Learning from Aerospace Industry

Manfred Müller

University Lecturer on Risk Management

Training Captain Airbus A330/340/350 (ret.)

former Head of flight Safety Research of the Lufthansa Group

How safe should it be?

100%! (vision zero)

Conflict

…for the Management: Profit + Safety

(increasing shareholder value)

…for the pilots: getting the job done + Safety

(working fast and efficient with limited and expensive resources)

Is maximum safety your prime target?

risk acceptance

self-determined / foreign determined

Passenger
Patient / Client

acceptance of risks

foreign determined

Tsunami:

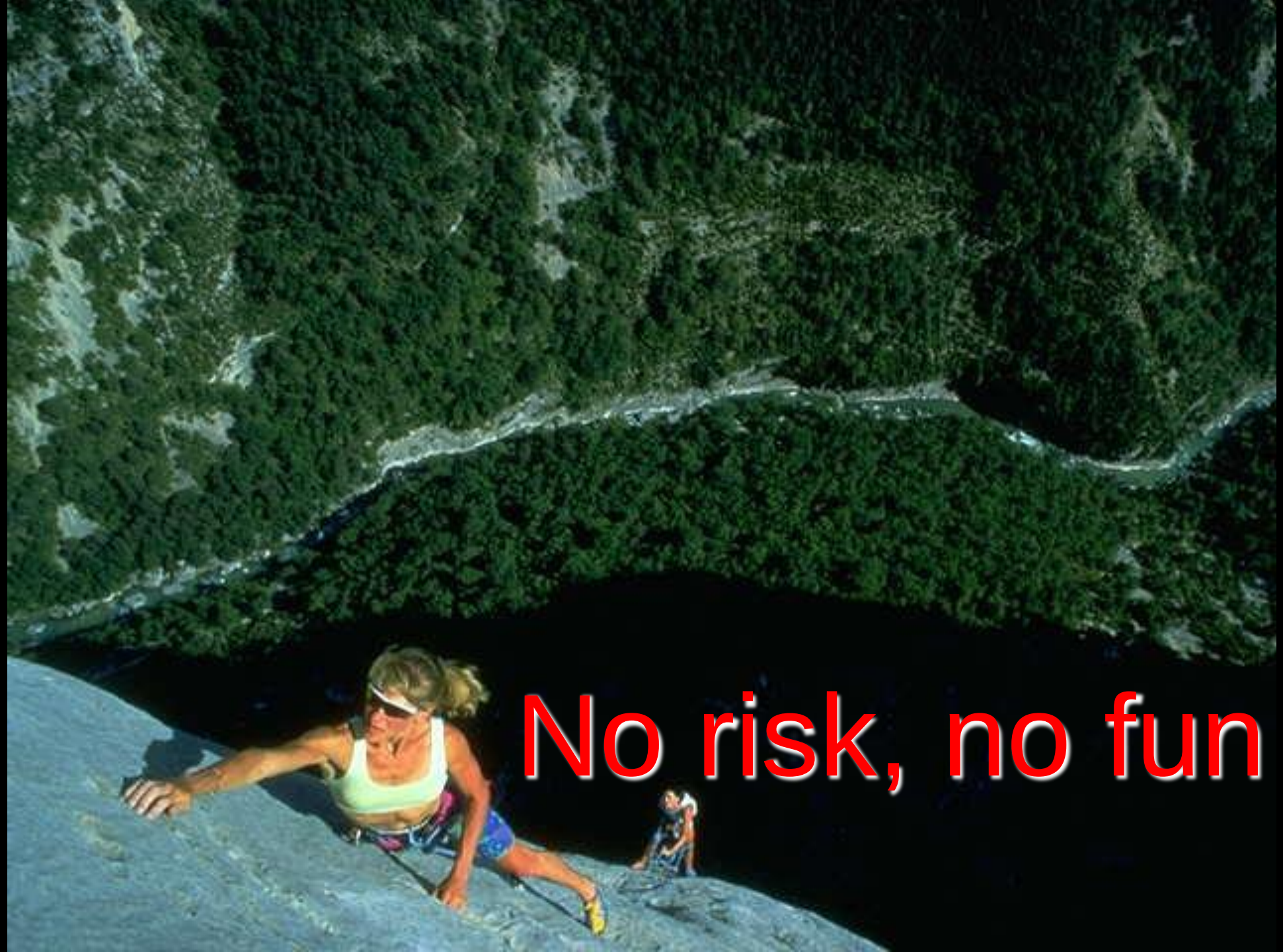
Probability for an European tourist being killed by a Tsunami in the Far East < 10^{-7}

risk < 0,00001%

risk acceptance

self-determined / foreign determined

Pilot
Engineer / Manager


No risk, no fun

Risk Acceptance

Self determined

Extreme mountain climbing (Himalaya)

Mount Everest

(ticket price: >60.000.-$)

2023: most deadly year

Fatality Risk ~ 5%

Risk Acceptance

Self determined

Extreme mountain climbing (Himalaya)

(Situation 2008)

Annapurna Expeditions:
(ticket price: 60.000.-$)

153 climbers reached the summit
66 climbers had a fatal accident

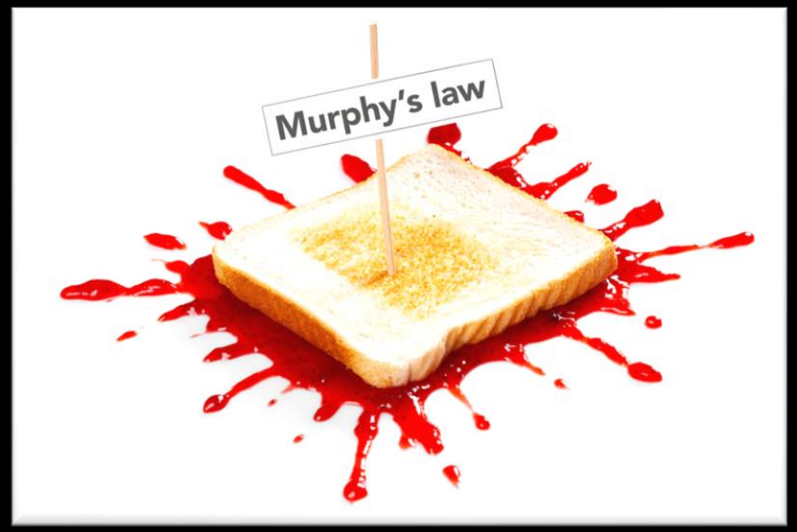
Risk ~40%

40%

versus

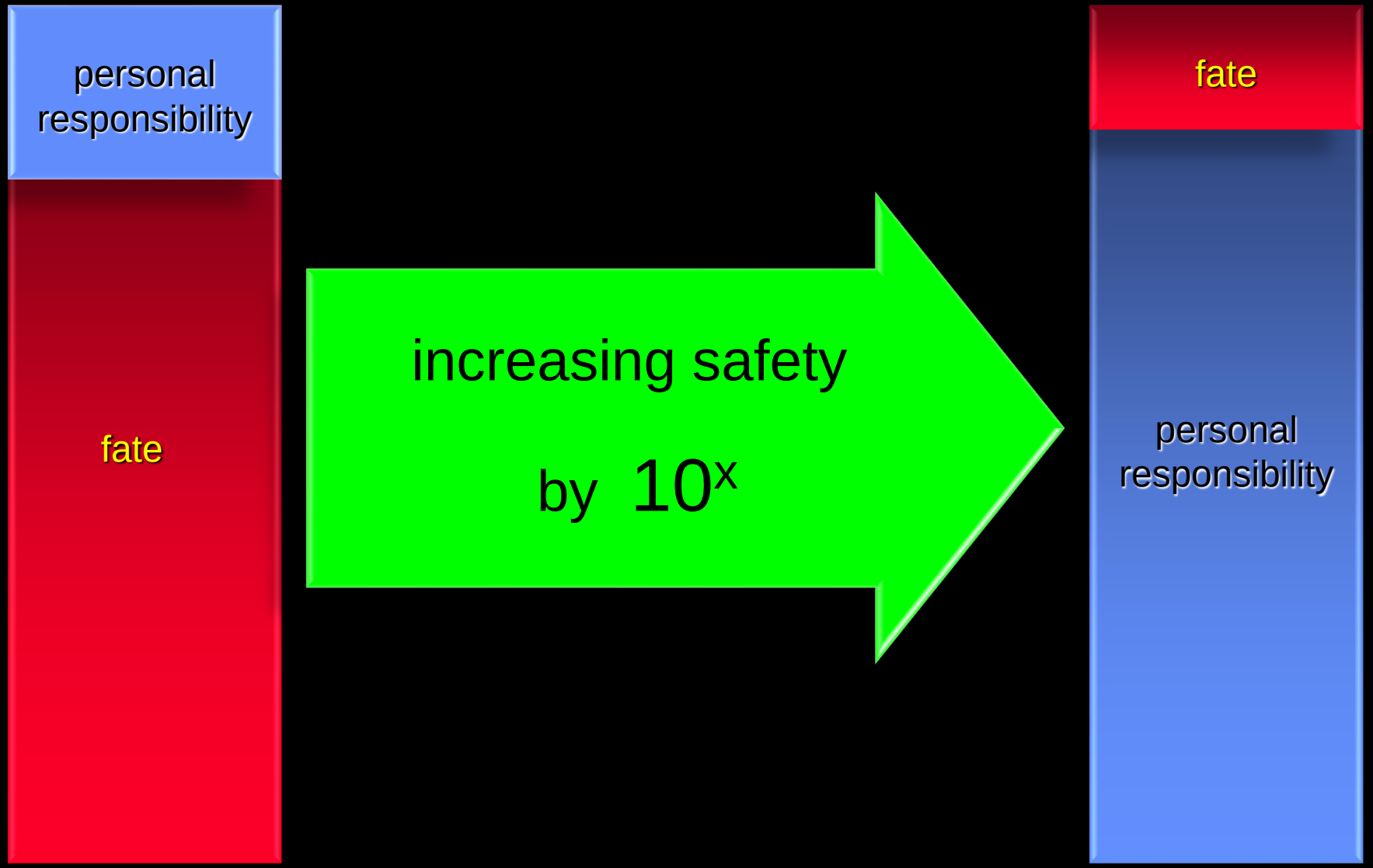
0,000001%

Why are things going wrong?




ASTROLOGY

Friday 13th


personal responsibility
fate
increasing safety
by 10x
fate
personal responsibility

What is an acceptable risk level?

10E-10 70% 90% 10E-9

99% ? 99,9%

99,99%

10E-8


12

Lufthansa-Group:

>1.000.000 flights per year

Examples for failure rates

NASA Space Shuttle

NASA forecasted safety level: 96%

consequences for Lufthansa:

>3.000 daily flights $\Rightarrow$ >100 accidents every day

Examples for failure rates

hospital intensive care

forecasted failure rate: 1‰

consequences for Lufthansa:

>3000 daily flights $\Longrightarrow$ >3 accidents every day

Examples for failure rates

more than 5 Million flights within 5 years

required safety level for Lufthansa:

>99,99998%

What is an acceptable accident rate for an Airline ?

ICAO Safety Management System (SMS)

ICAO DOC 9859:

…an Airline has to define an acceptable level of safety performance (ALoSP)

Definition: An acceptable level of safety is a safety level which is acceptable for the respective Airline. (z.B.: **10e-5**)

Do not rely on oversight authorities!

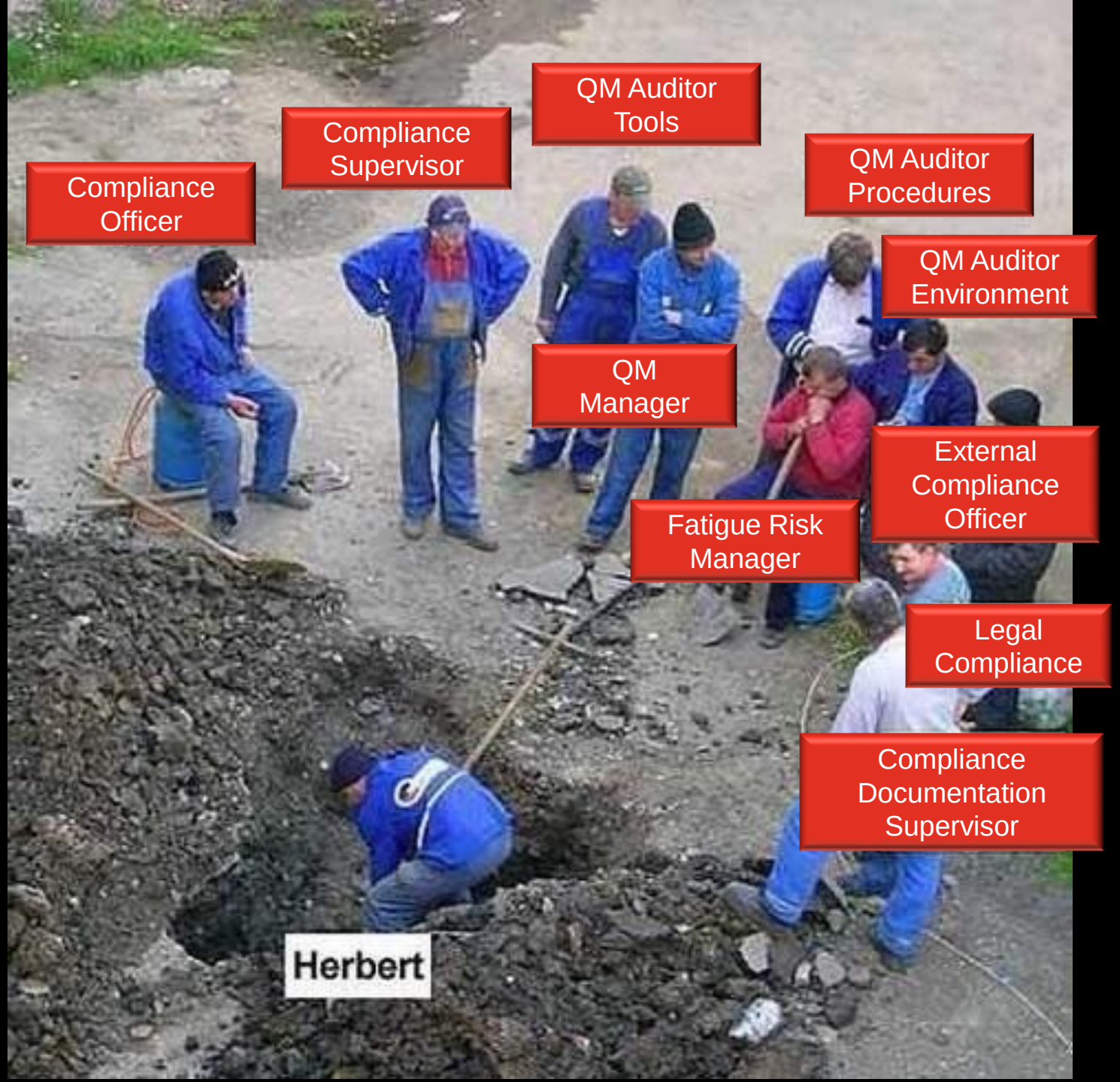
Safety Management System (SMS)

Future European Aviation Regulatory System

EASA is only looking for „compliance“!

Airlines are responsible for Flight Safety!

Maximum Safety is no EU-goal


QM Auditor Tools
Compliance Supervisor
Compliance Officer
QM Auditor Procedures
QM Auditor Environment
QM Manager
External Compliance Officer
Fatigue Risk Manager
Legal Compliance
Compliance Documentation Supervisor
Herbert

What is an acceptable accident rate
for an Airline ?

One total loss every **100 years**.

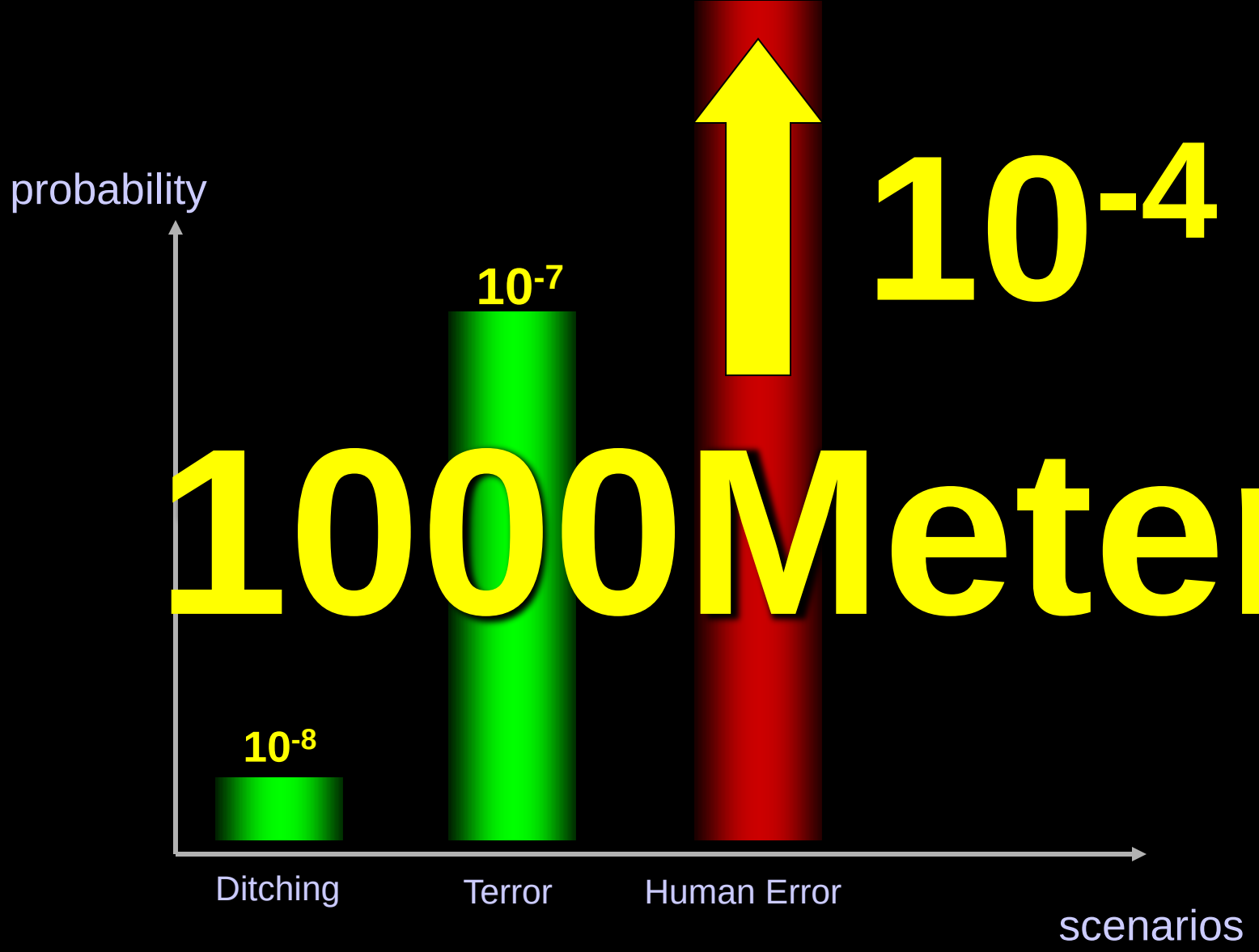
This means for Lufthansa:
~ one accident per **100 Million Flights**

1: 100.000.000 = 10^{-8}

1: 1.000.000 = 0,5 x 10^{-6}

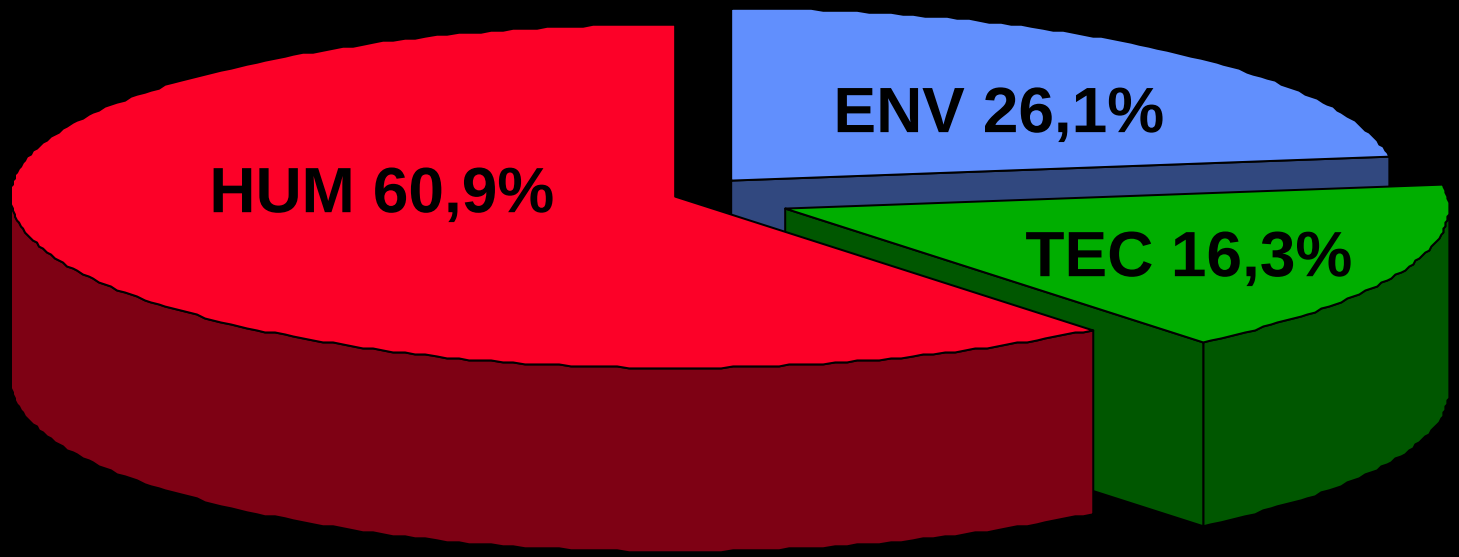

probability
10^{-4}
10^{-7}
10^{-8}
Ditching
Terror
Human Error
scenarios

Threats

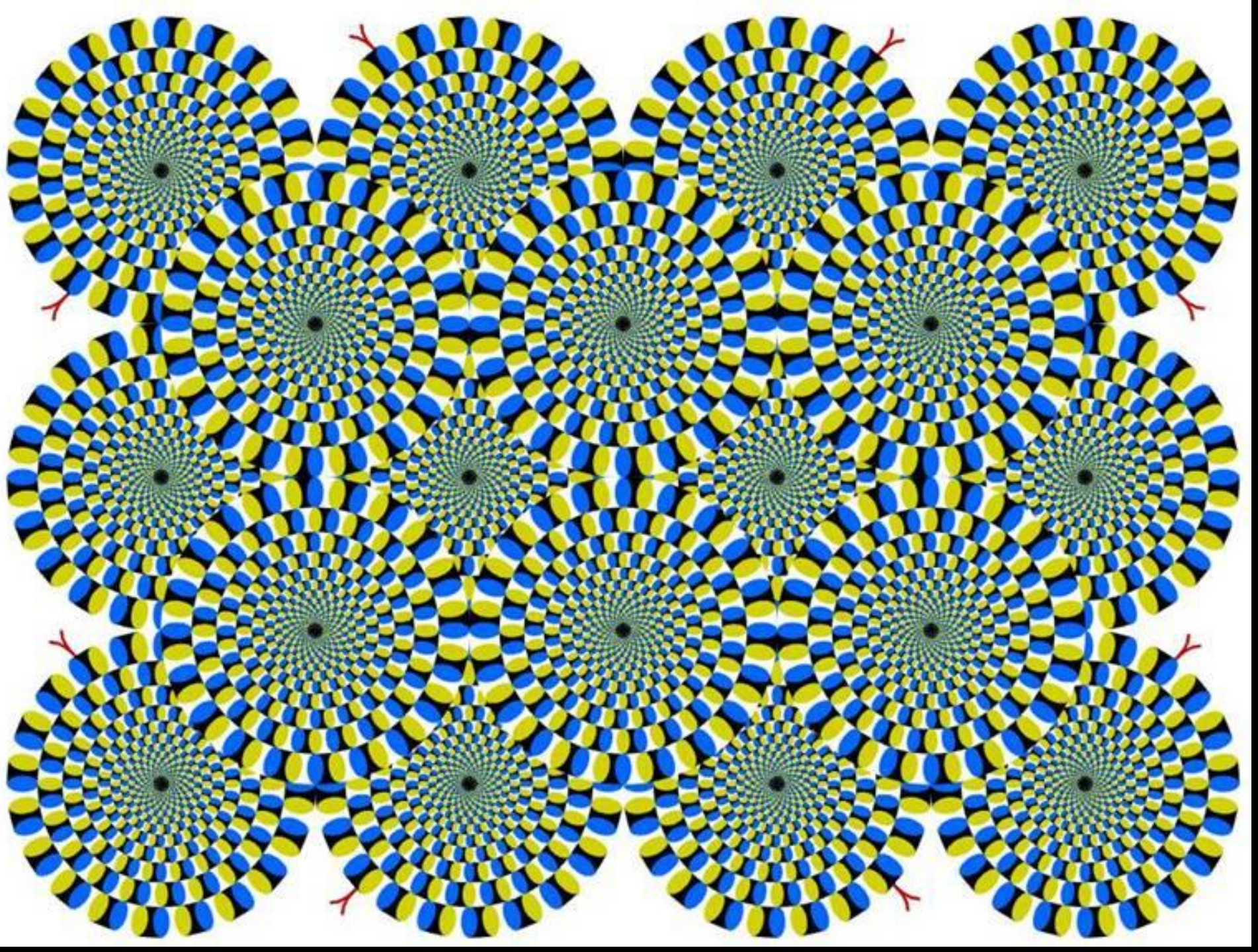

probability
10^{-4}
10^{-7}
10^{-8}
1000Meter
Ditching
Terror
Human Error
scenarios

Threats

Total Losses

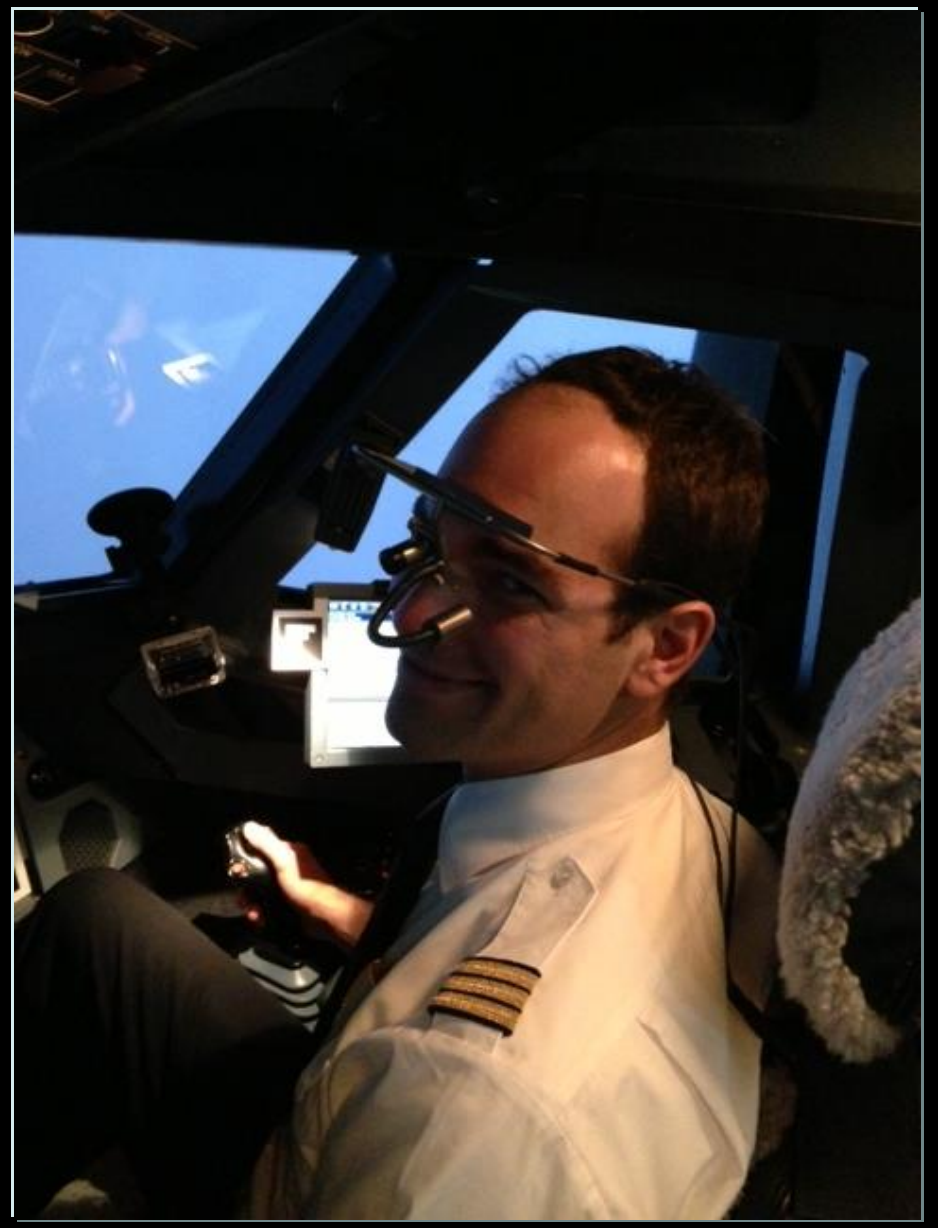


Errare humanum est.



FINISHED FILES ARE THE RESULT OF YEARS OF SCIENTIFIC STUDY COMBINED WITH THE EXPERIENCE OF YEARS


Dikablis - 4X46 - 4X46
00:00:00



Task Related Probability Of Errors MTBFs

Prof. Bubb TU-Munich

Category	Error probability	MTBF
Simple and regularely performed tasks at a low stress level.	$1 \cdot 10^{-3}$	~30 min
Complex, regularely performed tasks in a well known working environment at a low stress level.	$1 \cdot 10^{-2}$	~5 min
Complex tasks in unusual situations at a **high stress level** and / or **time pressure.**	**$1 \cdot 10^{-1}$**	**~30 sec**

27th of March 1977

KLM. From the people who made punctuality possible.

Building an airline of KLM's standing requires a special kind of dedication. Like making a point of being punctual. A quality that's very much part of the Dutch.

It was Christiaan Huygens after all, who gave it real significance – when he invented the spring balance that made timepieces transportable. A creation without which life is inconceivable. Or air travel, for that matter. And one that illustrates that singular Dutch ability for doing things well. As you'll discover when you fly KLM. You'll find your trust sincerely reciprocated. With efficiency, punctualness and friendly understanding.

For that is the way the people of Holland are. People whose involvement make KLM a big, reliable, international airline. As your travel agent will confirm.

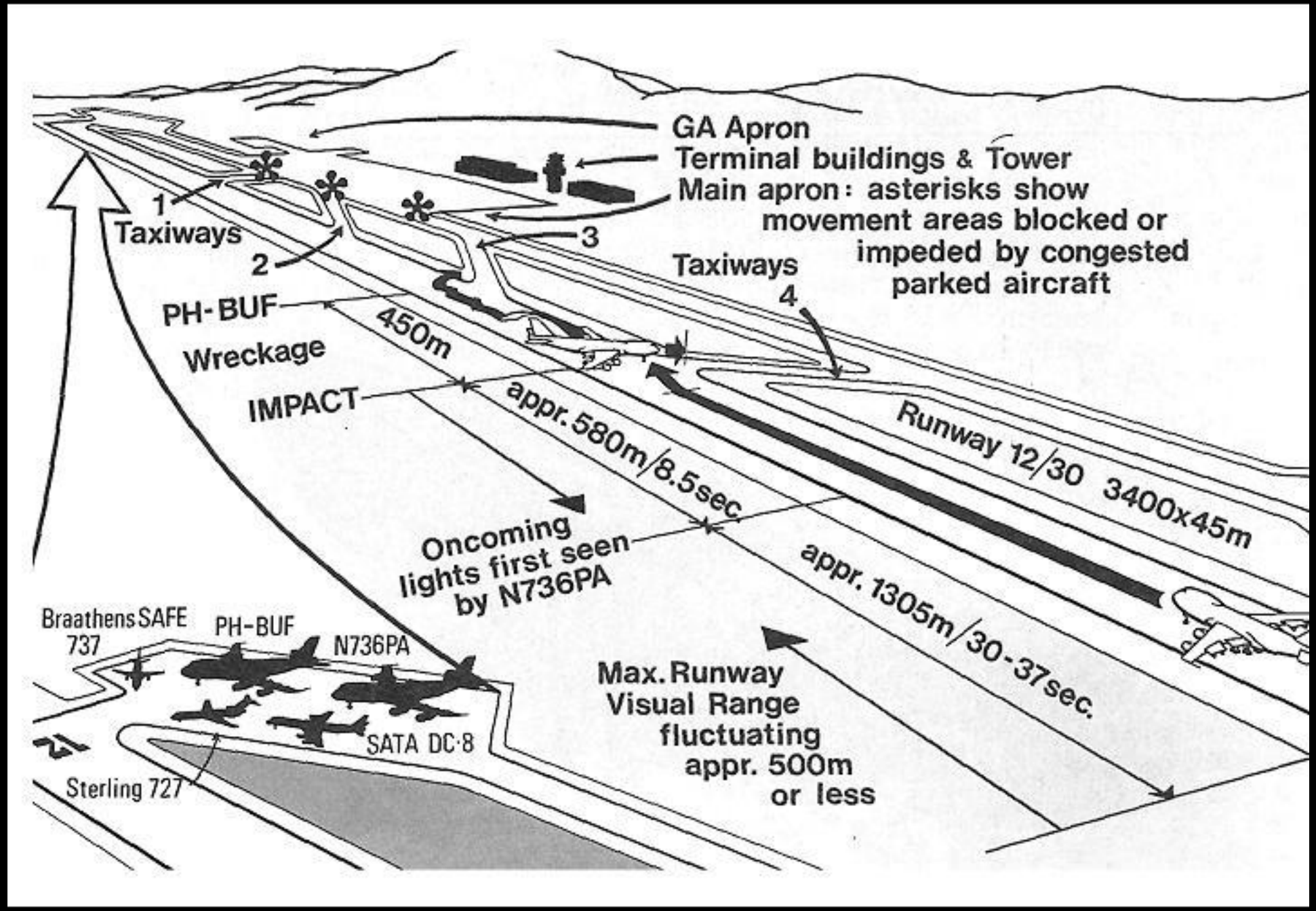
Visit any of Holland's clog-makers and watch Dutch craftmanship and precision in the old tradition. In this time-honoured process, logs are split, hollowed, shaped, smoothed and ultimately transformed into the article still worn in many parts of the country.

A right royal time is what you have in KLM's Royal Class Service is punctual and princely. Dinner for instance, is always rounded off with a choice of seven different coffees. But then, it's only in keeping with that stylish class far too good to be called just first.

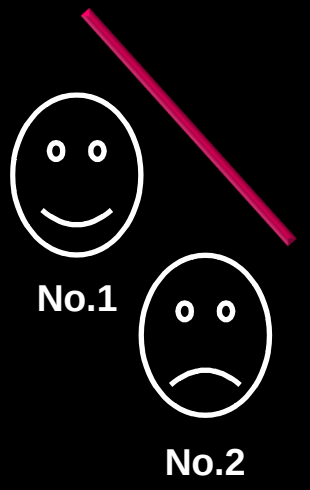
KLM

KLM

The reliable airline of those surprising Dutch.


GA Apron
Terminal buildings & Tower
Main apron: asterisks show movement areas blocked or impeded by congested parked aircraft
1
Taxiways
2
3
Taxiways
4
PH-BUF
Wreckage
IMPACT
450m
appr. 580m/8.5sec
Runway 12/30 3400x45m
Oncoming lights first seen by N736PA
appr. 1305m/30-37sec.
Braathens SAFE 737
PH-BUF
N736PA
SATA DC-8
Sterling 727
Max. Runway Visual Range fluctuating appr. 500m or less

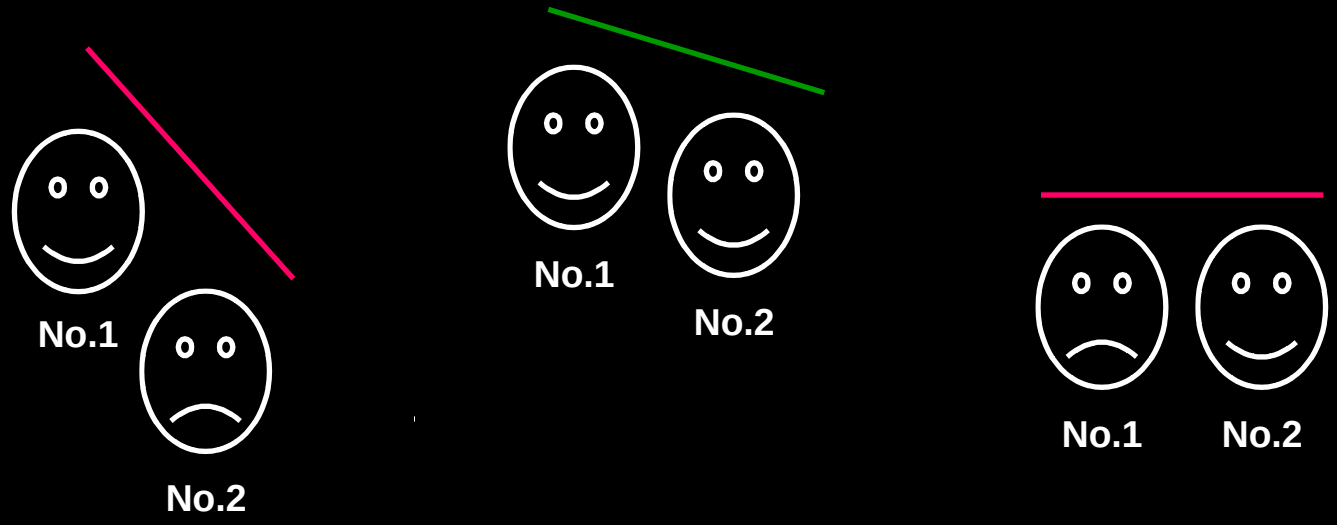
hierarchy



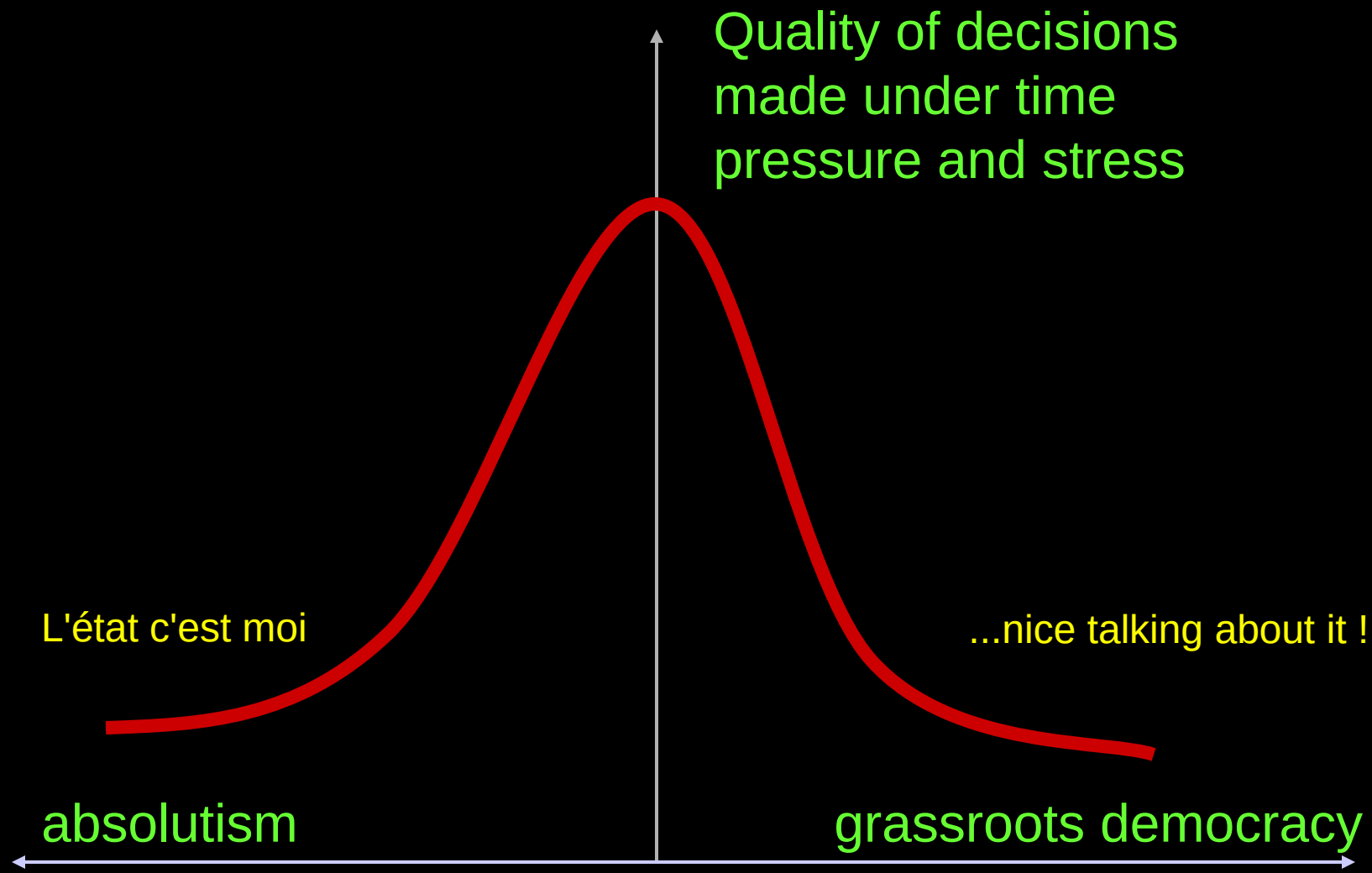
Tools for team interaction

Optimum hierarchical structure

Optimum hierarchical structure



Organizing teamwork

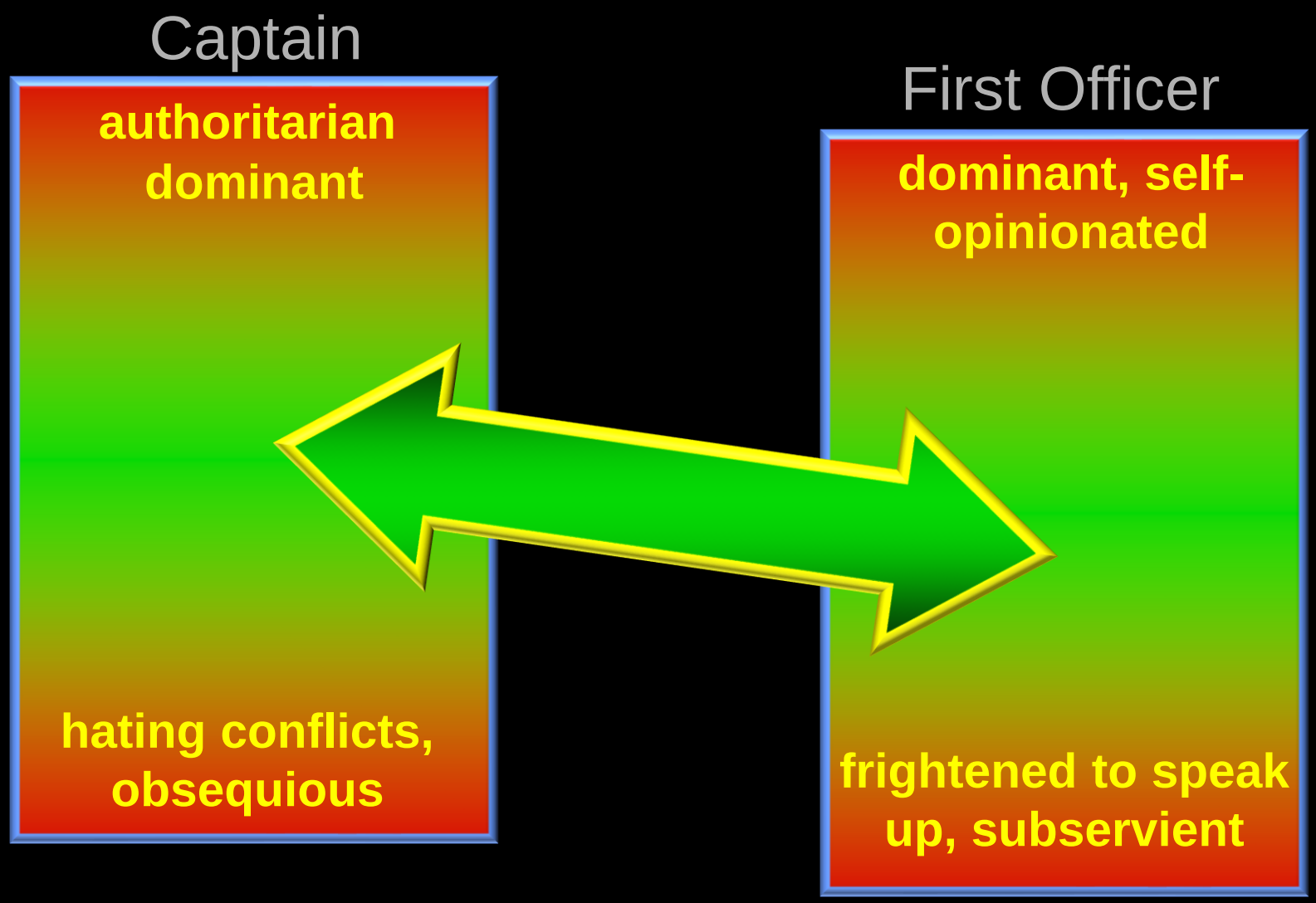


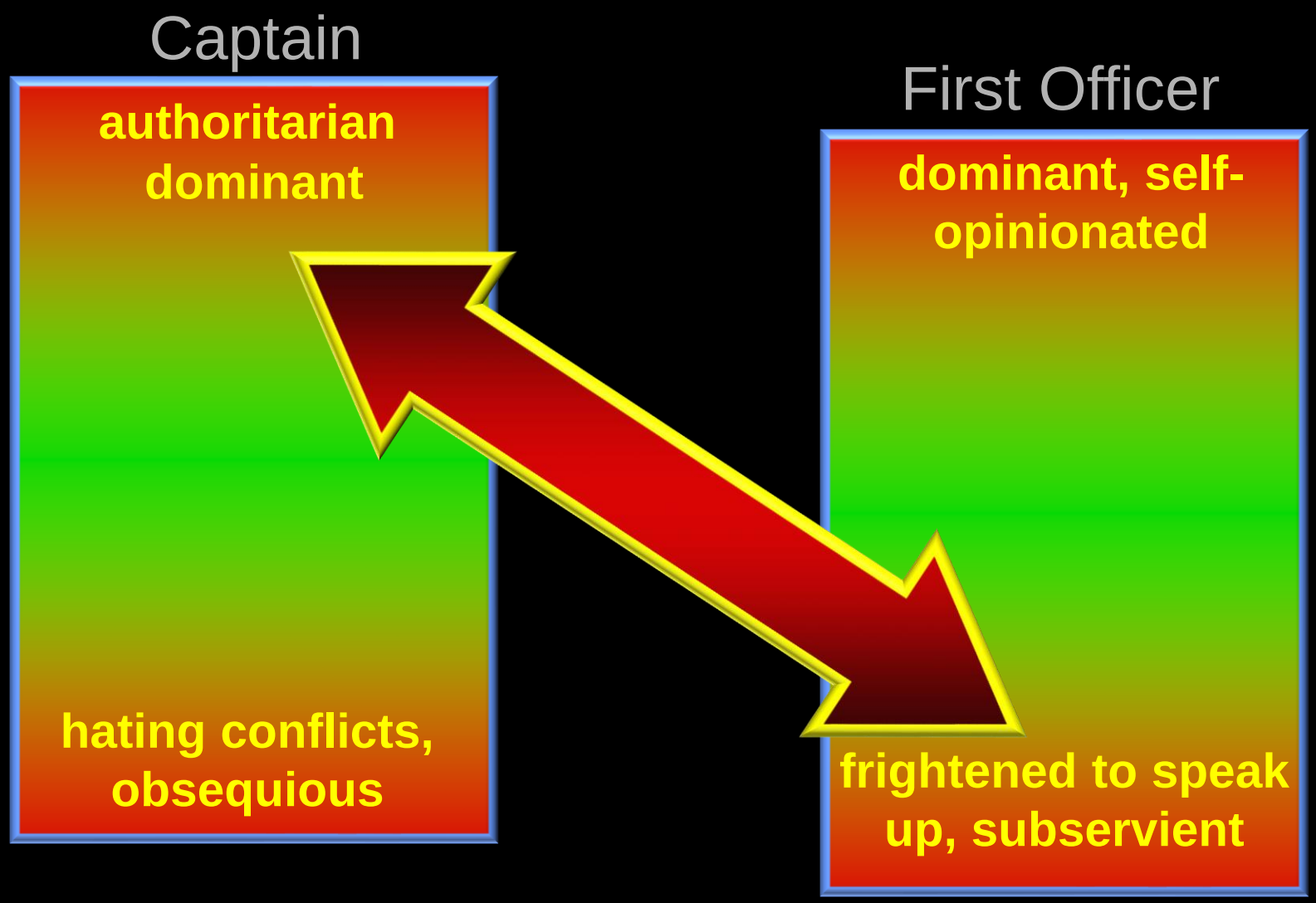
authoritarian
dominant

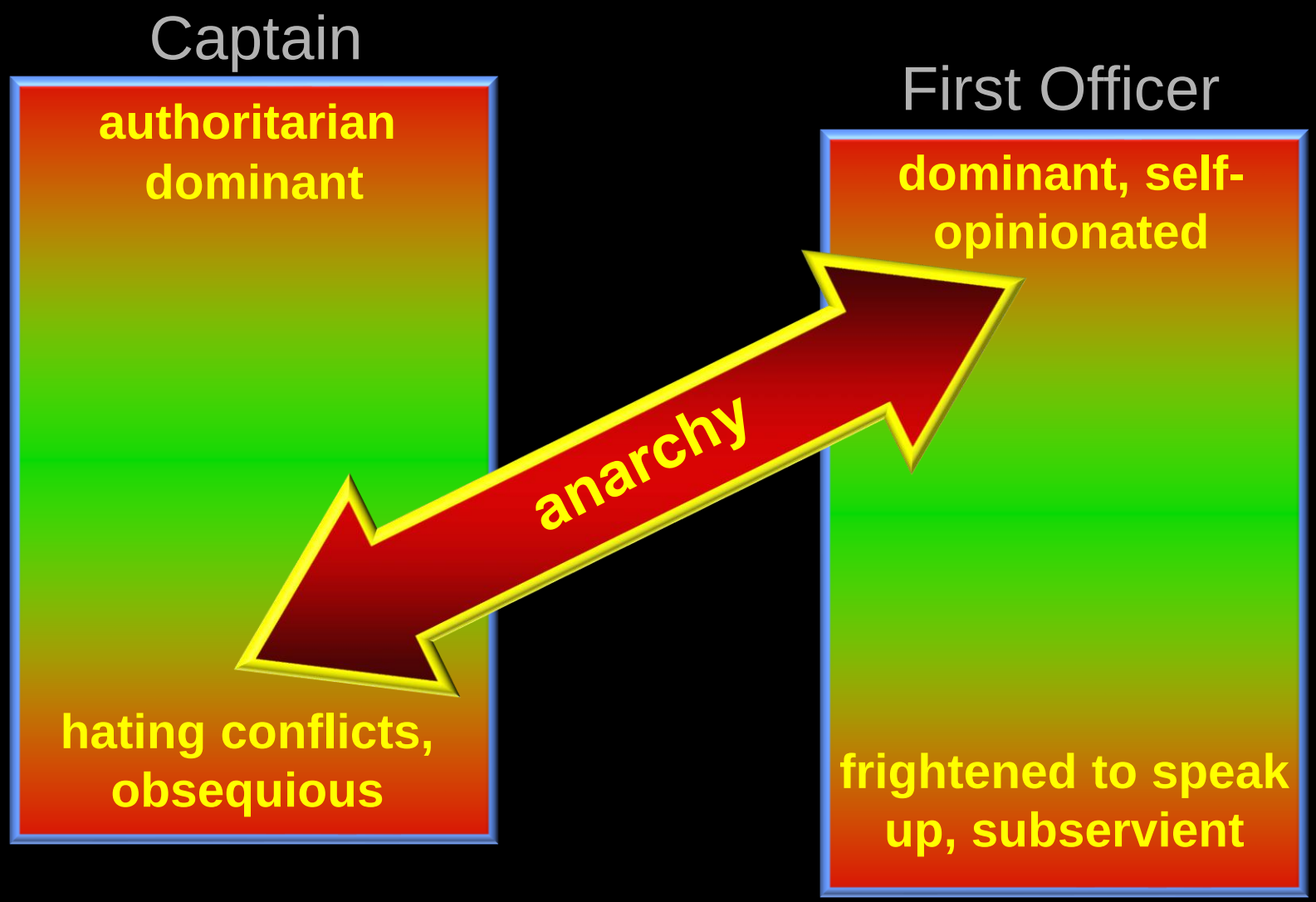
dominant, self-
opinionated

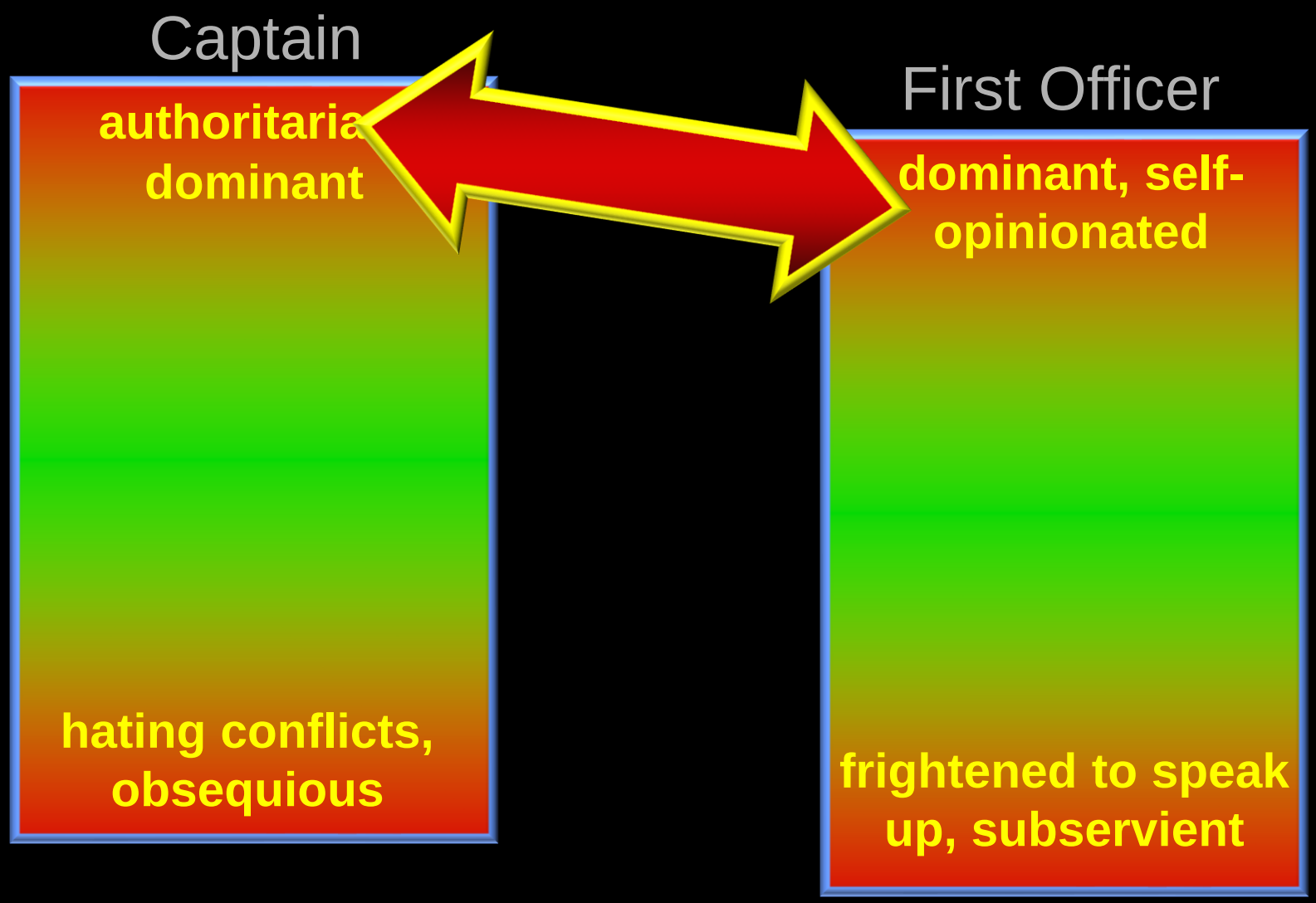
hating conflicts,
obsequious

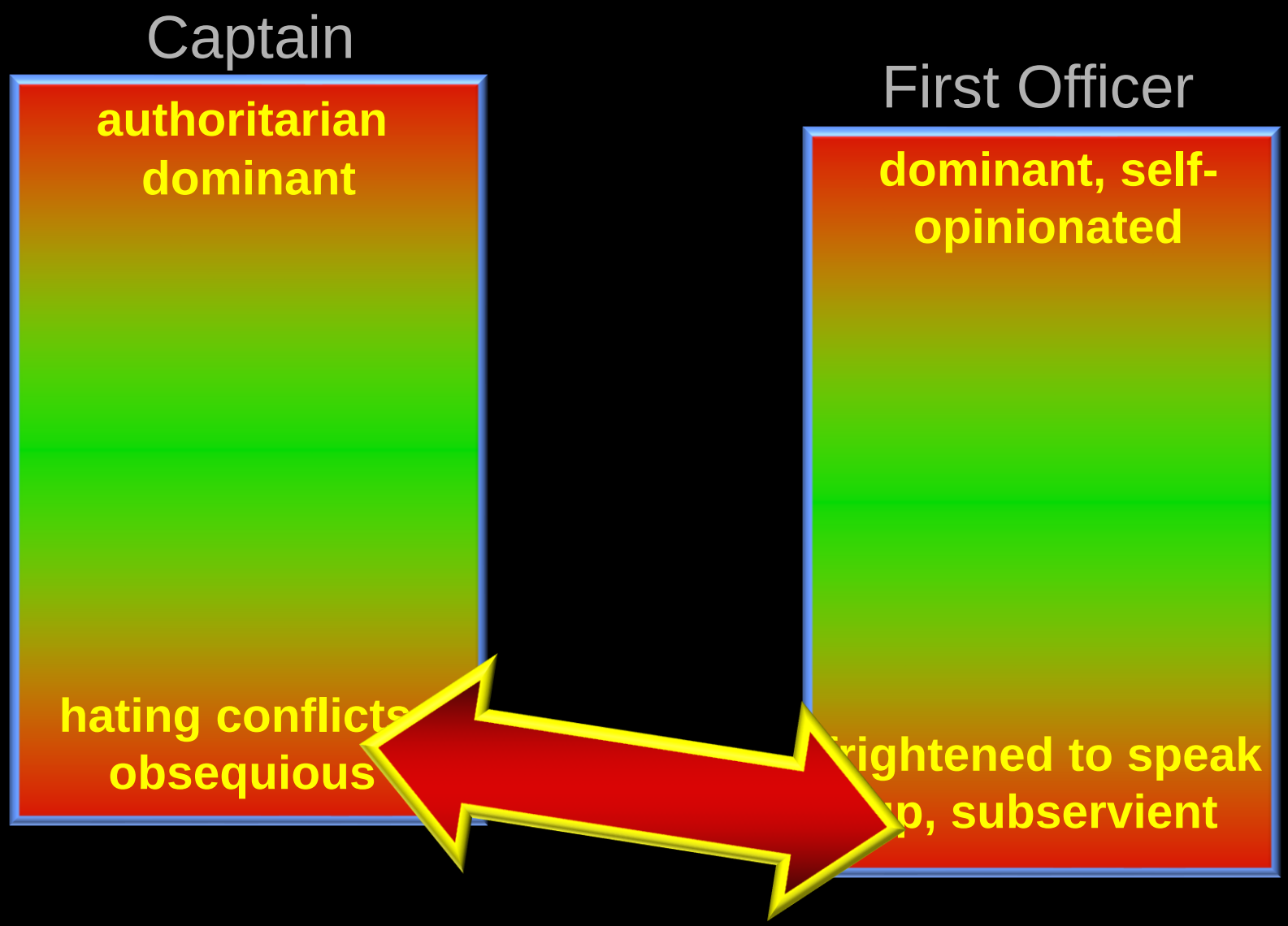
frightened to speak up
subservient


Captain
authoritarian
dominant
hating conflicts,
obsequious
First Officer
dominant, self-
opinionated
frightened to speak
up, subservient

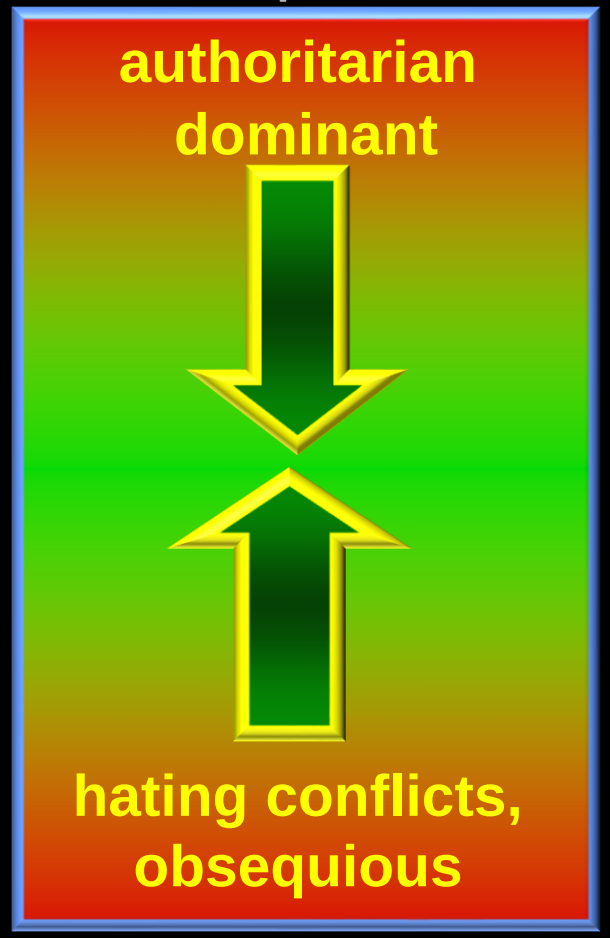

Captain
authoritarian
dominant
hating conflicts,
obsequious
First Officer
dominant, self-
opinionated
frightened to speak
up, subservient


Captain
authoritarian
dominant
hating conflicts,
obsequious
First Officer
dominant, self-
opinionated
frightened to speak
up, subservient
anarchy

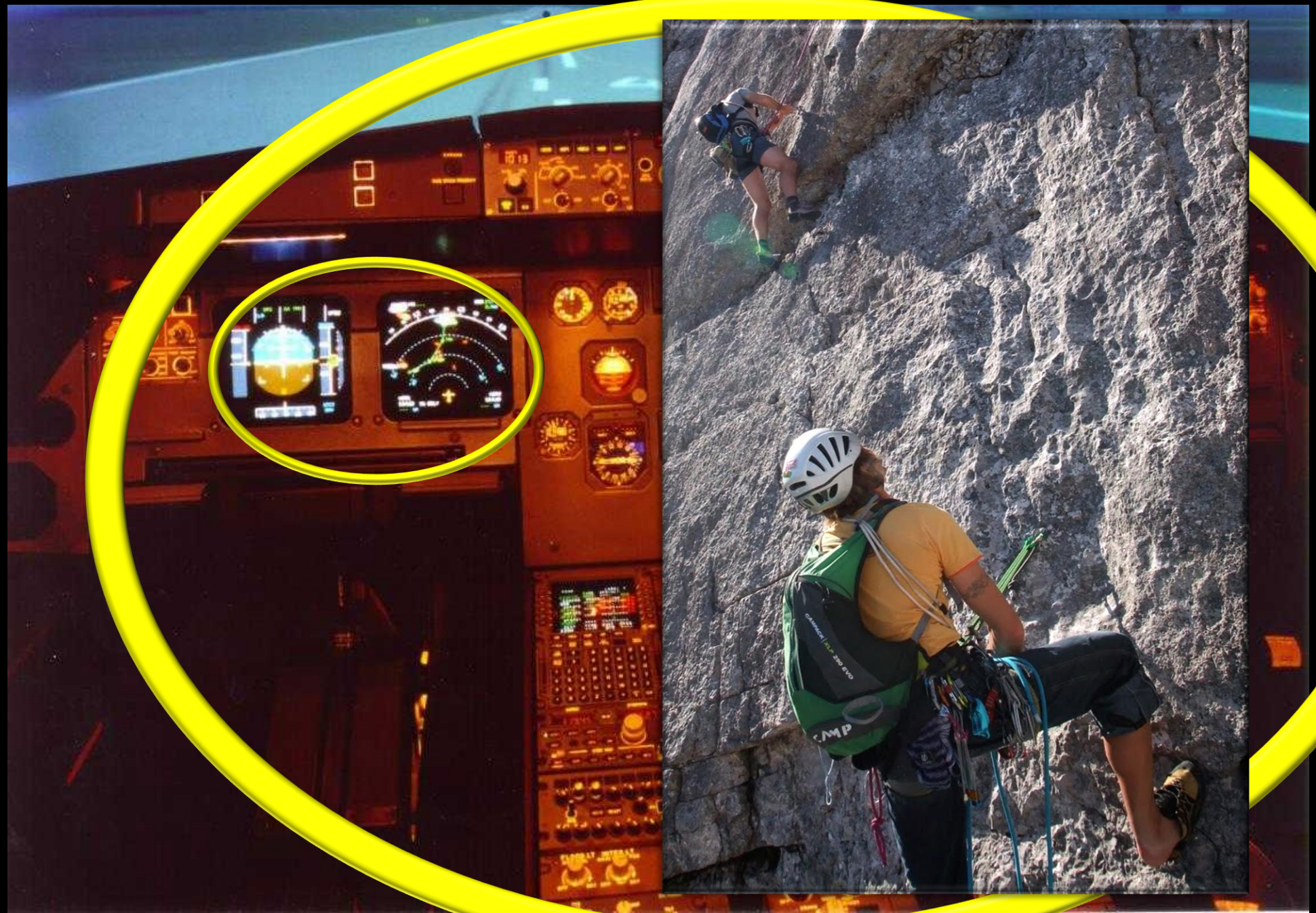

Captain
authoritaria
dominant
hating conflicts, obsequious
First Officer
dominant, self-opinionated
frightened to speak up, subservient


Captain
authoritarian
dominant
hating conflicts
obsequious
First Officer
dominant, self-
opinionated
rightened to speak
p, subservient

Captain



First Officer



Analysis of safety critical incidents

Human Factor Research Project

Inquiry

questionnaire with 120 pages

2100 Pilots gave detailed information about their last safety critical incident.

More than 3.200.000 sets of data have been evaluated.

Human Factor Research Project

risk categories

- TEC technical problems
- OPS operational problems
- HUM human error
- SOC social problems
  (team & culture)

Human Factor Research Project

human error

4,9% of all safety relevant incidents

IATA-statistic: ~60% ?

Human Factor Research Project

operational problems

+

human error

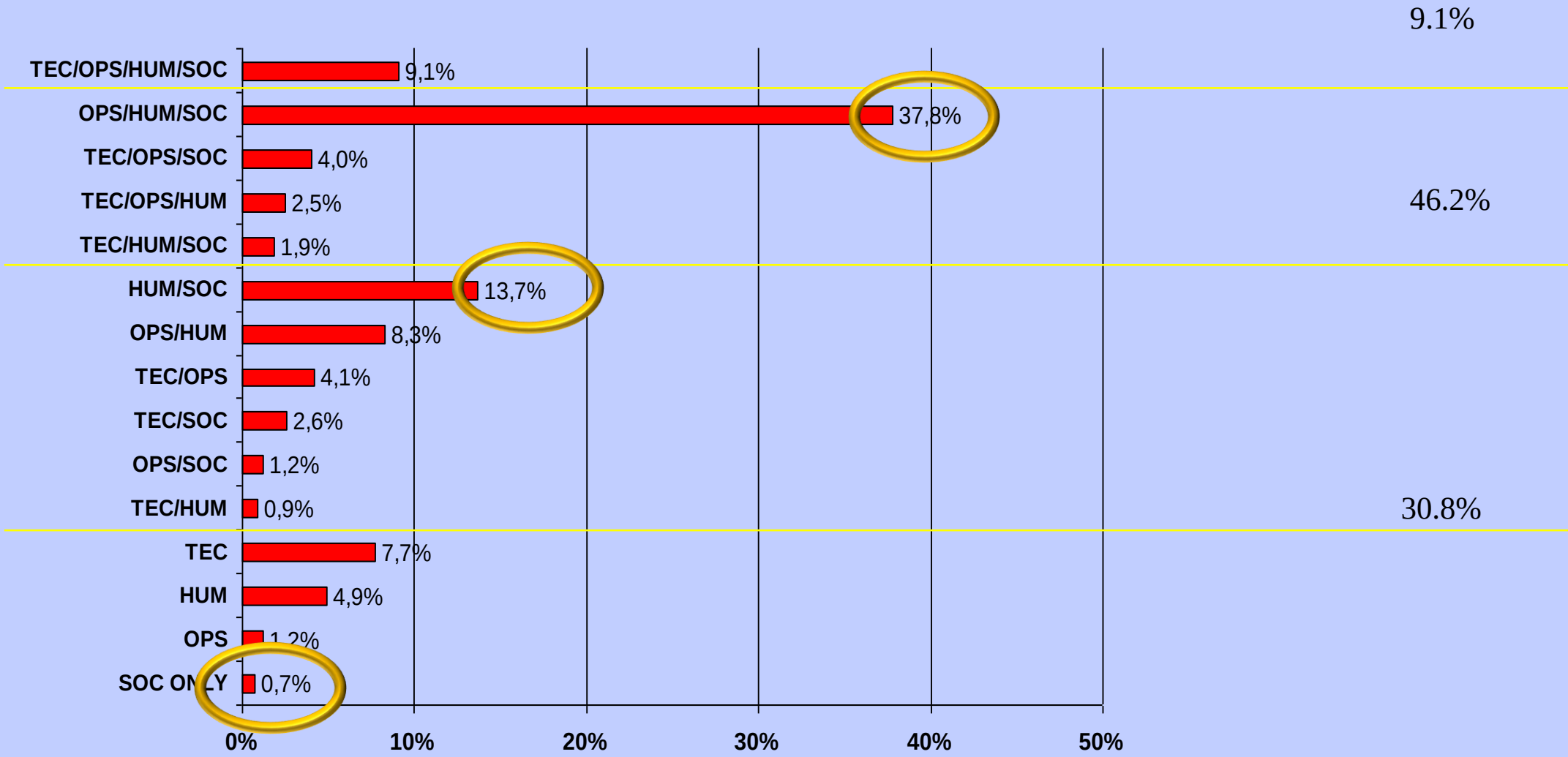
+

teamwork quality reduced by

“social problems“

37,8% of all safety relevant incidents

Frequency Distribution by Event-Configurations



Human Factor Research Project

human error
+
operational problems
+

Social problems within the team
increase the number of incidents by

factor 5

largest single event group

in 48% of all cases

- Necessary statements were not made, important information was not shared.
- Unclear concern was not addressed.
- Important information was incomplete, or was not heart correctly.

DESK

- Discipline

SOP

Standard Operating Procedures

Working processes


IGNORE
THIS SIGN

Risks for your individual life

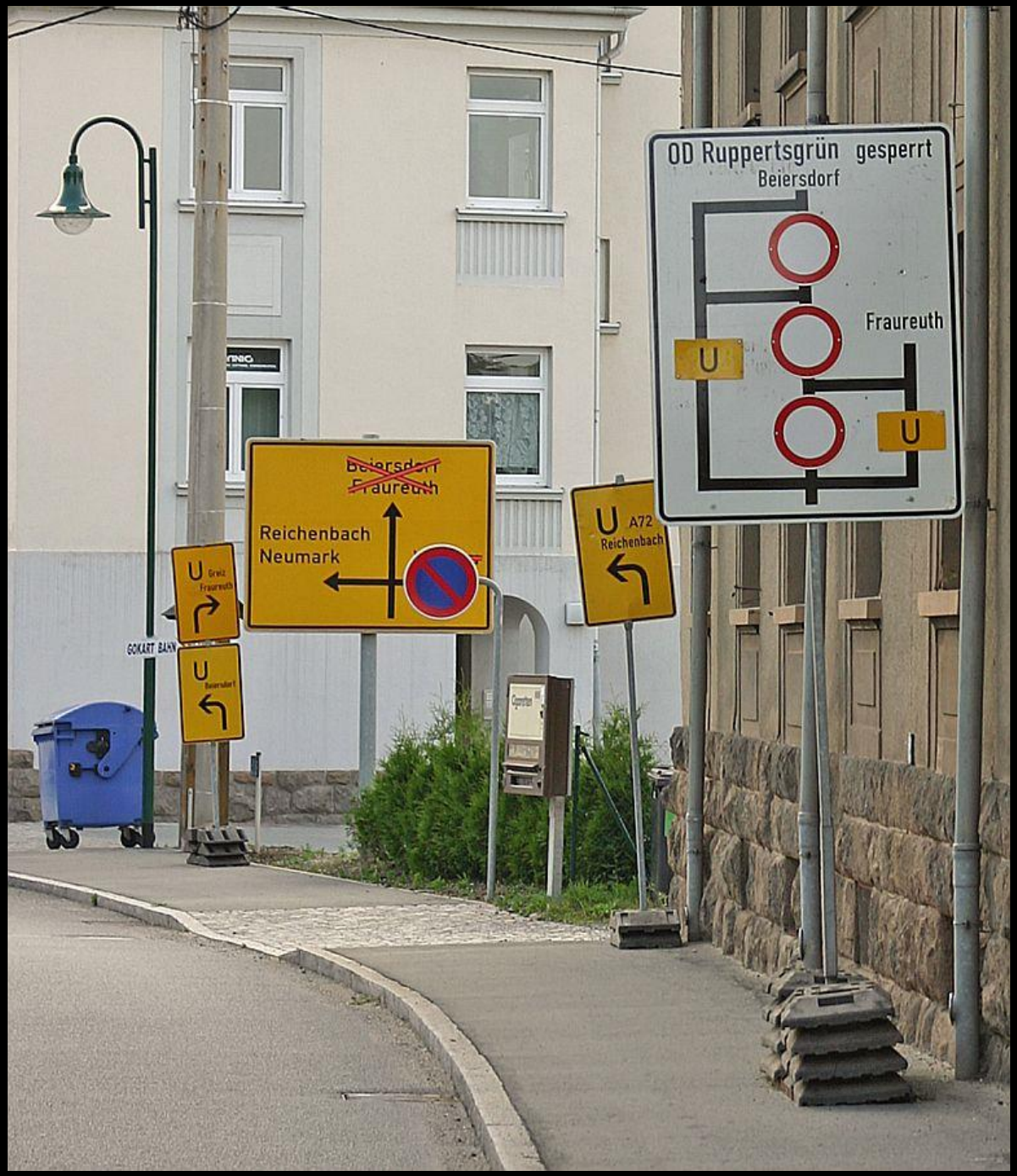
fatal car accident	1%
bankruptcy by divorce	3%
unemployment	10%
severe medical problem	30%
injury (car accident)	40%
injury playing Soccer	70%

Conflict for pilots

The risk for your own life is **> 1%**)

The risk for a single flight has to be
<0,000001%


8 30 - 16 u.
19 - 6 30 h
6 30 - 8 30 u.
16 - 19 h


OD Ruppertsgrün gesperrt
Beiersdorf
Fraureuth
U
U
Reichenbach
Neumark
U A72
Reichenbach
U
GOKART BAHN


Einbahnstraße
Koblenz 6 km

DESK

- Discipline
- Engagement (Motivation)

DESK

- Discipline
- Engagement (Motivation)
- Social Competence
  (Moral, Values, Childhood)

DESK

- Discipline
- Engagement (Motivation)
- Social Competence
  (Moral, Values, Childhood)
- K(C)ooperation (Task / Team)
  Ability to organize Teamwork

lonesome rider:
“Wild Bill“ Hopson


Jekyll & HYDE


LVER LAKE

Miami

Tools for team interaction

Optimum hierarchical structure

Active and passive criticism


SPEAK UP AND LIVE.
SHUT UP AND DIE.
PASSENGERPOWER.ORG.NZ

Training goal

Social Competence

- Accepting the fact to be fallable.

Don´t hide own weaknesses

Accident Statistics show:

Pilots not following the rules for optimum social interaction

(e.g. machismo, steep hierarchies, blaming)

operate on a significant higher risk level.

Training Target

Social Competence

80% of all "Human Errors" in complex situations can be handled using optimum social interaction.

Human Error
Prevention Strategies

However, errors will occur...


RECOVERY


MICHAEL LONG
TRUCK & CRANE HIRE


MICHAEL LONG
TRUCK & CRANE HIRE

Legal System

It is prohibited to make mistakes!

Making mistakes will be punished!

Errors & mistakes have to be reported

Quality Management
Error Prevention

ISO 9000 ff

~~Zero~~-Mistake-Strategy

Task Related Probability Of Errors MTBFs

Prof. Bubb TU-Munich

Category	Error probability	MTBF
Simple and regularely performed tasks at a low stress level.	$1 \cdot 10^{-3}$	~30 min
Complex, regularely performed tasks in a well known working environment at a low stress level.	$1 \cdot 10^{-2}$	~5 min
Complex tasks in unusual situations at a **high stress level** and / or **time pressure.**	**$1 \cdot 10^{-1}$**	**~30 sec**

Nonpunitive Reporting System

Errare humanum est

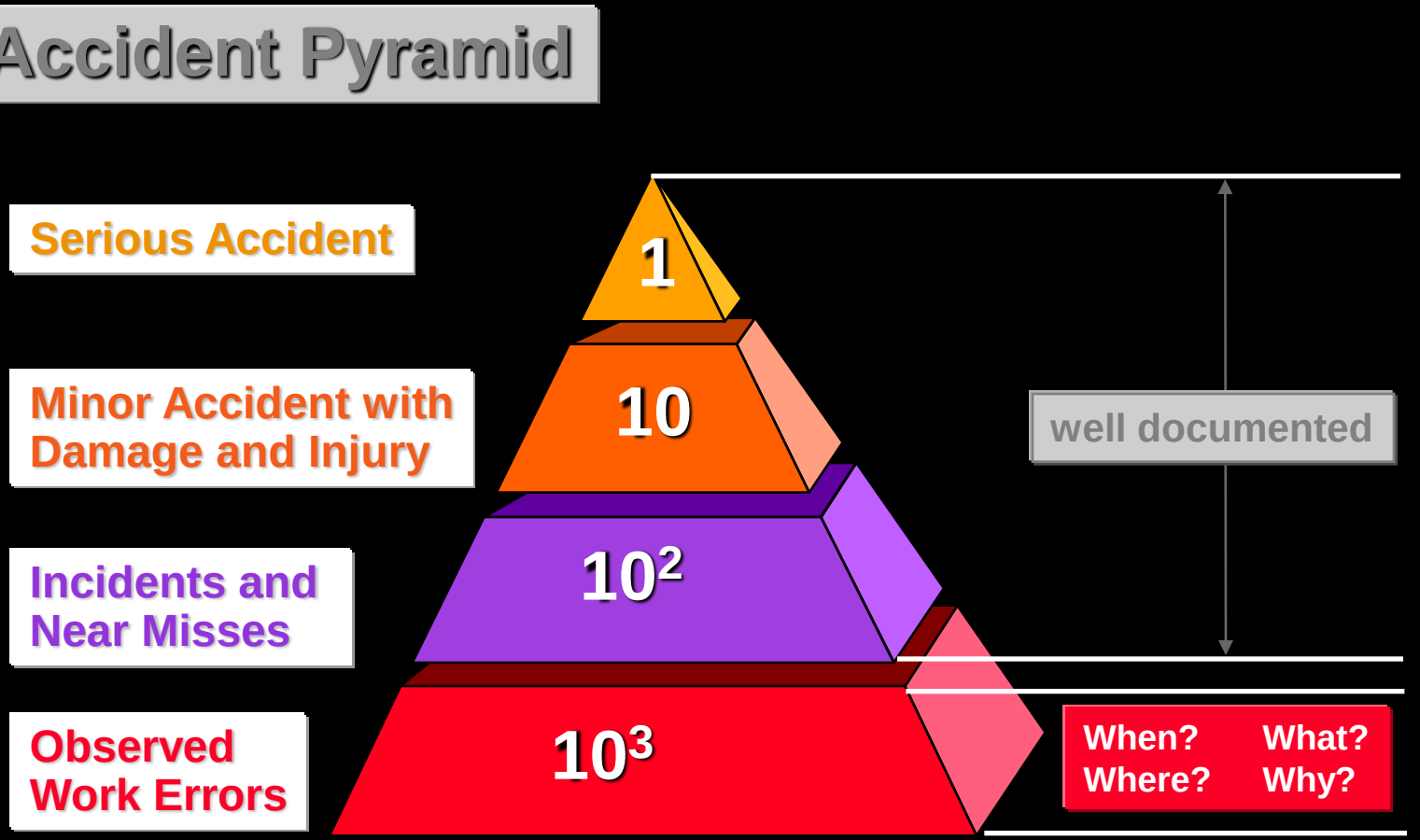
Accepting the fact that human beings make mistakes.

Nonpunitive Reporting System

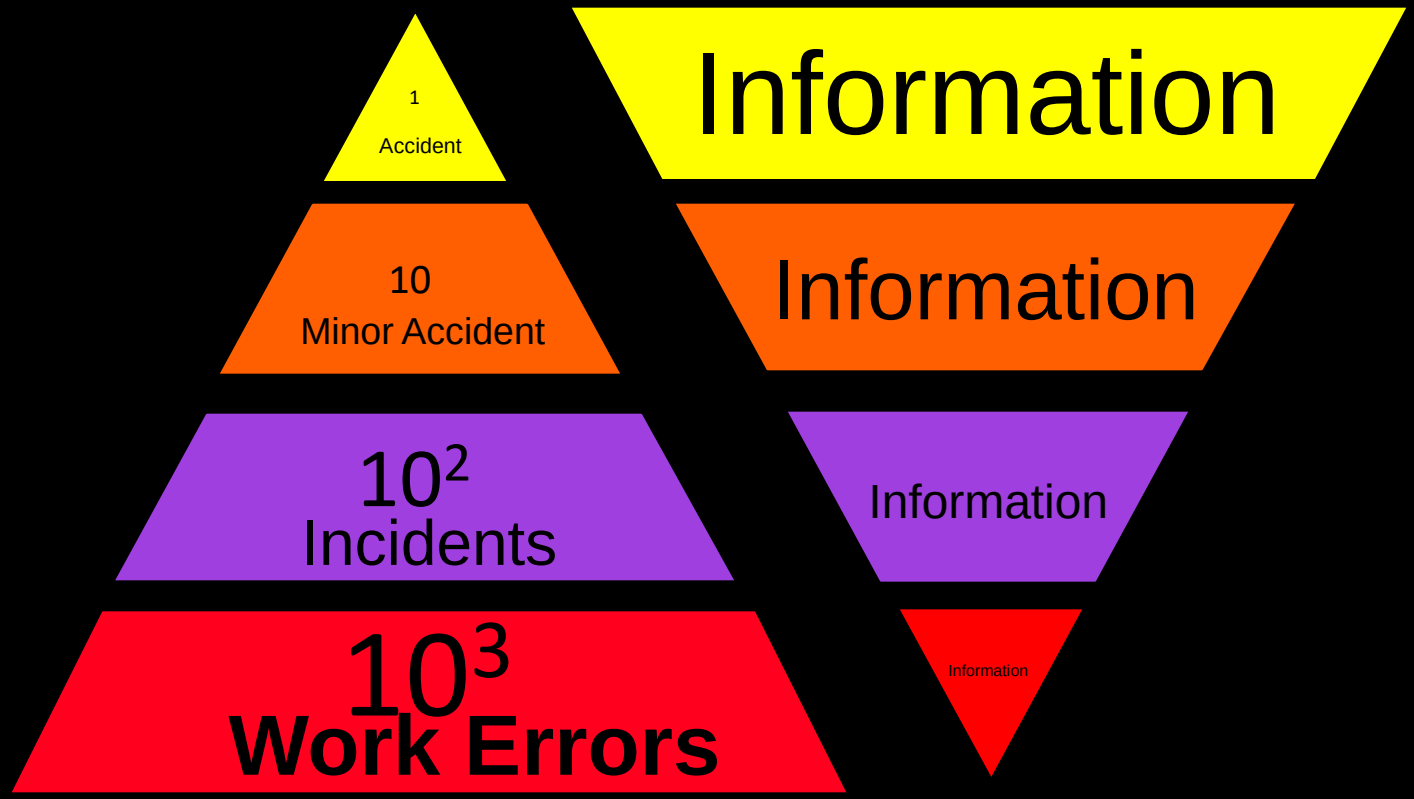
Analysing "secret" events

what?
why?
how often?

Accident Pyramid



Accident Pyramid



Nonpunitive Reporting System

Limits of confidentiality ?


CONFESSIO

Nonpunitive Reporting System

Limits of confidentiality ?

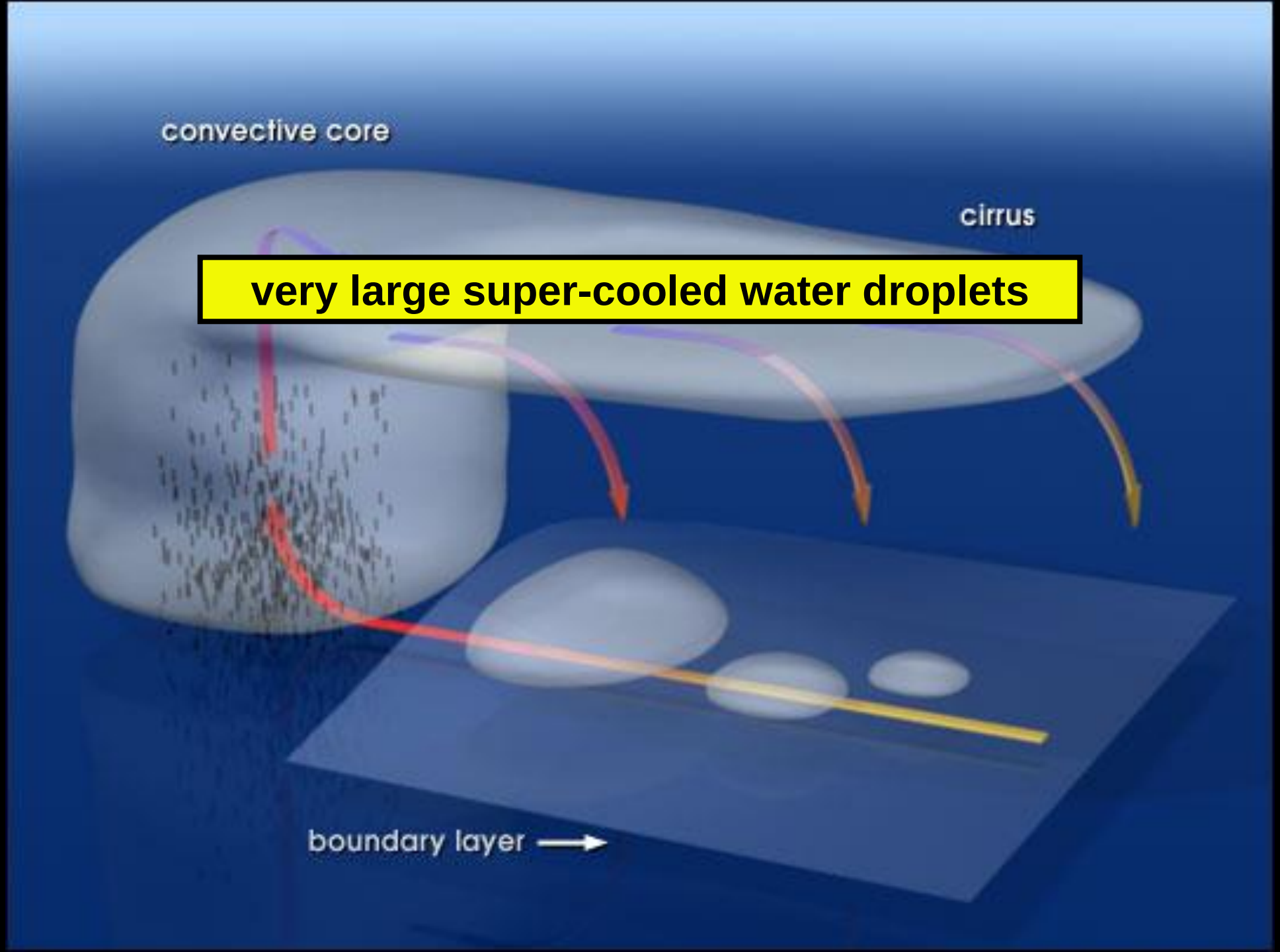
None!

(like secret of confession)

Nonpunitive Reporting System

Basic Requirement:

Independent of the disciplinary system


convective core
cirrus
very large super-cooled water droplets
boundary layer

2.700.000.- €


0220 GMT
AF 447 due in Senegal airspace but no contact received
SENEGAL
Atlantic Ocean
Thunderstorms
0214 GMT
Last automated messages indicate electrical fault
1230 GMT 2 June
Debris spotted
0148 GMT
Plane leaves radar surveillance
0133 GMT
1 June: Last radio contact
BRAZIL
2200 GMT
31 May: AF 447 departs Rio de Janeiro
Weather imagery: 1 June 0200 GMT

Nonpunitive Reporting System

Quantitative Study:

Only 4% of all pilots reported their own significant errors 10 years after system implemenation.

Accident Analysis
fact finding

Prime Causal Factor

Accident Analysis
fact finding

triggering condition

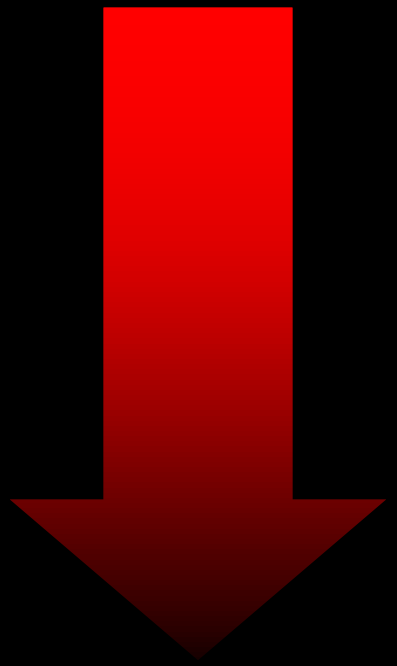
enabling factors

organisational deficiencies

private burden

Teamwork in the cockpit

negative private environment



discipline

motivation

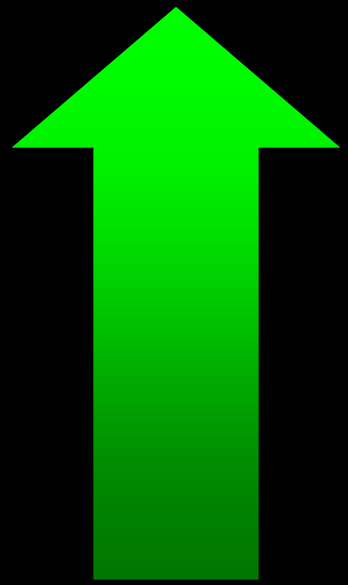
social competence

teamwork

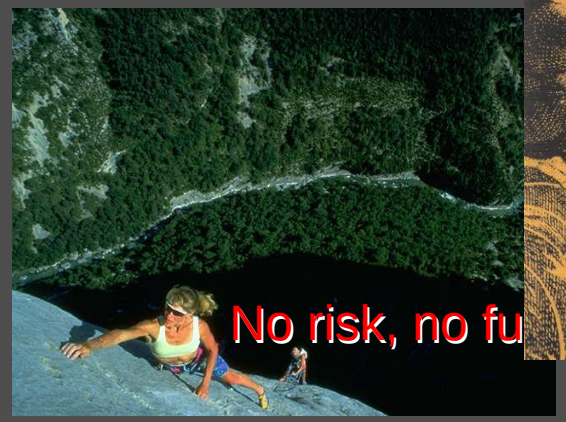
risk awareness

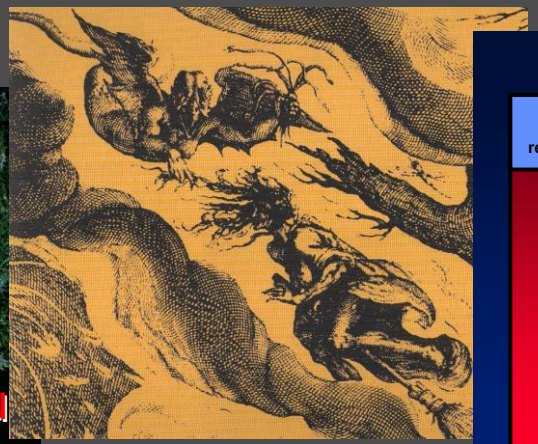
passive and active critisism

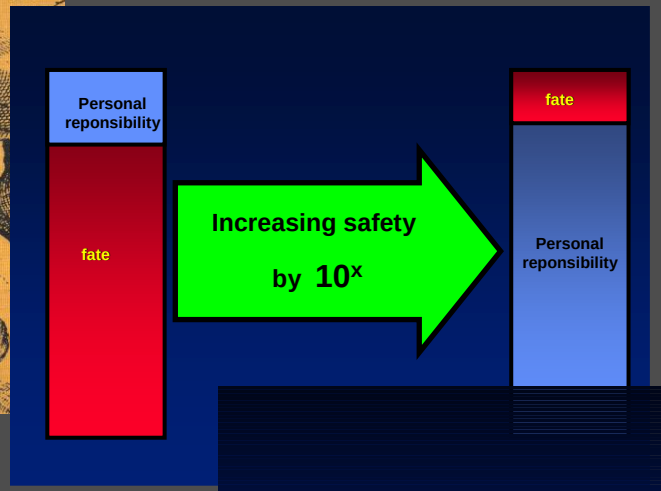
accepting human imperfection



positive private environment







FINISHED FILES ARE THE RESULT OF YEARS OF SCIENTIFIC STUDY COMBINED WITH THE EXPERIENCE OF YEARS