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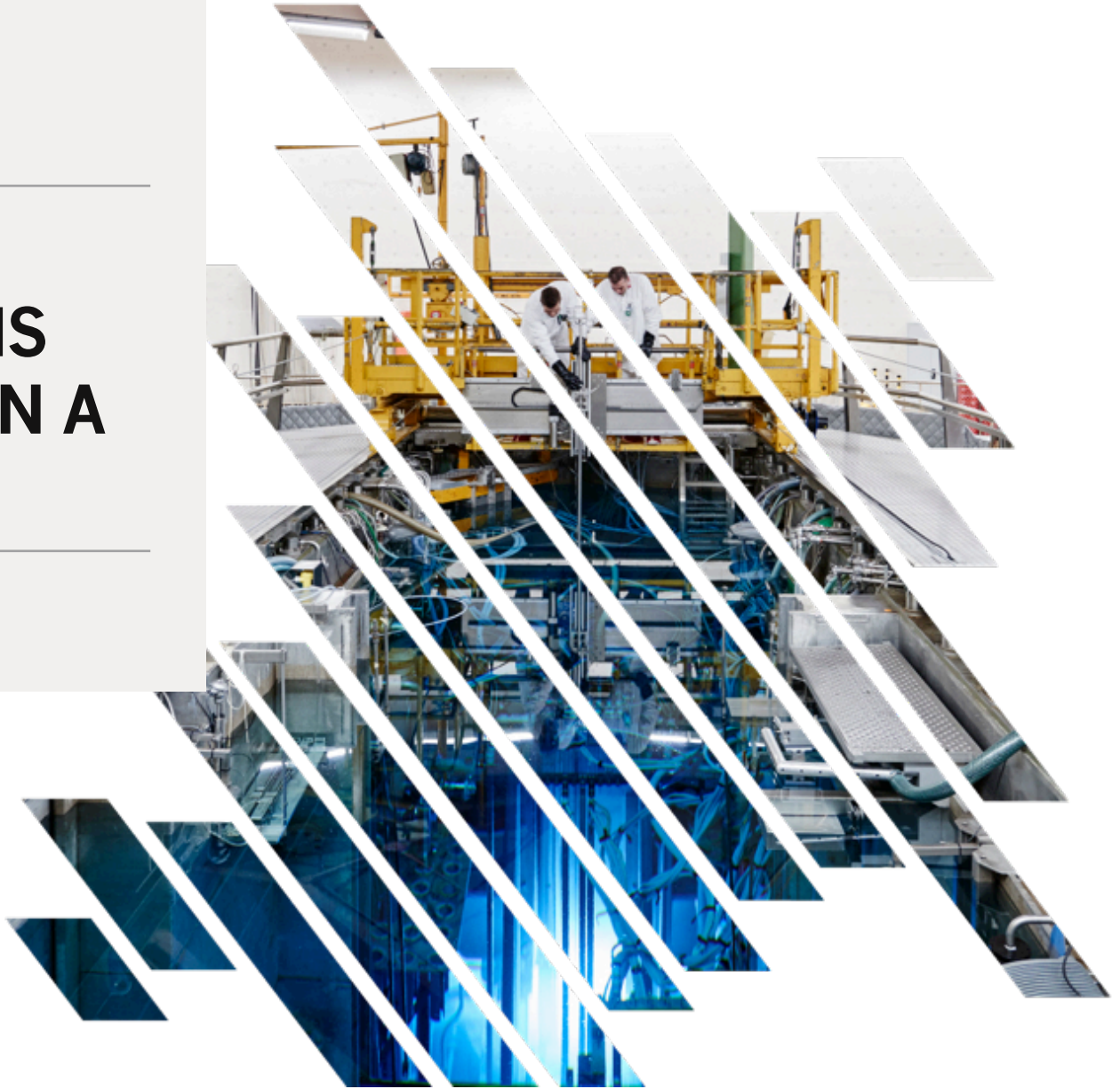
# ASSESSING COMBINATIONS OF HAZARDS IN A PSA

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PSAM14, paper 23

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2018-09-17



# INTRODUCTION

Nuclear Research and consultancy Group

High Flux Reactor (HFR)

- Research
- Medical isotopes

Consultancy & Services

- Team Safety & Reliability

New full scope PSA

- Starting from scratch
- Including combinations of hazards



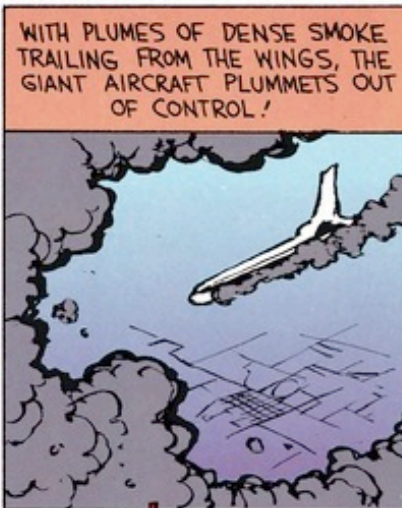
# PROGRAM

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- Introduction
- Combinations of hazards
  - Problem and goal
  - Basic approach
  - Dependent and independent
  - Screening criteria
  - Application
  - Results



AT 35,000 FEET, THE ENGINES OF FLIGHT 430 EXPLODE FOR NO REASON!



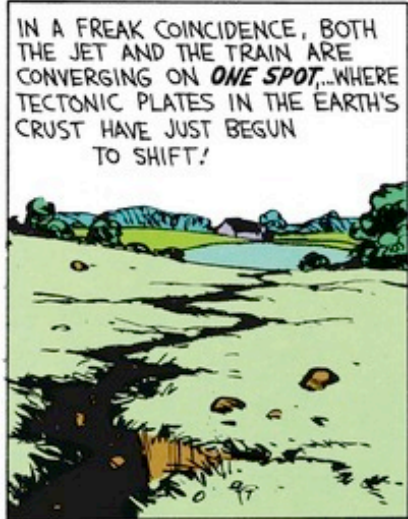
WITH PLUMES OF DENSE SMOKE TRAILING FROM THE WINGS, THE GIANT AIRCRAFT PLUMMETS OUT OF CONTROL!



MEANWHILE, A 50-CAR FREIGHT TRAIN HITS A PENNY ON THE RAIL AT 80 MILES AN HOUR AND JUMPS THE TRACKS, DRAGGING HALF A MILLION TONS OF METAL INTO THE AIR BEHIND IT!

calvin and hobbes

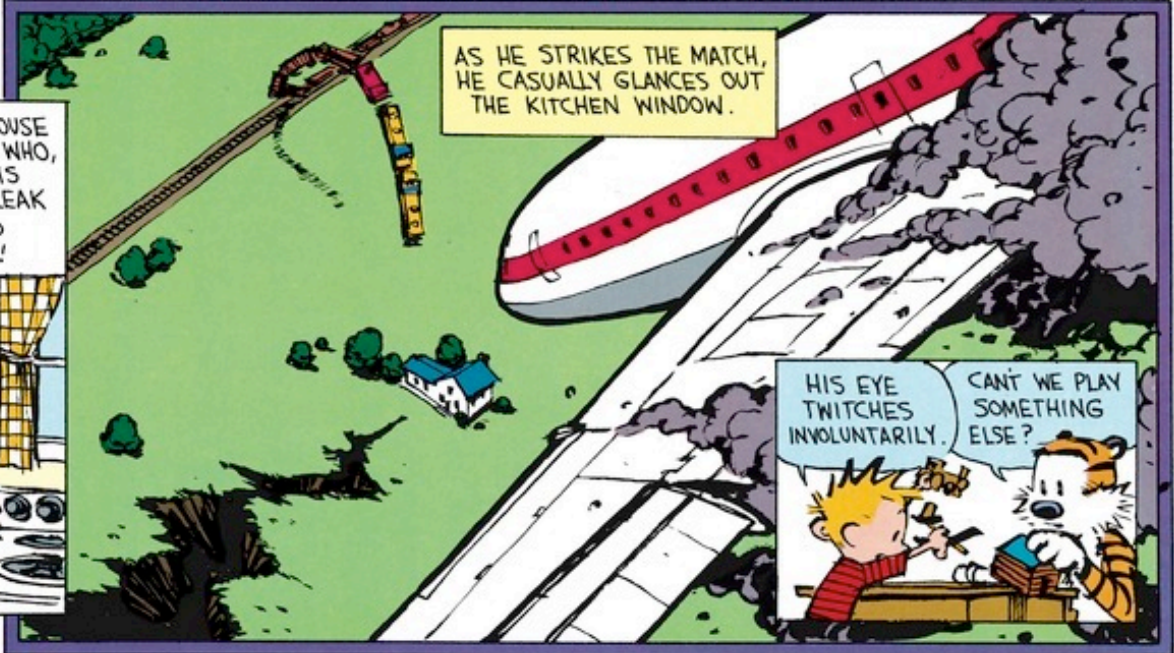
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IN A FREAK COINCIDENCE, BOTH THE JET AND THE TRAIN ARE CONVERGING ON *ONE SPOT*, WHERE TECTONIC PLATES IN THE EARTH'S CRUST HAVE JUST BEGUN TO SHIFT!



THAT SPOT IS THE HOUSE OF FARMER BROWN, WHO, AT THIS MOMENT, IS UNAWARE OF A GAS LEAK AS HE ATTEMPTS TO LIGHT HIS STOVE!



AS HE STRIKES THE MATCH, HE CASUALLY GLANCES OUT THE KITCHEN WINDOW.

HIS EYE TWITCHES INVOLUNTARILY.

CAN'T WE PLAY SOMETHING ELSE?

# PROBLEM AND GOAL

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Guidance on systematic assessment of combinations of hazards is scarce and in general only considers natural (external) hazards

Consideration of ALL combinations of hazards

- Internal and external hazards
- Starting with combinations of 2 hazards

Huge amount of combinations

- Framework
- Efficient and effective screening



# BASIC APPROACH

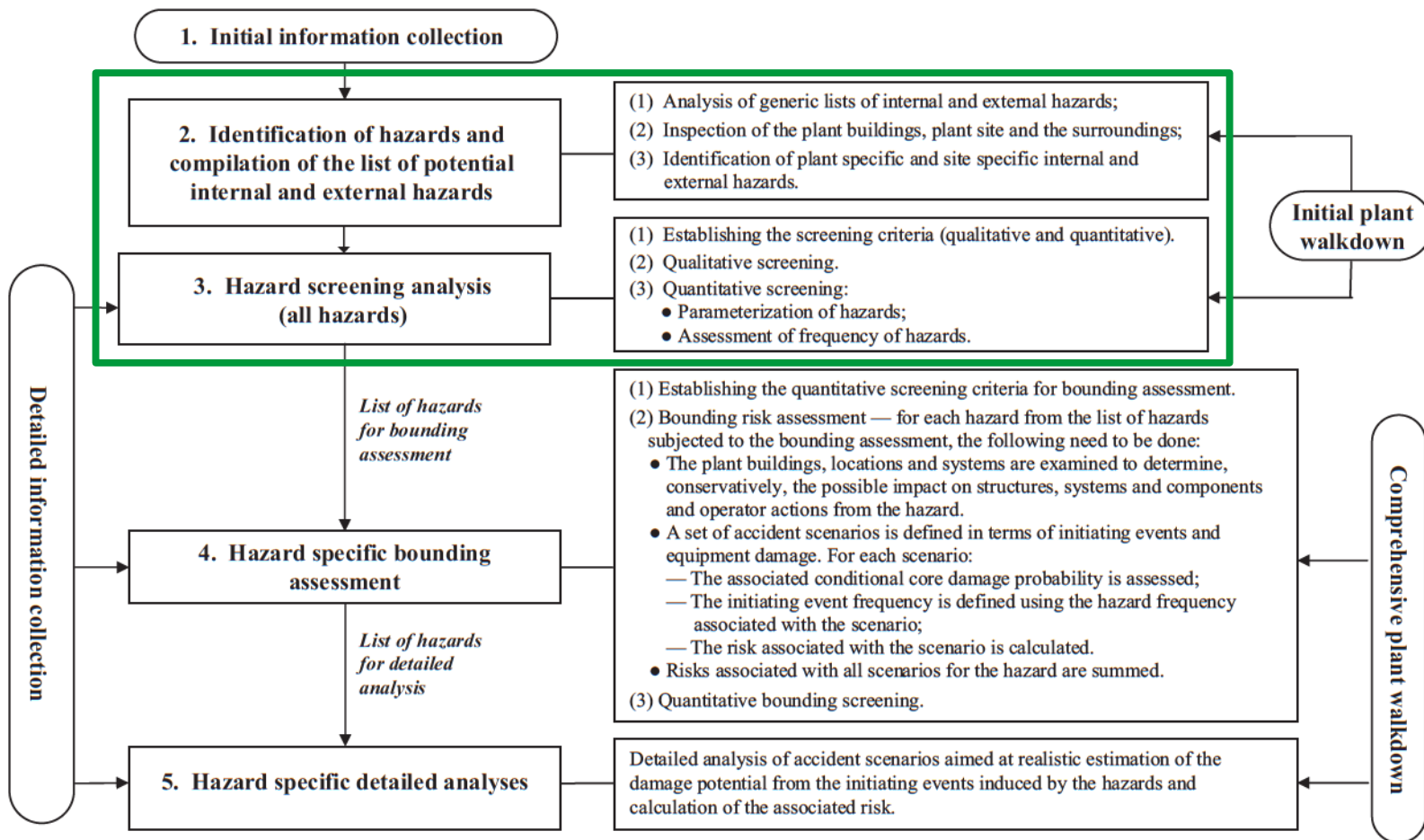


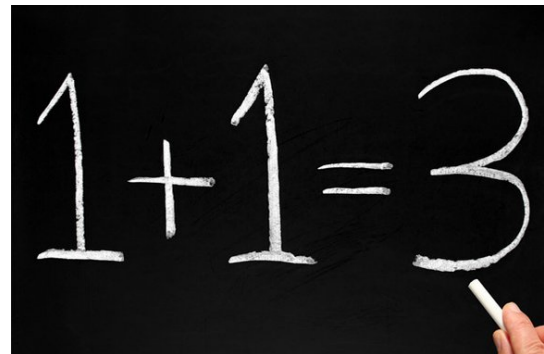
FIG. 2. Overall analysis approach for Level 1 PSA for internal and external hazards.

# IDENTIFICATION

From an analytical point of view, a combination of hazards does not differ significantly from a single hazard

Single hazards screening results can be used partly

- Qualitative screening
  - Keep screened out,
  - except “within design base”
- Quantitative screening
  - Reconsider


$$1 + 1 = 3$$



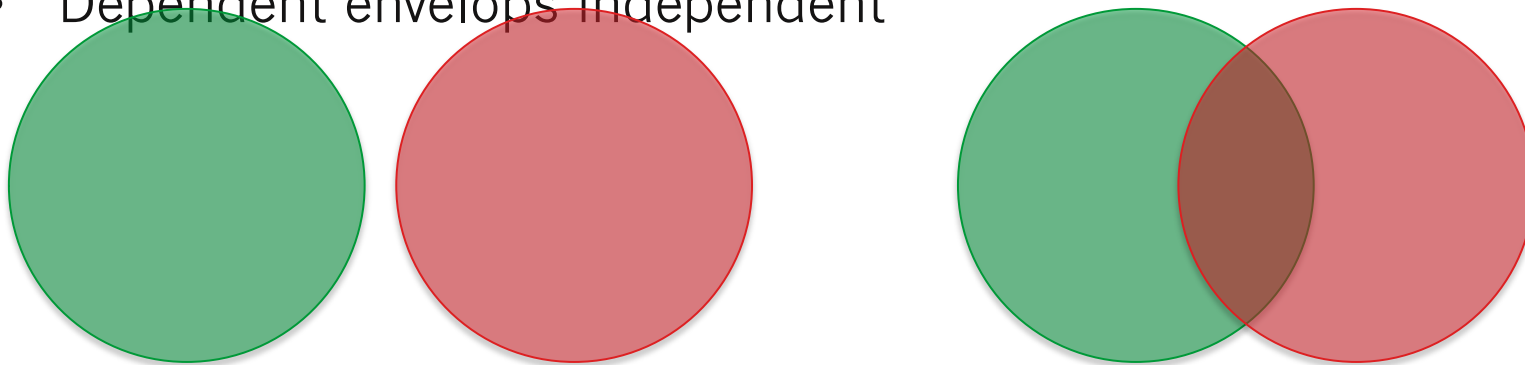
# DEPENDENT & INDEPENDENT

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Assumption: all combinations are both dependent and independent

All dependent combinations also exist as independent combination

- Impact is equal
- Frequency differs
- Dependent envelopes independent





# SCREENING CRITERIA

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Hazard Combination Criteria (HCC) based of SKI report [1]

- **HCC1: Frequency**  
The frequency is lower than screening value;
- **HCC2: Impact**  
The impact on front line systems of the hazard combination is equal to the impact of one of the single hazards in the combination;
- **HCC3: Inclusion**  
The combination is included in the definition or analysis of another event, which is already analyzed for the plant.

[1] M. Knochenhauer and P. Louko, "Guidance for External Events Analysis, SKI Report 02:27," Swedish Nuclear Inspectorate (SKI), February 2003.

# APPLICATION

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## HCC2: **Impact**

The impact on front line systems of the hazard combination is equal to the impact of one of the single hazards in the combination;

- Based on the mitigation path
- Impact on front line systems is not more severe
  - Freq. combination  $\lll$  Freq. individual hazard
  - Individual hazard is enveloping

# APPLICATION

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## HCC2: **Impact**

The impact on front line systems of the hazard combination is equal to the impact of one of the single hazards in the combination;

### **Example:**

Airplane Crash – Direct core damage

Tornado – All buildings except the dome are lost

HCC2 is applicable, no mitigation path with << freq.

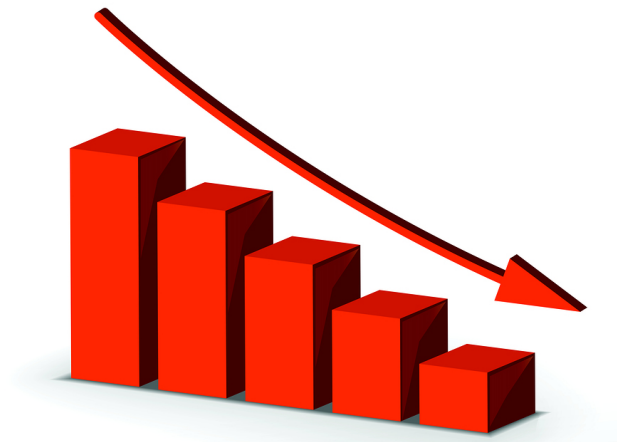
# RESULTS

Evaluation of all combinations

HFR PSA results	Before	After
Internal hazards	6	3
External hazards	61	5
Combinations	4489	64

Method is applicable if single hazard analysis is finished

Effective and efficient: approx. 1 hour per combination



# QUESTIONS

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