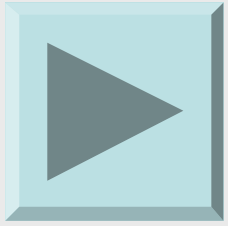
HAZARD AND RISK MANAGEMENT FOR OPERATORS AND MAINTENANCE ORGANISATIONS

Dr Rob Lee

An early aviation example of poor risk management



- The physical hazards of aviation operations are well known
- But it is human factors which constitute the greatest area of risk
- Consequently, a basic knowledge of human factors is essential for key personnel in all aspects of aviation risk management

- Human factors are involved at all levels, because people

•operate
•maintain
•design
•manage
•build
•regulate
•finance

the aviation system

‘Human Factors’ refers to:

- the study of humans as components of complex systems made up of people and technology.
- These are often called ‘sociotechnical’ systems.

There are two main dimensions of human factors:

- the individual and the system
- a system can be defined as a collection of **interconnected** components consisting of people and technology, which interact to produce a given output (US SAE)
  - such as ‘effective, efficient and safe aviation’

- A system can be made up of many sub systems
- such as, flight operations, maintenance, or air traffic control

- Human factors is concerned with understanding the performance capabilities and limitations of the individual human operator
- as well as the collective role of all the people in the system which contribute to its output
- Which therefore includes factors such as organisational culture

In sporting terms, human factors is concerned with the performance of the individual player…

…and of the team as a whole.

In aviation terms, human factors is concerned with the performance of the individual ‘player’…

…and of the ‘team’ as a whole

What human factors is **NOT**

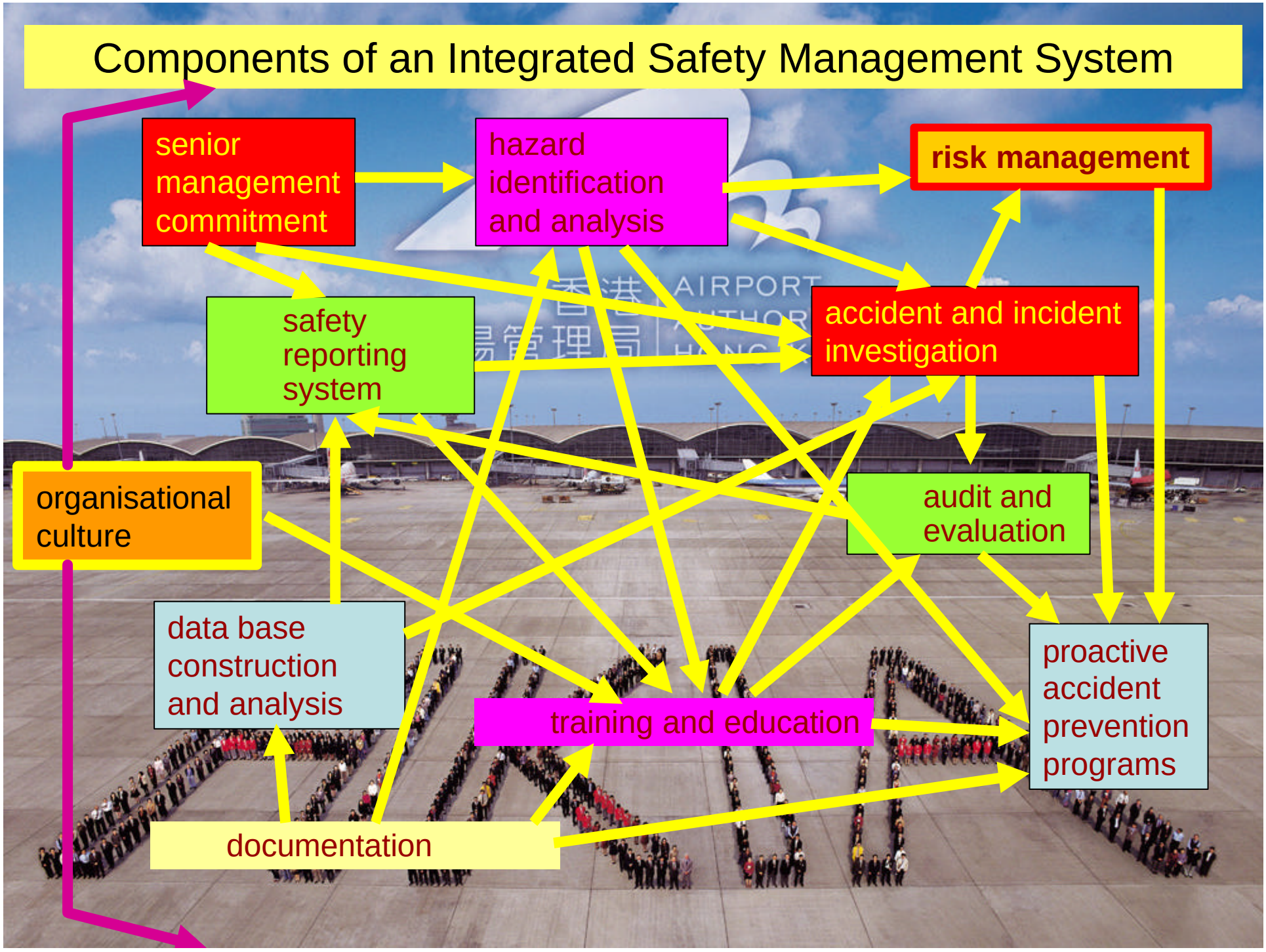
- Consideration of human factors in safety management does **not** minimise individual responsibility.
- Its objective is to understand human performance in the context of the systems in which the people concerned are components, and to consider all the factors which may influence their behaviour

Risk Management

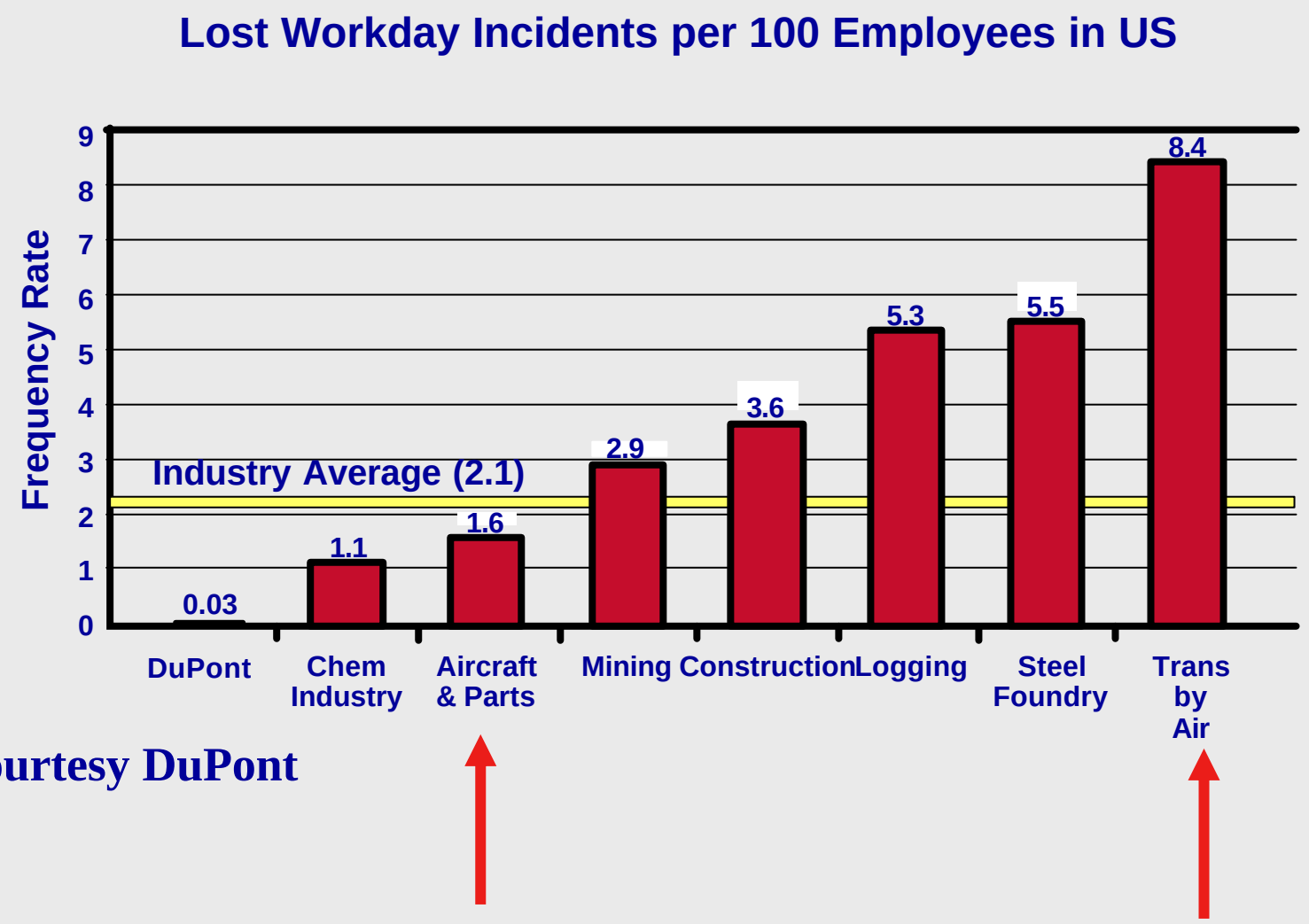
- Risk management is one component of an Integrated Safety Management System
- It must communicate and interact with all other components of the ISMS
- **Any changes in the risk management process will therefore impact upon all other components of the ISMS**

The 10 basic steps in implementing a Safety Management System:

1. Gain senior management commitment.
2. Set safety management policies and objectives.
3. Appoint a safety officer.
4. Set up a safety committee (usually only for large or complex organisations).
5. **Establish a process to manage risks.**
6. Set up a reporting system to record hazards, risks and actions taken.
7. Train and educate staff.
8. Audit your operation and investigate incidents and accidents.
9. Set up a system to control documentation and data.
10. Evaluate how the system is working.

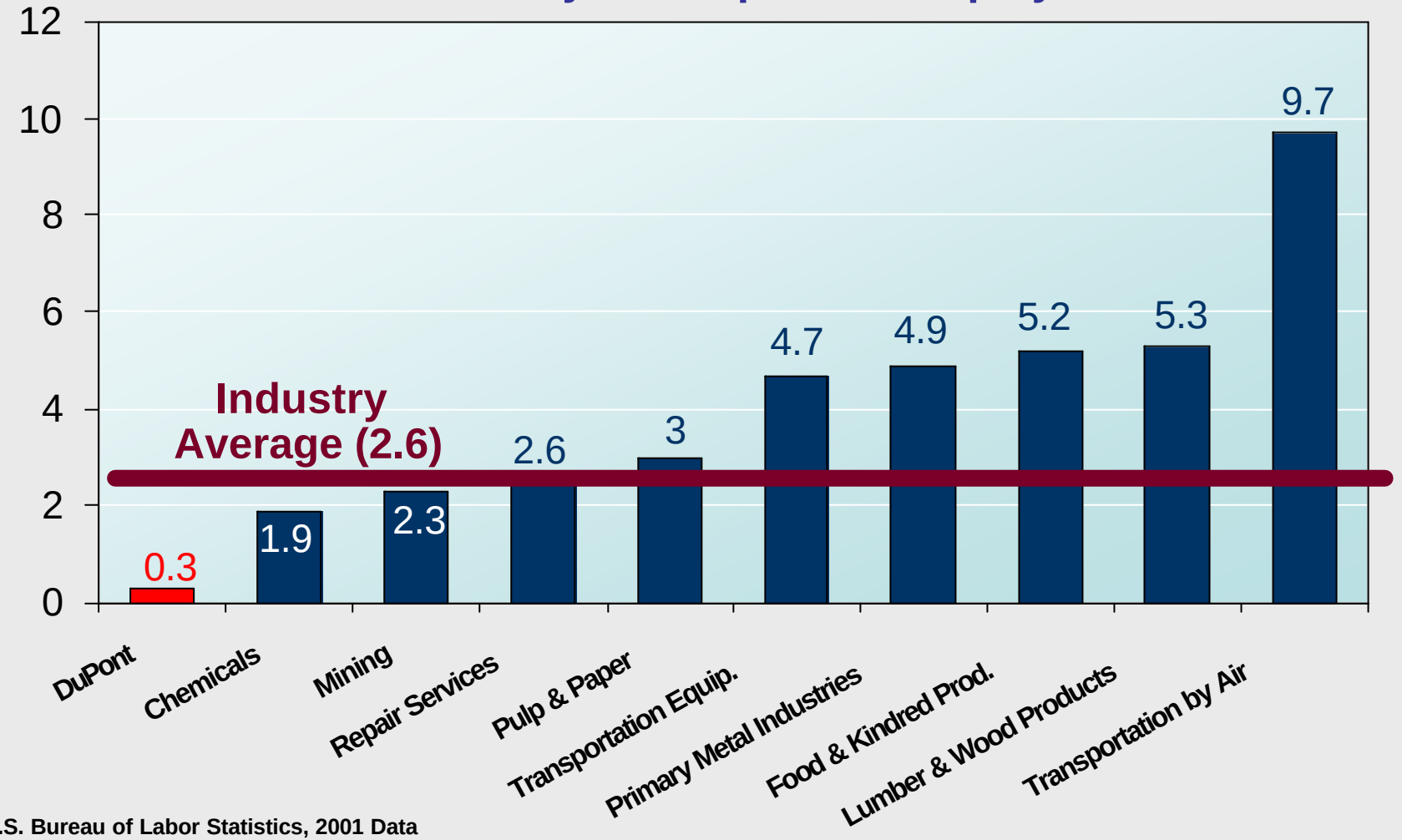

Components of an Integrated Safety Management System
senior management commitment
hazard identification and analysis
risk management
safety reporting system
accident and incident investigation
organisational culture
audit and evaluation
data base construction and analysis
training and education
proactive accident prevention programs
documentation

Aviation isn't that safe
US data — 1997



Courtesy DuPont

It doesn't get better 2001



* U.S. Bureau of Labor Statistics, 2001 Data

The process of Risk Management

- Establish the context
- Identify hazards
- Analyse risks
- Evaluate risks
- Apply defences, or controls
- Monitor and review

The process of Risk Management

- Establish the context
- **Identify hazards**
- **Analyse risks**
- **Evaluate risks**
- Apply defences, or controls
- Monitor and review

Hazard register

- In managing risk in your organisation, at the outset, you need to develop a ‘hazard register’ for your operating environment
- This is a list of the primary hazards associated with your business

Hazards are defined as:

Energy sources, materials, conditions, etc., which have the potential to cause either one of, or a combination of the following:

- harm, including, death ill health and injury,
- damage to property or environment,
- production losses
- loss of assets
- increased liabilities

Examples of typical hazards in aviation

- Toxic chemicals
- Aircraft
- Birds
- Vehicles
- Flammable gases
- Flammable liquids
- Pressure vessels
- Radiation
- Working at height
- Machinery
- Lightning
- Hot liquids

The Bow Tie Risk Analysis Method

The Bow Tie method provides a very effective, and proven, way of understanding, and analysing, the defences in the Reason Model

It is particularly useful in **proactive** accident incident prevention, and the management of safety within a system

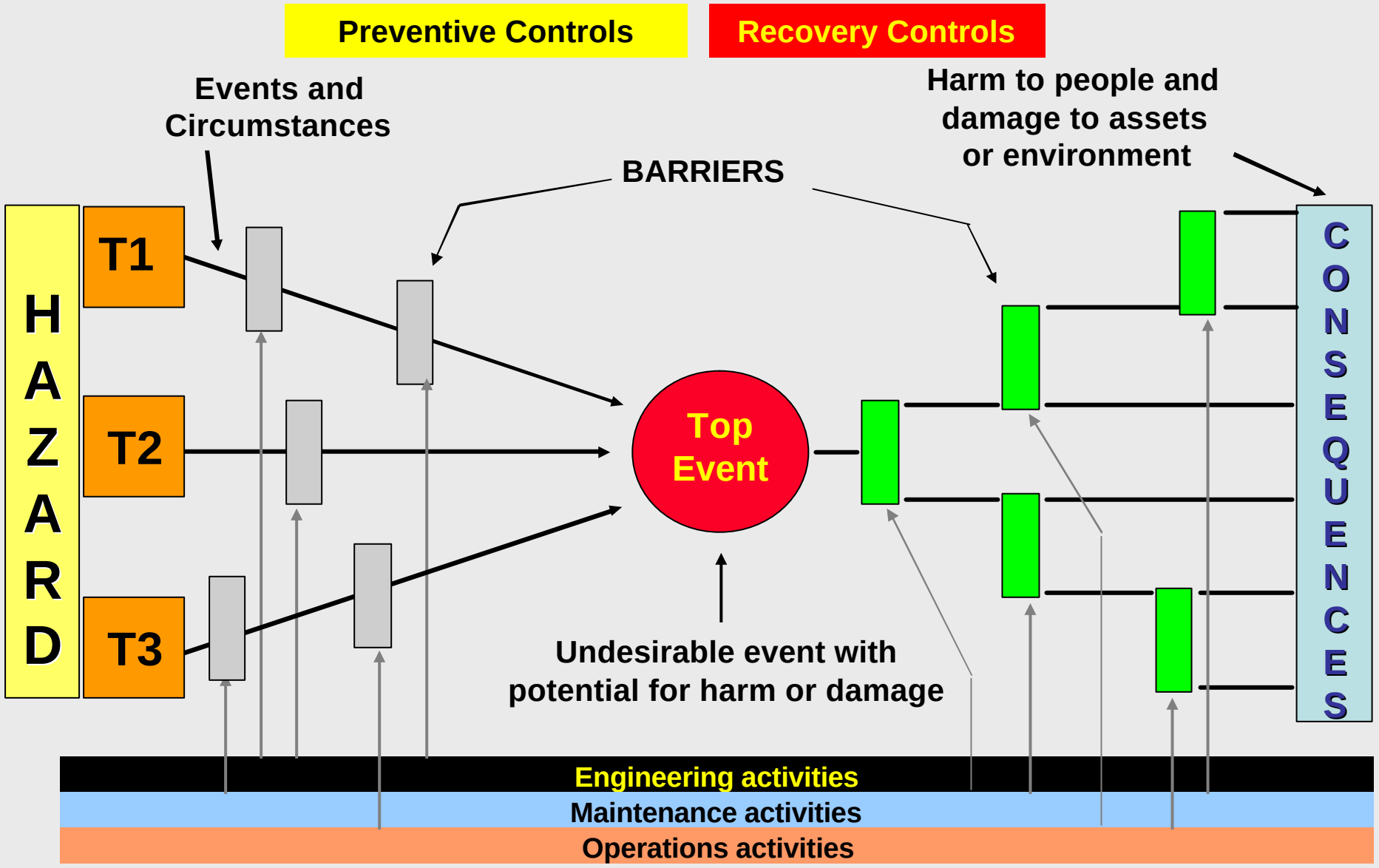
The Bow Tie Analysis Method

- developed as a technique for developing safety cases in the Oil and Gas industry
- by linking the hazards and the consequences through a series of event lines it is possible to develop a diagram illustrating the routes to accidents
- preventive and recovery controls are illustrated to show the fundamental components of the safety management system
- further understanding is gained by examining the routes by which the controls can fail and identifying the critical components of the system that prevent these failures.

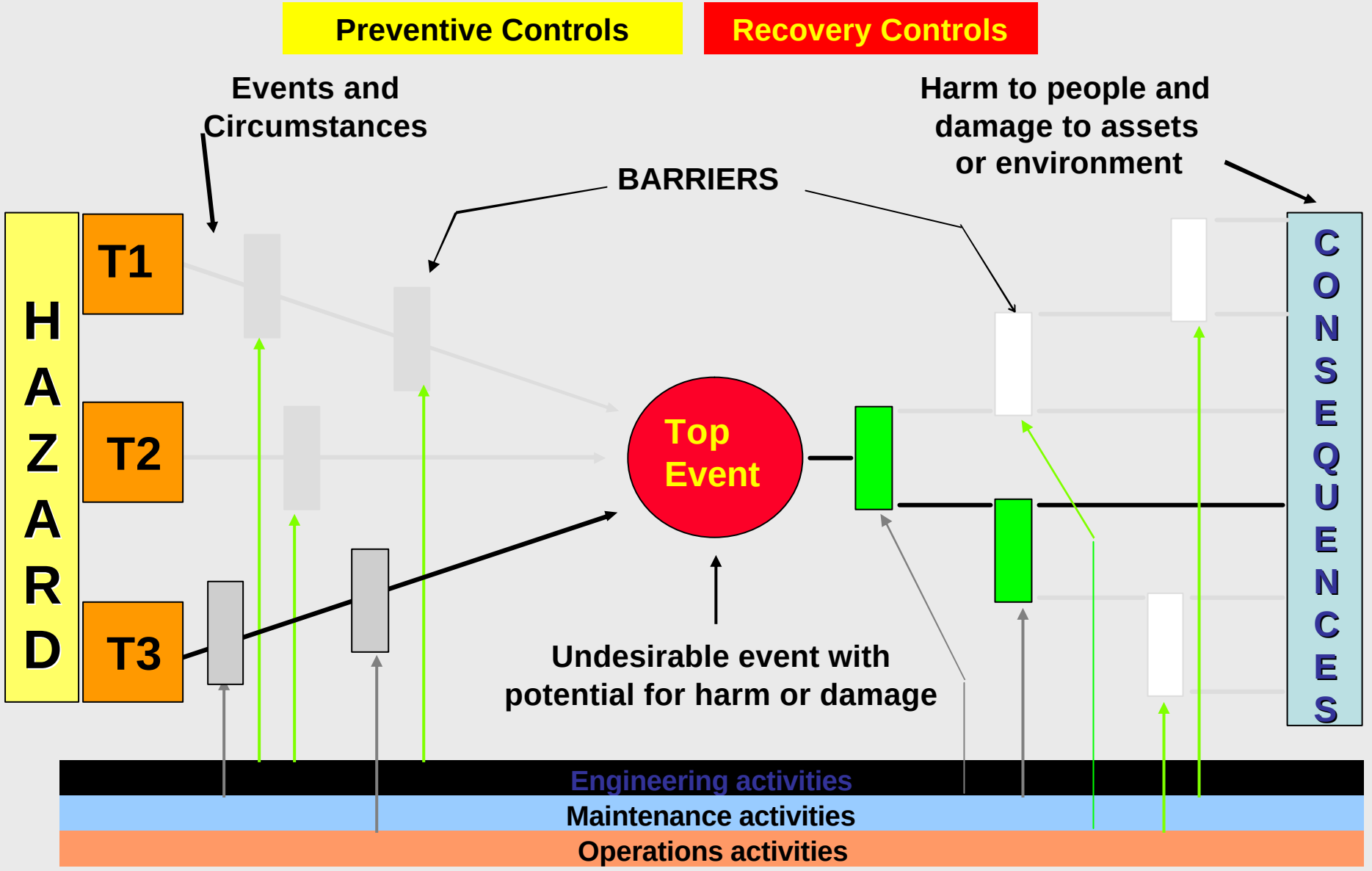
Bow Tie Analysis

- designed for the management of risk rather than the detailed quantitative assessment of risk.
- provides a diagrammatic representation of the relationship between the management system and the hazards being managed.
- this is then used to identify the outcome of any changes that might take place in the management systems.
- the Bow Tie system is not designed to identify hazards, but rather to illustrate the physical and procedural controls that are in place to manage hazards.
- It has been adopted by the US FAA to replace its previous risk analysis method

Basic Bow Tie Concept



Bow Tie Concept



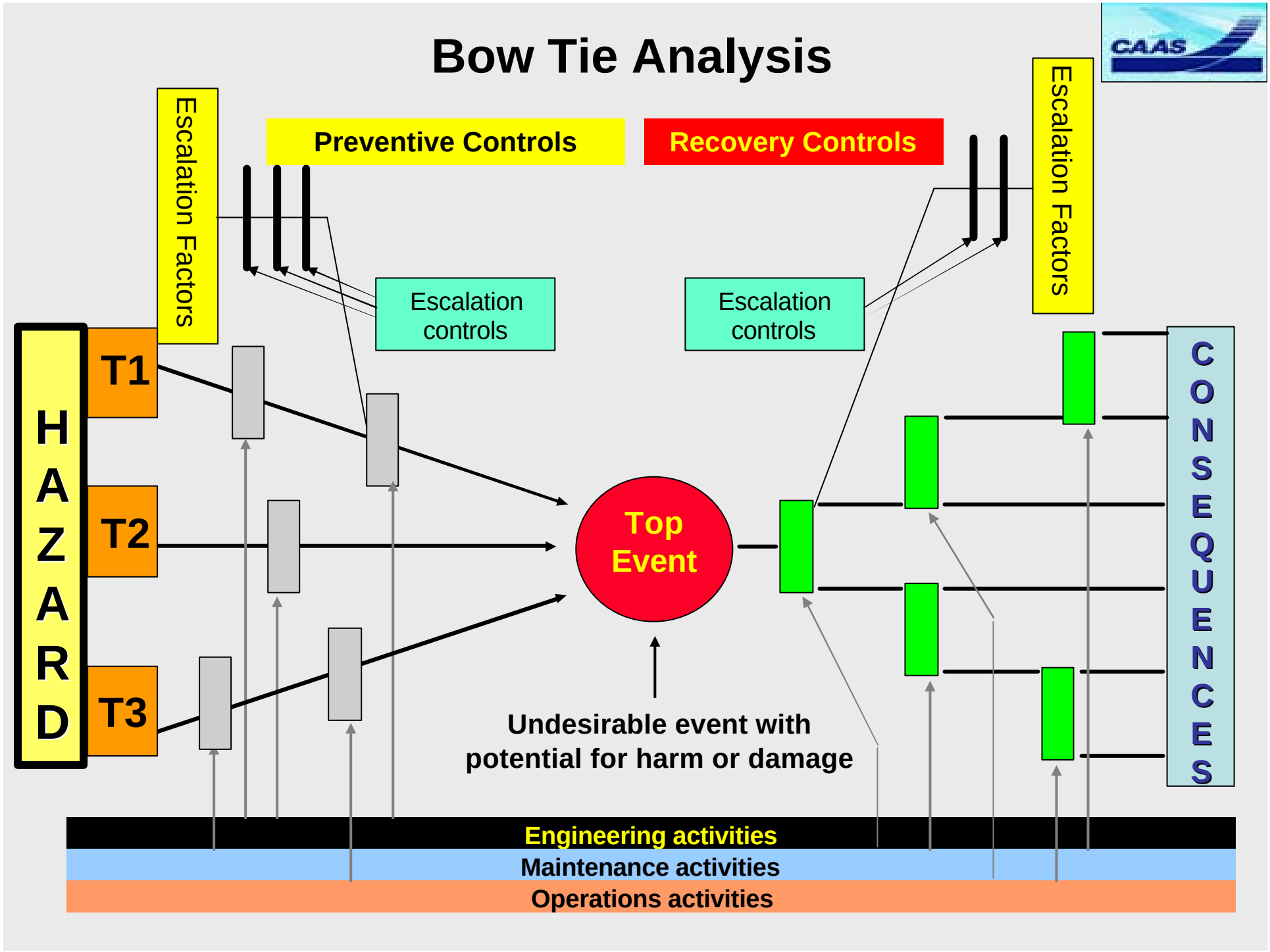
The **Top Event** must be assigned for the hazard under consideration.

Top Event

The **Top Event**, is defined as: **‘The point at which control of the hazard is lost’.**

It is important to define precisely what the nature of the top event is in order that the controls can be effectively placed as either ‘preventive’ or ‘recovery’ controls.

- In the case of the ‘toxic chemical’ hazard, the top event would be a spillage of the chemical.
- Because this is the point at which the control of the situation is lost and any further controls are only able to mitigate the outcome of the event.


Bow Tie Analysis
CAAS
Escalation Factors
Preventive Controls
Recovery Controls
Escalation Factors
Escalation controls
Escalation controls
HAZARD
T1
T2
T3
Top Event
CONSEQUENCES
Undesirable event with potential for harm or damage
Engineering activities
Maintenance activities
Operations activities

Identify the threats for each hazard

Threats

- Threats represent the failure modes through which the hazard can materialise
- They can be thought of as system or equipment failure modes that would be identified through a structured review process such as Failure Modes and Effects Analysis (FMEA).
- Understanding of the threats is essential in order to manage them effectively.

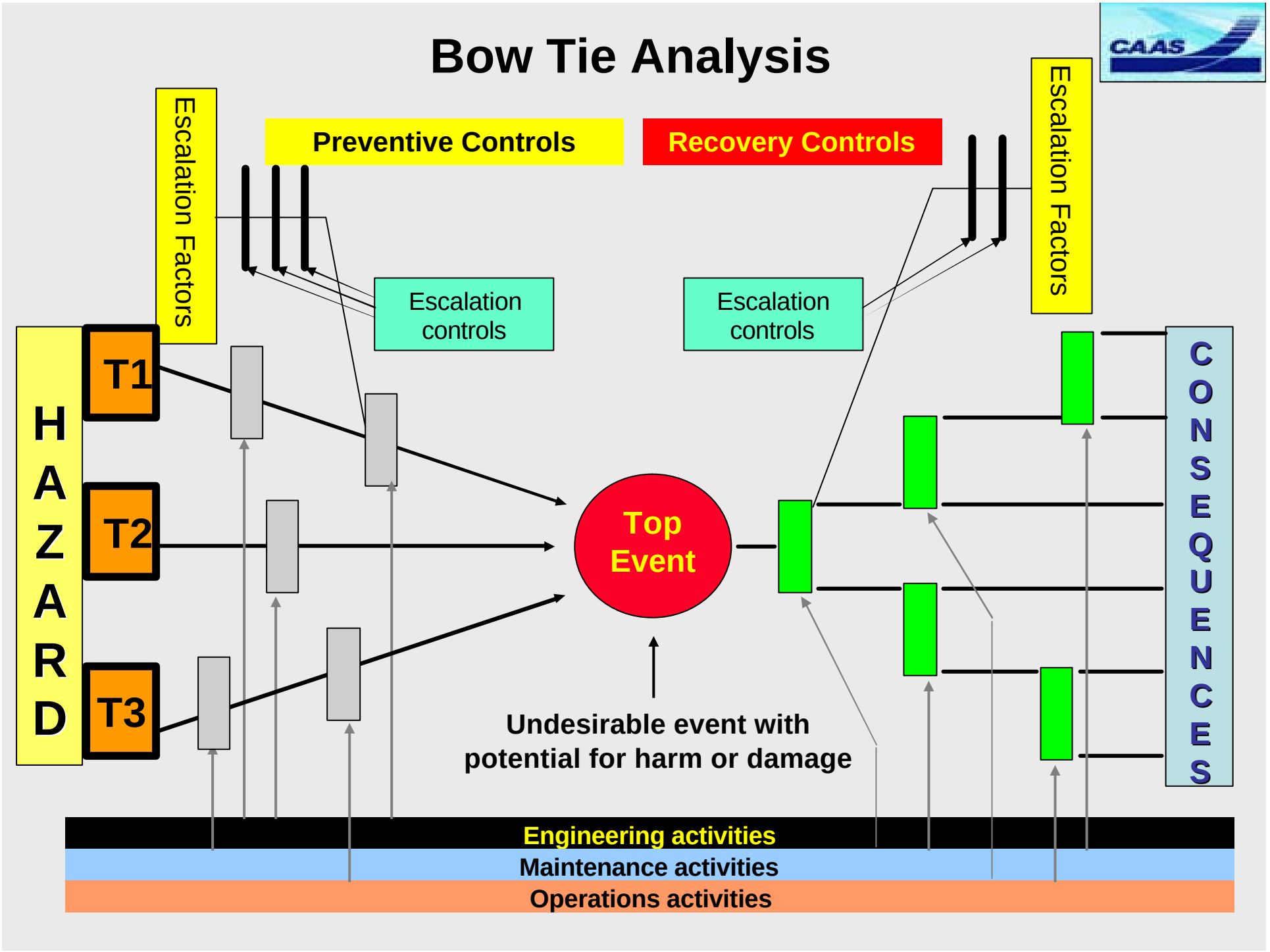
Threat

- An agent acting to defeat the “protection” of a hazard, and cause its release.

- What can release the hazard ?

Threats – toxic chemical hazard

- Corrosion of container
- Poor design of container
- Dropping of container from height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Identify the consequences for each hazard

Consequences

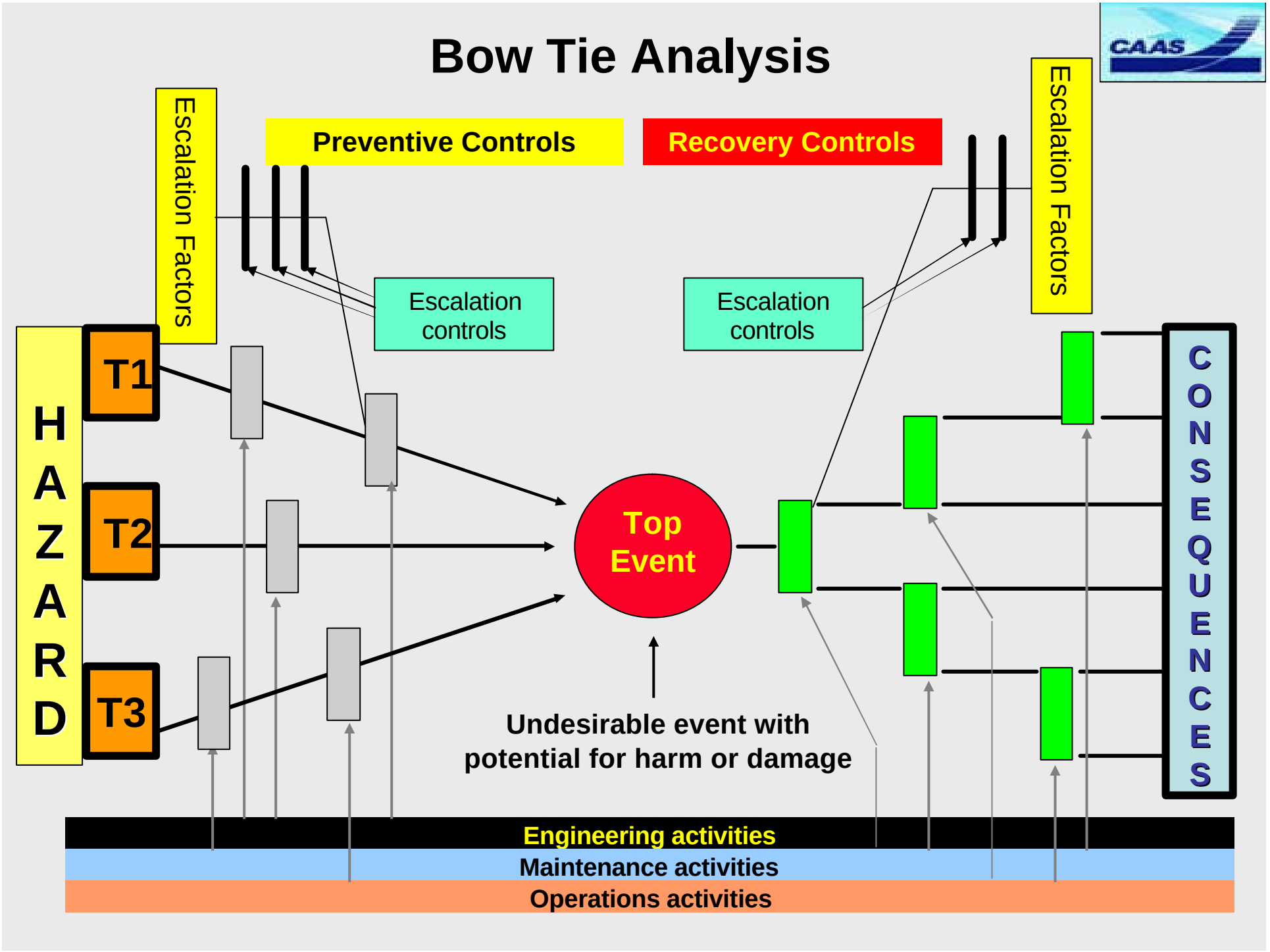
- The ‘consequences’ are the final results that could occur in the event of the entire accident sequence being realised.

- The “Ultimate Price” paid in the form of one, or all of:
  - damage to environment,
  - asset write off / shut down
  - hospitalization / death,
  - reputation and integrity loss
  - increased insurance liabilities.

- **that is, what will happen in an accident resulting from a loss of control of a hazard, that is a ‘top event’, and the failure of the recovery controls**

Consequences – toxic chemical hazard

- Death or injury from contact with chemical
- Contamination of workplace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Identify controls for each hazard

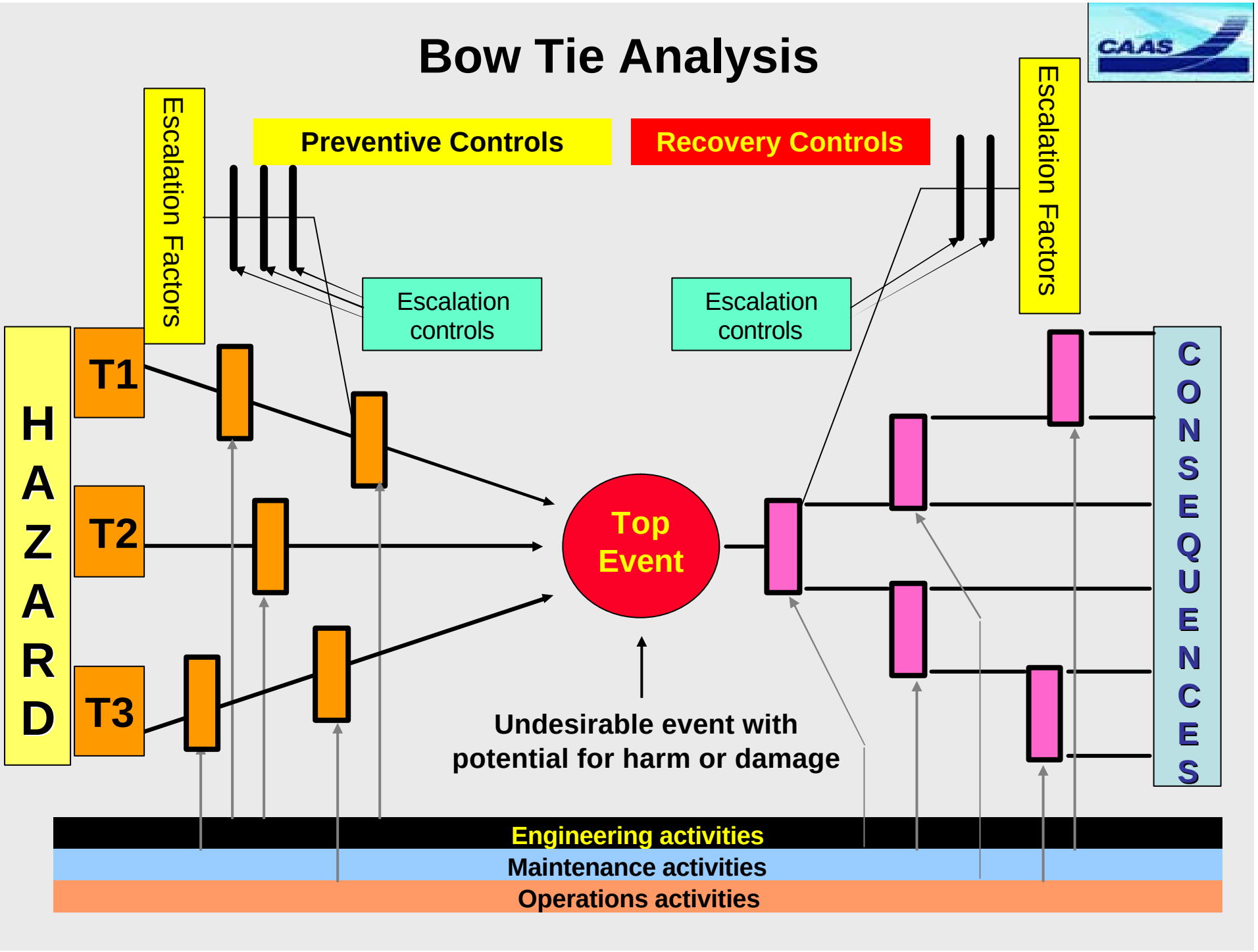
Controls

- the controls are the mechanisms or systems that are in place:
  - to prevent threats realising the top event **(preventive controls)** or**,**
  - to recover control following the occurrence of the top event **(recovery controls)** prior to one of the potential consequences being realised.
- **Controls may be equipment or procedural systems and are required to act as barriers, or defences, to the event sequences.**

Controls for toxic chemical hazard

- **Preventive Controls** – **before** the top event (spillage)
  - maintenance program
  - inspection schedule
  - chemical handling procedures
  - container transport procedures
- **Recovery Controls** – **after** the top event (spillage)
  - neutralising chemicals
  - personal protective equipment
  - emergency evacuation procedures
  - water sprays

Bow Tie Analysis



Identify Escalation Factors:

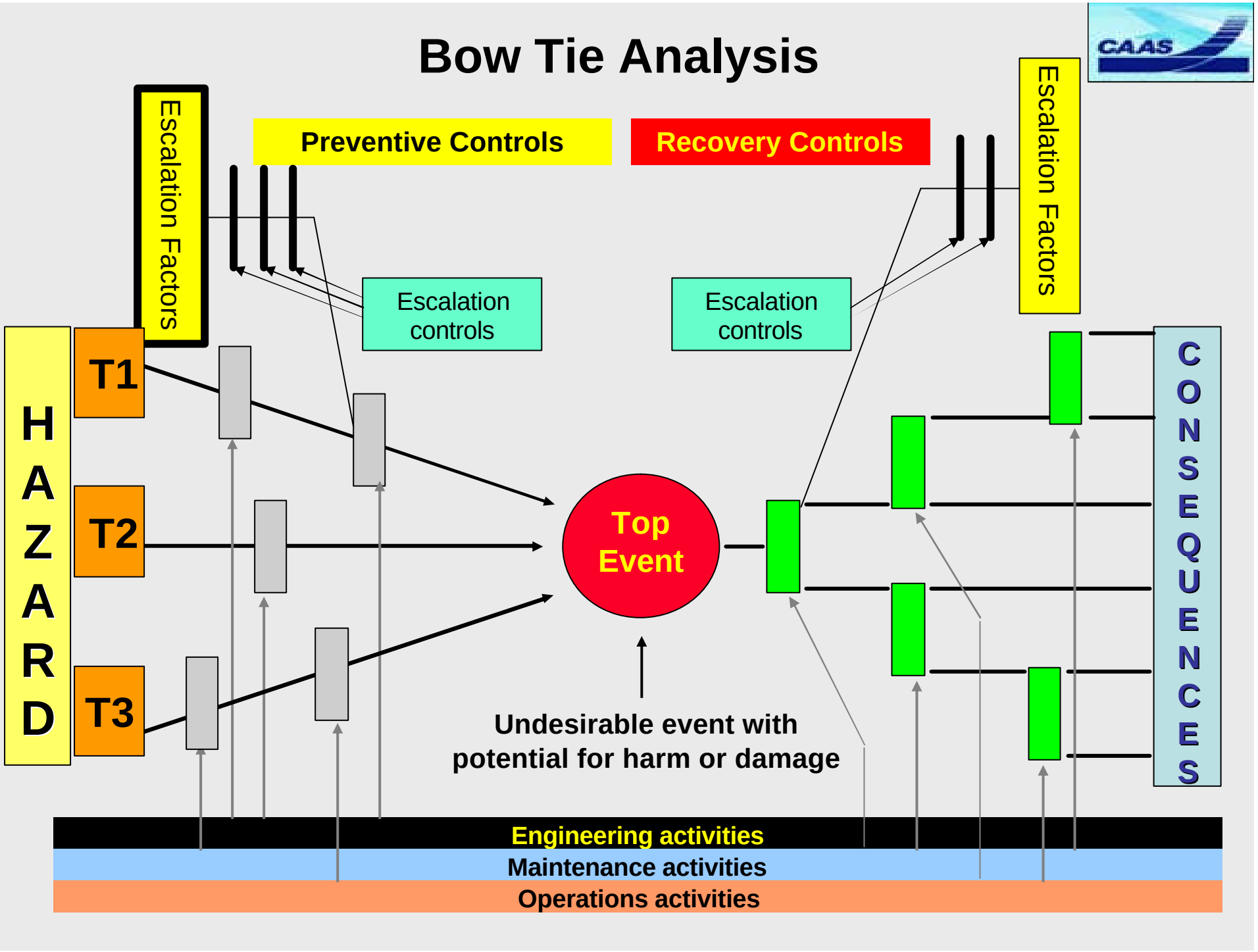
Escalation Factors:

- For each of the independent controls possible escalation factors need to be identified.
- These can be thought of as threats or operational issues that could compromise the effectiveness of the control they affect.
  - examples of escalation factors could be ‘Infrequent maintenance’ or ‘Incorrect design standard’.

Escalation factors for toxic chemical: preventive controls

Preventive Control	Escalation Factor
maintenance program	lack of maintenance
inspection schedule	non compliance with inspection schedule
chemical handling procedures	procedures misunderstood by workers
container transport procedures	non compliance with procedures

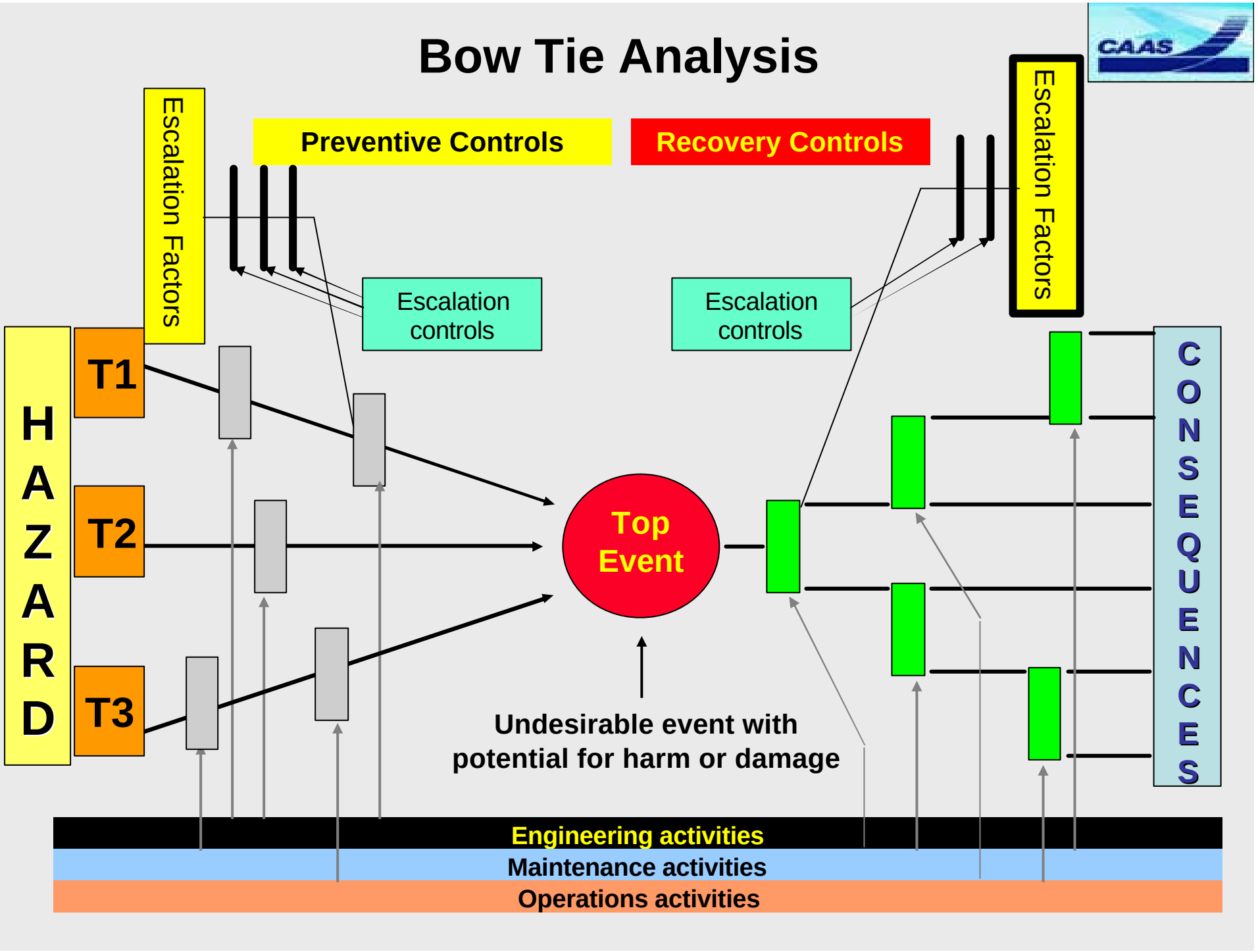
Bow Tie Analysis



Escalation factors for toxic chemical: recovery controls

Recovery Control	Escalation Factor
neutralising chemicals	chemicals time expired
personal protective equipment (PPE)	PPE not fit for purpose
emergency evacuation procedures	procedures not known by workers
water sprays	spray nozzles blocked

Bow Tie Analysis



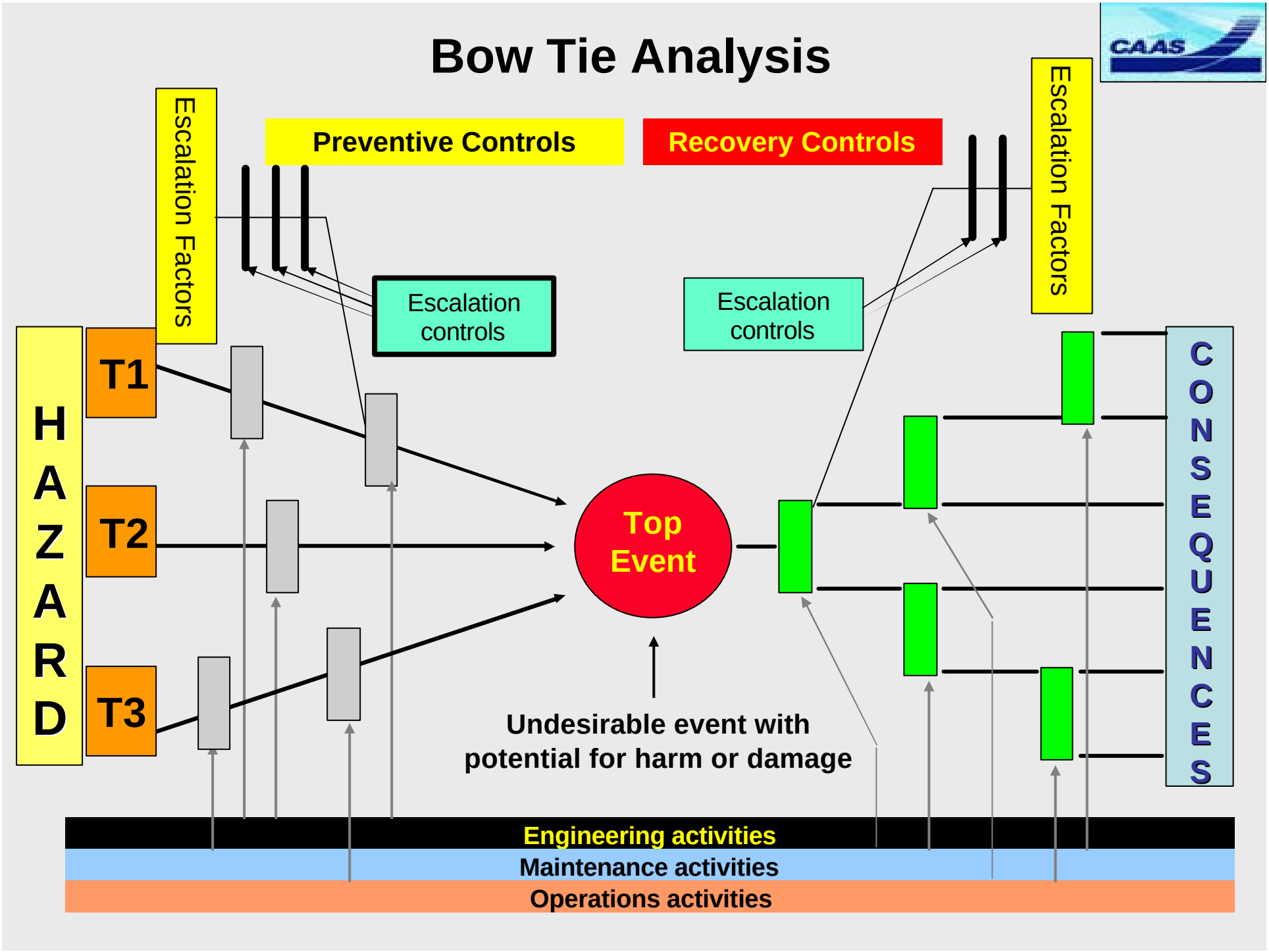
Identify Escalation Controls:

Escalation Controls

- In the same way as the escalation factors are directly related to the recovery and preventive controls, so the escalation controls are directly relevant to a given escalation factor.
- The escalation controls are typically management procedures that are designed to directly prevent the escalation factors from affecting the performance of the recovery and preventive controls

Escalation controls for toxic chemical preventive control escalation factors

Preventive Control	Escalation Factor	Escalation control
maintenance program	lack of maintenance	Regular maintenance audits
inspection schedule	non compliance with inspection schedule	Regular audits/checking of compliance with inspection schedule
chemical handling procedures	procedures misunderstood by workers	Clarification of procedures in all languages
container transport procedures	non compliance with procedures	Regular training in procedures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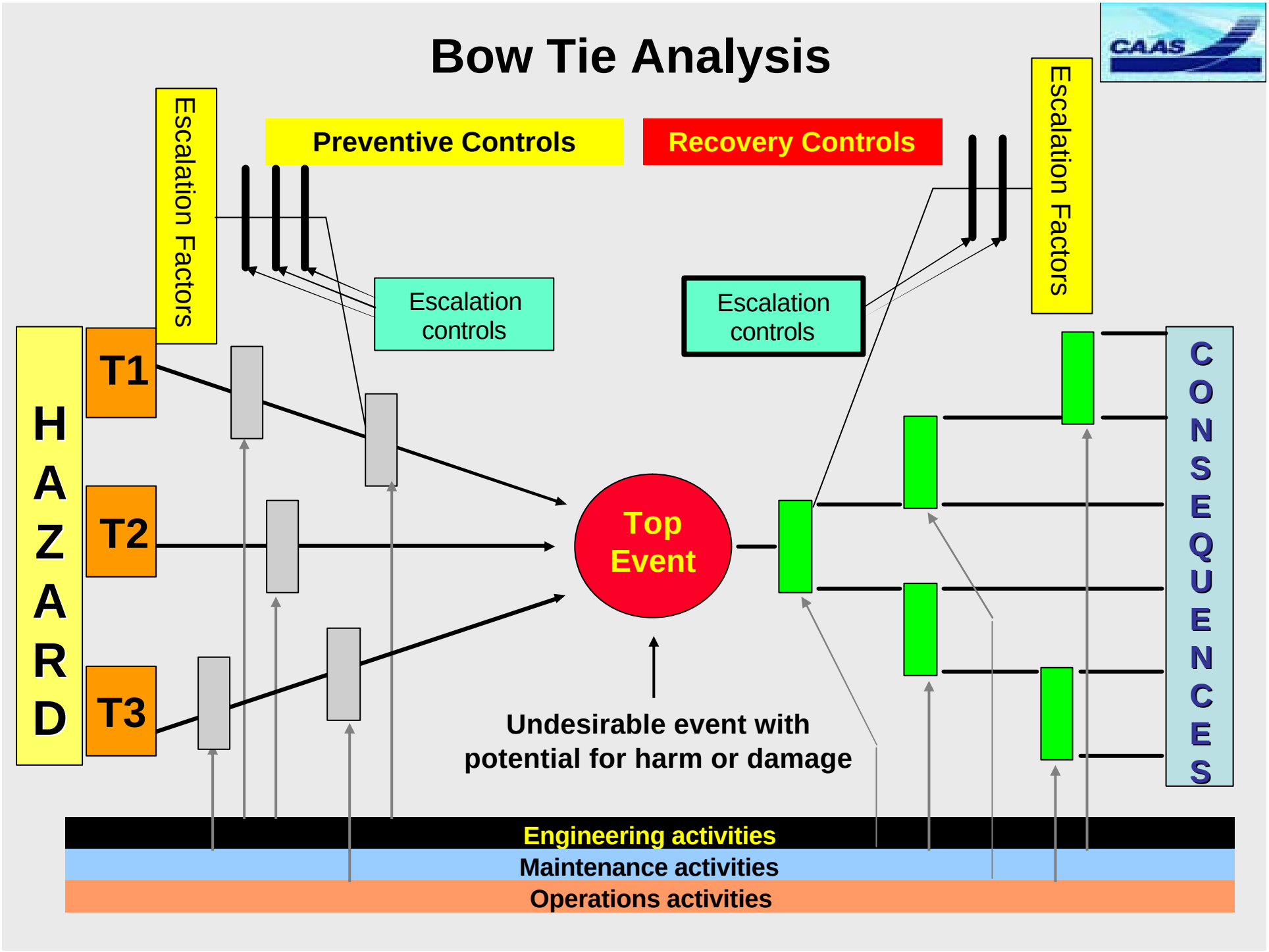
Escalation factors for toxic chemical: recovery control escalation factors

Recovery Control	Escalation Factor	Escalation control
neutralising chemicals	chemicals time expired	regular replacement schedule
personal protective equipment	PPE not fit for purpose	ongoing review and testing of PPE
	procedures not known by workers	regular EP training program
emergency evacuation procedures		
	spray nozzles blocked	regular nozzle cleaning program
water sprays		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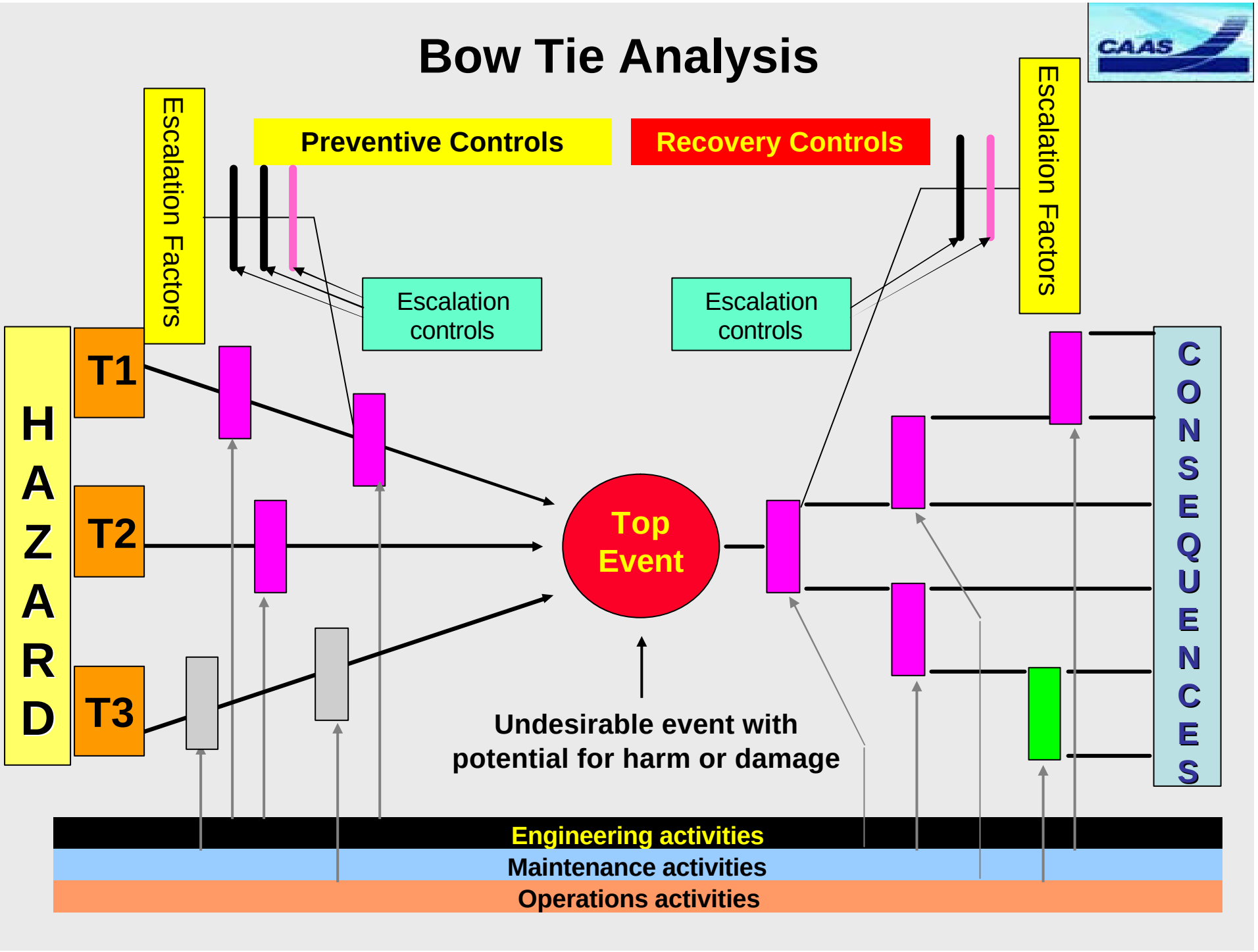


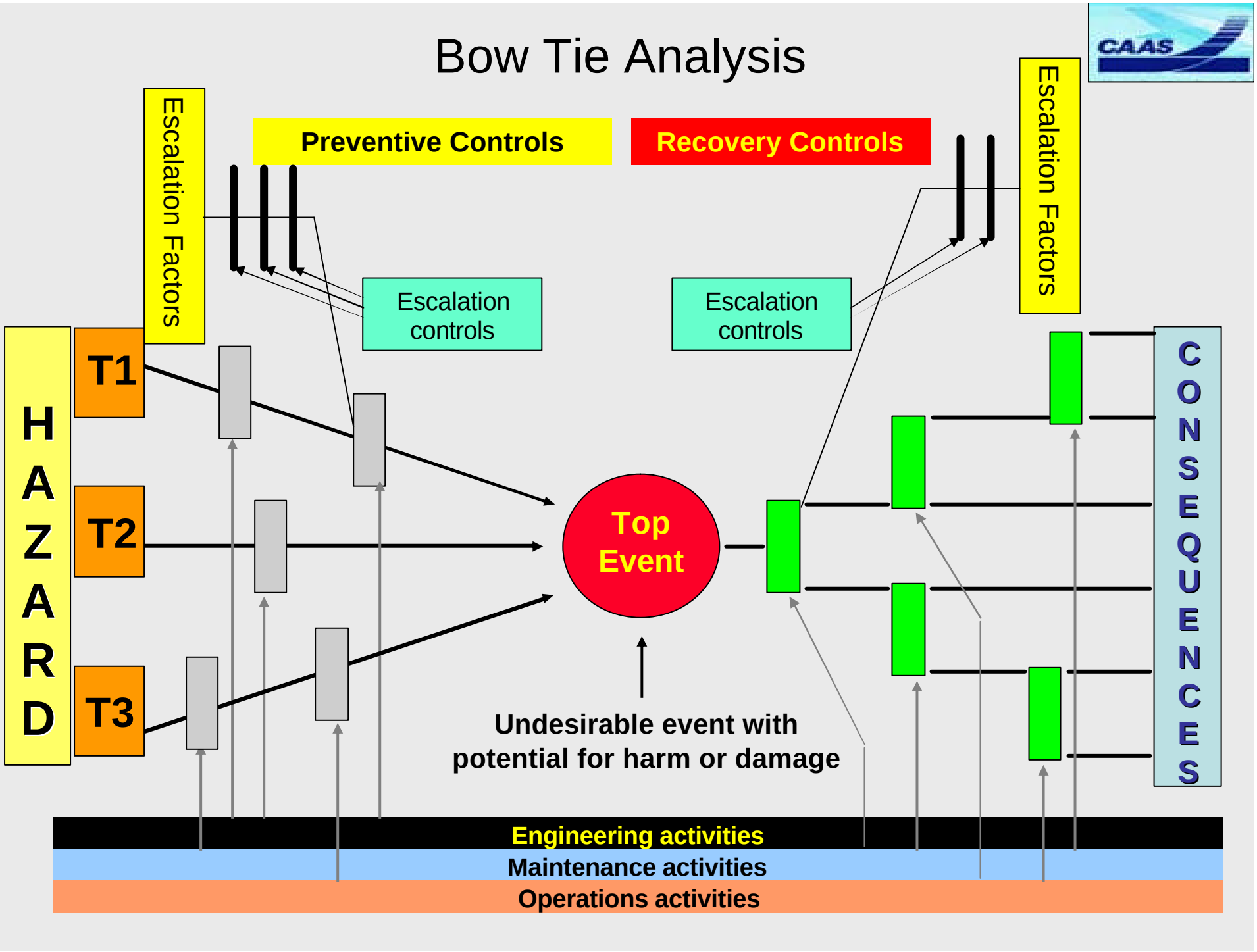
Bow Tie Checklist:

- Select a hazard
- Assign the Top Event for that hazard
- Identify:
  - Threats
  - Consequences
  - Preventive Controls
  - Recovery Controls
  - Escalation Factors
  - Escalation Controls

- Bow Tie Analysis – Bird Hazard

- Bird Hazard - consequence

Bow Tie Analysis



Bird Hazard – a preventive control

Why is the Bow Tie a useful tool in risk management?

- **It concentrates our primary safety management focus on the top event rather than the consequence.**
- This facilitates a more cost-effective allocation of resources than would be gained by going directly to the consequences, without going via the intermediate step of the top event, and identifying the various preventive and recovery control pathways.
- It is directly compatible with the Reason Model, and provides a way of better understanding the nature of the defences in a system
- **Which is essential to effective risk management**

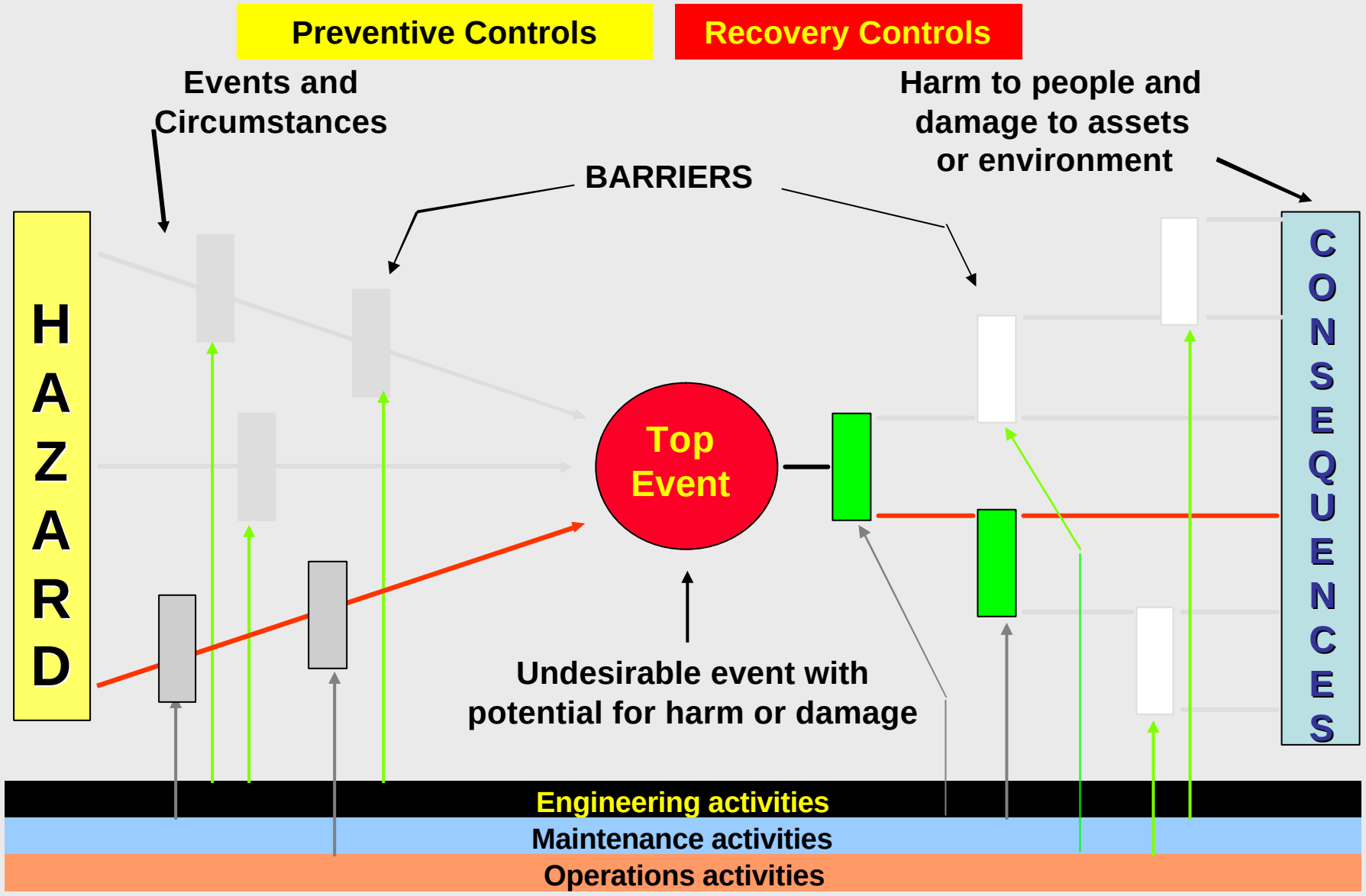
- All the hazards, threats, consequences, preventive and recovery controls, escalation factors and escalation controls can be recorded in the safety information system for your ISMS
- Thereby **integrating** these two components

The Bow Tie is a **proactive** risk management tool

- If you have an accident/incident associated with a particular hazard, you should be able to go immediately to your Bow Tie Analysis for that hazard
- And determine which of your preventive and recovery controls were not effective

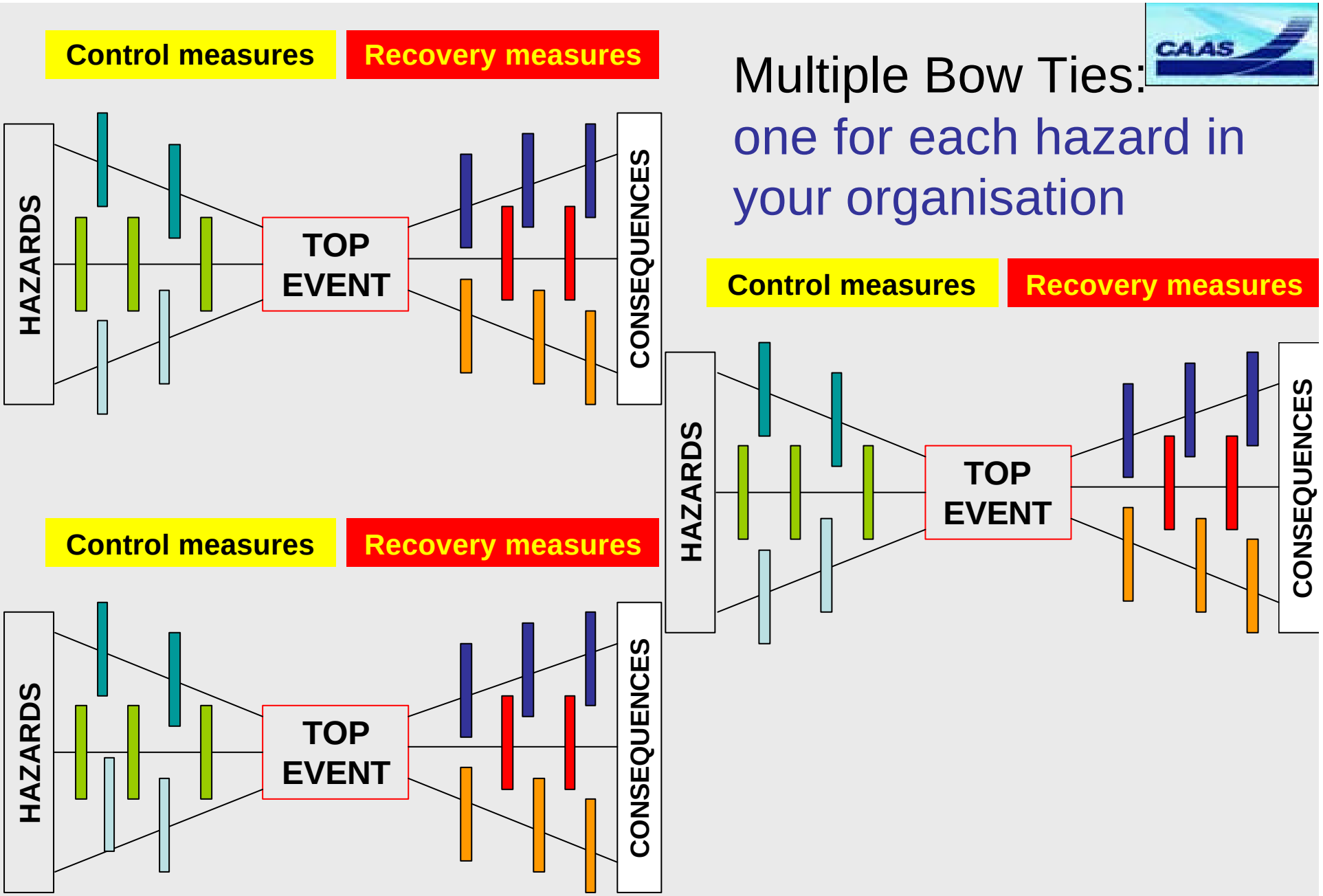
- **If they are not present in that analysis, then your original Bow Tie analysis for your risk management process was inadequate**

Bow Tie Concept

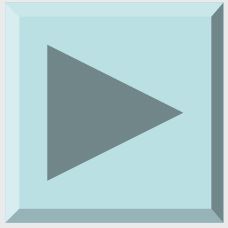


Multiple Bow Ties:

one for each hazard in your organisation



A final maintenance example of inadequate risk management:




Questions?