IADC/SPE
DRILLING CONFERENCE
AND EXHIBITION

1–3 March 2016
FORT WORTH, TEXAS
Fort Worth Convention Center

IADC / SPE 178841

Human Systems Integration

Key Enabler for Improved Driller Performance and Successful Automation Application

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Paper built on insights from renowned authorities

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Human Systems Integration impacts performance & automation

- Background and best practices in HSI
- HFE design in drillers consoles
- Levels of Human and Systems interaction
- Levels of Automation Taxonomy (LOAT) – aviation to drilling
- Driller feedback in manual and automation mode
- Conclusions from badly treating the driller to manual-to-automation transfer

Background and Best Practices of Human Systems Integration

- Military mapped functional requirements of force protection systems to the military personnel
    - Airforce Human Systems Integration Manual
    - Specific responsibilities and tasks for HSI SME's
- Initially analysis of user-centered requirements
    - Human based approach in an automated world
    - Human required in automation with various roles based on automation level
- Transitionary period as automation increases
    - need to address HSI needs of personnel

Subject Matter Expert areas in HSI during progress in DSA

- **Manpower**
  - Identify requirements near and long terms
- **Personnel**
  - Competency models along with cognitive and job task analyses
- **Training**
  - The most powerful and sophisticated automated system may fail completely if personnel are not properly trained how to interact with it

Subject Matter Expert areas in HSI during progress in DSA

- **Safety and Occupational Health**
  - Address personnel safety
  - Address process safety
- **Human Factors Engineering**
  - Greatly reduce the potential for human error, promote operational efficiency
- **Organizational factors**
  - Barriers such as industry business models that are embedded in the tradition of modern-day operations

Drilling consoles require redesign for performance and automation

- Legacy systems design on the past and not developed for today
    - Need to benchmark interaction of drilling personnel with technology
- Task analysis of driller – task hierarchy
    - Physical interaction with drilling controls
    - Cognitive steps / thought processes to accomplish tasks
- Human Factors Engineering (HFE) demonstrates information is better perceived, understood and responded to when presented in specific ways that cater to the limitations of human information processing
    - one aspect is grouping controls

Drilling consoles require redesign for performance and automation

- Legacy systems design on the past and not developed … today … with
- Tas… …asks
- Hu… …on is better pe… …n specific wa… …cessing

Too often we design systems from the designers point of view and fail to recognize the designer has a much different perspective and knowledge base than the end user.

Drillers have mental models of operations

- One to one to one equipment control activation to action of the equipment
    - mental model is preserved
- One-to-many correspondence between control activation and action of the equipment
    - mental model is vulnerable
- Mental model break down
    - less adept at troubleshooting and developing operational strategies
    - more prone to experiencing operational errors
    - **less effective driller**

Drillers have mental models of operations

Mental model issues lead to two observations:

- Surface equipment activation conforms readily to surface action correspondence
- Surface equipment activation often does not conform to downhole action correspondence

- Effective graphic interface design integrated with automation using systems modelling can significantly improve downhole action correspondence improving the drillers mental model

Levels of Human and Systems Interaction – Sheridan et al

- Levels from fully manual to autonomous are have been well established
  - Initially 10, modified to 8
  - Adapt the level discretion to the system under investigation
- Second dimension add to the levels
  A. Acquire information
  B. Analyze and display
  C. Decide action
  D. Implement action
- Four stage model applies to human as well as automation sequencing

Transferring cycle of functions from manual to automated control

A. Acquisition of Information
  - applies to the sensing and registration of input data.
  - equivalent to the first human information processing stage, supporting human sensory processes

B. Analysis of Information
  - involves cognitive functions such as working memory and inferential processes.
  - this includes analysis by algorithms and prediction.

C. Decision - Decision and action selection
  - selection from among decision alternatives.
  - varying levels of augmentation or replacement of human selection of decision options with machine decision making.

D. Action – Implementation
  - execution of the action choice.
  - different levels of machine execution of the choice of action, and typically replaces the hand or voice of the human

Levels of Automation Taxonomy (LOAT)

- Matrix of both human information processing and systems functions against the levels of automation.
- Single European Sky ATM (Air Traffic Management) Research
  - An automated system cannot have one ‘overall’ level of automation
  - One automated system can support more than one function, each having a different level of automation.
  - The description of each automation level follows the reasoning that automation is addressed in relation to human performance

Levels of Automation Taxonomy (LOAT)

SESAR and DSA face corresponding interactions:
- The cockpit / the driller
- ATC / the remote centers

- An automated system cannot have one 'overall' level of automation
- One automated system can support more than one function, each having a different level of automation.
- The description of each automation level follows the reasoning that automation is addressed in relation to human performance

	Information Acquisition	Information Analysis	Decision and Action Selection	Action Implementation
0	Manual Information Acquisition	Working Memory Based Information Analysis	Human Decision Making	Manual Action and Control
1	Artefact-Supported information Acquisition	Artefact-Supported Information Analysis	Artefact-Supported Decision Making	Artefact-Supported Action Implementation
2	Low-Level Automation Support of Information Acquisition	Low-Level Automation Support of Information Analysis	Automated Decision Support	Step-by-step Action Support:
3	Medium-Level Automation Support of Information Acquisition	Medium-Level Automation Support of Information Analysis	Rigid Automated Decision Support	Low-Level Support of Action Sequence Execution
4	High-Level Automation Support of Information Acquisition	High-Level Automation Support of Information Analysis	Low-Level Automatic Decision Making	High-Level Support of Action Sequence Execution
5	Full Automation Support of Information Acquisition	Full Automation Support of Information Analysis	High-Level Automatic Decision Making	Low-Level Automation of Action Sequence Execution
6			Full Automatic Decision Making	Medium-Level Automation of Action Sequence Execution
7				High-Level Automation of Action Sequence Execution
8				Full Automation of Action Sequence Execution

	Information Acquisition	Information Analysis	Decision and Action Selection	Action Implementation
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5	Full Auto[illegible] Inform[illegible]	[illegible]ion Support of [illegible]on Analysis	High-Level Automatic Decision Making	Low-Level Automation of Action Sequence Execution
6			[illegible]	Medium-Level Automation of Action Sequence Execution
7				High-Level Automation of Action Sequence Execution
8				[illegible]

Manual

Fully Automated

Fully Automated

Fully Automated

LOAT DSA Tabulation Example – Std Auto driller

INFORMATION ACQUISITION	INFORMATION ANALYSIS	DECISION AND ACTION SELECTION	ACTION IMPLEMENTATION
Manual	Memory Analysis	Human Decision	Manual Action and Control
Artifact-Supported	Artefact-Supported	Artefact-Supported	Artefact-Supported
Low Level Automation	Low-Level Automation	Automated Decision Support	Step-by-step Action Support
Medium-Level Automation	Medium-Level Automation	Rigid Automated Decision Support	Low-Level Support Action Execution
High-Level Automation	High-Level Automation	Low-Level Automatic Decision	High-Level Support Action Execution
Full Automation	Full Automation	High-Level Automatic Decision	Low-Level Action sequence
		Full Automatic Decision Making	Medium-Level Action sequence
			High-Level Action Sequence
			Full Automation

Feed system

LOAT DSA Tabulation Example – Advanced Auto Driller

INFORMATION ACQUISITION	INFORMATION ANALYSIS	DECISION AND ACTION SELECTION	ACTION IMPLEMENTATION
Manual	Memory Analysis	Human Decision	Manual Action and Control
Artifact-Supported	Artefact-Supported	Artefact-Supported	Artefact-Supported
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Full Automation	Full Automation	High-Level Automatic Decision	Low-Level Action sequence
		Full Automatic Decision Making	Medium-Level Action sequence
			High-Level Action Sequence
			Full Automation

Intelligent system

Automated

LOAT DSA Tabulation Example – Advanced Auto Driller

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		Full Automatic Decision Making	Medium-Level Action sequence
			High-Level Action Sequence
			Full Automation

Advisory

Intelligent system

LOAT DSA Tabulation Example - MPD

INFORMATION ACQUISITION	INFORMATION ANALYSIS	DECISION AND ACTION SELECTION	ACTION IMPLEMENTATION
Manual	Memory Analysis	Human Decision	Manual Action and Control
Artifact-Supported	Artefact-Supported	Artefact-Supported	Artefact-Supported
Low Level Automation	Low-Level Automation	Automated Decision Support	Step-by-step Action Support
Medium-Level Automation	Medium-Level Automation	Rigid Automated Decision Support	Low-Level Support Action Execution
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			Full Automation

Conclusions for the drilling industry

- Drilling industry has failed to provide the driller with relevant data and information displays that enable performance
  - legacy systems that mimic mechanical recording systems
- HSI is a developed proficiency that can be applied to both the driller interface and drilling systems automation
  - enhance manual drilling performance / an interface system for automation
- LOAT adopted in this paper from SESAR provides a powerful map for transferring drilling operations from the human to the automated system
  - Simply automating the action implementation without automating information acquisition / analysis and decision and action selection minimizes the value that is delivered

Acknowledgements

Co-Authors / Co-Developers:
Thomas B Sheridan – Professor Emeritus MIT
Amanda DiFiore – AMD Consulting
Luca Save – Deep Blue

Thank You / Questions

John de Wardt