

IRSN

INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

APPLICATION OF THE HORAAM METHOD FOR THE UPDATING OF THE IRSN LEVEL 2 PSA MODEL

HONG KONG - PSAM 9

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Système de management
de la qualité IRSN certifié

HORAAM : HUMAN AND ORGANIZATIONAL RELIABILITY ANALYSIS IN ACCIDENT MANAGEMENT

- HORAAM METHOD: IRSN HRA MODEL USED TO MODEL HUMAN ACTIONS OF THE LEVEL 2 PSAs
- METHOD WAS ALREADY PRESENTED AT THE PSA 99 CONGRESS
- TODAY PRESENTATION
 - ✓ FIRSTLY - REMINDER OF THE MAIN FEATURES OF THE METHOD
 - ✓ SECONDLY - AN APPLICATION: THE CONTAINMENT SPRAY SYSTEM (CSS) MANAGEMENT

HORAAM : HUMAN AND ORGANIZATIONAL RELIABILITY ANALYSIS IN ACCIDENT MANAGEMENT

- WHY A SPECIFIC MODEL FOR LEVEL 2 PSAs ?
- AFTER THE BEGINNING OF CORE DAMAGE
- SITUATION UNCONTROLLED BY OPERATORS
- ABORT OF EOPs TO ENTER THE SEVERE ACCIDENT MANAGEMENT GUIDE (SAMG)
- GOAL: NO LONGER TO PREVENT CORE DAMAGE
- : TO LIMIT RADIOLOGICAL RELEASE OUTSIDE THE CONTAINMENT
- : TO ENABLE THE PUBLIC AUTHORITIES TO TAKE OFFSITE MEASURES

HORAAM : HUMAN AND ORGANIZATIONAL RELIABILITY ANALYSIS IN ACCIDENT MANAGEMENT

- WHY A DECISION TREE STRUCTURE ?
- HOPEFULLY EXPERIENCE FEEDBACK FROM SEVERE ACCIDENTS IS RARE
- CHOICE OF THE DEVELOPERS : DECISION TREE APPROACH
 - ABILITY TO ESTIMATE HEPs FOR UNKNOWN SITUATIONS [the severe accident area]
 - BASED ON KNOWN SITUATIONS [simulator experiments, actual plant data, expert judgment]
- 7 INFLUENCE FACTORS WERE SELECTED
 - THE DECISION TIME
 - THE DECISION DIFFICULTY
 - THE DEGREE OF INVOLVEMENT OF THE CRISIS ORGANIZATION
 - THE INFORMATION AND MEASURE MEANS
 - THE DIFFICULTY FOR OPERATORS
 - THE DIFFICULTY INDUCED BY ENVIRONMENTAL CONDITIONS
 - THE SCENARIO DIFFICULTY

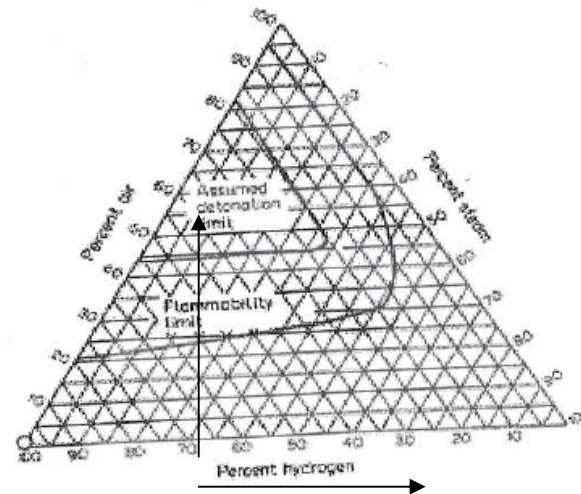
EXAMPLE OF APPLICATION OF THE HORAAM MODEL

- **EXAMPLE: THE CONTAINMENT SPRAY SYSTEM MANAGEMENT (CSS) IN THE SEVERE ACCIDENT MANAGEMENT GUIDE (SAMG)**
- **FUNCTION OF THE CSS: TO REDUCE RADIOLOGICAL RELEASE OUTSIDE THE CONTAINMENT**
- **ACTIONS OF 2 TYPES:**
 - **IMMEDIATE IMPLEMENTATION OF THE CSS WHEN THE OPERATORS ENTER THE SAMG**
 - **LATER, DELAYED IMPLEMENTATION OF THE CSS POSSIBLE 6 HOURS AFTER CORE DAMAGE**

EXAMPLE OF APPLICATION OF THE HORAAM MODEL

■ WHY IS THE CSS IMPLEMENTATION POSSIBLE AFTER 6H ?

- ✓ BEGINNING OF CORE MELTING: IMPORTANT QUANTITY OF H₂ IS PRODUCED BECAUSE OF THE ZIRCONIUM CLADDING OXIDATION



- ✓ RAPIDLY: RISK OF H₂ BURNING INSIDE THE CONTAINMENT (early leak of containment) - THE CSS MAY CONDENSE THE STEAM
- ✓ TO AVOID THE RISK: 6H ARE NECESSARY FOR PASSIVE RECOMBINEURS ACTIONS

EXAMPLE OF APPLICATION OF THE HORAAM MODEL

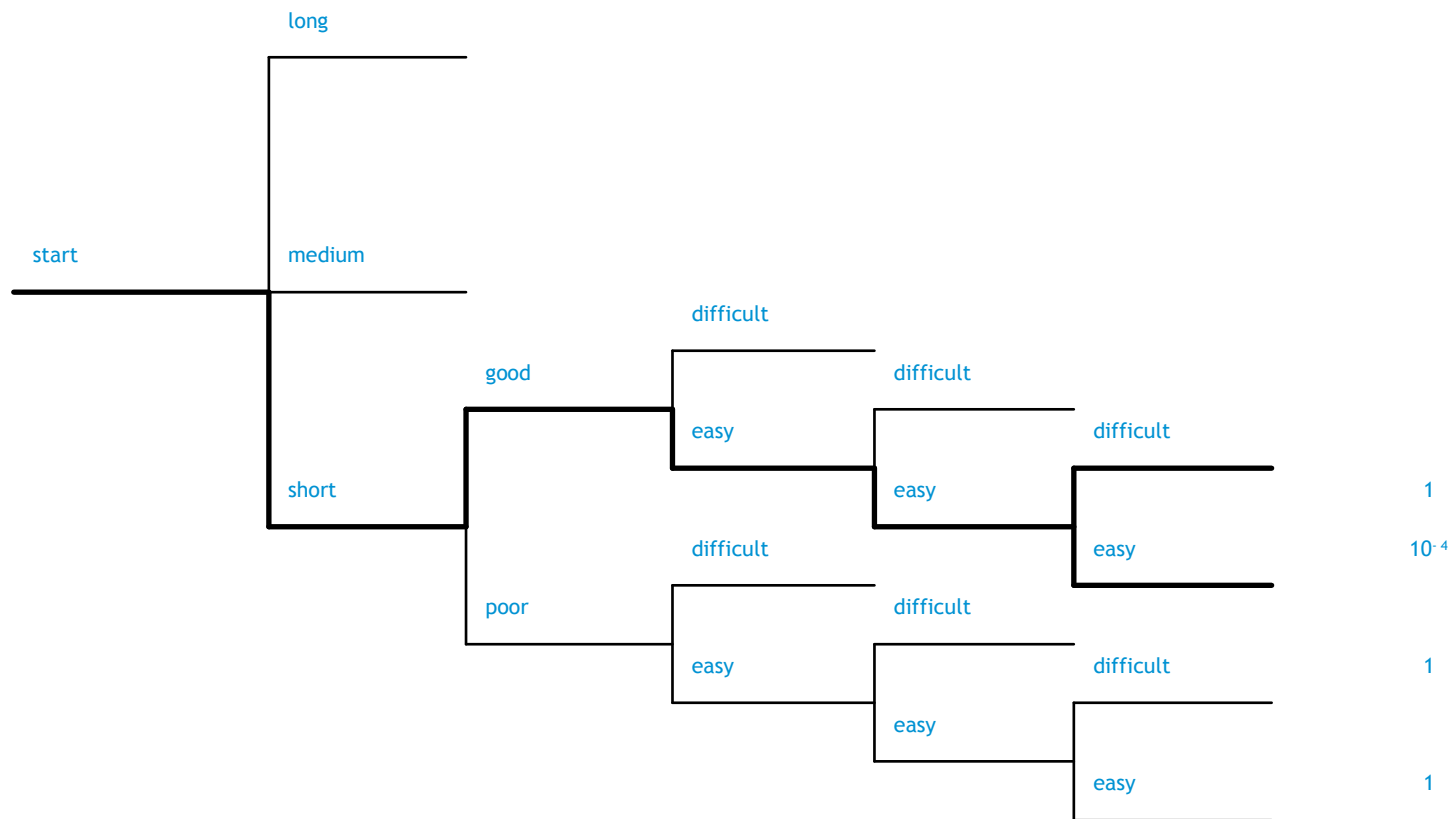
- MODELIZATION OF IMMEDIATE ACTION
- 7 INFLUENCE FACTORS
 - THE DEGREE OF INVOLVEMENT OF THE CRISIS ORGANIZATION
 - IF not applicable for immediate action
 - availability of the crisis organization not necessary
 - THE DECISION TIME
 - IF : short
 - immediate action have to be performed quickly
 - INFORMATION AND MEASURE MEANS
 - IF : good
 - Slightly degraded information can't disturb operators

EXAMPLE OF APPLICATION OF THE HORAAM MODEL

- **DECISION DIFFICULTY**
 - **IF : easy**
 - **decision easy : operators are trained to execute immediate action when core melt down criteria are reached**
- **DIFFICULTY FOR OPERATORS**
 - **IF : easy**
 - **Well known by the operators**
- **DIFFICULTY INDUCED BY ENVIRONMENTAL CONDITIONS**
 - **IF not applicable for immediate action**
 - **Activation of the CSS done from the main control room**
- **SCENARIO DIFFICULTY**
 - **IF not specific for this action but depends on entry data**
 - **Particularly degraded situations such as very fast transients are considered to increase HEPs**

EXAMPLE OF APPLICATION OF THE HORAAM MODEL

Human Intervention	Decision time	Info/ measures	Decision difficulty	Operator difficulty	Scenario difficulty	HEP
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EXAMPLE OF APPLICATION OF THE HORAAM MODEL

- **INTENTIONALLY: VERY SIMPLE EXAMPLE (IMMEDIATE IMPLEMENTATION OF THE CSS)**
- **HEPs OUTCOME: 1 OR 10^{-4}**
- **IN THE MODEL: A COMBINATION OF SEVERAL UNFAVORABLE MODALITIES RAPIDLY LEADS TO A FAILURE PROBABILITY OF 1**
- **ON THE OPPOSITE A COMBINATION OF FAVORABLE MODALITIES LEADS TO 10^{-4}**
- **MIXED COMBINATIONS OF FAVORABLE AND UNFAVORABLE MODALITIES LEADS TO PROBABILITIES OF 10^{-1} OR 10^{-2} (THE CASE OF DELAYED ACTIONS)**
- **DIFFERENCES OBSERVED IN THE CASE OF DELAYED IMPLEMENTATION OF THE CSS**
 - **DECISION TIME : IF OPERATORS CANNOT START THE CSS IMMEDIATELY, THEY HAVE TO WAIT 6 H → MODALITY “ MEDIUM “**
 - **DECISION DIFFICULTY : THERE IS A RISK (IMPLEMENTATION FORBIDDEN FOR 6 H) → MORE DIFFICULT TO DECIDE TO OPERATE THE CSS**

CONCLUSION

- HORAAM HAS BEEN EMPLOYED TWICE AT THE IRSN
- FIRST TIME: SAMG WAS SIMPLE [JUST CONSIDERING IF A COMPONENT WAS AVAILABLE OR NOT TO ASK FOR ITS ACTUATION]
- SECOND TIME: THE CURRENT VERSION OF THE SAMG (MORE COMPLICATED)
 - EXPERTISE OF THE CRISIS ORGANIZATION WERE ADDED: CRITERIA AND PHYSICAL CONDITIONS ARE CONSIDERED BEFORE SYSTEM ACTUATION
 - PRODUCES HEPs FOR THE ACCIDENT PROGRAM EVENT TREE (APET) OF THE IRSN LEVEL 2 PSA MODEL (PRESENTED AT PSAM 9 BY MARC VILLERMAIN)
- THE STRONG POINTS OF HORAAM MODEL
 - A LIMITED NUMBER OF INFLUENCE FACTORS
 - INFLUENCE FACTORS EASY TO QUANTIFY (ONLY 2 OR 3 MODALITIES)
 - THE EVENT TREE STRUCTURE GUARANTEES THE TRACEABILITY OF THE ANALYSES