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THE ETTO PRINCIPLE:

EFFICIENCY-THOROUGHNESS TRADE-OFF
OR
WHY THINGS THAT GO RIGHT SOMETIMES GO WRONG

ERIK HOLLNAGEL
PROFESSOR, PH.D.

E-MAIL: HOLLNAGEL.ERIK@GMAIL.COM

Single European Sky (SES)

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The objective of the Single European Sky (SES) is "to enhance current air traffic safety standards, to contribute to the sustainable development of the air transport system and to improve the overall performance of air traffic management (ATM) and air navigation services (ANS) for general air traffic in Europe, with a view to meeting the requirements of all airspace users."

Safety

Environment

Capacity

Cost-efficiency

Specific objectives for RP2

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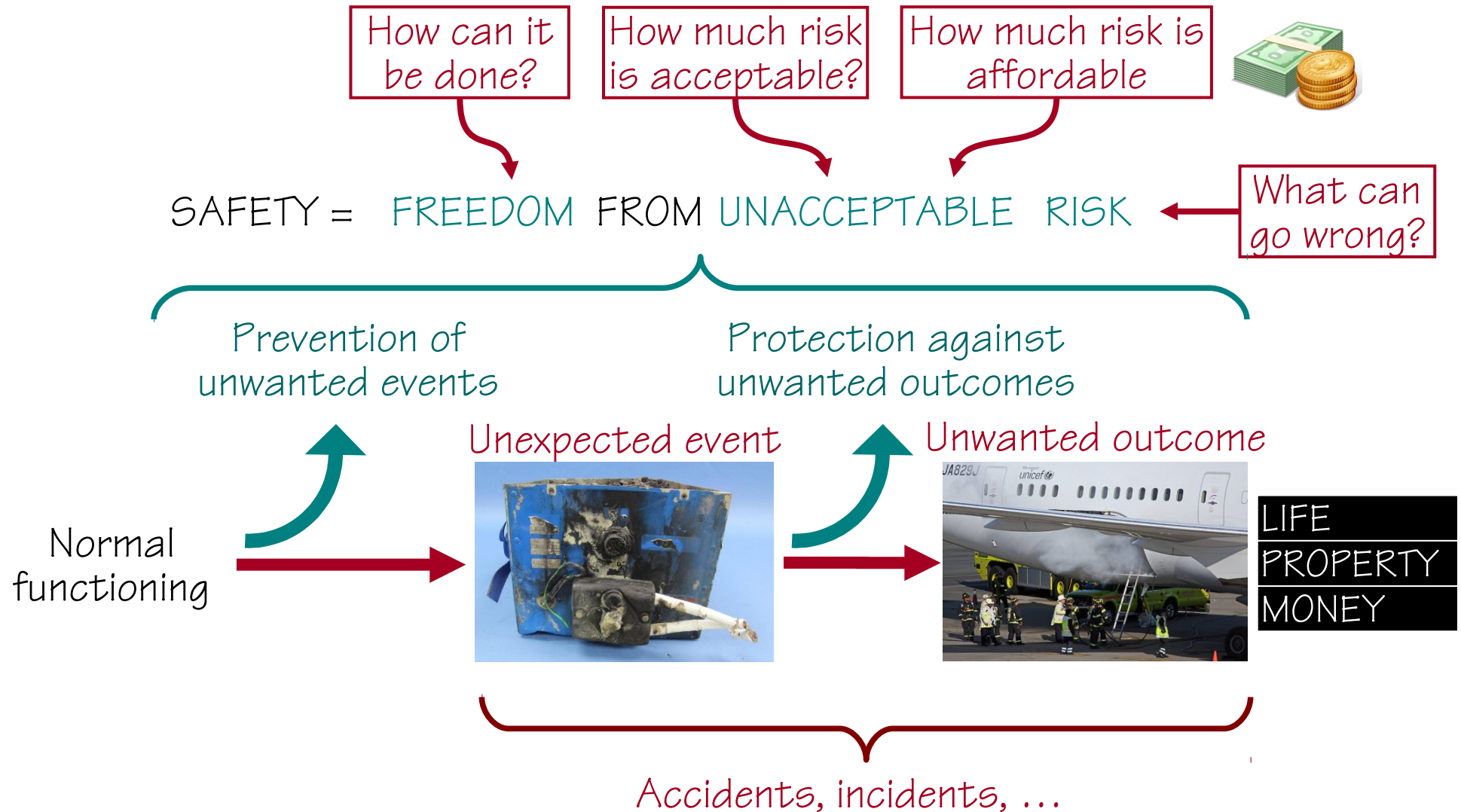|	
Safety	Effectiveness of safety management Application of severity application scheme based on the Risk Analysis Tool (RAT) methodology.

Environment	Horizontal flight efficiency
	    - Using last filed flight plan
	    - Using radar data for the actual trajectory

Capacity	En route ATFM delay per flight
Cost-efficiency	Determined unit cost for en route air navigation services Determined unit cost for terminal air navigation services

SESAR specific targets

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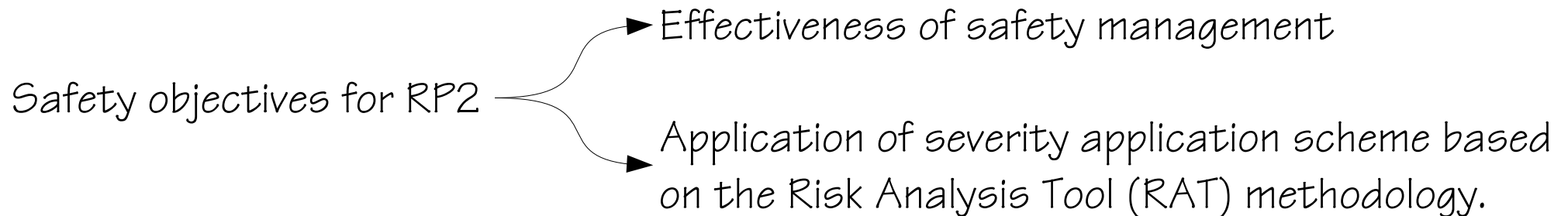| Safety	Effectiveness of safety management Application of severity application scheme based on the Risk Analysis Tool (RAT) methodology. **SESAR: Improve safety by a factor of 10**

Environment	Horizontal flight efficiency
	   - Using last filed flight plan
	   - Using radar data for the actual trajectory
	SESAR: Reduce environmental impact by 10%

Capacity	En route ATFM delay per flight **SESAR: Enable threefold increase in capacity**
Cost-efficiency	Determined unit cost for en route air navigation services Determined unit cost for terminal air navigation services **SESAR: Cut ATM costs by half**

The meaning of safety

How can it be done?

How much risk is acceptable?

How much risk is affordable

What can go wrong?

SAFETY = FREEDOM FROM UNACCEPTABLE RISK

Prevention of unwanted events

Protection against unwanted outcomes

Unexpected event

Unwanted outcome

Normal functioning

LIFE PROPERTY MONEY

Accidents, incidents, …

Safety through occurrence reporting

Each organisation established in a Member State shall develop a process to analyse the details on occurrences collected in accordance with Articles 4 and 5 in order to identify the safety hazards associated with identified occurrences. Based on this analysis it shall determine any appropriate corrective or preventive action required for the enhancement of safety.

National SSPs should include safety performance indicators that measure identified safety risks and set corresponding risk mitigation measures and targets.
A common and harmonised European methodology for development of safety performance indicators and corresponding targets on state level.

Safety objectives for RP2

▶ Effectiveness of safety management

▶ Application of severity application scheme based on the Risk Analysis Tool (RAT) methodology.

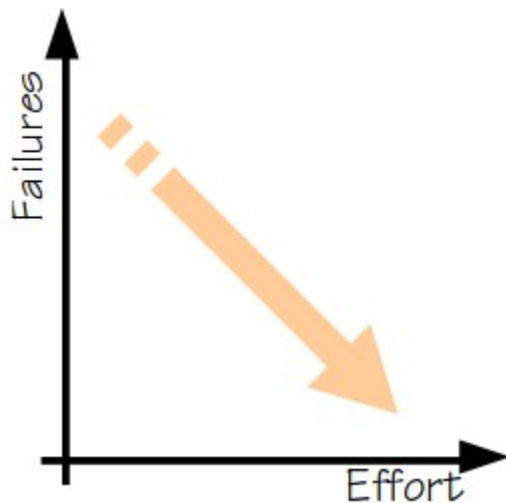# Safety-I – when nothing goes wrong

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Safety-I: Safety is defined as a condition where the number of adverse outcomes (accidents / incidents / near misses) is as low as possible.

Safety has traditionally been defined by its opposite – the lack of safety.

The lack of safety means that something goes wrong or can go wrong.

Safety-I requires the ability to prevent that something goes wrong. This is achieved by:

1. Find the causes of what goes wrong (RCA).
2. Eliminate causes, disable possible cause-effect links.
3. Measure results by how many fewer things go wrong.

Failures

Effort

Different process => different outcome

Function (work as imagined) ⟶ Success (no adverse events)   Acceptable outcomes 🙂

"Actions that succeed are different from actions that fail"

Malfunction, non-compliance, error ⟶ Failure (accidents, incidents)   Unacceptable outcomes 🙁

Increasing safety by reducing failures

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Function (work as imagined) → Success (no adverse events) — Acceptable outcomes 🙂

"Identification and measurement of adverse events is central to safety."

Malfunction, non-compliance, error — Failure (accidents, incidents) — Unacceptable outcomes 🙁
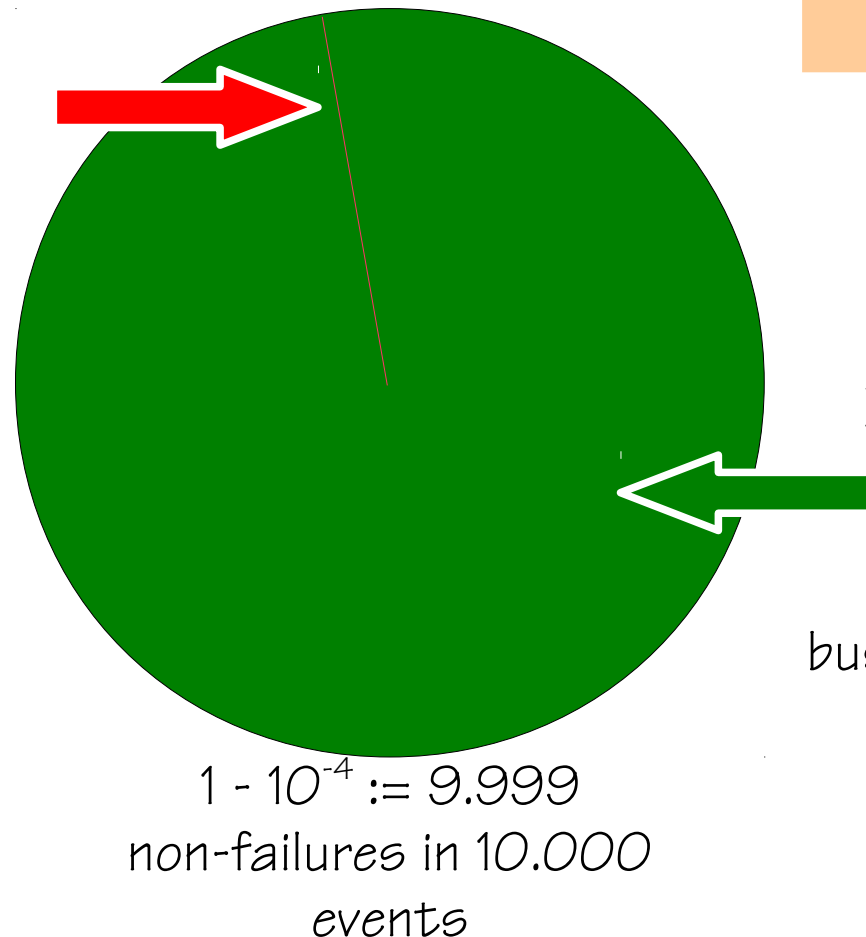
Why only look at what goes wrong?

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Safety-I = Reduced number of adverse events.

$10^{-4} :=$ 1 failure in 10.000 events

Safety-II = Ability to succeed under varying conditions.

Focus is on what goes wrong. Look for failures and malfunctions. Try to eliminate causes and improve barriers.

Focus is on what goes right. Use that to understand everyday performance, to do better and to be safer.

Safety and core business compete for resources. Learning only uses a fraction of the data available

Safety and core business help each other. Learning uses most of the data available
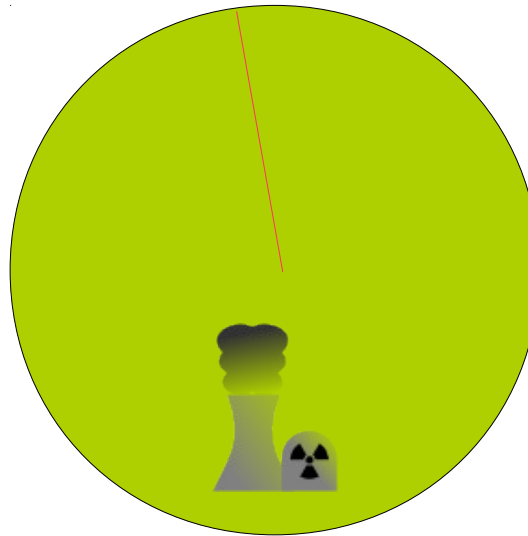
$1 - 10^{-4} :=$ 9.999 non-failures in 10.000 events

Various risks in practice

Likelihood of being in a fatal accident on a commercial flight.
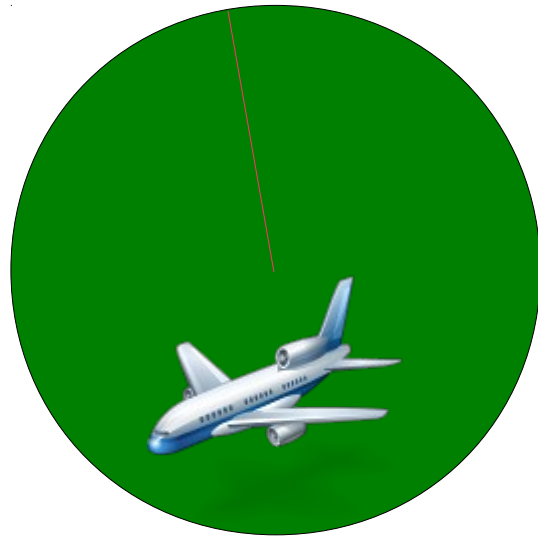
Core Damage Frequency for a nuclear reactor (per reactor year).

Likelihood of iatrogenic harm when admitted to a hospital.

1 : 7,000,000

1.4×10^{-7}

1 : 20,000

5.0×10^{-5}
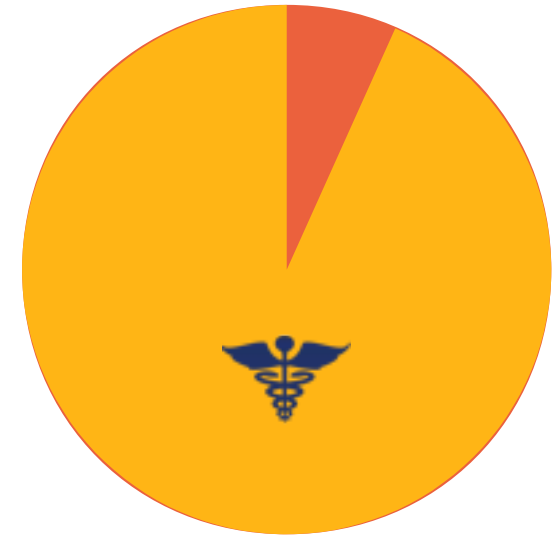
1 : 10

1.0×10^{-1}

ESARR 4: 1.55×10^{-8} / flight hour

Failures or successes?

When something goes wrong, e.g., 1 event out of 10.000 (10E-4), humans are assumed to be responsible in 80-90% of the cases.
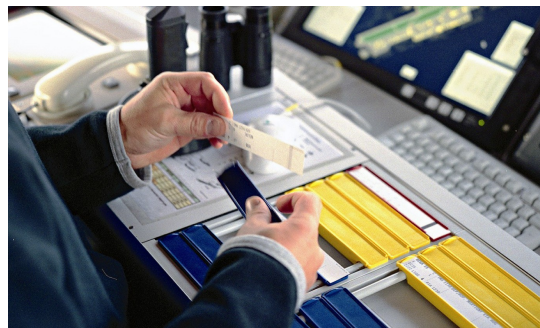
When something goes right, e.g., 9.999 events out of 10.000, are humans also responsible in 80-90% of the cases?

Who or what are responsible for the remaining 10-20%?

Who or what are responsible for the remaining 10-20%?

Investigation of failures is accepted as important.

Investigation of successes is rarely undertaken.

Safety II – when everything goes right

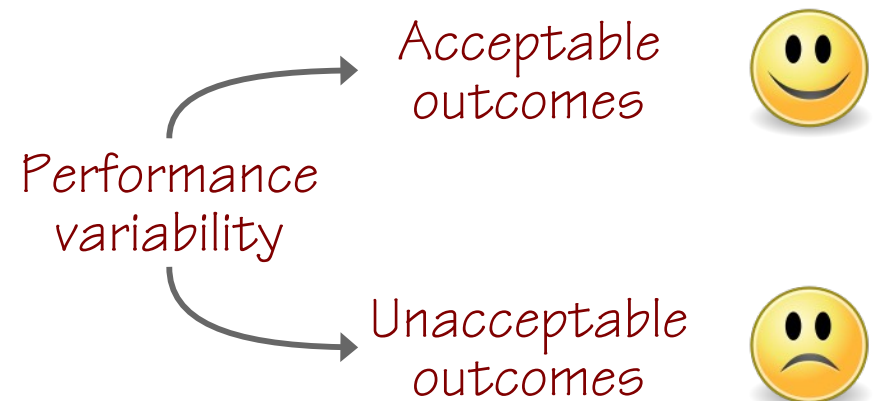Safety is the ability to succeed under varying conditions.
(Risk is the likelihood that this does not happen, that people do not succeed.)
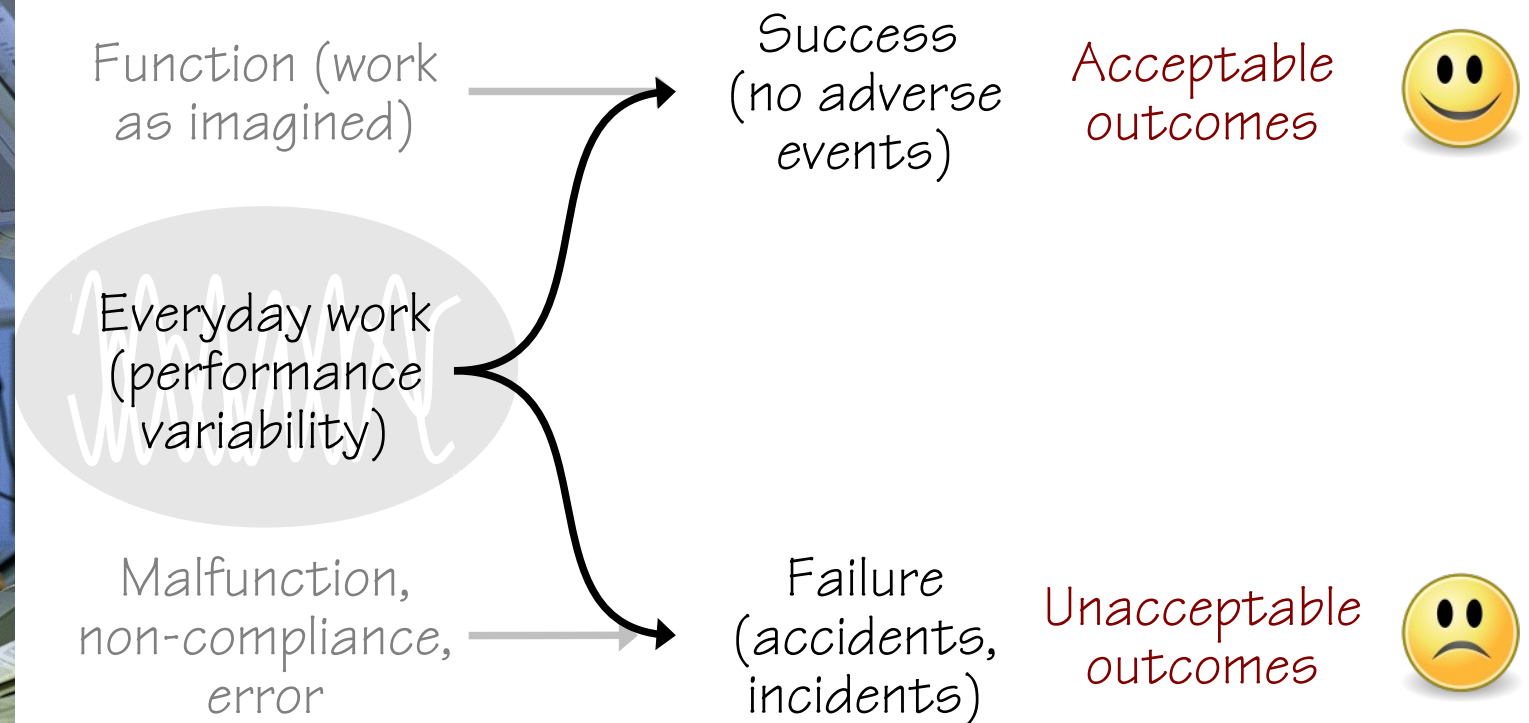The emphasis is on how things go right, how they work in the first place.

Different outcomes ("normal" results vs. failures) are not distinct binary categories, but rather judgements of value.
Unexpected outcomes are not necessarily a consequence of unexpected processes.

Individuals and organisations must adjust everything they do to match the current conditions. Everyday performance must be variable in order for things to work.

Performance variability

Acceptable outcomes

Unacceptable outcomes

Same process => different outcomes

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Function (work as imagined) → Success (no adverse events) — Acceptable outcomes 🙂

Everyday work (performance variability)

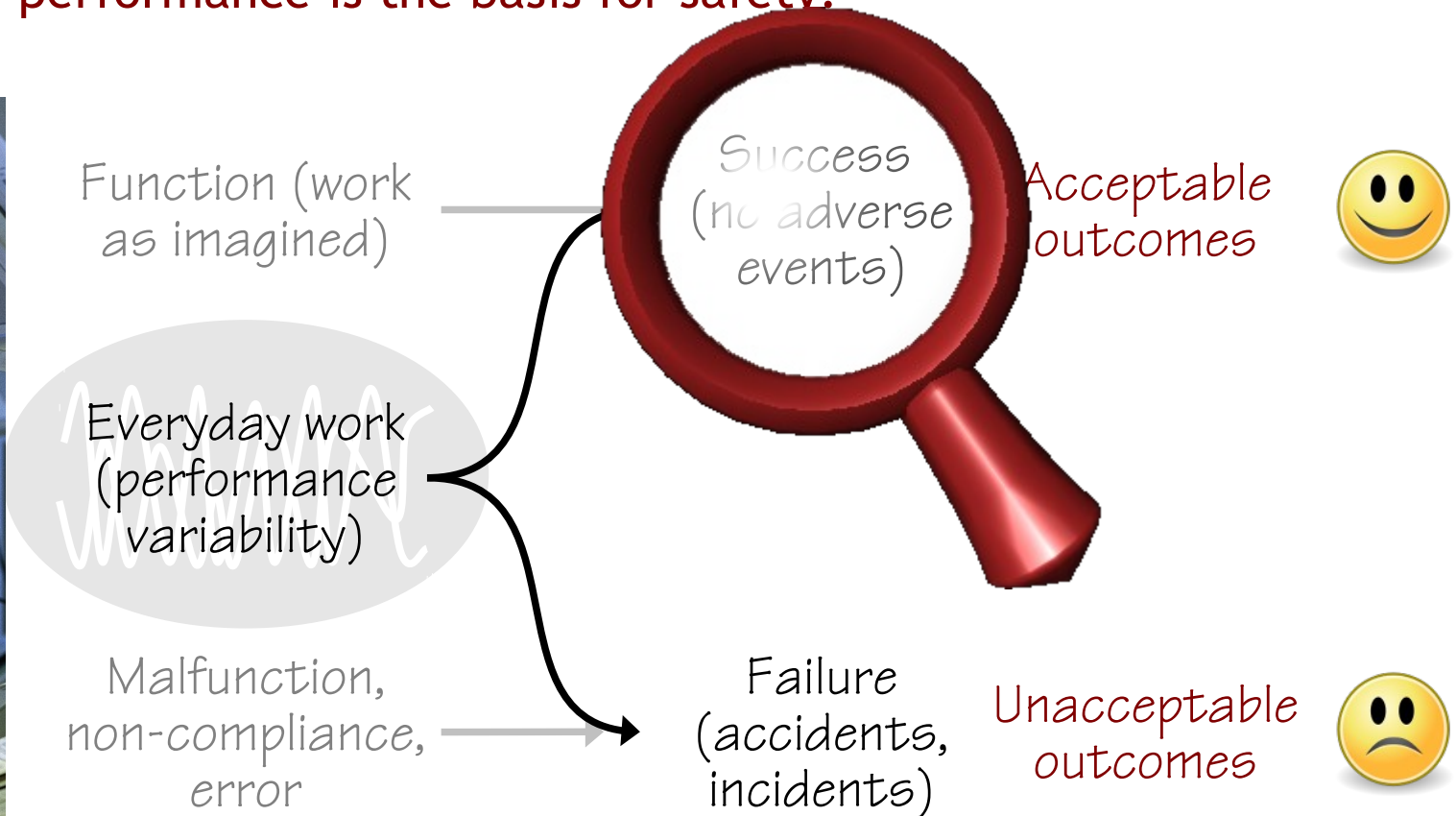Malfunction, non-compliance, error → Failure (accidents, incidents) — Unacceptable outcomes 🙁

Increase safety by facilitating work

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Understanding the variability of everyday performance is the basis for safety.

Function (work as imagined) — Success (no adverse events) — Acceptable outcomes 🙂

Everyday work (performance variability)

Malfunction, non-compliance, error → Failure (accidents, incidents) — Unacceptable outcomes 🙁

Constraining performance variability to remove failures will also remove successful everyday work.

The ETTO principle

The ETTO principle describes the fact that people (and organisations) as part of their activities practically always make a trade-off between the resources (time and effort) they spend on preparing an activity and the resources (time, effort and materials) they spend on doing it.

When throughput and output are the prioritised, efficiency is more important than thoroughness. When safety and quality are prioritised, thoroughness is more important that efficiency.

It follows from the ETTO principle that it is impossible to maximise efficiency and thoroughness at the same time. Nor can an activity expect to succeed, if there is not a minimum of either.

Efficiency-Thoroughness Trade-Off

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Thoroughness: Time to think

Recognising situation.
Choosing and planning.

If thoroughness dominates, there may be too little time to carry out the actions.
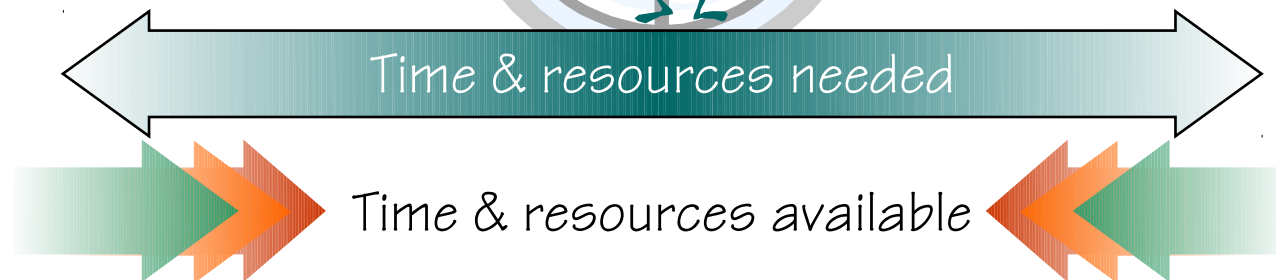
Neglect pending actions
Miss new events

Efficiency: Time to do

Implementing plans.
Executing actions.

If efficiency dominates, actions may be badly prepared or wrong

Miss pre-conditions
Look for expected results

Time & resources needed

Time & resources available

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Some ETTO heuristics

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Cognitive (individual)

Judgement under uncertainty

Cognitive primitives (SM – FG)

Reactions to information input overload and underload

Cognitive style

Confirmation bias

Idiosyncratic (work related)

Looks fine

Not really important

Normally OK, no need to check

I've done it millions of time before

Will be checked by someone else

Has been checked by someone else

This way is much quicker

No time (or resources) to do it now

Can't remember how to do it

We always do it this way

It looks like X (so it probably is X)

We must get this done

Must be ready in time

Must not use too much of X

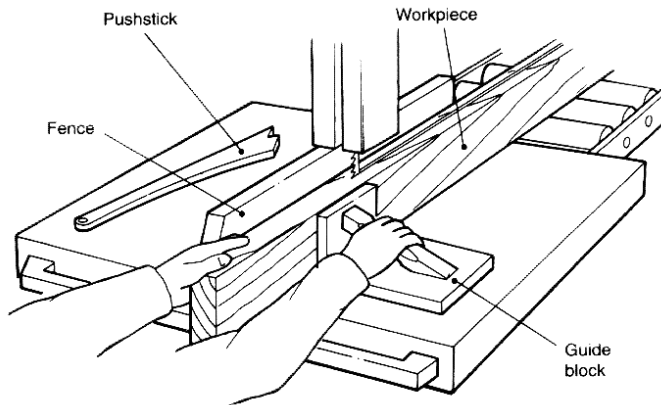## Collective (organisation)

Negative reporting

Reduce redundancy
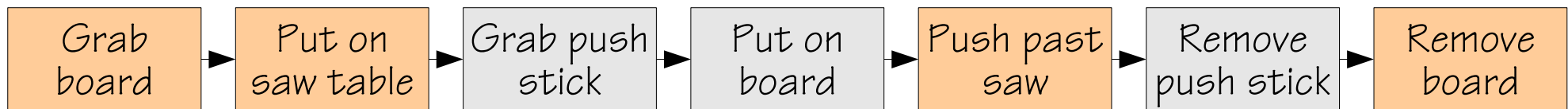
Meet "production" targets

Reduce unnecessary cost

Double-bind

Reject conflicting information

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Thoroughness takes time

Pushstick — Workpiece
Fence
Guide block

"In splitting a board, a circular-saw operator suffered the loss of his thumb when, in violation of instructions, he pushed the board past the saw with his fingers, instead of using the push stick that had been provided for the purpose."

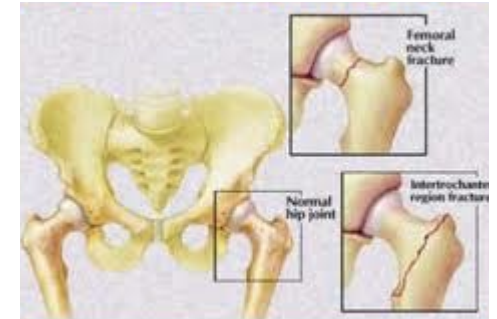| Grab board | → | Put on saw table | → | Grab push stick | → | Put on board | → | Push past saw | → | Remove push stick | → | Remove board |

"He stated that he had always done such work in this manner and had never before been hurt. He had performed similar operations on an average of twenty times a day for three months and had therefore exposed his hand in this way over one thousand five hundred times." (Heinrich, 1931 "Industrial accident prevention")

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Work as imagined – follow the rules!

Box 1: Professional bodies and national agencies who publish guidelines for anaesthetists

- Association of Anaesthetists of Great Britain and Ireland
- Academy of Medical Royal Colleges
- Association of Cardiac Anaesthetists
- Association of Paediatric Anaesthetists
- British Association of Day Surgery
- *British National Formulary*
- British Pain Society
- Department of Health
- Difficult Airway Society
- European Society of Anaesthesiology
- Faculty of Pain Medicine
- General Medical Council
- Health and Safety Executive
- Intensive Care Society
- Medicines and Healthcare Products Regulation Authority
- National Patient Safety Agency
- National Institute for Health and Clinical Excellence
- Obstetric Anaesthetists Association
- Resuscitation Council (UK)
- Royal College of Anaesthetists
- Scottish Intercollegiate Guidelines Network

Emergency surgery on a fractured neck of femur involves app. 75 clinical guidelines and policies.

UK Government guideline on "Working Together to Safeguard Children" is 390 pages long!

Carthey et al (2011). Breaking the rules: understanding non-compliance with policies and guidelines. BMJ

Why do people adjust their work?

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AVOID

anything that may have negative consequences for yourself, your group, or organisation

COMPENSATE FOR

unacceptable conditions so that it becomes possible to do your work.

MAINTAIN / CREATE

conditions that may be of use in case of future problems.

Pushback going wrong

The crew had not realized that the ground crew was about to commence the pushback. They were waiting for, the ground crew to command them to release the parking brakes, where after the pushback would begin.

The driver received the "thumbs up" signal, and applied power to begin the pushback. Noticing resistance, he applied more power. Then suddenly, without any signs, the nose landing gear collapsed rearwards, without braking the shear pin.

Thoroughness

Every airline has its own handling procedures. Aircraft of one airline will often be handled by another airline. The airline has to provide the handling company with a copy of the procedures to be used, the handling company then has to train its personnel in the use of the procedures to be used.

Efficiency

Ground crew handle many airlines, with different procedures. It is therefore not uncommon that they use some form of "general" procedure, which can differ from the official one.

FRA Approach Phraseology

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Standard phraseology

"DLH123, Langen Radar identified, cleared OSMAX 25 Transition, high speed approved"

Non-standard phraseology

"Gude, DLH123, OSMAX 25 Transition, high speed"

Duration:
About 4.7 seconds

Duration:
about 3.0 seconds

Time saved: about 1.7 seconds

How much is 1.7 seconds worth?
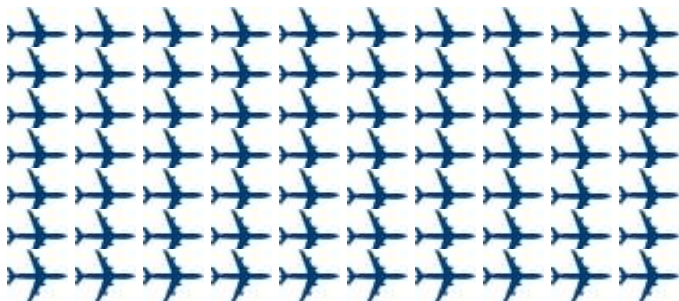

Number of movements during peak days — > 1.500 movements/day

Number of arrivals during peak times — > 50 arrivals/hour

There are about 14 transmissions per arrival – not including the time for readbacks.

With 50 arrivals/hour this means more than 700 transmissions/hour on frequency.

Saving just 1 second per transmission corresponds to 11 minutes saved per hour.

Where can we find ETTOing?

Efficiency-Thoroughness Trade-Offs are made by all professions and can be found on all levels of an organisation – from top management to daily operations.

The impact of ETTO on safety

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Safety (SPIs)

The EoSM indicator is measured by computing scores based on the verified responses to questionnaires completed by the State/competent authorities (normally the NSA) and ANSPs respectively.

Effectiveness of safety management (EoSM)

Application of severity application scheme based on the Risk Analysis Tool (RAT) methodology.

All ANSPs should report ATM Ground using the RAT severity classification for all investigations. In addition, all Regulators should report ATM Overall using the RAT severity classifications for almost all investigations.
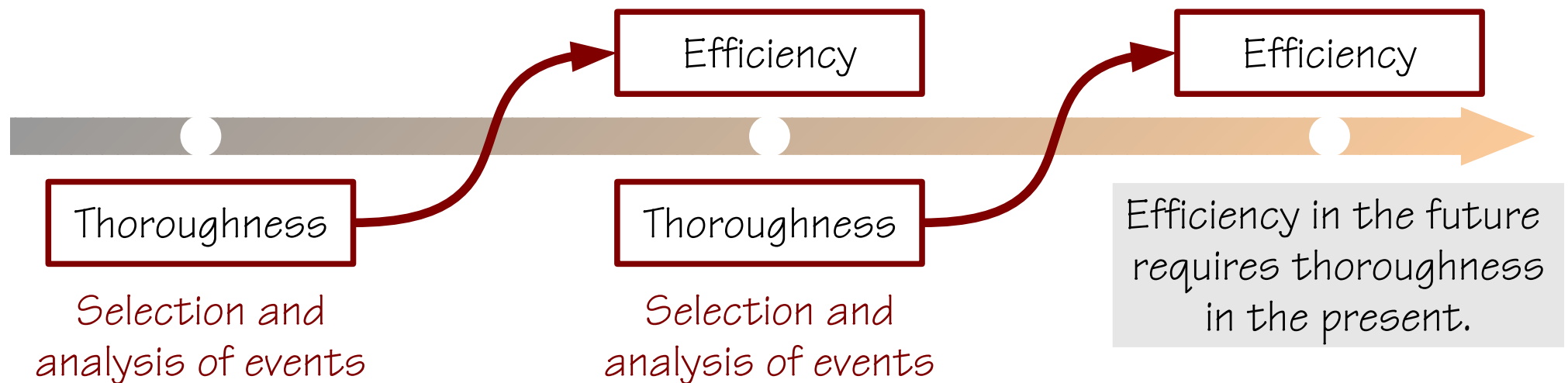
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The impact of ETTO on safety

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Investigations that search for causes (risk elements), and recommendations that focus on such elements represent a Safety-I rather than Safety-II perspective, hence chooses efficiency over thoroughness.

The Risk Analysis Tool (RAT) provides a method for consistent and coherent identification of risk elements. It also allows users to effectively prioritise actions designed to reduce the effect of those elements.

Efficiency (safety) in the present requires thoroughness in the past.

Efficiency

Efficiency

Thoroughness

Thoroughness

Efficiency in the future requires thoroughness in the present.

Selection and analysis of events

Selection and analysis of events

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ETTO – successes and failures

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Trade-offs between efficiency and thoroughness (ETTO) are both normal and necessary.

In the vast majority of cases, the outcome is a success (outcome is as expected). Since this is taken for granted, it is rarely analysed or investigated.

In very few cases, the outcome is a failure (outcome is not as expected). If the consequences are serious (loss of time, material, money or life), the event is investigated to find the cause.

An ETTO is always approximate – because of the very reasons that make it necessary! Making an efficiency-thoroughness trade-off is never wrong in itself!

People are expected to be both efficient and thorough at the same time – or rather to be thorough, when with hindsight it was wrong to be efficient.

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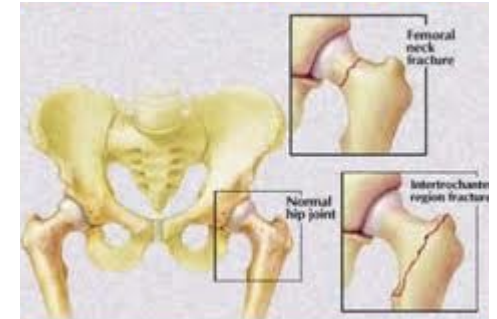
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