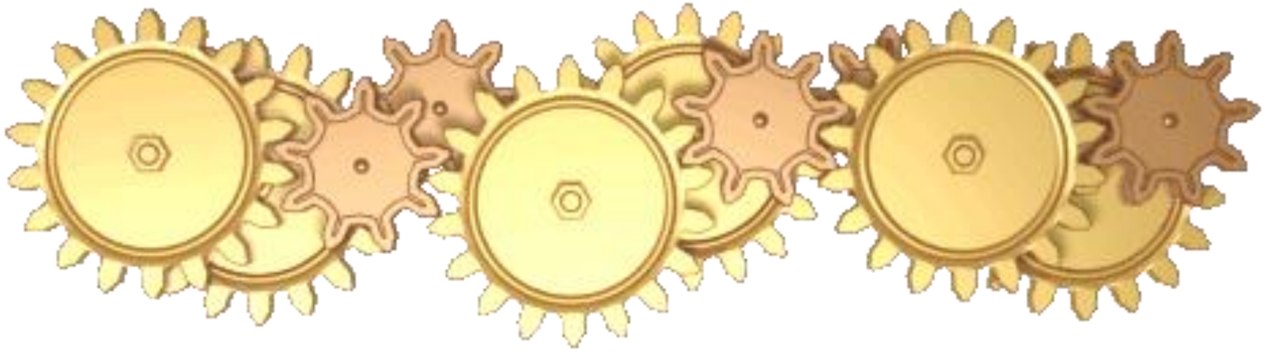
# Threat and Error Management



## Luxair TEM Concept


**Captain Marc Frank**


Luxembourg, February 3rd 2024

# Presentation Objectives

The learning objectives of this presentation are:

- Provide insight into the Luxair TEM concept
- Demonstrate the Luxair TEM concept in a case study

# Threat and Error Management

What is Threat and Error Management?

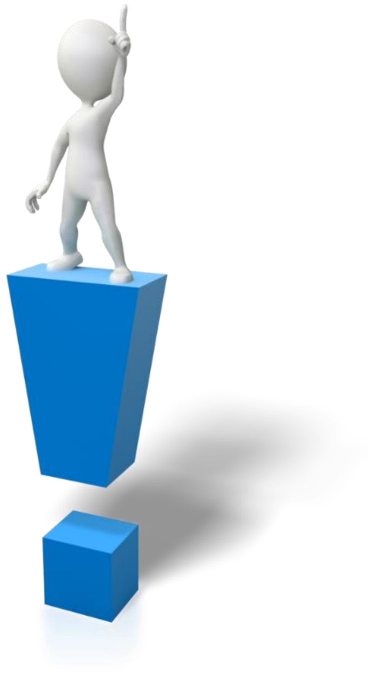
# Threat and Error Management

## Threats and Error Management

TEM is a systems’ approach to aviation safety. The basic concept of TEM is to provide pilots with the skills necessary to manage and reduce safety risks present in their everyday flying.

Merrit & Klinect, 2006

# Threat and Error Management



## Threats and Error Management

TEM promotes a philosophy of anticipation and thinking ahead.

TEM incorporates 3 components:

- Threat management
- Error management
- Undesired aircraft state management.

# Threat and Error Management

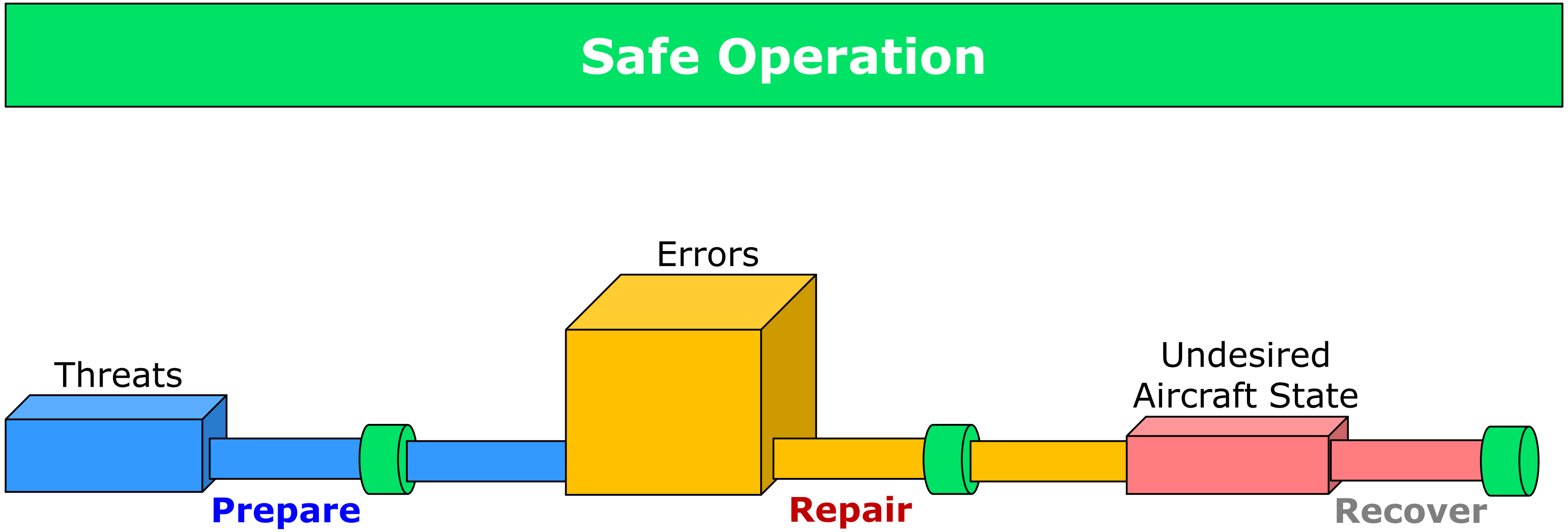

**TEM is the Goal!**

**CRM is the way to it!**

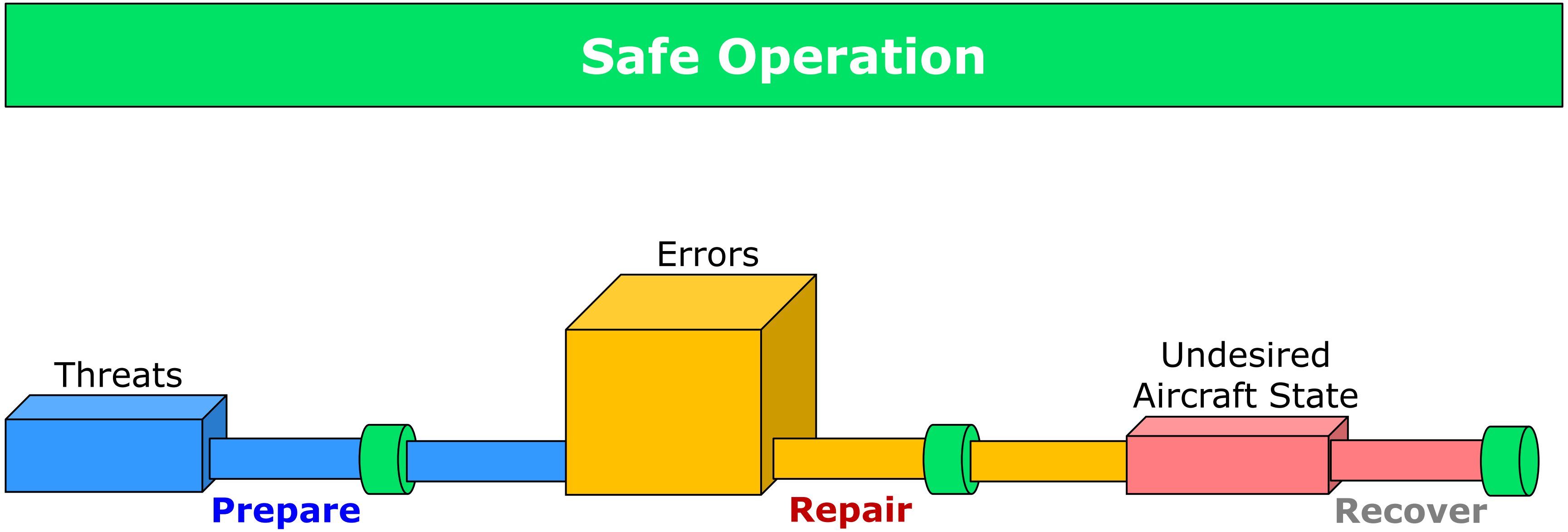
# Threat and Error Management


**The Luxair View**

# Luxair TEM Concept



# Luxair TEM Concept

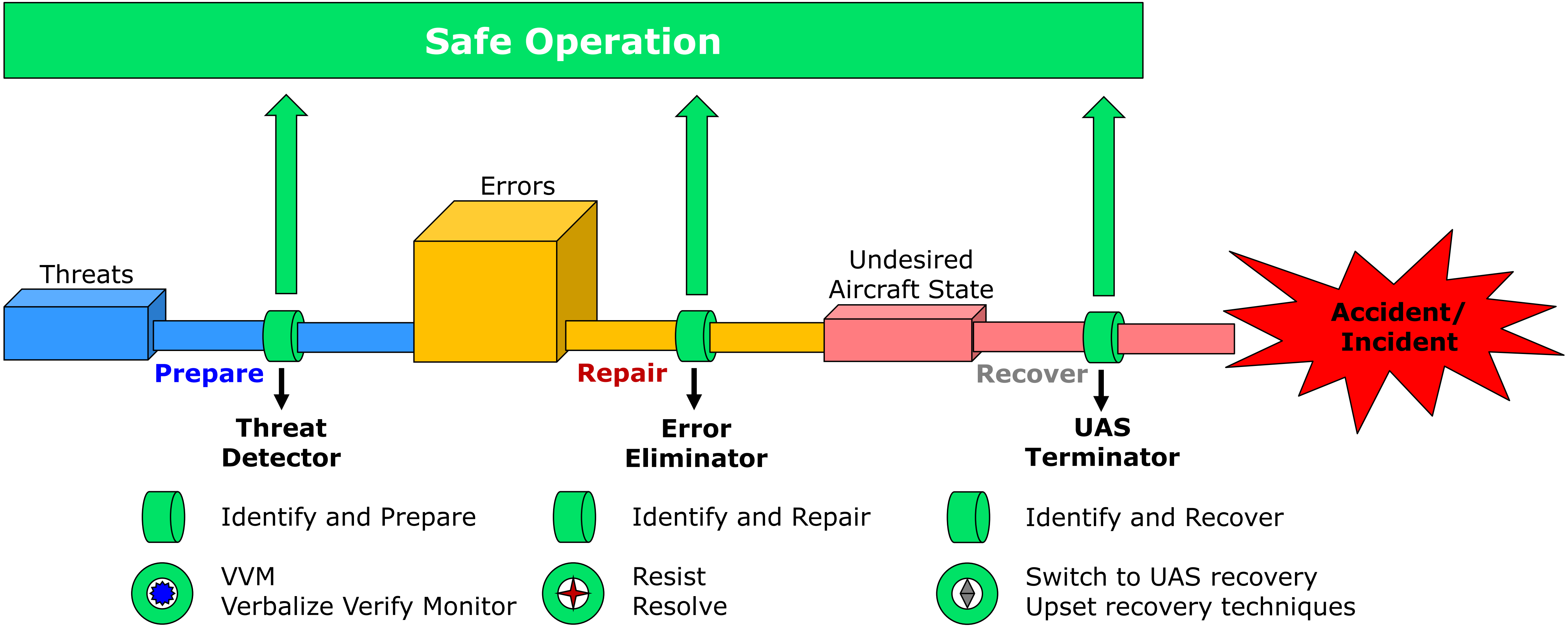



Identify and Prepare
VVM
Verbalize Verify Monitor

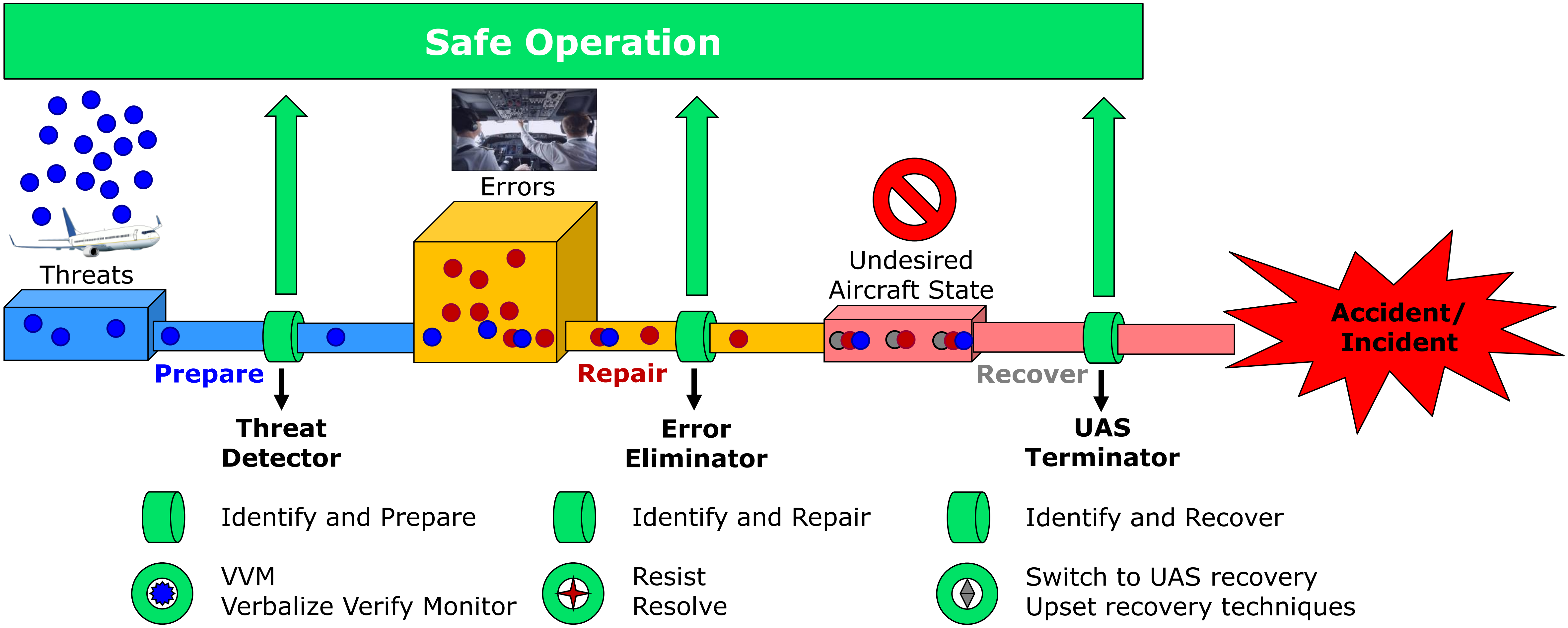
Identify and Repair
Resist
Resolve

Identify and Recover
Switch to UAS recovery
Upset recovery techniques

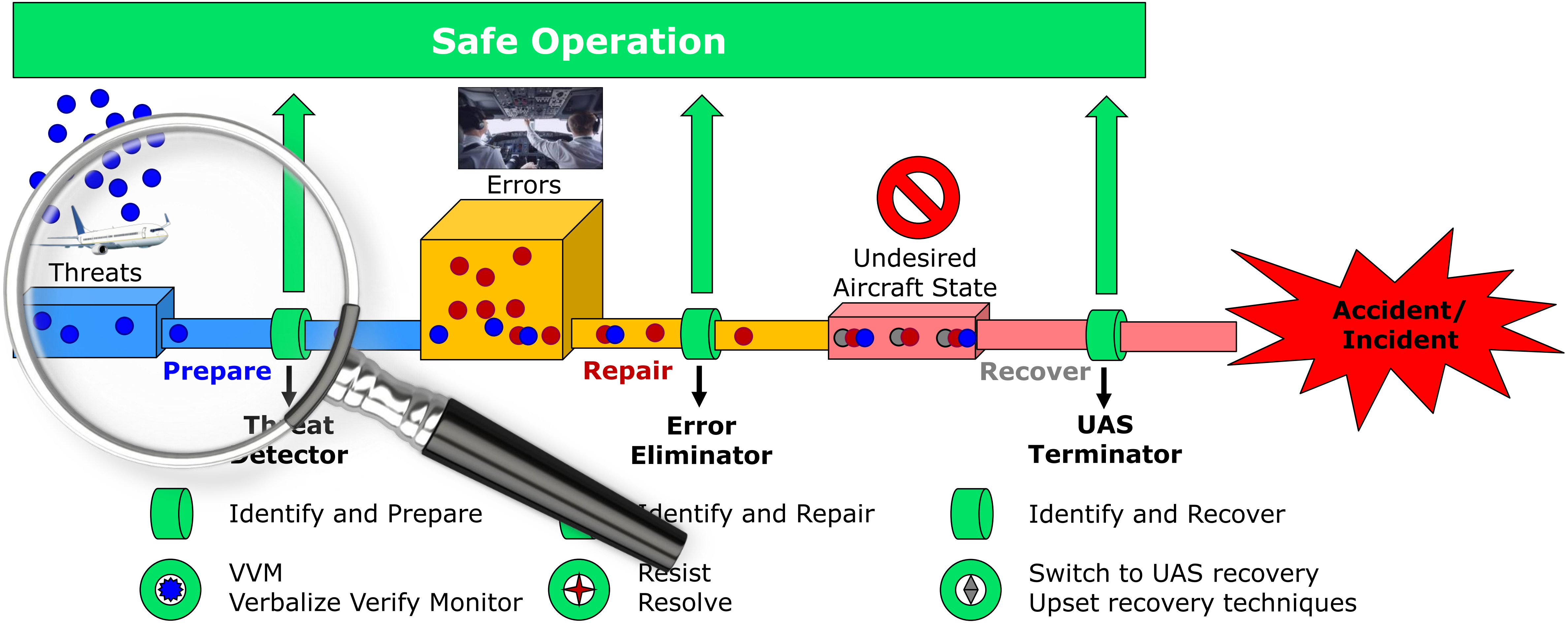
# Luxair TEM Concept



# Luxair TEM Concept



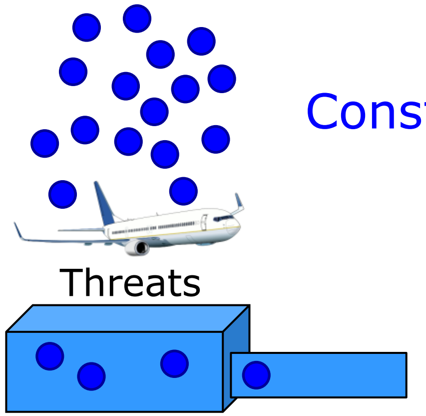
# Luxair TEM Concept



# Luxair TEM Concept

**Safe Operation**

Constant Rain of Threats



# Threat and Error Management

What is a Threat?

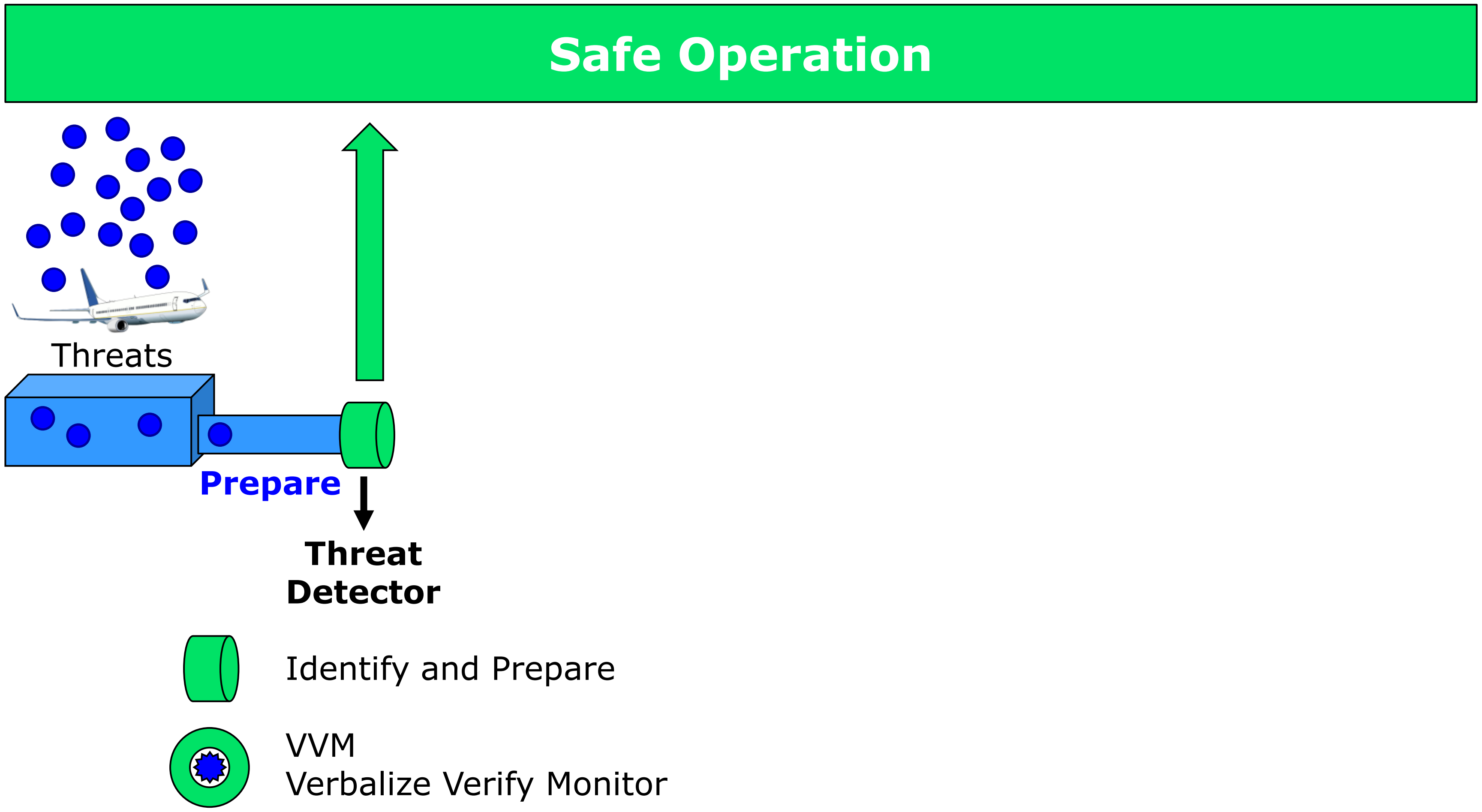
# Threat and Error Management

## Threats

Threats are occurrences or events that increase the operational complexity.

Threats
- Occur outside of the influence of the flight crew (not caused by the crew)
- Require crew attention if safety margins are to be maintained
- Promote an opportunity for pilot error.

# Luxair TEM Concept



# Luxair TEM Concept

**Threat Detector**

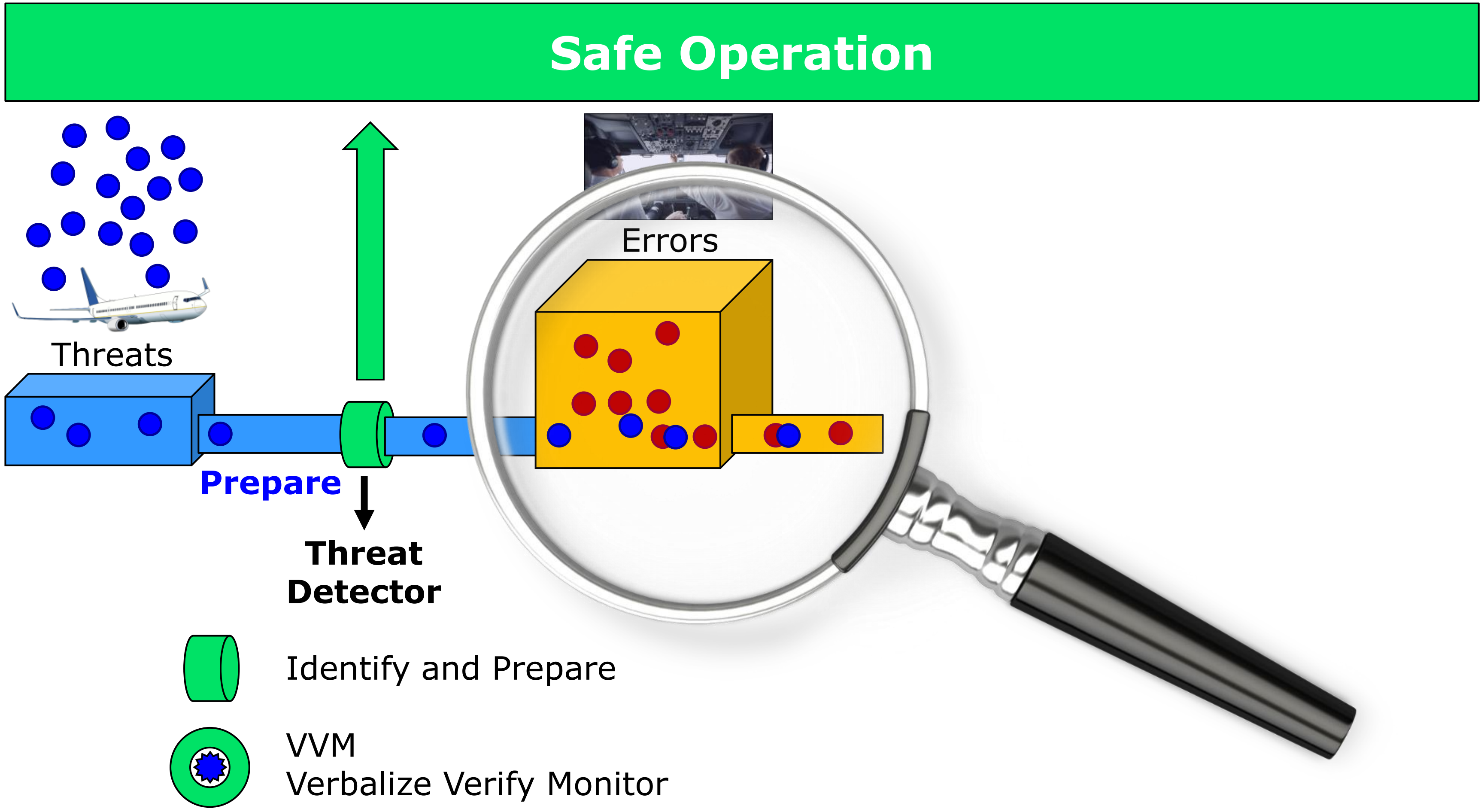
Identify and Prepare

VVM
Verbalize Verify
Monitor

**Tools:**

Monitoring Shield
Situation Awareness
Communication
Teamwork
Threat Briefing
Cabl$_3$
FOReDEC
VVM

# Luxair TEM Concept



# Threat and Error Management

What is an Error?

# Threat and Error Management

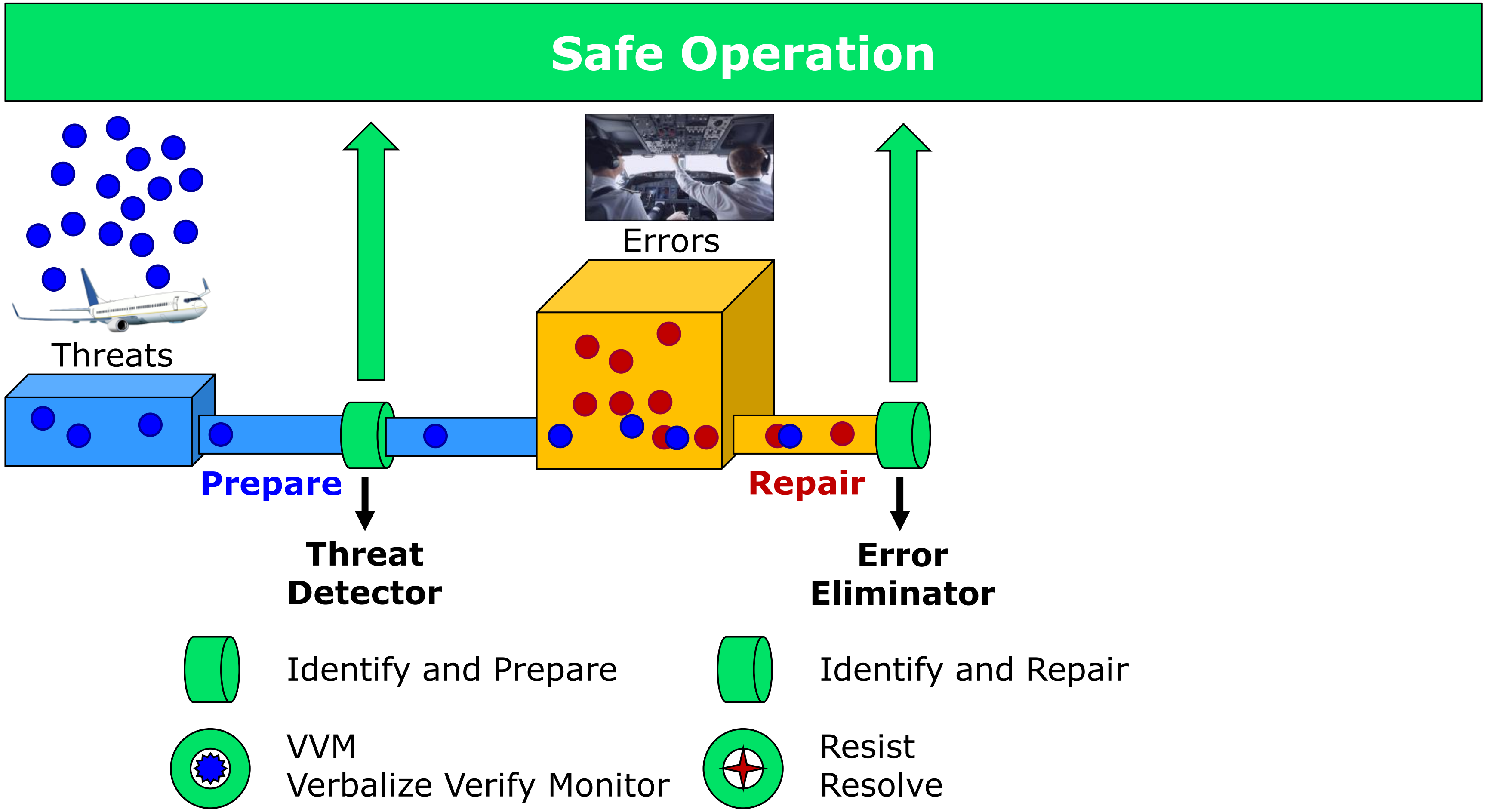
## Errors

Errors are defined as flight crew actions or inactions that:

- Lead to a deviation from crew or organizational intentions or expectations
- Reduce safety margins
- Increase probability of adverse operational events on the ground or during flight.

EASA May 2019

# Luxair TEM Concept



# Luxair TEM Concept

**Error Eliminator**

Identify and Repair

Resist
Resolve

**Tools:**

Resist
Resolve

# Luxair TEM Concept

**Error Eliminator**

Identify and Repair

Resist
Resolve

**Tools:**

Resist
Resolve

# Luxair TEM Concept

**Error Eliminator**

Identify and Repair

Resist
Resolve

## Tools:

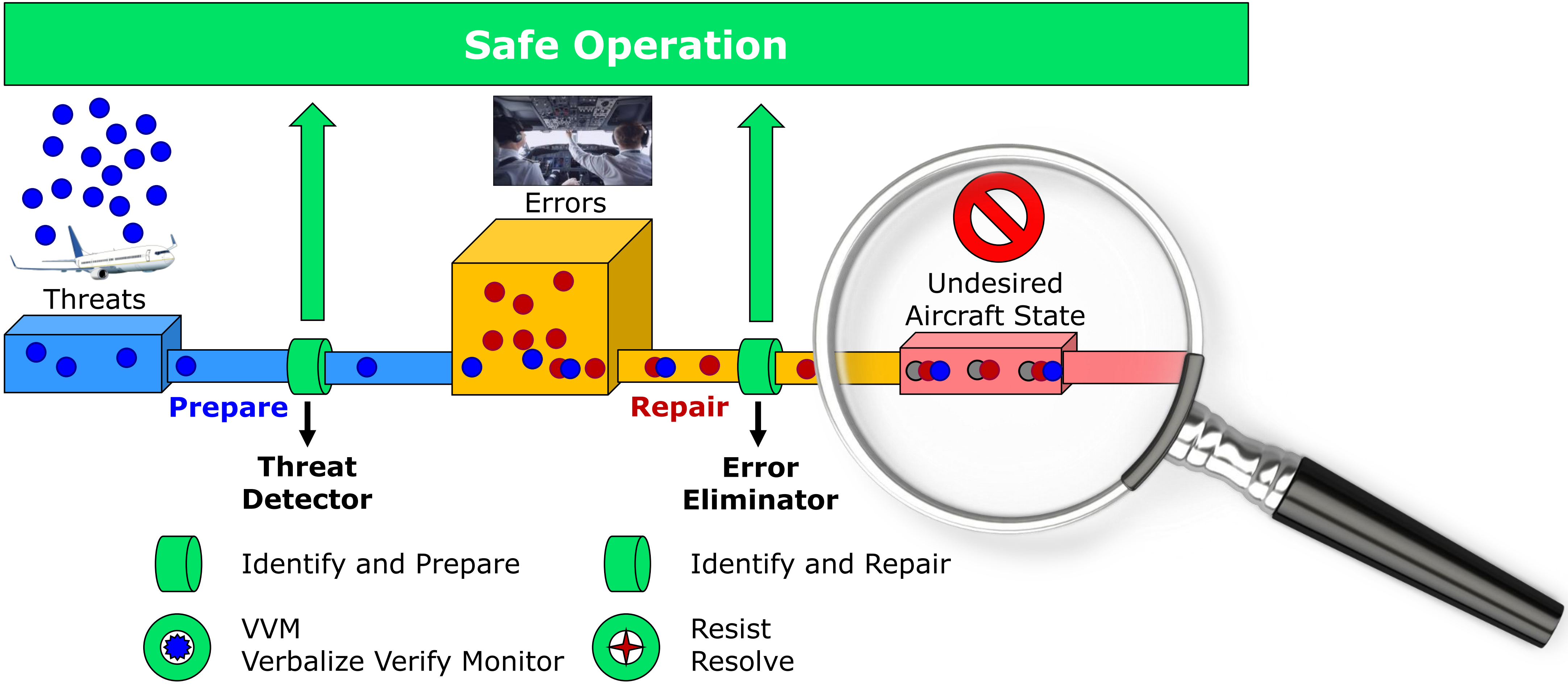
| | |
|---|---|
| Resist | Systemic countermeasures: |
| | TCAS, SOP's, GPWS, Windshear Detector, Weather Radar, Autopilot, Warning Systems, checklists, briefings… |
| Resolve | Human Skills countermeasures: |
| | Knowledge, Attitude, Experience, Monitoring, Teamwork, Workload management, Health… |

# Threat and Error Management

Threats come at the crew,
Errors come from the crew.

Predictive monitoring is identifying threats.
Reactive monitoring is identifying errors.

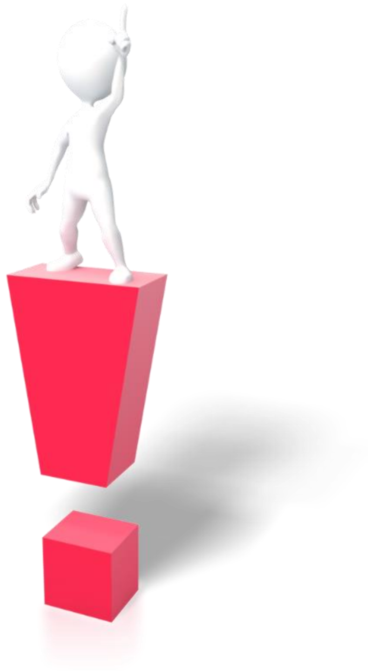
# Luxair TEM Concept



# Threat and Error Management

What is an Undesired Aircraft State (UAS)?

# Threat and Error Management

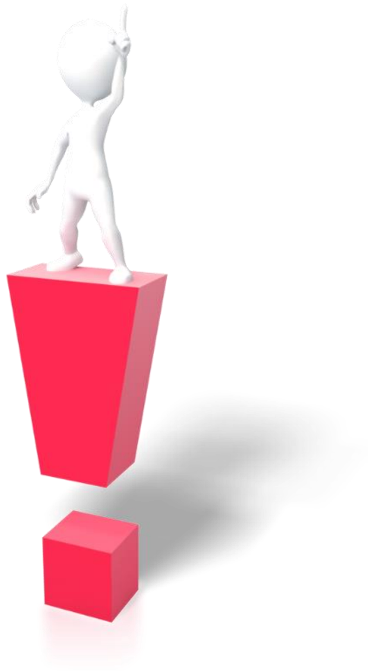


## Undesired Aircraft State

An Undesired Aircraft State:

- is a position, speed, attitude condition or configuration of an aircraft that clearly reduces safety margins
- results from pilot errors, action or inaction.

# Threat and Error Management

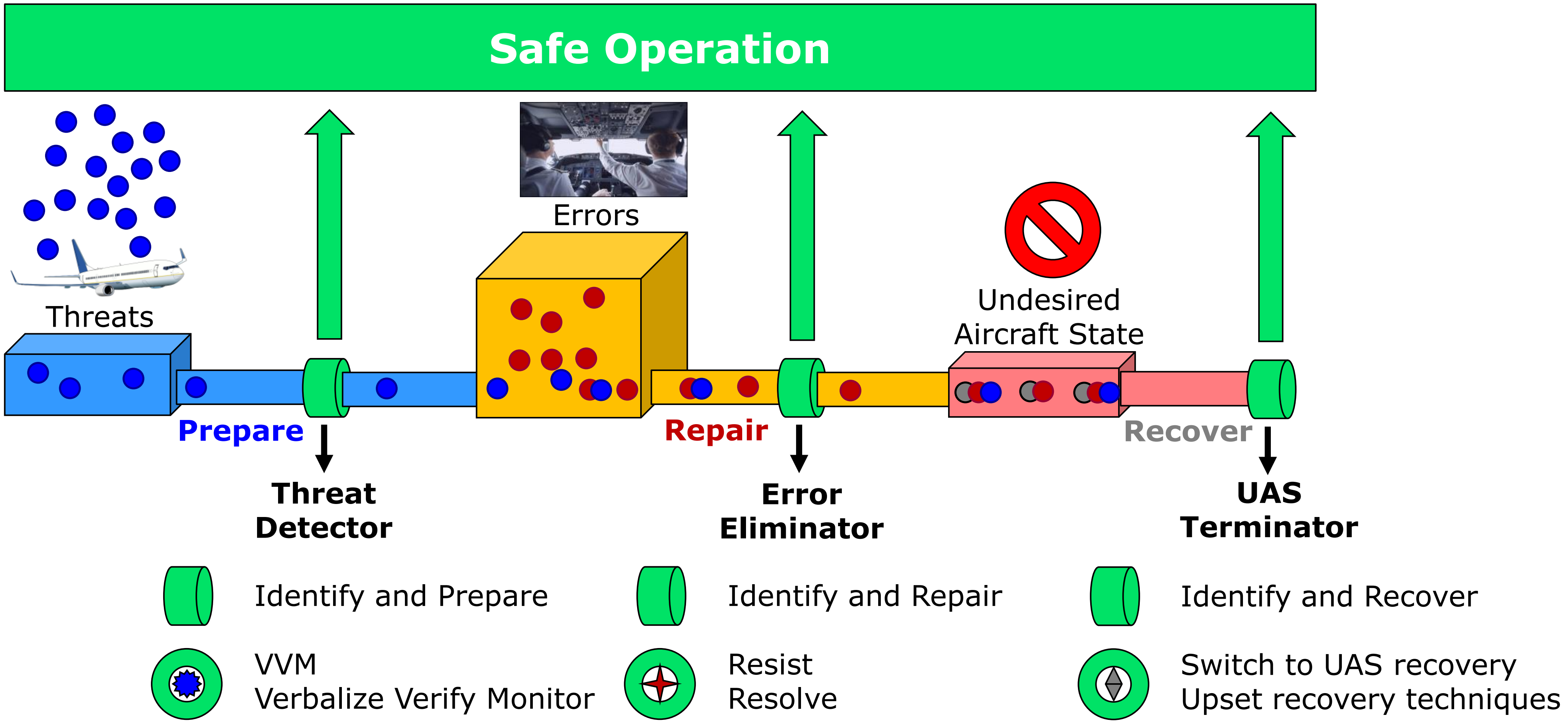


## Undesired Aircraft State

An aircraft upset due to a sudden technical malfunction can be seen as a latent threat. It will not be classified as an UAS if no pilot behavior contributed to the upset.

CASA Australia P15

# Luxair TEM Concept



# Luxair TEM Concept

**UAS**
**Terminator**

Identify and Recover

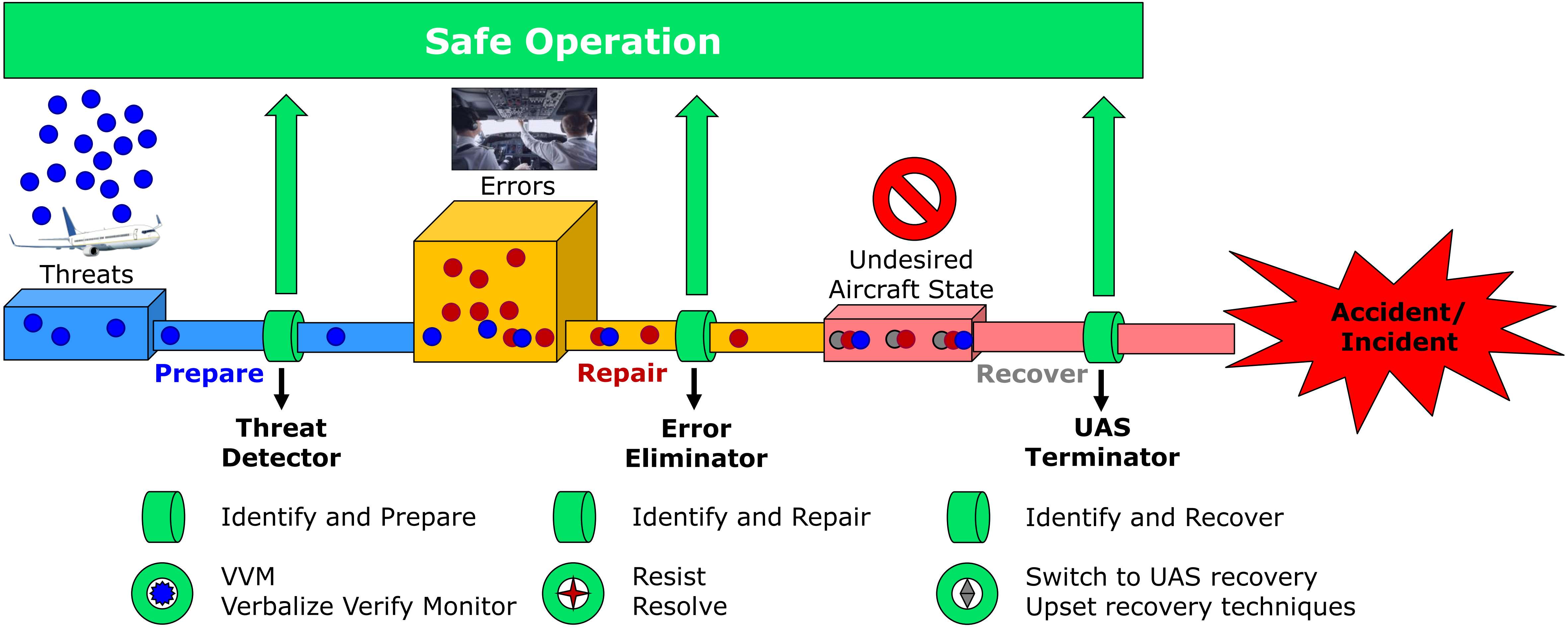
Switch to UAS recovery
Upset recovery techniques

## Tools:

- Recognize UAS
- Recover aircraft flight vector
- Switch rather quickly from error identification to UAS recovery
- Upset Prevention and Recovery Training and Upset recovery techniques.

It is important that crews understand when to switch from Error management to UAS management.

# Luxair TEM Concept



# Threat and Error Management

**Dealing with threats is predicting the future.**

**Dealing with errors is correcting the past.**

**Dealing with UAS is managing the present.**

# Threat and Error Management


**TEM is the Goal!**

**CRM is the way to it!**

# Teaching TEM

# Case Study

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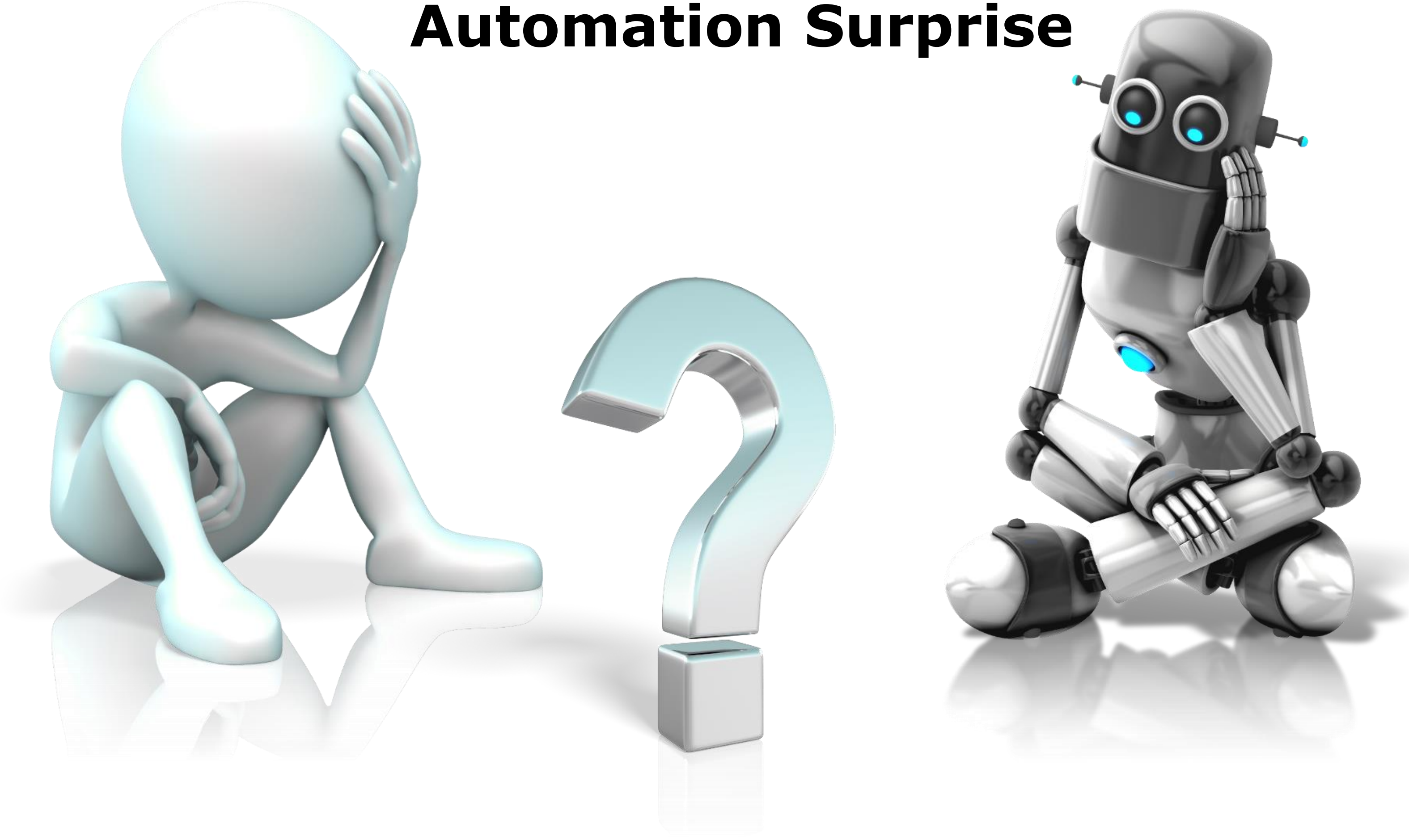
# Case Study

**TEM**
**and**
**Automation Surprise**



# Dealing with Automation

**Definition:**

An automation surprise can be defined as a behavior of the automation system which was not anticipated by the pilot. This behavior can emerge from internal working routines, inadequate manipulation, deficient transparency and lack of understanding and can seriously impact the pilot's cognitive capacities.

Marc Frank, 2021

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# Dealing with Automation

# Case Study Thai Airways TG461

**Thai Airways TG461 Bangkok – Melbourne**
**24.07.2011**

# Case Study Thai Airways TG461

**Preliminary Information:**

- Non-precision VOR approach Runway 34 in Melbourne
- Boeing 777
- Night Time
- Wx: Wind from Northerly directions with 11 kt Good Visibility 8 km with occasional Rain Showers High Clouds, aircraft was out of clouds
- Co-pilot is pilot flying

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# Case Study Thai Airways TG461

The « Outside View »

The « Inside View »

Luxair

# Case Study Thai Airways TG461

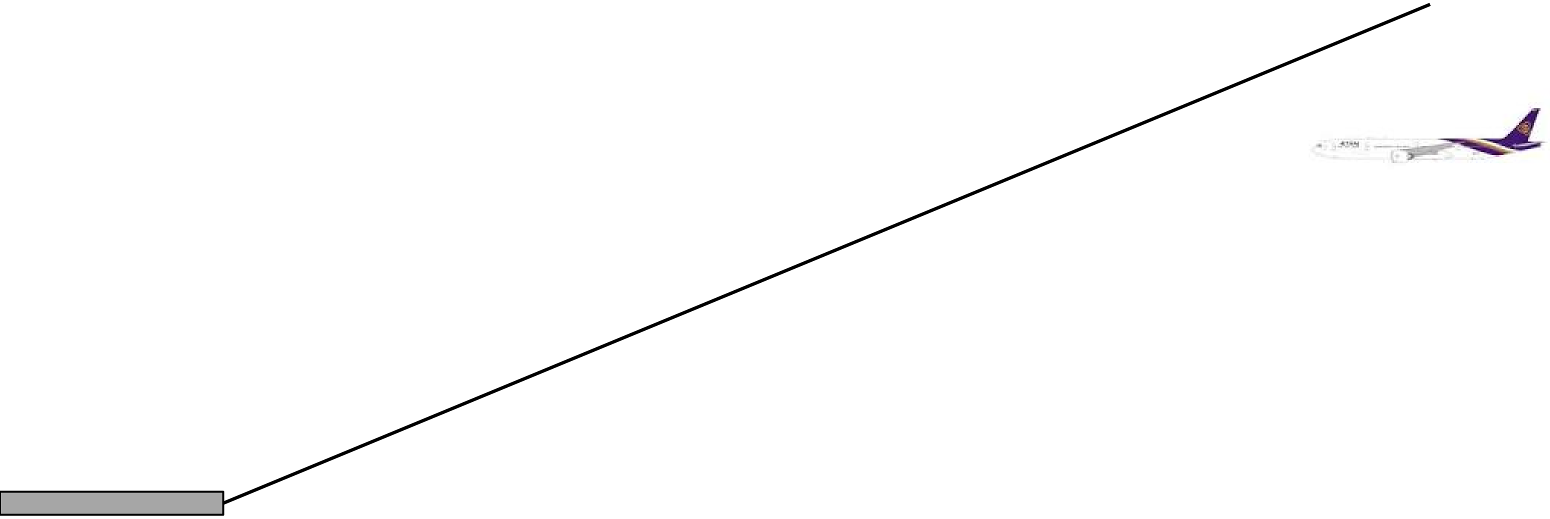
The « Outside View »

The « Inside View »

# Case Study Thai Airways TG461

**Facts:**

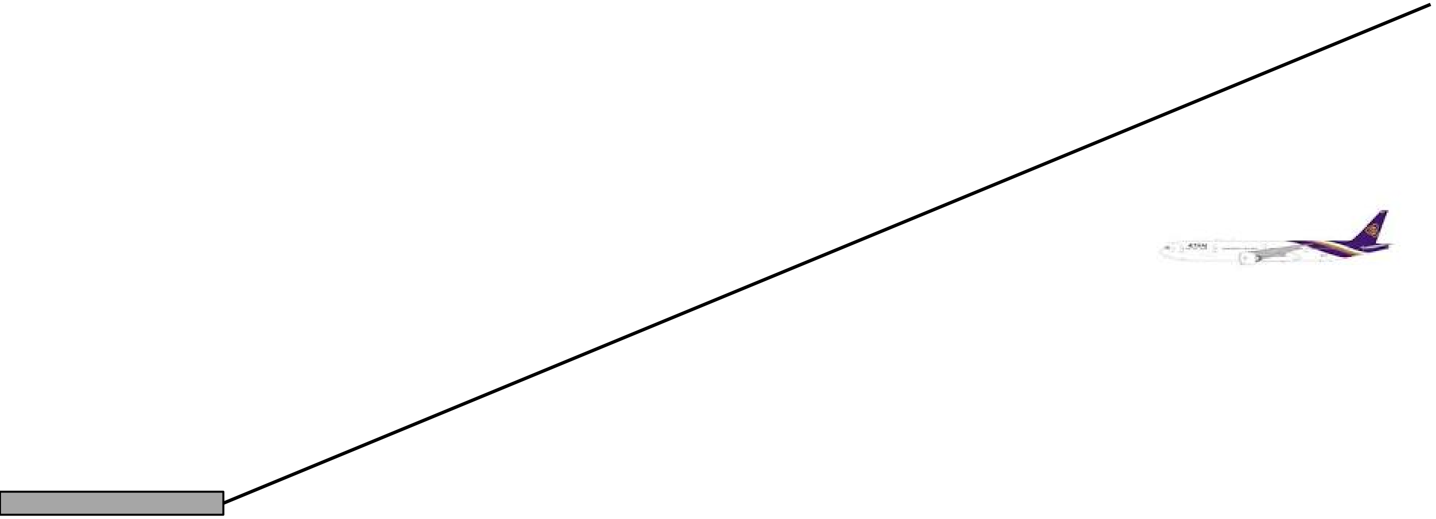
The Tower Controller observed both visually and on his radar screen that the aircraft was lower than required and asked the flight crew to check their altitude.



# Case Study Thai Airways TG461

**Facts:**

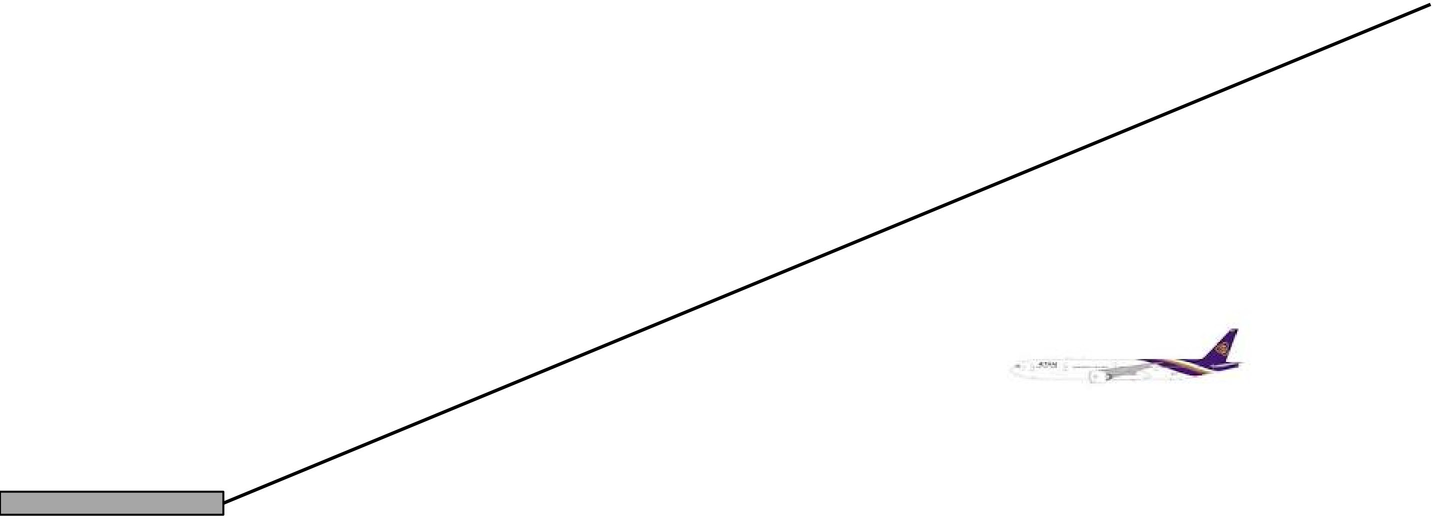
Since there was no reply from the flight crew, the tower controller instructed Thai461 to go around and execute the missed approach procedure for runway 34. To this instruction the crew replied “climbing”.



# Case Study Thai Airways TG461

**Facts:**

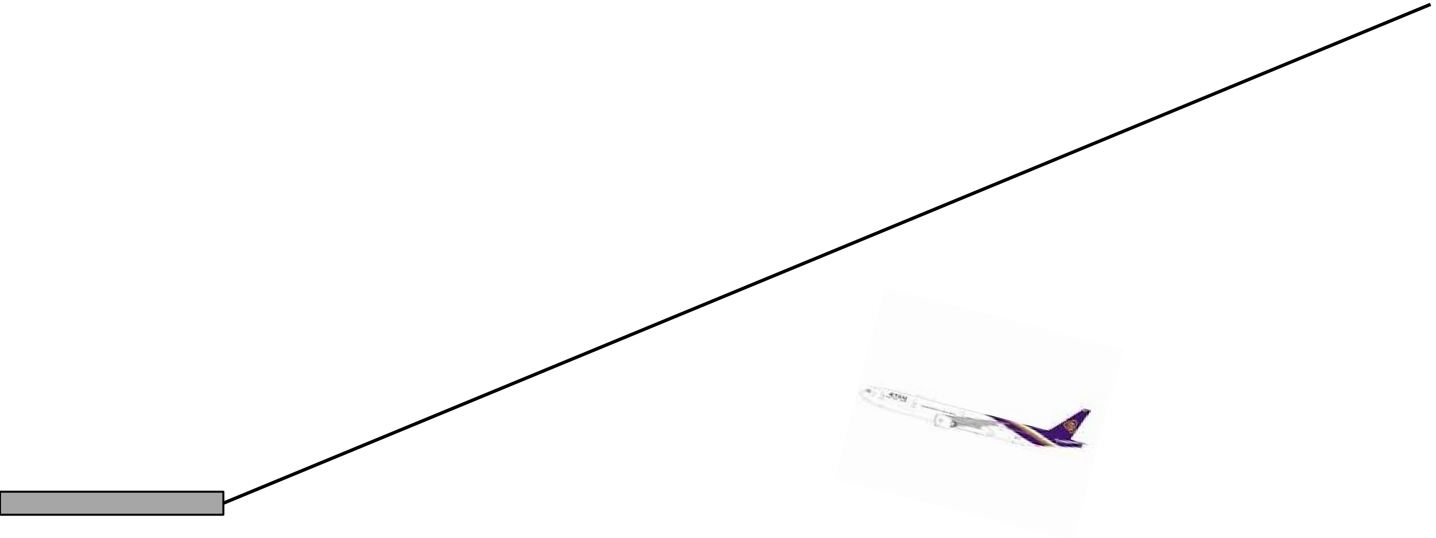
The Tower Controller could not detect a climb and issued the go around instruction again, to which the crew replied to be on a visual approach. "We are climbing Thai 461 we are maintaining 1,200 copy".



# Case Study Thai Airways TG461

**Facts:**

The tower controller then responded “negative, missed approach runway 34, climb to 4,000 ft”.
The flight crew reported that they were climbing to 4,000 ft.



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# Case Study Thai Airways TG461

The « Outside View »

The « Inside View »

# Case Study Thai Airways TG461

## Sequence of Events:


| Time | Action |
|---|---|
| 20:13:00 | The aircraft is cleared to descend to 3000ft for VOR approach runway 34. |
| 20:15:00 | The aircraft autopilot (AFDS) is tracking LNAV and VNAV with the correct approach selected. |
| 20:15:47 | At 3300 ft, the autopilot automatically changes from VNAV SPEED to VNAV PATH to ensure compliance with the approach procedure. The calculated FMC interception altitude is 3400 ft. Accordingly, the autopilot initiates a climb. |
| 20:16:05 | The crew changes the selected altitude to 2000 ft and selects FLIGHT LEVEL CHANGE (LVL CHG) mode. |

**Remark:**

LVL CHG mode is an open descent mode where the target value is the selected altitude. The AFDS will reduce thrust to idle, maintain the speed by modulating pitch until the altitude is reached. During an approach, altitude constraints will be disregarded.

# Case Study Thai Airways TG461

## Sequence of Events:


| Time | Action |
|---|---|
| 20:16:46 | The crew changes the target altitude to 3000 ft. The autopilot (AFDS) captures and maintains 3000 ft. |
| 20:17:04 | The crew changes target altitude to 970 ft and reselects FLIGHT LEVEL CHANGE (LVL CHG) mode. |
| 20:18:31 | The aircraft intercepts the final approach inbound track and the crew reports airfield in sight. The aircraft is cleared for a visual approach. |
| 20:18:48 | The autopilot is disconnected. The aircraft is at 8,5 DME at an altitude of 1284 ft, which means about 1300 ft too low. **Minimum** altitude for the approach at this point is 1970 ft. |

# Case Study Thai Airways TG461

**Sequence of Events:**


| Time | Action |
|---|---|
| 20:18:56 | The Tower controller observed both visually and on the radar that the aircraft was too low and asks the crew to check altitude. |
| 20:19:00 | Lack of a reply the controller instructs the crew to go around. The crew replies 'climbing.' |
| 20:19:10 | Lowest recorded altitude occurs at 6,4 NM at an altitude of 984 ft. Aircraft is about 1000 ft below the approach path. |
| 20:19:26 | The aircraft is still low at 1167 ft and the controller asks the crew to confirm that they are going around. The crew replies: 'we are climbing Thai 461 we are maintaining 1,200 copy.' |

# Case Study Thai Airways TG461

**Sequence of Events:**


| Time | Action |
|---|---|
| 20:19:40 | The Tower Controller replies ‘negative, missed approach runway 34, climb to 4,000 ft.’ |
| 20:19:50 | The flight crew reports that they are climbing to 4,000 ft. |

The subsequent runway 34 VOR approach was conducted by the Captain using both LNAV and VNAV modes.

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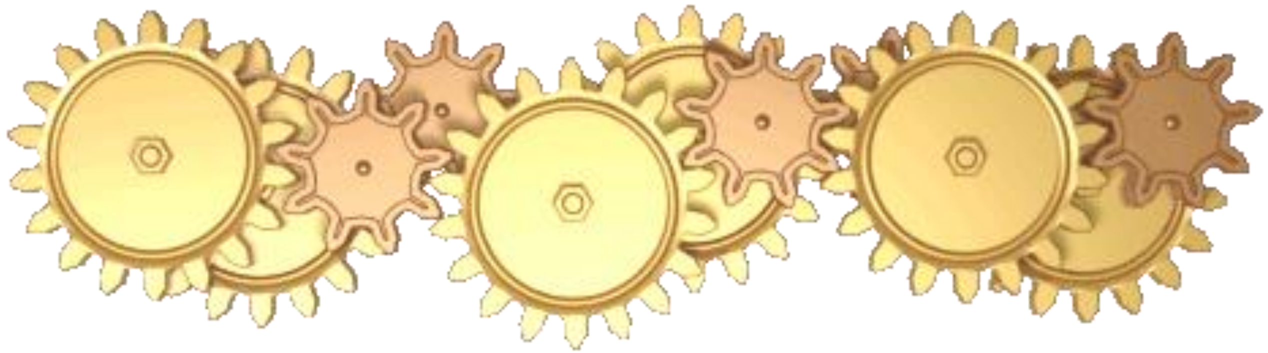
# Case Study Thai Airways TG461

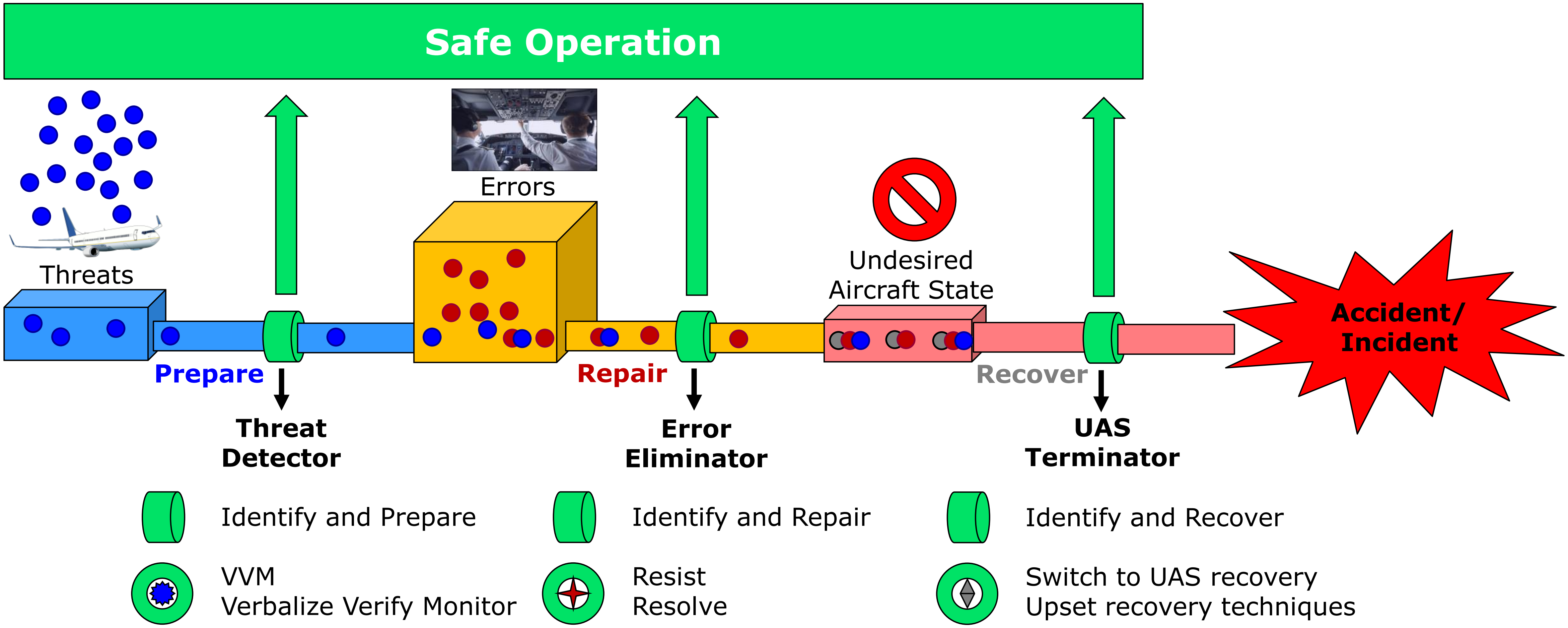
Another View on the Situation

# Case Study Thai Airways TG461

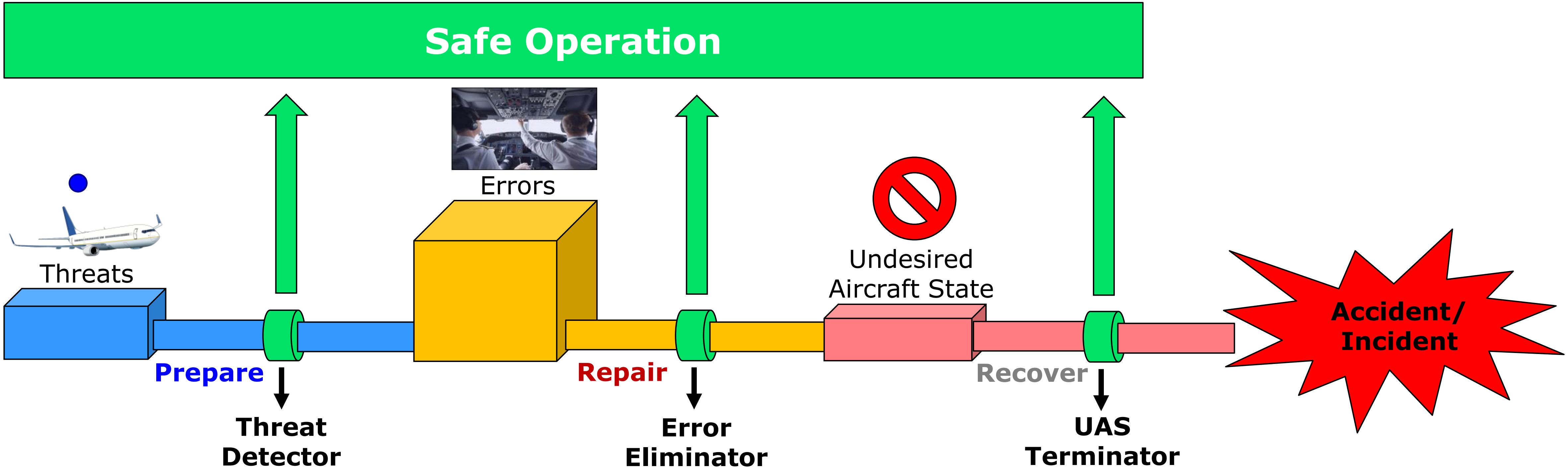
## Luxair TEM Concept: The TEM Machine



# Luxair TEM Concept



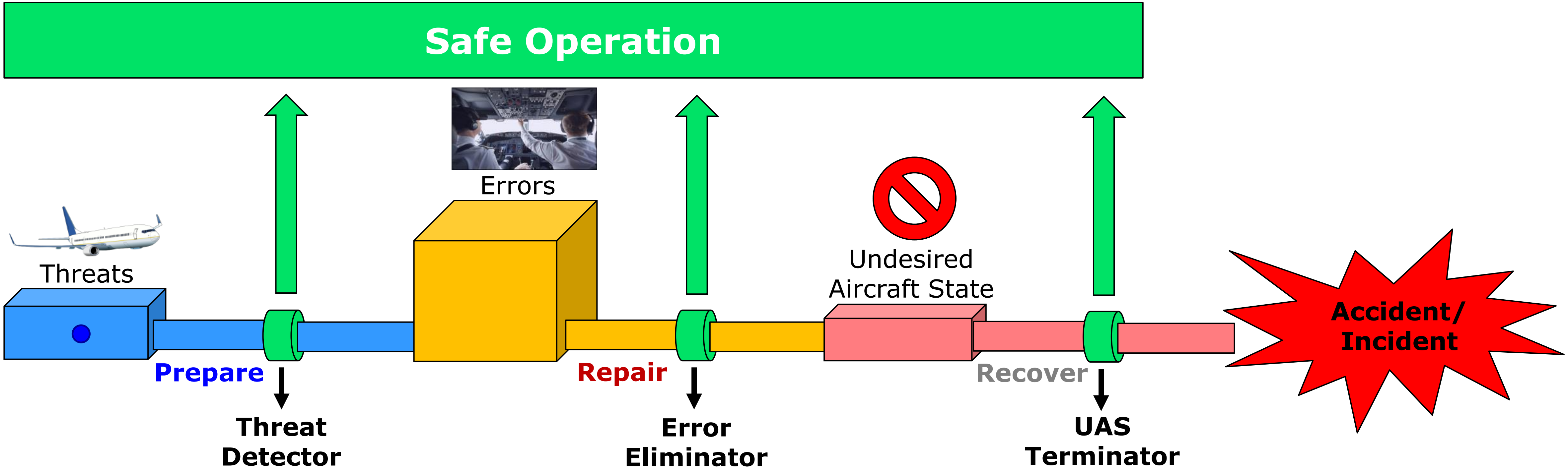
# Case Study Thai Airways TG461




**Threat:** Below path for non-precision approach

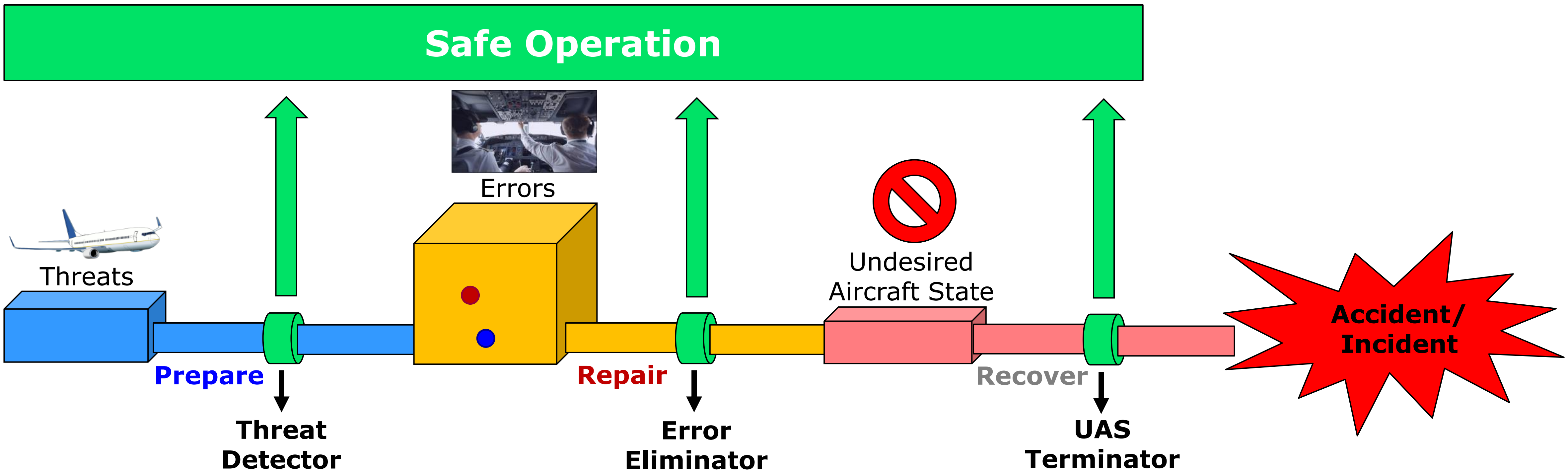
**Tool:** Predictive Monitoring – Enhanced Situation Awareness

# Case Study Thai Airways TG461



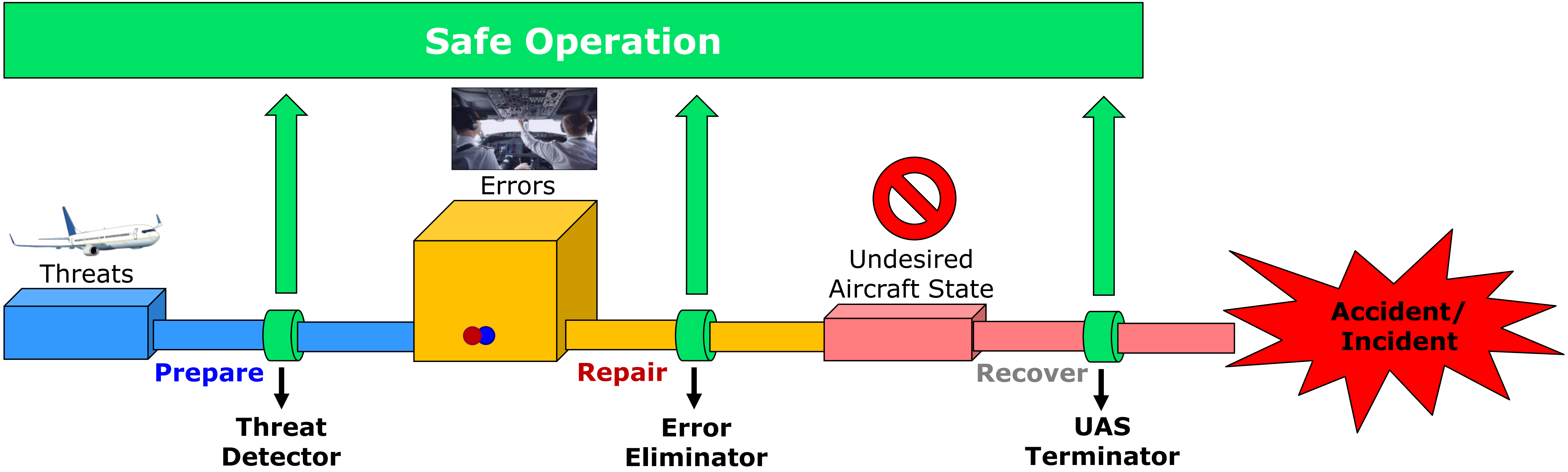

**Trigger:** AFDS captures VNAV PATH and initiates a **climb**

# Case Study Thai Airways TG461




**Error:** Crew interpretes an autopilot malfunction and initiates descent without control of rate of descent during NPA

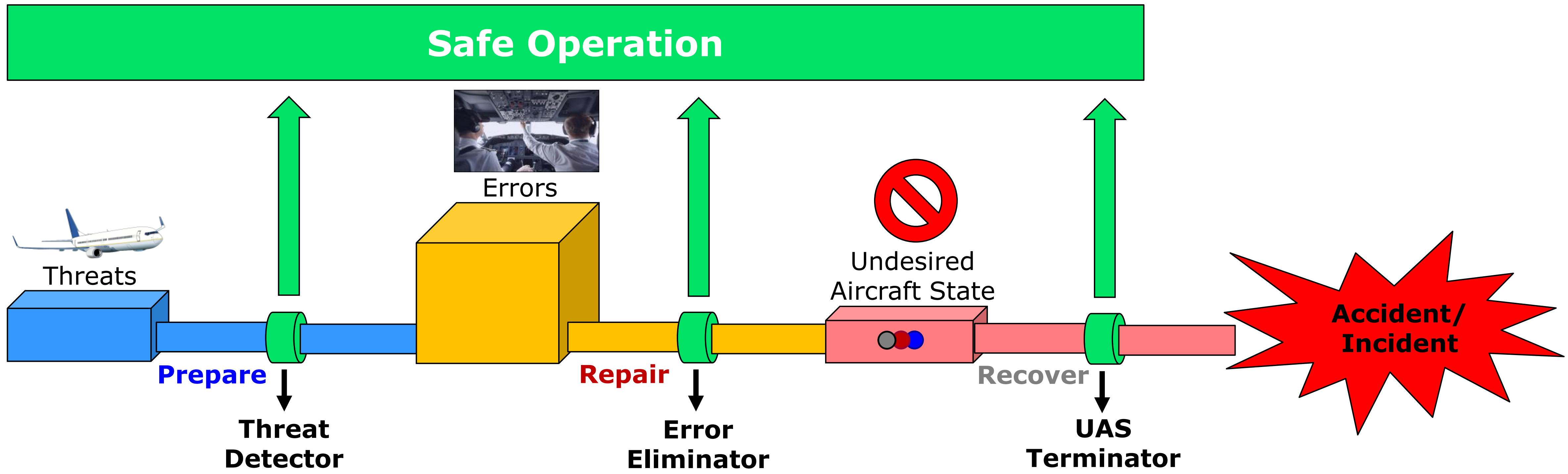
# Case Study Thai Airways TG461




**Trigger:** Use of
FLT CHG mode for
approach

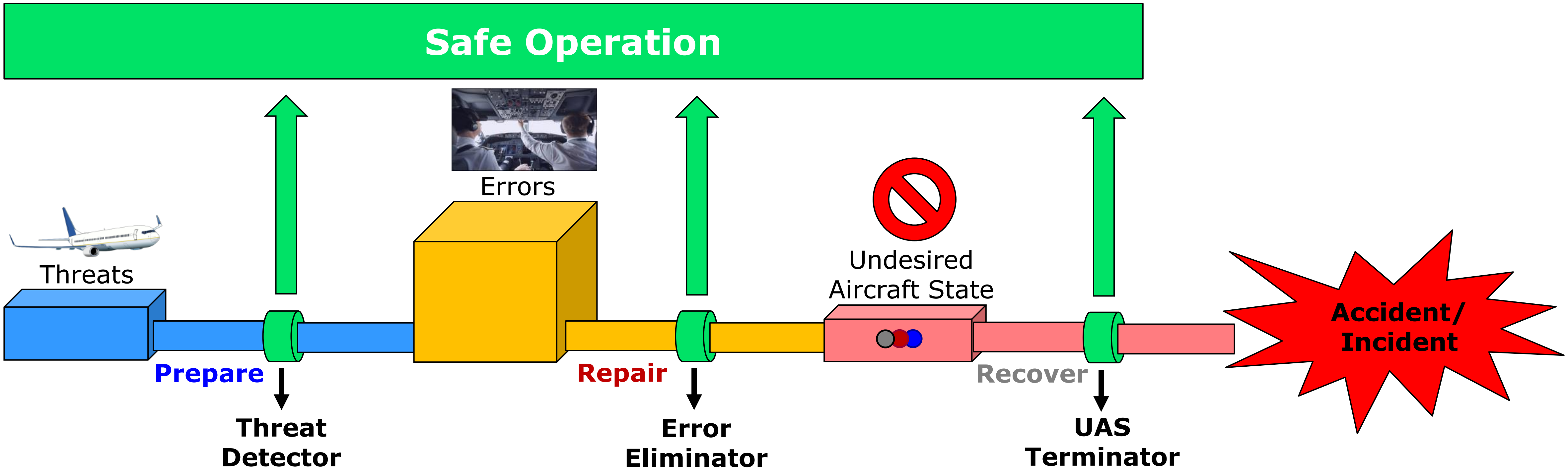
Boeing procedure/OM-B procedure:
# Do not use LVL CHG on final approach below 1000 feet Airfield Elevation.

# Case Study Thai Airways TG461




**UAS:** Aircraft
below profile

# Case Study Thai Airways TG461




**Trigger:** Failure to comply with instruction to go around

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# Case Study Thai Airways TG461

A Go-around instruction from Tower must be followed promptly.

If related to another traffic, disregarding the instruction might lead to disaster.

For Thai Airways TG461, the time delay between the tower controller’s initial go-around instruction and selection of go-around thrust was about 50 seconds.

# Case Study Thai Airways TG461


**Summary:**

- Closely monitor aircraft flight path
- Ensure trajectory complies with published procedure
- Crosscheck actual against published altitudes
- Use appropriate automation modes
- Use the TEM machine
- Redirect attention to the priority task

# AOPA Luxembourg 2024

Threat and Error Management is a Concept to **enhance** Flight Safety.

The Luxair TEM Machine is a Tool to **create** Flight Safety at a Pilot Level.

The Luxair TEM Machine

**Comments, remarks or questions?**