ANK 315 AIRCRAFT MAINTENANCE

Lecture 10

AVIATION SAFETY & HUMAN FACTOR

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AGENDA:

1. SAFETY IN AVIATION
2. AIRWORTHINESS SAFETY
3. HUMAN FACTOR
4. HUMAN FACTOR IN MANTENANCE

AVIATION SAFETY

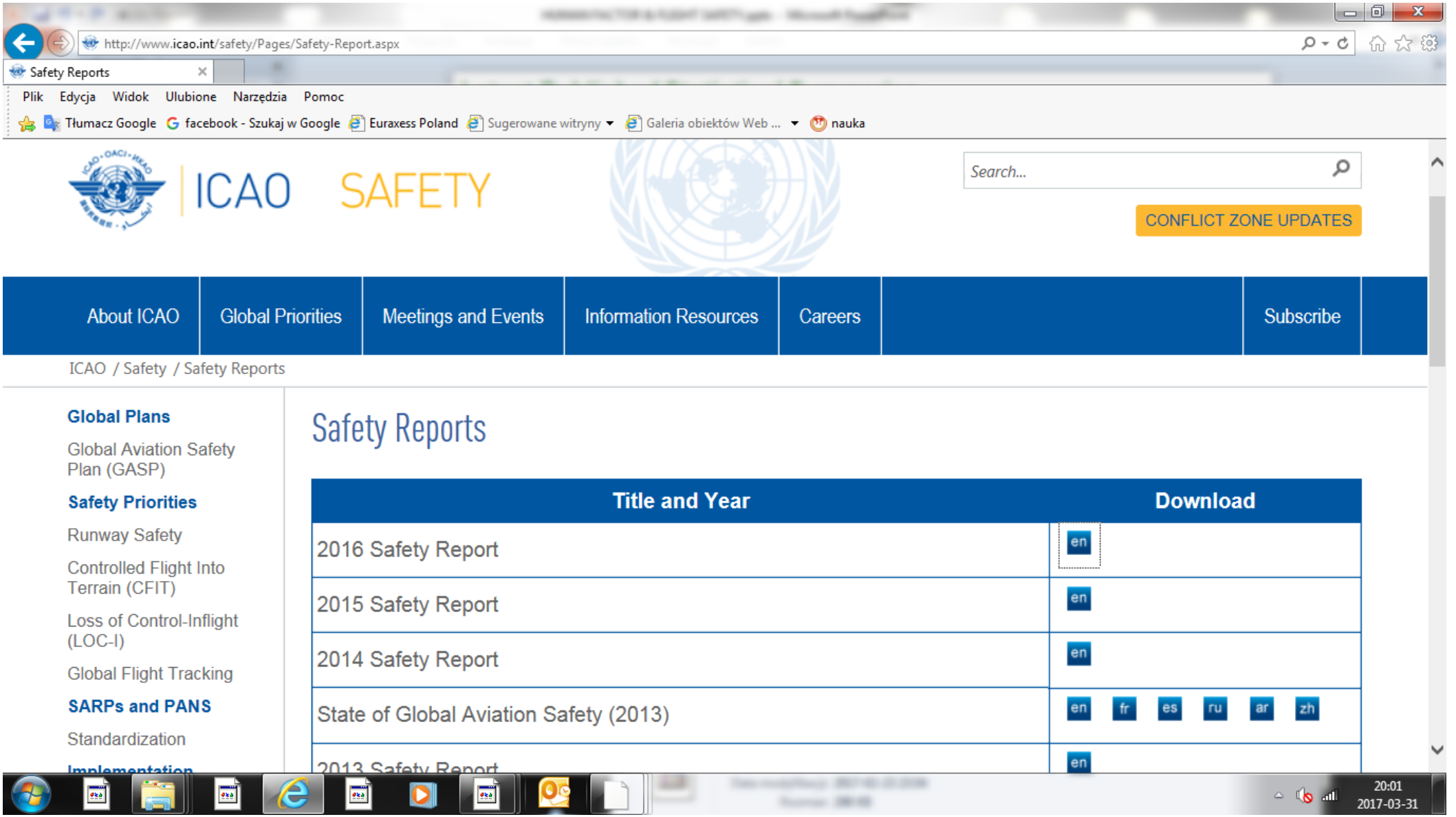
.Aviation Safety Statistics

Sources of Statistical Information

Latest Published Statistical Summaries

Latest Published Statistical Summaries

ICAO Safety Review:



Latest Published Statistical Summaries

Global Aviation Safety Study - Allianz

Commercial Aviation accidents 1958-2015, a summary by Airbus

ICAO 2016 Safety Report

IATA Safety Report 2015

Boeing STATSUM 1959-2015, published in 2016.

EASA Annual Safety Review: 2016

UK CAA Global Fatal Accident Review 2002-2011

Data Boundaries

- Injury Sustained
- Extent of Aircraft Damage
- Nature of Event
- Geographical Boundary
- Aircraft Weight
- Domicile of Manufacturer

Data Boundaries

- Injury Sustained

  - **Fatality - death consequent upon an aircraft accident is typically classified as such a death which occurs within 30 days of the accident**

  - **Serious Injury - injury consequent upon an aircraft accident or serious incident is typically classified as serious if it results in hospitalisation for more than 48 hours commencing within 7 days of the event.**

Data Boundaries

- Injury Sustained
- Extent of Aircraft Damage

  - **Substantial Damage - usually taken as damage or structural failure which adversely affects the structural strength, performance of flight characteristics of an aircraft and which would normally require major repair or replacement of the affected component(s)**

Data Boundaries

- Injury Sustained
- Extent of Aircraft Damage
- Nature of Event
  - **Hull Loss – An aircraft is totally destroyed or assessed to have been damaged beyond economic repair. Assessment as a hull loss is always affected by the age (measured in any or all of years-since-new, cycles flown or landings made) of the damaged aircraft and sometimes by the concern of the operator to avoid the 'public declaration of a hull loss.**
  - **Total Loss/Constructive Total Loss - Statistical data which originates in the insurance market is traditionally a very reliable source of data. Insurers use the terms "Total Loss" and "Constructive Total Loss" which is not quite the same as Hull Loss.**
  - **Major Accident – An accident in which any of the following conditions is met: The aircraft was destroyed; or there were multiple fatalities; or there was one fatality and the aircraft was substantially damaged.**
  - **Fatal Accident - An accident that results in a fatal injury, where death was not due to natural causes or self inflicted injuries, or injuries inflicted by other passengers, and was not due to a malicious act such as terrorism**

Data Boundaries

- Injury Sustained
- Extent of Aircraft Damage
- Nature of Event
- Geographical Boundary
  - **ICAO Regions are the most often used regional definition**
  - **There is a particular difficulty with the 'definition' of Europe which may include, amongst other options ECAC, EU, EASA Member States or JAA. Political and regulatory evolution in Europe means that these definitions have themselves appeared, disappeared or varied over time**

Data Boundaries

- Injury Sustained
- Extent of Aircraft Damage
- Nature of Event
- Geographical Boundary
- Aircraft Weight

  For fixed wing aircraft, 60,000 lb /27, 000 kg is commonly used as a minimum aircraft weight for event data to be included in accident statistics for larger aircraft - those making up the majority of most airline jet fleets, whereas 12,500 lb / 5,700 kg is often used in statistics intended to cover the majority of multi crew commercial operations. Alternatively, some statistical presentations have used a 33,000 lb / 15, 000 kg boundary

Data Boundaries

- Injury Sustained
- Extent of Aircraft Damage
- Nature of Event
- Geographical Boundary
- Aircraft Weight
- Domicile of Manufacturer

Western/Eastern-built Aircraft - some statistics make this distinction or exclude the latter altogether because data for many operations of Eastern-built aircraft (those originating in the former USSR) have historically been unavailable or unreliable

Źródło: /www.skybrary.aero

Safe aviation operations
are more than just the lack of accidents – safety comes from consistent attention to the factors in all sectors of the Aviation Safety Triangle

Źródło: www.faa.gov

Technology and system improvements have made great contributions to safety

However, part of being safe is about attitudes and paying attention to what your surroundings are telling you

Whether through data or through the input of employees and others, recognizing that many opportunities exist to stop an accident is the first step in moving from reactive to predictive thinking

Safety begins from both the top down and the bottom up

Everyone from the receptionist, ramp worker, pilot, manager, and Aviation Authority's Inspector has a role to perform

SMS is all about decision-making

Thus it has to be a decision-maker's tool, not a traditional safety program separate and distinct from business and operational decision making

Hypothetical Scenario Demonstrating the Need for SMS

Źródło: www.faa.gov

A well-designed aircraft with a history of reliable service is being prepared for a charter flight. Employees tow the aircraft from the hangar to the terminal. One employee sees wetness on the right tire as he unhooks the tow bar. However, he does not give it attention, as he is very busy and has three other aircraft to move in the next 15 minutes

At the same time, a safety inspector is walking through the hangar when she encounters a hydraulic oil spill on the hangar floor. She notifies a janitor to clean up the slip hazard as she leaves. While cleaning the spill, the janitor wonders aloud where the spill came from. Afterwards, both the inspector and the janitor continue with their respective jobs

Soon afterwards, the pilot is fired for failure to perform an adequate preflight inspection. Six months later, an aircraft is being towed out of a hanger. One of the employees sees wetness on the left main landing gear tire as he unhooks the tow bar...

Meanwhile, the Chief Pilot assigns the charter flight to a new pilot with the company. While new to the company, the pilot is well trained and prepared for the flight. He is also eager to do a good job and to impress the chief pilot. The chief tells him that the passengers and the aircraft are waiting at the terminal, and the new pilot has to get over there right away to keep the clients happy and on schedule

Źródło: www.faa.gov

The flight requires a little more fuel, so a fuel truck is called. While the aircraft is being filled, the fueler notices a small puddle of reddish fluid under the right main landing gear. He sees the pilot walking out to the aircraft, but before he can say anything, his supervisor calls and tells him to get right over to another aircraft. Recently, the fueler was criticized by his supervisor for taking too long to finish his work, so he quickly jumps in his truck and drives off to the next job without saying anything to the pilot

Źródło: www.faa.gov

The pilot, wanting to make a good impression on his passengers and the chief pilot, personally escorts them to the aircraft and begins his preparation for the flight
One passenger asks him a brief question as he is on the right side of the aircraft. In a moment of distraction, he does not bend down to inspect the right hand main landing gear
During taxi, the pilot feels the aircraft is taking the bumps a little hard, but continues to the runway for take-off. Meanwhile, up in the tower, an air traffic controller, who happens to like this particular model of aircraft, picks up her binoculars to take a look at the taxiing aircraft. She notices a "wet spot" on the right main tire and radios the pilot
The pilot tells the controller that he probably ran over a puddle and asks for his clearance
At the destination airport, the pilot executes a perfect landing and applies the brakes. The leaking hydraulic fluid heats up and ignites. The right main landing gear is engulfed in flames
The controller notifies the pilot and then calls the crash fire rescue squad
The pilot calmly and proficiently manages the situation, successfully evacuating everyone from the aircraft without injury
The pilot and passengers watch from a safe distance while a perfectly good aircraft burns to the ground. "How could this have happened?" wonders the pilot.

Źródło: www.faa.gov

Evolution of Safety Management

Safety Management Systems (SMSs) are the product of a continuing evolution in aviation safety

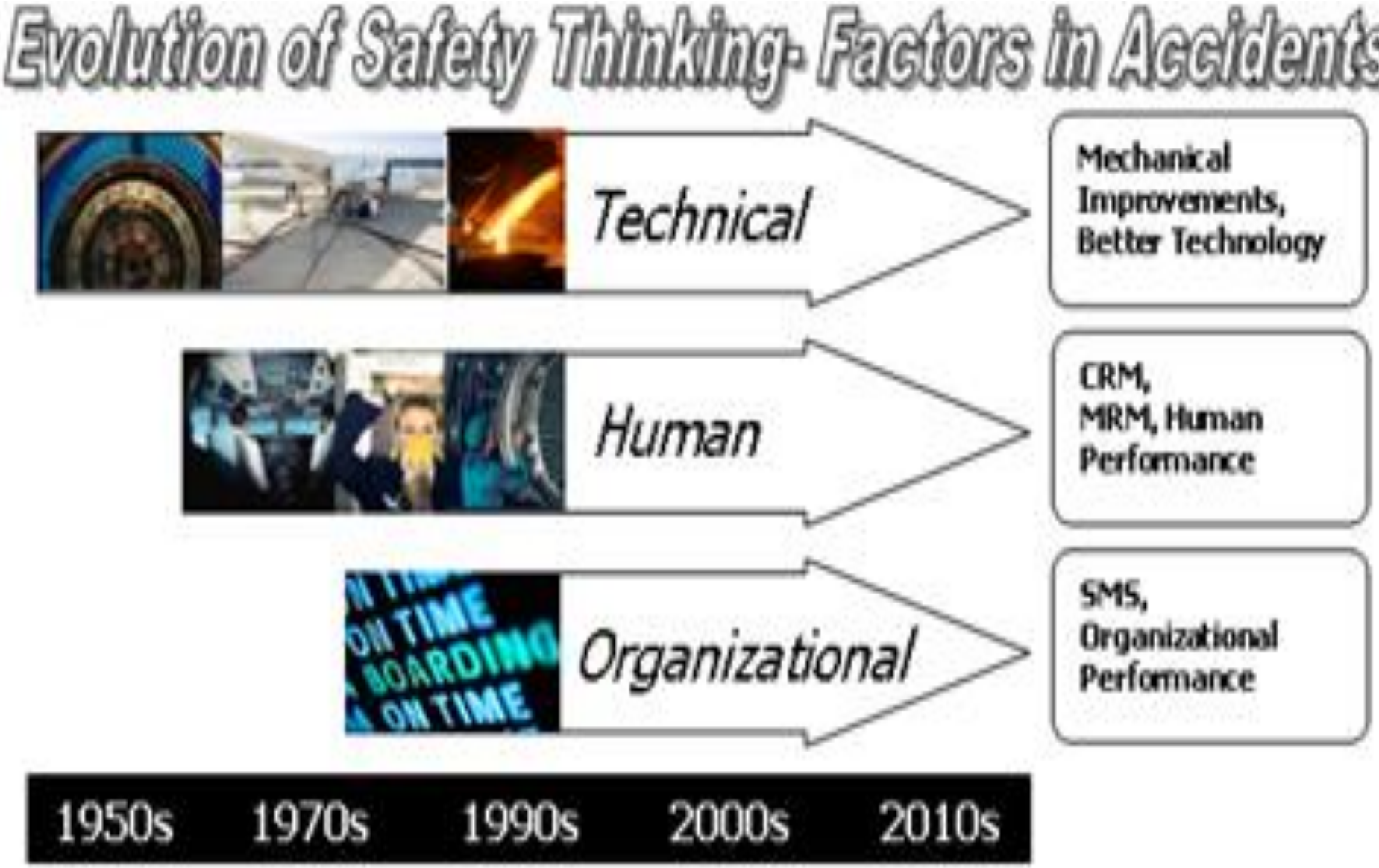
Early aviation pioneers had little safety regulation, practical experience, or engineering knowledge to guide them

Over time, careful regulation of aviation activities, operational experience, and improvements in technology have contributed to significant gains in safety. In the next major phase of improvement to safety, a focus on individual and crew performance or "Human Factors" further reduced accidents

Each approach has led to significant gains in safety. However, even with these significant advances, we still have opportunities to take preventative action against accidents.

The question for the aviation community is, "what is the next step?"

Źródło: www.faa.gov



crew resource management (CRM)
maintenance resource management (*MRM*)

Źródło: www.faa.gov

Careful analysis typically reveals multiple opportunities for actions that could have broken the chain of events and possibly prevented an accident

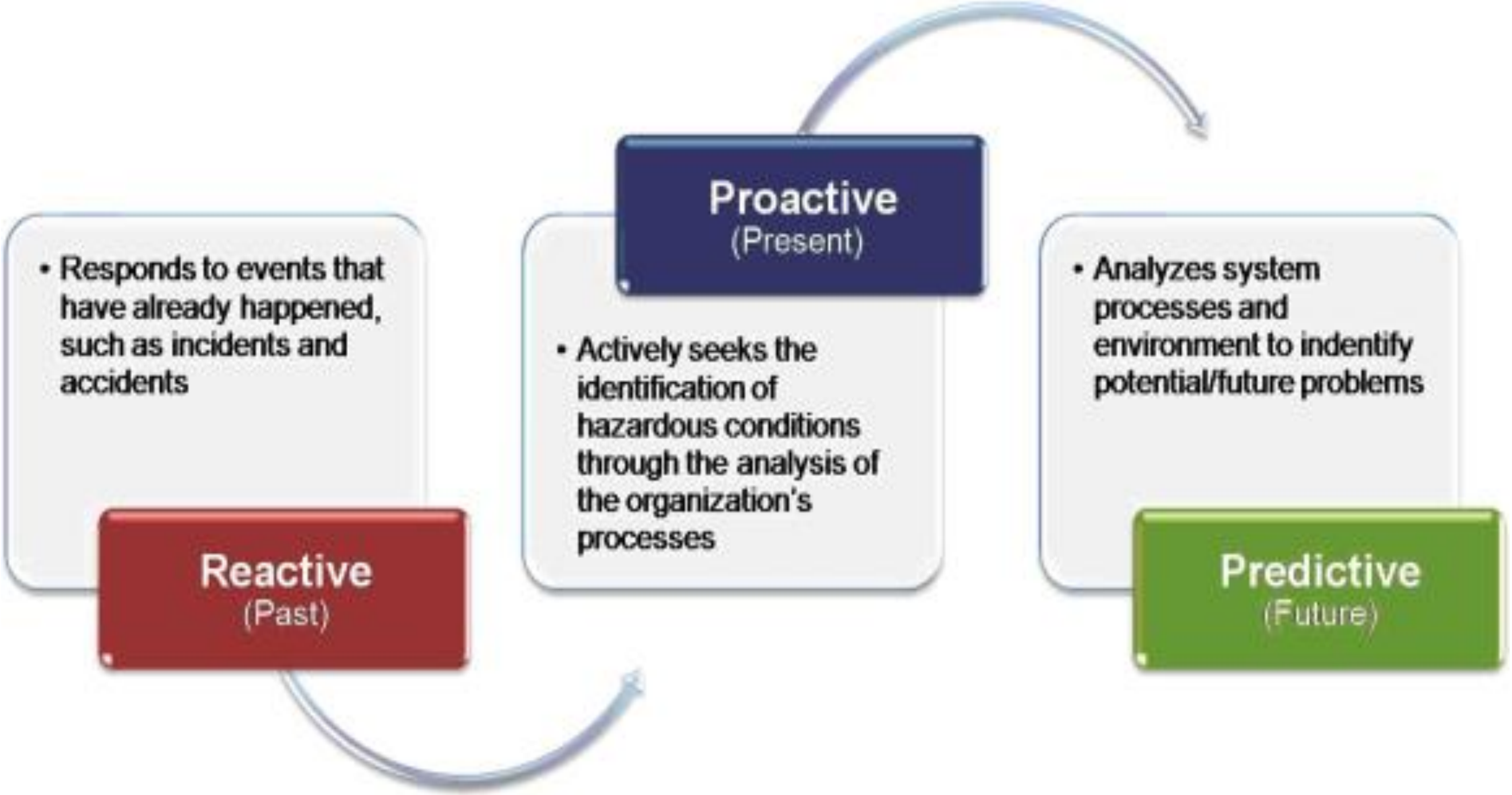
These opportunities represent the organization's role in accident prevention

The term "organizational accident" was developed to describe accidents that have causal factors related to organizational decisions and attitudes

SMS is an approach to improving safety at the organizational level

Źródło: www.faa.gov

How Safety Management System Addresses the Organization's Role in Safety



Airworthiness Risk Indicator

AS/NZS 4360:1999 : *"Risk - the chance of something happening that will have an impact upon objectives. It is measured in terms of consequences and likelihood"*

AS/NZS 4360:1999 Risk Management analysis matrix

AS/NZ	Catastrophic	Major	Moderate	Minor	Insignificant
Almost certain	Extreme	Extreme	Extreme	High	High
Likely	Extreme	Extreme	High	High	Moderate
Moderate	Extreme	Extreme	High	Moderate	Low
Unlikely	Extreme	High	Moderate	Low	Low
Rare	High	High	Moderate	Low	Low

There is a need for a quantitative measurement of risk

Quantitative Hazard Probability

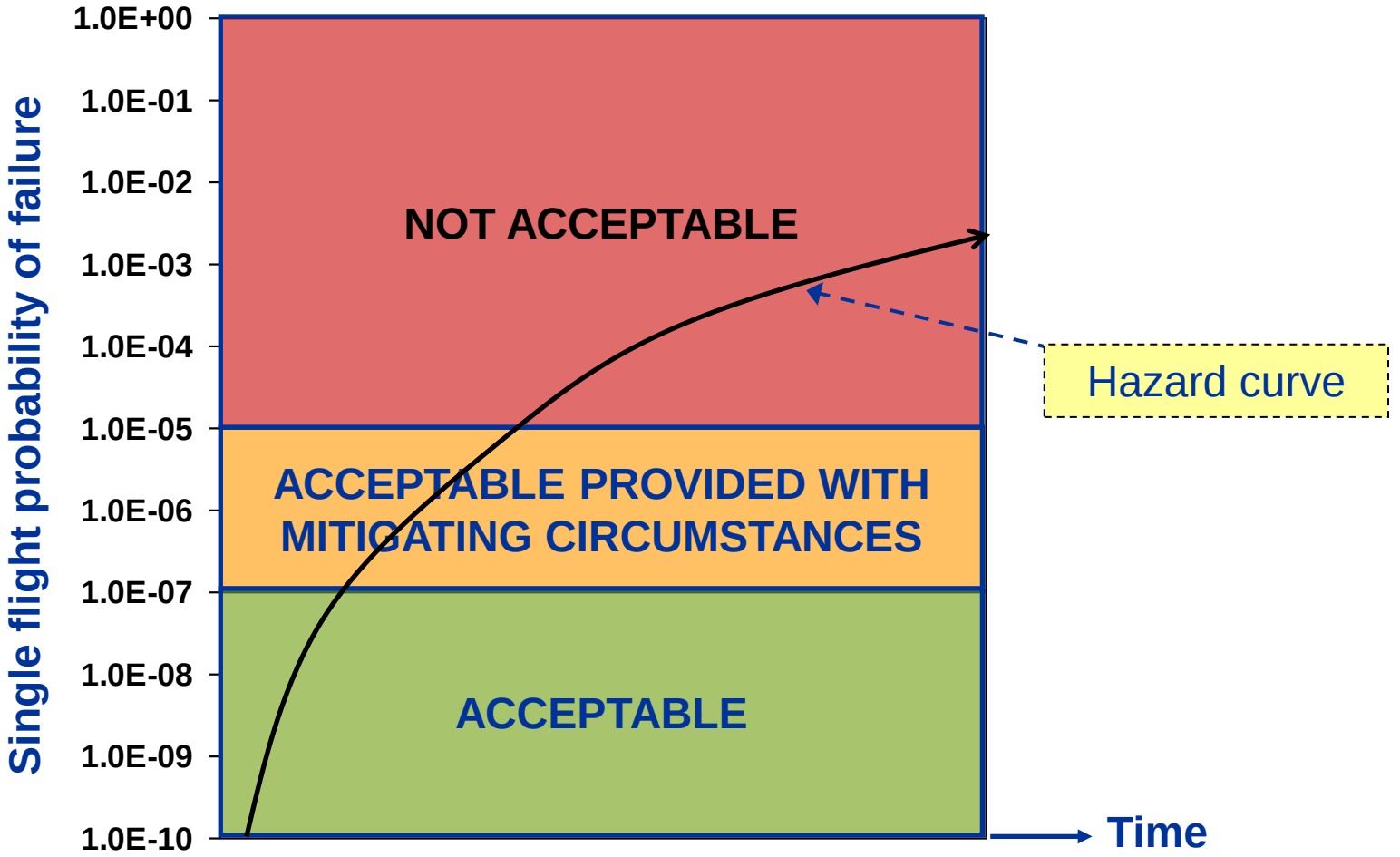
Hazard Probability Level	Hazard Probability Threshold (Per Flight Hour)			
	DND Passenger Carrying Aircraft	Military Aircraft		
		Military Aircraft	Military Aircraft – Ejection seat Equipped	Unmanned Aerial Vehicles (UAVs) Above 150 kg
Frequent	> $1x10^{-3}$	> $1x10^{-3}$	> $1x10^{-3}$	> $1x10^{-2}$
Reasonably Probable	< $1x10^{-3}$	< $1x10^{-3}$	< $1x10^{-3}$	< $1x10^{-2}$
Remote	< $1x10^{-5}$	< $1x10^{-5}$	< $1x10^{-4}$	< $1x10^{-3}$
Extremely Remote	< $1x10^{-7}$	< $1x10^{-6}$	< $1x10^{-5}$	< $1x10^{-5}$
Extremely Improbable	< $1x10^{-9}$	< $1x10^{-8}$	< $1x10^{-7}$	< $1x10^{-6}$

Source: Liao, Bombardier and Renaud (2009), National Research Council Canada

Probabilistic Risk Analysis provides a quantitative measure for the specific hazard level

Quantitative Hazard Probability

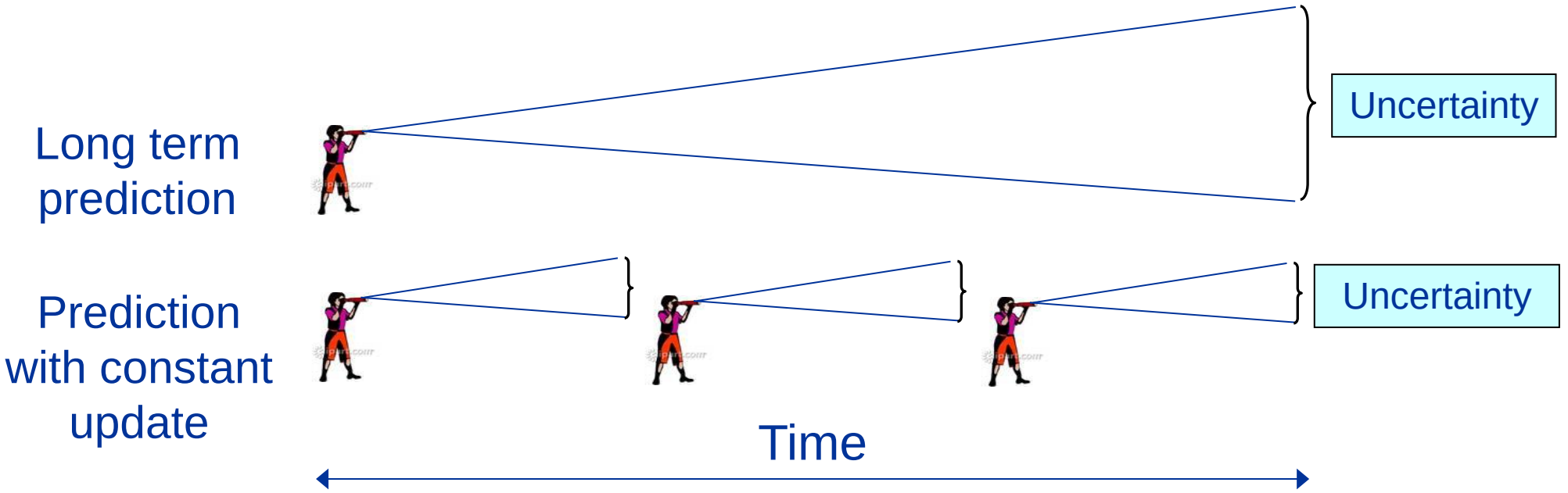
MIL-STD 1530C :



Probabilistic Risk Analysis provides a quantitative measure for the specific hazard level

.Challenges in probabilistic risk analysis

- Predicting too far ahead increases uncertainty



by Bayesian approach

Incorporating new observation into the data improves prediction

CONSEQUENCES OF ERRORS IN AVIATION MAINTENANCE

WHAT ARE ERRORS?

- *A failure arising from*
  - *an action that was not completed as intended*
  - *a plan for action that was inadequate to begin with*

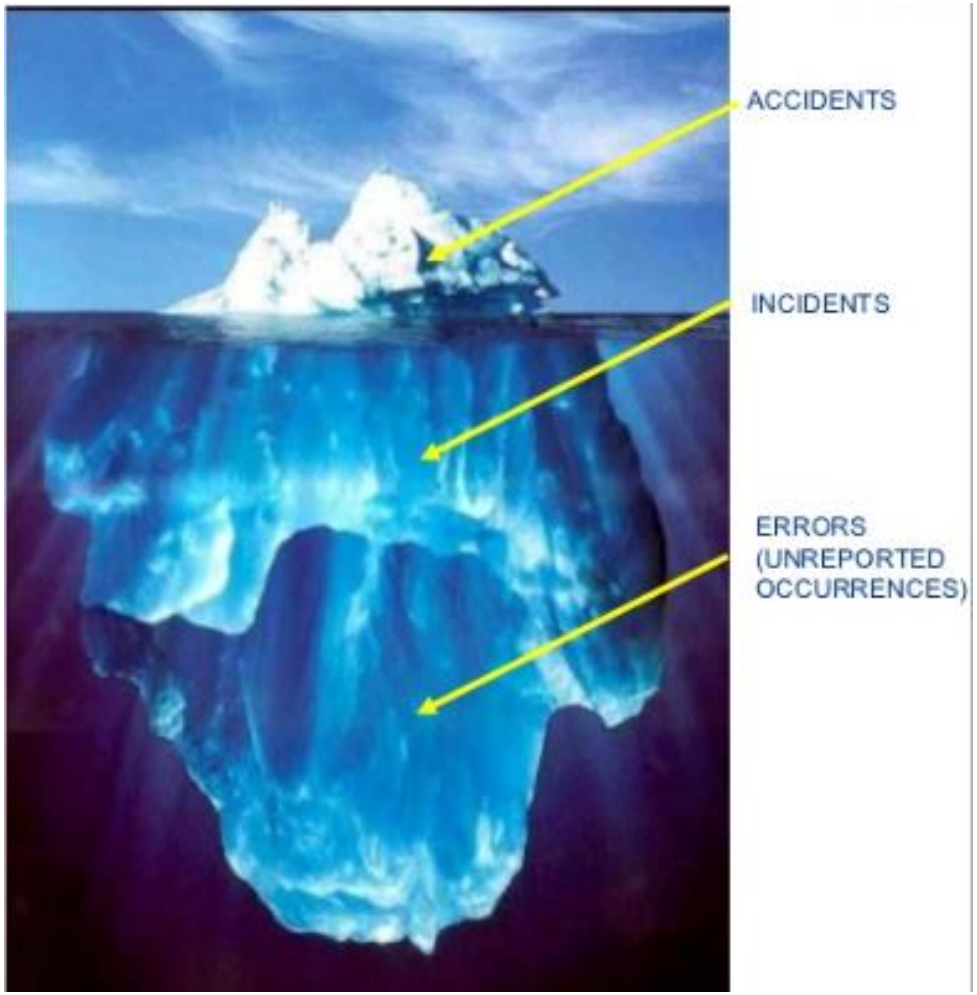
- **Slips & Lapses (skill-based)**
  - occur at execution stage (memory and attention errors)

- **Mistakes (rule- and knowledge-based)**
  - occur at judging or inference stage (planning errors)

(Reason, 1990)

MAINTENANCE ERROR

"A maintenance error is considered to have occurred when the maintenance system, which includes the human element, fails to perform in the manner expected in order to achieve its safety objectives."



Human Error & Aviation Safety

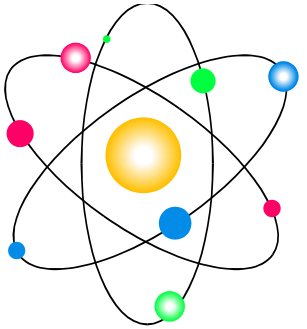
Old View

- Human error is the cause of accidents
- Human is the most unreliable component
- Improve safety by restricting human action

New View Revised

- Human error is the effect of deeper issues
- Human is necessary to create safety
- Get away from blame and ask "why"?
- Improve safety by understanding (and leveraging) human and organizational performance

HUMAN FACTOR IN AVIATION MAINTENANCE

Event  Reaction

Event | RATIONAL MIND | EMOTIONAL MIND | Reaction

ADULT / CHILD

Early Life Decisions

Individual reactions to events depend upon the following :

- FATIGUE
- STRESS
- COMPLACENCY
- COMMUNICATION
- AWARENESS
- DISTRACTION

Individual reactions to events :

- LACK OF KNOWLEDGE
- TEAMWORK
- RESOURCES
- PRESSURE
- LACK OF ASSERTIVENESS
- NORMS


These are the
DIRTY
DOZEN

Maintenance Resource Management

.As well as some safety nets for each one

.COMPLACENCY

….. a feeling of smug or uncritical satisfaction with oneself or one's achievements

.and the safety nets are ....

- Always follow the checklist or work cards
- Never work from memory
- Be sure to vary your routine periodically
- Be aware of the dangers of complacency

.DISTRACTION

.The safety nets . . .

- Use a detailed check list.
- Always finish the job.
- Double inspect the work.
- Use torque seal and/or safety wire.
- Record or tag uncompleted work.
- When you go back to the job, always go back three (3) steps.

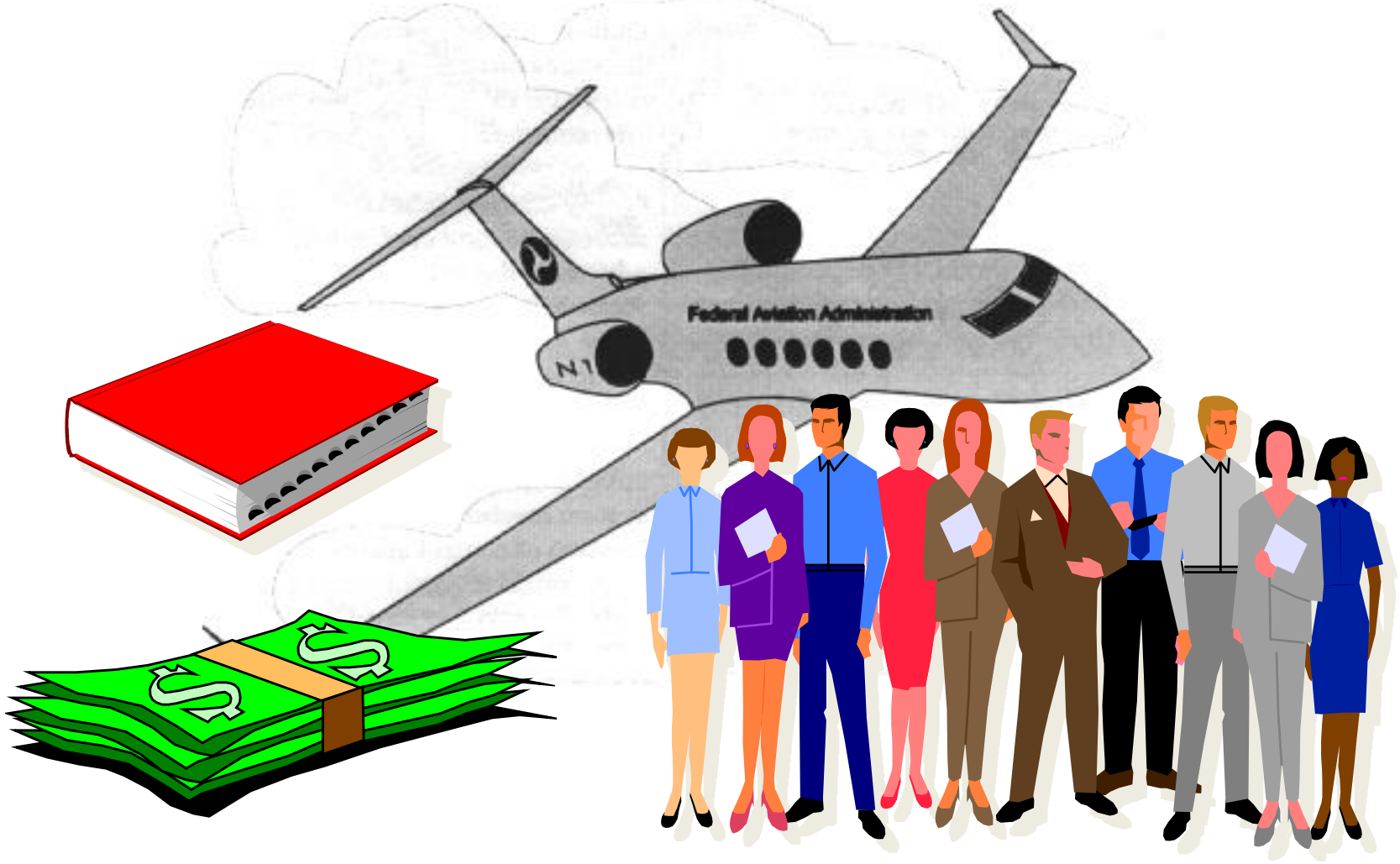
.PRESSURE

.The safety nets . . .

- STOP! assess the situation.
- LOOK at the situation rationally.
  a. Can I safely do the job on time?
  b. Have I voiced my concerns clearly?
  c. What is the worst thing that can happen to me?
- LISTEN to your rational mind!
  a. Has this happened before?
- ACT Speak up, ask for help or time.

.SHOW ME THE MONEY!!!

.RESOURCES



.Lack of Resources Safety Nets

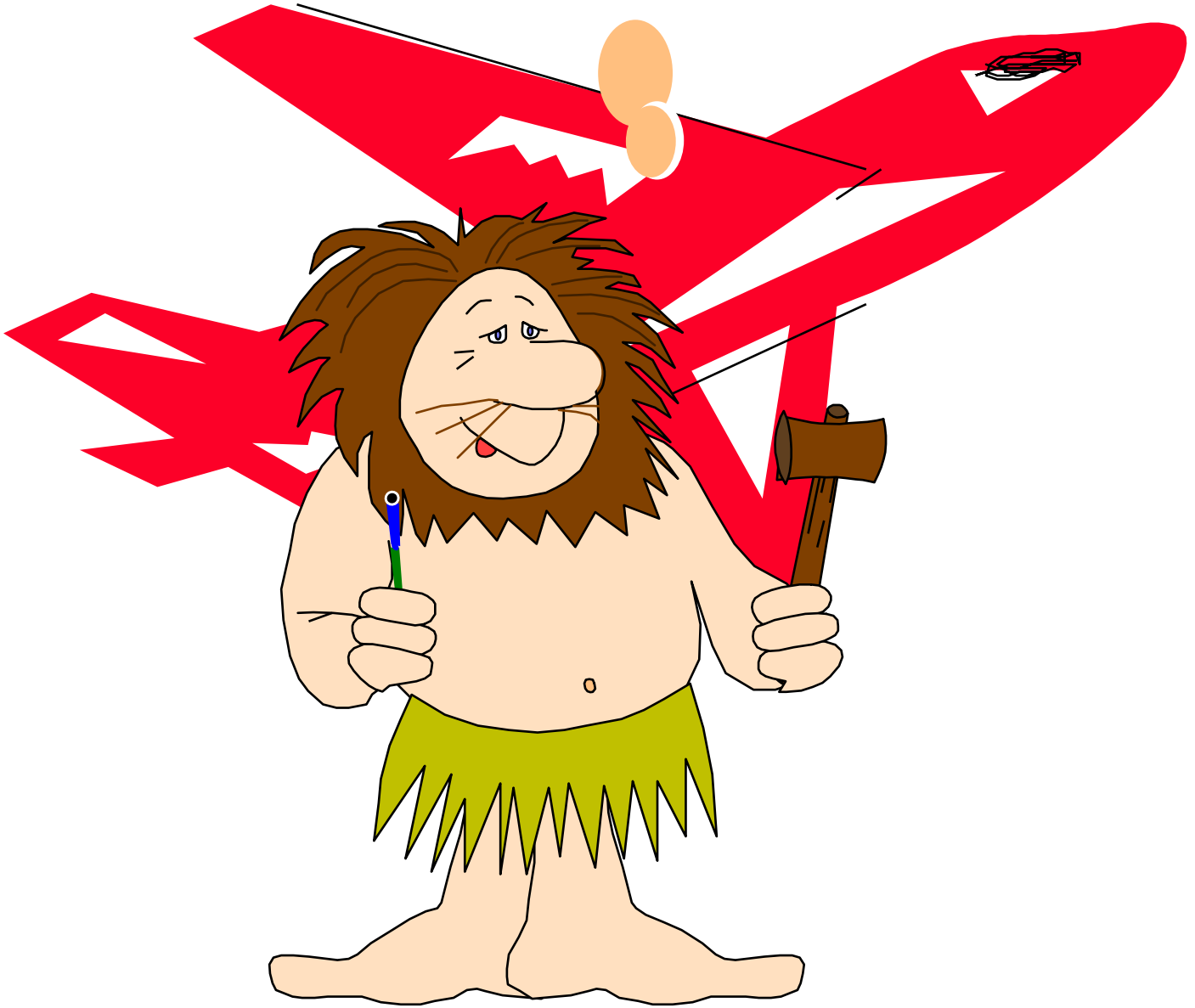
- Check all suspect areas at the beginning of all inspections and AOG the required parts.
- Order & stock parts before they're required.
- Know your sources, arrange for pooling a/o loaning
- Maintain aircraft to the highest Std, if in doubt X.

.LACK OF KNOWLEDGE

.Lack of knowledge .. Safety Nets

- Obtain school training on type, and model.
- Get supervised OJT
- Use current manuals, old data doesn't cut it!
- Tech Rep's are there for a purpose...use them.

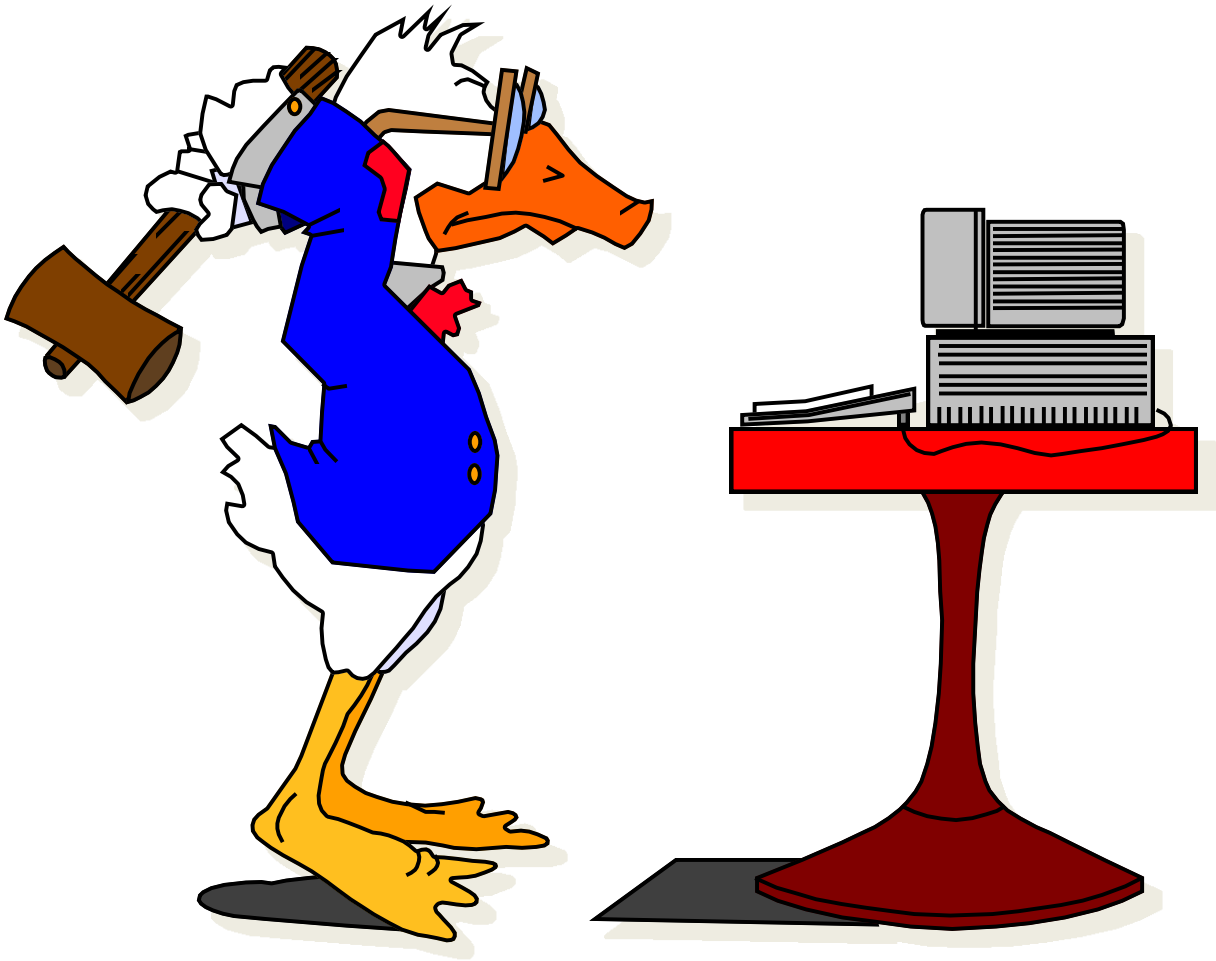
.LACK OF AWARENESS

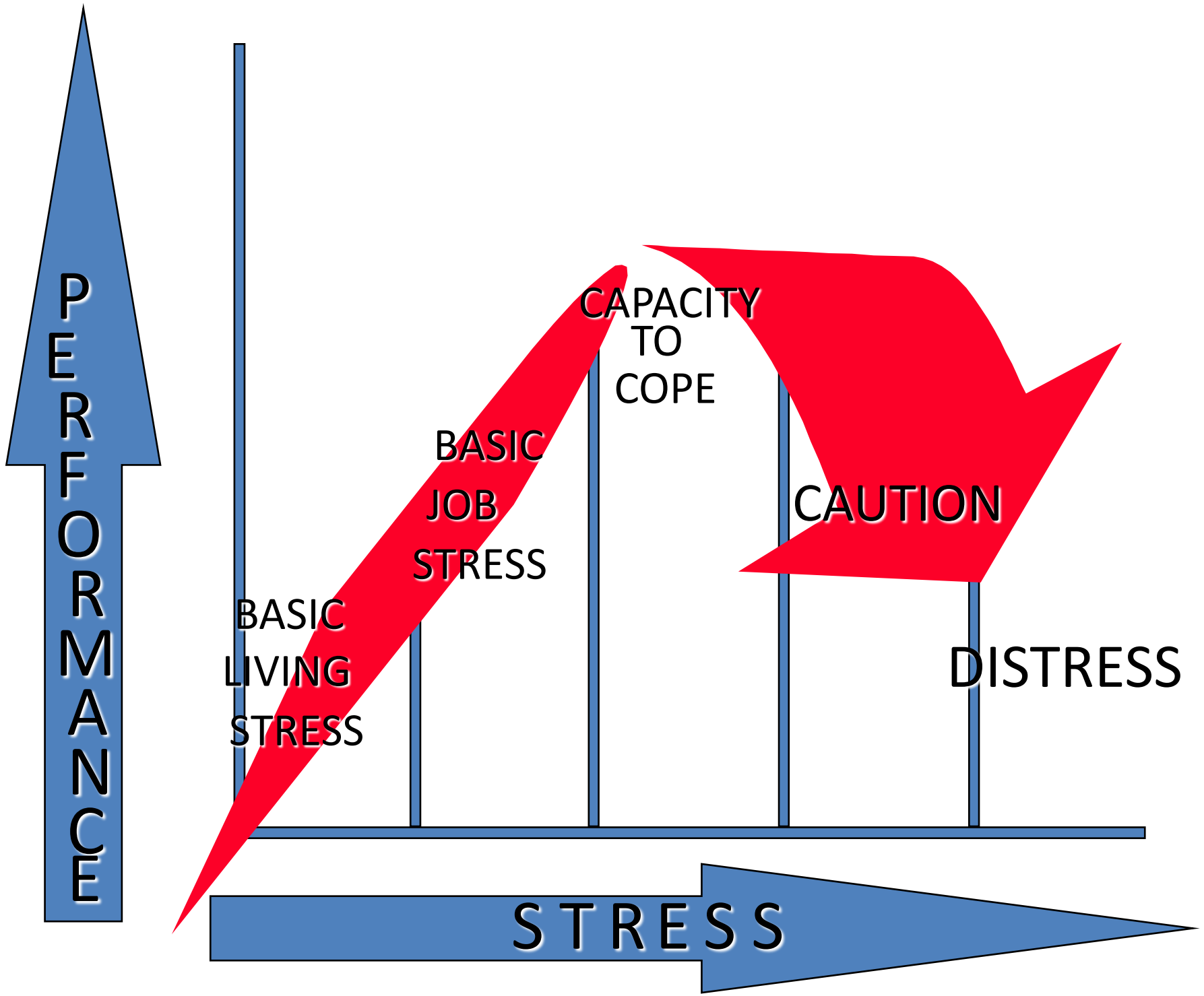


.AWARENESS SAFETY NETS

- **THINK ... what could occur in the event of an accident.**
- **CHECK ... will your work conflict with a previous or existing repair a/o modification.**
- **ASK ... see if anyone else can spot a problem you overlooked.**

.STRESS




PERFORMANCE
CAPACITY
TO
COPE
BASIC
JOB
STRESS
CAUTION
BASIC
LIVING
STRESS
DISTRESS
STRESS

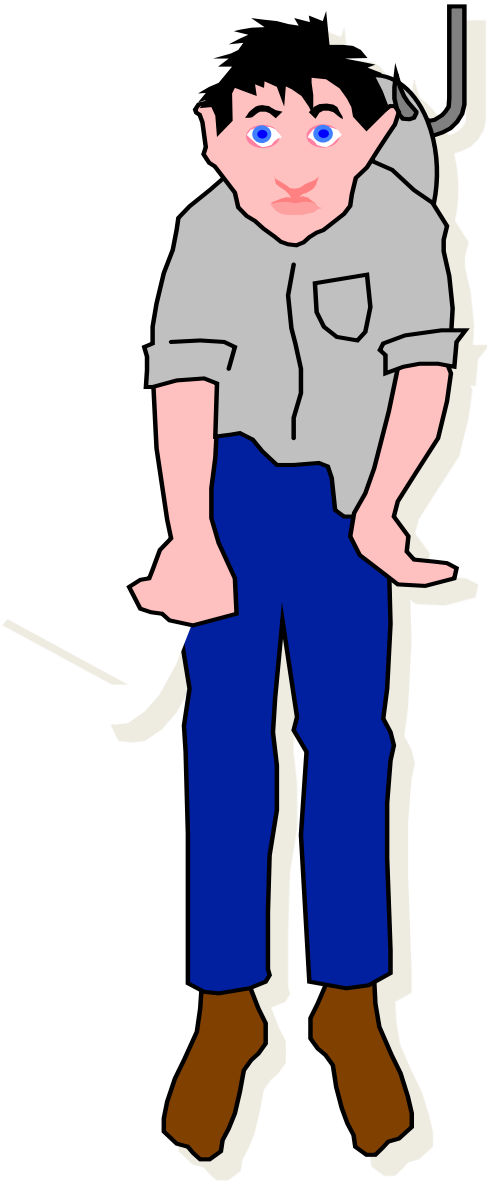
.HOW TO MANAGE STRESS

- **If you don’t manage stress, it <u>will</u> manage YOU!**
- **STOP stop burning up emotional energy**
- **LOOK rationally at the problem**
- **LISTEN to your rational not emotional mind**
- **ACT once you have a plan, do**

.OTHER STRESS HELPERS

- **Be sure the solution starts with "I"**
- **Be realistic and practical.**
- **TAKE a BREAK !!**
- **Talk to someone who is not emotionally involved with the problem.**
- **Don't expect miracles.....just keep trying.**

.FATIGUE



.WHAT IS FATIGUE ?

- Fatigue is the bodies normal reaction to a physical or mental stress of a prolonged duration.
- There are TWO types of fatigue.
- ACUTE ... short duration, cured with good nights sleep.
- CHRONIC ... occurs over a period long period of time, long recovery!

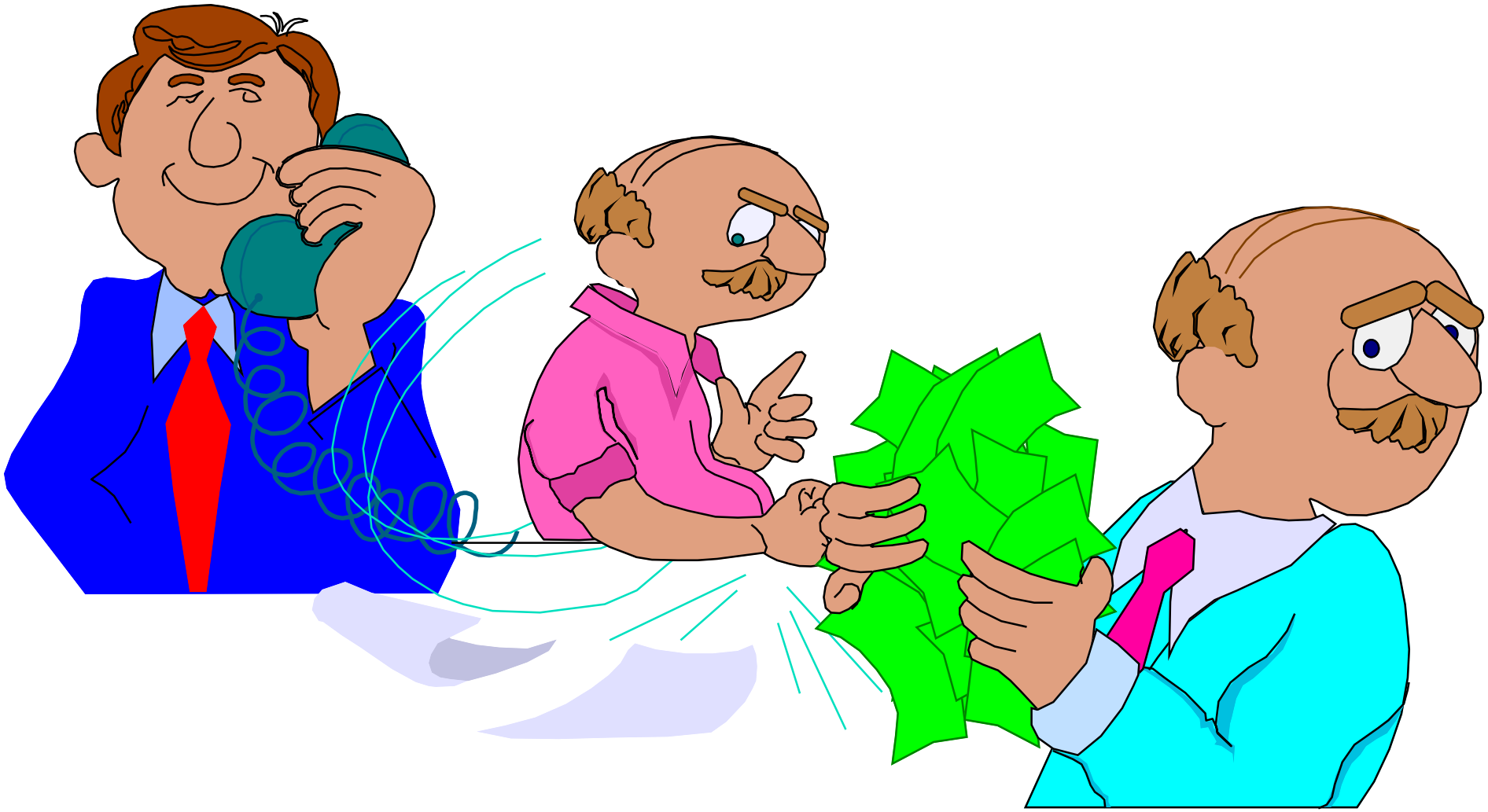
.CAUSES OF FATIGUE

- Long hours of labor (any type).
- Stress of high intensity.
- Large temperature variations.
- Noise ... above 80 db for long duration.
- Vibration for long periods and sufficient intensity.
- STRONG lighting.

.SYMPTOMS OF FATIGUE

- Enhanced stimulus required in order to respond.
- Attention reduced
- Memory diminished
- Mood becomes withdrawn.
- Circadian Rhythm (time of day effect).

.COMMUNICATIONS



.This is Communications ....

“ I have to tell you that what you heard and what I said are two different things and what you think I said is definitively not what I meant ”

SOUND FAMILIAR ?

.THE SECRET TO GOOD COMMUNICATIONS

You have

2 Ears

2 Eyes

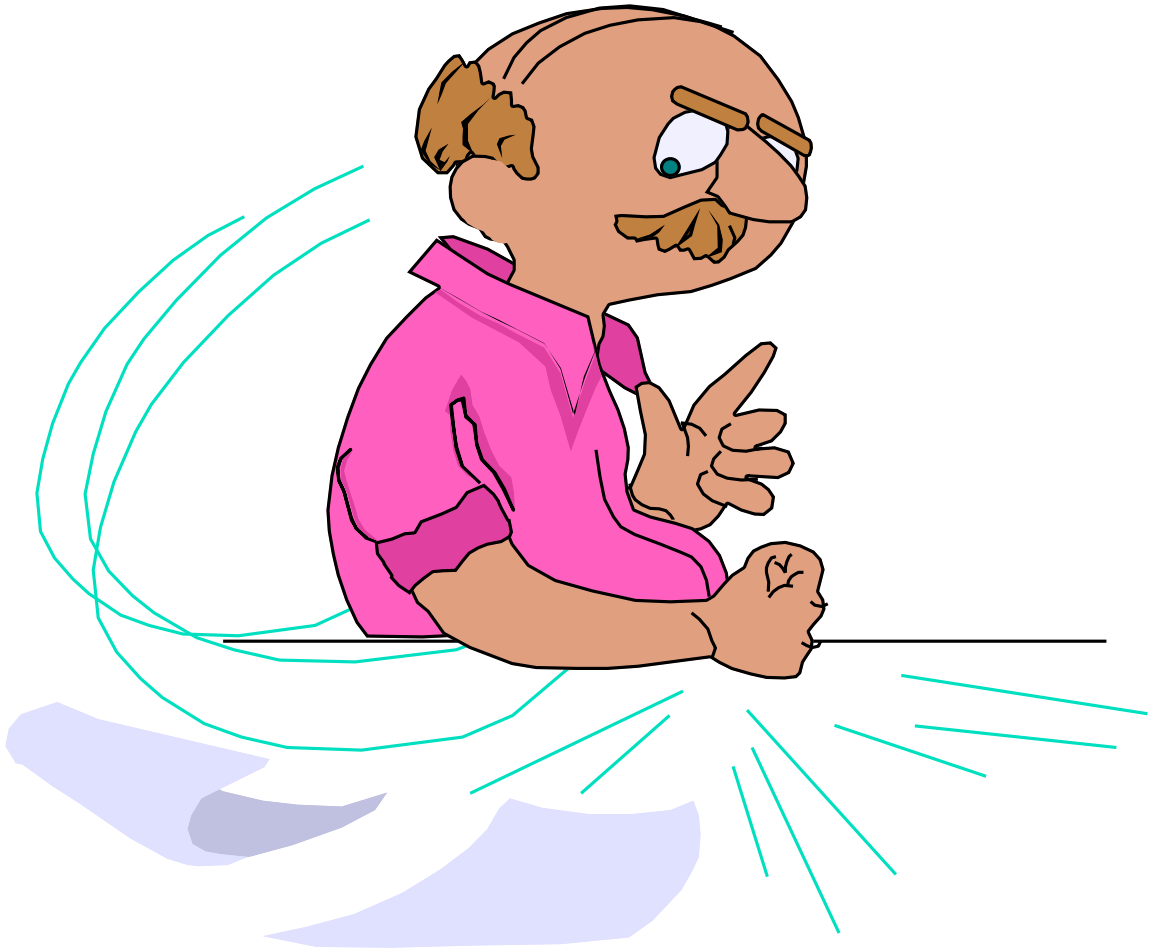
1 Mouth

Use them in that order

.To Improve Communication "*Learn to Listen*"

- **Don't :**
  1) **Debate**
  2) **Detour**
  3) **Pre-plan**
  4) **Tune-out**
- **Do :**
  1) **Ask Questions**
  2) **Paraphrase**
  3) **Make eye contact**
  4) **Use positive body language**

.LACK OF ASSERTIVENESS



.What is it anyhow ?

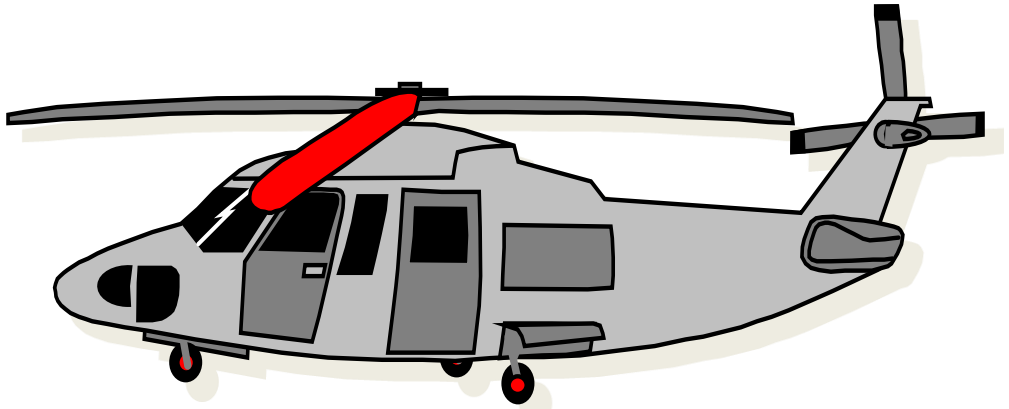
- “being disposed to or characterized
  by bold or confident assertions”.
- Record all the work you do in the
  log book, but only sign for that which is serviceable.
- Refuse to compromise your standards.

.LACK OF TEAMWORK

.Teamwork Safety Nets ....

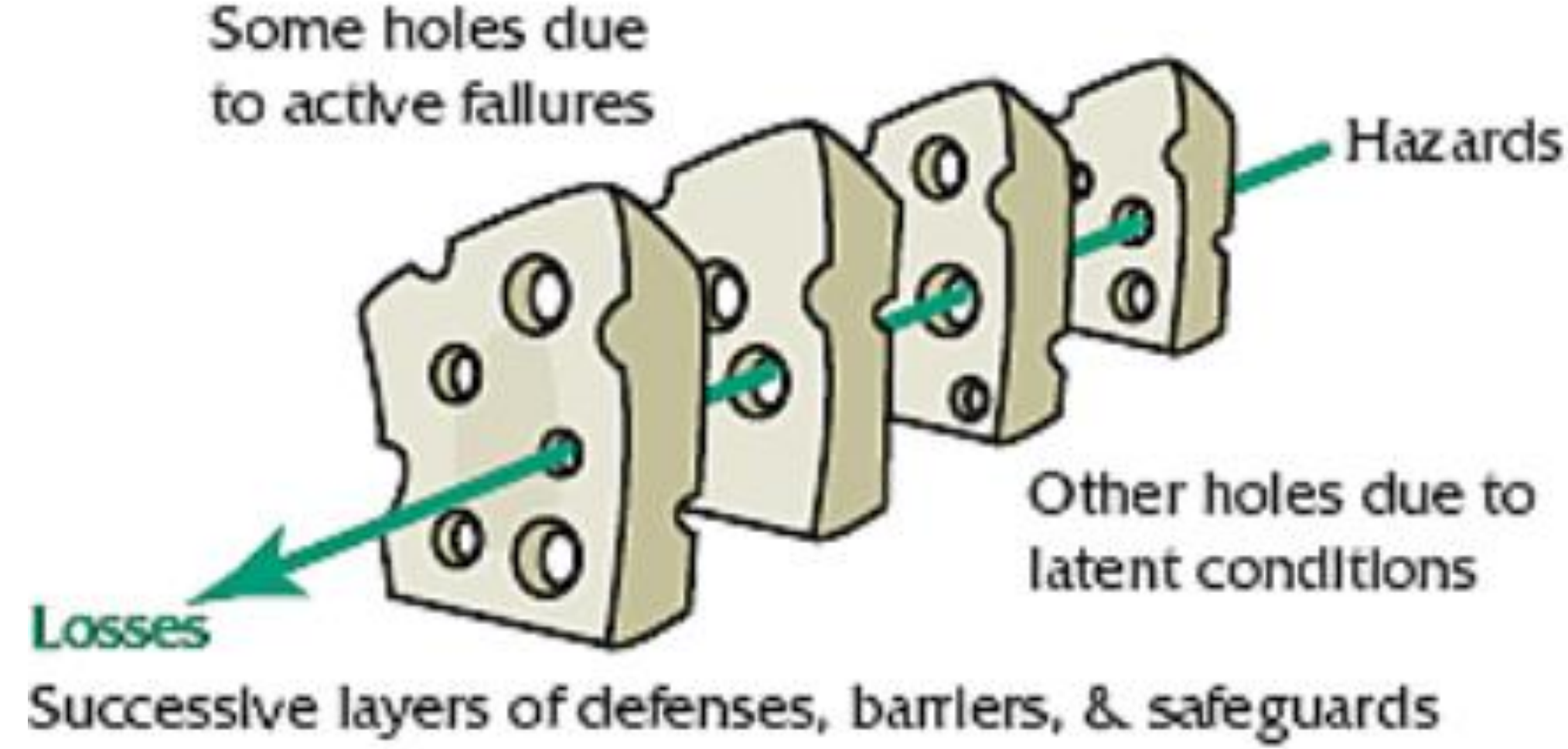
- Always discuss and plan the WHO, WHAT, WHEN, WHERE, and HOW of the job to be done.
- Insure that everyone understands
  and agrees!

.NORMS

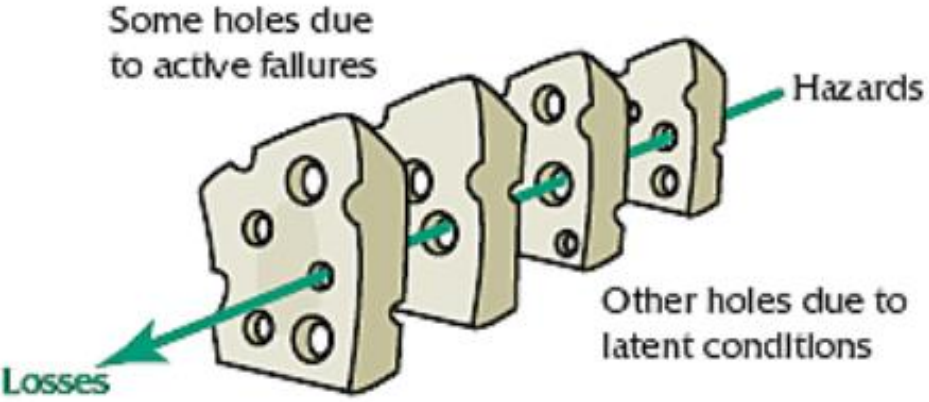


"Never mind the "right way", it's quicker the way I do it…!"

The Swiss Cheese Model of Accident Causation

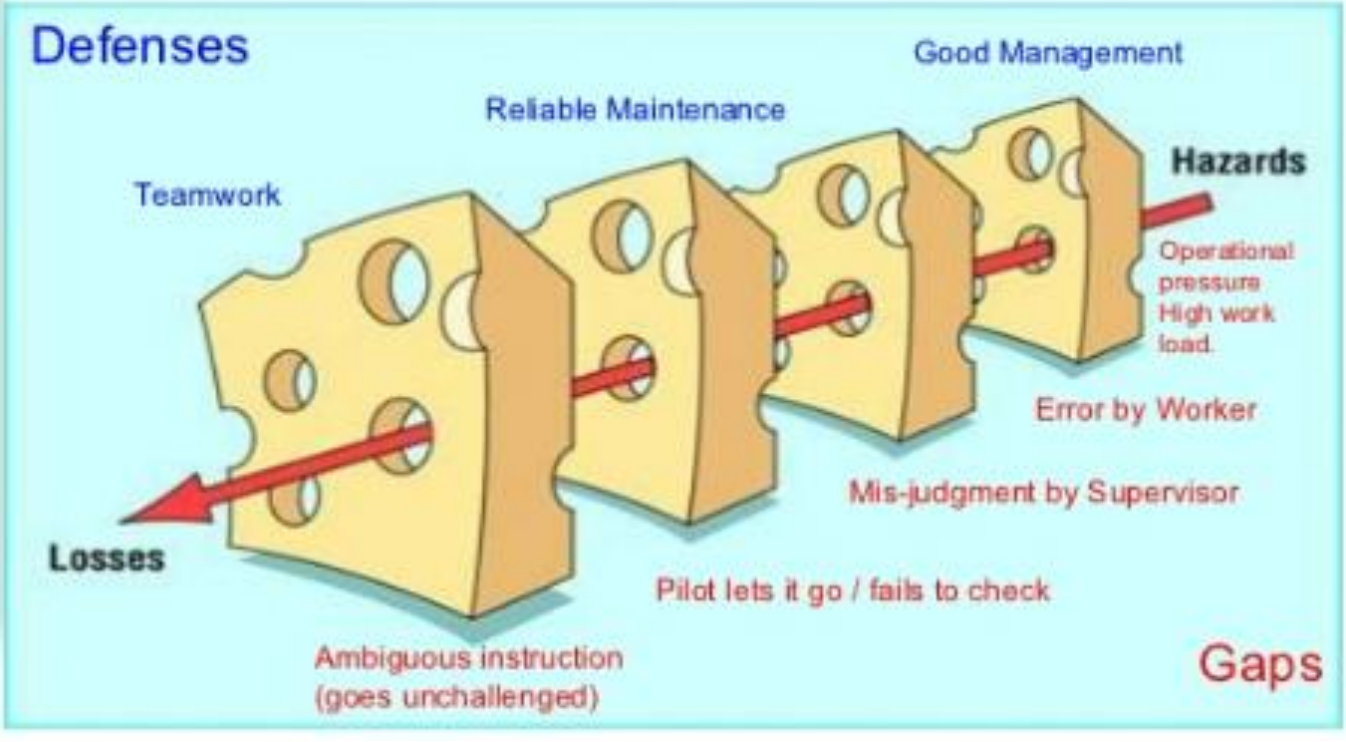


The Swiss Cheese Model of Accident Causation



Successive layers of defenses, barriers, & safeguards

HUMAN FACTORS ACCIDENT SCENARIO



ORGANIZATIONAL & LOCAL FACTORS CRITICAL TO DEVELOPING A SAFETY CULTURE

Organizational	Local
Training and selection of personnel.	Knowledge and skill of personnel.
Quality of resources as distributed.	Quality of resources at Flight Lines / Shops / COE.
Organizational Structure	Hangar environment.
Opportunities for career development.	Morale & personalities of Aircraft Technicians.

"We cannot change the Human Condition but we can change the conditions in which humans work."

James Reason