Building Team Situation Awareness in Power Systems

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Situation Awareness is Critical to Power Transmission & Distribution

- **August 14, 2003 - Northeast US/Canada**
  - “Inadequate situation awareness”

- **August 10, 1996 - Western US**
  - “train operators to make them aware of system conditions and changes”
  - “develop displays that give operators immediate information on changes in status”

- **July 2, 1996 - Western US**
  - “review need … to monitor operating conditions on a regional scale”

- **July 13, 1965 - Northeast US/Canada**
  - “System control centers should be equipped with display and recording equipment which provide the operator with as clear a picture of system conditions as possible”
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
Situation Awareness

Data

Perception
- Frequency
- System voltage
- Direction of flow
- Breaker status

Comprehension
- Impact of interchange
- Violation of thermal limit
- Frequency violation

Projection
- Projected impact on system of losing element
- Projected limit violations

What?
So What?
Now What?

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Situation awareness is key to good decision making and good performance
Team Operations in Power Systems

- **Collaborative & Joint Action**
  - Synchronization

- **Team Situation Awareness**
  - Optimizes Decision Making of Whole Team
  - Within Team
  - Between Teams
Getting on the Same Page

• What is the current status of the system?
• What has been done so far?
• What are they doing now?
• How will that affect my tasks?
• How does what I’m doing affect them?
• What will they do next?
Information falls between the cracks

Information bridges between teams are weak and easily broken
Failures in Team SA

• US Air Crash on Take-off at LaGuardia (9/89)
  – Mis-trimmed rudder, aborted take-off, but ended up in the bay
  – Captain said “Got the steering” and advised F/O to correct track with right rudder
  – F/O only heard “got the steering”
  – Each thought the other was in control

• Air Florida Crash on Take-off at Washington National Airport (1/82)
  – Icing
  – Captain failed to reject take-off although F/O repeatedly noted anomalous engine readings
Failures in Team SA

• Dryden - Air Ontario Accident
  – Flight attendant saw ice & snow on wings
  – Passenger (off-duty pilot) also saw problem
  – Did not pass information to cockpit
    • Culture did not encourage
    • Believed cockpit crew knew

• Kegworth - British Midlands Accident
  – Pilots incorrectly shut off
    # 2 engine
  – Flight attendants and passengers
    saw flames coming out of
    #1 engine
  – Did not pass information to cockpit
Failures in Team SA

• Incident on Mir
  – Power cable accidentally disconnected during routine maintenance
  – Interrupted power to central computer and send Mir into a drift
  – Crew received never before seen computer messages & asked ground control for help
  – Part of communication garbled by static
  – Ground control did not understand problem and treated it as routine “We’ll get back to you”
  – Had to wait for next comm pass to get help
  – Mir’s batteries were drained and station lost power
Team SA

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

The Degree to Which Team Members Possess the Same SA on Shared SA Requirements
Meaning is not determinate

Workplace → Building
Sightseeing
Terrorist Target → Obstacle

Like Beauty.
Information is in the eye of the beholder
Sometimes we just talk past each other.....

Off the coast of Newfoundland in October, 1995.

Americans: Please divert your course 15 degrees to the North to avoid a collision.

Canadians: Recommend you divert YOUR course 15 degrees to the South to avoid a collision.

Americans: This is the Captain of a US Navy ship. I say again, divert YOUR course.

Canadians: No. I say again, you divert YOUR course.

Americans: THIS IS THE AIRCRAFT CARRIER USS LINCOLN, THE SECOND LARGEST SHIP IN THE UNITED STATES' ATLANTIC FLEET. WE ARE ACCOMPANIED BY THREE DESTROYERS, THREE CRUISERS AND NUMEROUS SUPPORT VESSELS. I DEMAND THAT YOU CHANGE YOUR COURSE 15 DEGREES NORTH, THAT'S ONE FIVE DEGREES NORTH, OR COUNTER-MEASURES WILL BE UNDERTAKEN TO ENSURE THE SAFETY OF THIS SHIP.

Canadians: This is a lighthouse. Your call.
Individual SA vs. Team SA

Mental Models

Goals

SA

Displays Environment

Mental Models

Goals

SA

Displays Environment

Mental Models

Goals

SA

Displays Environment
Failures in Team SA

- **Perception**
  - Is needed information clearly passed?

- **Comprehension**
  - Is information interpreted in the same way?

- **Projection**
  - Is same projection of actions formed to guide expectations?
Model of Team SA

(Endsley & Jones, 1997)

**Team SA Requirements**
- Data
  - system
  - environment
  - other team members
- Comprehension
  - status relevant to own goals/requirements
  - status relevant to other’s goals/requirements
  - impact of own actions/changes on others
  - impact of other’s actions on self & mission
- Projection
  - actions of team members

**Team SA Devices**
- Communications
  - Verbal
  - Non-verbal
- Shared Displays
  - Visual
  - Audio
  - Other
- Shared Environment

**Team SA Mechanisms**

**Team SA Processes**
- 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
SA of Distributed Teams

Maintaining SA in Teams in which Members are Separated by Distance, Time and/or Obstacles

- Shared SA Requirements are the same
- However
  - Fewer Shared SA Devices
    - No Shared Environment
    - No Non-verbal Cues
  - Puts Heavy Load on
    - Verbal Communications
    - Shared Displays if available
    - Often Becomes the Bottleneck
  - Frequently Distributed Teams do not have good shared mental models
    - Creates Opportunity for Mis-Understandings
Failures in Team SA

• Different teams are not aware of what information needs to be passed
  – One does not know what the other already knows
  – Don’t pass higher level SA

• Little support for good Team SA processes between teams
  – Few shared devices
  – Shared Displays inadequate
  – Non-supportive culture or limited opportunities for communication

• Information that gets passed may be interpreted differently
  – Different mental models
How Do We Improve SA?

Organizational System

Technical System

Social System

Safety Culture

SA Oriented Design

SA Oriented Training
SA-Oriented Design

SA Requirements Analysis → SA-Oriented Design → SA Measurement

50 Design Principles

Goals

Decisions

- Projection Requirements
- Comprehension Requirements
- Data Requirements
Current tools are not sufficient

- Does it have the right information?
- Does it support between teams?
45 - Build a common picture to support team operations
   - Information sources should be consistent

46 - Avoid display overload in shared displays
   - Must be tailored to individual needs based on SA requirements of position

47 - Provide needed display flexibility to support shared SA across functions
   - Goal orientation or comparative shifts
   - Vantage Point
   - Semantics
48 - Support transmission of different comprehension and projections across teams
  - Quick look to other’s perspective
  - Build Team SA
    • What task is he on?
    • Is what she is doing going to effect me?
    • Is what I’m doing going to effect them?

49 - Limit non-standardization of display coding techniques
  - Need to be able to communicate on consistent symbology, color coding

50 - Support transmission of SA within positions by making status of elements and states overt
SA Training

- What is SA?
- SA Errors
- SA Demons
- How to Avoid Problems
  - Individual strategies
  - Individual skills
- Improving SA in Team
  - Techniques for building SA in co-located & distributed teams

Get SA

- Foundational information on each topic
- Examples in domain
- Interactive exercises for class
- Handout materials for reinforcement

What? So What? Now What?

- Have I looked for all the information I need?
- Did I double-check the readings?
- Is the information reliable? Can I check it?
- What information is missing?
- Are my teammates on the same page?

Level 1 SA
- How does this information compare to the desired state of the system?
- What is the impact of this information on system safety and performance?
- Have I checked for information that supports alternate diagnoses?
- Have I cross-checked my understanding of the system with others?

Level 2 SA
- What is likely to happen next based on the current system state?
- What could go wrong?
- What are possible contingency plans?
- Am I always trying to anticipate & think ahead of the system?
Communicate Effectively & Directly at all 3 Levels

**Comprehension**
- Is information interpreted in the same way?
- Interpretation — “So What” of the data

**Projection**
- Is same projection of actions formed to guide expectations?
- Projections — “What’s Next”

**Perception**
- Is needed information clearly passed?
- Why as well as What
  - Transmit- Repeat- Confirm
Training Situation Awareness Knowledge, Skills, & Behaviors

Virtual Environment Situation Awareness Rating System (VESARS)

Interactive Situation Awareness Trainer (ISAT)

SA Feedback
Mental Models & Schema Training
Basic Skills
Meta-Cognitive Skills

SA Trainer

Situation Awareness Virtual Instructor (SAVI)
Conclusion

- Situation Awareness is critical for effective decision making
- Shared SA is an important component of the successful functioning of both collocated and distributed teams, and ad hoc teams of teams
- Situation Awareness can be directly enhanced through improved systems design to enhance information sharing and integration
  - Use a systematic approach to determining the individual and shared SA requirements
  - Tailor displays to support SA for each team member & shared SA requirements
  - Critical to support the relevant comprehension & projection analysis of data provided to the decision makers
- Training of Team SA Skills can improve effective information sharing and understanding