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HAZARD ASSESSMENT OF MAJOR ACCIDENTS TRIGGERED BY INTENTIONAL ACTS OF INTERFERENCE

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INTRODUCTION (1)

An increasing attention of the risk analysts in the last years was devoted to the evaluation of the risk brought by external sources, as natural events (floodings, earthquakes) or intentional acts of interference, in sites where relevant quantities of dangerous substances are handled or stored

SVAs
PROCEDURES
(API-NPRA,
SFK)

- SECURITY
- LIKENESS of the
ATTACK

SCARCE ATTENTION on
CONSEQUENCES



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From literature analysis the need of a **NEW METHOD** arises, able to estimate the **CONSEQUENCES** of an attack to a process plant

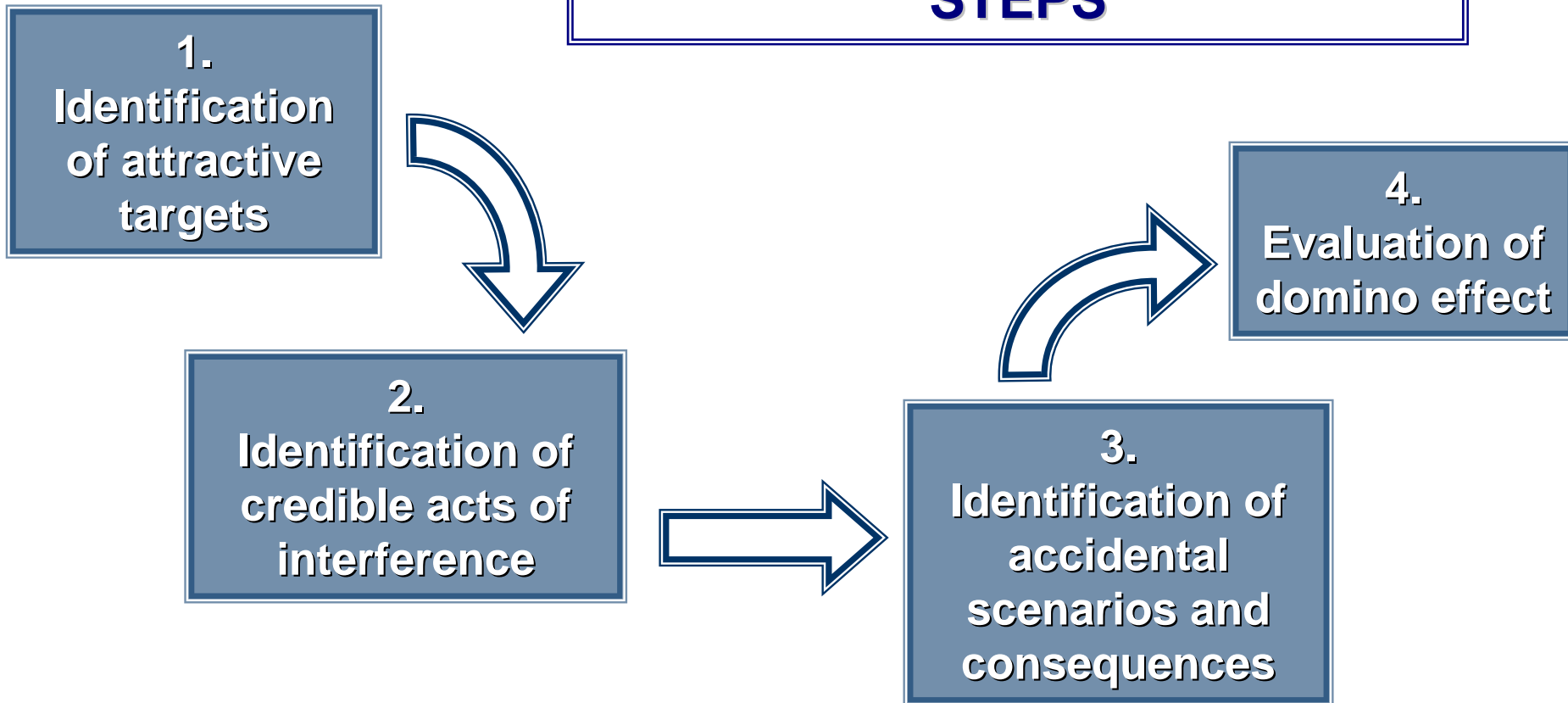
**EMERGENCY
PLANNING**

**RESOURCES
MANAGEMENT**

**SCREENING of
an
INDUSTRIAL
SITE**



CONSEQUENCES ASSESSMENT STEPS



| TYPE OF INTERFERENCE | REQUIRED LEVEL OF INFORMATION | EXPECTED RELEASE RATE (ATMOSP. EQ.) | EXPECTED RELEASE RATE (PRESSUR. EQ.) |
|------------------------------|-------------------------------|-------------------------------------|--------------------------------------|
| DELIBERATE MISOPERATION | C | R2 | R1 |
| INTERFERENCE BY SIMPLE MEANS | C | R2 | R1 |
| INTERFERENCE BY MAJOR AIDS | C | R3 | R2 |
| ARSON BY SIMPLE MEANS | C | R3 | R2 |
| ARSON BY INCENDIARY DEVICES | B | R4 | R3 |
| SHOOTING (MINOR) | A | R1 | R1 |
| SHOOTING (MAJOR) | A | R4 | R4 |
| EXPLOSIVES | B | R4 | R4 |
| VEHICLE IMPACT | B | R3 | R3 |
| PLANE IMPACT | A | R4 | R4 |

1. IDENTIFICATION OF ATTRACTIVE TARGETS (1)

THE MOST SEVERE POSSIBLE CONSEQUENCES are aimed to be achieved by the executors of the attack

ATTRACTIVENESS
(likeness of the attack)



DAMAGE DISTANCES

- TYPE OF HAZARD
(flammable, toxic or both)
- PHYSICAL CONDITIONS
(post-release behaviour: adiabatic expansion, pool vaporization, etc.)
- AMOUNT OF SUBSTANCE IN THE UNIT (hold up: devices having the same volumes may contain different quantities of hazardous material)

ATTRACTIVENESS RANKING
from 1 to 4



1. IDENTIFICATION OF ATTRACTIVE TARGETS (2)

ATTRACTIVENESS RANKING TABLE

| | LIQUEFIED GAS STORED UNDER PRESSURE | FLUIDS WITH LOW VAPOR PRESSURE STORED IN LIQUID PHASE | GAS | CRYOGENIC STORAGE | LIQUID |
|----------------------------|-------------------------------------|---|-----|-------------------|--------|
| TANKS | 4 | 3 | 3 | 2 | 1 |
| LARGE DIAMETER PIPELINES | 4 | 3 | 2 | 2 | 1 |
| COLUMN-TYPE EQUIPMENTS | 3 | 2 | 2 | 2 | 1 |
| REACTORS / HEAT EXCHANGERS | 3 | 2 | 1 | 1 | 1 |



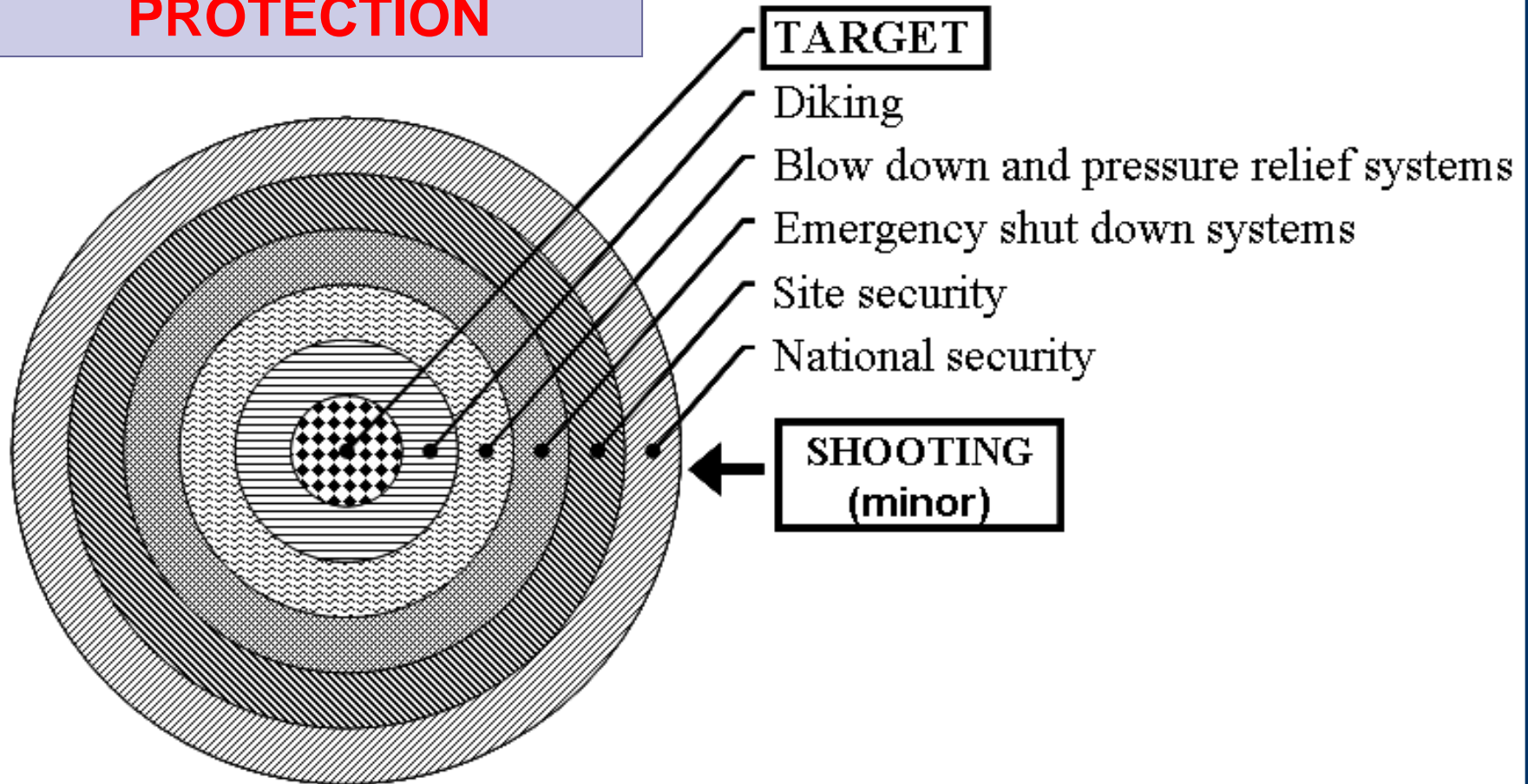
2. IDENTIFICATION of CREDIBLE ACTS OF

| ACT of INTERFERENCE | DAMAGE VECTOR | VULNERABILITY MODELS |
|--|-----------------|--|
| Deliberate Misoperation, Interference using Simple or Major Aids | EXTERNAL ACTION | Availability on demand for protection and mitigation systems |
| Arson using Simple or Incendiary Devices | RADIATION | Equipment vulnerability models and reliability models |
| Shooting (1) o (2) | MISSILES IMPACT | Equipment vulnerability models and reliability models |
| Explosives | OVERPRESSURE | Equipment vulnerability models and reliability models |
| Vehicle or Plane Accident | VEHICLE IMPACT | Equipment vulnerability models |



2. IDENTIFICATION of CREDIBLE ACTS OF INTERFERENCE (2)

SCHEMATIZATION OF the LAYERS of PROTECTION



3. IDENTIFICATION OF ACCIDENTAL SCENARIOS AND CONSEQUENCES EVALUATION

From the previous phases
RELEASE RATES for each ACT OF INTERFERENCE can be obtained

TRADITIONAL SAFETY ANALYSIS METHODS
may be used to assess the consequences of loss of containment

ACCIDENTAL SCENARIOS



CONVENTIONAL EVENT TREES may be used

SPECIFIC ACTS OF INTERFERENCE
(Arson or Explosives) may affect the probabilities of the scenarios, since **IGNITION** is largely more probable than in usual conditions



4. EVALUATION of DOMINO EFFECT

PROVEN CORRELATIONS
for the **EVALUATION OF**
PHYSICAL EFFECTS
(Yellow Book ones)

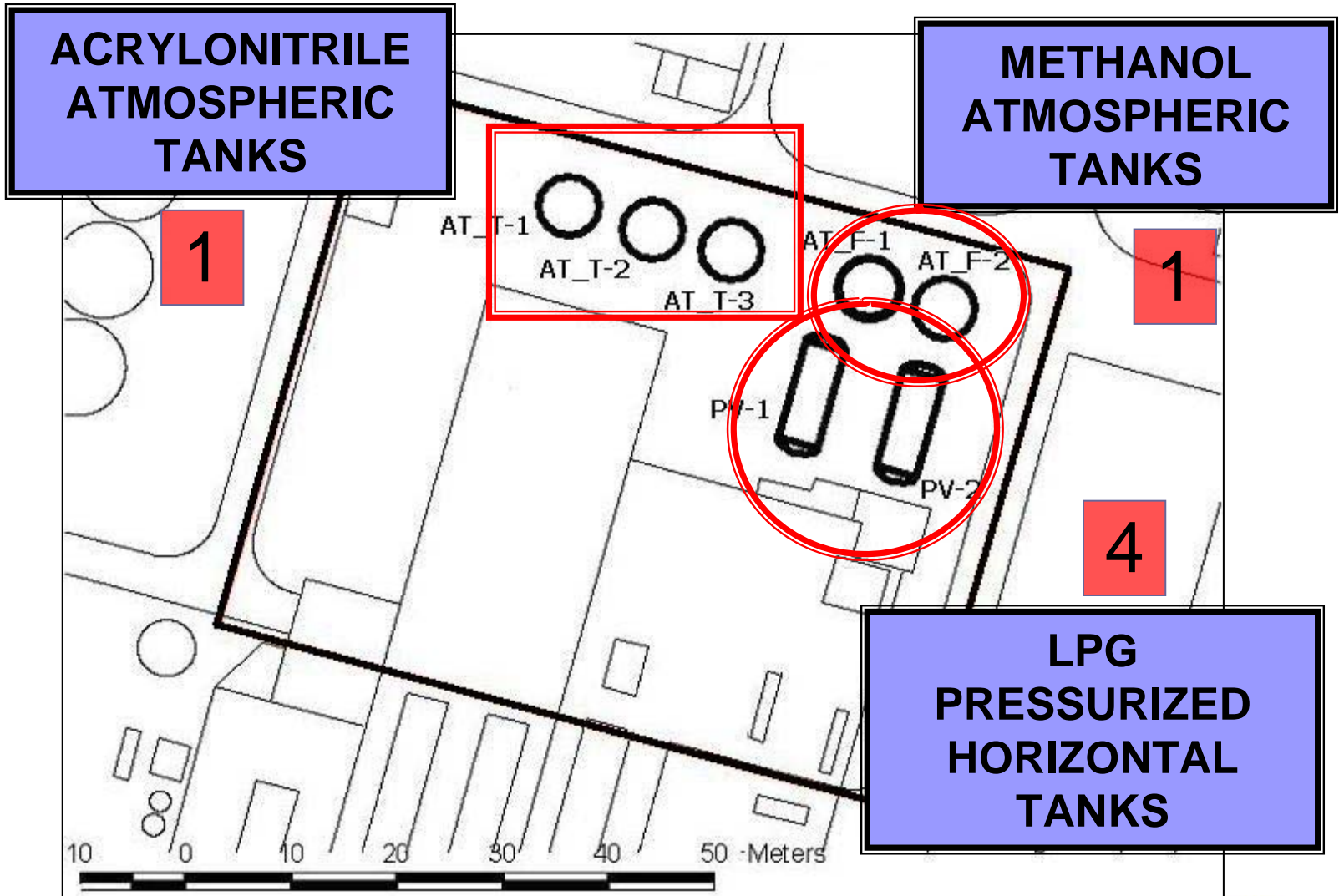
PHYSICAL EFFECTS on
PEOPLE
(proper thresholds provided
by Seveso III)

PHYSICAL EFFECTS on
DEVICES

External attacks may trigger
ESCALATION EVENTS
Conventional escalation
thresholds (defined by literature)
may be successfully used



CASE STUDY



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| ACT of INTERFERENCE | ITEM | SCENARIO | RATE of RELEASE | DAMAGE DISTANCE (m) |
|--------------------------------|------------|------------------|-----------------|---------------------|
| DELIBERATE MISOPERATION | PV-1/2 | VCE | R2 | 354 |
| INTERFERENCE USING SIMPLE AIDS | PV-1/2 | VCE | R2 | 354 |
| INTERFERENCE USING MAJOR AIDS | PV-1/2 | VCE | R2 | 354 |
| ARSON USING SIMPLE MEANS | PV-1/2 | Jet fire | R2 (PSV) | 183 |
| ARSON USING INCENDIARY DEVICES | PV-1/2 | Jet fire | R2 (PSV) | 183 |
| SHOOTING (MINOR) | AT_T-1/2/3 | Toxic Dispersion | R1 | 118 |
| SHOOTING (MAJOR) | PV-1/2 | Jet fire | R3 | 249 |
| EXPLOSIVES | PV-1/2 | VCE | R4 | 2318 |
| VEHICLE IMPACT | (Unlikely) | ---- | ---- | ---- |
| PLANE IMPACT | PV-1/2 | VCE | R4 | 2318 |

CONCLUSIONS

- ✓ A method to evaluate consequences of an external attack was developed
- ✓ Expected release rates, likelihood of the success of the attack and impact distances (also considering domino effect) may be estimated
- ✓ A ranking of the “attractiveness” of the equipment may be performed



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**THANK YOU FOR YOUR
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