Risque Industriel-Effet Domino

de l'aléa à la résilience

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cnrs

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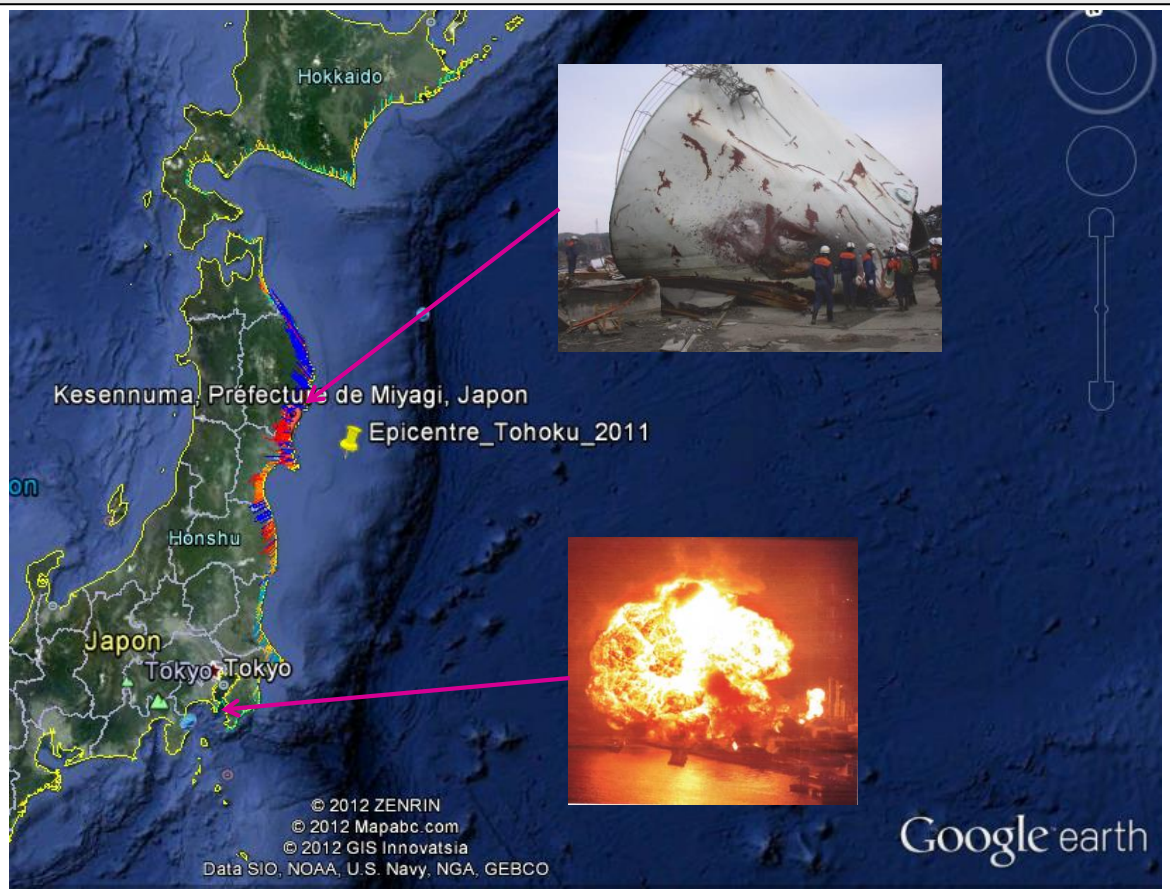
PARTIE #1

Cadre = Réduction Risque de Désastre



Images prises de : Google Earth et Nishi (2012)

Sendai Framework for Disaster Risk Reduction 2015-2030

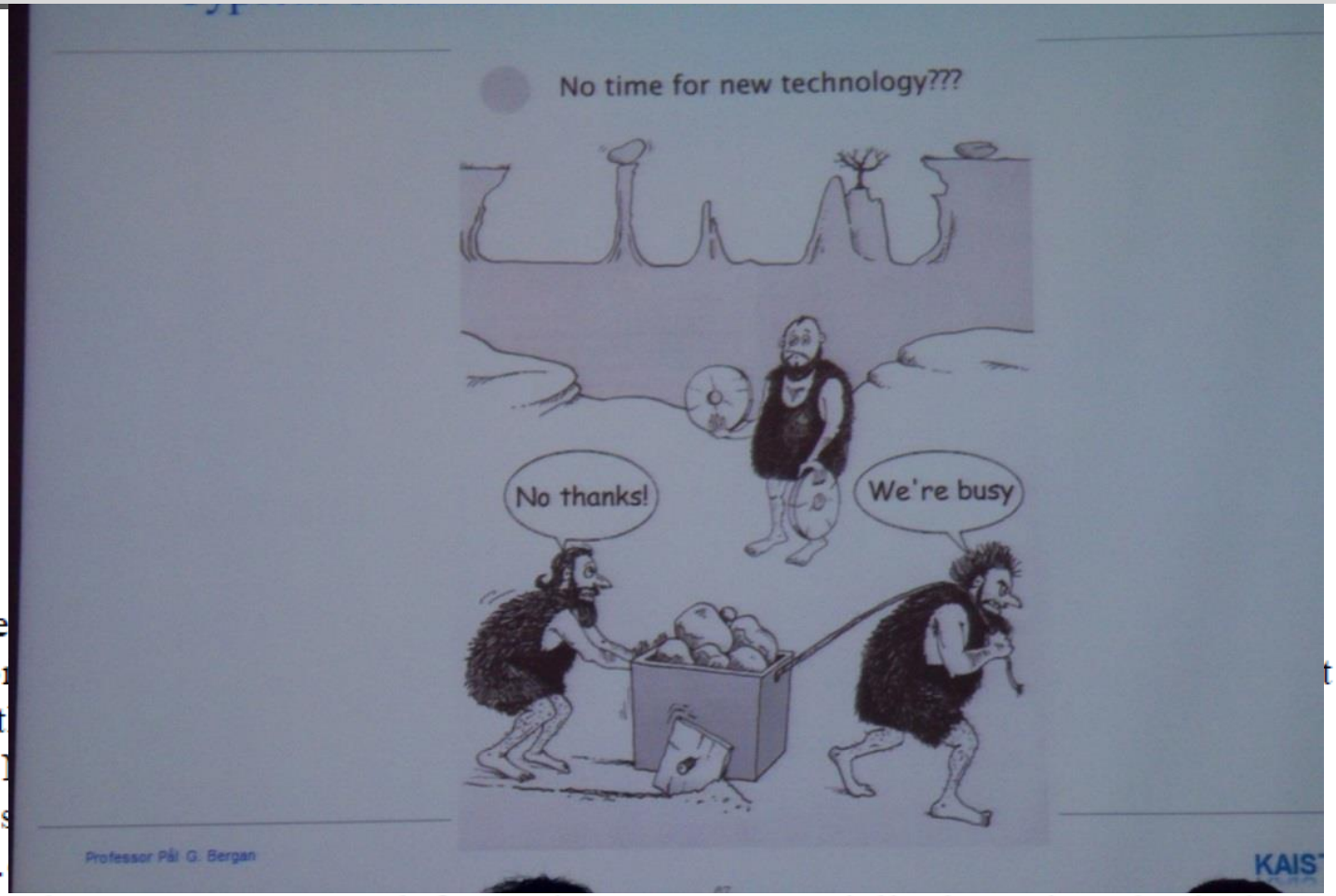
IV. Priorities for action

20. Taking into account the experience gained through the implementation of the Hyogo Framework for Action, and in pursuance of the expected outcome and goal, there is a need for focused action within and across sectors by States at local, national, regional and global levels in the following four priority areas:

1. Understanding disaster risk;
2. Strengthening disaster risk governance to manage disaster risk;
3. Investing in disaster risk reduction for resilience;
4. Enhancing disaster preparedness for effective response, and to "Build Back Better" in recovery, rehabilitation and reconstruction.

Ingénierie: *Mesurer / Gérer*

Aléas & Résilience ➔ Risques industriels



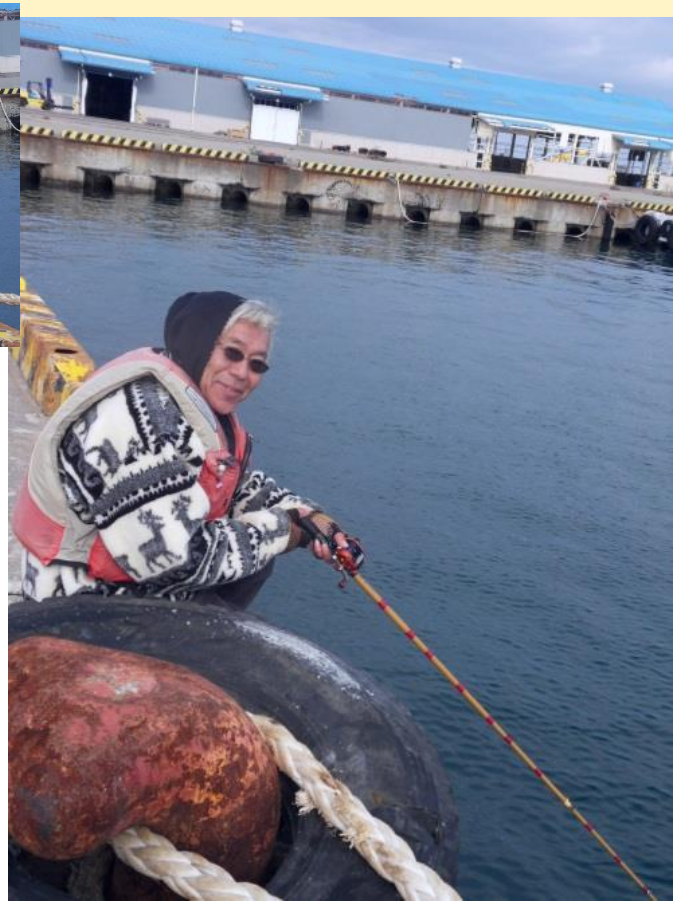
2 Resilience is define
resist, absorb, acco
manner, including t
functions", United
Terminology on Dis
(http://www.unisdr.

3 Hazard is defined in the Hyogo Framework for Action as: "A potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. Hazards can include latent conditions that may represent future threats and can have different origins: natural (geological, hydrometeorological and biological) or induced by human processes (environmental degradation and technological hazards).

SENDAI : RISQUES & RESILIENCE

Carte du Japon avec la Préfecture de Miyagi mise

- ***Mission Technique (Nov. 2011)***



- ***Tsunamis:*** *Mars 2011*
- ***Protocole:*** *Mars 2015*

PARTIE #1 - CONCLUSIONS

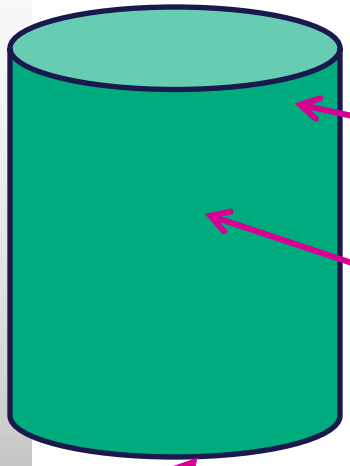
- Risques & Résilience:
  Interdépendants

- Défi: Synergies
  SPI+ SHS

PARTIE #2

Aléas: Inondations / Tsunamis / Houle

Cas de TSUNAMIS



- Pression : Excès
- Impacts : débris
- Mouvement : solide

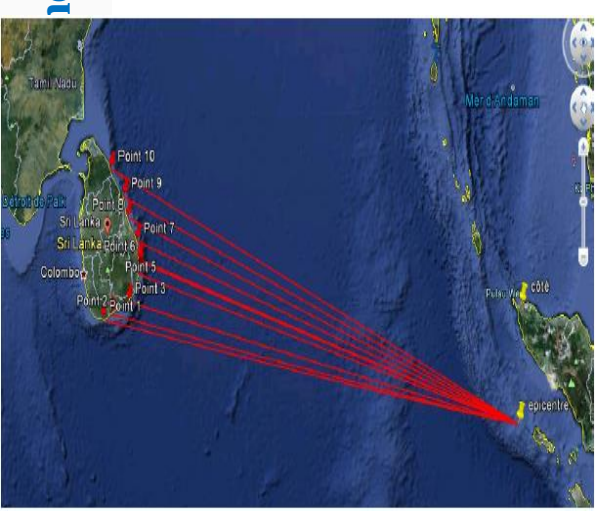
Oil leakage due to *collapse of pipelines*
(Sendai JX Nippon Oil refinery)

[Goto, 2008]

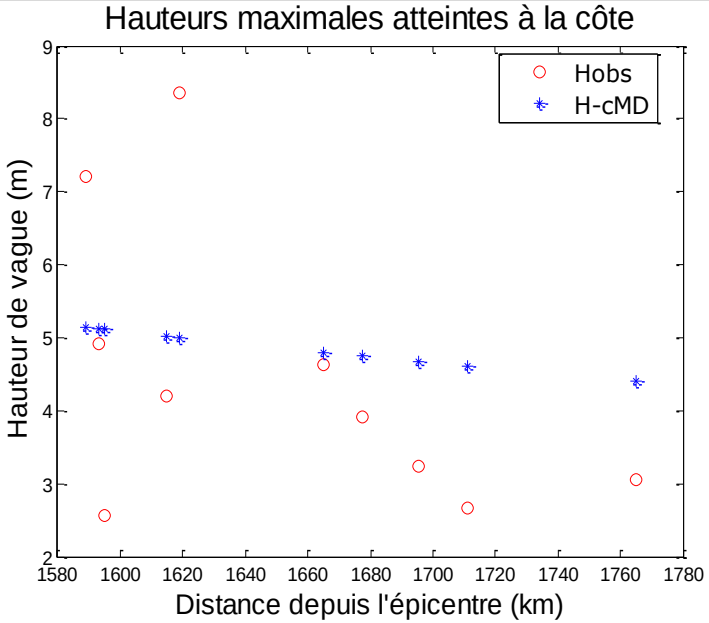
Couplage: Séismes + Tsunamis

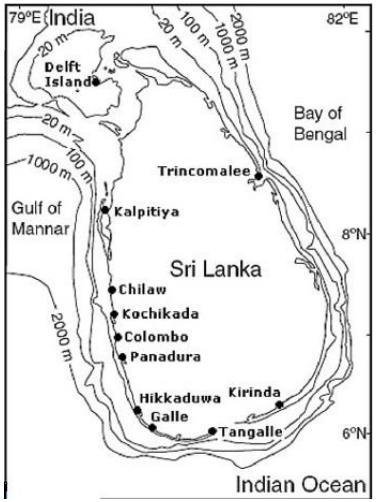
- Vulnérabilité: Réservoirs, Pipes…
- Débris/Impacts: Voitures, arbres, containers, et bâteaux !

INDONESIE (2004), JAPON (2011)

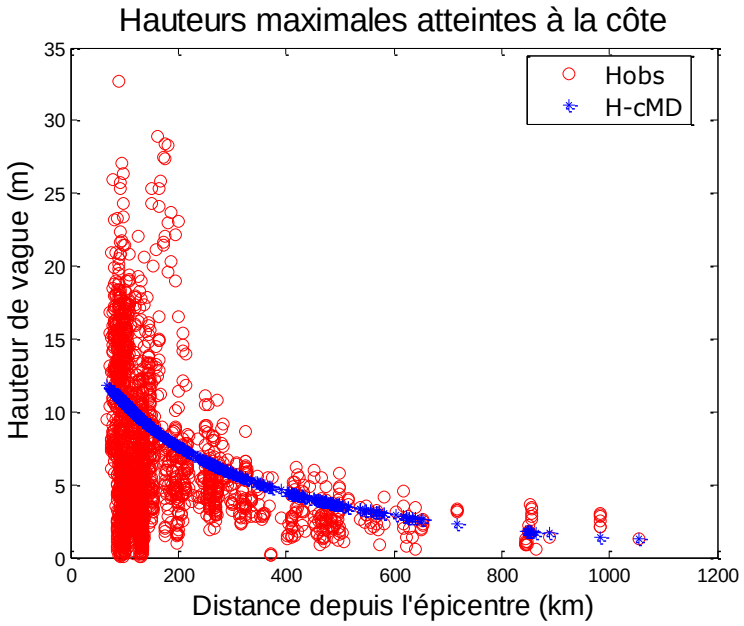


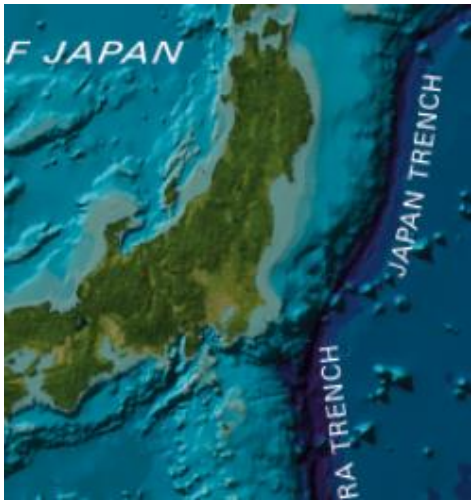
Images prises de Google earth]





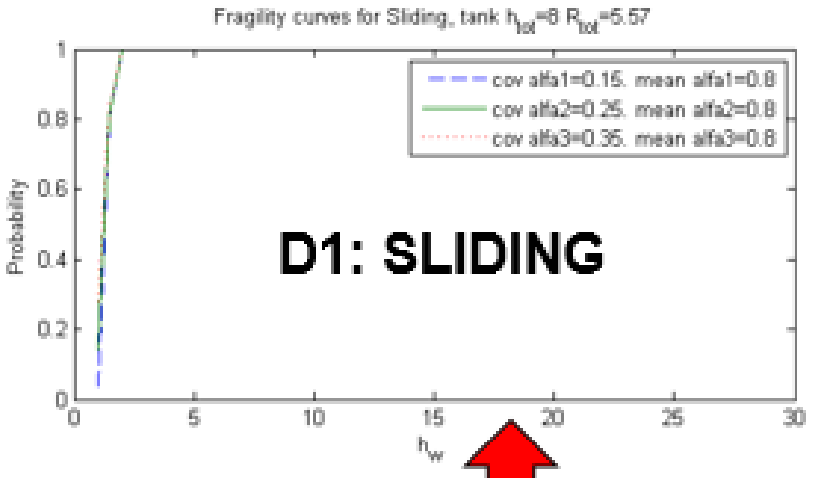
[Wijeratne et al, 2010]

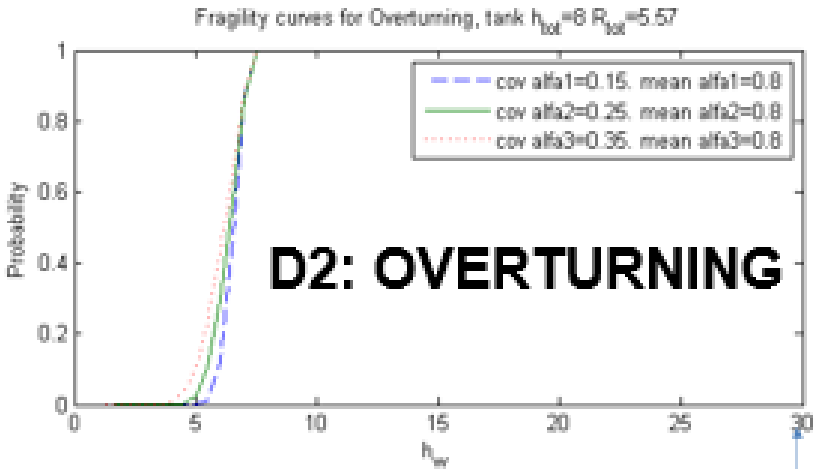


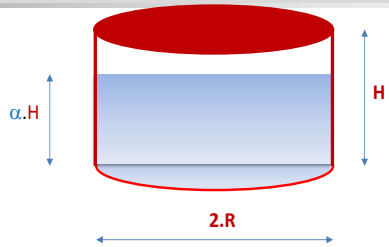


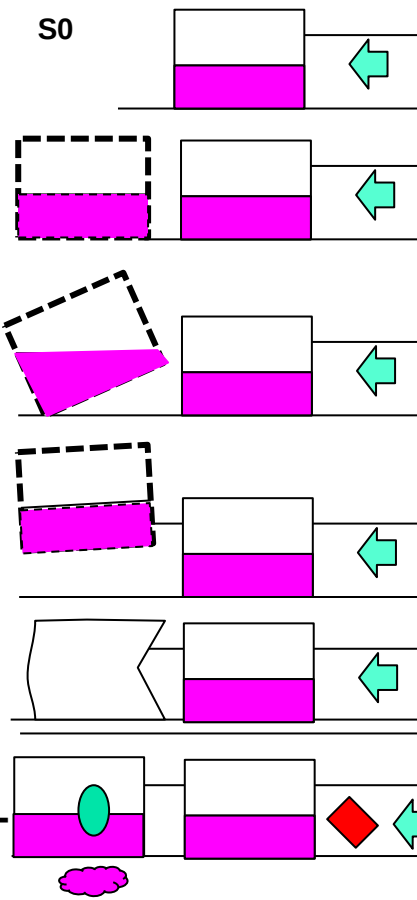
[Gebco, 12/08/2012]

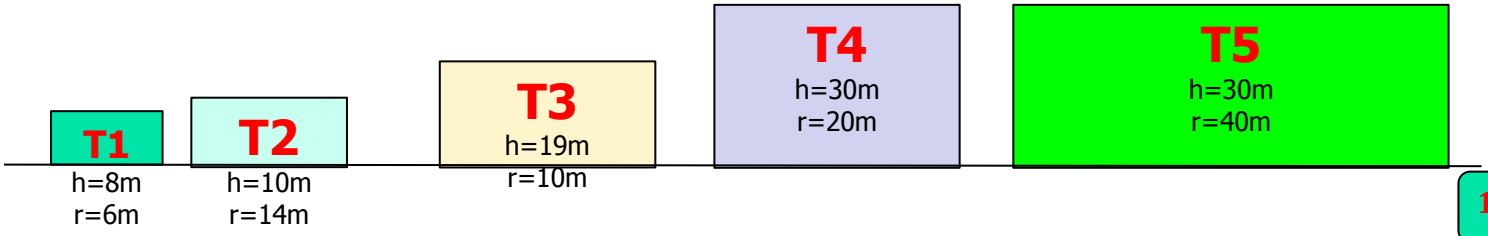
RÉSERVOIRS (RAFFINERIE): SIMULATION











PARTIE #2 - CONCLUSIONS

- Aléas: Inondation/Tsunami /Houle
- Débris/Impacts: Effets induits
- Cibles: Réservoirs, Pipes…
- Approches scientifiques:
  - Collecte données / observation
  - Simulations
  - Courbes de fragilité ➔ risques

PARTIE #3

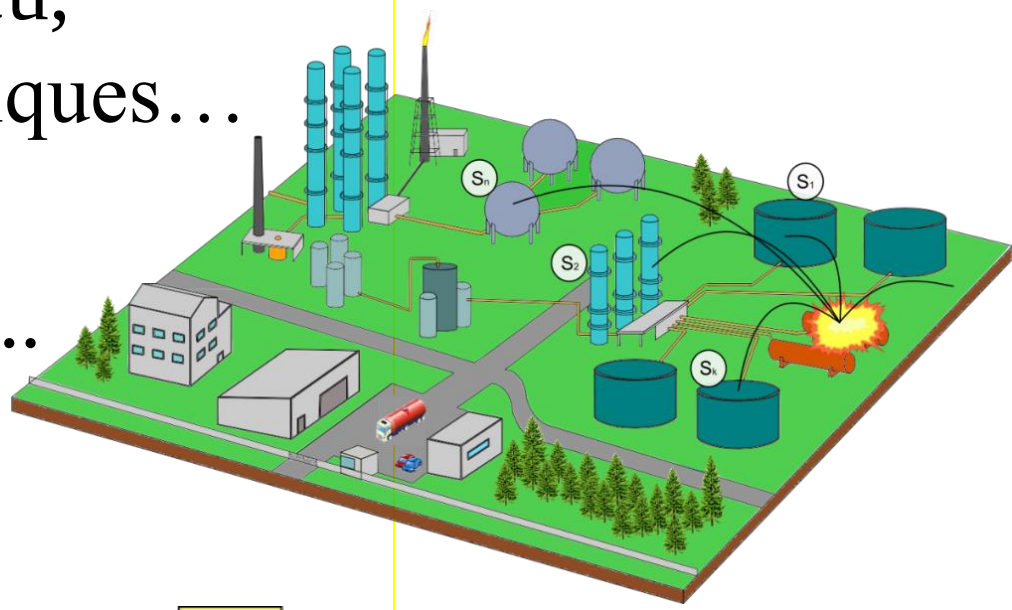
Aléas: Explosions/Feux

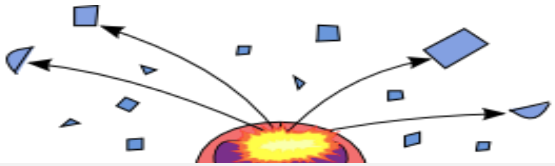
Endogènes ➔ Surpressions, Emballements…

Exogènes ➔ Malveillance…

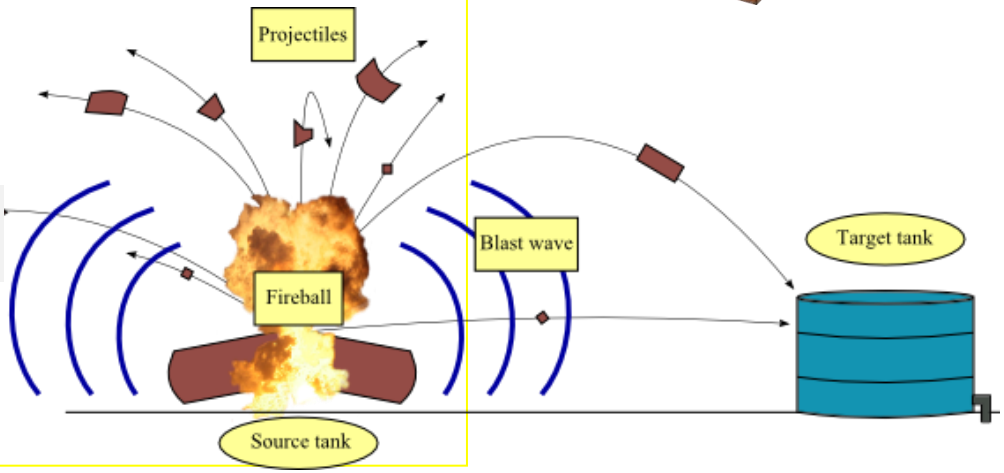
APPROCHES MULTI-PHYSIQUES … *Multi-Enjeux*

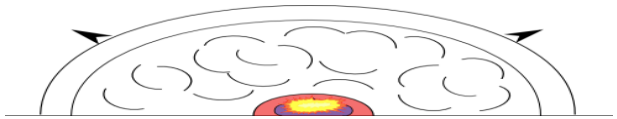
- **Effets:** Fragments, Feu, Souffles, Produits toxiques…
- **Cibles :** Installations, Personnels, Voisinage..





Projectiles





{Onde+ Feu}

- REX (Japon 2011): Explosions réservoirs GPL à Chiba

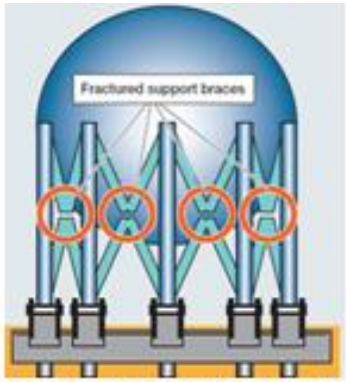
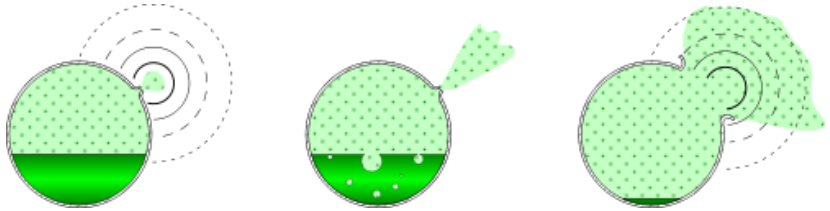


Figure 42 : Fractured support braces collapsed by strength ground motion

Rho eau : 1

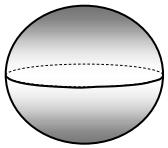
Rho GPL ~ 0,650



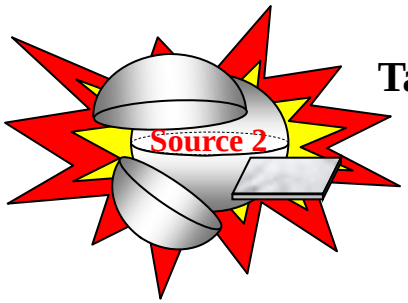
- Choc principal: plastification contreventements
- Chocs secondaires: Rupture contreventement et Ruine réservoir
- Effet Domino: Incendie puis BLEVE

EFFETS DOMINOS – SUR-ACCIDENT… *Simulation*

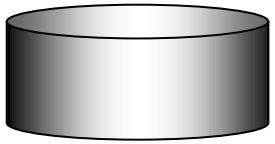
Target 5



Target 4

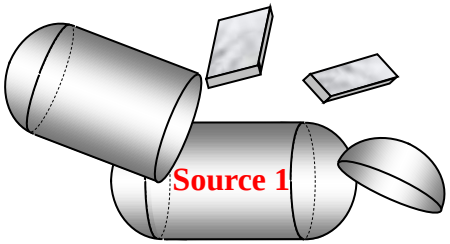


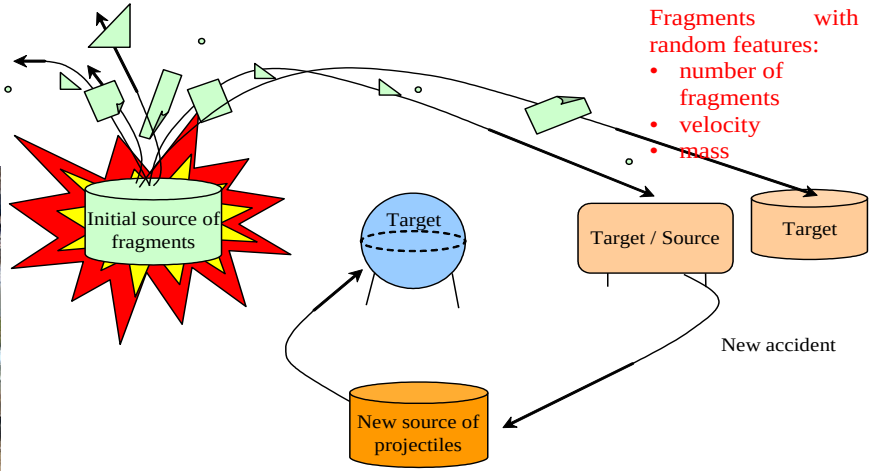
Target 1



Targets 2 & 3

Effet Domino

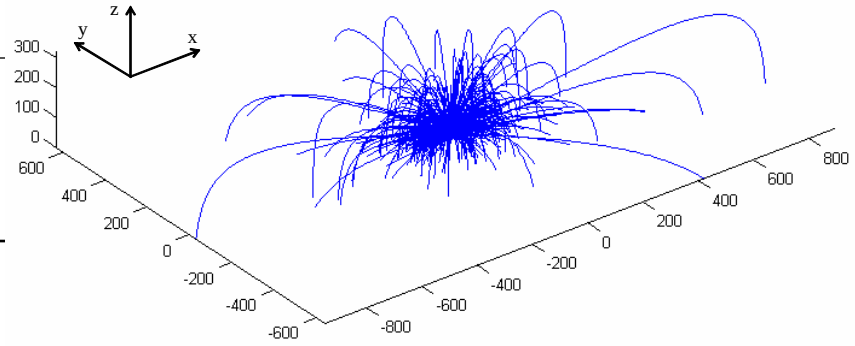




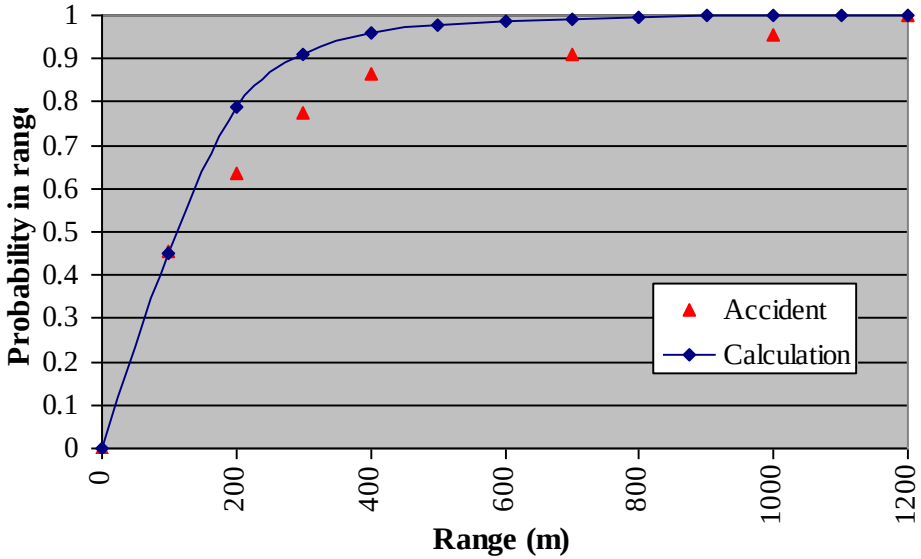
Domino effect sequences originated from an initial pressure vessel explosion (Mébarki et al., 2009).

Exemples: simulations …

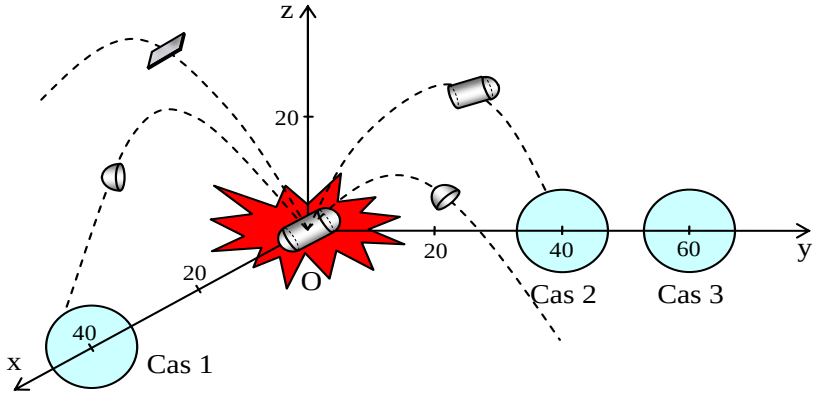
	Réservoir horizontal (Source Explosion)	Réservoir Sphère (Cible)
Rayon [m]	2.3	7.2
Epaisseur [m]	0.007	0.007
Longueur [m]	6	
Centre	(0, 0, 0)	(40, 0, 8) m



Simulations: Trajectoires de Fragments (for 500 simulations)



Cas réel: Mexique



Recherche agencement optimal

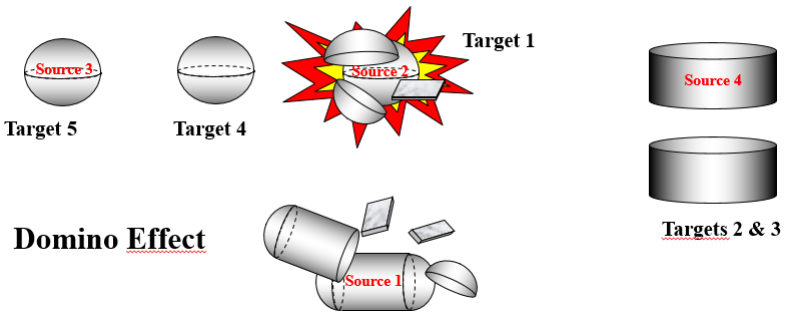
SIMULATION: CAS CONSIDÉRÉ

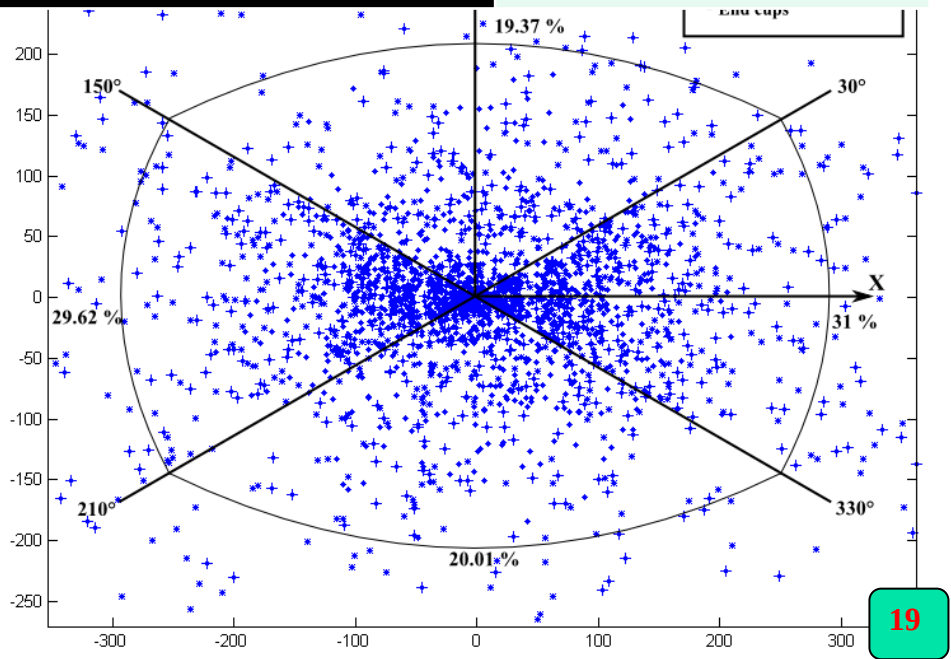
Source (réservoir) = cylindrique pressurisé
Cible (réservoir) = Cylindre atmosphérique

	Source	Cible
Rayon (R)	3.5 m	6 m
Longeur/hauteur (L)	15 m	12 m
Capacité (V)	757 m^3	1350 m^3
Epaisseur coque (e)	0.007 m	0.005 m

PROBABILITÉ D'IMPACTS

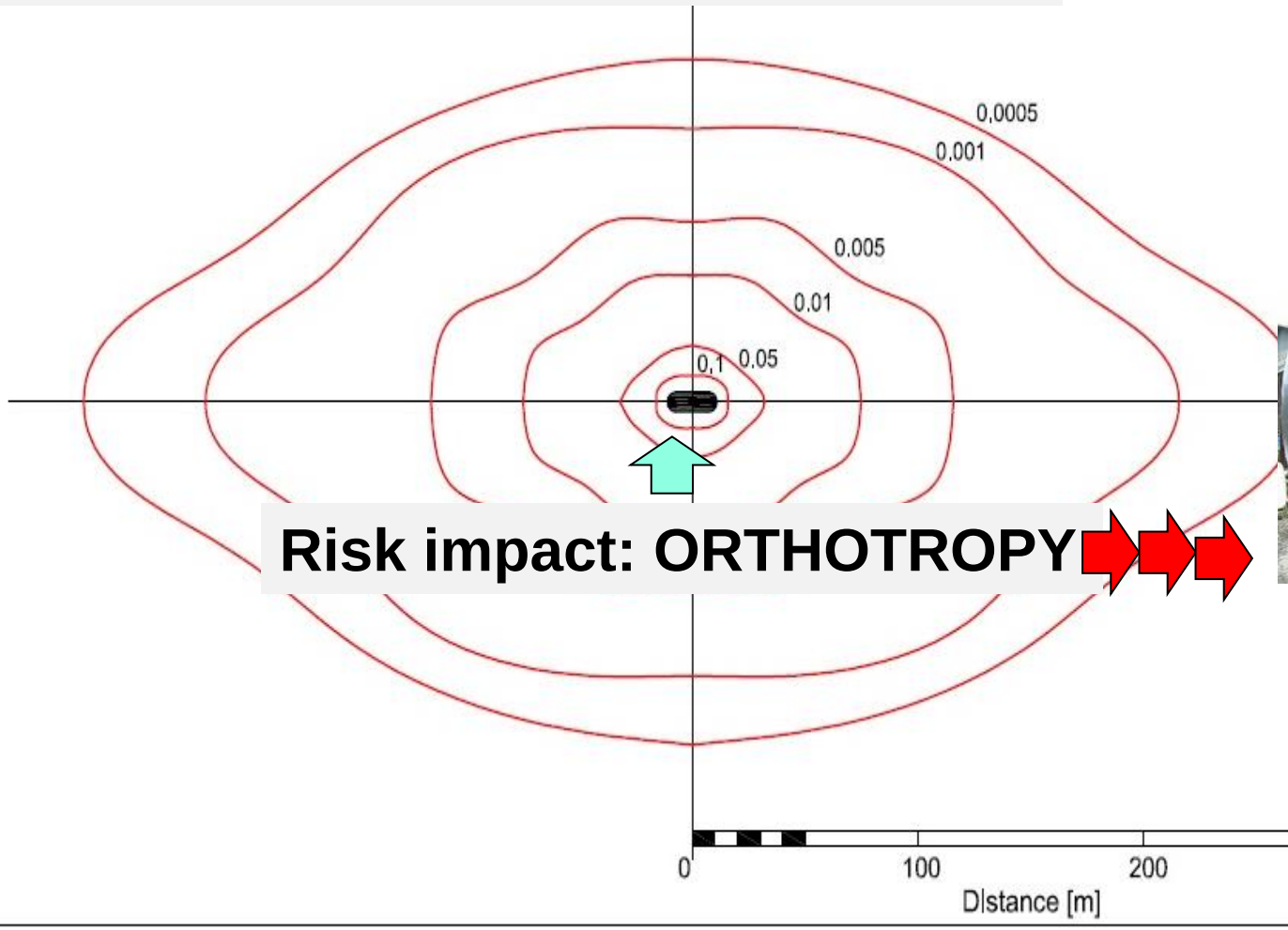
Projectiles impactants	**Vitesse moyenne à l'impact**	**82.98 m/s**
	Energie cinétique moyenne à l'impact	14.463 MJ
	Masse moyenne des projectiles	8954 kg
	Taux de fonds de cuve	9.09 %
	Taux de fonds oblongs	45.45 %
	Taux de plaques	45.45 %
	P_{imp} : Probabilité d'impact	5.5×10^{-3}





PROBABILITÉ D'IMPACTS …

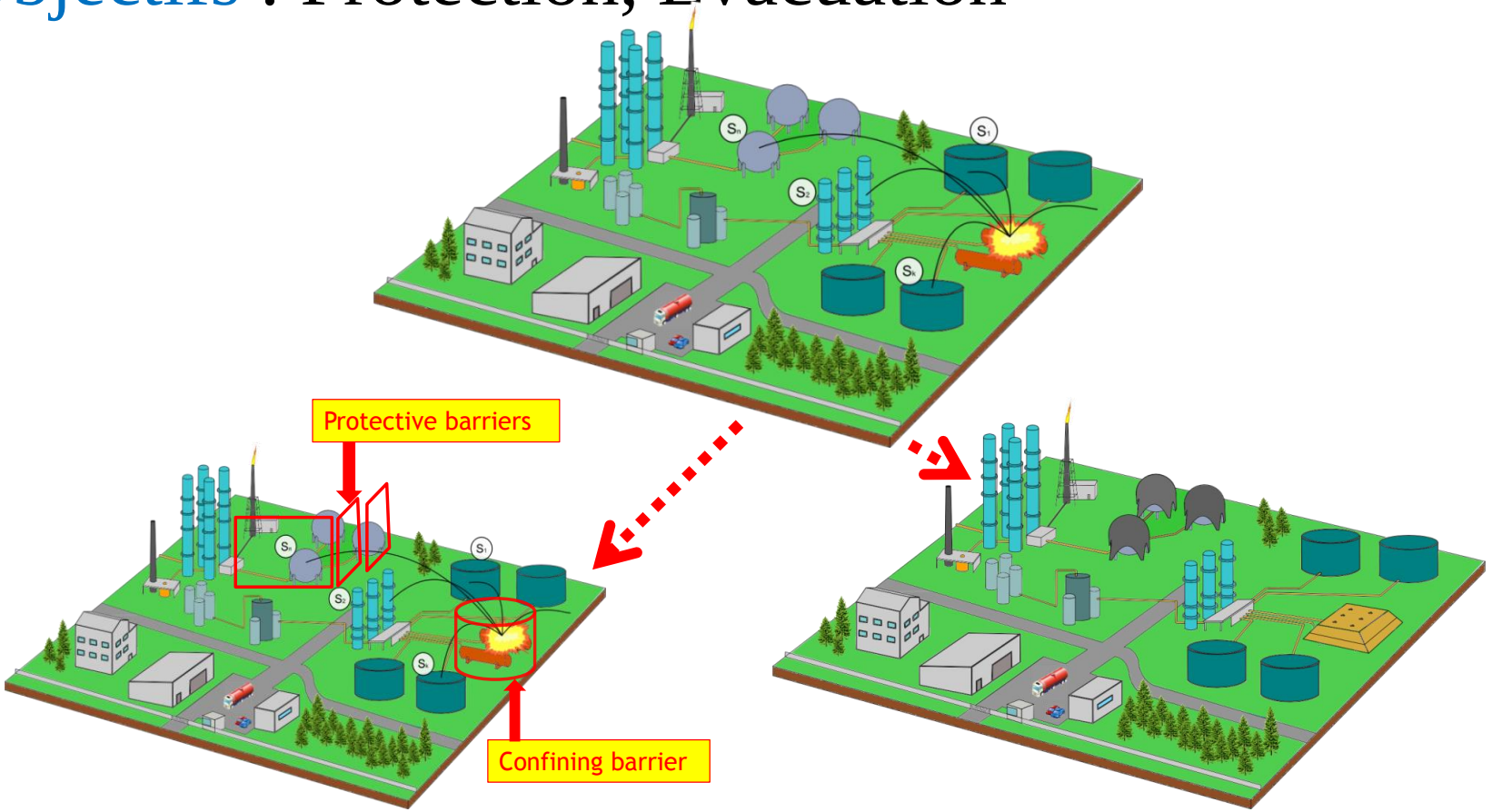
Isovaleurs de probabilité d'impact au sol



Risk impact: ORTHOTROPY

EFFETS COMBINÉS – APPROCHE GLOBALE

- Ensemble industriel: réservoirs, voisinage, staff
- Objectifs : Protection, Evacuation



Risques et disposition optimale: Simulations…

Partie #3 - Conclusions

- Aléas: Eléments déclencheurs endogène ou exogène
- Multi-effets: Fragments, Onde souffle, Flux thermique, Toxicité…
- Cibles: Voisinage ➔ Réservoirs, habitations, Personnes
- Que faire ?

  Minimiser/Optimiser/confiner

PARTIE #4

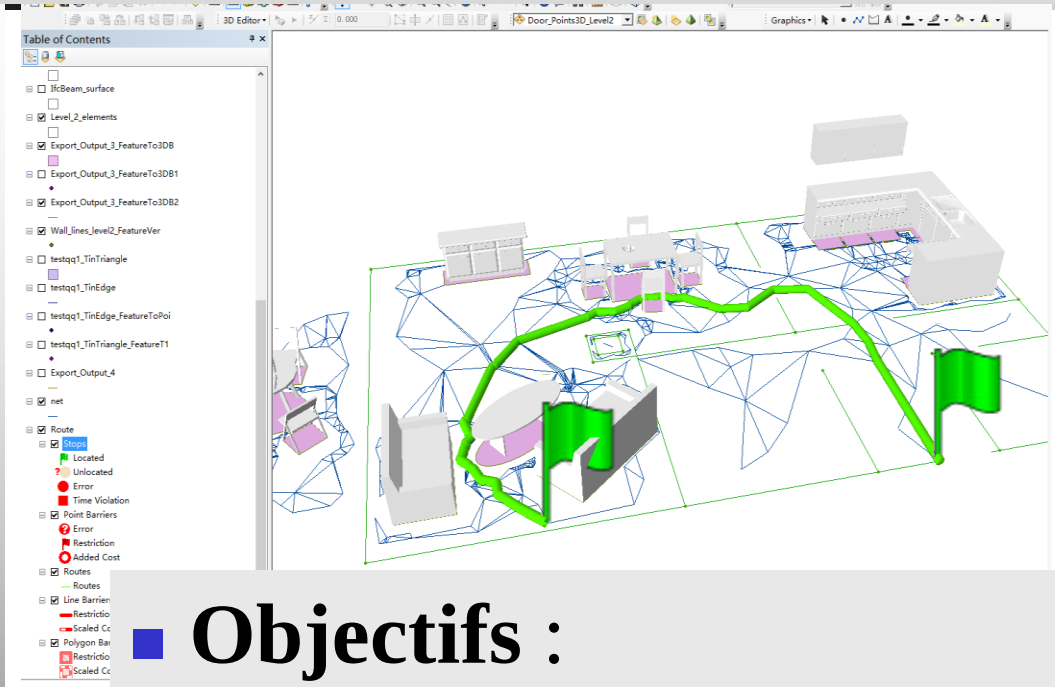
Défis et Enjeux ➔ Risques optimaux:

Agencement optimal

et

Protection de personnes

BIM + GIS + IoT ➔ Evacuation



- **Objectifs** :

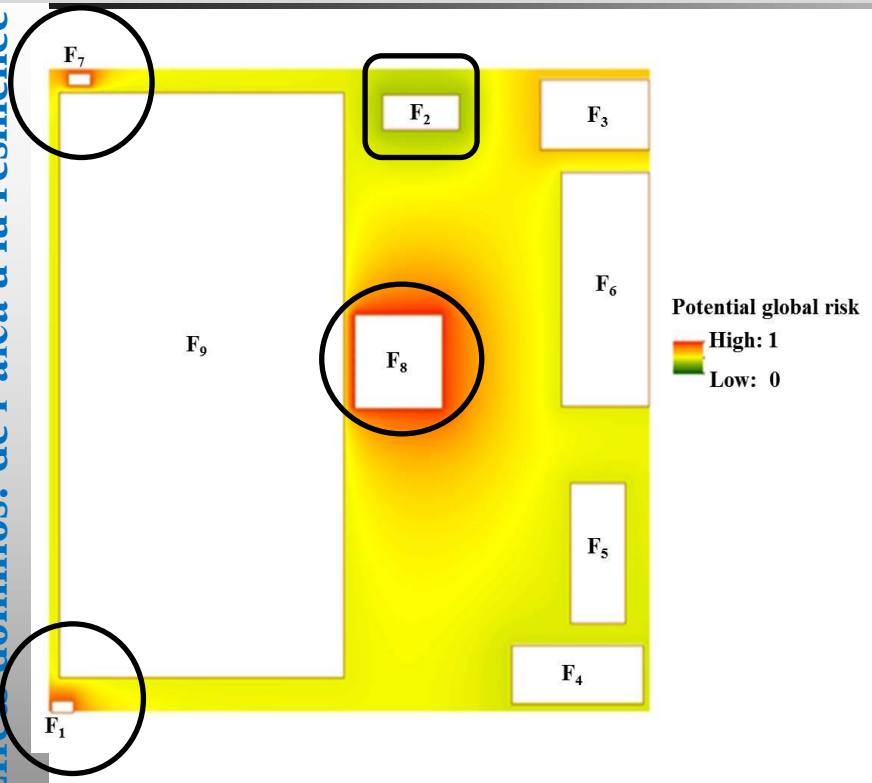
  Optimiser risques par agencement optimal

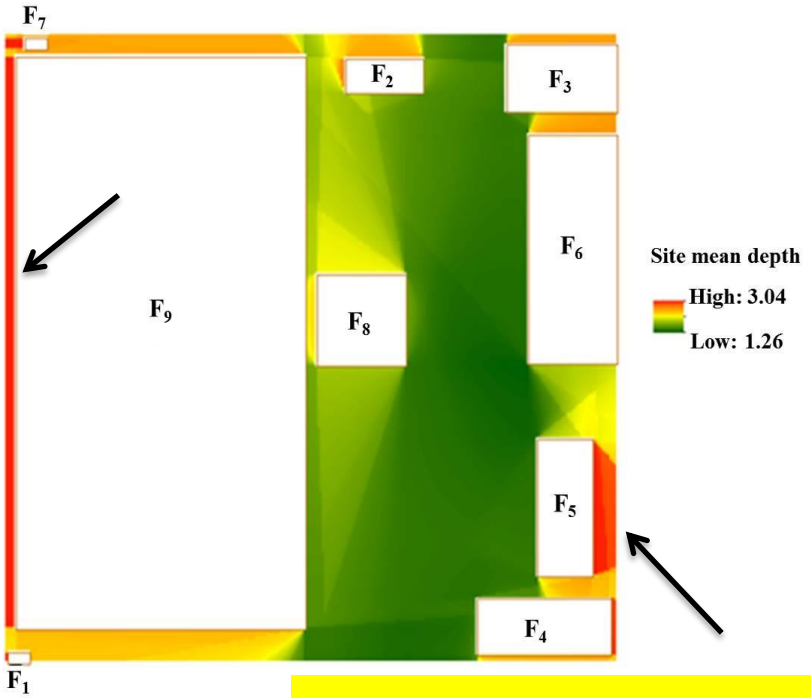
- **Usages modernes** :

  Building Information Modeling – BIM

  IoT

Risques : Optimisation, Agencement et Evacuation



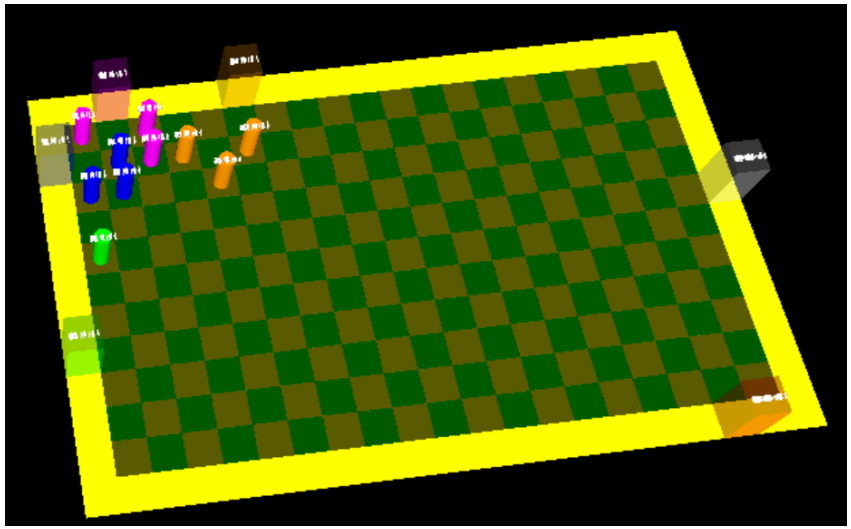


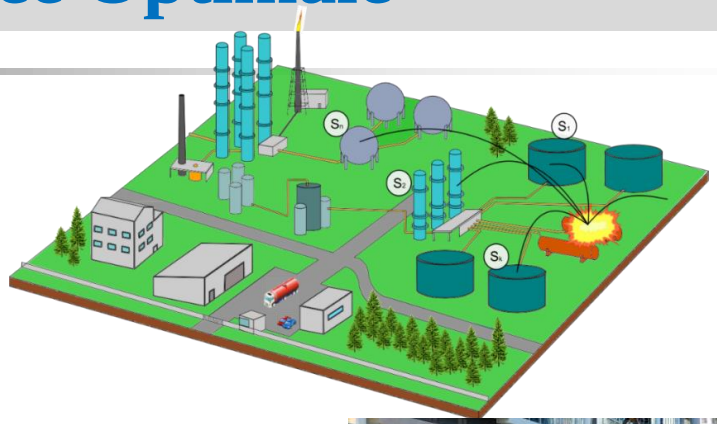
Site mean depth

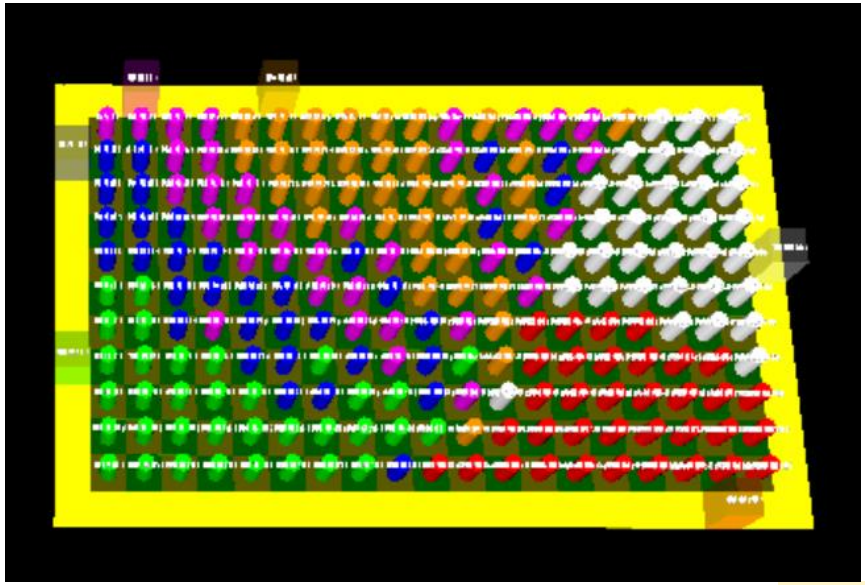
*** Vert:** Bonne visibilité ~ position "proche"

*** Rouge:** Mauvaise visibilité ~ position "lointaine"

Evacuation Guidée Optimale







PARTIE #4 - CONCLUSIONS

- Optimisation des risques: simulation numérique, modèlisation BIM (onthologie)

- Protection et évacuation des personnes: Guidage et IoT, modèles panique…

RISQUE – EFFET DOMINO - RÉSILIENCE

Shark captures fish, then bird captures shark, then photographer captures it all

- ***Faible probabilité vs. Ampleur Conséquences***

YAHOO!

Lifestyle

A bird carrying a shark carrying a fish: Photographer gets 'one in a trillion' picture

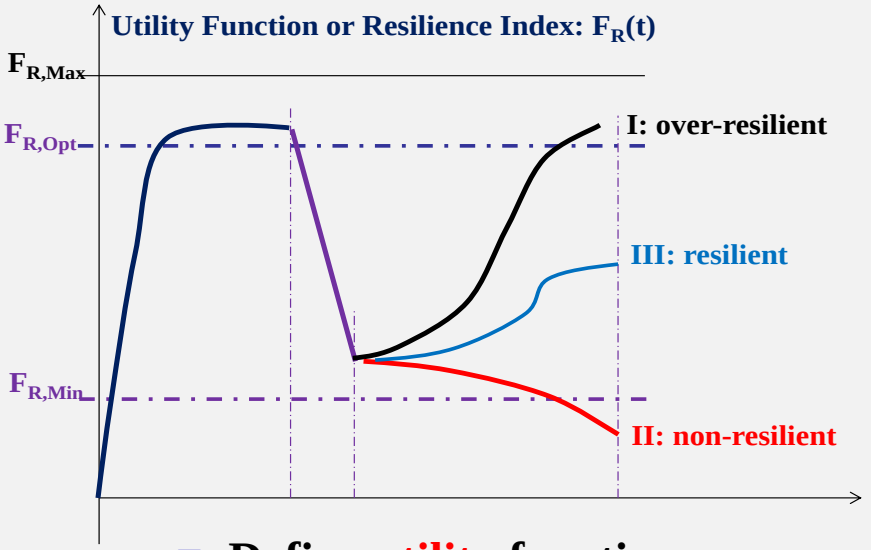
Miami Herald Tue, May 1 1:00 PM GMT+8

RÉSILIENCE: FONCTIONS UTILITÉ & MÉTRIQUES

$$F_R(t) = F_R\left(t\middle|_{V,T_{REF}}\right) = \left[F_R(t_{d,i}).(1-[H(t-t_d \geq 0).D_{Fr}(t_d)])\right].\left[(1+\Phi_a(t-t_d).\chi_{m,c}.\chi_{m,r}\right]$$

[Mébarki, 2016]

RESILIENCE | **Pre-Disaster State** | **Damage** | **Recovery** | **Resources** | **PD Management capacity**



- (Squelette, Muscles, Peau, Sang, Nerfs…)
  + (Mental / Formation …)
- (Bâti, Réseaux, Management …) + (Social & Culture..)

- Define utility functions
- Identify hazards and distribution
- Evaluate damages / utility functions drops
- Define limit values : for utility functions and recovery period