USING STAMP TO IMPROVE PLATFORM SAFETY

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CONTENTS

• Problem statement
• Theoretical foundation
• Research design
• Results:
  • Assessment of control loop effectiveness using STAMP
  • Safety Performance
• Conclusions
PROBLEM STATEMENT
GROUND SERVICES EXECUTES AIRCRAFT TURN-AROUND

- Baggage Services
- Pushback and Towing
- Catering and Onboard Supply
- Cleaning
- Aircraft refueling
- Water and toilet services
HIGH NUMBER OF RULE VIOLATIONS
PLATFORM THREATS INCLUDE MOSTLY ORGANISATIONAL ISSUES

• Non-adherence to procedures
• (Macho) behaviour
• Performing activities beyond procedures
• Cargo leaks
• High personnel turnover (experience)
• Early taxi-out
• Short turnaround times
• Differences in procedures
• Driving
• Thunderstorms
THEORETICAL FOUNDATION
ORGANISATIONS ARE COMPLEX SYSTEMS

Complex system characteristics

- Are open to influences from the environment and vice-versa
- Components are ignorant of system behavior and effects of own actions on it
- Interaction is complex, not necessarily the components
- Complex systems not in static equilibrium: feedback loops required
- History or path dependence (non-Markov)
- Non-linear interactions (“Butterfly effect”) 
- New structures are generated “internally”

EXAMPLE OF EMERGENT BEHAVIOR: 
THE CASE OF THE LATE-COMING PARENTS

Rule violation in day care
• 10 day-care centers in Israel
• Operate 07:30 - 16:00
• Frequent late parents (1~2 daily)
  • Teacher has to stay
  • No consequences for parents
  • Parents rarely came after 16:30
• Solution: introduce fine for delay > 10 minutes

Gneezy and Rustichini 2000
INTRODUCTION OF FINES LED TO A UNYIELDING INCREASE IN RULE VIOLATION

Gneezy and Rustichini 2000
PROBING AND SENSING IS ESSENTIAL IN THE COMPLEX DOMAIN

The Cynefin framework

**Probe** by safe to fail experiments

**Sense** emerging patterns

**Respond** by amplifying or dampening

Snowden & Boone 2007
STAMP SEEMS A SUITABLE TOOL TO ASSESS SAFETY MANAGEMENT SYSTEMS

- Targeted at complex socio-technical systems
- Focuses on safety as emergent behavior
- Utilizes a feedback control loop perspective
  - To probe / sense / respond
  - To maintain equilibrium
  - Sensitive to “weak signals”

Leveson (2013)
“WEAK SIGNALS”

• A violation of a safety constraint with no / little consequence
• Therefore very little attention
• May be a precursor for a more serious incident at some future point in time

See also Dokas, Feehan and Imran (2013)
Aim of the control loop is to maintain controlled process at set point. Requires appropriate (implicit or explicit) single set point. Process model identifies gap between current and target state based on sensor input. Control algorithm creates control signal based on gap. Actuator receives, transmits and presents control signal at controlled process. Sensor receives, transmits and presents (limited observation of) current state of process. Multiple channel sensors and actuators for calibration & “weak signals.”
CONTROL STRUCTURE REFLECTS SCOPE OF INTEREST

Approximation for higher level control loops
STAMP DOES NOT EXCLUDE FEEDFORWARD
RESEARCH DESIGN
RESEARCH AIM:
CONFIRM PREDICTED RELATION

Additional aims:
• Use prediction to enhance safety at a Ground Service Provider
• Adapt STAMP framework if and where necessary to support the diagnostic capabilities of the framework.
RESEARCH METHOD: LONGITUDINAL SINGLE CASE STUDY

• Retrospective (2010) versus current situation
• @ Dutch Ground Service Provider (different to original GSP)
  • Semi-structured interviews
  • Personal experience of the junior researcher as a platform employee
• Use of STPA according to Leveson (2013)
ASSESSMENT OF CONTROL LOOP EFFECTIVENESS USING STAMP
HAZARDS AND SAFETY CONSTRAINTS

- In operational circumstances, safety regulations generally exist to enforce:
  - Aviation safety
  - Occupational health.
- Hazard: “a system state or set of conditions that together with a worst-case set of environmental conditions, will lead to an accident (loss)”
  - Every violation of the safety regulations (assuming these are correctly defined) constitutes a hazard
- “Enforce safety constraints on system behavior” to avoid hazards
  - safety regulations = safety constraints

Leveson (2013)
CONTROL STRUCTURE & POTENTIAL FLAWS (2010)

Legend:
A. Sensor
B. Process model
C. Setpoint
D. Control algorithm
E. Actuator
F. Out of range disturbances
G. Cognitive resistance
SAFETY* IS MANAGED THROUGH SIX GENERIC MANAGEMENT CONTROL ACTIONS

1. Set goals and direction
2. Establish work processes and standards
3. Staff, schedule and train
4. Manage facility and equipment
5. Allocate financial resources; and

* As is everything else…
(Helferich 2013, Fayol 1949)
**ALLOCATION OF SAFETY REQUIREMENTS**

<table>
<thead>
<tr>
<th>Component</th>
<th>Allocated safety constraint</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Controlled Process)</td>
<td>(Compliant execution of process)</td>
</tr>
<tr>
<td>Sensor loop 1</td>
<td>Receival, transmission and presentation of compliancy of process to Platform coordinator</td>
</tr>
<tr>
<td>Process Model loop 1</td>
<td>Platform coordinator can identify gap between current and target compliancy based on information</td>
</tr>
<tr>
<td>Control Algorithm loop 1</td>
<td>Platform coordinator can generate required control actions as a function of gap</td>
</tr>
<tr>
<td>Actuator loop 1</td>
<td>Receival, transmission and presentation of control signal at controlled process</td>
</tr>
<tr>
<td>Sensor loop 2</td>
<td>Receival, transmission and presentation of current state of platform coordinator to supervisor</td>
</tr>
<tr>
<td>Process Model loop 2</td>
<td>Supervisor can identify gap between current and target state of platform coordinator based on information</td>
</tr>
<tr>
<td>Control Algorithm loop 2</td>
<td>Platform supervisor can generate required control actions as a function of gap</td>
</tr>
<tr>
<td>Actuator loop 2</td>
<td>Receival, transmission and presentation of control signal at platform coordinator</td>
</tr>
<tr>
<td>Set Point</td>
<td>Implicit or explicit target state(s) for platform coordinator process and process compliancy available</td>
</tr>
</tbody>
</table>
# CONTROL LOOP EFFECTIVENESS TABLE

<table>
<thead>
<tr>
<th>LOOP 1</th>
<th>Mgt task 1</th>
<th>Mgt task 2</th>
<th>...</th>
<th>Mgt task 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set Point</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensor</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Process model</td>
<td></td>
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<tr>
<td>Control Algorithm</td>
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<td>...</td>
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<tr>
<td>LOOP 2</td>
<td></td>
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<tr>
<td>...</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
SUMMARY OF CONTROL LOOP EFFECTIVENESS

2010: Poor

- Platform coordinator is not executing the safety management tasks
- Does not accept platform safety as his responsibility
- Does not initiate interventions.
- Is not instructed otherwise by platform supervisor
- Limited analysis of out-of-scope disturbances
CURRENT CONTROL STRUCTURE & POTENTIAL FLAWS

Legend:
A. Sensor
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F. Out of range disturbances
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SUMMARY OF CONTROL LOOP EFFECTIVENESS

2010: Poor

• Platform coordinator is not executing the safety management tasks
• Does not see platform safety as his responsibility
• Does not initiate interventions.
• Is not instructed by platform supervisor
• Limited analysis of out-of-scope disturbances

2013: Adequate

• Safety management control loop is vastly improved
• Responsibilities have been assigned
• Control actions are effectuated.
• However, Q&S Department in staff role
• Does not hold executive rights
• Limited analysis of out-of-scope disturbances
SAFETY PERFORMANCE
COMPARISON OF SAFETY PERFORMANCE

2010: Poor

• Two damages to customer aircraft requiring major repairs,
• A separation loss for Schengen and non-Schengen passengers
• Number of significant safety audit findings from a client airline.

2013: Good

• High reporting rates of both risks and occurrences
• Zero incidents with damage or injury.
• Audit reports are without significant findings.
CONCLUSIONS
RELATION BETWEEN EFFECTIVENESS OF CONTROL LOOP AND SAFETY PERFORMANCE
ENHANCE SAFETY AT A GROUND SERVICE PROVIDER

• Retrospective (2010)
  • Poor safety management across all six control actions
  • Actions were taken only after several serious incidents

• Current situation
  • Safety management assigned to the Quality & Safety Department.
  • However, allocated a staff role, do not hold executive rights

• Future: plan to allocate safety role to line management
  • Redo analysis, take safety constraints into account
STAMP METHODOLOGY SLIGHTLY MODIFIED FOR MANAGEMENT CONTEXT AND CLARITY

Original
• Establish the system engineering foundation
  • Scope relevant losses, identify hazards, specify safety requirements
  • Describe the control structure
• Identify potentially unsafe control actions;
• Create safety requirements
• Determine how each potentially hazardous control action could occur.

Modified
1. Hazards and safety requirements
2. Functional control structure
3. Control actions (6 generic)
4. Allocation of safety requirements to components
5. Control loop effectiveness

Leveson (2013)
FURTHER RESEARCH

• Continued Research / application of STAMP to supervisory / management processes
  • Other Ground Service Company
  • NedTrain maintenance plant
  • EASA: oversight of SMS at maintenance service providers
  • Various smaller SME maintenance facilities
• Multi-agent modeling incorporating social interaction
  • Using current process state as a vector, and applying mathematics to model control loop
  • With Delft University of Technology & Free University Amsterdam
• Instability of control loop (time, gain issue)
• Alignment with work at MIT
DO TRY THIS AT HOME

- Paper and .ppt available
- Interested in testing this approach?
  ➤ Send me an email at rj.de.boer@hva.nl

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REFERENCES


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Professor of Aviation Engineering
- Research into:
  - Lean maintenance
  - Composite defect detection
  - Collaboration & supervision for aviation safety

Consultant / trainer
- Collaboration in socio-technical systems
- Engineering management / Systems engineering

Education:
- MSc HF in Aerospace Engineering (1988), Delft University of Technology
- PhD (2012), Delft University of Technology

Previous experience:
- Director of Engineering, Fokker Aerostructures
- Consultant A.T. Kearney
- Unilever Engineering
CONTROL THEORY 101
SIMPLE DIRECT FEEDBACK CONTROL

John

me presenting
SIMPLE DIRECT FEEDBACK CONTROL

Controller

Controlled Process
SIMPLE FEEDFORWARD CONTROL

Controller

Controlled Process
TRADITIONAL FEEDBACK CONTROL USING SENSORS AND ACTUATORS
FEEDBACK

- Feedback makes a system insensitive to
  - external disturbances
  - variations in its individual elements.
- **Without needing to understand the nature of the disturbances**

Astrom and Murray (2008)
ADVANTAGE OF FEEDBACK CONTROL: ROBUSTNESS TO UNCERTAINTY

Astrom and Murray (2008); mass =1000 – 3000 kg
DISADVANTAGES OF FEEDBACK

- Instability
- Measurement noise
- Added complexity
- Cost of sensing, computation and actuation

Astrom and Murray (2008)
FEEDBACK REQUIRES A SETPOINT

- **Target Volume**
  - **Setpoint**
  - **Controller**
    - **Actuator**
    - **Controlled Process**
  - **Sensor**
    - **Current Volume**
Feedback is limited to chosen parameters

Setpoint

Controller

Actuator

Sensor

Controlled Process

Volume

Volume Content Visuals...
FEEDBACK NEEDS TO BE CONVERTED TO AN APPROPRIATE CONTROL SIGNAL
EFFECT OF TIME PRESSURE

ARRIVAL RAMP WORKERS

- In time
- Too late

DEPARTURE VERSUS ARRIVAL

- Arrival
- Departure
EFFECT OF FATIGUE

11:30-12:00  Rest of the day

0%  5%  10%  15%  20%  25%  30%
EFFECT OF BAD WEATHER

FOD check not performed

Fuel process not monitored properly
# POOR CONTROL LOOP EFFECTIVENESS (2010)

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
<th>Positive:</th>
<th>Negative:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Set goals and direction</td>
<td>Aim to report as many risks and incidents as possible is well understood.</td>
<td>--</td>
</tr>
<tr>
<td>2</td>
<td>Establish work processes and standards</td>
<td>All employees know how to report risks and incidents</td>
<td>All employees know how to report incidents</td>
</tr>
<tr>
<td>3</td>
<td>Staff, schedule and train</td>
<td>All employees know how to report incidents</td>
<td>--</td>
</tr>
<tr>
<td>4</td>
<td>Manage facility and equipment</td>
<td>Reporting system and email always available</td>
<td>--</td>
</tr>
<tr>
<td>5</td>
<td>Allocate financial resources</td>
<td>Supervisor platform actually monitors reports of incidents.</td>
<td>--</td>
</tr>
<tr>
<td>6</td>
<td>Monitor and evaluate performance</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

1A Sensor
**VERIFICATION MATRIX (2010)**

<table>
<thead>
<tr>
<th>Error 1D Control Algorithm</th>
<th>task 1 Set goals and direction</th>
<th>task 2 Establish work processes and standards</th>
<th>task 3 Staff, schedule and train</th>
<th>task 4 Manage facility and equipment</th>
<th>task 5 Allocate financial resources</th>
<th>task 6 Monitor and evaluate performance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Negative: The platform coordinator does not see platform safety as his responsibility and does not initiate interventions.</td>
<td>Negative: The platform coordinator does not see the an intervention to improve compliance to safety procedures as his responsibility</td>
<td>The platform coordinator understands how to intervene in case of resource mismatches</td>
<td>The platform coordinator does not initiate the management of facility and equipment as his task</td>
<td>The platform coordinator does not have budget responsibility</td>
<td>The platform coordinator does not take initiatives to monitor platform safety</td>
</tr>
<tr>
<td>Error 1E Actuator</td>
<td>task 1 Set goals and direction</td>
<td>task 2 Establish work processes and standards</td>
<td>task 3 Staff, schedule and train</td>
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<td>---------------------------------------------</td>
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<td>---------------------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>N/A</td>
<td>N/A</td>
<td>Positive: The platform coordinator intervenes in case of resource mismatches Negative: --</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>
## VERIFICATION MATRIX (2010)

<table>
<thead>
<tr>
<th>Error F Out of Range process</th>
<th>task 1 Set goals and direction</th>
<th>task 2 Establish work processes and standards</th>
<th>task 3 Staff, schedule and train</th>
<th>task 4 Manage facility and equipment</th>
<th>task 5 Allocate financial resources</th>
<th>task 6 Monitor and evaluate performance</th>
</tr>
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<tr>
<td>Negative: The platform coordinator does not prepare for out of range disturbances</td>
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<td>Monitor and evaluate performance</td>
</tr>
</tbody>
</table>

| Error 1G Cognitive Resistance | Positive: -- Negative: The platform coordinator does not see platform safety as his responsibility and does not react to signals of decaying safety margins | Positive: -- Negative: The platform coordinator does not see the creation of safety procedures as his responsibility | Positive: -- Negative: The platform coordinator does not see the training of safety procedures as his responsibility | Positive: -- Negative: The platform coordinator does not see the management of facility and equipment as his task | Positive: -- Negative: The platform coordinator does not have budget responsibility | Positive: -- Negative: The platform coordinator does not see monitoring platform safety as his responsibility |
