Network Manager
nominated by
the European Commission

EUROCONTROL

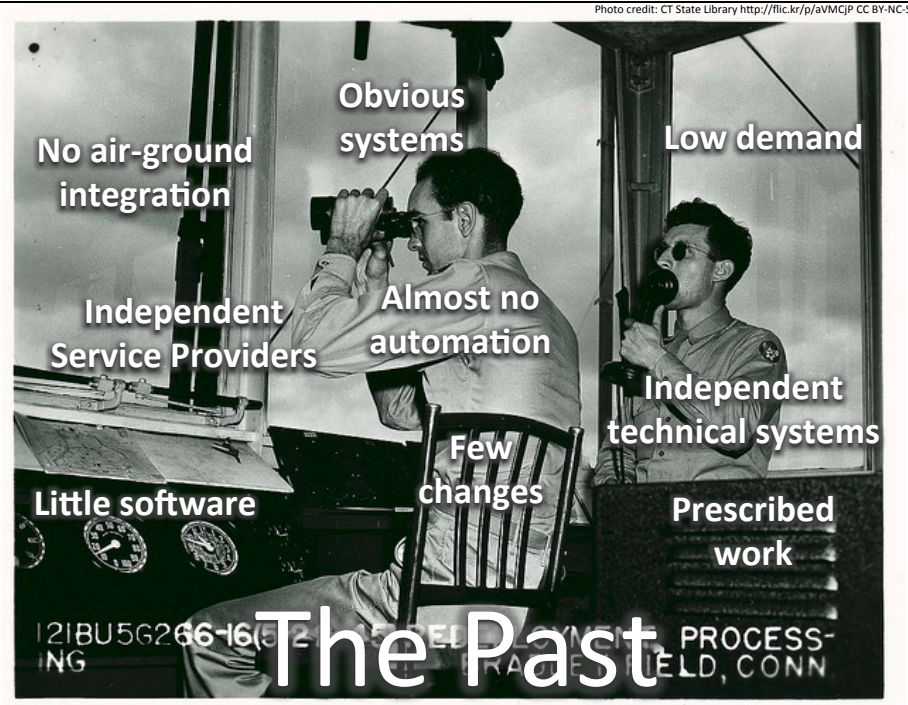
# Systems Thinking for Safety: Ten Principles

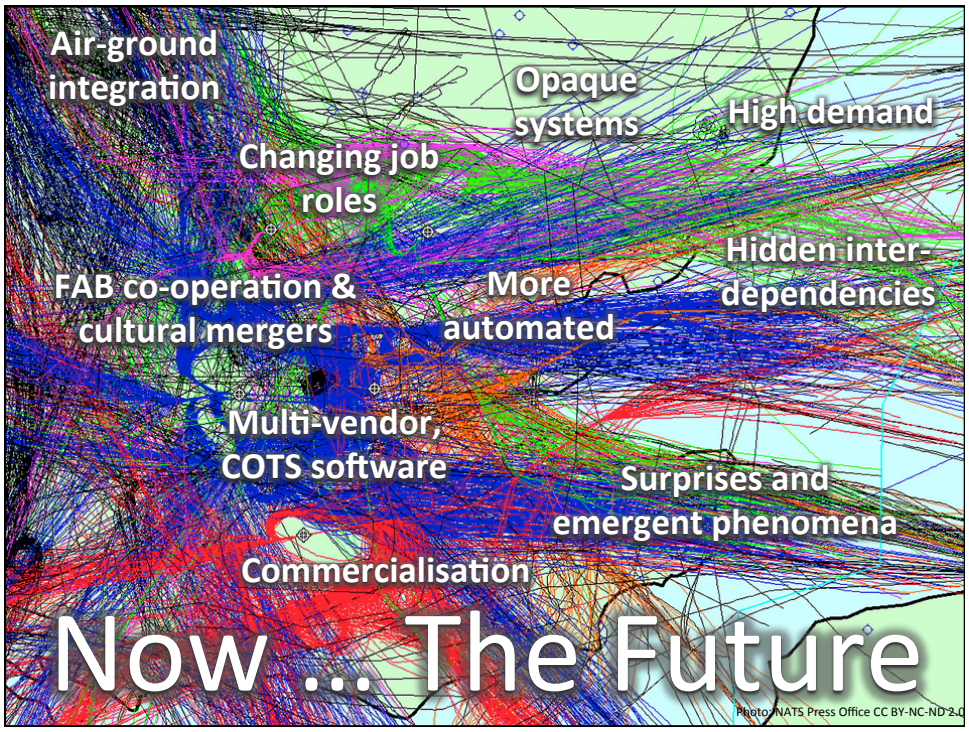
Moving toward Safety-II

Steven Shorrock

A EUROCONTROL Network Manager White Paper by:
Steven Shorrock, Jörg Leonhardt, Tony Licu & Christoph Peters








## Part 1: Safety-I & Safety-II

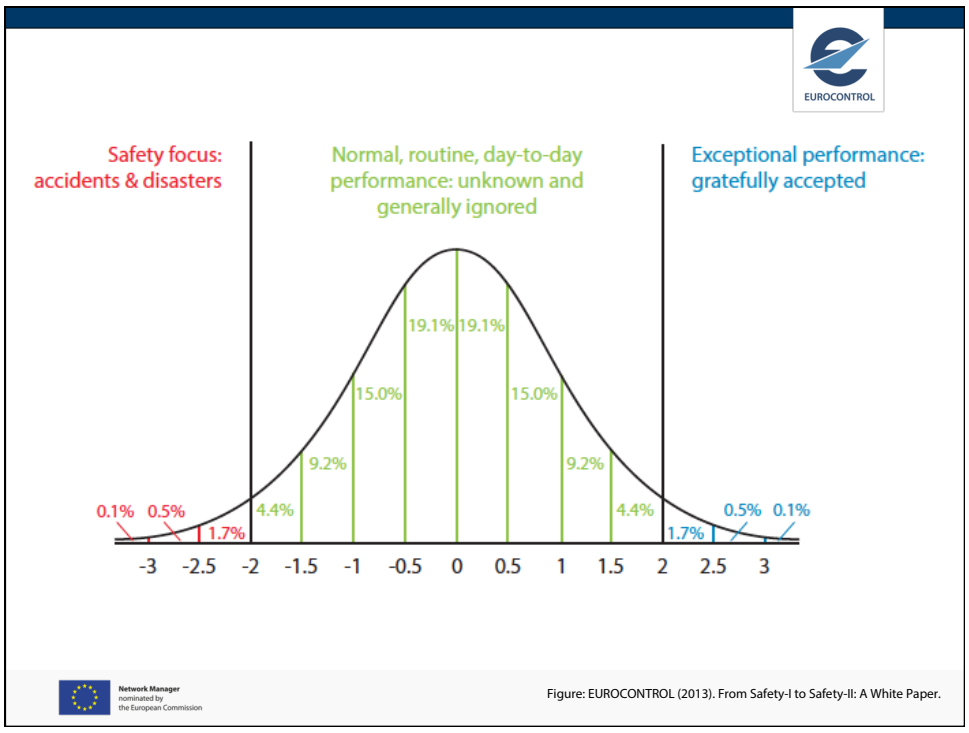
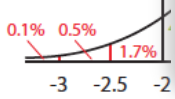




Figure: EUROCONTROL (2013). From Safety-I to Safety-II: A White Paper.

Safety focus:
accidents & disasters

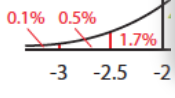



**"A way of seeing is also a way of not seeing — a focus upon object A involves a neglect of object B"**

Burke, K. (1984) *Permanence and Change.*

Network Manager
nominated by
the European Commission

Safety focus:
accidents & disasters



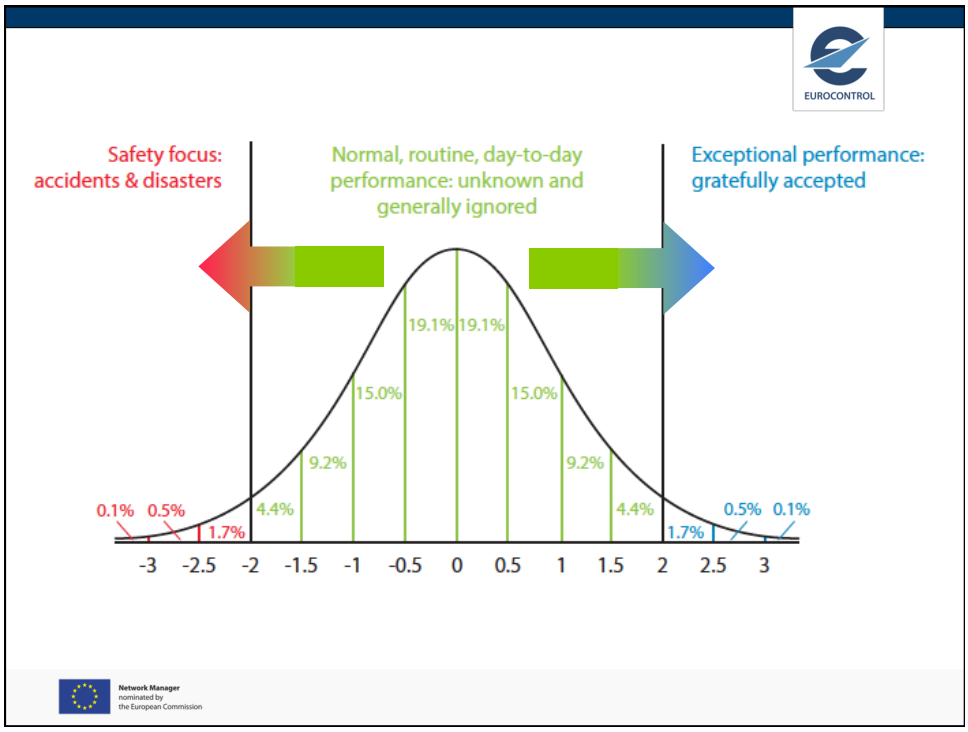


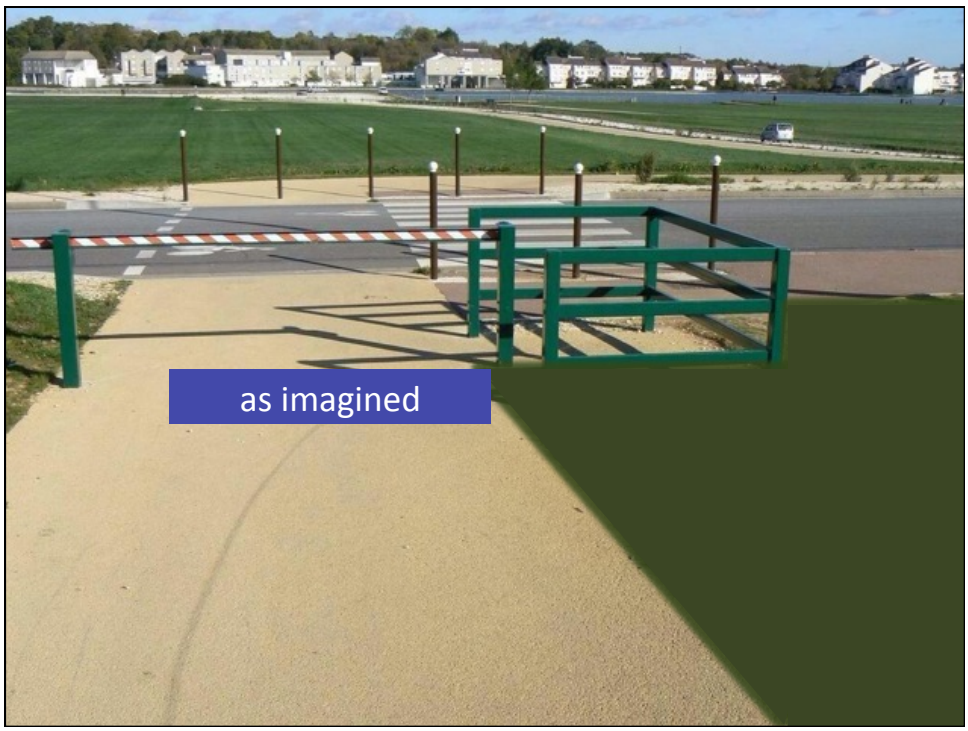
**Trained incapacity?**

**"state of affairs in which one's abilities serve as inadequacies or blind spots"**

Merton, R. (1984) *Social Theory and Social Structure.*
Photo: C. P. Storm https://flic.kr/p/fN4HC CC BY 2.0

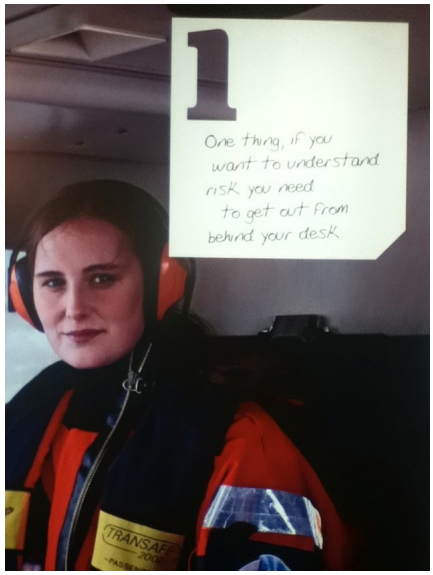
Network Manager
nominated by
the European Commission


EUROCONTROL
Safety focus: accidents & disasters
Normal, routine, day-to-day performance: unknown and generally ignored
Exceptional performance: gratefully accepted
0.1%
0.5%
1.7%
4.4%
9.2%
15.0%
19.1%
19.1%
15.0%
9.2%
4.4%
1.7%
0.5%
0.1%
-3 -2.5 -2 -1.5 -1 -0.5 0 0.5 1 1.5 2 2.5 3
Network Manager
nominated by
the European Commission

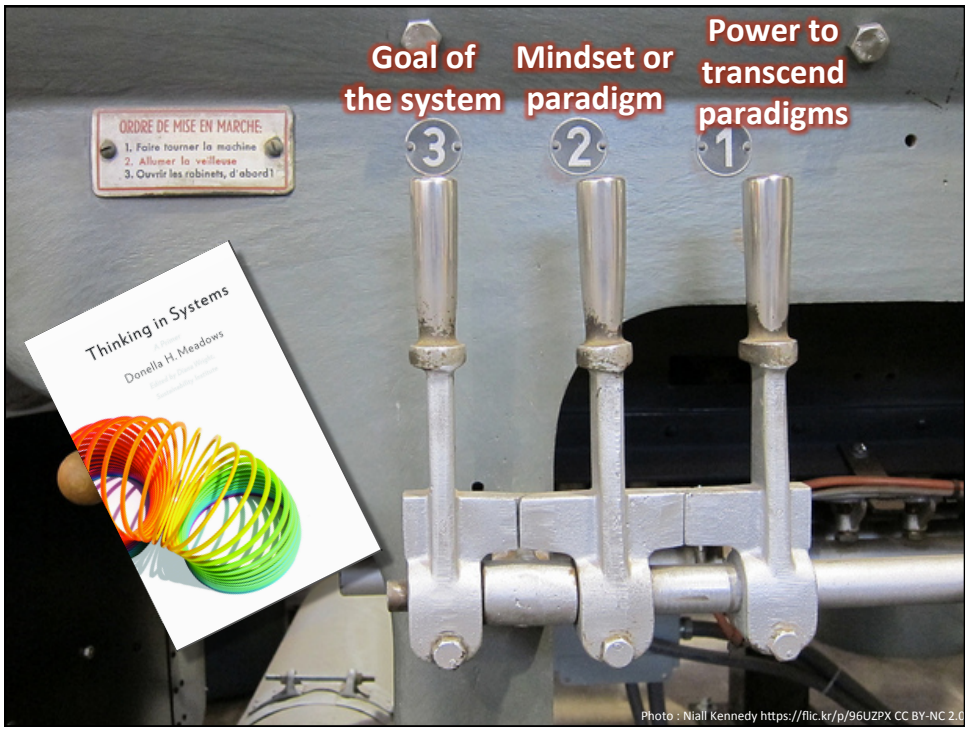

as imagined

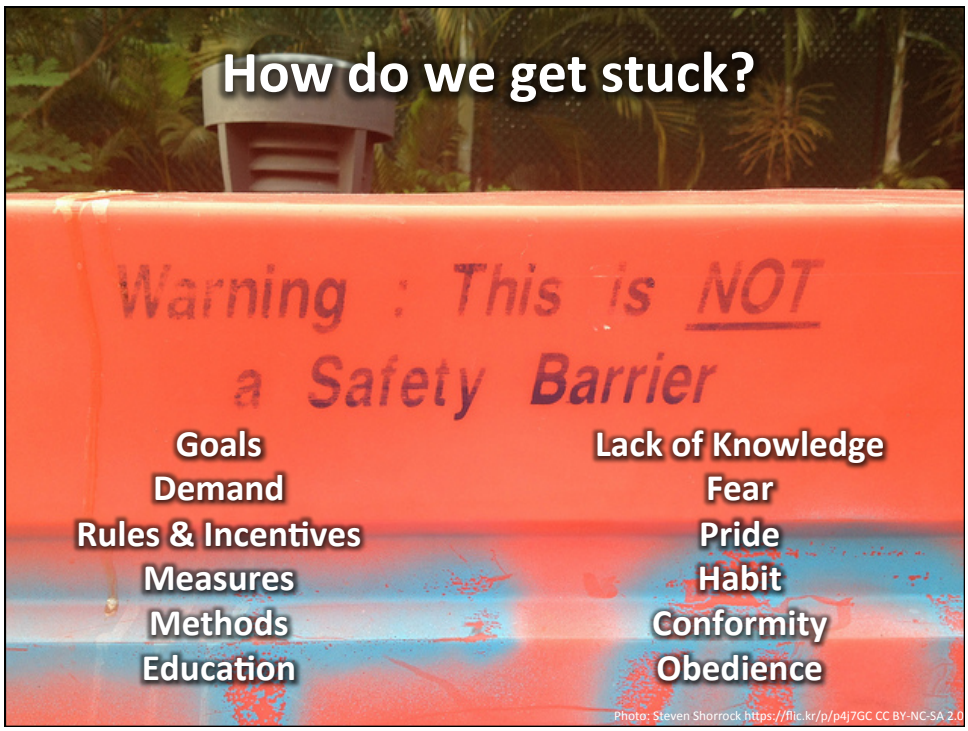
Allianz the insurer's view…

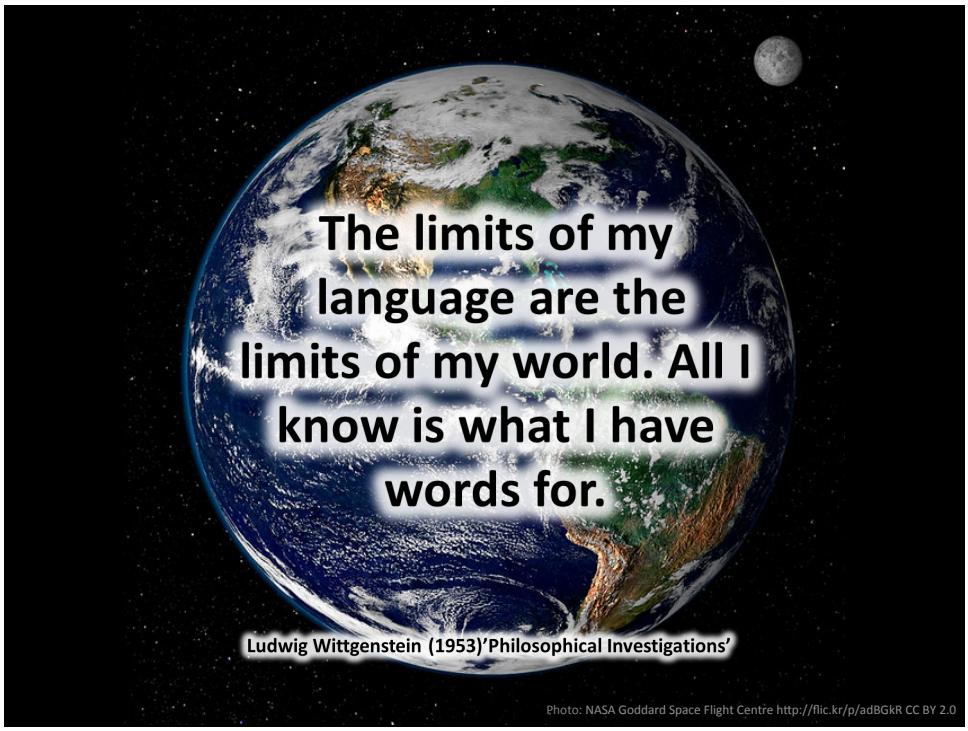
"One thing, if you want to understand risk you need to get out from behind your desk"

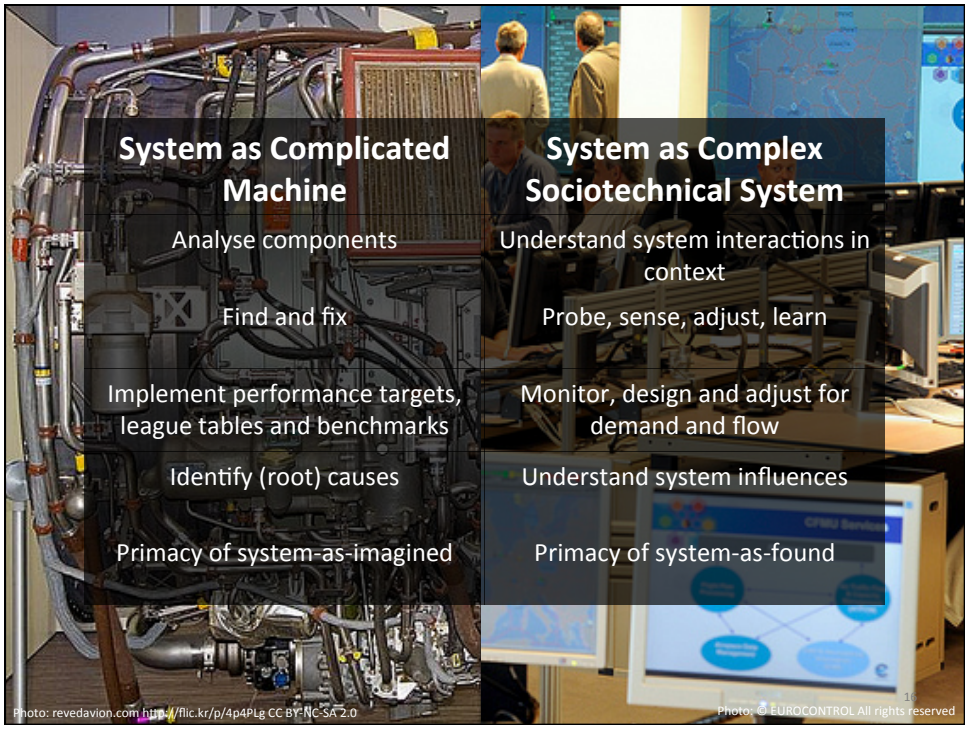



## Part 2: Perspectives on Systems

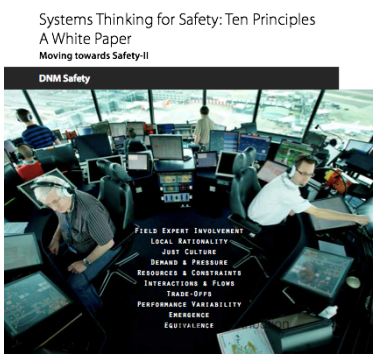

Goal of the system
3
Mindset or paradigm
2
Power to transcend paradigms
1
ORDRE DE MISE EN MARCHE:
1. Faire tourner la machine
2. Allumer la veilleuse
3. Ouvrir les robinets, d'abord!
Thinking in Systems
Donella H. Meadows
Photo : Niall Kennedy https://flic.kr/p/96UZPX CC BY-NC 2.0


How do we get stuck?
Warning : This is NOT a Safety Barrier
Goals
Demand
Rules & Incentives
Measures
Methods
Education
Lack of Knowledge
Fear
Pride
Habit
Conformity
Obedience
Photo: Steven Shorrock https://flic.kr/p/p4j7GC CC BY-NC-SA 2.0


The limits of my language are the limits of my world. All I know is what I have words for.
Ludwig Wittgenstein (1953)'Philosophical Investigations'
Photo: NASA Goddard Space Flight Centre http://flic.kr/p/adBGkR CC BY 2.0


System as Complicated Machine
Analyse components
Find and fix
Implement performance targets, league tables and benchmarks
Identify (root) causes
Primacy of system-as-imagined
System as Complex Sociotechnical System
Understand system interactions in context
Probe, sense, adjust, learn
Monitor, design and adjust for demand and flow
Understand system influences
Primacy of system-as-found
Photo: revedavion.com http://flic.kr/p/4p4PLg CC BY-NC-SA 2.0
Photo: © EUROCONTROL All rights reserved


# Part 3: Systems Thinking for Safety



**Purpose** To encourage a systems thinking approach to help make sense of – and improve – system performance

**Target audience** *All inclusive*: front line, specialists, managers, decision makers, regulators…

**Scope** Total system, primacy of real system


austro CONTROL

Belgocontrol

DFS Deutsche Flugsicherung

dgac

DSNA

ENAV

EUROCONTROL

HungaroControl Hungarian Air Navigation Services Pte. Ltd. Co.

NATS

NAV NAV-Portugal, E.P.E.

romatsa

Aprocta Asociación profesional de controladores de tránsito aéreo

IFATCA

IFALPA International Federation of Air Line Pilots' Associations

## Making sense of situations

How has the work been affected by performance targets?

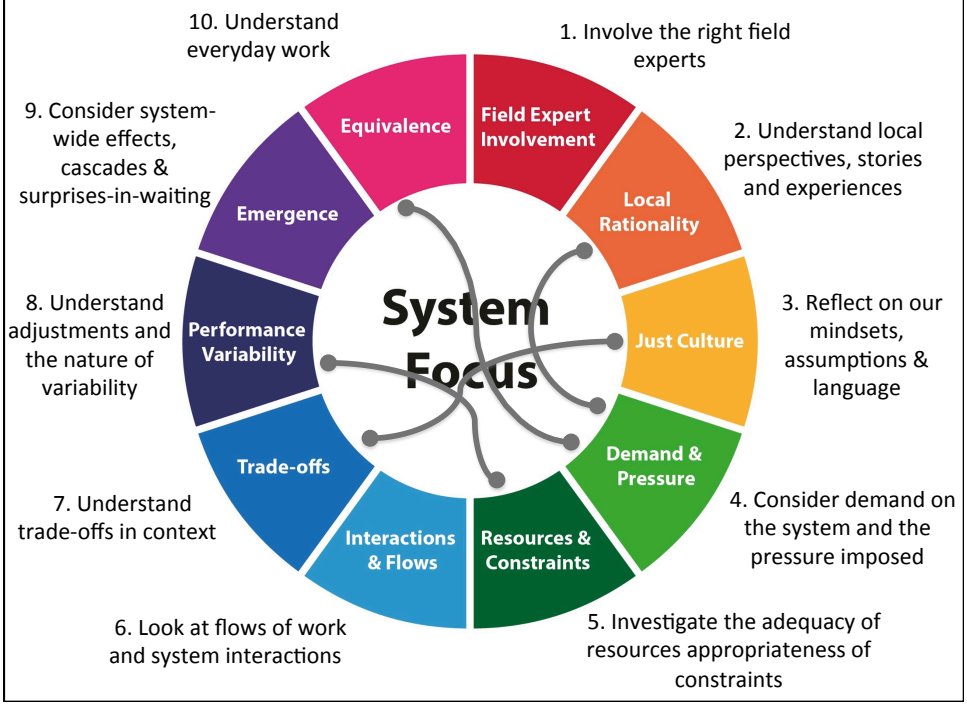
How might a supervisor league table affect decision making?

Why do we have so much rework in engineering?

Why would an engineer take a hazardous shortcut?

Why would a controller allow an aircraft to fly below minimum safe altitude?

Why would employees 'cheat'?


Who observes who?
Field experts as co-investigators?
Patterns of demand over time?
Interaction with equipment?
Flows of activity?
ETTOs in practice?
Local adjustments & variation?
Surprises?
Observation & Noticing
Image: Naviair (All rights reserved)

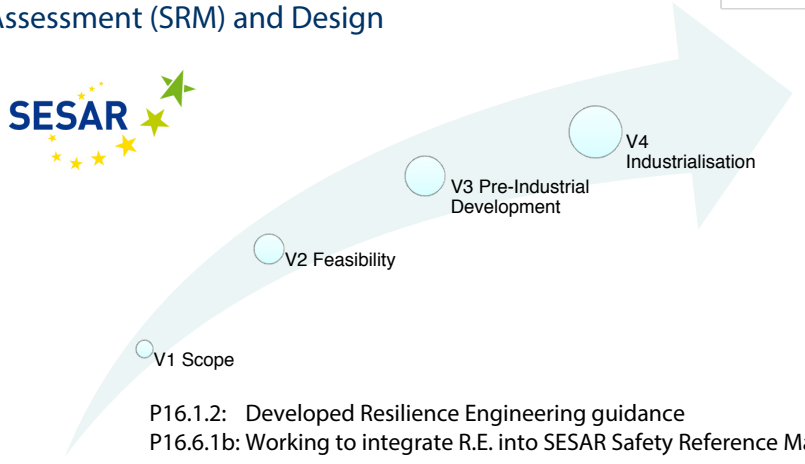

Has the system's purpose changed?
Field experts as co-designers?
Multiple perspectives on events?
Consequences of trade-offs?
Pressure imposed by targets?
CNS/AIS/MET/ATS flow of work?
Local understanding of patterns?
How are things done now?
Discussion
Image: David Goehring CC BY 2.0 http://flic.kr/p/4fJu6r

## Systems Thinking Methods

- System Maps & Influence Diagrams
- Causal Loop Diagrams
- Seven Samurai
- Functional Resonance Analysis Method (FRAM)
- SESAR Resilience Guidance Material for Safety Assessment (SRM) and Design
- AcciMaps
- Systems Theoretic Accident Model and Processes (STAMP)
- …

Network Manager nominated by the European Commission

## SESAR Resilience Guidance Material for Safety Assessment (SRM) and Design

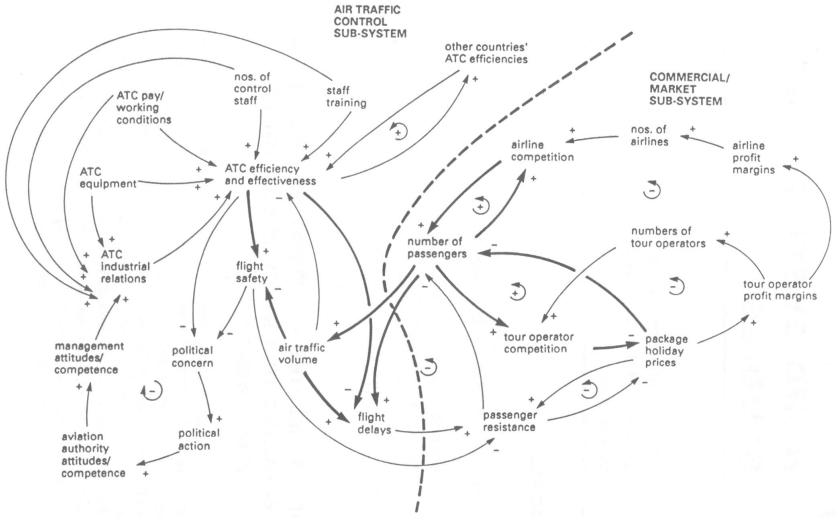



P16.1.2: Developed Resilience Engineering guidance
P16.6.1b: Working to integrate R.E. into SESAR Safety Reference Material

Common theme:
*Maximising the positive contribution of ATM to aviation safety*

Network Manager nominated by the European Commission

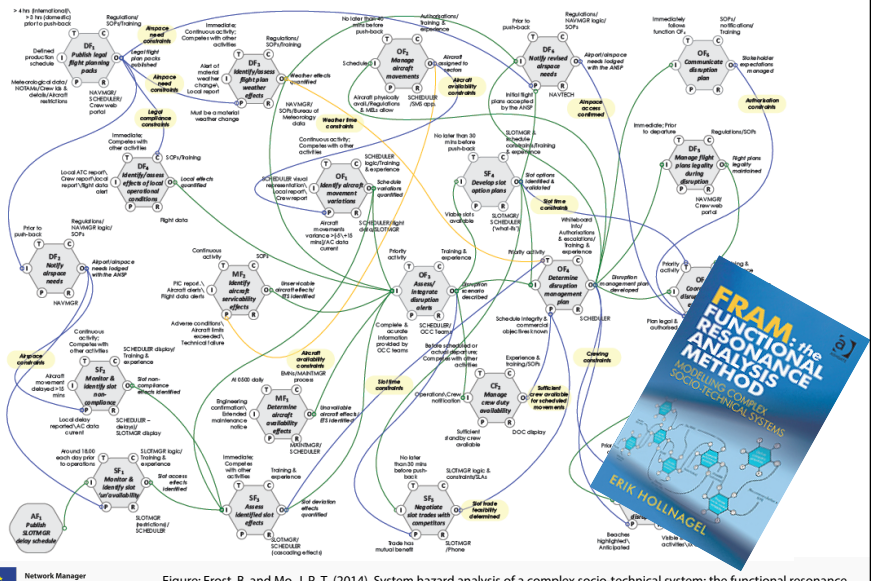
## Causal Loop Diagram




Network Manager nominated by the European Commission

Figure: Waring, A. (1996). *Practical systems thinking*. Thomson Learning.

## Functional Resonance Analysis Method (FRAM)




Network Manager nominated by the European Commission

Figure: Frost, B. and Mo, J. P. T. (2014). System hazard analysis of a complex socio-technical system: the functional resonance analysis method in hazard identification. Australian System Safety Conference, Melbourne Australia. 28 — 30 May 2014.

## Seven Samurai

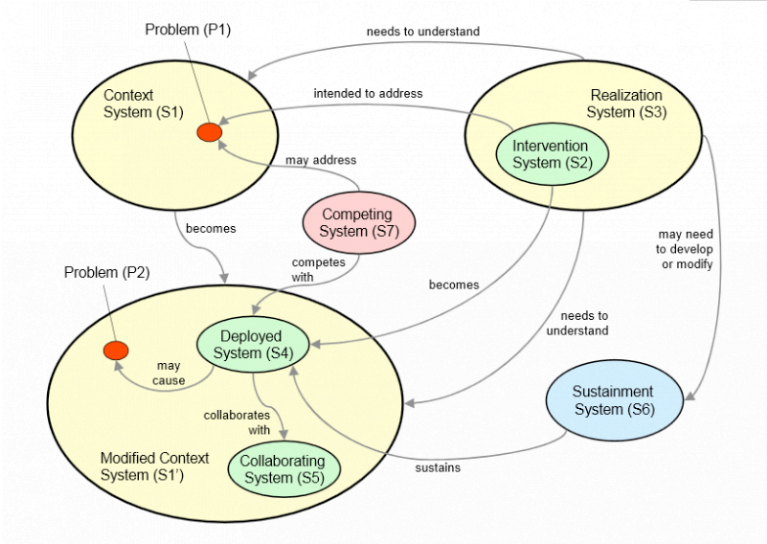
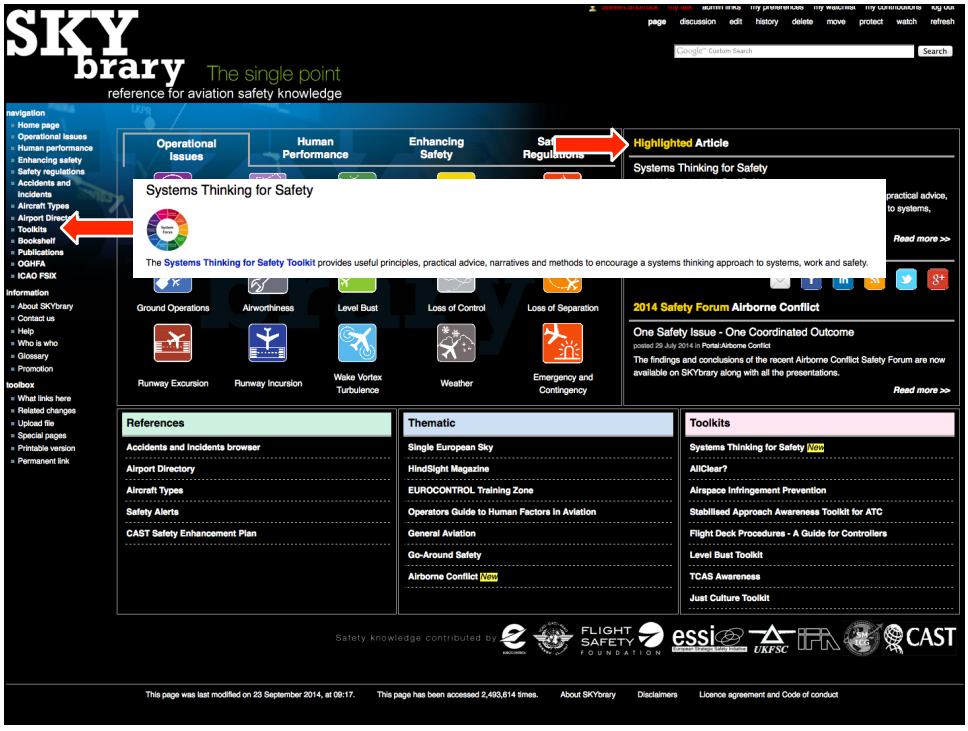



Figure: Martin, J. N. (2004). The Seven Samurai of Systems Engineering: Dealing with the Complexity of 7 Interrelated Systems. Presented at the 2004 Symposium of the International Council on Systems Engineering (INCOSE).



SKYbrary

toolkit discussion edit history delete move protect watch refresh

Search

navigation
- Home page
- Operational issues
- Human performance
- Enhancing safety
- Safety regulations
- Accidents and incidents
- Aircraft Types
- Airport Directory
- Toolkits
- Bookshelf
- Publications
- OGHFA
- ICAO FSIX

information
- About SKYbrary
- Contact us
- Help
- Who is who
- Glossary
- Promotion

toolbox
- What links here
- Related changes
- Upload file
- Special pages
- Printable version
- Permanent link

# Toolkit:Systems Thinking for Safety: Ten Principles

## Executive Summary

[edit]

Toolkit Navigation
- Summary
- The Foundation. System Focus
- Principle 1. Field Expert Involvement
- Principle 2. Local Rationality
- Principle 3. Just Culture
- Principle 4. Demand and Pressure
- Principle 5. Resources and Constraints
- Principle 6. Interactions and Flows
- Principle 7. Trade-offs
- Principle 8. Performance Variability
- Principle 9. Emergence
- Principle 10. Equivalence
- Principles in Action
- Systems Thinking Methods
- Narratives: Systems Thinking in the Wild
- References and Further Reading
- Authors and Acknowledgements

"To understand and improve the way that organisations work, we must think in systems." Image: NATS Press Office CC BY-NC-ND 2.0

To understand and improve the way that organisations work, we must think in systems. This means considering the interactions between the parts of the system (human, social, technical, information, political, economic and organisational) in light of system goals. There are concepts, theories and methods to help do this, but they are often not used in practice. We therefore continue to rely on outdated ways of thinking in our attempts to understand and influence how sociotechnical systems work. This White Paper distills some useful concepts as principles to encourage a 'systems thinking' approach to help make sense of – and improve – system performance. It is hoped that these will give new ways of thinking about systems, work and safety, and help to translate theory into practice.

Principles 1, 2 and 3 relate to the view of people within systems – our view from the outside and their view from the inside. To understand and design systems, we need to understand work-as-done. This requires the involvement of those who do the work in question – the field experts. (Principle 1. Involvement of Field Experts). It follows that our understanding of work-asdone – past, present and future – must assimilate the multiple perspectives of those who do the work. This includes their goals, knowledge, understanding of the situation and focus of attention situated at the time of performance (Principle 2. Local Rationality). We must also assume that people set out to do their best – they act with good intent. Organisations and individuals must therefore adopt a mindset of openness, trust and fairness (Principle 3. Just Culture).

Principles 4 and 5 relate to the system conditions and context that affect work. Understanding demand is critical to understanding system performance. Changes in demands and pressure relating to efficiency and capacity, from inside or outside the organisation, have a fundamental effect on performance. (Principle 4. Demand and Pressure). This has implications for the utilisation of resources (e.g. staffing, competency, equipment) and constraints (e.g. rules and regulations) (Principle 5. Resources and Constraints), which can increase or restrict the ability to meet demand.

Principles 6, 7 and 8 concern the nature of system behaviour. When we look back at work, we tend to see discrete activities or events, and we consider these independently. But work-as-done progresses in a flow of interrelated and interacting activities (Principle 6. Interactions and Flows). Interactions (e.g. between people, equipment, procedures) and the flow of work through the system are key to the design and management of systems. The context of work requires that people make trade-offs to resolve goal conflicts and cope with complexity and uncertainty (Principle 7. Trade-offs). Finally, continual adjustments are necessary to cope with variability in system conditions. Performance of the same task or activity will and must vary. Understanding the nature and sources of variability is vital to understanding system performance (Principle 8. Performance Variability).

Principles 9 and 10 also relate to system behaviour, in the context of system outcomes. In complex systems, outcomes are often emergent and not simply a result of the performance of individual system components (Principle 9. Emergence). Hence, system behaviour is hard to understand and often not as expected. Finally, success and failure are equivalent in the sense that they come from the same source – everyday work, and performance variability in particular (Principle 10. Equivalence). We must therefore focus our attention on work-as-done and the system-as-found.

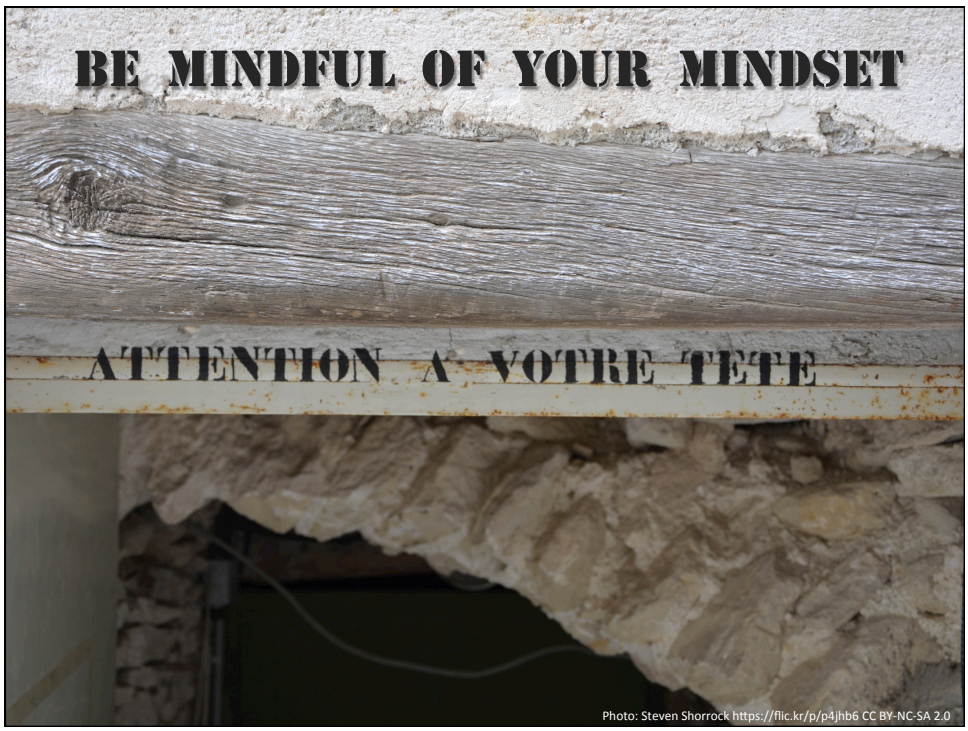



Photo: Steven Shorrock https://flic.kr/p/p4jhb6 CC BY-NC-SA 2.0


fairness zone