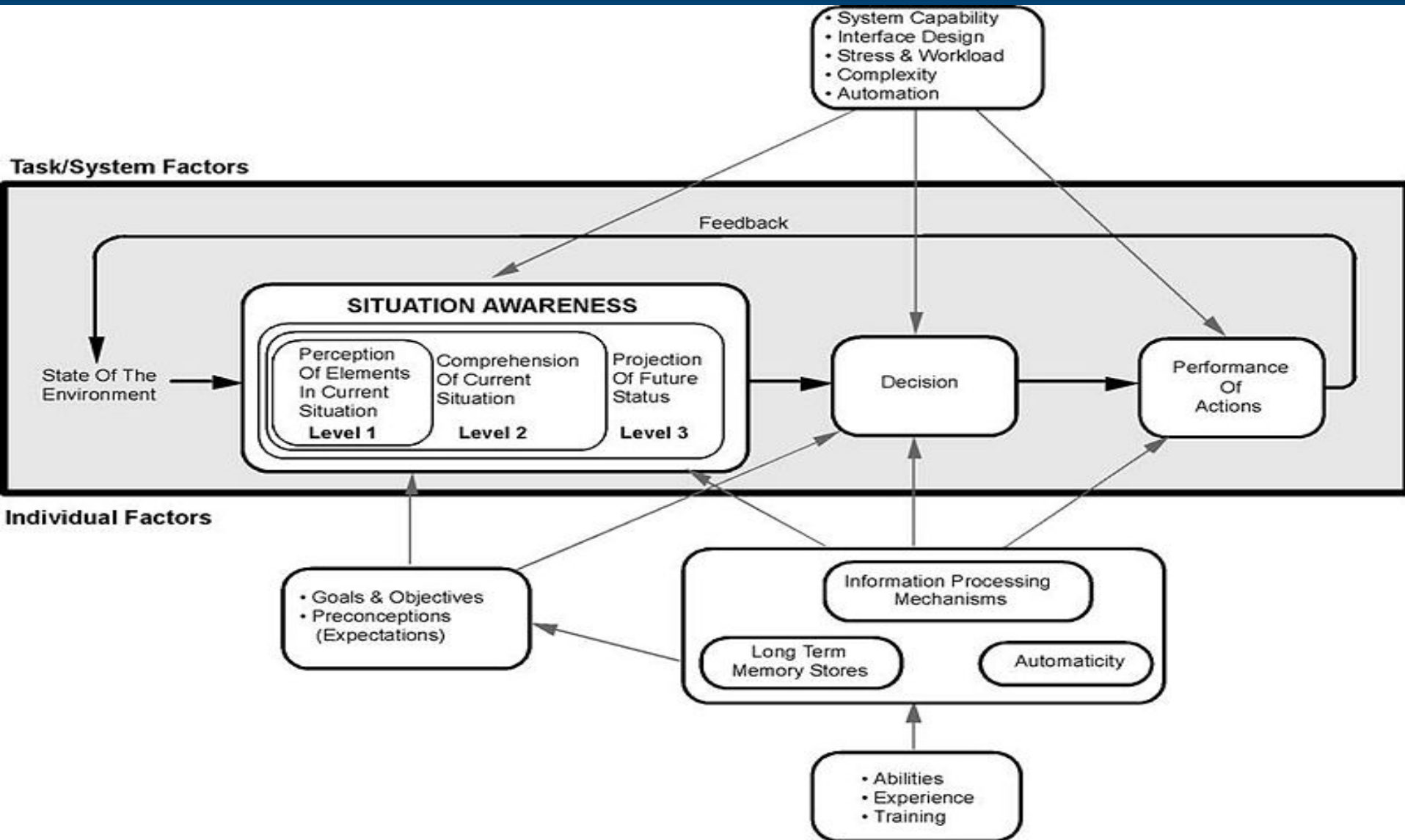4. Conclusion

DECISION-MAKING loop (OODA)

John Boyd's OODA Loop

Technological/Cognitive Systems

Technological Systems

Perceptual and Cognitive Systems

Lenses consist of local situation, doctrine, experience

A

B

C

1
All data in the environment

2
Data detected by technological systems

3
Data available on local C2 system

4
Data perceived by decision maker

5
Comprehension of decision maker

6
Projection of decision maker

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Situation Awareness (SA)

Situation Awareness

Measurement Approaches

Process Indices
- Eye Movements
- Information Acquisition
- Communications & Verbalizations

Direct Measures
- Objective Measures
  - Post-test
  - On-line probes
  - SAGAT
- Subjective Measures
  - Self-Ratings
  - Observer Ratings

Behavioral Measures
- Attack/run/wait
- Fire point selection
- Verbalizations

Performance Measures
- Tactical Performance

Assessment Processes → Enviroment & System Interface → Situation Awareness → Decisions → Actions

Moderating Factors:

Strategies
Skills
Knowledge
Abilities

Strategies
Tactics
Training
Personality Factors

System Capabilities
Enemy Capabilities
Environmental Conditions
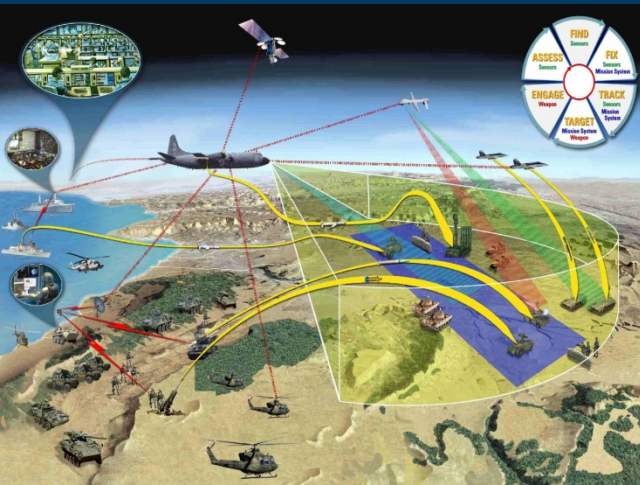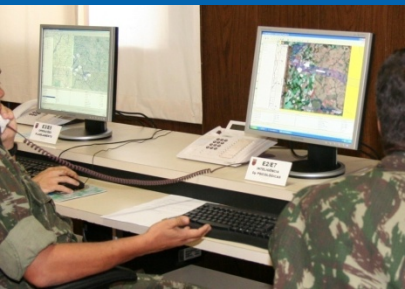
Information Age

- Network centric warfare
  - Suggests a new thinking about combat;
  - Proposes a geograficaly dispersed Force, net-centric linked, to acquire a common operational overview of the military actions.

- Digital C2 Systems
  - Improve information advantage that translates into combat profits;
  - Communications resources and stratified vision increases C2 agility.

C2 Systems Challenges

- Many C2 systems out there.
- What information, to whom and when?

- Time latency of data/data update rates
- Human factor:SA, mental workload, cognitive processes.

Promissing Technology ...

- a computer system to monitor the data stream and provide alerts when critical events occur to ensure they are not missed by the operator.

AUTOMATED ALERTING SYSTEM

- **Intrusion Alerts Automatic System (IAAS)**
  - □ Increase the "C2 em Combate" Brazilian software with an automatic alerts system.
  - □ Can set which events should be monitored and adjusted when alerts are triggered.
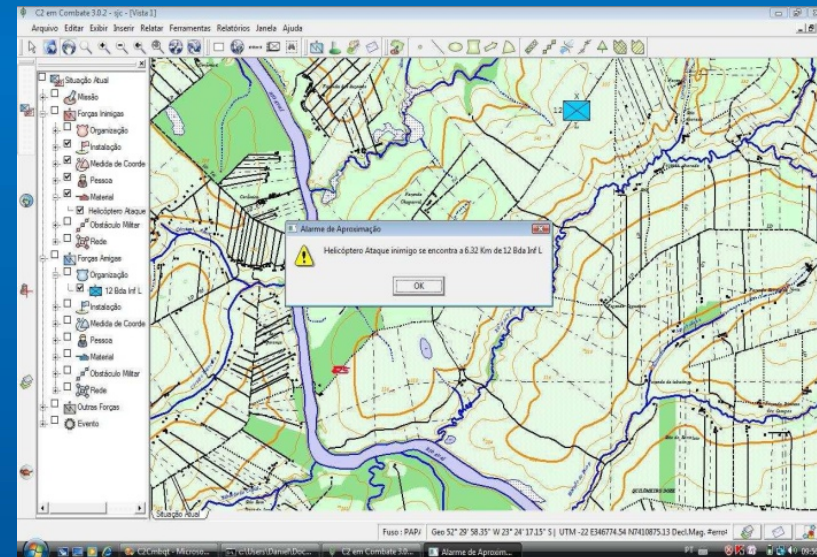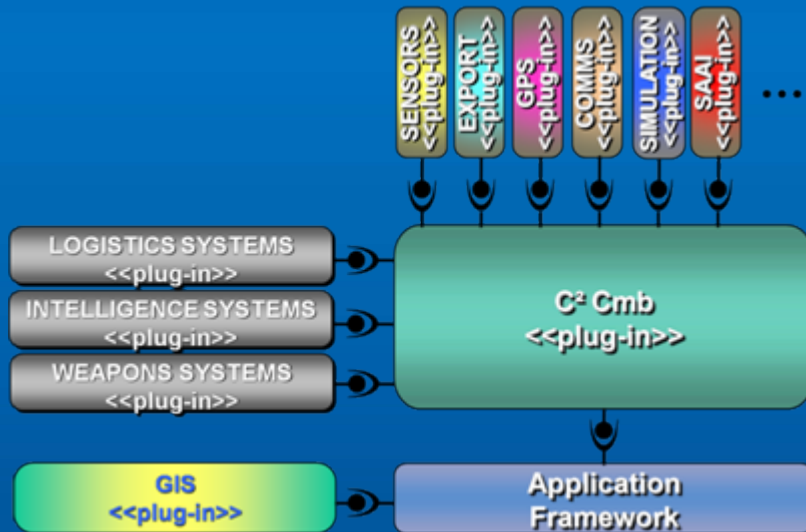
AUTOMATED ALERTING SYSTEM

Remark:

- Alerts can "blind" the operator, capturing the attention in inopportune moments.

Experiment

- Issue:

How immediate feedback from an automated alerting system affects SA under changeable workload conditions?

Experiment: hypotheses

- Null hypothesis: the SA is equal in both conditions of alerts (enabled or disabled).
- Alternative hypothesis: the SA is different from enabled alerts to disabled alerts

- The hypotheses were tested under different workload conditions.

Experiment: procedure

- Participants:
  - fifteen Brazilian Army Infantry Soldiers.

- Material:
  - "C2 em Combate" software.
  - "IAAS" alerts system.
  - SAGAT Questionnaire .

Experiment: procedure

- uses agreement term and demographic questionnaire.
- tool training sessions.
- training evaluation.
- practice scenario and SAGAT questionnaire.
- two experimental sessions both with low and high difficulty; and enabled and disabled alerts.
- SAGAT questionnaire
- Final questionnaire.

Experiment: results

Raw data of the SAGAT questionnaire

name	With alerts Scenario A- low	With alerts Scenario A- high	With alerts Scenario B- low	With alerts Scenario B- high	Without alerts Scenario A-low	Without alerts Scenario A- high	Without alerts Scenario B low	Without alerts Scenario B- high
Military 1	8,64	6,36					6,96	8,4
Military 2			6,36	6,24	11,88	9		
Military 3	4,56	2,52					3,36	0,6
Military 4			5,28	6,12	5,04	5,04		
Military 5	6,6	6,36					6,24	7,32
Military 6			8,28	5,28	9,96	9,84		
Military 7	4,8	6,6					4,56	6,96
Military 8			4,8	3,12	3,96	6,84		
Military 9	5,52	5,76					7,56	6,84
Military 10			7,08	5,16	9,48	9		
Military 11	6	7,92					7,56	9,48
Military 12			10,44	8,88	9	6,48		
Military 13	7,92	9,48					8,16	12
Military 14			7,68	6,96	9,12	9,36		
Military 15			8,76	6,24	7,8	9,6		
Partial Sum	44,04	45	58,68	48,0	66,24	65,16	44,4	51,6
Total Sum	195,72				227,4			
Average	6,524				7,58			

Experiment: results

Individual SAGAT score
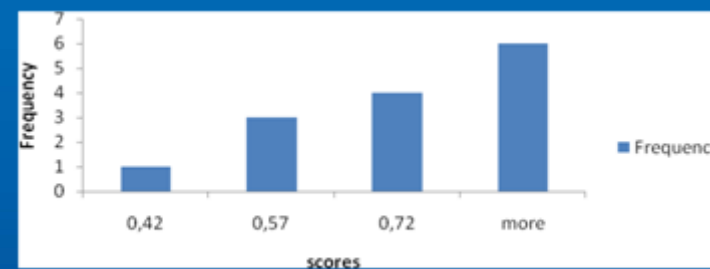
• The individual SAGAT scores are varied and do not indicate a tendency.

•The histograms show that the samples are well distributed.
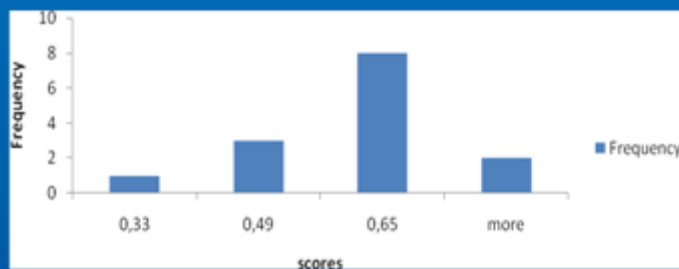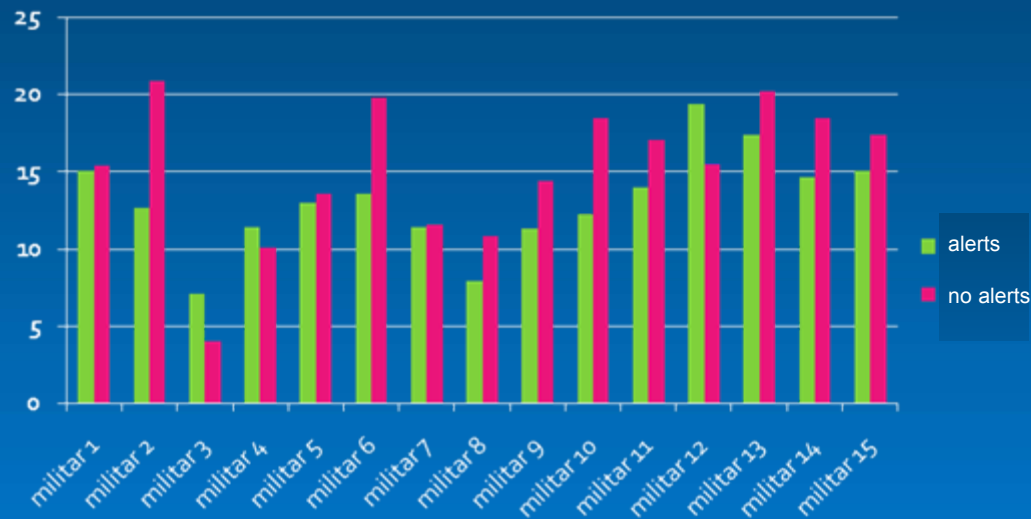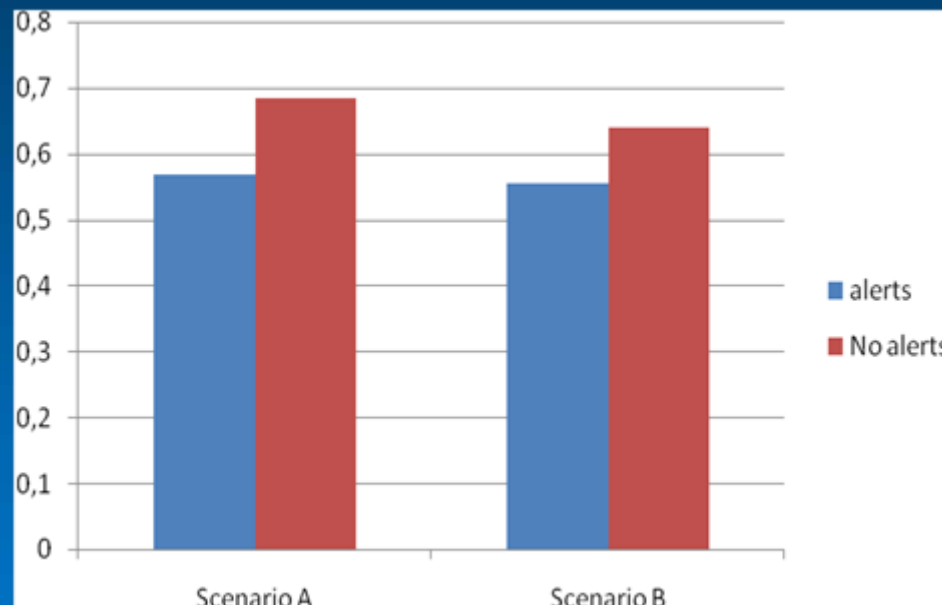

Histogram with alerts enabled

Histogram with alerts disabled
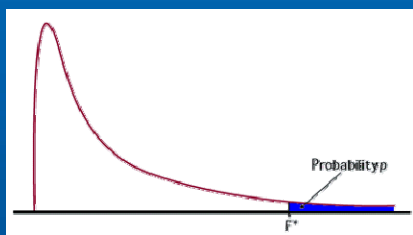
Experiment: results

•The results apparently suggest that SAGAT score is better when alerts were disabled in both scenarios.

• An F test showed that the samples have the same variance.

SAGAT score in scenarios 'A' and 'B'

F - Test: two samples

|	Without Alerts	With Alerts
Mean	7,98	6,737
Variance	4,012	2,645
ocurrences	28	28
df	27	27
F	1,517	
P(F<=f) one-sided	0,143	
F critical one-sided	1,905	

Experiment: results

•In the T-test, with a confidence level of 95% we can discard the null hypothesis and we can argue that the mean from the use of alerts is lower when alerts are disabled .

•However in the ANOVA approach, with a confidence level of 95% and considering the scenario as a block, we can not discard the null hypothesis.

	With Alerts	Without Alerts
Mean	0,561428571	0,665
Variance	0,013705495	0,021665385
occurrences	14	14
Variance group	0,01768544	
Hypothesis	$\mu_1 - \mu_2 = 0$	
df	26	
Stat t	-2,060540037	
P(T<=t) one-sided	0,024741902	
t critical one-sided	1,705617901	
P(T<=t) two-sided	0,049483804	
t critical two-sided	2,055529418	
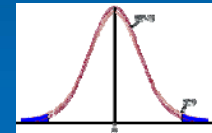
T-test: two samples, $\alpha = 0,05$

•The results confirm that scenarios A and B can be considered equivalent.

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
scenario	1	0.05316	0.05316	0.7053	0.40928
alerts	1	0.27087	0.27087	3.5941	0.07009
scenario:alerts	1	0.00688	0.00688	0.0912	0.76521
residuals	24	1.80874	0.07536		

ANOVA with two factors and two levels

Experiment: results

• We verify that under low workload conditions alerts were not significant, however under high workload the t-test revealed that the SAGAT scores without alerts were higher than enabled alerts, with a confidence level of 95%.
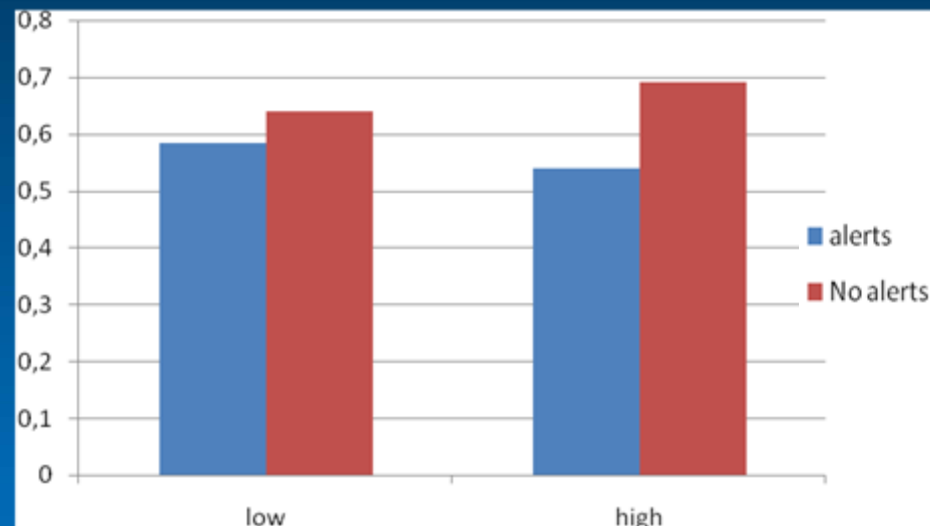
SAGAT score with alerts and workload conditions

	With Alerts	Without Alerts
Mean	0,538571	0,691429
Variance	0,017275	0,022552
occurrences	14	14
Variance group	0,019913	
Hypothesis	0	
df	26	
Stat t	-2,86592	
P(T<=t) one-sided	0,004064	
t critical one-sided	1,705618	
P(T<=t) two-sided	0,008129	
t critical two-sided	2,055529	

T-test: high workload

	With Alerts	Without Alerts
Mean	0,584286	0,638571
Variance	0,019749	0,033813
Occurrences	14	14
Variance group	0,026781	
Hypothesis	0	
df	26	
Stat t	-0,87764	
P(T<=t) one-sided	0,194087	
t critical one-sided	1,705618	
P(T<=t) two-sided	0,388175	
t critical two-sided	2,055529	

T-test: low workload

Experiment: results

Demographic Questionnaire

	A with alerts	B with alerts	A without alerts	B without alerts	Total	age	Term of service
military 2	-	12,6	20,88	-	34,875	41	23
military 4	-	11,4	10,08	-	22,375	44	24
military 6	-	13,56	19,8	-	34,75	43	19
military 8	-	7,92	10,8	-	19,5	37	19
military 10	-	12,24	18,48	-	32	40	20
military 12	-	19,32	15,48	-	36,25	34	-
military 14	-	14,64	18,48	-	34,5	32	9
military 15	-	15	17,4	-	33,75	38	18
military 3	7,08	-	-	3,96	11,75	46	-
military 9	11,28	-	-	14,4	26,75	37	18
military 7	11,4	-	-	11,52	23,875	36	17
military 5	12,96	-	-	13,56	27,625	41	19
military 11	13,92	-	-	17,04	32,25	35	12
military 1	15	-	-	15,36	31,625	30	9,5
military 13	17,4	-	-	20,16	39,125	33	15

Experiment: results

- The results indicated that alerts did not affect SA as a whole, but under high workload conditions these alerts decreased the SA.

- Alerts sometimes confuse the monitoring of the situation and distract the operator. Once an alert appears, the operator concentrate on it and temporarily loses the overview.

- Curiously, most of the operators reported that the alerts system influenced their performance in a positive way.

Conclusion

- The results suggest that automated alerting systems diminish the SA in high levels of workload.

- This result should not necessarily be interpreted as a suggestion of not using alerts, rather than, attention should be given to the relationship between workload and the use of alerts in order to not disturbing agility.