

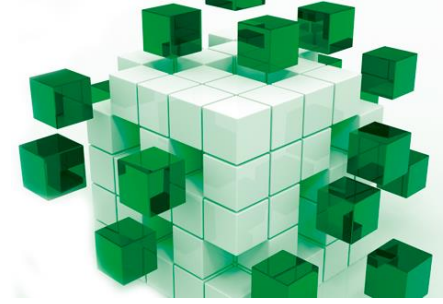
# XVIII Congreso de Confiabilidad

Madrid. 23 y 24 de noviembre de 2016



Organiza:

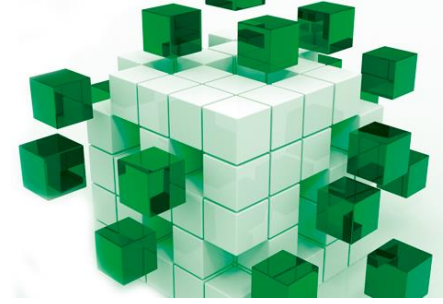




# **INSPECTION SCHEDULE ADJUSTMENT THROUGH MONTECARLO ANALYSIS**

**Juan Antonio Sánchez Lantarón**

**Aircraft Safety Engineer – Airbus Defence and Space**



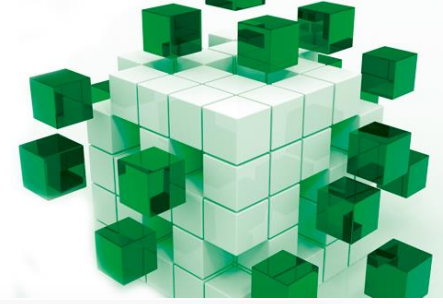
# AIRBUS

## DEFENCE & SPACE

Military Aircraft

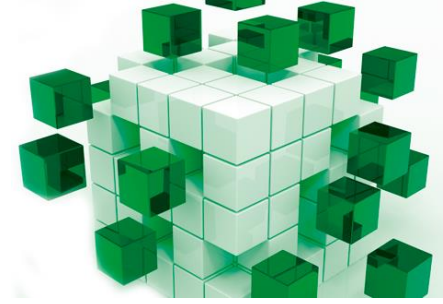


# Continued Airworthiness Process



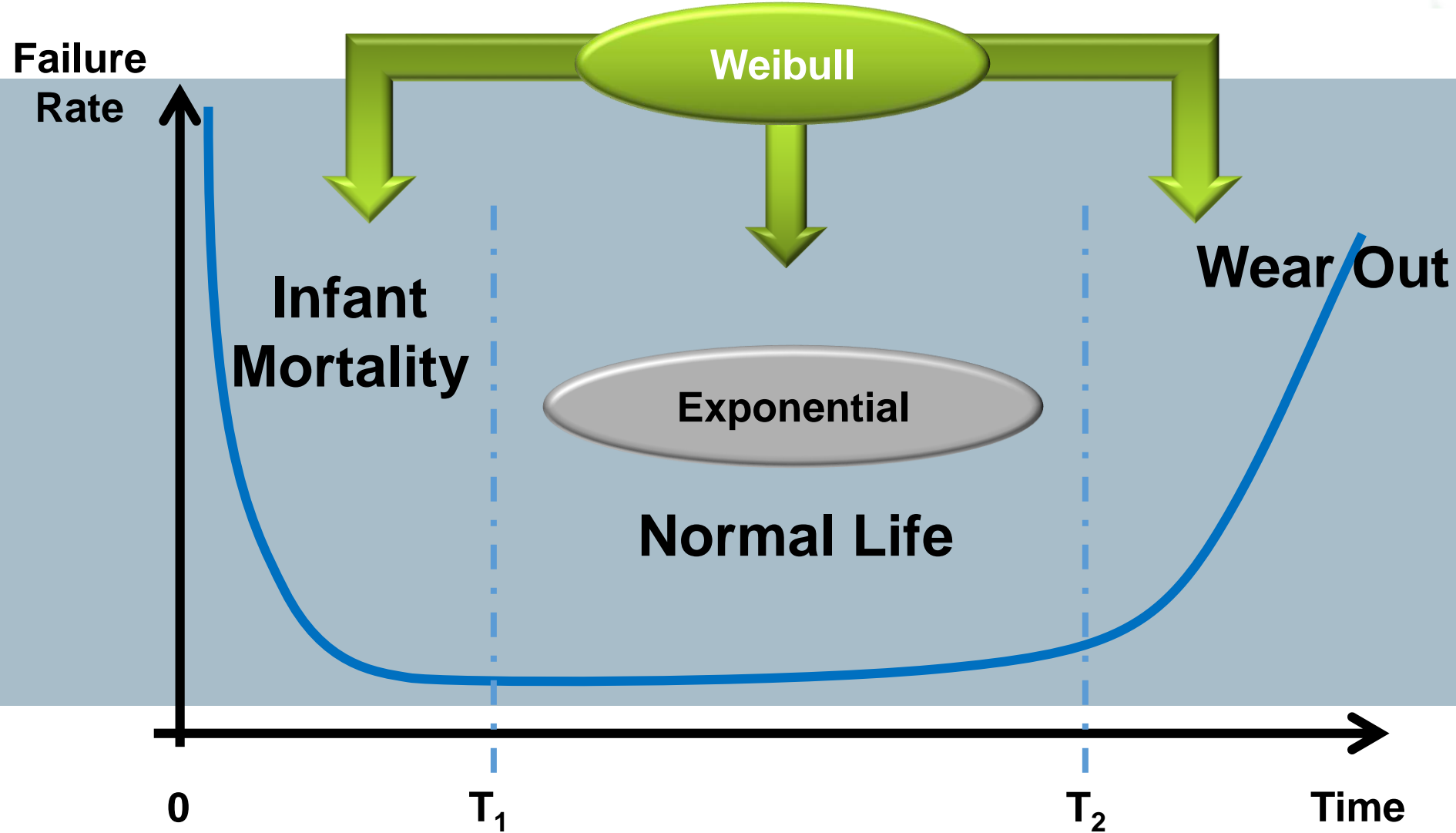
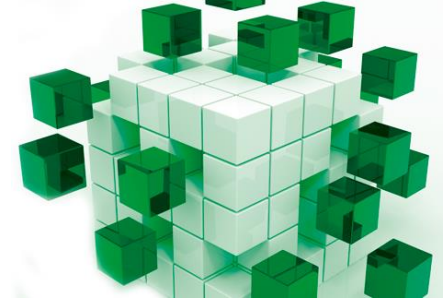
- Continued Airworthiness definition (ICAO)
- European regulations:
  - Collection and analysis of Data
  - Report of occurrences
  - Investigate the reason for the deficiency
  - Corrective Actions and Reaction Time
- Airworthiness Directive (AD)



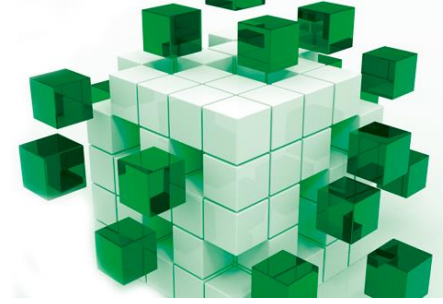


- Event detected beginning 2016
- Failure mode related with early fatigue degradation:
  - Crack initiation
  - Crack propagation
  - Small fragment detachment
  - Complete item detachment
- Potential Engine in-flight Shut down

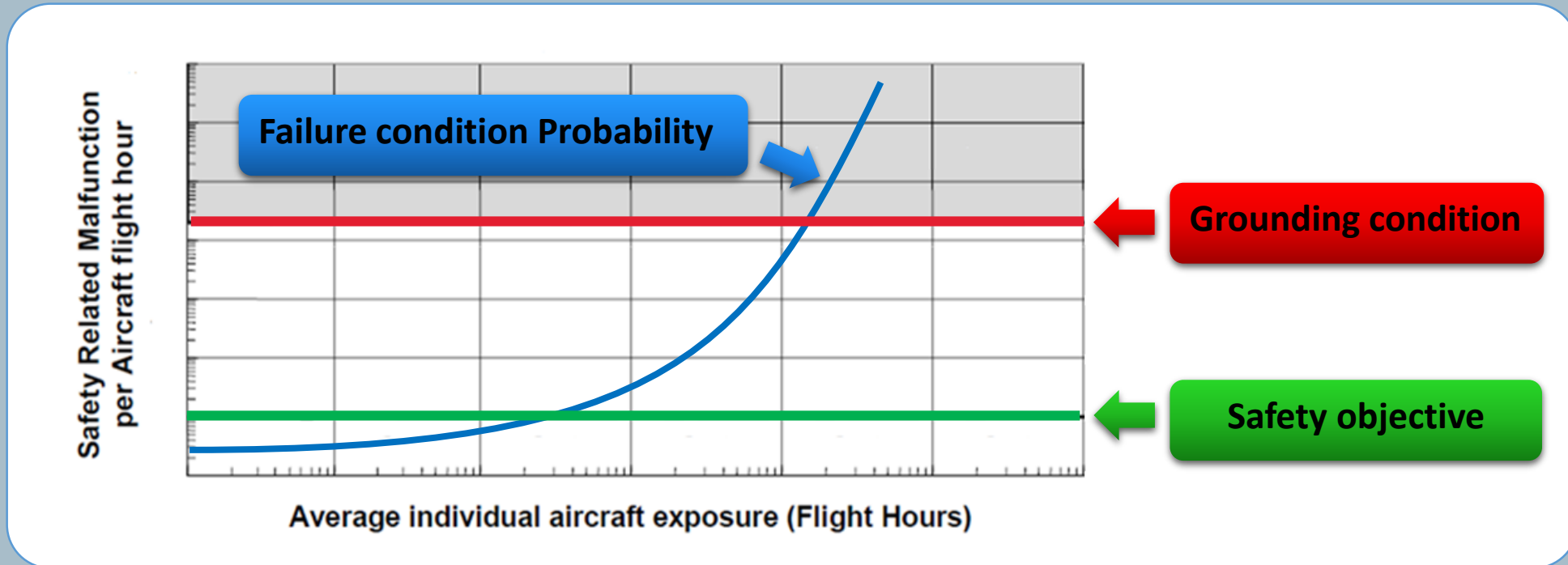
# Failure Mode Analysis



# Unsafe condition and Airworthiness Directive

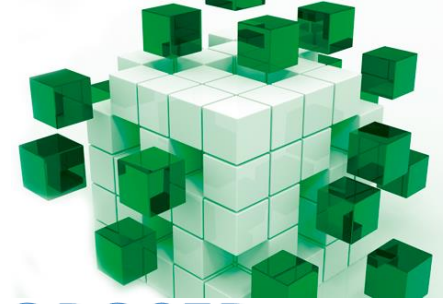


- Fatigue related failure mode with increasing failure rate



- Declaration of Unsafe Condition  $\Rightarrow$  Reaction Time
- Issue of Airworthiness Directive  $\Rightarrow$  Scheduled inspections

# AD Inspection threshold evaluation



**DOES THE SYSTEM MEET THE SAFETY OBJECTIVES WITH THE PROPOSED  
INSPECTION SCHEDULE?**

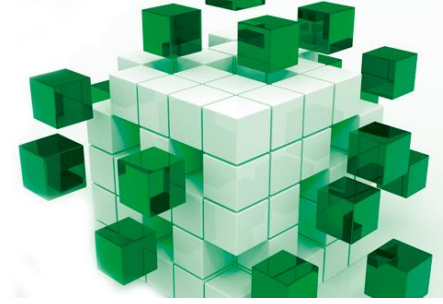


**IS THE INSPECTION THRESHOLD WELL ADJUSTED?**

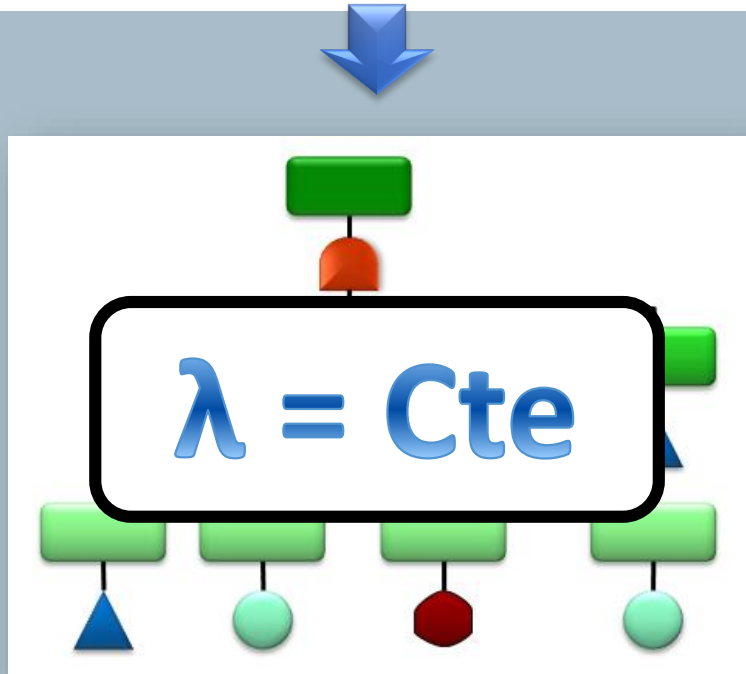
Engineering judgement Vs. Available data



# Risk Level Evaluation



## Failure Condition



Prob / FH

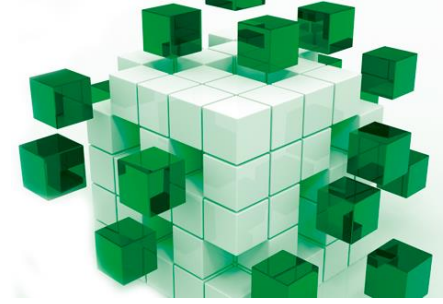
SSA



Safety  
Objectives?



# Monte Carlo Analysis



# Monte Carlo Analysis



The Monte Carlo analysis is a stochastic process based on the systematic repetition of a mathematical model considering probabilistic inputs

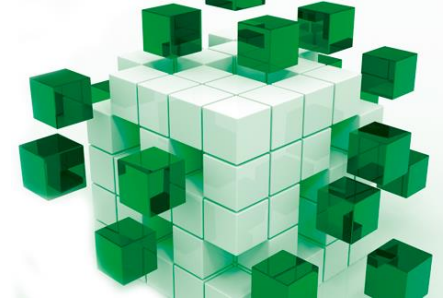
The Monte Carlo analysis is based on the Law of Large Numbers

**RANDOM  
INPUTS**



**OUTPUT**

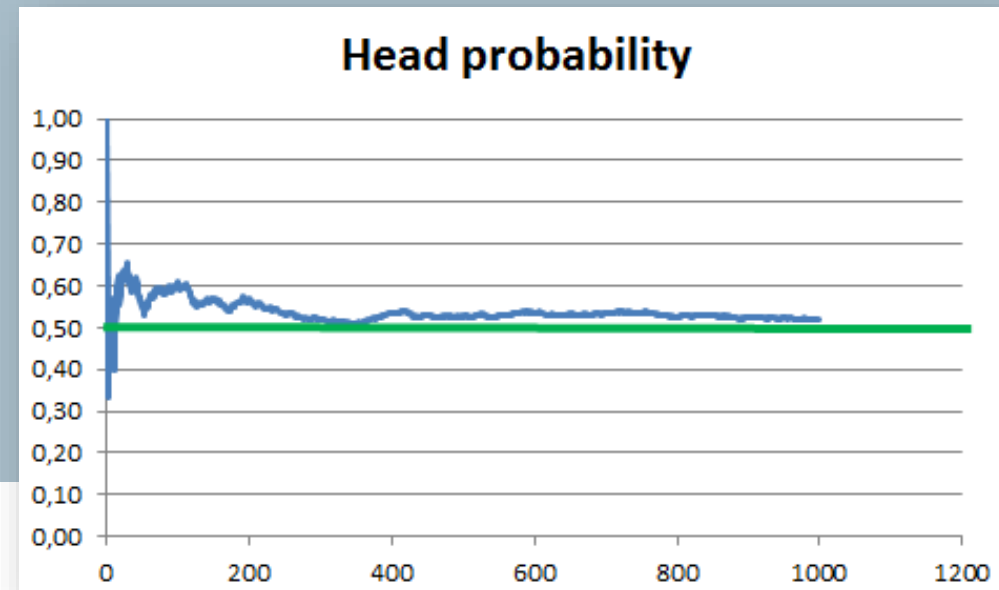




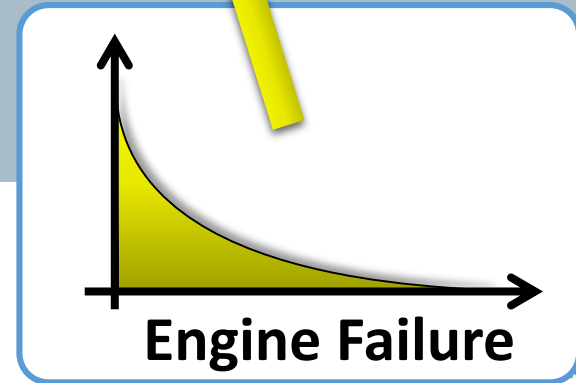
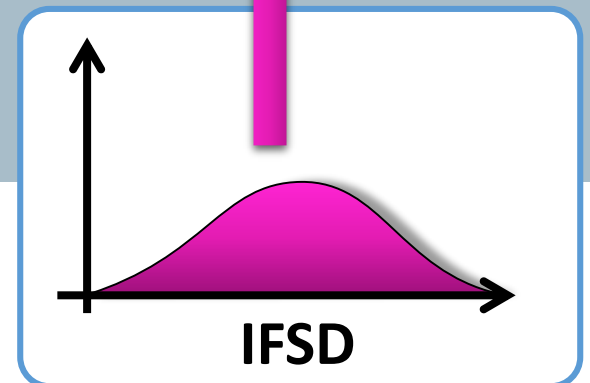
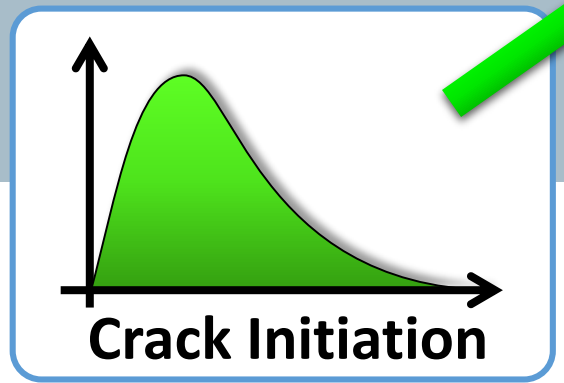
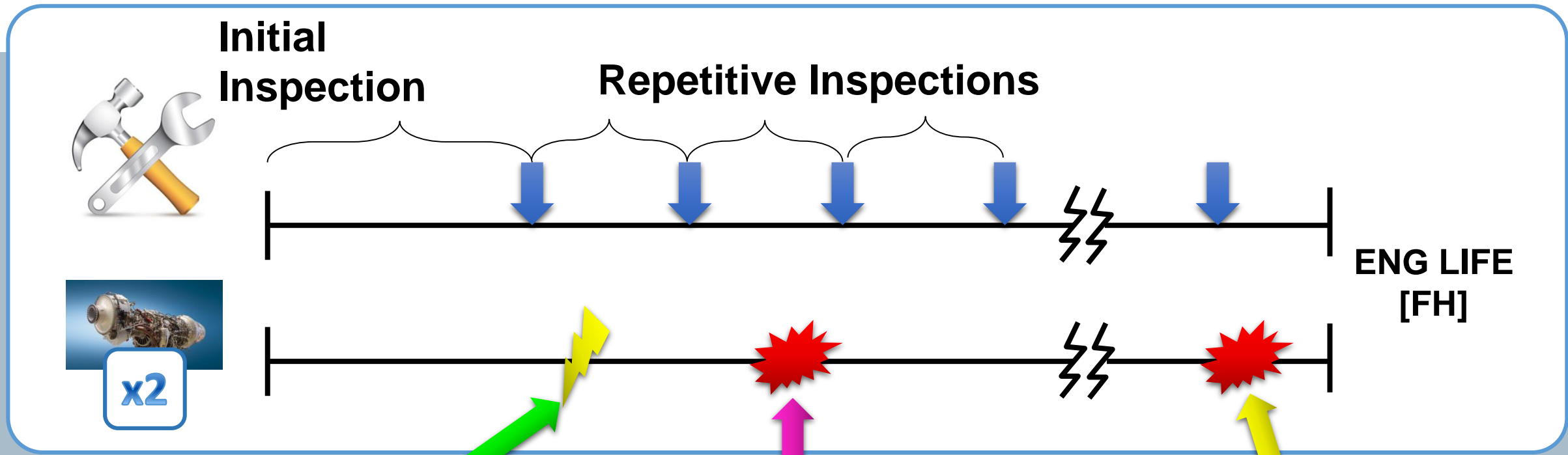
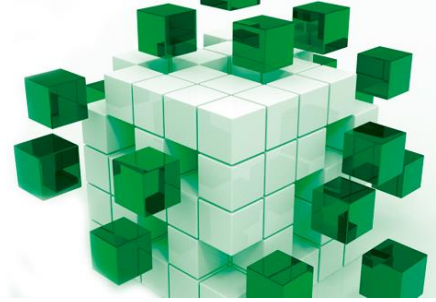
## Quick example: Coin flipping



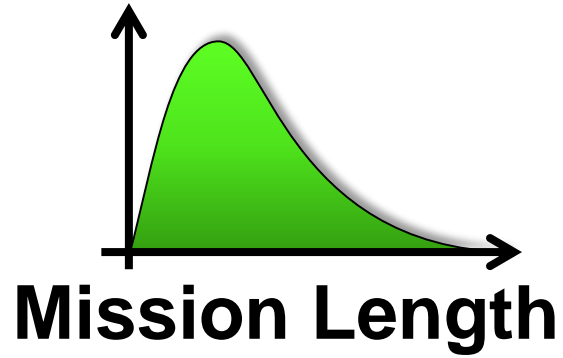
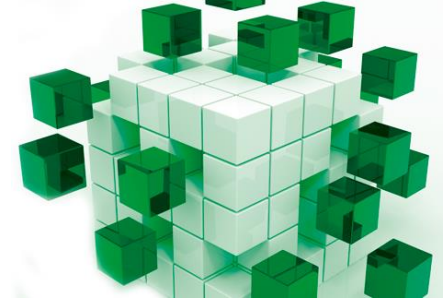
What is the probability of a coin landing on head?



# Monte Carlo Model: Engine Life & Maintenance Tasks Setup

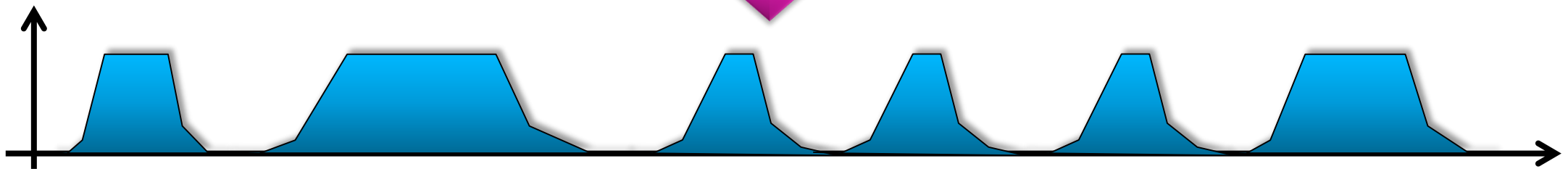
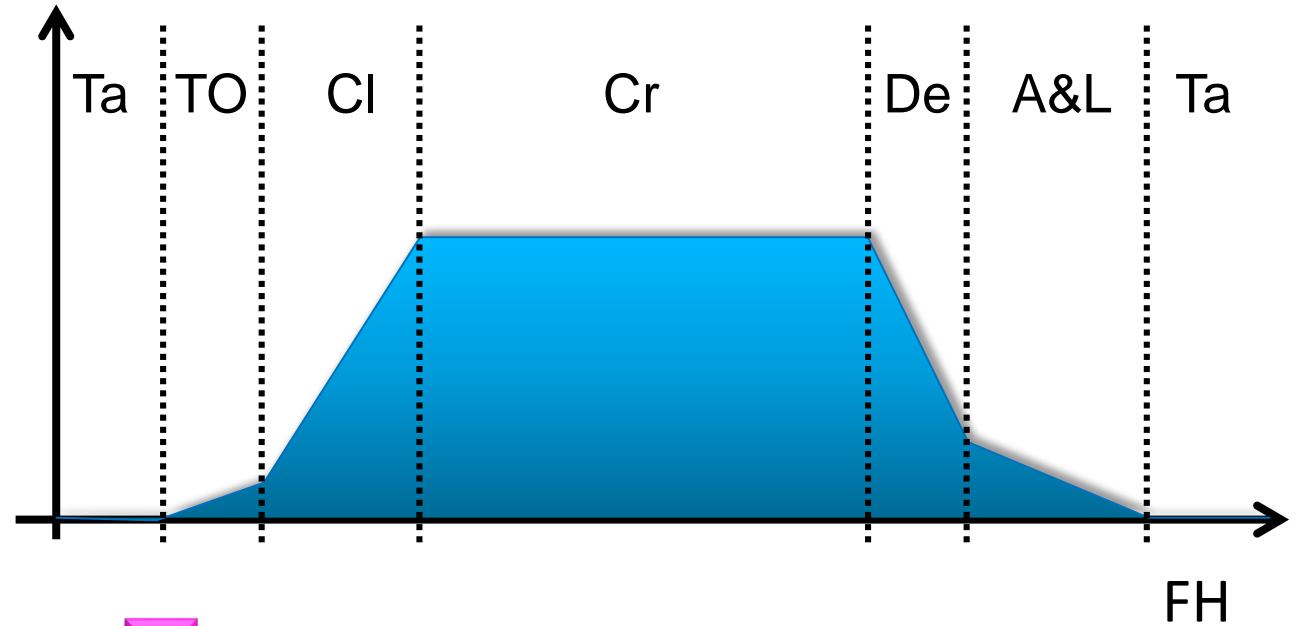


# Monte Carlo Model: Mission Length & Flight Phase Definition

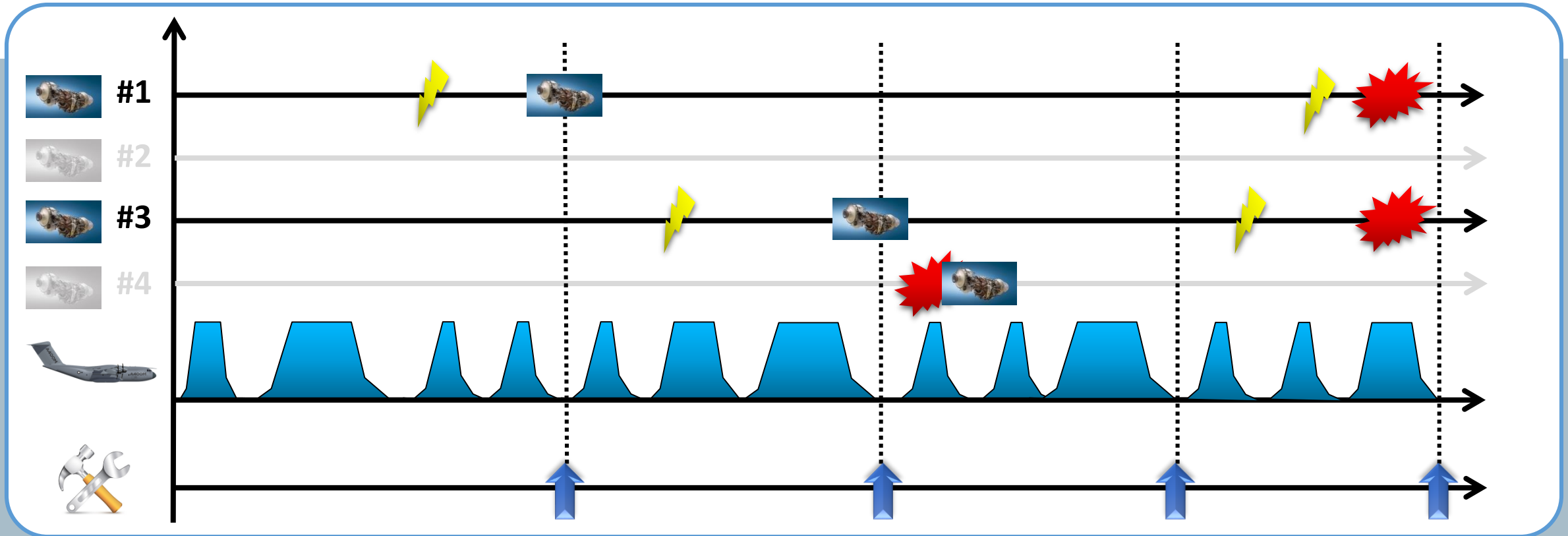
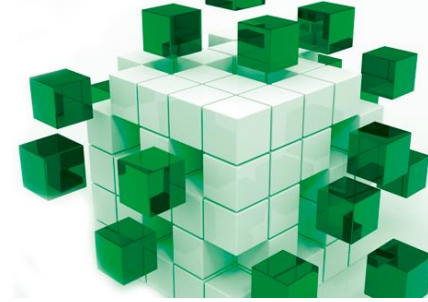


+

Flight phase distribution



# Monte Carlo Model: Evaluation of IFSD and Repercussion



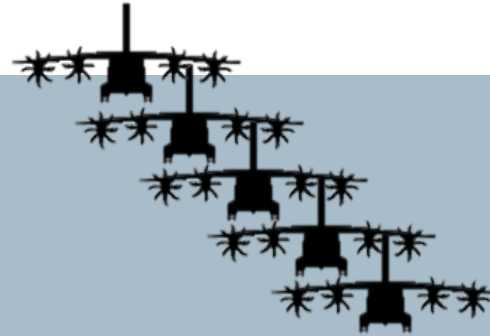
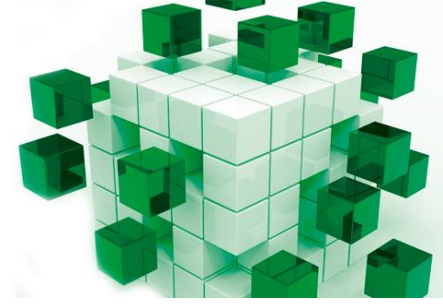
Count of Events

Repercussion



FC Prob / FH

# Monte Carlo Model: Number of Iterations



A/C Life

A/C Fleet

Iterations

$3 \cdot 10^4$  FH

180

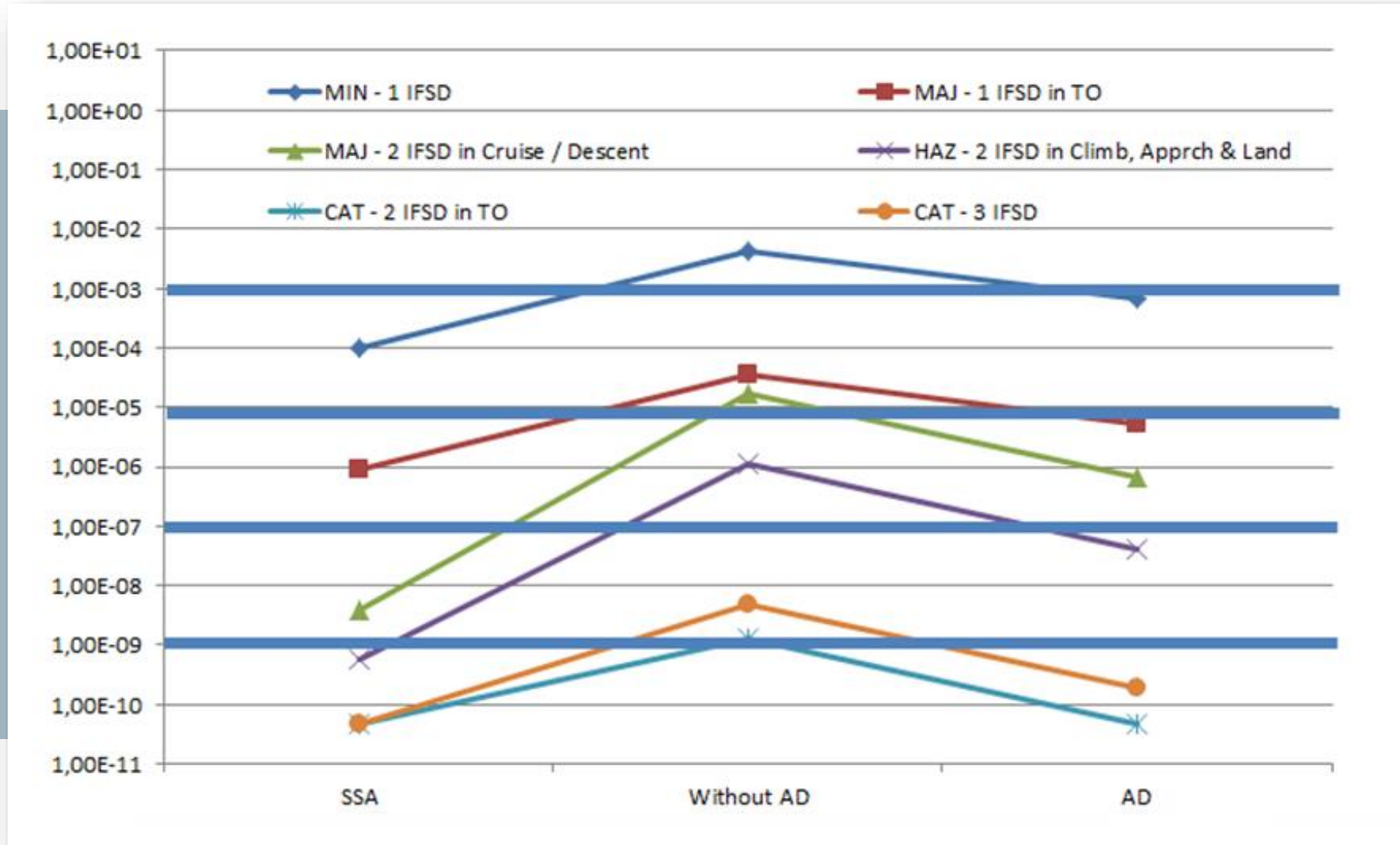
40.000

$5,4 \cdot 10^6$  FH

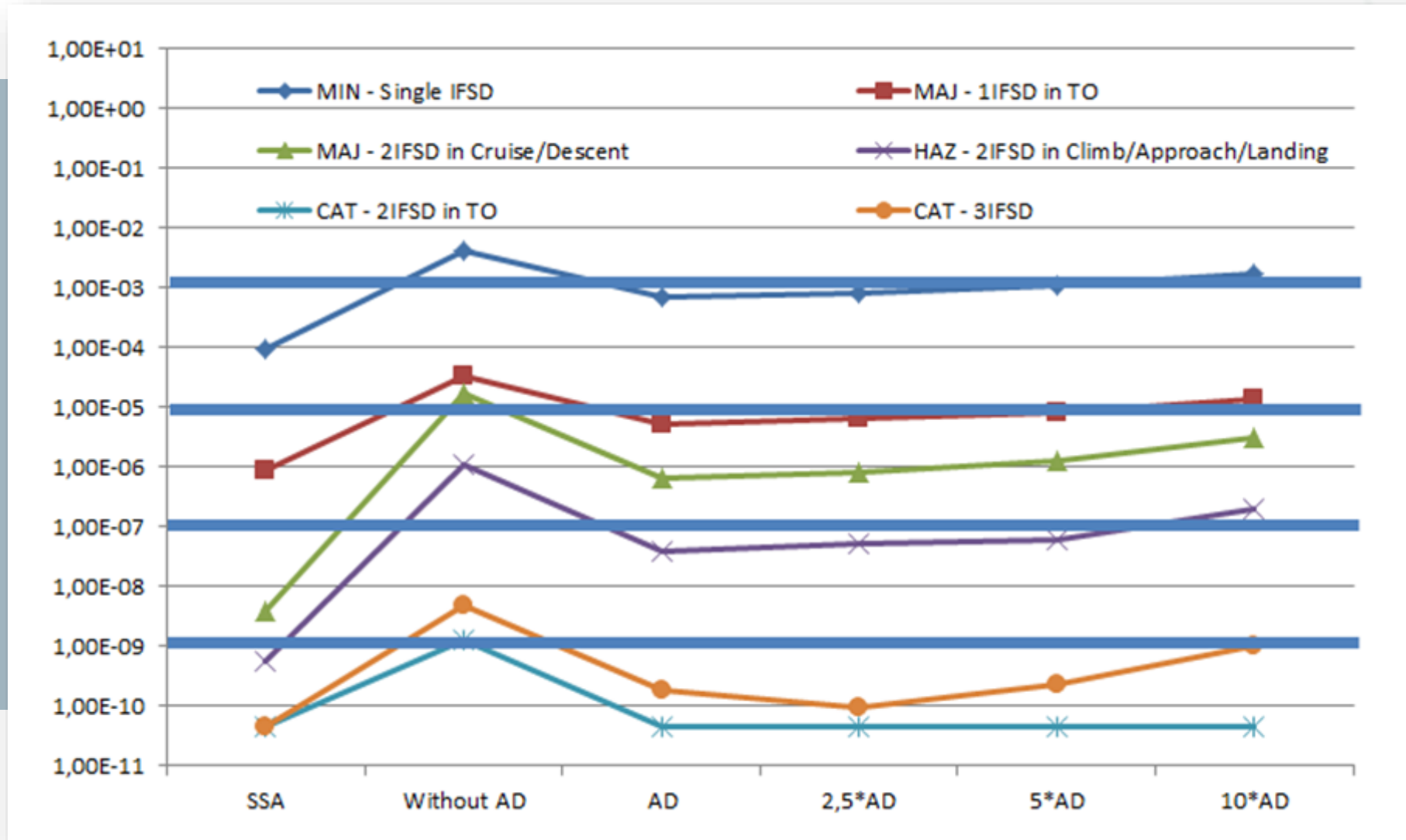
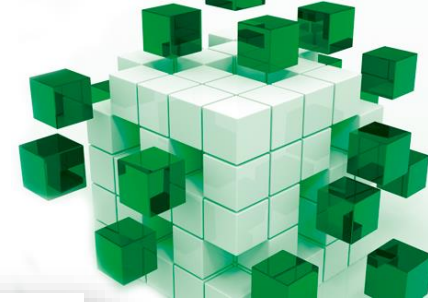
$2,2 \cdot 10^{11}$  FH



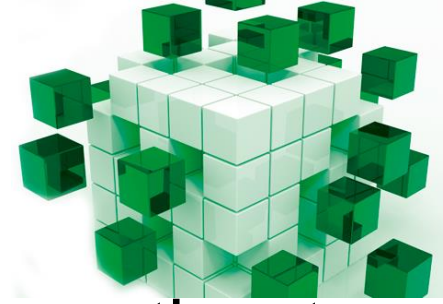
## Monte Carlo Results



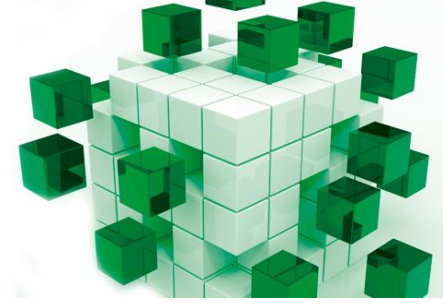
# AD Maintenance Threshold Adjustment



## Summary



- This study presents the Monte Carlo Method as an alternative to evaluate the benefit of the mandatory inspections
  - Monte Carlo Analysis provides approximate solution to a variety of problems which are too complicated to solve analytically
  - It is based on the massive repetition of statistical sampling experiments
- As the output of this study, Monte Carlo Results allowed to set up the basis for the review and optimization of the inspection threshold imposed by the Airworthiness Authorities



**Thank you**