A silhouette of a soldier in a field of viewfinder, set against a hazy, sunset-like background. The soldier is wearing a helmet and has a rifle slung over their shoulder. The scene is captured from a first-person perspective, looking through the viewfinder of a rifle. The background is a soft, warm glow of orange and yellow, suggesting a sunrise or sunset. The soldier's silhouette is dark and detailed, showing the helmet, the rifle, and the soldier's posture. The overall mood is one of focus and readiness in a natural, outdoor setting.

Developing Situation Awareness in Teams of Leaders

Cheryl A Bolstad, Ph.D.
SA Technologies, Inc.

*Presentation to the 4th Annual Army Operational
Knowledge Management (AOKM) Conference*

Challenge of the Information Age



Overcoming the **Information Gap** to
Develop an Understanding of the
Information Available

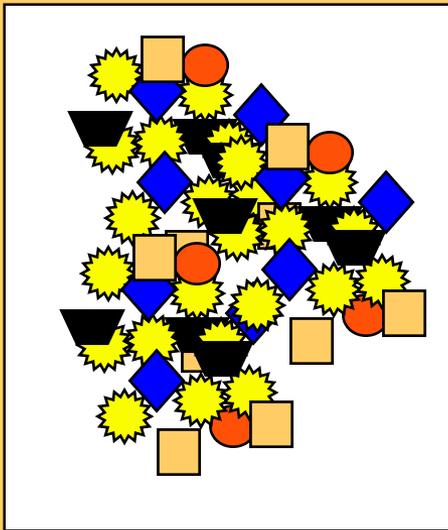


Support Situation Awareness

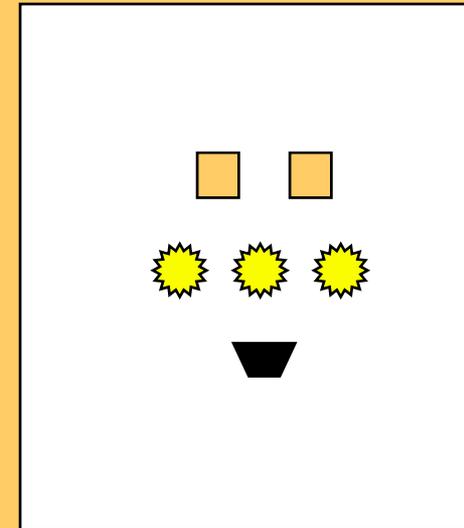


Information Gap

Data Produced

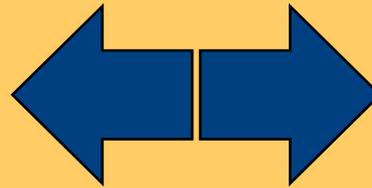


Information Needed



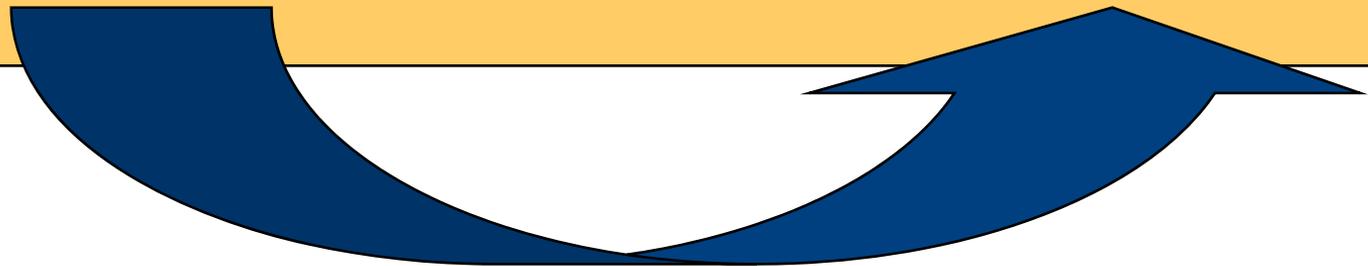
Sort

Find



Integrate

Process





SA is Critical to Decision Making



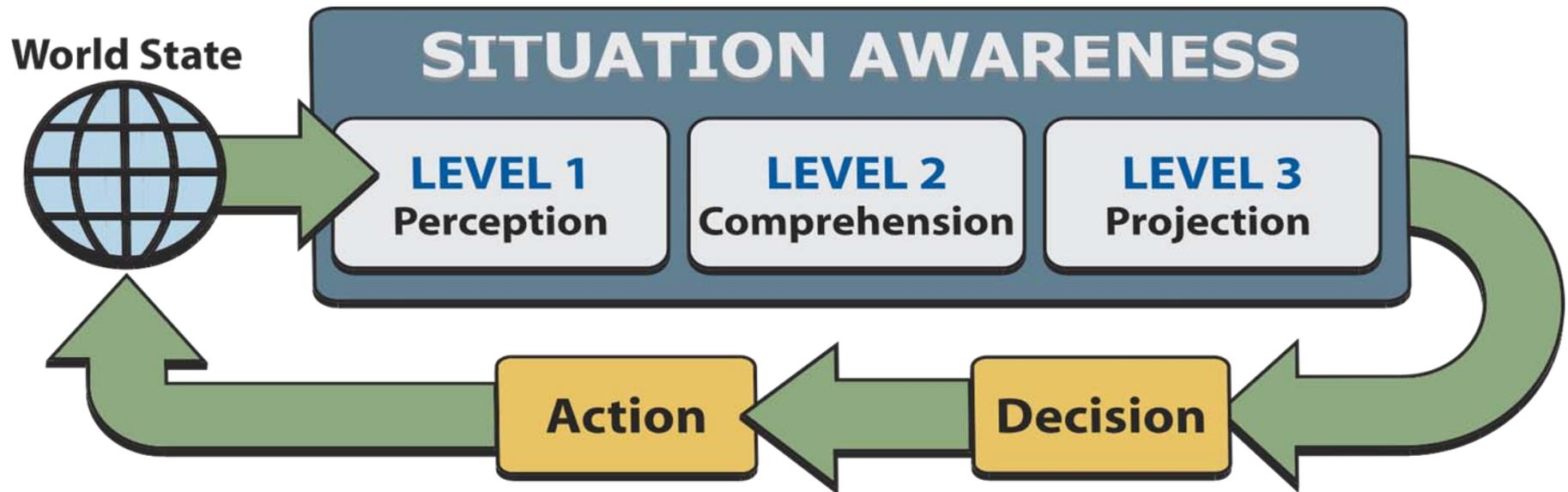
SA is the most challenging portion of human performance in many different complex domains



- Aviation
- ATC
- Naval Operations
- Power T&D
- Driving
- Military Operations
- Advanced Manufacturing
- Space
- Medicine
- Education



What is Situation Awareness?



Situation Awareness is the *Perception* of elements in the environment within a volume of time and space, the *Comprehension* of their meaning, and the *Projection* of their status in the near future.*

*Endsley, 1988

Lack of SA Is Pervasive



SA is the most challenging portion of human performance

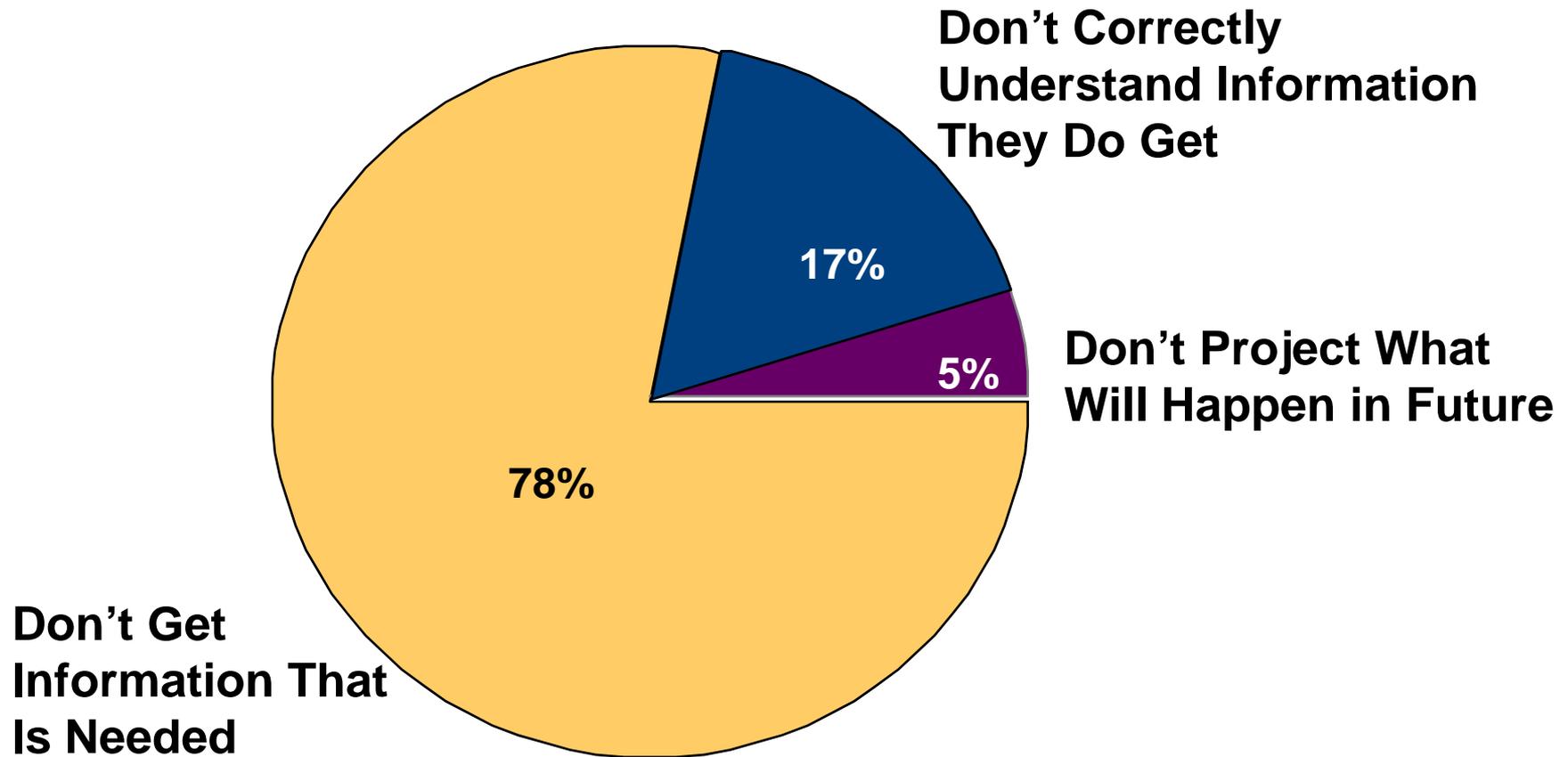
SA is a key step in decision making & human performance

– 88% of human error found to be due to SA problems

Development of SA takes up the majority of decision-makers time and effort



What Kinds of SA Problems Do People Have?



What Makes Some People Better at SA?

Abilities

- Spatial
- Attention
- Memory
- Perceptual
- Cognitive

Knowledge

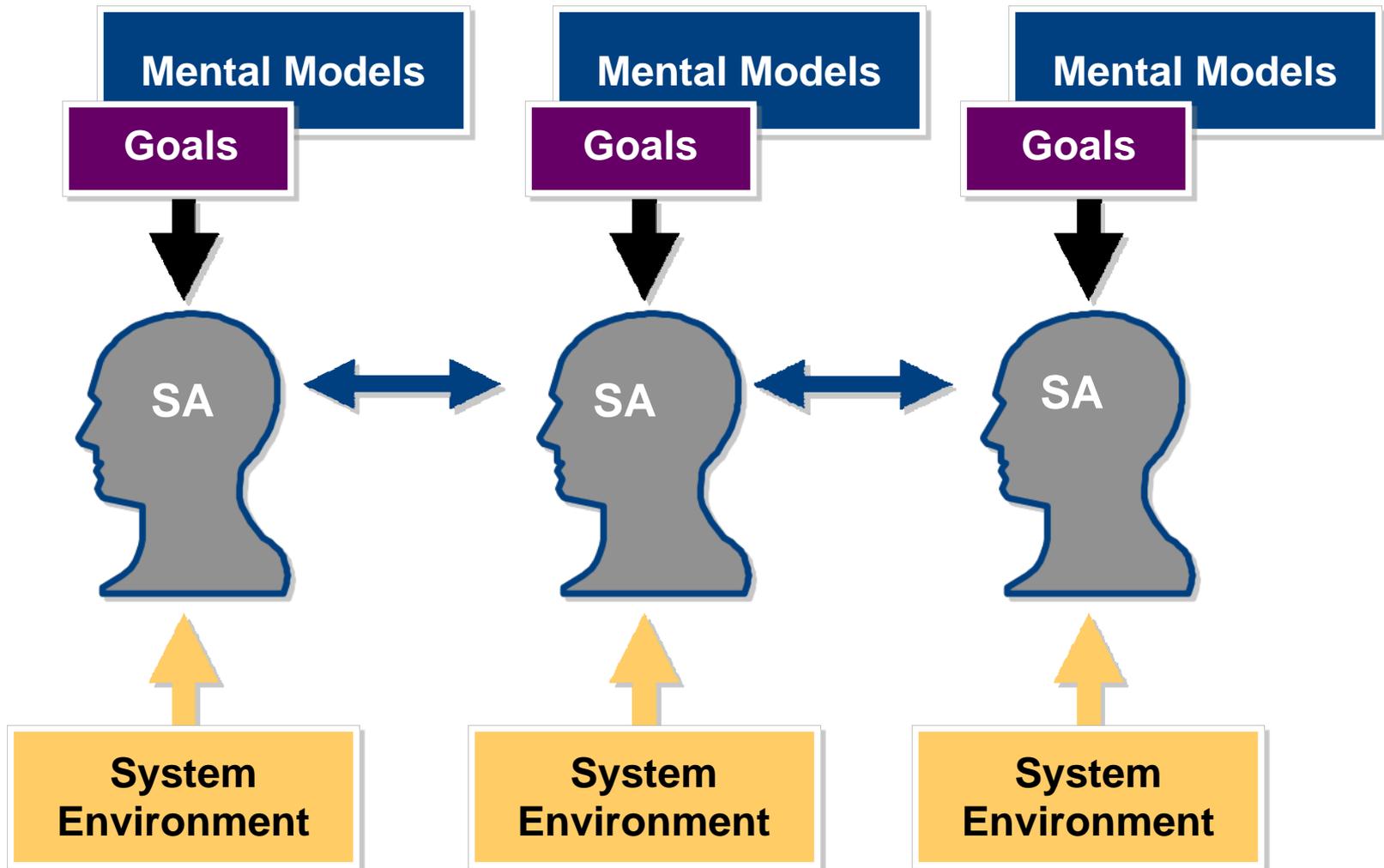
- Mental Models
 - schema
 - critical cues
- Goals
- Preconceptions & Objectives

Skills

- Information Management
- Communications
- System operations
- Scan patterns

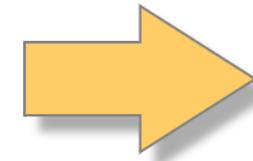
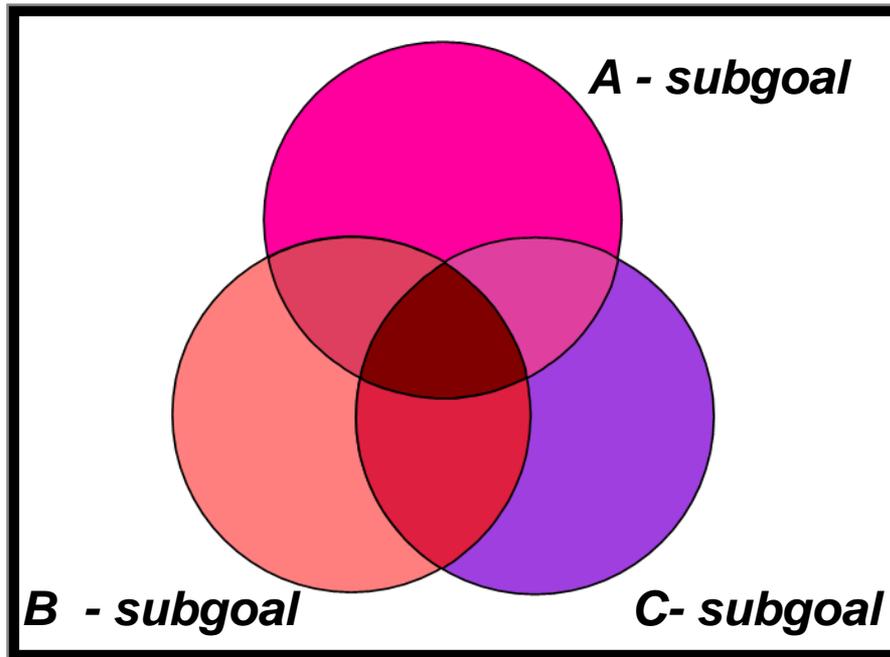
***Ten fold difference in SA
In experienced pilots***

Individual SA vs Team SA



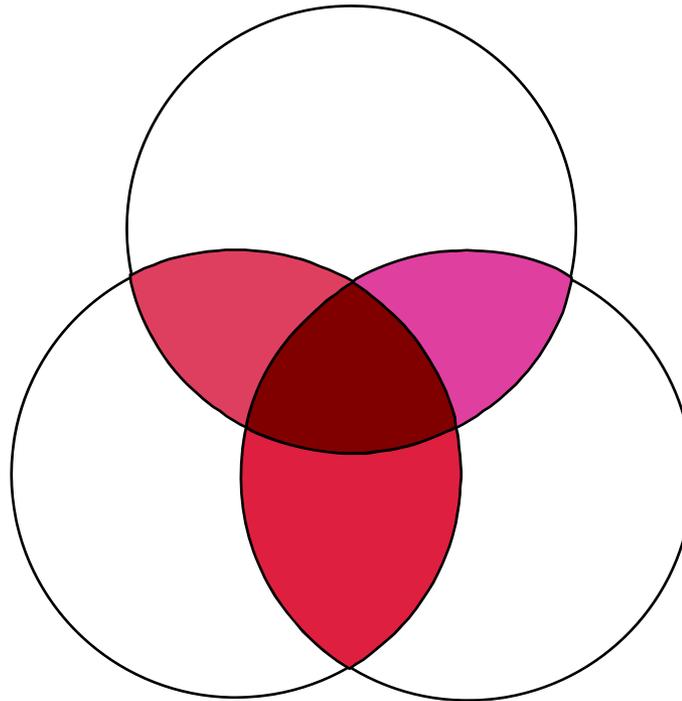
The Army is a Team





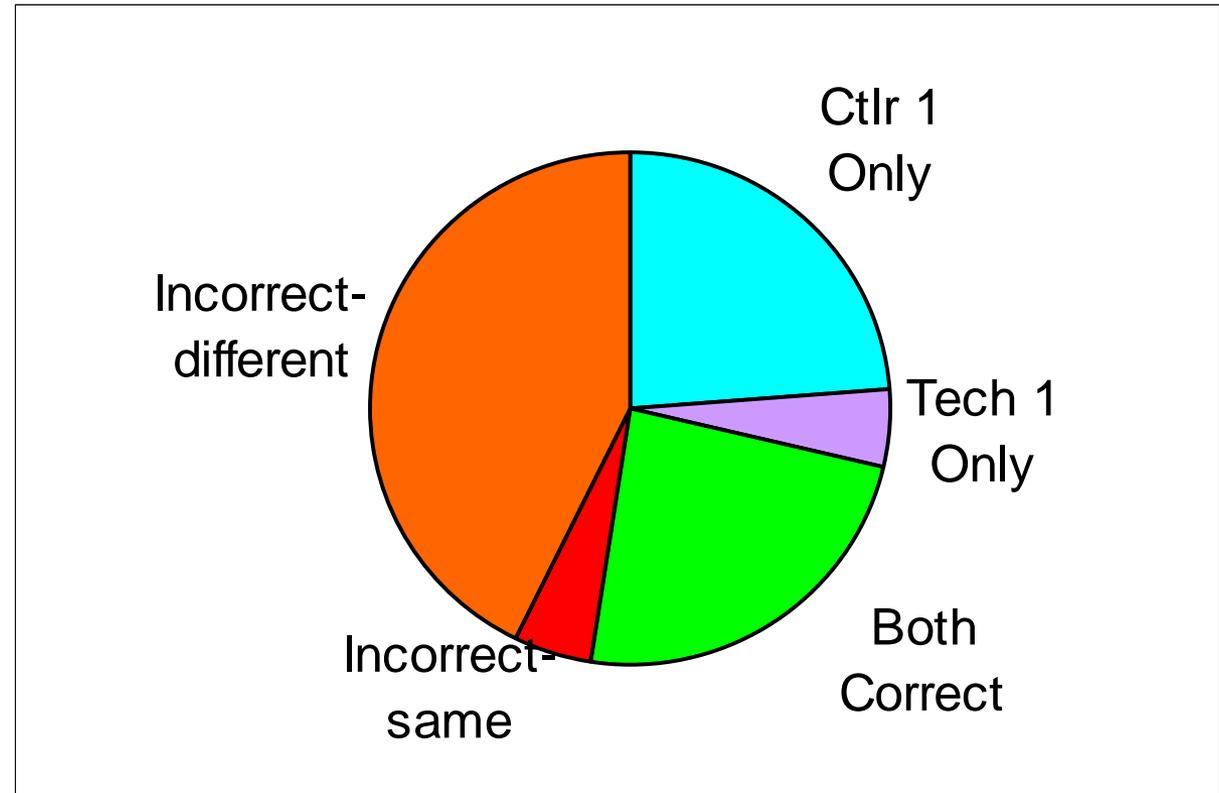
**TEAM
GOAL**

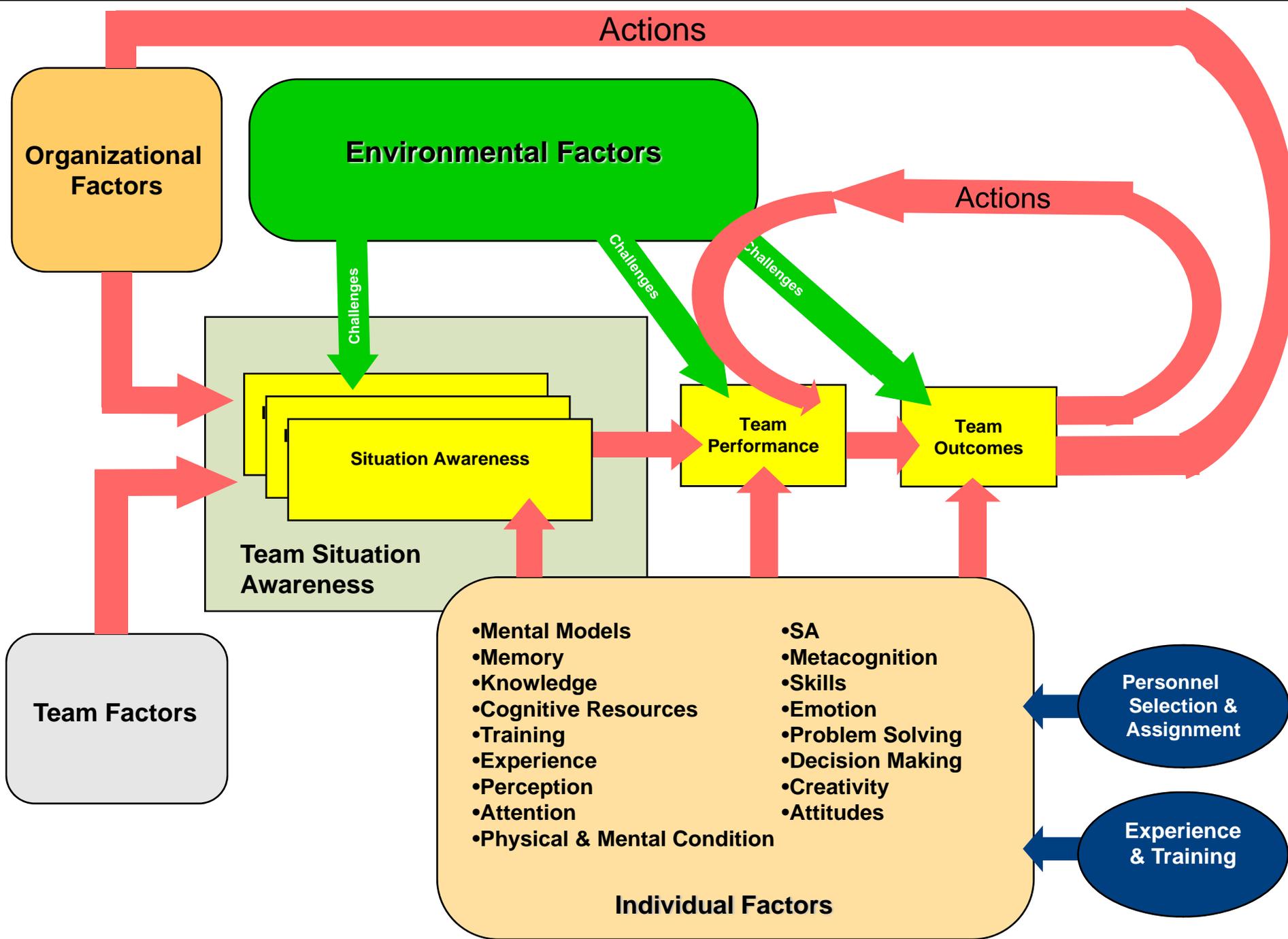
The Degree to Which Every Team Member Possesses the SA Required for his/her Job



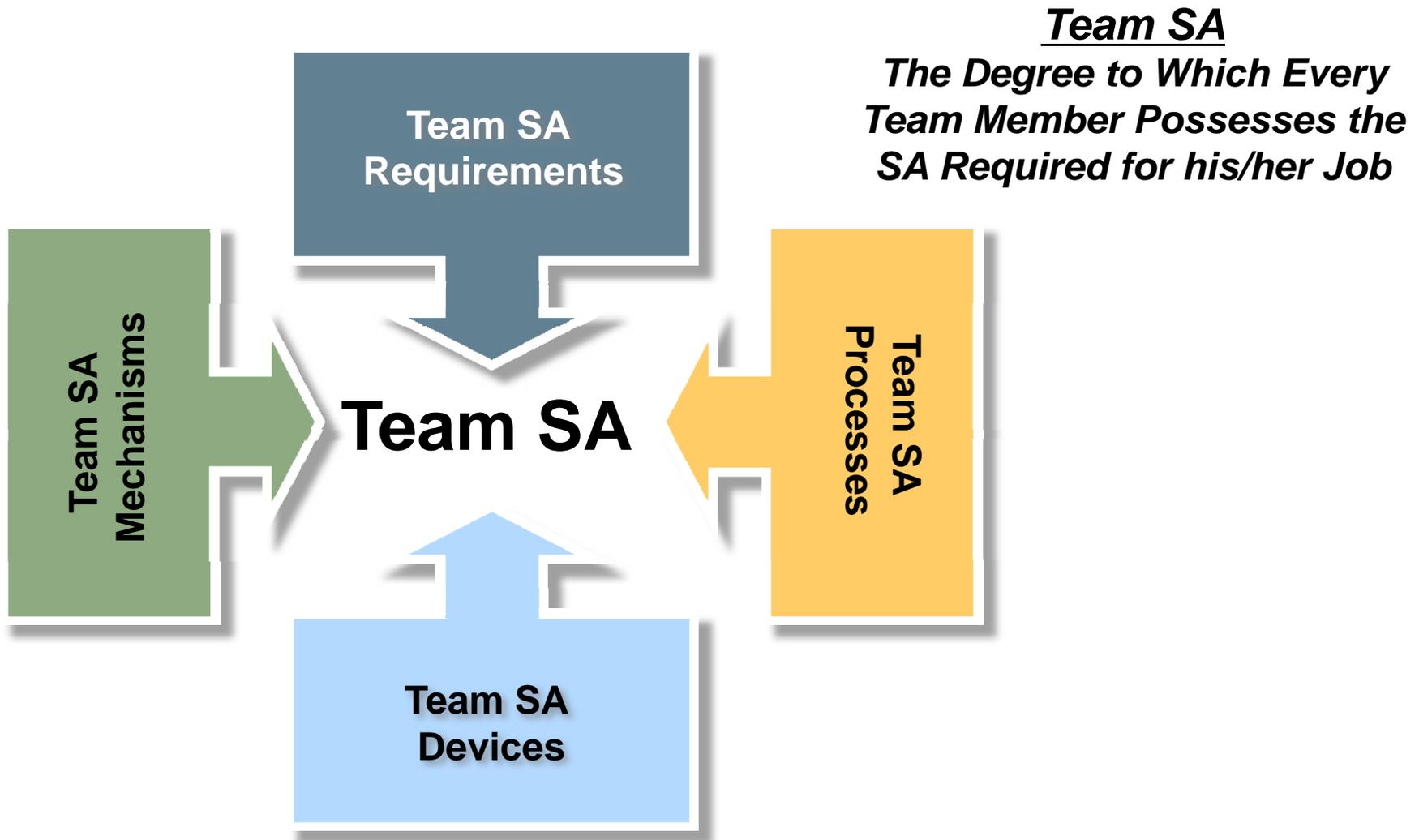
**The Degree to Which Team Members Possess
the Same SA on Shared SA Requirements**

Degree of Shared SA can be established as well as types of breakdowns in Shared SA

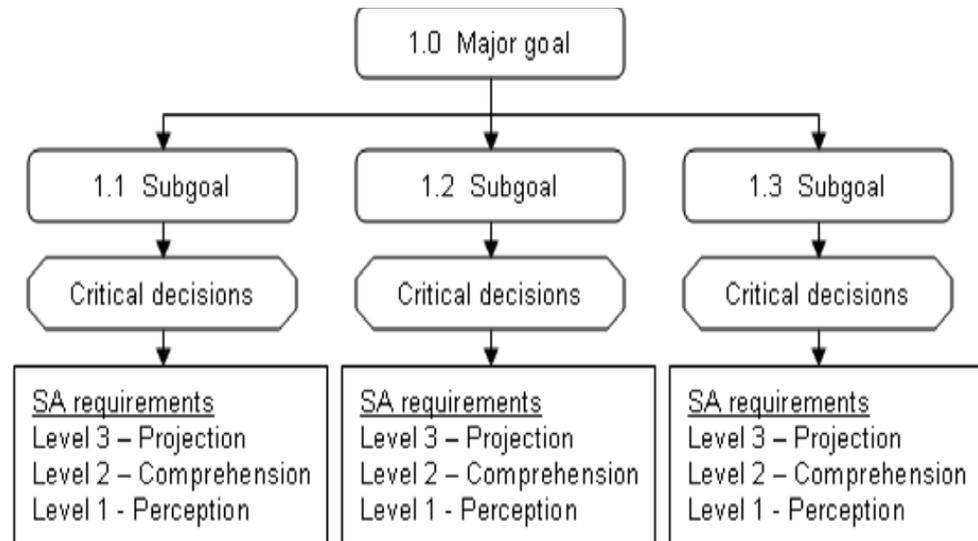




Factors affecting team situation awareness



- **What needs to be shared –> SA Requirements**
- **SA Requirements created from a GDTA**
- **Goal Directed Cognitive Task Analysis (GDTA)**
 - Establish major goals & subgoals
 - Determine major decisions needed to meet each goal/subgoal
 - Identify dynamic information needs associated with each decision & subgoal

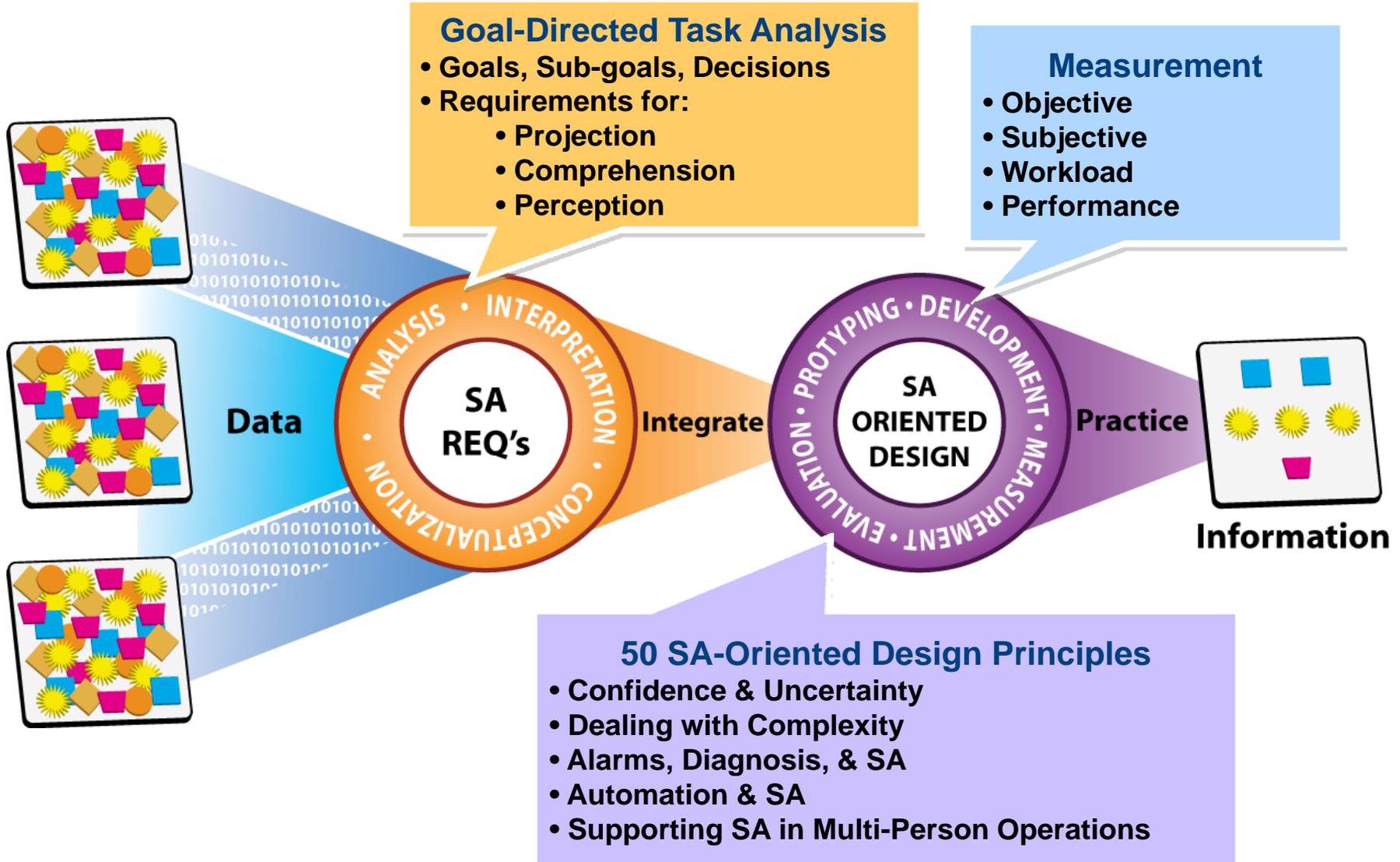


Enemy Requirements

Intelligence Officer (S2)	Logistics Officer (S4)
<p>Level 1</p> <p>Enemy</p> <ul style="list-style-type: none"> • Anticipated Actions <ul style="list-style-type: none"> • Enemy intent • Enemy objective • Likely location • Current Activities <ul style="list-style-type: none"> • Location • Time of activity • Assets <ul style="list-style-type: none"> • Location • Number by location • Type (e.g. ground and air to ground) • Coverage • Composition <ul style="list-style-type: none"> • Organization Structure • Leadership • Unit type • Equipment • Transmission types • Weaponry • Experience Level • Morale/Commitment • Vehicle • Capabilities/skills/training • Pattern of Movements <ul style="list-style-type: none"> • Movement of weapons • Enemy center of gravity • Disposition <ul style="list-style-type: none"> • Dispersion • Numbers • Weapons • Ammo/supplies • Objective • Doctrines • Recent activities • Location of: <ul style="list-style-type: none"> • Weapon systems • Location of Ammo/supplies • Troops • Enemy assets • Enemy commander • Enemy's cache • Water 	<p>Level 1</p> <p>Enemy</p> <ul style="list-style-type: none"> • Number • Type • Proximity

Intelligence Officer S2	Operations Officer S3	Logistics Officer S4	Engineer
Level 2 Terrain			
<ul style="list-style-type: none"> • Enemy limitations/advantages due to terrain • Friendly limitations/advantages due to terrain • Effect of terrain on enemy and friendly assets • Effect of terrain on anticipated troop movement time • Effect of terrain on system detection capability 	<ul style="list-style-type: none"> • Accessibility of routes • Effect of terrain on movement times/time to position troops • Effect of terrain on rate of enemy closure • Effect of terrain on visual capabilities • Effect of terrain on communication capabilities • Effect of terrain on route difficulty 	<ul style="list-style-type: none"> • Suitability of land for unit • Effect of terrain on ability to access location with each vehicle type • Effect of terrain on type of vehicles to be supported 	<ul style="list-style-type: none"> • Potential approaches and exiting areas • Potential staging areas • Potential terrain suppression areas • Traffic ability • Visibility of the locations • Critical obstacle information • Past enemy usage of obstacles • Effect of terrain on location of enemy counter attacks.
Level 3 Terrain			
<ul style="list-style-type: none"> • Predicted effects of terrain on enemy COAs ▪ Projected effects of terrain on friendly COAs ▪ Projected terrain • Projected effect of terrain on troop movements 	<ul style="list-style-type: none"> • Predicted effects of terrain on enemy COAs 	<ul style="list-style-type: none"> • Projected effect of terrain on usage rates per item per unit • Projected effect of terrain on security of resources 	<ul style="list-style-type: none"> • Estimated obstacle effectiveness • Predicted most secure location for assets, soldiers, vehicles • Predicted most survivable routes

SA-Oriented Design





- **Provide SA — not Data**
 - focus on integrated system
 - integrate according to goals
 - higher levels of SA
- **Take into Account Limitations of Attention, Sampling, Stressors**
 - beware of tradeoffs
- **Support Global SA**
 - detailed information for specific goals on demand
- **Trigger Critical Cues to Activate “Situation Classification”**
 - information salience
- **Reduce Extraneous Data**
- **Support Parallel Processing**

Synergy – Main Map



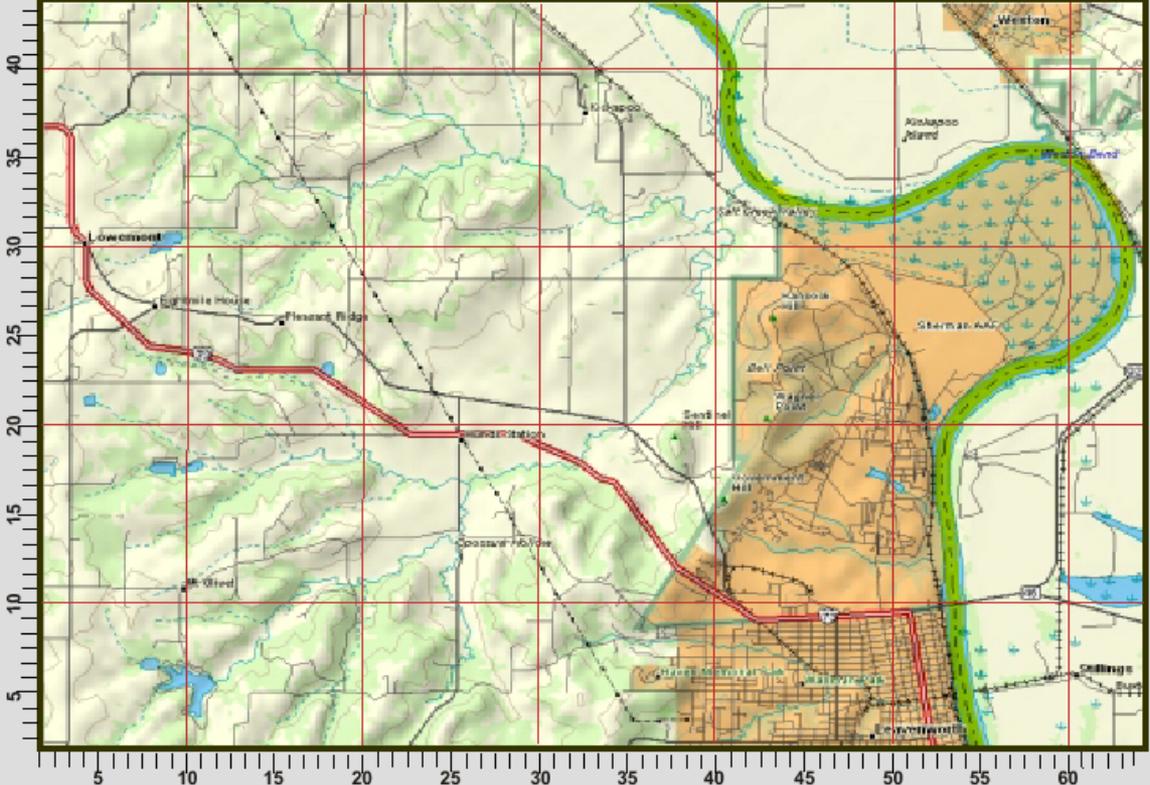
Zoom Out Zoom In

100,000 50,000 25,000

Grid Zone 100,000M 10,000M 1,000M

16S GL 08 35

Center Return to Previous



↑ Unit	Ruler	Create Route	Add Supply Points
↓ Unit	Tools	Compare Routes	

Friendly	Enemy	Others	COA	AOI	Weather	Supply
Contours	Hydrology	Vegetation	Structures	Roads	Boundaries	Comm
History Trace	Sensor Coverage	Visibility	Weapons	Trafficability	Status	

Synergy – Logistic (CASCOM)

Synergy - 3/2/04

Back EVENT 2 - Hour 18 Ahead

Information

- IST UA HQ, HHC
- IST UE, ADA BTRY, HQ AND MTR M
- IST UE, ADA BTRY, SENSOR PLT
- IST UA HQ, MBL CMD GRP 2
- IST UA, BIC CO, PLUG
- IST UA, 3RD CA BN HQ, HHC
- IST UA HQ, MBL CMD GRP 1
- IST UA, 1ST CA BN HQ, HHC**
- IST UA, 1ST CA BN HQ, MOB CM
- IST UA, 1ST CA BN, NLOS MTR B
- IST UA, 1ST CA BN, RECCE HQ
- IST UA, 1ST CA BN, MCS A, HQ
- IST UA, 1ST CA BN, MCS B, HQ
- IST UA, 1ST CA BN HQ, TACP
- IST UA, 1ST CA BN, INF C, HQ
- IST UA, 1ST CA BN HQ, SPT SEC
- IST UA, 1ST CA BN, INF D, HQ
- IST UA, 1ST CA BN HQ, MED PLT
- IST UA, FSB MAINT CO, IST MAI
- IST UA, FSB MED CO, EVAC PLT.
- IST UA, 2ND CA BN HQ, HHC
- IST UE, DIVARTY, HIMARS BN, B B'
- IST UA, FSB HQ, HHC
- IST UA HQ, MEDICAL SPT SEC
- IST UA, BIC CO HQ, HHC (-)
- IST UA, AYN SQDRN HQ, HHT
- IST UA, NLOS BN HQ, HHC
- IST UA HQ, TACP
- IST UE, MCM ENGR CBT MOB PLT

Units	Troops	Equipment	Ammo	Fuel	Mission
IST UA, 1ST CA BN HQ, HHC 80.39%	100%	100%	99.37% 795 CTG, 25MM	80.39% 40 Gallons of JP 1 Gallons of PAC	OFFENSIVE COM
IST UA, 1ST CA BN HQ, MOB CMD GRP 35.69%	100%	100%	97.12% 385 CTG, 40MM 392 CTG, 25MM	35.69% 92 Gallons of JP 2 Gallons of PAC	OFFENSIVE COM
IST UA, 1ST CA BN, NLOS MTR BTRY HQ 20.38%	100%	100%	99.58% 1195 CTG, 25MM	20.38% 41 Gallons of JP 1 Gallons of PAC	OFFENSIVE COM
IST UA, 1ST CA BN, RECCE HQ 29.64%	95.23% 1 Dead or Wound	100%	79.76% 1914 CTG, 25MM 2 JAVELIN MISS	29.64% 248 Gallons of JI 4 Gallons of PAC	OFFENSIVE COM
IST UA, 1ST CA BN, MCS A, HQ 28.52%	100%	100%	96.19% 37 CTG, 120MM I 773 CTG, 25MM	28.52% 85 Gallons of JP 0 Gallons of PAC	OFFENSIVE COM
IST UA, 1ST CA BN, MCS B, HQ 26.17%	100%	100%	95.13% 34 CTG, 120MM I 767 CTG, 25MM	26.17% 75 Gallons of JP 3 Gallons of PAC	OFFENSIVE COM
IST UA, 1ST CA BN HQ, TACP 22.14%	100%	100%	98.55% 1971 CTG, 25MM	22.14% 94 Gallons of JP 5 Gallons of PAC	OFFENSIVE COM
IST UA, 1ST CA BN HQ, TACP 32.55%	100%	100%	97.83%	32.55%	OFFENSIVE COM

- **The method by which a team shares SA information.**
 - **Communication**
 - **Shared Display**
 - **Shared Environment**

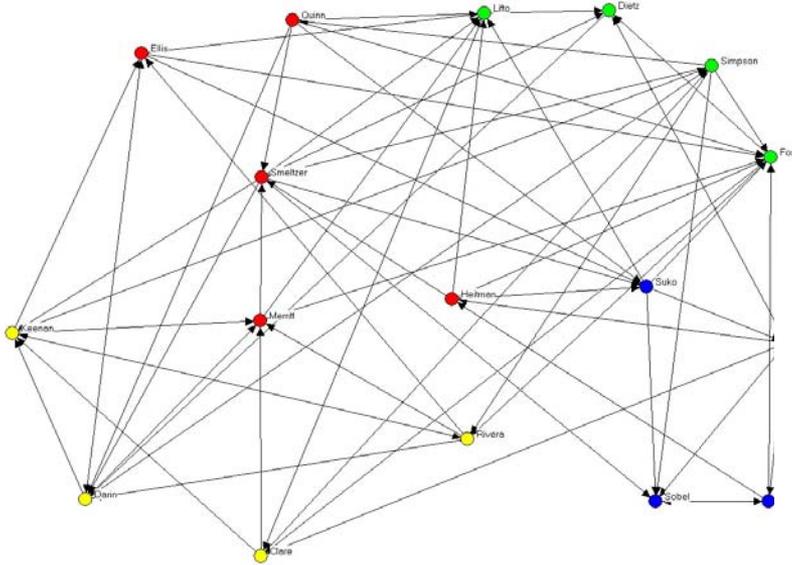


Joint Personnel Recovery Agency (JPRA)

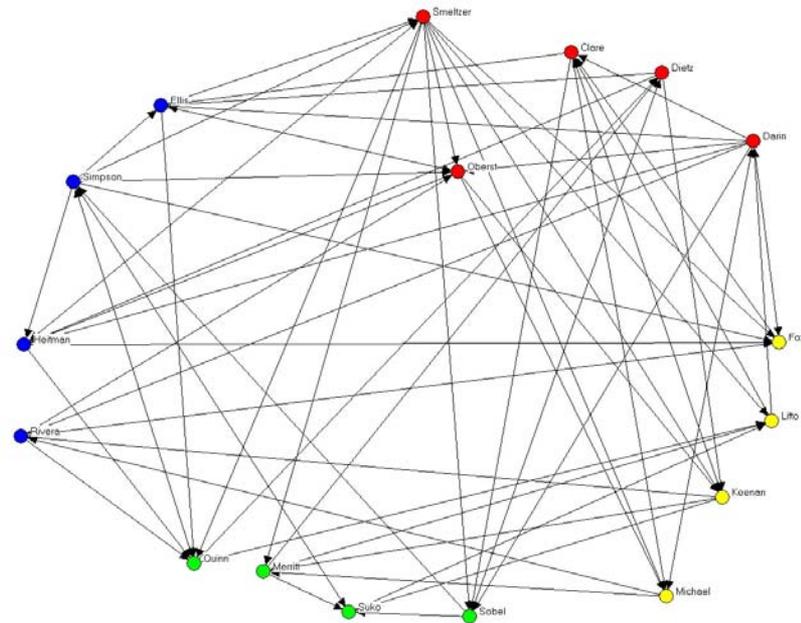
- **JPRA Responsible for Personnel recovery, such as Prisoners of War**
- **Does the exercise improve SA?**
- **Does the exercise improve performance?**



PRETC: Shared Environment and Shared Communication

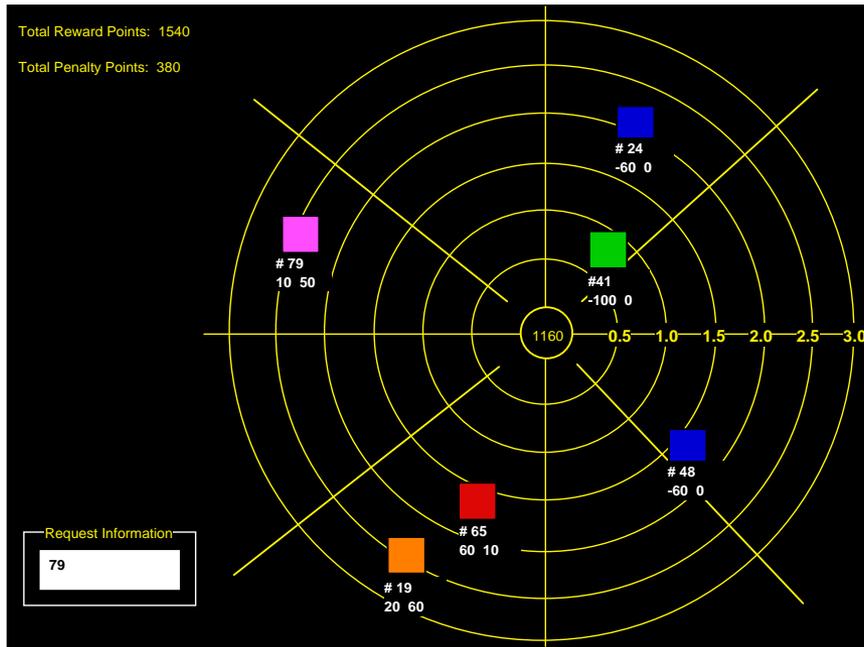


Scenario 1



Scenario 4

Theatre Defense



Air Commander

Target Information					Target Feedback			
View Information	Target Number	Source A	Source B	Source C	Target Number	Classified As	Actual Type	Results
1	41				79	Mig-29		
2	24	F-16	F-16	F-16	101	Tu-22M	Tu-168	Destroyed
3	48				84	B-52		Expired
4	65				32	F-15E	F-15E	Expired
5	19				7	C-21	C-21	Expired
6					97	Su-37	Su-37	Destroyed
7								
8								
9								

Fighters	Bombers	Transports
<input type="radio"/> F-15E	<input type="radio"/> B-52	<input type="radio"/> C-130J
<input type="radio"/> F/A-18	<input type="radio"/> B-1	<input type="radio"/> C-21
<input checked="" type="radio"/> F-16	<input type="radio"/> B-2	<input type="radio"/> KC-135
<input type="radio"/> Su-35	<input type="radio"/> Tu-22M	<input type="radio"/> An-124
<input type="radio"/> Su-37	<input type="radio"/> Tu-168	<input type="radio"/> An-225
<input type="radio"/> Mig-29		

Send Information

Requested Information: 79 41 24

Intelligence Officer

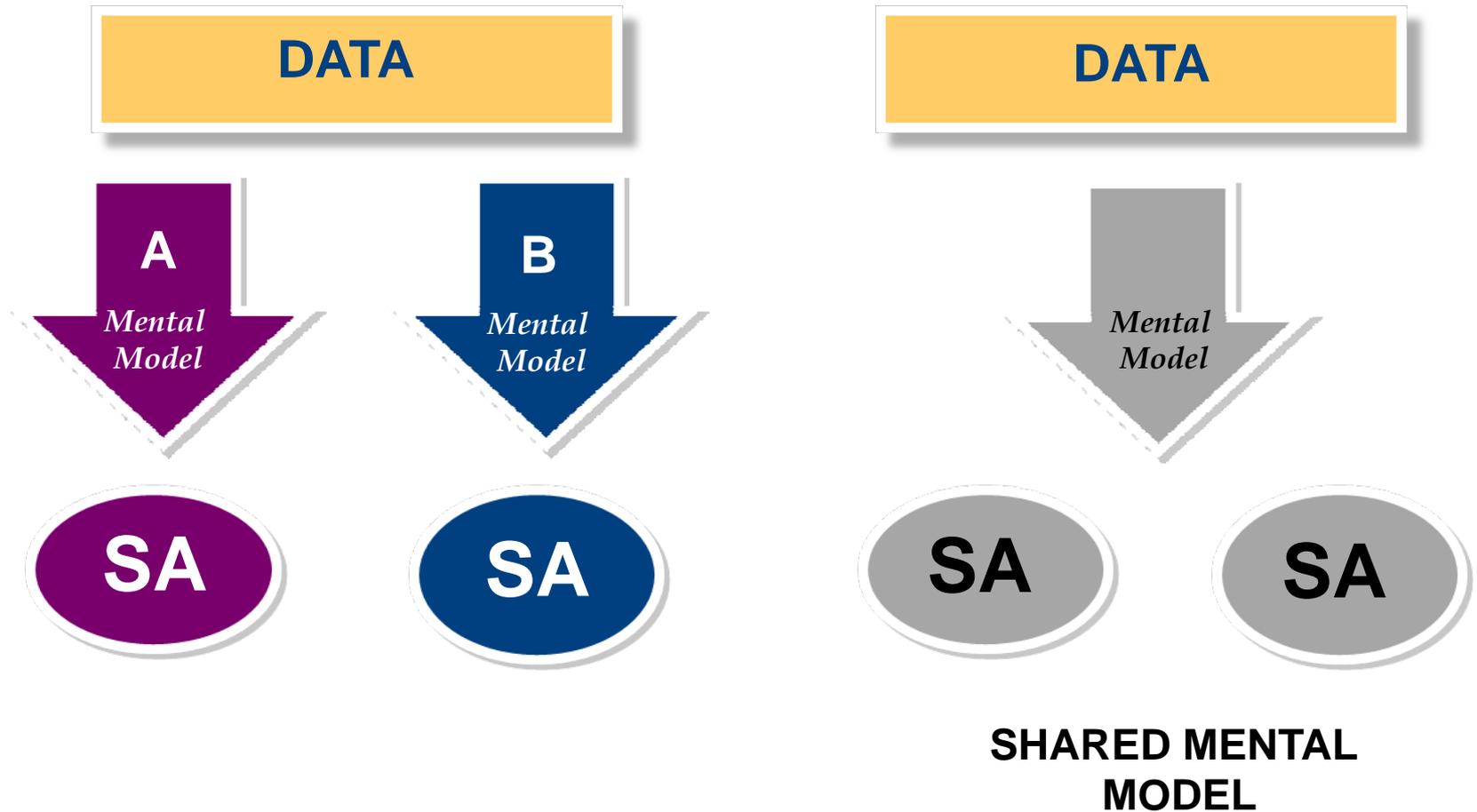
Collaboration Tools

Tool Category	Collaboration Characteristics				Tool Characteristics			Information Types						Processes							
	Time	Predictability	Place	Interaction	Recordable /Traceable	Identifiable	Structured	Verbal	Textual	Spatial/ Graphical	Emotional	Photo- graphic	Video	Planning	Scheduling	Tracking	Brainstorm ing	Document Creation	Data Gathering	Data Distribution	Shared SA
Face-to-Face	Synchronous	Scheduled or Unscheduled	Collocated	High	No	High	Unstructured	Good	Good	Good	High	Good	Good	Good	Good	Moderate	Good	Moderate	Moderate	Moderate	Medium- High
Video Conferencing	Med-High synchronicity	Scheduled or Semi-scheduled	Distributed	Medium-High	Possible	Moderate	Unstructured	Good	None	Poor	Good	Poor	Good	Moderate	Decentralized Small N	Limited	Limited	Poor	Limited	Good	Medium- High
Audio Conferencing	Med-High synchronicity	Scheduled or Semi-scheduled	Distributed	Medium-High	Possible	Poor	Unstructured	Good	None	None	Moderate	None	None	Moderate	Decentralized Small N	Limited	Limited	Poor	Limited	Good	Medium- High
Telephone	Med-High synchronicity	Unscheduled	Distributed	Medium-High	Possible	Good	Unstructured	Good	None	None	Moderate	None	None	Moderate	Good	Limited	Limited	Poor	Limited	Good	Medium- High
Net Radio	Med-High synchronicity	Unscheduled	Distributed	Medium-High	No	Poor	Unstructured	Good	None	None	Moderate	None	None	Moderate	Decentralized Small N	Limited	Limited	Poor	Limited	Good	Medium- High
Chat/Instant Messaging	Med-High synchronicity	Semi-scheduled or Unscheduled	Distributed	Medium-High	Moderate	Good	Unstructured	None	Good	None	Poor	None	None	Poor	Decentralized Small N	Limited	Poor	Poor	Limited	Moderate	Moderate y-Low
White Board	Synchronous or Asynchronous	Scheduled or Unscheduled	Distributed or Collocated	Moderate	Moderate	Moderate or Good	Unstructured	None	Moderate	Good	Poor	Good	None	Moderate	Decentralized Small to Medium N	Moderate	Limited	Moderate (non-text)	Limited	Moderate	Moderate
File Transfer	Asynchronous	Unscheduled	Distributed or Collocated	Low	Good	??	Unstructured or Structured	None	Good	Good	None	Good	Moderate (Pre- recorded)	Poor	Centralized & Decentralized, Small to Medium N	Limited	Poor	Good	Moderate	Moderately Good	Moderate
Program Sharing	Synchronous	Scheduled	Distributed or Collocated	Moderate	Possible	??	Unstructured or Structured	None	Good (if program supports)	Good (if program supports)	Poor	Good (if program supports)	Moderate (Pre- recorded)	Moderate	Centralized & Decentralized, Small to Medium N	Moderate	??	??	Low	Low	Low
Email	Asynchronous	Unscheduled	Distributed or Collocated	Moderate- Low	Good	Good	Semi- structured	None	Good	None	Poor	None	None	Low	Moderate	Limited	Poor	Moderate	Low	Moderately Good	Moderate y-Low
Groupware	Synchronous or Asynchronous	Scheduled or Semi-scheduled	Distributed or Collocated	Moderate	Good	Yes or No	Semi- structured	None	Good	None	Poor	None	None	Poor	Poor	None	Moderate	Moderate	Moderate	Low	Low
Bulletin Board	Asynchronous	Unscheduled	Distributed	Moderate	Good	Yes or No	Semi- structured	None	Good	None	Poor	None	None	Poor	Poor	None	Moderate	Moderate	Moderate	Low	Low
Domain Specific Tools	Synchronous or Asynchronous	Scheduled or Unscheduled	Distributed or Collocated	Low	Low	Poor	Structured	Poor	Good (if program supports)	Good (if program supports)	Poor	Good (if program supports)	Good (if program supports)	High	High	High	Limited	Limited	High	High	High

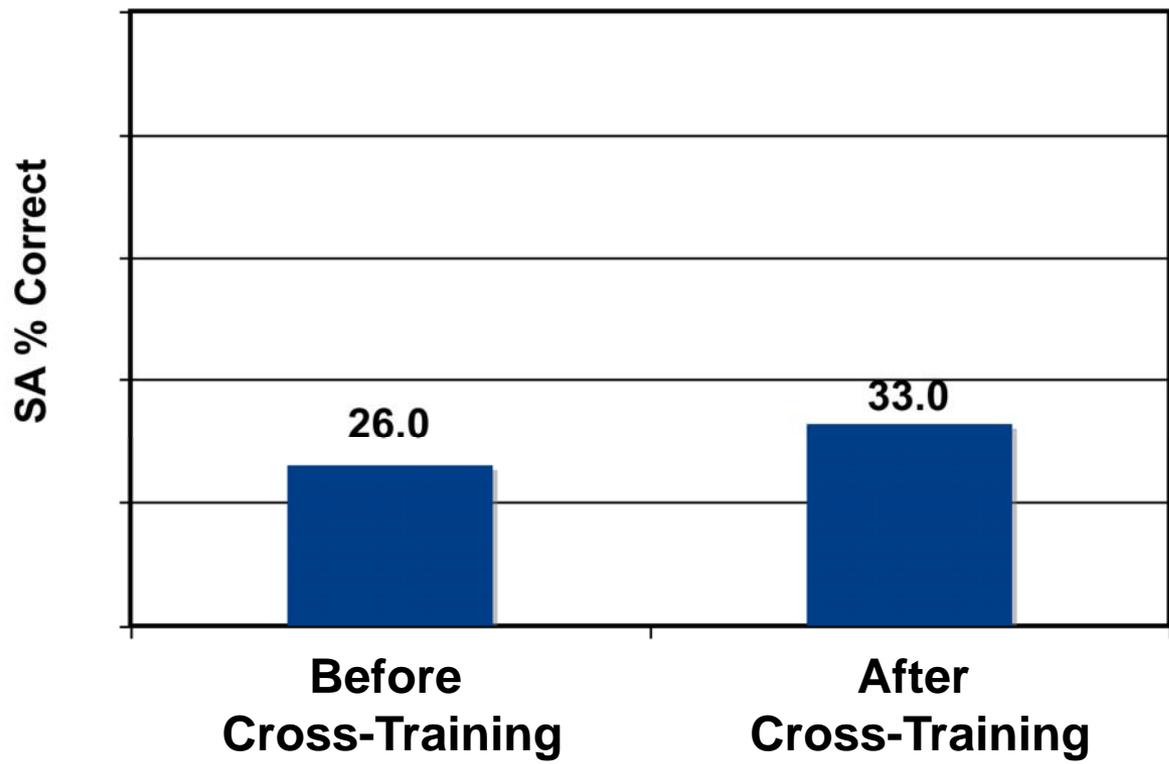
The Right Tool for the Job

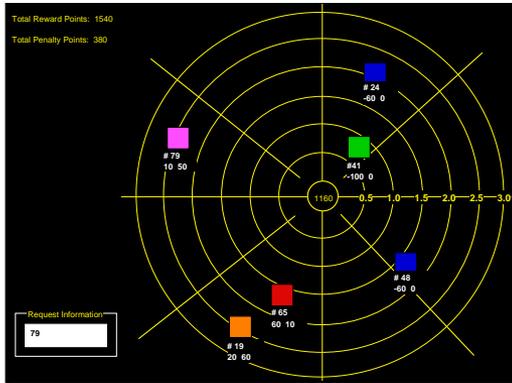
- **Internal Mechanism for facilitating development of shared SA**
 - **Shared Mental Model (developed via)**
 - » Shared Experience (Familiarity)
 - » Shared Training and Cross-Training
 - » Communication





Cell Directors





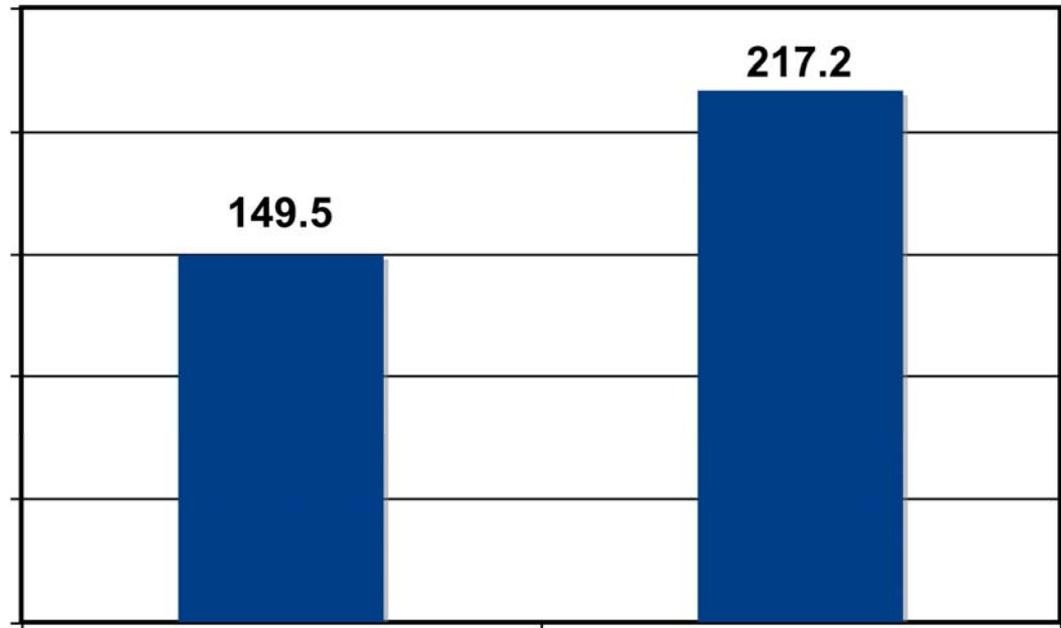
Target Information				Target Feedback				
View	Target Number	Source A	Source B	Source C	Target Number	Destroyed	Actual Type	Results
1	41				79	Mg-29		
2	24	F-16	F-16	F-16	101	Tu-22M	Tu-168	Destroyed
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6					97	Su-37	Su-37	Destroyed
7								
8								
9								
5								

Fighters			Bombers			Transports		
<input type="checkbox"/> F-15E	<input type="checkbox"/> B-52	<input type="checkbox"/> C-130J						
<input type="checkbox"/> F/A-18	<input type="checkbox"/> B-1	<input type="checkbox"/> C-21						
<input type="checkbox"/> F-16	<input type="checkbox"/> B-2	<input type="checkbox"/> KC-135						
<input type="checkbox"/> Su-35	<input type="checkbox"/> Tu-22M	<input type="checkbox"/> An-124						
<input type="checkbox"/> Su-37	<input type="checkbox"/> Tu-160	<input type="checkbox"/> An-225						
<input type="checkbox"/> Mg-29								

Requested Information: 79 41 24

Team Performance

Average Penalty Points



Shared
Mental Model

Non-Shared
Mental Model

- **Team Processes and behaviors that impact a team's ability to develop SA**
 - **Group processes affected by:**
 - » Environment
 - » Organization
 - » Social context
 - **Effective behaviors such as team contingency planning, shared problem understanding --> Shared Mental Models**
 - **Ineffective behaviors such as 'group think', reluctance to share information**

In-Effective

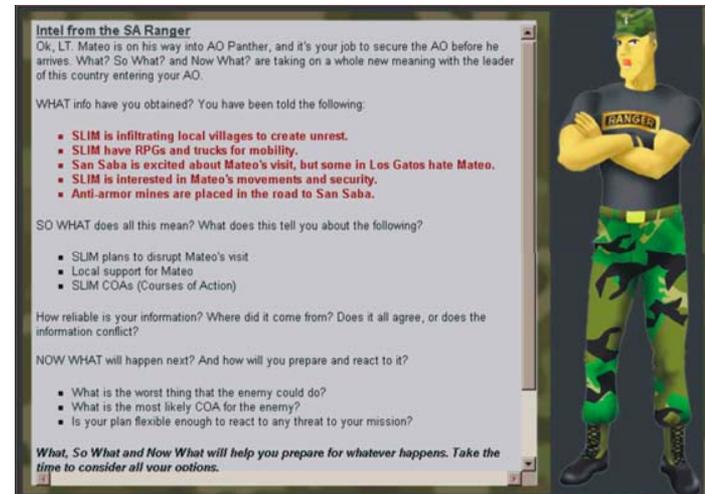
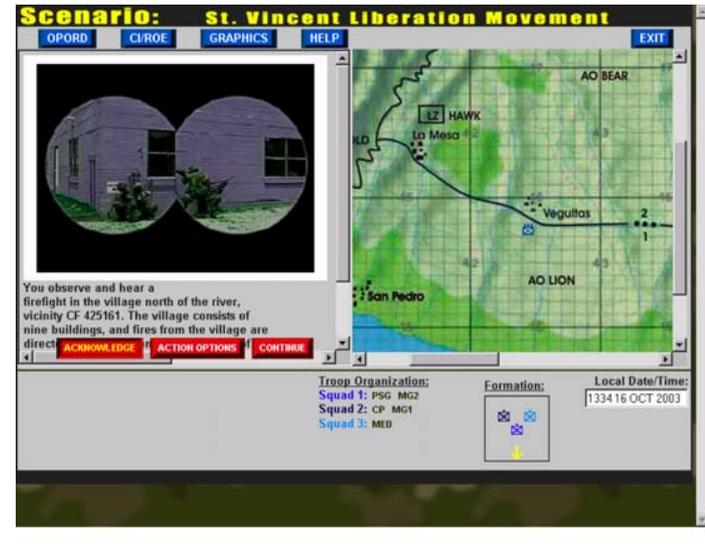
- **SA Blackhole**
 - one member would lead others off
- **Didn't Share Pertinent Info**
 - group norm
- **Failure to Prioritize**
 - members went in own directions
 - lost track of main goal
- **Relied on Expectations**
 - unprepared to deal with false expectations

Effective

- **Self-checking**
 - checked against others at each step
- **Coordinated**
 - to get information from each other
- **Prioritized**
 - set-up contingencies
 - re-joining
- **Questioning**
 - as a group

(Taylor, Endsley & Henderson, 1996)

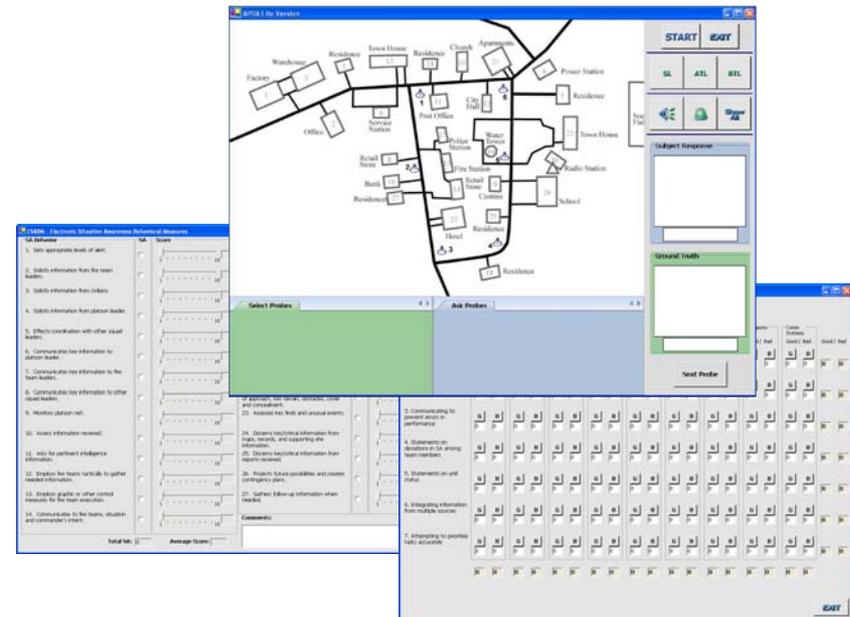
- **Infantry SA Trainer (ISAT)**
 - **Time Management**
 - **Task Prioritization**
 - **Schema**
 - **Contingency Planning**
 - **Communications**



VESARS (Situation Awareness in Virtual Reality)

Army Research Institute - Orlando

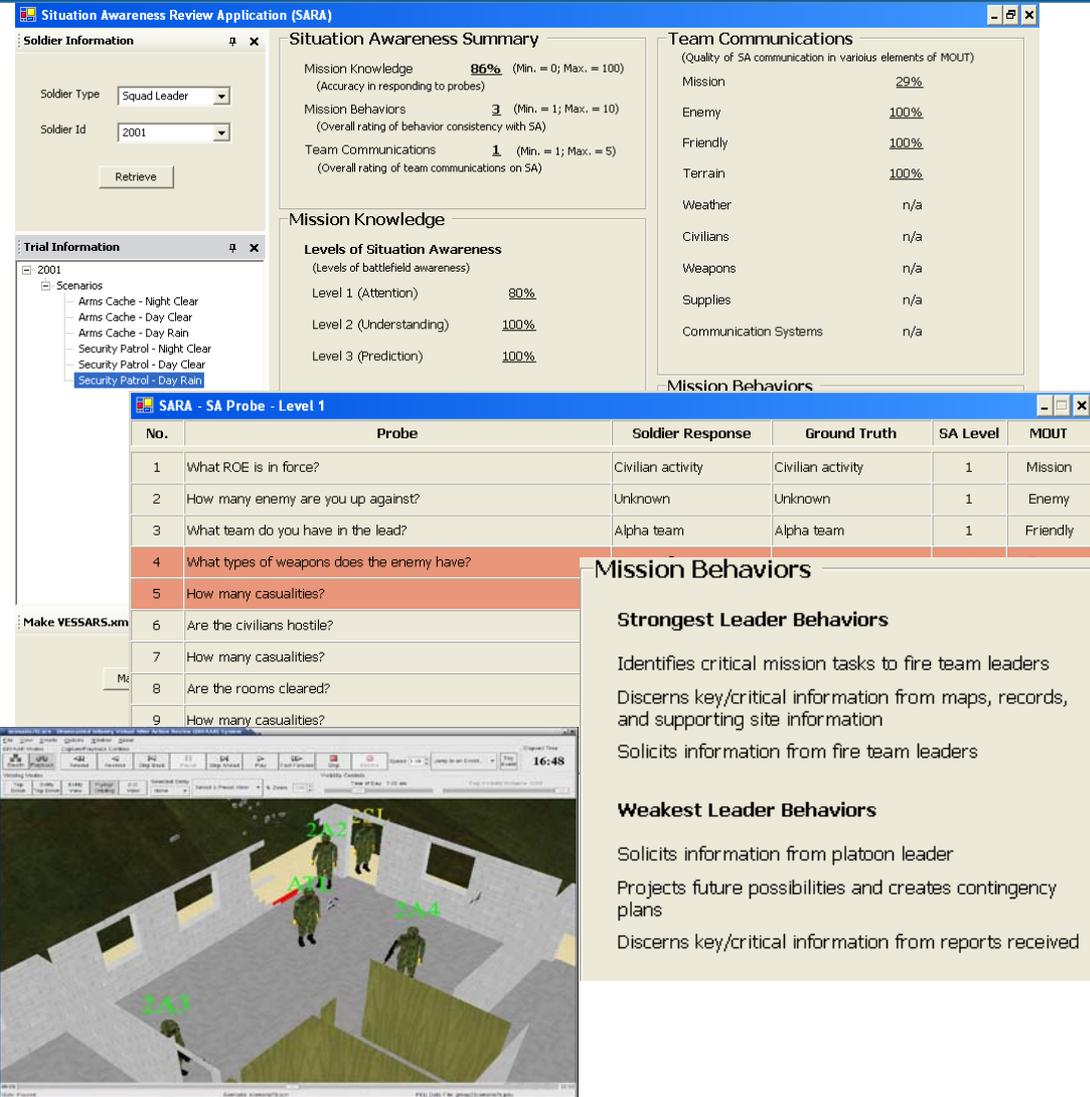
- **Prototype SA measurement system for VE training systems**
 - **Real Time Probes**
 - **Communications Measures**
 - **Behavioral Measures**
 - **Used to Assess SA and provide SA feedback during training exercises in VR simulations**



VESARS (Situation Awareness in Virtual Reality)

Feedback

- Support after action review through examination of SA
- Provide overview and detailed results
- SA probe accuracy
- Strongest and weakest behaviors observed
- Quality of SA communications



Situation Awareness Review Application (SARA)

Soldier Information

Soldier Type: Squad Leader
Soldier Id: 2001
Retrieve

Situation Awareness Summary

Mission Knowledge: 86% (Min. = 0; Max. = 100)
(Accuracy in responding to probes)

Mission Behaviors: 3 (Min. = 1; Max. = 10)
(Overall rating of behavior consistency with SA)

Team Communications: 1 (Min. = 1; Max. = 5)
(Overall rating of team communications on SA)

Team Communications
(Quality of SA communication in various elements of MOUT)

Mission	29%
Enemy	100%
Friendly	100%
Terrain	100%
Weather	n/a
Civilians	n/a
Weapons	n/a
Supplies	n/a
Communication Systems	n/a

Mission Knowledge

Levels of Situation Awareness
(Levels of battlefield awareness)

Level 1 (Attention)	80%
Level 2 (Understanding)	100%
Level 3 (Prediction)	100%

SARA - SA Probe - Level 1

No.	Probe	Soldier Response	Ground Truth	SA Level	MOUT
1	What ROE is in force?	Civilian activity	Civilian activity	1	Mission
2	How many enemy are you up against?	Unknown	Unknown	1	Enemy
3	What team do you have in the lead?	Alpha team	Alpha team	1	Friendly
4	What types of weapons does the enemy have?				
5	How many casualties?				
6	Are the civilians hostile?				
7	How many casualties?				
8	Are the rooms cleared?				
9	How many casualties?				

Mission Behaviors

Strongest Leader Behaviors

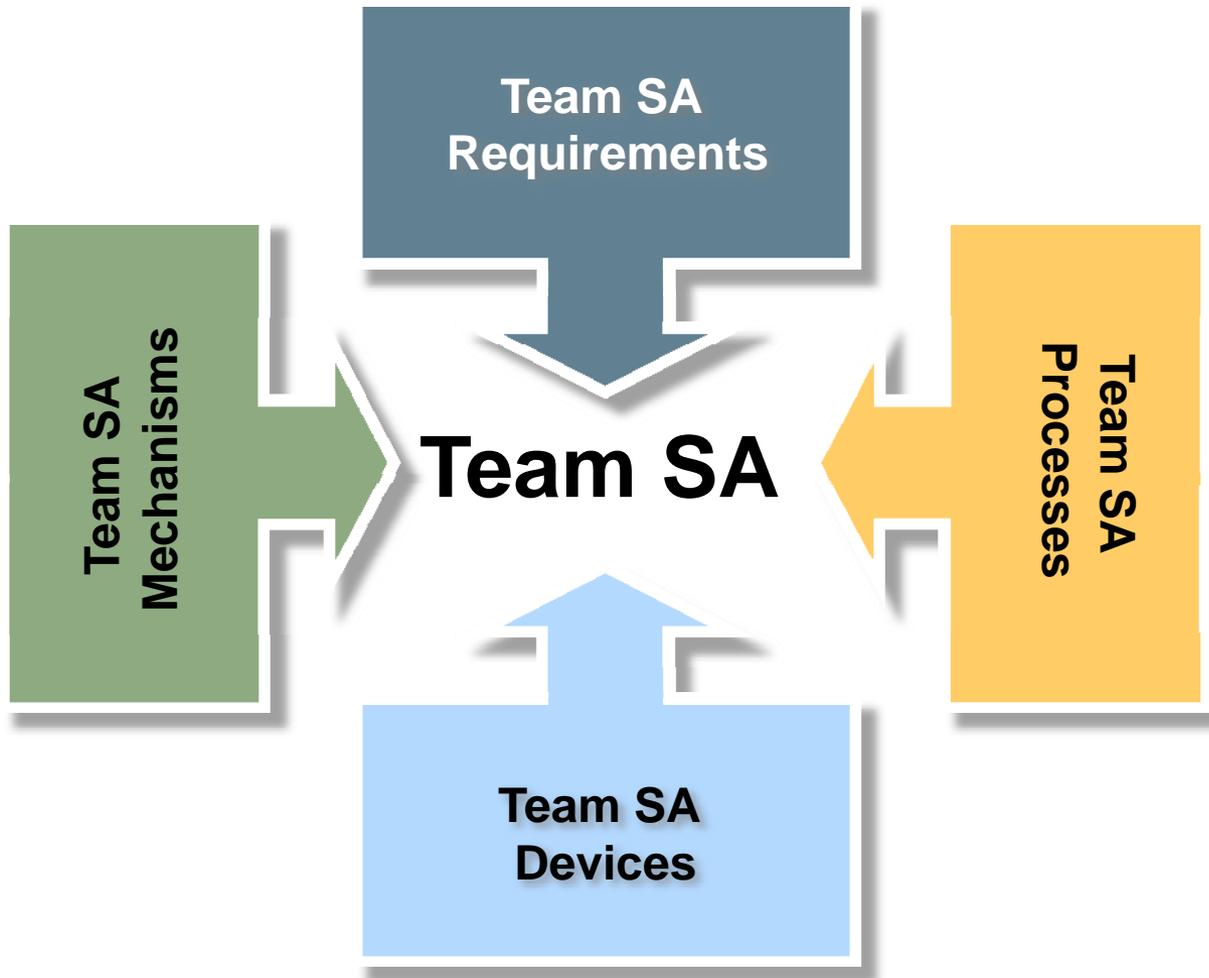
- Identifies critical mission tasks to fire team leaders
- Discerns key/critical information from maps, records, and supporting site information
- Solicits information from fire team leaders

Weakest Leader Behaviors

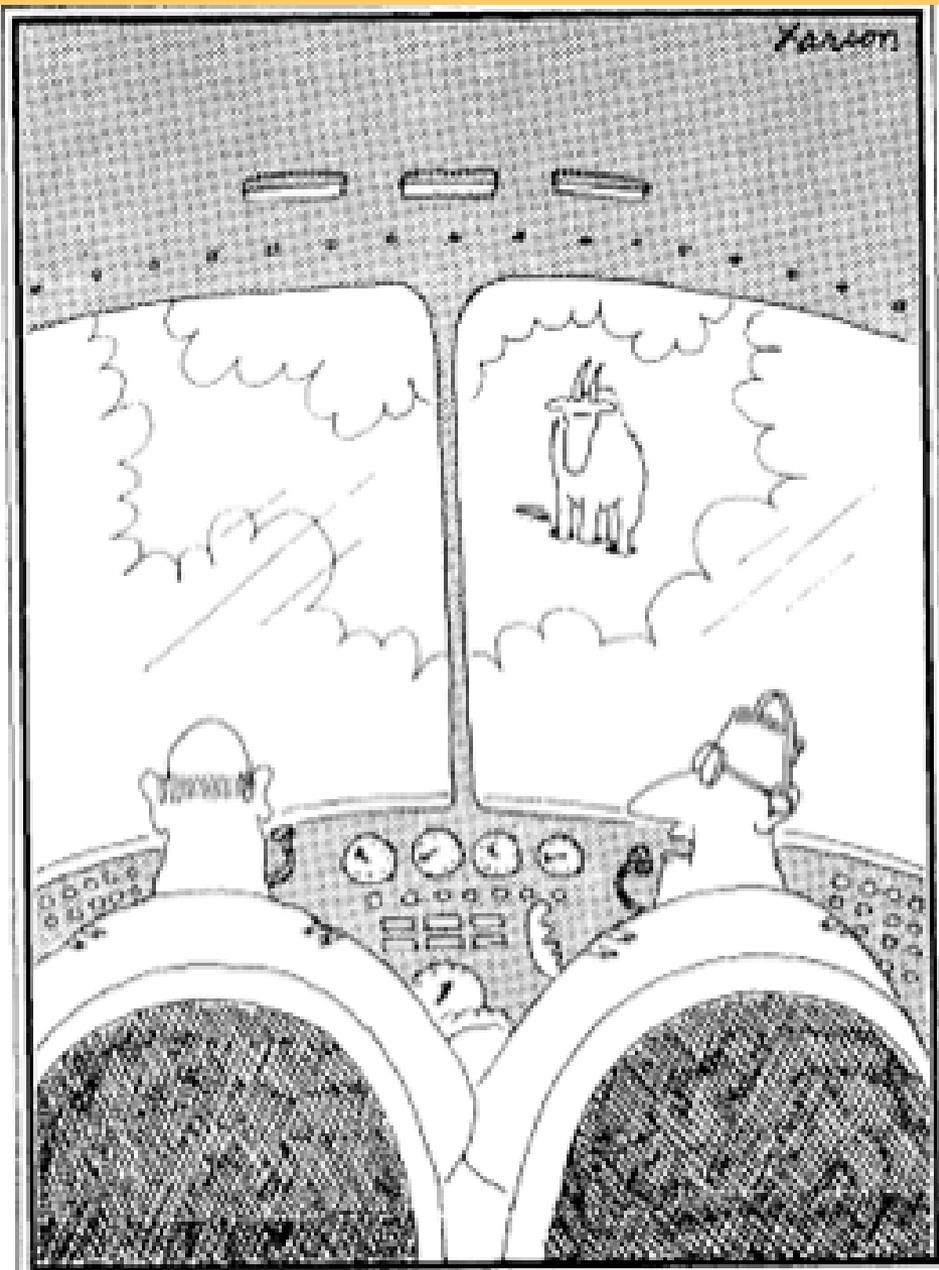
- Solicits information from platoon leader
- Projects future possibilities and creates contingency plans
- Discerns key/critical information from reports received

3D VR Environment

3D visualization of a virtual environment with soldiers and terrain.



Questions?



"Say . . . What's a mountain goat doing way up here in a cloud bank?"