Where Technology Shapes Solutions.

Hardie Voges, Mischa Tolsma, Jamie Errington
ASM Compliant HMI Graphics Design
Introduction

SASOL

reaching new frontiers

– Integrated oil and gas company with substantial chemical interests in Africa, Europe, Asia & North America
– Member of the ASM® Consortium
– World leader in Fischer-Tropsch expertise
  • Complemented by interests in technology development and oil and gas exploration and production
– Major production facility in Secunda, South Africa

Human Centered Solutions

Helping People Perform

– Human Factors design company
  • Provides comprehensive Human Factors designs & products to improve Operator Effectiveness
– Member of the ASM® Consortium
## Team

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Education</th>
<th>Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardie Voges</td>
<td>Chief Technologist, Sasol Synfuels</td>
<td>Degree in Computer Science (B.SC. Hon IT)</td>
<td>15 years instrumentation and control experience</td>
</tr>
<tr>
<td>Mischa Tolsma</td>
<td>Engineering Manager, Sasol Synfuels</td>
<td>MSc and PhD in Applied Physics</td>
<td>Interests include Abnormal Situation Management, Real-Time Dynamic Optimization and Work Process Design</td>
</tr>
<tr>
<td>Jamie Errington</td>
<td>Senior Partner, Human Centred Solutions</td>
<td>Degree in Chemical Engineering</td>
<td>25 years process control and project engineering experience</td>
</tr>
</tbody>
</table>
Introduction

• Outline
  – DCS replacement project Rectisol
  – Replacing all TDC technology with Experion C300
  – Designing a new Human Machine Interface according to the Abnormal Solutions Management (ASM) guidelines.
  – What is ASM?
  – Design approach
  – Challenges and mitigation plans
  – Successes achieved
  – Other changes
  – Path forward
  – Conclusion
Rectisol DCS Project

- TDC 2000 replacement Rectisol West
  - TDC was installed in 1978, it did exceptionally well **but:**
    - Bathtub curve effect – increasing failure rate
    - Spares availability – some spares no longer available
    - Ability to maintain – resources
    - Available spare capacity - Limited to no capacity for expansion
    - Lack in functionality – need more advance functions

- In 2008 Sasol decided to replace the TDC 2000 system with Experion C300 DCS system
Rectisol DCS Project

• The hardware replacement was relatively easy.
  – The complete hardware change over was done during a two week shutdown – September 2009

• The challenge faced was the HMI

What to do?
Abnormal Situation Management®
A Joint Research and Development Consortium

Founded in 1994

Creating a new paradigm for the operation of complex industrial plants, with solution concepts that improve Operations’ ability to prevent and respond to abnormal situations.

www.asmconsortium.org

Sasol joined ASM in 2006

A Honeywell Company
What is an Abnormal Situation?

- An industrial process is being disturbed and the automated control system can not cope.
- Consequently, the operations team must intervene to supplement the control system.

An Abnormal Situation Impacts Process Safety
ASM in relation to Process Safety Mgt.

Safety Pyramid Illustration

- **Major Incidents**: Incident above threshold for Process Safety Incident
- **Minor Incidents**: Incident below impact threshold for PS Incident
- **Near Miss**: System failure that could lead to an incident
- **Unsafe Behaviors**

Illustration based on: CCPS *Process Safety Leading and Lagging Metrics.*
ASM® Consortium Guidelines

• Initial ASM® Research
  – Started in 1994 with multiple site-assessments
    • Determined breadth of the ASM problem
  – AEGIS (Abnormal Event Guidance and Information System)
    • Developed prototype of technologies that could avoid abnormal situations or manage improved response

• Site Assessments and Research
  – Led to the development of ASM® Effective Practice G/Ls
    • Effective Operations Practices
    • Effective Operator Display Design
    • Effective Alarm Management Practices
    • Effective Procedural Practices
  – Initially internal documents – now three are published
**Objective**
- Define concepts and features that **improve usability and effectiveness of the human-machine interactions** in the process control operations environment

**Key Solution Concepts & Innovations**
- Single, Integrated View of Multi-Level Hierarchy
- Mixed Initiative Approach
- Effective Window Management and Layout
- Effective Navigation Scheme
- Visual Coding Scheme
- Interaction Objects
- Contextual Menus & Information Presentation
- Task View Organization
ASM Supervisory Control Model

- Based on Human Information Processing model
- Includes Psychological stages of Situation Awareness

**Operator Mental & Physical Activities**

<table>
<thead>
<tr>
<th>Situation Awareness (1-3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orienting</td>
</tr>
<tr>
<td>(1) Sensing, Perception, and/or Discrimination</td>
</tr>
<tr>
<td>Evaluating</td>
</tr>
<tr>
<td>(2) Analysis, Interpretation, and/or (3) Projection</td>
</tr>
<tr>
<td>Acting</td>
</tr>
<tr>
<td>Physical and/or Verbal Response</td>
</tr>
</tbody>
</table>

**Inputs from Process**
(sensors, analyzers, radios, video, instructions, sounds & smells)

**Outputs to Process**
(SP, OP%, Manual adjustments)

**Process State**

**Assessing**

**Evaluating**

**Orienting**

**Acting**

**Internal Feedback**

**External Feedback**
### 6.1 Use a minimum of colors for display hierarchy levels

**Why?** Consistent, distinguishable, and meaningful behind a hierarchy.

**How it Works**

The number of colors used should be seven or less, and be consistent across different types of information (see section on color coding, e.g., [7, 1999]). In general, color coding should be consistent and meaningful behind a hierarchy. For example, red color-coded emergency information, alerting workers to a serious condition. The color should be chosen based on its distinctiveness from other colors in the display. For example, a less saturated yellow might be used for alerting information.

In general, color coding should be consistent across different types of information. For example, red color-coded emergency information, alerting workers to a serious condition. The color should be chosen based on its distinctiveness from other colors in the display. For example, a less saturated yellow might be used for alerting information.

- **6.1 Use a minimum of colors for display hierarchy levels**
- **Why?** Consistent, distinguishable, and meaningful behind a hierarchy.
- **How it Works**
  - The number of colors used should be seven or less, and be consistent across different types of information.
  - In general, color coding should be consistent and meaningful behind a hierarchy. For example, red color-coded emergency information.

### ASM Consortium Guidelines

**Effective Operator Display Design**

2008

<table>
<thead>
<tr>
<th>Number</th>
<th>Category</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1: Display Types</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2: Display Content</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3: Display Style</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>4: Display Layout</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>5: Navigation</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>6: Color</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>7: Symbols and Process Connections</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>8: Text and Numbers</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>9: Interactions and Displays</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>10: Alarm Configuration Scheme</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>11: Audible Annunciation of Alarms</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>12: Visual Annunciation of Alarms</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>13: Training Program</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>14: Online user assistance</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>15: Design Methodology</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>16: Management of Change</td>
<td></td>
</tr>
</tbody>
</table>

**Total** 81
What Makes an Operator Interface ASM Compliant?

- It is much more than a display with a grey background!
- Sasol implementation meets over 90% of the ASM® Consortium’s 81 Effective Operator Display Design Guidelines
- “Cherry picking” select Guidelines may not lead to an effective interface

<table>
<thead>
<tr>
<th>Categories</th>
<th>No. of G/Ls</th>
<th>Compliance %</th>
<th>Exceptions to the G/Ls</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: Display Types</td>
<td>7</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>2: Display Content</td>
<td>7</td>
<td>89</td>
<td>interlock / permissive status</td>
</tr>
<tr>
<td>3: Display Style</td>
<td>6</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>4: Display Layout</td>
<td>5</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>5: Navigation</td>
<td>6</td>
<td>83</td>
<td>Soft key navigation – replaced w/ tabs</td>
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<tr>
<td>6: Color</td>
<td>8</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>7: Symbols and Process Connections</td>
<td>4</td>
<td>100</td>
<td></td>
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<tr>
<td>8: Text and Numbers</td>
<td>6</td>
<td>83</td>
<td>Mixed case messages</td>
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<tr>
<td>9: Interactions and Displays</td>
<td>8</td>
<td>75</td>
<td>2 G/Ls on field devices n/a</td>
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<tr>
<td>10: Alarm Configuration Scheme</td>
<td>5</td>
<td>96</td>
<td>No dedicated display for alarm inhibits</td>
</tr>
<tr>
<td>11: Audible Annunciation of Alarms</td>
<td>5</td>
<td>80</td>
<td>1 G/L on field annunciation n/a</td>
</tr>
<tr>
<td>12: Visual Annunciation of Alarms</td>
<td>2</td>
<td>100</td>
<td></td>
</tr>
<tr>
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<td>100</td>
<td></td>
</tr>
<tr>
<td>16: Management of Change</td>
<td>2</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>81</strong></td>
<td><strong>92.5</strong></td>
<td>Includes 3 G/Ls n/a</td>
</tr>
</tbody>
</table>
Sasol Required an Operator Interface:

- Hardwired switches, buttons, etc.
- Radio, Telephone, Dedicated lines, etc.

Optional –
- Hardwired switches, buttons, etc.
- Radio, Telephone, Dedicated lines, etc.

Designed for the Console Operator:
- View Angles
- Secondary support position
- Ancillary equipment
Multi-Window Operator Interface

- Level 1
  Console-wide Overview

- Level 2
  PFD Summary

- Level 3
  P&IDs / Tasks

- Level 4
  Multi-Faceplate

- Tag Detail
  - Custom Faceplate
  - Focus Tag details with “strip-chart” trend
Display Coordination

• Linked Displays
  – Selecting a target on an upper level display
  – Automatically opens more corresponding detailed displays

• Selected tag is put in Focus
  – Opens new Faceplate
  – Detail Trend
HMI Design Methods

- The design process consisted of four phases.
HMI Design Methods

• Phase 1 Process
  – Collects information, MFD’s
  – Arrange meeting with operations management to discuss process. Establish team.
  – Arrange first workshop with operations and maintenance
  – Explain design process, Level 1,2,3,4
  – Compile MFD’s into process flow hierarchy

• Phase 2 Process
  – Build graphics using process flow hierarchy starting at level 3
  – Arrange review session and correct deviations.
  – This phase should not take more that four sessions
  – Graphics must be design to cater for needs not wants
HMI Design Methods

• Phase 3 Process
  – Finalize graphics
  – Train maintenance and build in all the links
  – Arrange review session with production
  – Maintenance to lead review session and test all links on graphics
  – Maintenance to correct minor deviations

• Phase 4 Process
  – Load graphics on system to be CFAT
  – All deviations must be recorded
  – Maintenance to correct deviations and production to sign off graphics for operation
Obstacles Encountered

• The HMI design was not without problems.

• Obstacles
  – Operator resistance to change
  – Operator lack of participation in the design process
  – Operator lack of participation in the CFAT

• Operator perception
  – Paradigm shift to control via graphics instead of groups
  – Navigation between four screens on quad will be a problem
  – Grey color scheme will not make operating easier
Overcoming Obstacles

- The HMI team tried to overcome the problems by.
  - Overcoming obstacles
    - Making the operators part of the change, giving them ownership
    - Negotiating overtime for operators partaking in the design and CFAT process
    - Taking the workshop offsite to limit distractions
  - Overcoming operator perception
    - Giving the operators extensive training on the navigation of the graphics and the colors used
    - Incorporating the old groups into the level 4 graphics
Benefits of New HMI

- Some benefits achieved
  - Newer operators more relaxed, no need to remember group numbers
  - Training time for new DCS operators has been reduced, due to existing plant knowledge
  - After shutdown Rectisol started up first time
  - Operator more attentive to color changes
  - Tab navigation makes it easy to navigate to problem area
  - Improved fault finding capabilities for maintenance personnel
Other Changes

• New console design
  – Designed a new console with adjustable work areas to cater for all operators
  – Incorporate other interfaces into new console (fire and gas, Moore PLC, personal computer, Vibration monitoring)

• Control room.
  – Upgrade lighting for optimum working conditions

• Alarming
  – Implemented a distinctive alarm sound for each console and each alarm priority (critical, high and low)
  – Followed a alarm rationalization process to optimized the alarms and reduce nuisance alarms
Secunda Path Forward

- Implementation completed at 3 other plant
- Future plan to roll out process to rest of Sasol Synfuels
  - To upgrade control rooms
  - To upgrade consoles
  - Build new centralizes control rooms
  - Upgrade from TDC to Experion
Project Summary

• The project has succeeded in:
  – Manage a successful changeover from TDC to Experion
  – Manage a successful HMI design approach with operations
  – Manage a successful implementation of the new HMI
  – Manage a successful startup with a totally new system
  – Manage to create a improved training environment for new DCS operators

• But you can’t win all:
  – Alternative plan required for personnel close to retirement