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USING STAMP TO IMPROVE PLATFORM SAFETY

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2014 STAMP Conference
March 27th, 2014
MIT, Cambridge, MA

CREATING TOMORROW

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CONTENTS

- Problem statement
- Theoretical foundation
- Research design
- Results:
  - Assessment of control loop effectiveness using STAMP
  - Safety Performance
- Conclusions

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PROBLEM STATEMENT

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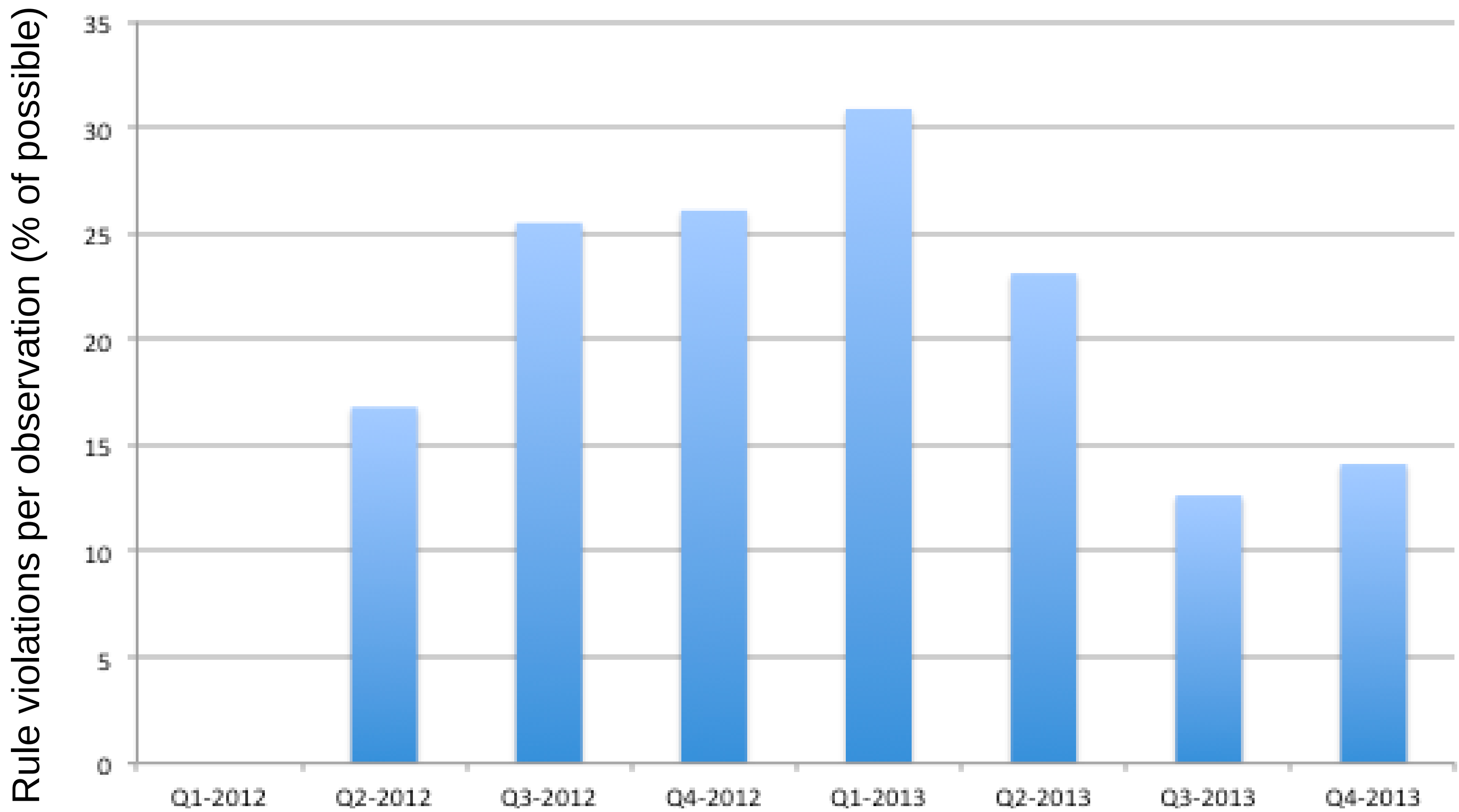
GROUND SERVICES EXECUTES AIRCRAFT TURN-AROUND

- Baggage Services
- Pushback and Towing
- Catering and Onboard Supply
- Cleaning
- Aircraft refueling
- Water and toilet services

HIGH NUMBER OF RULE VIOLATIONS



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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

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THEORETICAL FOUNDATION

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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"**

"Emergent behavior"

Dekker , Cilliers, Hofmeyr 2013; Cilliers 1998; Dekker, 2011, cited in Salmon, McClure, Stanton 2012

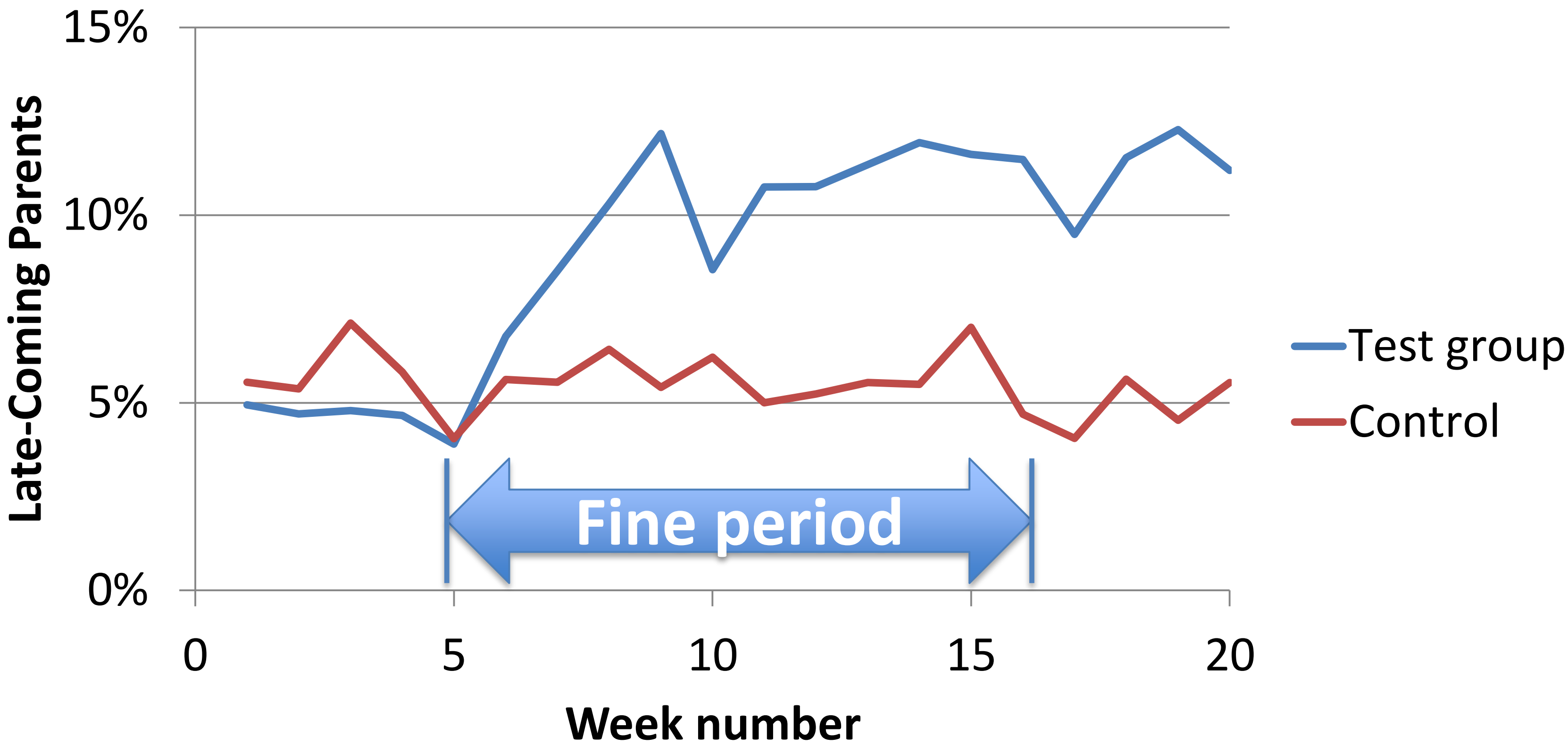
EXAMPLE OF EMERGENT BEHAVIOR: THE CASE OF THE LATE-COMING PARENTS

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

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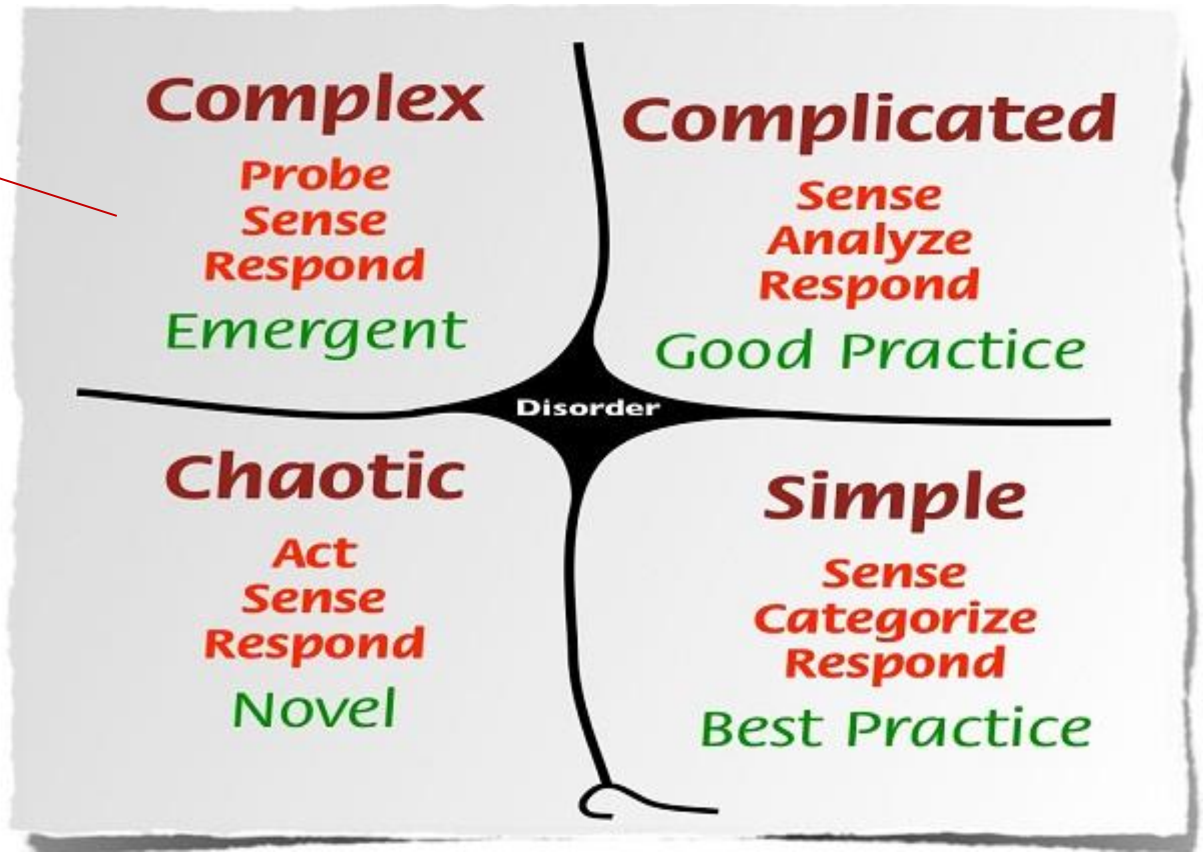
PROBING AND SENSING IS ESSENTIAL IN THE COMPLEX DOMAIN

The Cynefin framework

Probe by safe to fail experiments

Sense emerging patterns

Respond by amplifying or dampening



Snowden & Boone 2007

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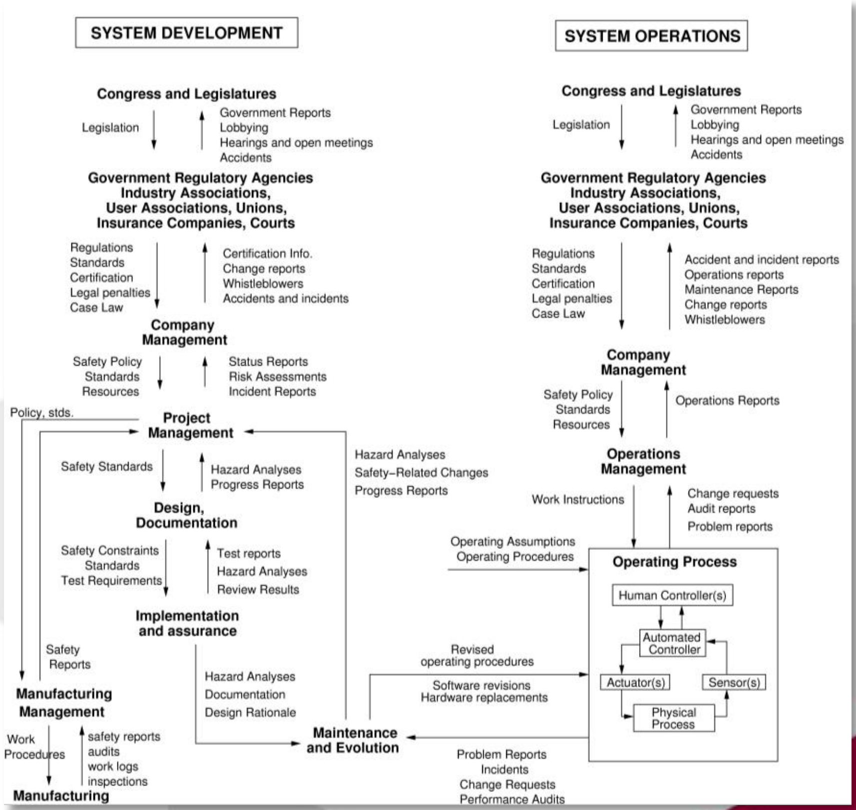
STAMP SEEMS A SUITABLE TOOL TO ASSESS SAFETY MANAGEMENT SYSTEMS

- 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 contraint with no / little consequence
- Therefore very little attention
- May be a precursor for a more serious incident at some future point in time

example

JUN2114

See also Dokas, Feehan and Imran (2013)

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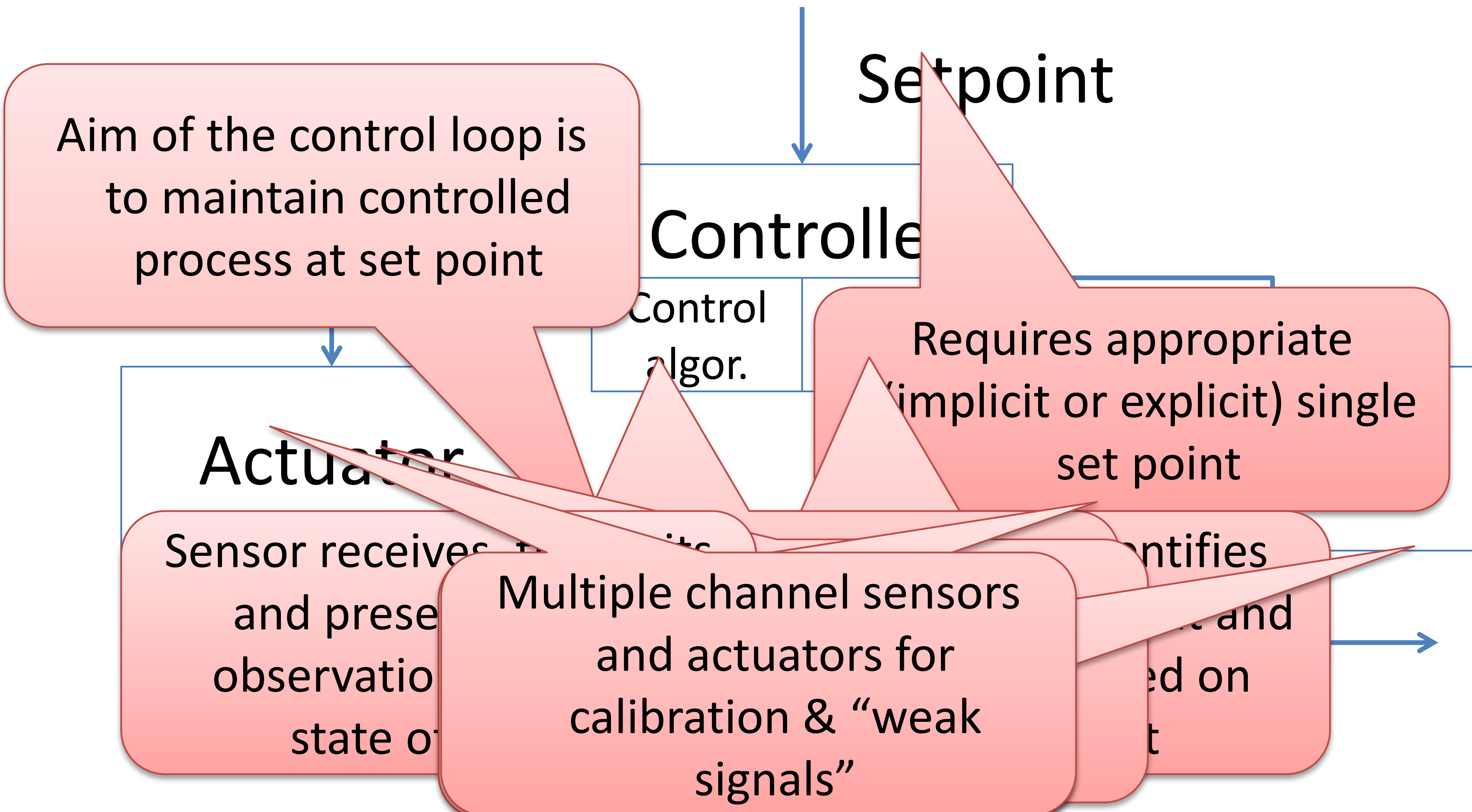
STAMP ASSUMES AN EFFECTIVE CONTROL LOOP TO ENFORCE SAFETY CONSTRAINTS



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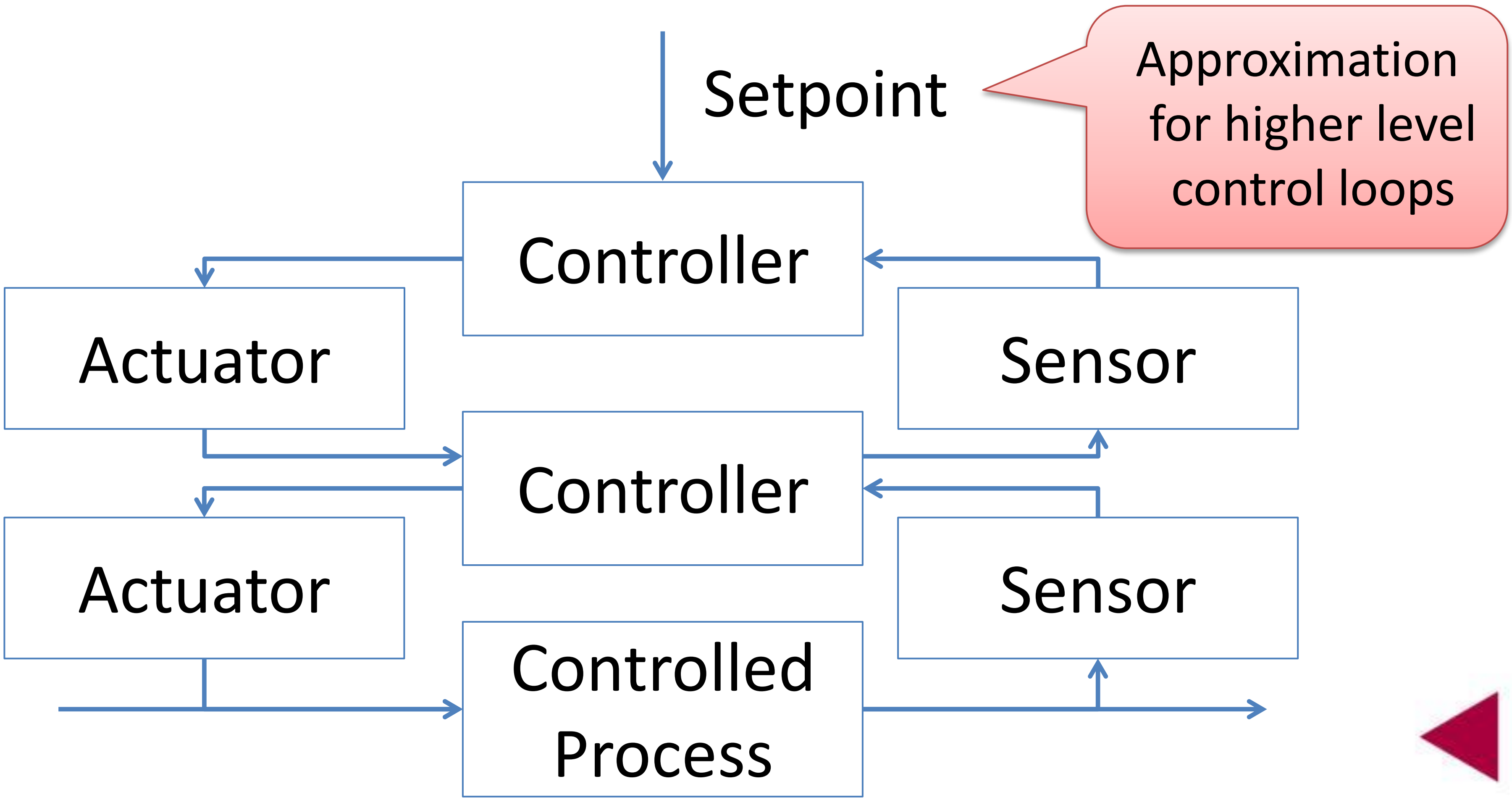
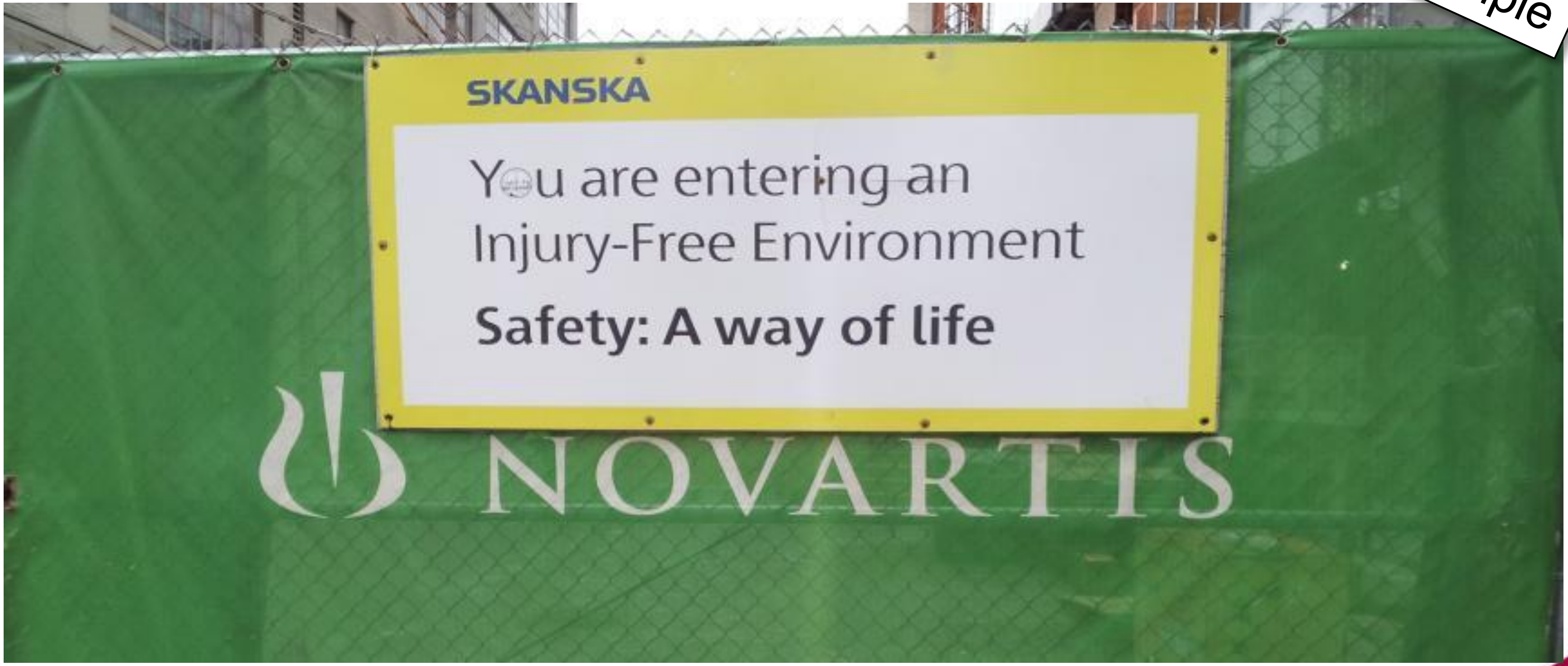
CONTROL STRUCTURE REFLECTS SCOPE OF INTEREST



STAMP DOES NOT EXCLUDE FEEDFORWARD

Example



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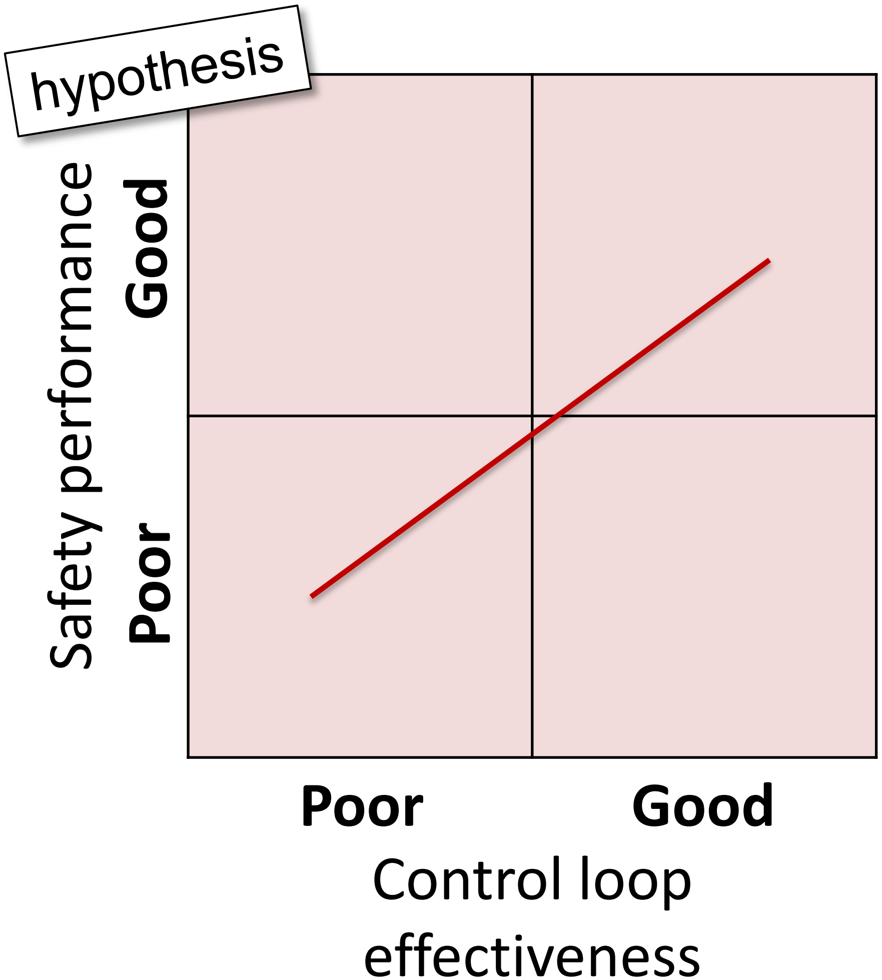
RESEARCH DESIGN

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)

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ASSESSMENT OF CONTROL LOOP EFFECTIVENESS USING STAMP

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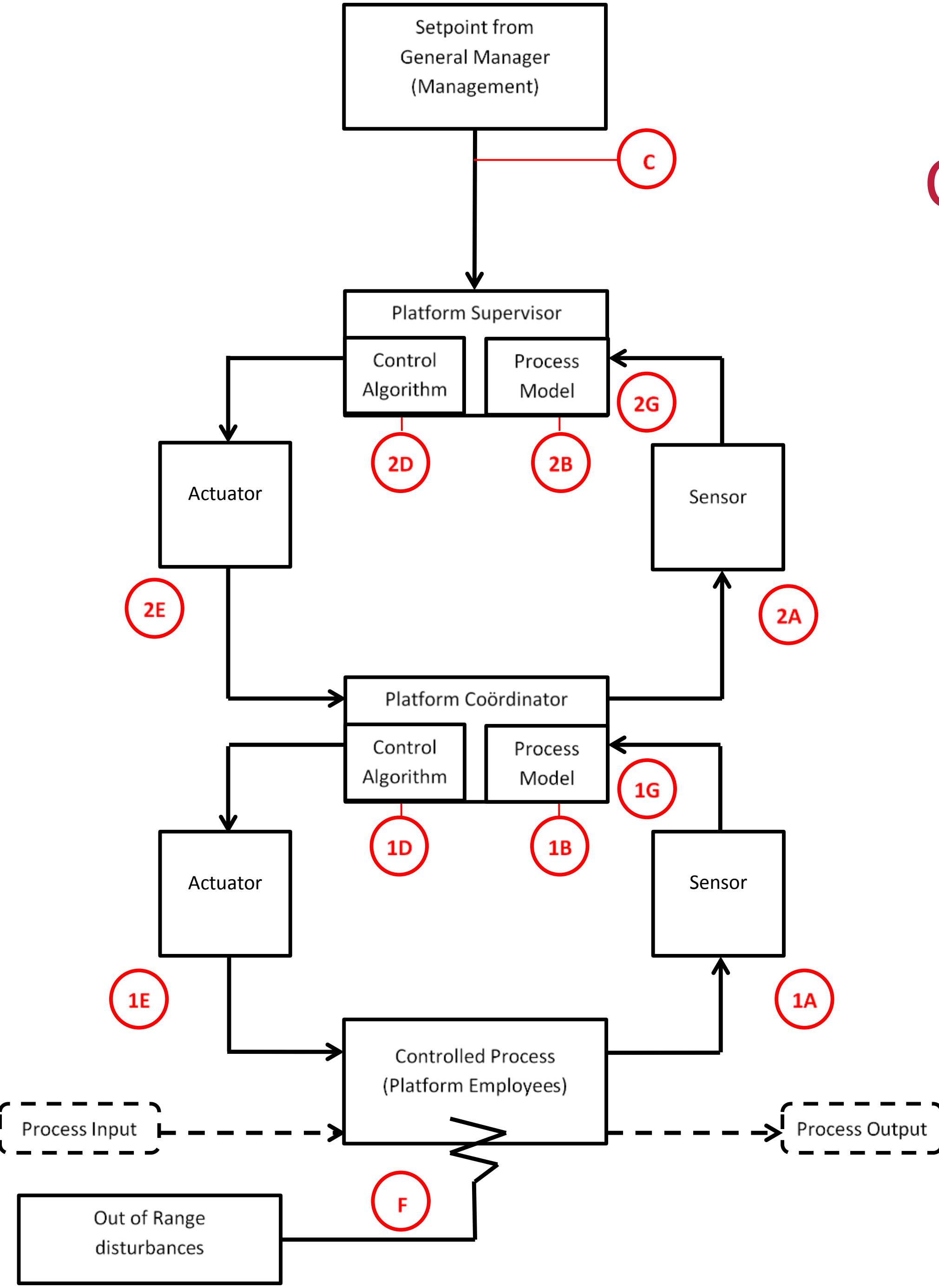
HAZARDS AND SAFETY CONSTRAINTS

- 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
6. Monitor and evaluate performance.

* As is everything else…

(Helferich 2013, Fayol 1949)

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ALLOCATION OF SAFETY REQUIREMENTS

Component	Allocated safety constraint
(Controlled Process)	(Compliant execution of process)
Sensor loop 1	Receival, transmission and presentation of compliancy of process to Platfom coordinator
Process Model loop 1	Platfom coordinator can identify gap between current and target compliancy based on information
Control Algorithm loop 1	Platfom coordinator can generate required control actions as a function of gap
Actuator loop 1	Receival, transmission and presentation of control signal at controlled process
Sensor loop 2	Receival, transmission and presentation of current state of platform coordinator to supervisor
Process Model loop 2	Supervisor can identify gap between current and target state of platform coordinator based on information
Control Algorithm loop 2	Platfom supervisor can generate required control actions as a function of gap
Actuator loop 2	Receival, transmission and presentation of control signal at platform coordinator
Set Point	Implicit or explicit target state(s) for platform coordinator process and process compliancy available

CONTROL LOOP EFFECTIVENESS TABEL

	Mgt task 1	Mgt task 2	…	Mgt task 6
LOOP 1				
Set Point				
Sensor				
Process model				
Control Algorithm				
…				
LOOP 2				
…				

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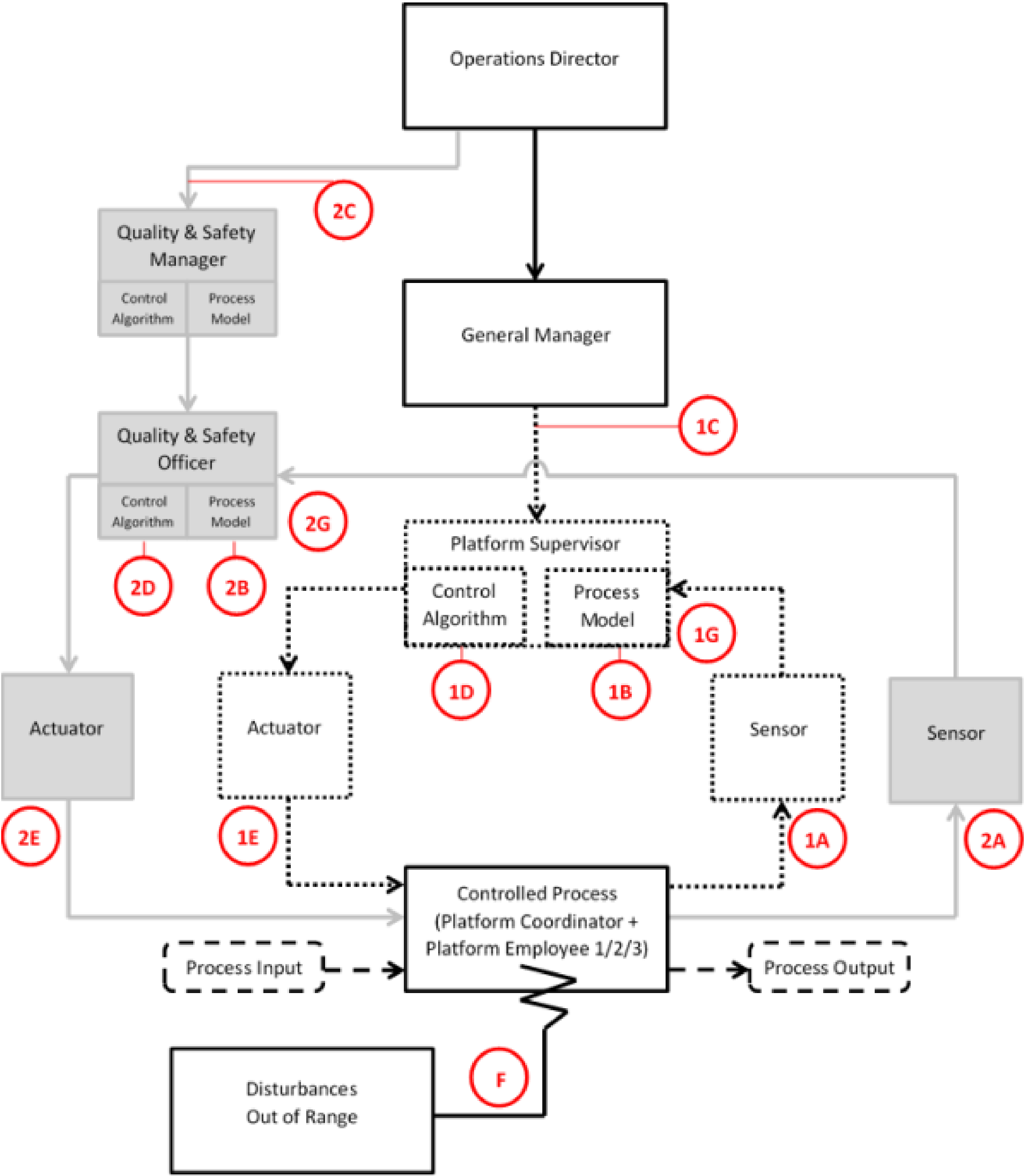
SUMMARY OF CONTROL LOOP EFFECTIVENESS

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
B. Process model
C. Setpoint
D. Control algorithm
E. Actuator
F. Out of range disturbances
G. Cognitive resistance

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

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SAFETY PERFORMANCE

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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

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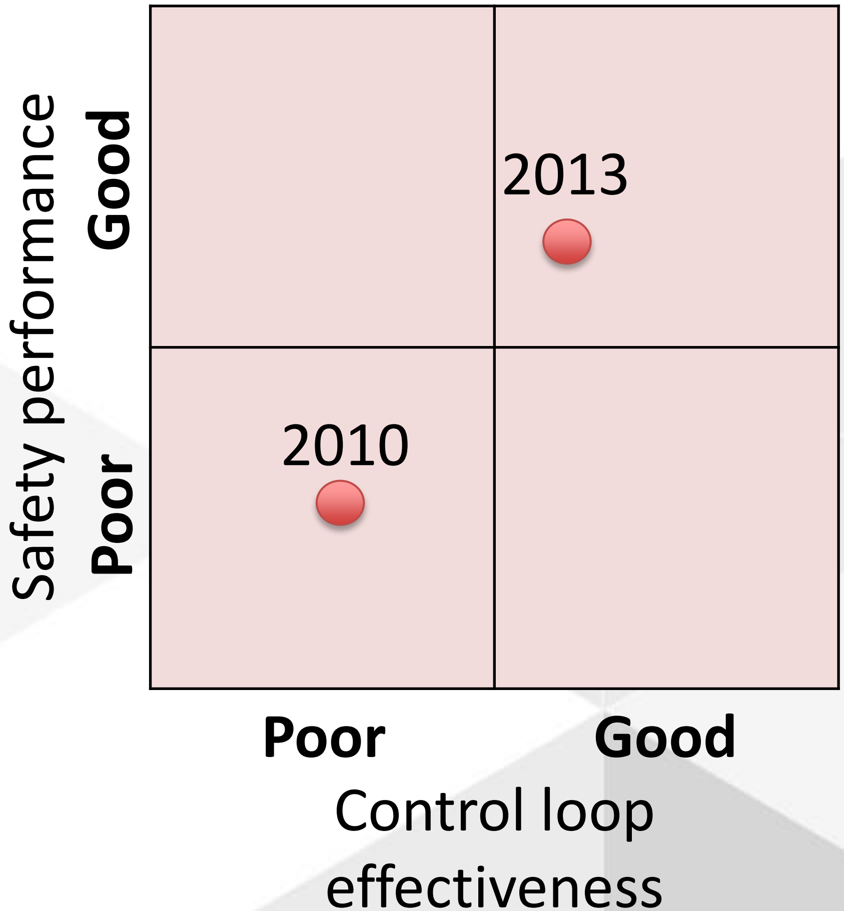
RELATION BETWEEN EFFECTIVENESS OF CONTROL LOOP AND SAFETY PERFORMANCE



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

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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)

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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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Professor of Aviation Engineering

- Research into:
  - Lean maintenance
  - Composite defect detection
  - Collaboration & supervision for aviation safety

Education:

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

Blue Wave Consulting Company
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Consultant / trainer

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

Previous experience:

- Director of Engineering, Fokker Aerostructures
- Consultant A.T. Kearney
- Unilever Engineering

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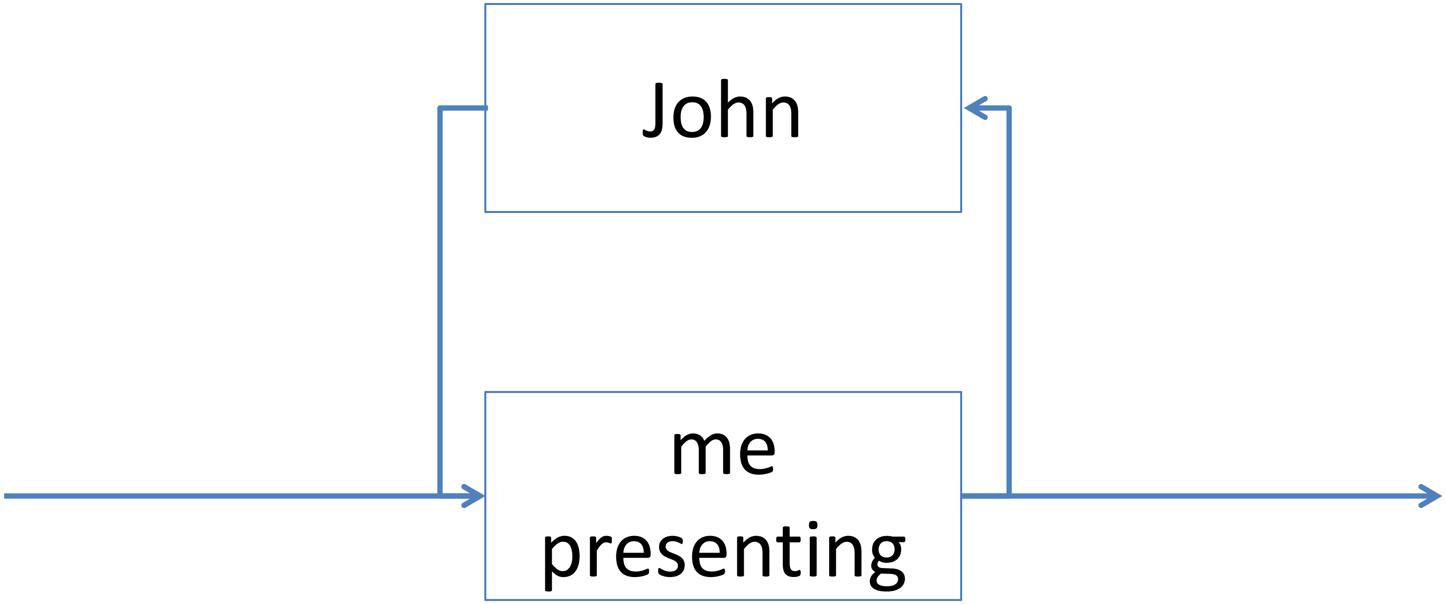
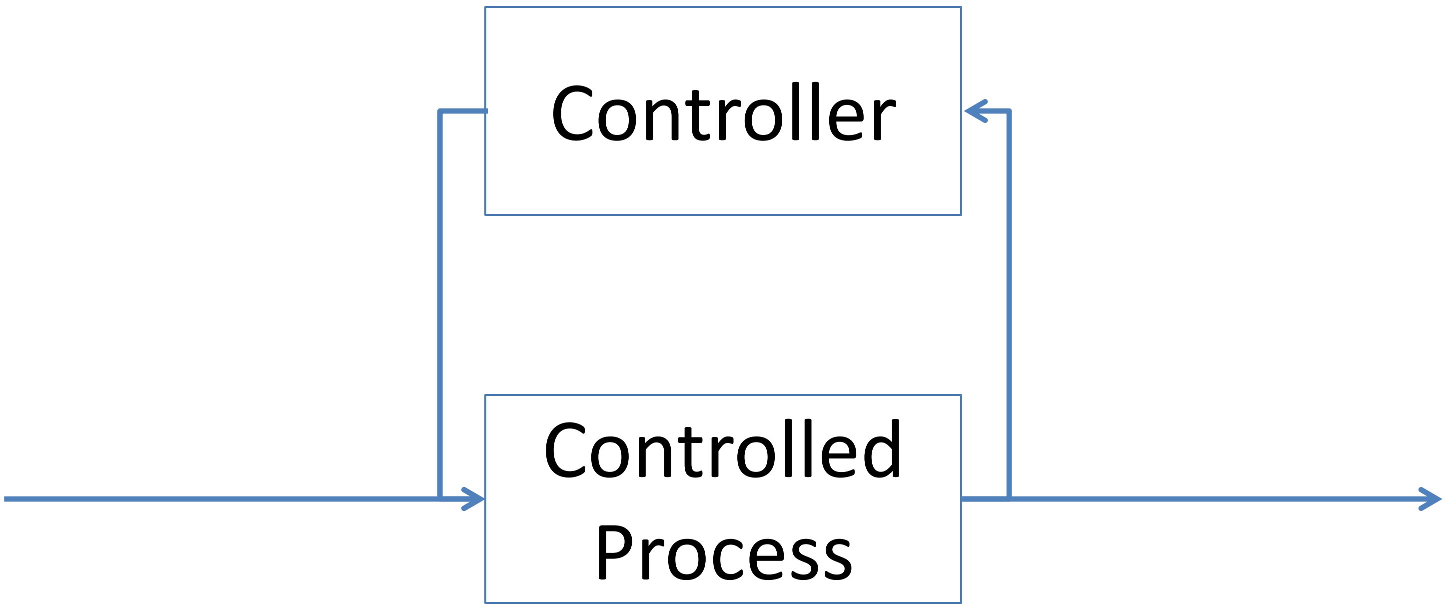
CONTROL THEORY 101

www.international.hva.nl

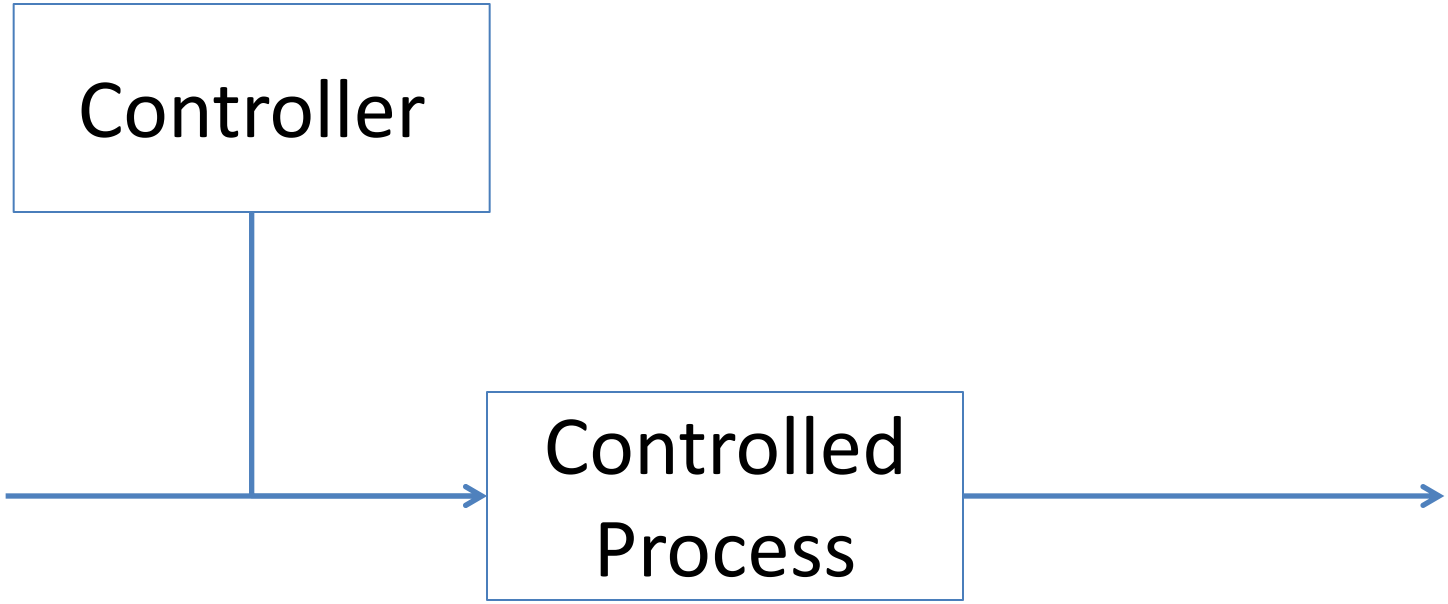
SIMPLE DIRECT FEEDBACK CONTROL



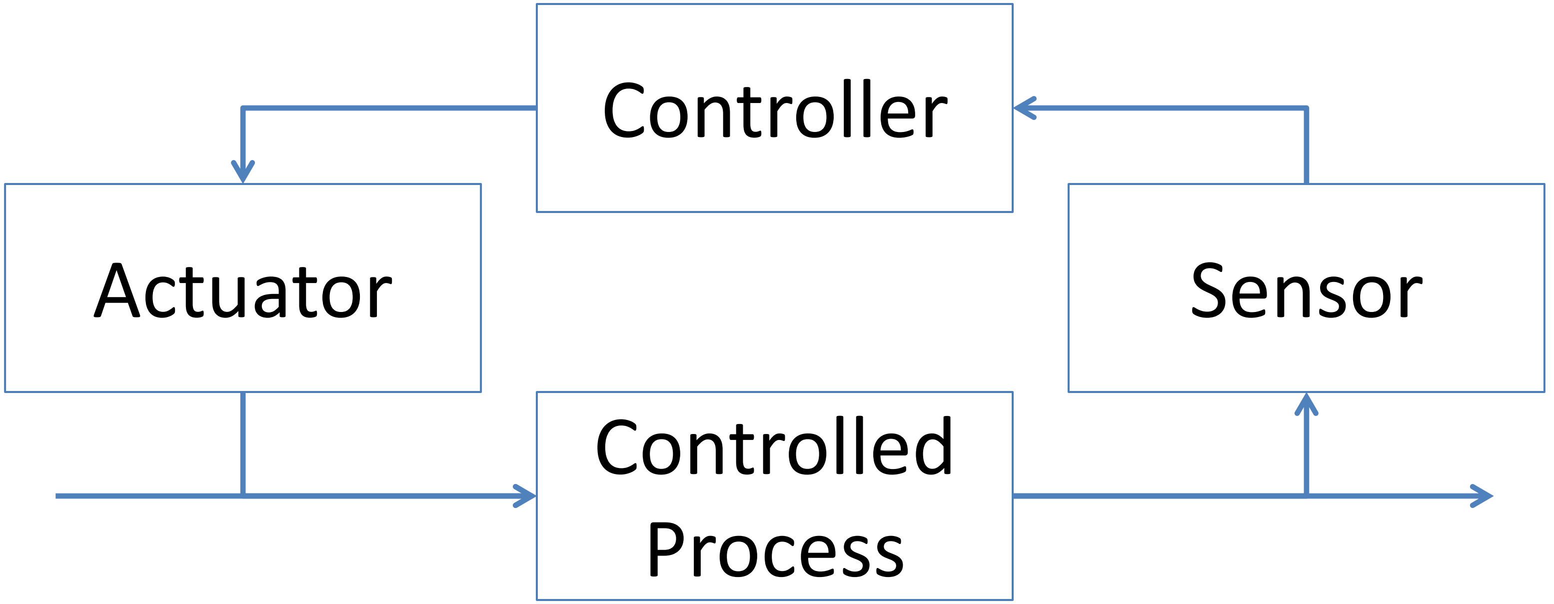
SIMPLE DIRECT FEEDBACK CONTROL



SIMPLE FEEDFORWARD CONTROL

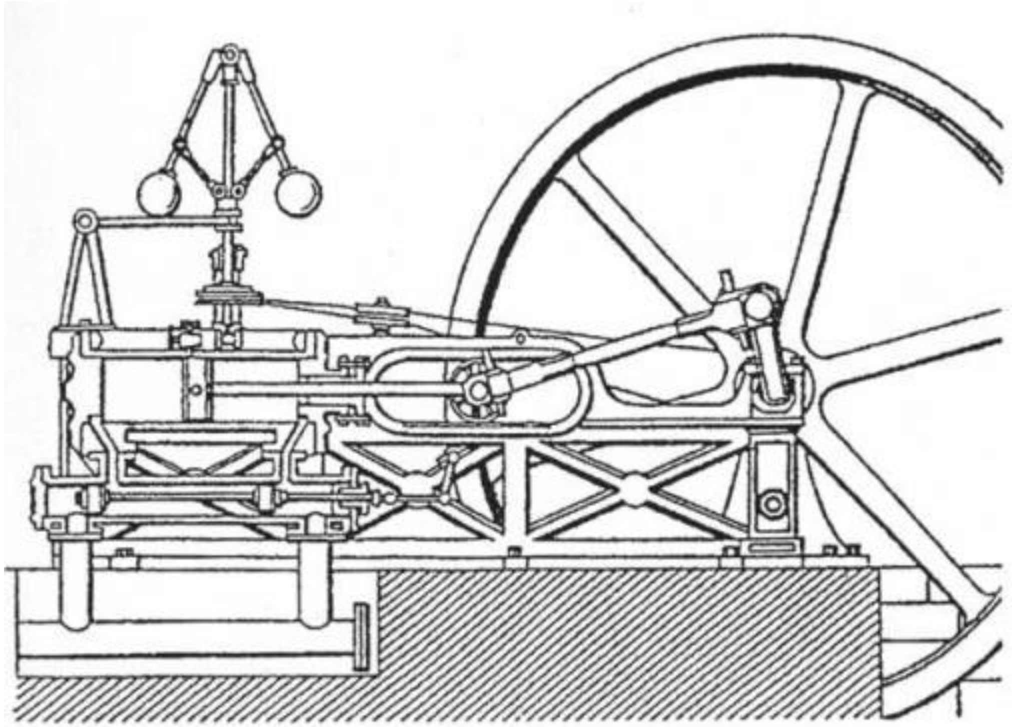


TRADITIONAL FEEDBACK CONTROL USING SENSORS AND ACTUATORS



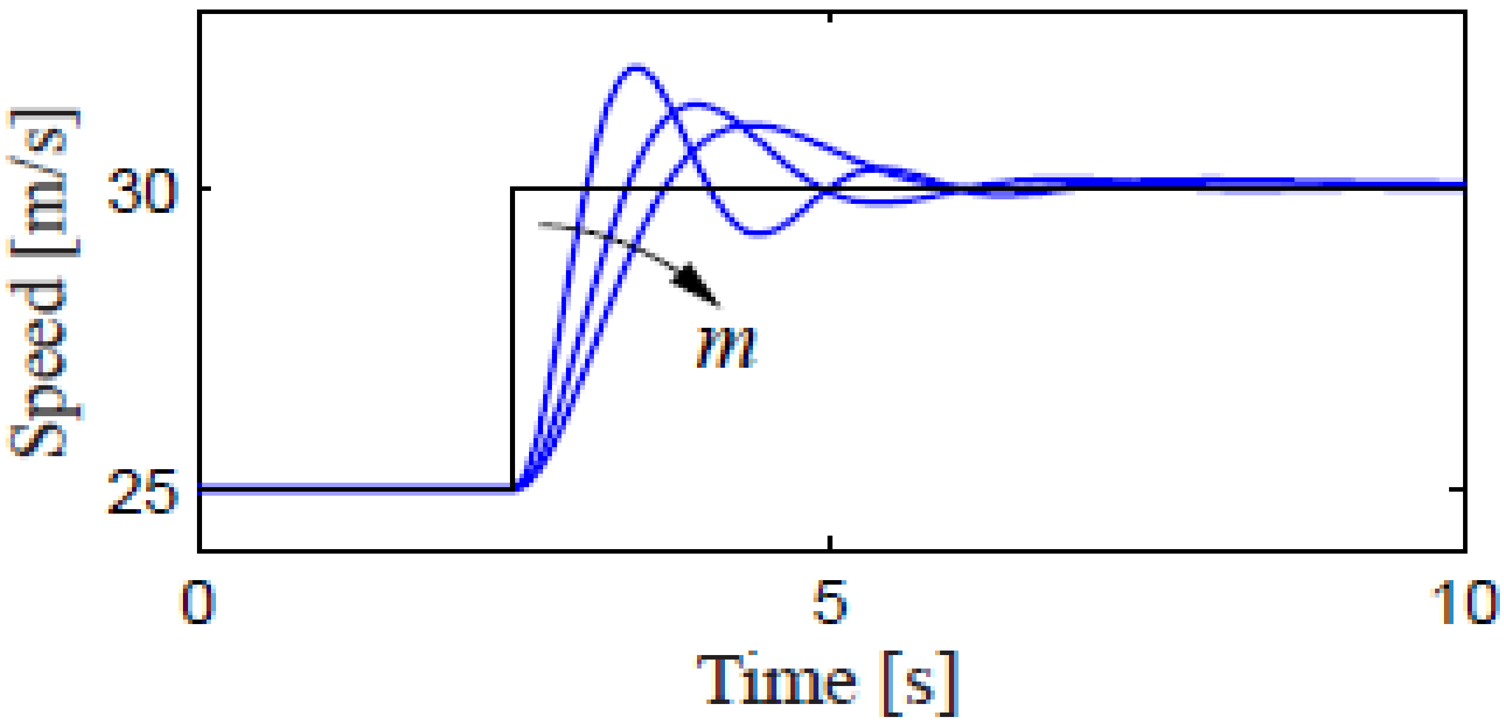
FEEDBACK

- 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



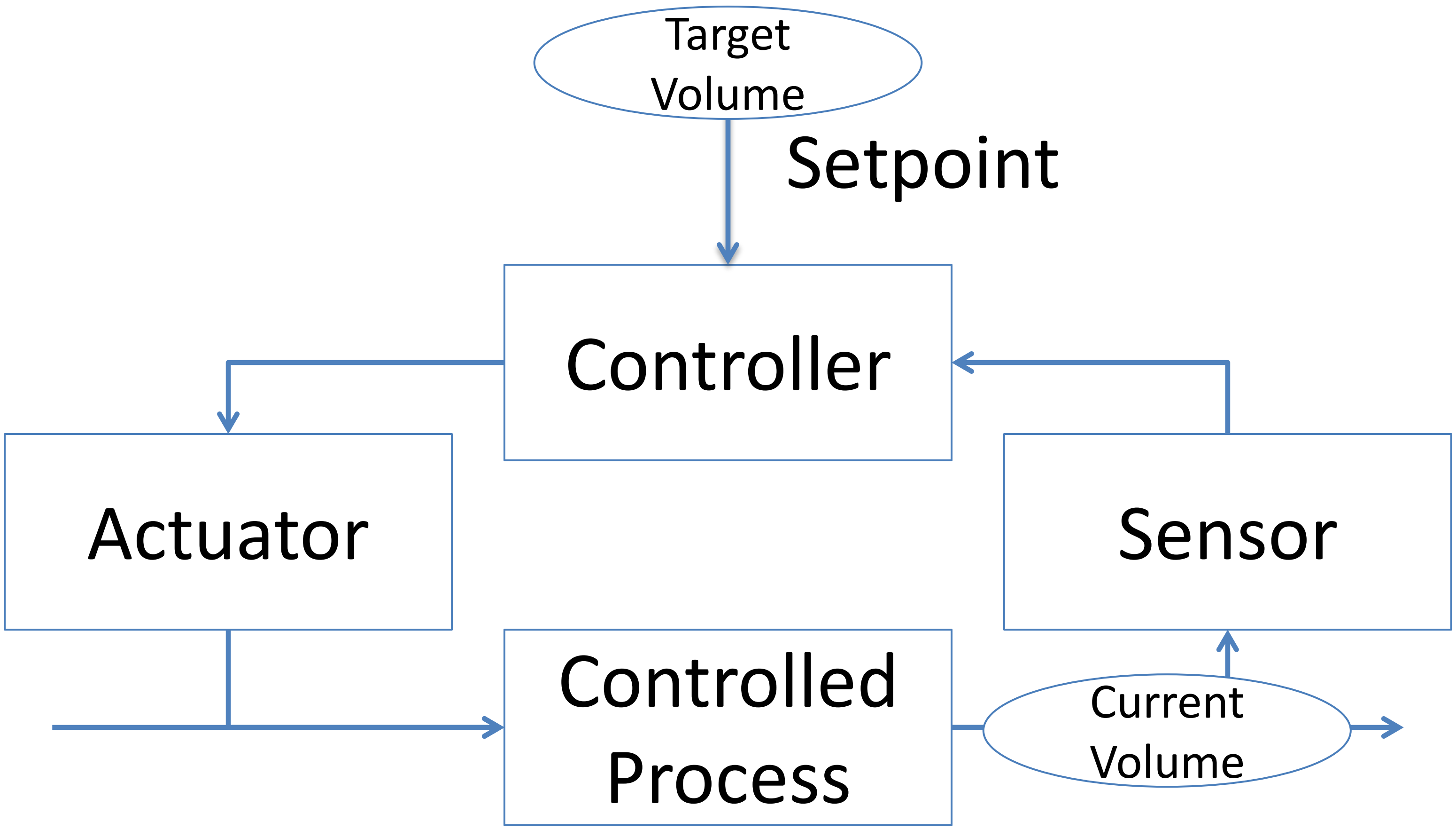
Astrom and Murray (2008); mass =1000 – 3000 kg

DISADVANTAGES OF FEEDBACK

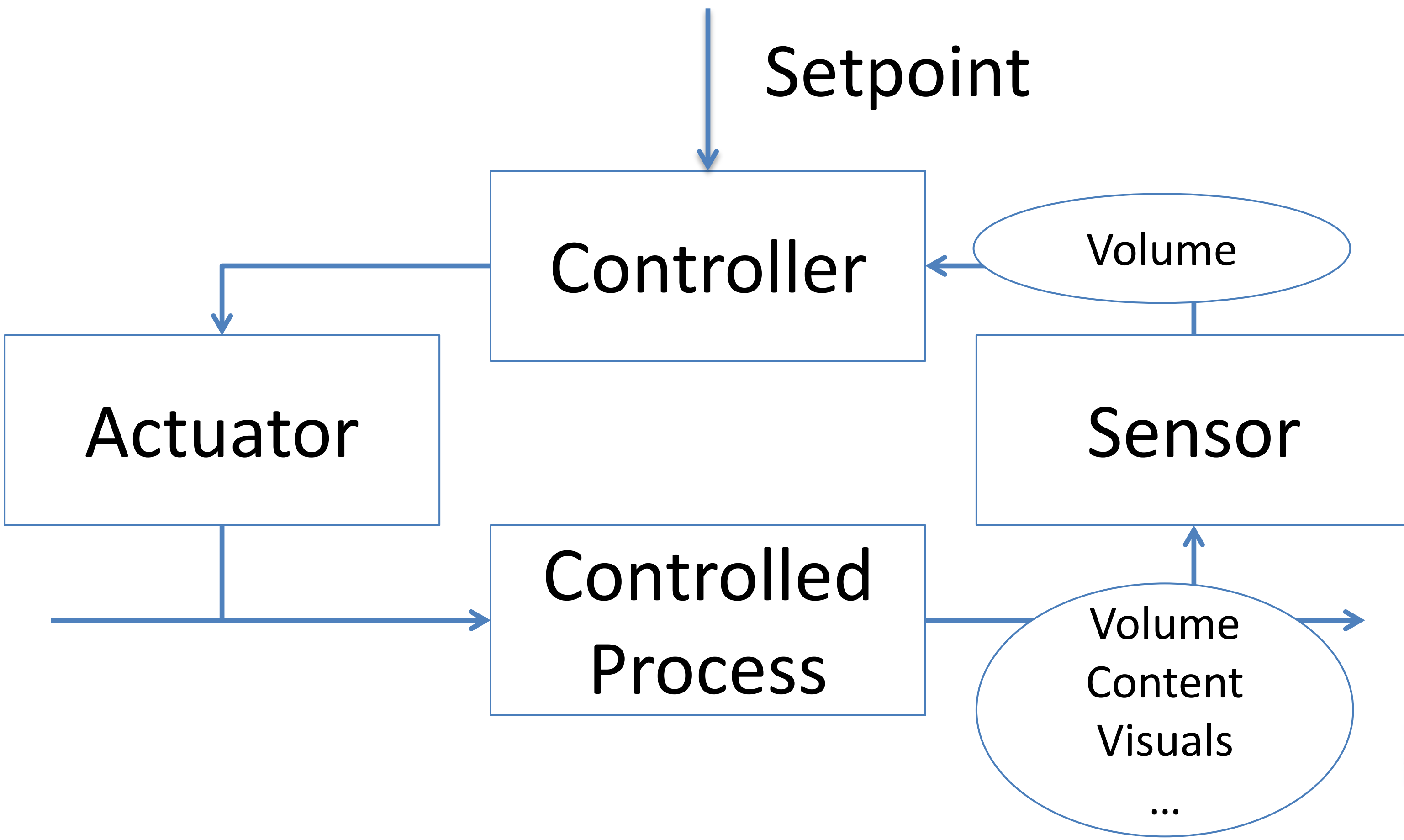
- Instability
- Measurement noise
- Added complexity
- Cost of sensing, computation and actuation

Astrom and Murray (2008)

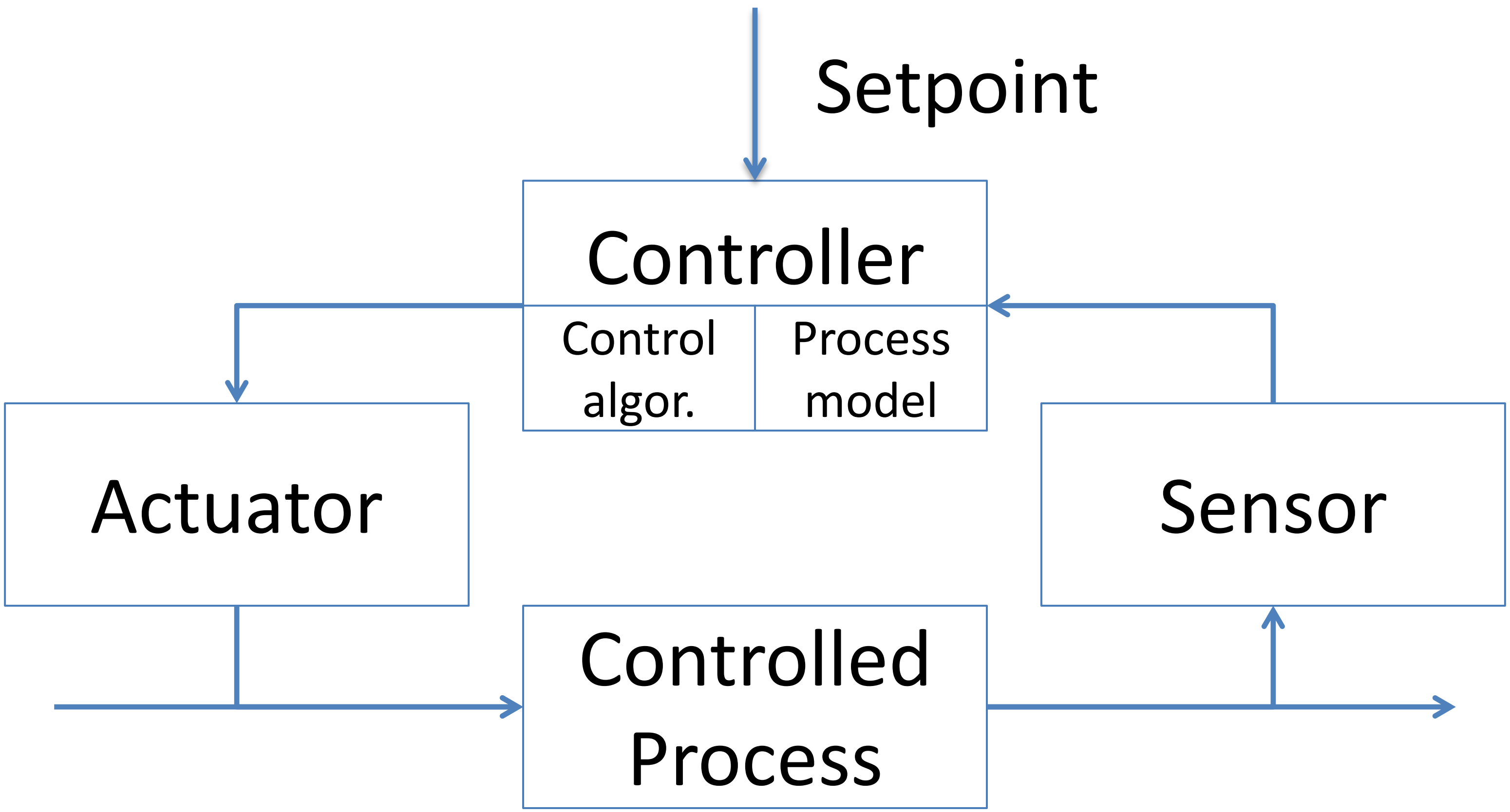
FEEDBACK REQUIRES A SETPOINT



FEEDBACK IS LIMITED TO CHOSEN PARAMETERS



FEEDBACK NEEDS TO BE CONVERTED TO AN APPROPRIATE CONTROL SIGNAL



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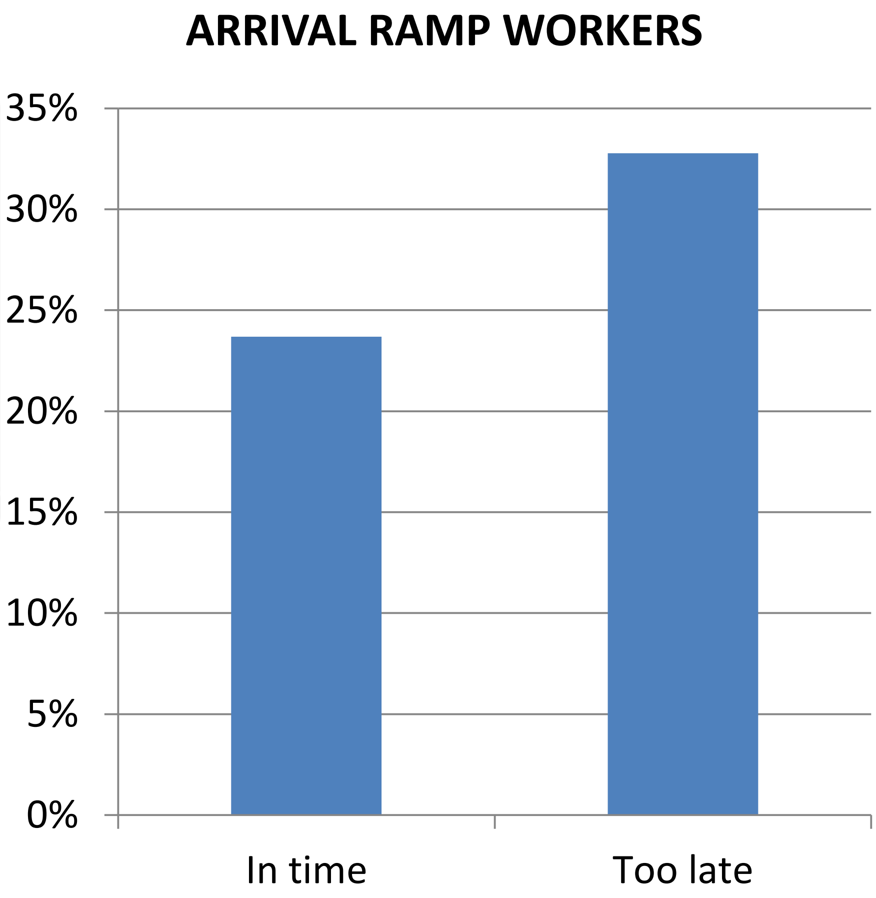
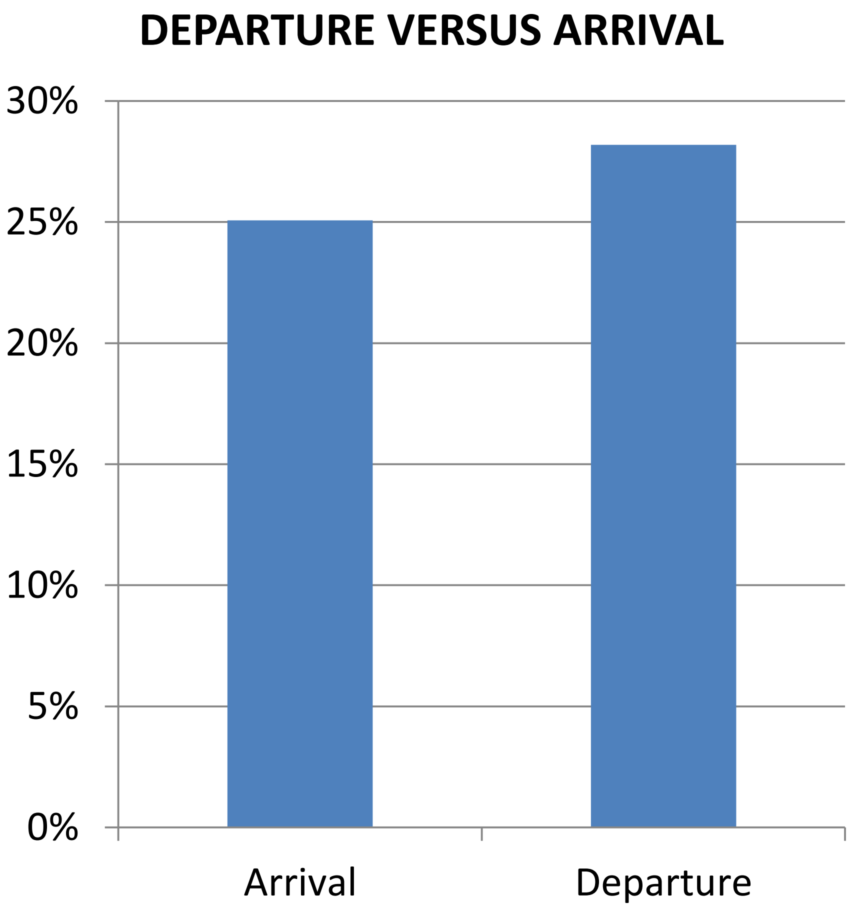
EFFECT OF TIME PRESSURE





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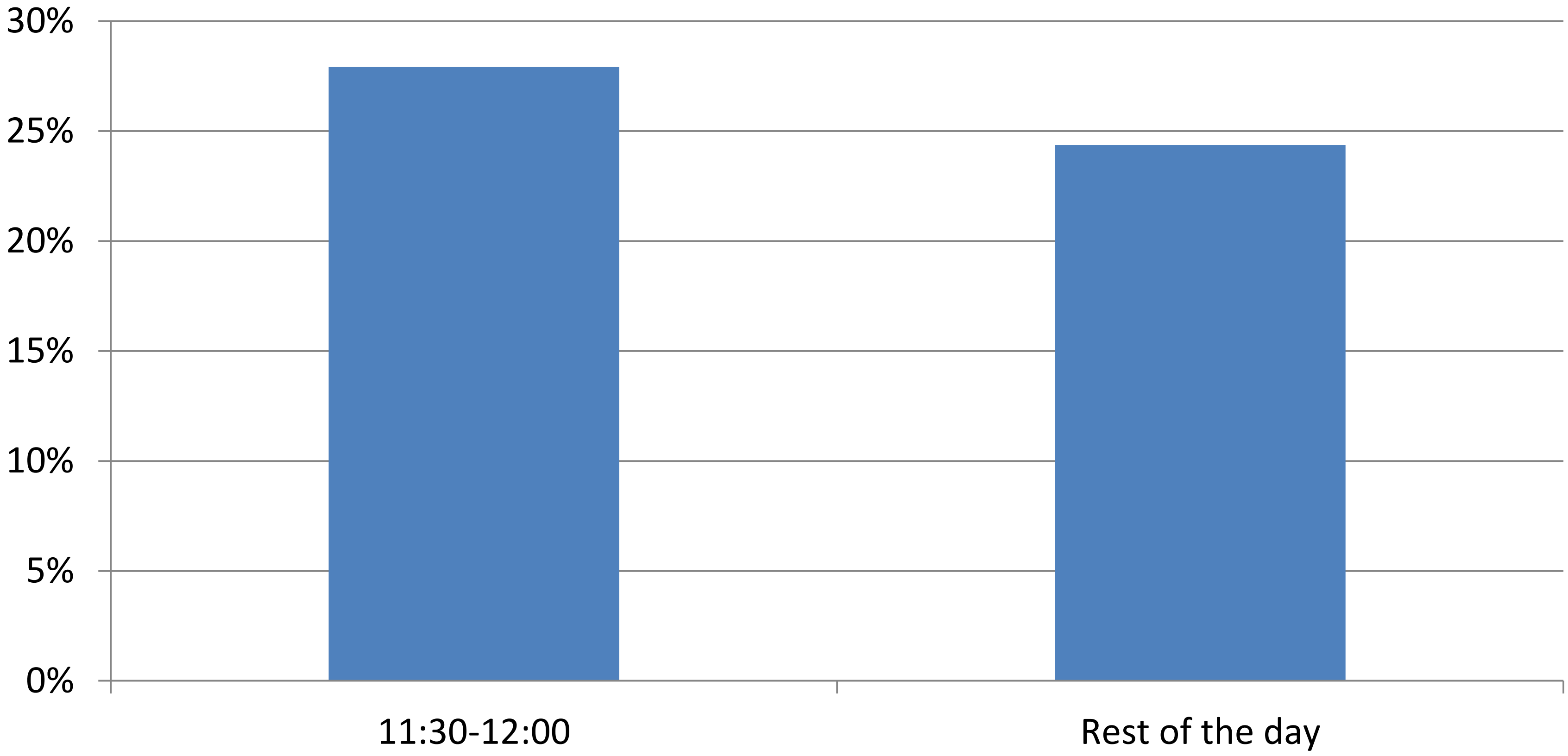
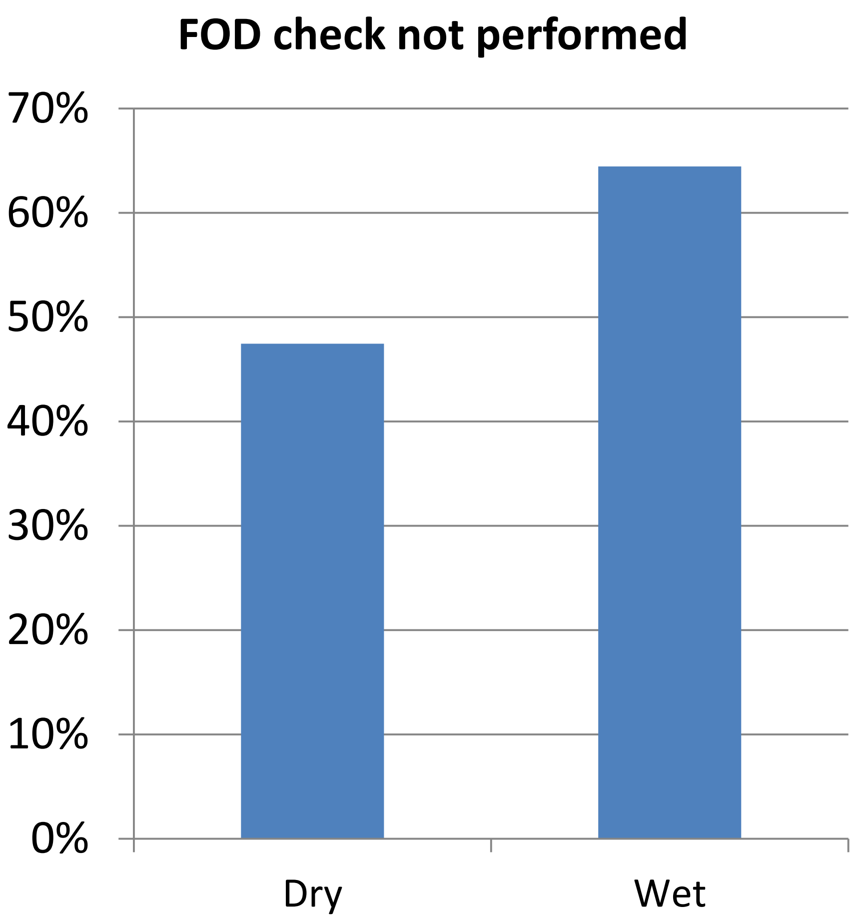
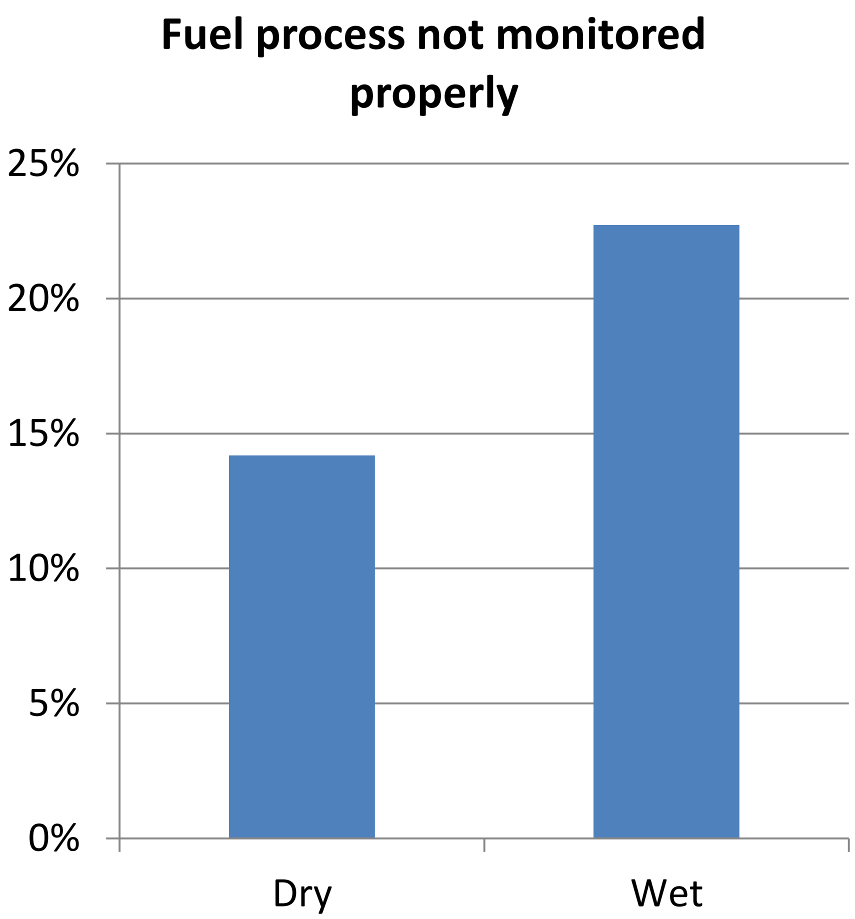
EFFECT OF FATIGUE



EFFECT OF BAD WEATHER





POOR CONTROL LOOP EFFECTIVENESS (2010)

	task 1 Set goals and direction	task 2 Establish work processes and standards	task 3 Staff, schedule and train	task 4 Manage facility and equipment	task 5 Allocate financial resources	task 6 Monitor and evaluate performance
1A Sensor	Positive: Aim to report as many risks and incidents as possible is well understood. Negative: --	Positive: All employees know how to report risks and incidents Negative: Reporting sometimes forgotten or ignored	Positive: All employees know how to report incidents Negative: There is not always sufficient time between flights to report, so that the incident is forgotten	Positive: Reporting system and email always available Negative: --	N/A	Positive: supervisor platform actually monitors reports of incidents. Negative: ..but he does not see the proactive (risk) reports

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VERIFICATION MATRIX (2010)

	task 1 Set goals and direction	task 2 Establish work processes and standards	task 3 Staff, schedule and train	task 4 Manage facility and equipment	task 5 Allocate financial resources	task 6 Monitor and evaluate performance
Error 1D Control Algorithm	Positive: -- Negative: The platform coordinator does not see platform safety as his responsibility and does not initiate interventions.	Positive: -- Negative: The platform coordinator does not see the an intervention to improve compliance to safety procedures as his responsibility	Positive: The platform coordinator understands how to intervene in case of resource mismatches Negative: The platform coordinator does not initiate training of safety procedures	Positive: -- Negative: The platform coordinator does not initiate 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 take initiatives to monitor platform safety

VERIFICATION MATRIX (2010)

	task 1 Set goals and direction	task 2 Establish work processes and standards	task 3 Staff, schedule and train	task 4 Manage facility and equipment	task 5 Allocate financial resources	task 6 Monitor and evaluate performance
Error 1E Actuator	N/A	N/A	Positive: The platform coordinator intervenes in case of resource mismatches Negative: --	N/A	N/A	N/A

VERIFICATION MATRIX (2010)

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

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CONTROL LOOP EFFECTIVENESS (2010)

	task 1 Set goals and direction	task 2 Establish work processes and standards	task 3 Staff, schedule and train	task 4 Manage facility and equipment	task 5 Allocate financial resources	task 6 Monitor and evaluate performance
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