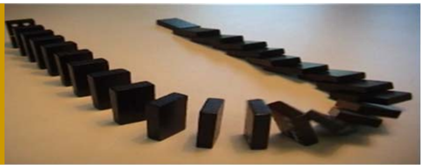
WG 2:

Modelling of hazards

ton vrouwenvelder/bernt leira

the netherlands/norway



$$Risk = p(H_i)\,p(D_j|H_i)\,p(S_k|D_j)\,C(S_k)$$

Exposure
Action/hazard models

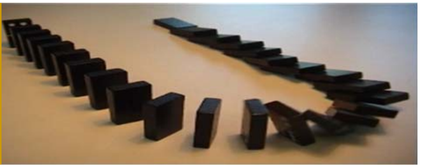
(activity 4)

Member models

Post failure models

(activity 5)

Model = physics + statistics



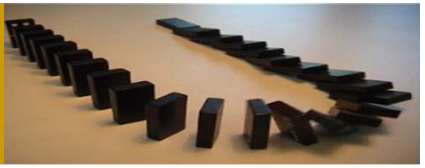
hazards

Earthquake
Landslide
Tornado
Avalanche
Rock fall
High groundwater
Flood
Volcano eruption

Internal explosion
External explosion
Internal fire
External fire
Impact by vehicle etc
Mining subsidence
Environmental attack

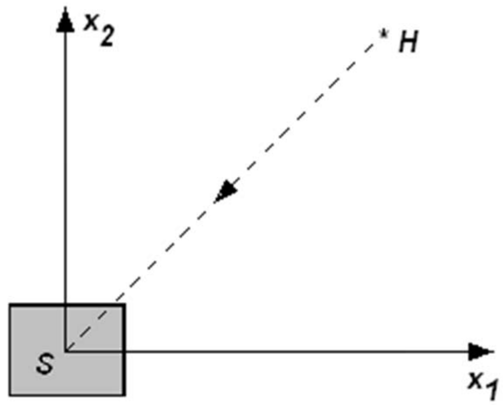
Vandalism
Demonstrations
Terrorist attack

Design error
Material error
Construction error
User error
Lack of maintenance

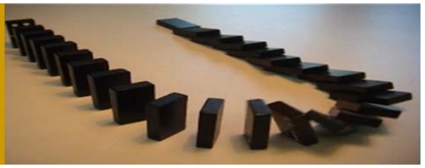


Modelling of accidental actions (natural / man made)

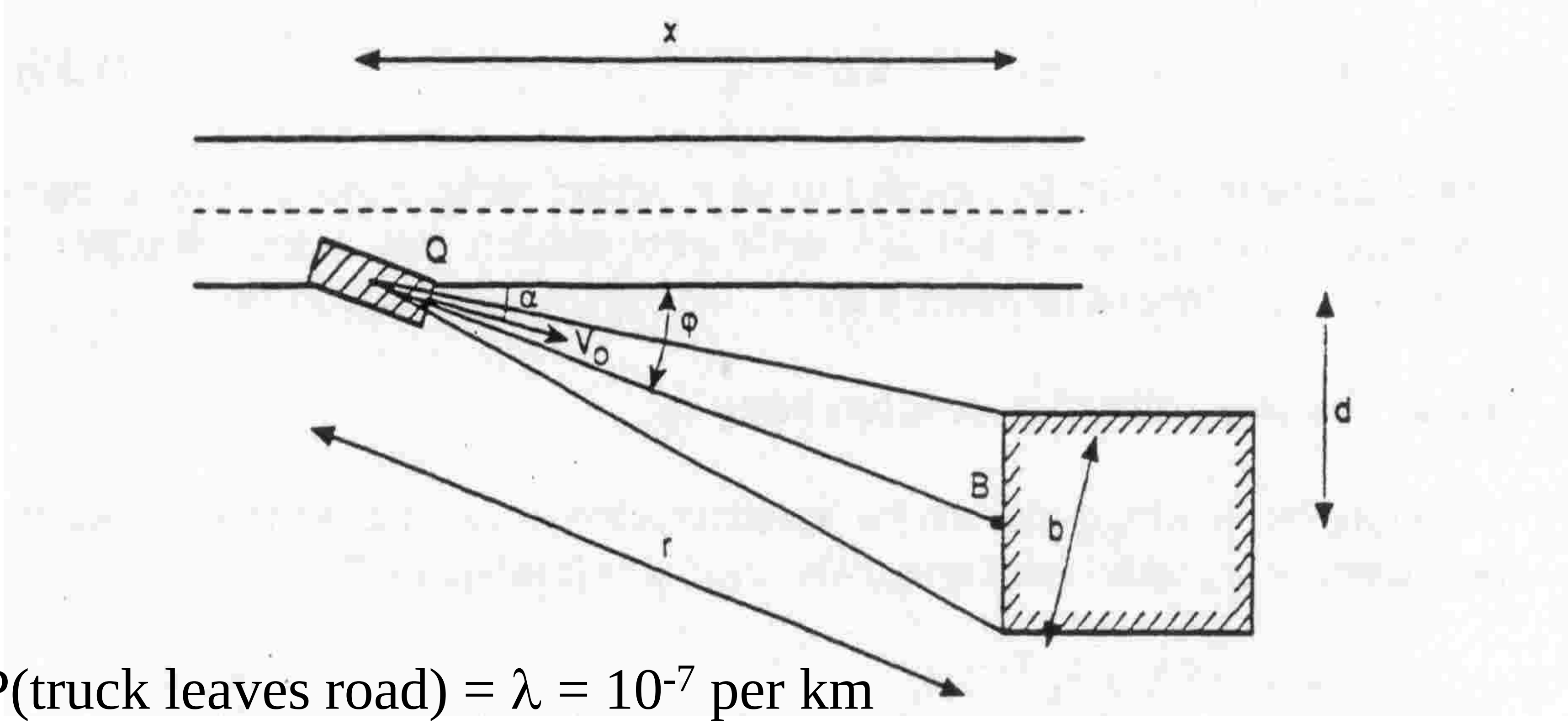
- Triggering event *H* (place **x,** time *t)*
- Magnitude possibly some other parameters.
- Physical interactions (environment, structure S)
- Damage
- Consequences



Components for the extreme event modelling (S=Structure, H= Hazard event)



Impact scenario model



P(truck leaves road) = $\lambda = 10^{-7}$ per km

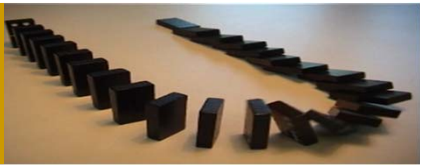
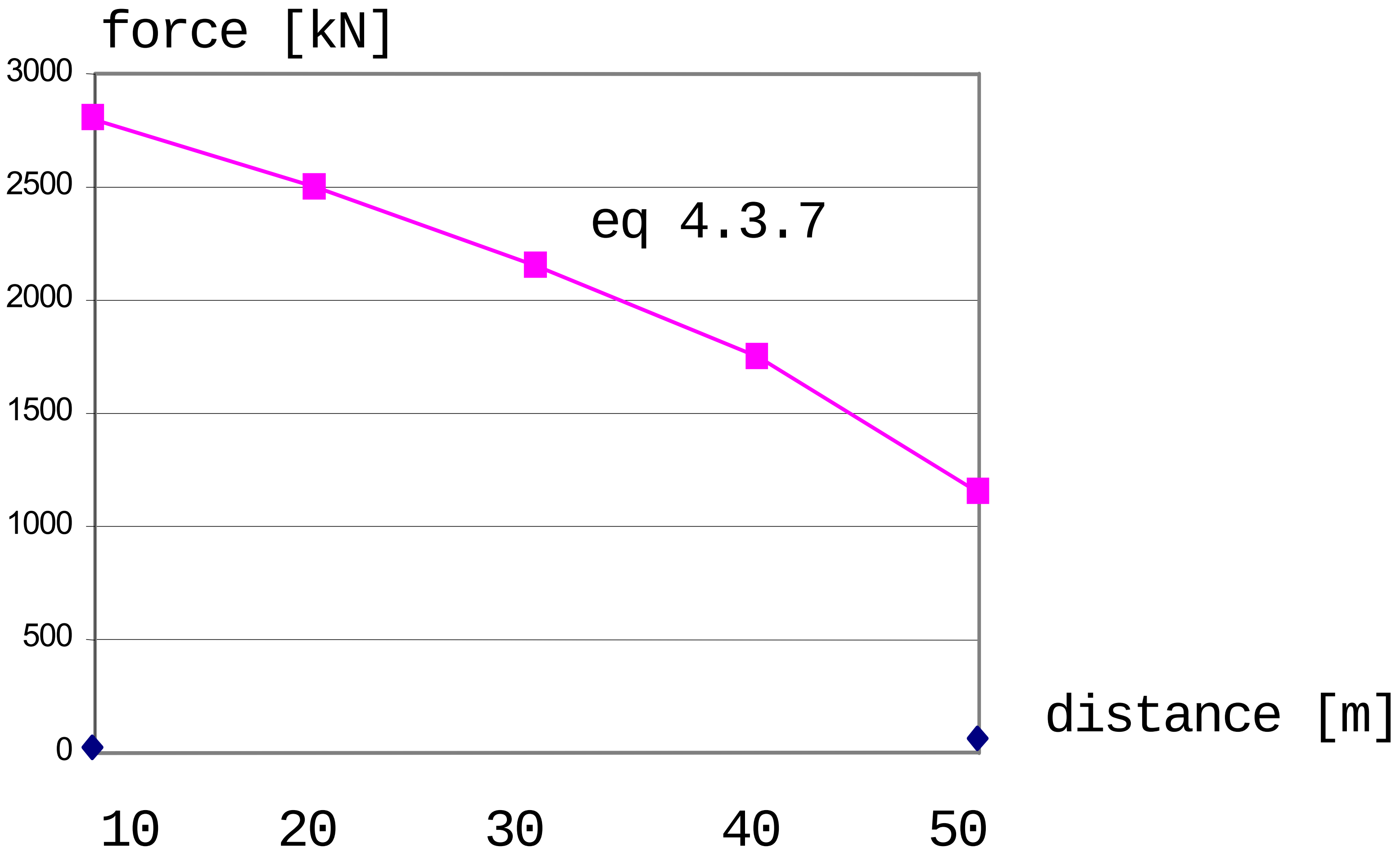
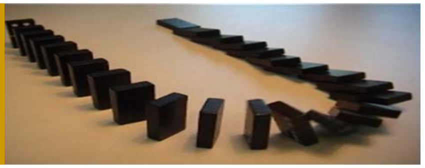


Table 4.2.1: Data for probabilistic collision force calculation

variable	designation	type	mean	stand dev
n	number of lorries/day	deterministic	5000	-
T	reference time	deterministic	100 years	-
λ	accident rate	deterministic	10^{-10} m^{-1}	-
b	width of a vehicle	deterministic	2.50 m	-
α	angle of collision course	rayleigh	10^o	10^o
v	vehicle velocity	lognormal	80 km/hr	10 km/hr
a	deceleration	lognormal	4 m^2/s	1.3 m/s^2
m	vehicle mass	normal	20 ton	12 ton
k	vehicle stiffness	deterministic	300 kN/m	-



Life time exceedence probability: 10^{-3}



INTERNAL NATURAL GAS EXPLOSIONS

$p_d = \max\{3 + p_v,\ 3 + 0.5p_v + 0{,}04/(A_v/V)^2\}$

p_d = equivalent static pressure [kN/m²]

A_v = area of venting components [m²]

V = volume of room [m³]

load duration = 0.2 s

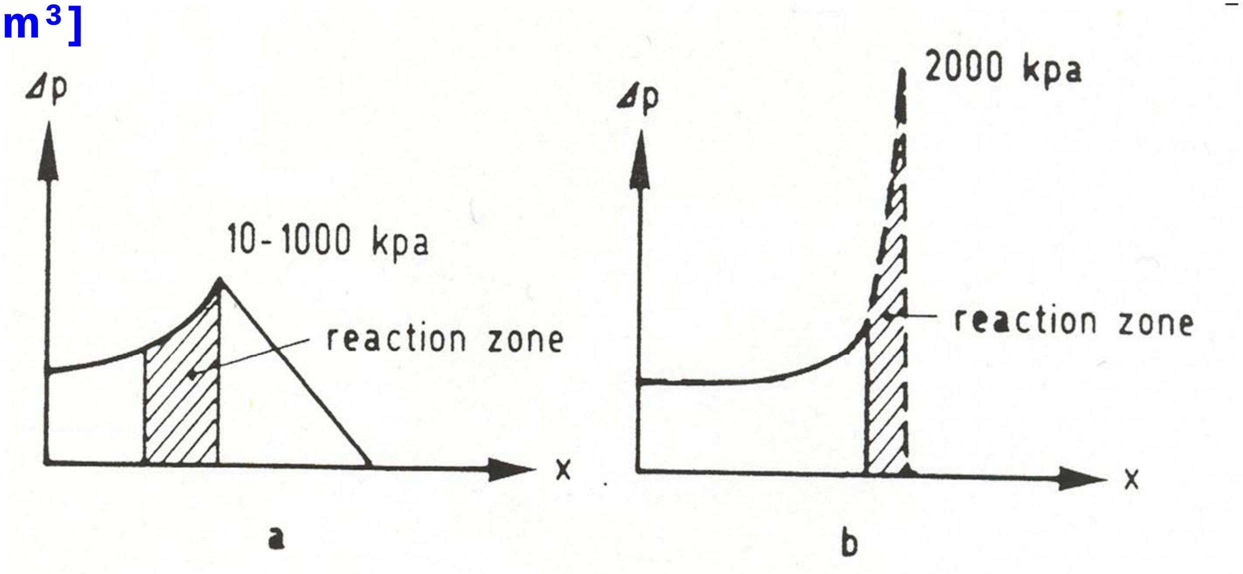
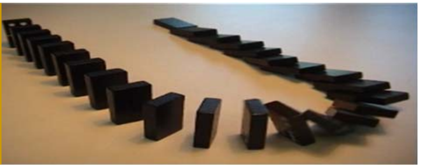


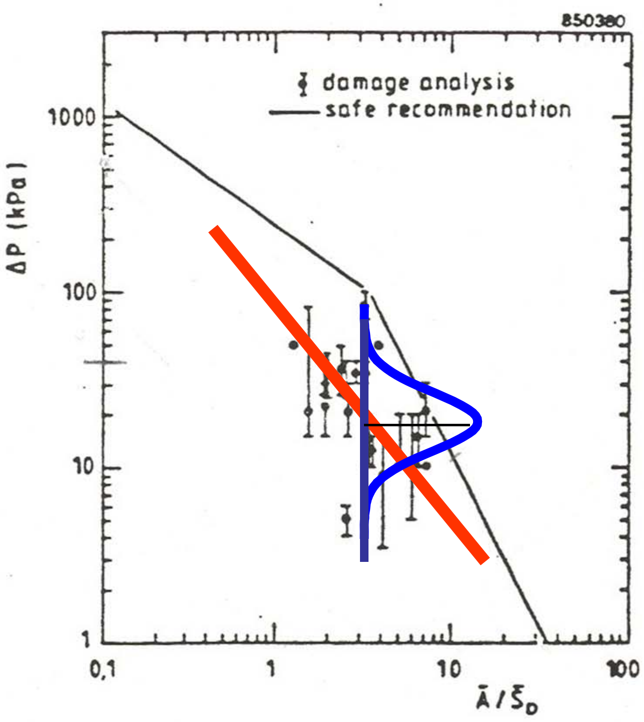
Figure 1: Pressure waves inside the explosion medium: (a) deflagration, (b) detonation

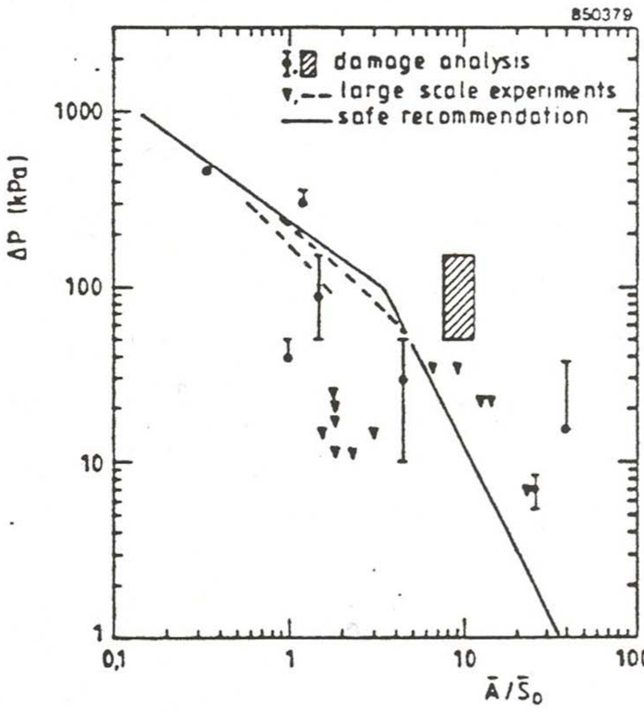
UK statistics

	Annual probability of occurrence in dwellings	Possible pressure
Reported explosion but not significant	0.064×10^{-4}	$<<17\ kN/m^2$
Moderate explosion	0.010×10^{-4}	$<17\ kN/m^2$
Severe explosion	0.005×10^{-4}	$>17\ kN/m^2$
Very severe explosion	0.0002×10^{-4}	$>>17\ kN/m^2$



Observed scatter in explosions





Human error model

- **Probability of making an error P(H)**
- **Magnitude of the error**
- **Effect on R: Δ ,e.g. zero mean, normal, sd $\sigma(\Delta)$**

$$P(F) = [1-P(H)]\,P(F|\text{no error}) + P(H)\,P(F\,|\,\text{error})$$

where $P(F|\,\text{error}) = P(Z_e < 0) = P(R+\Delta - S < 0)$

Human error model

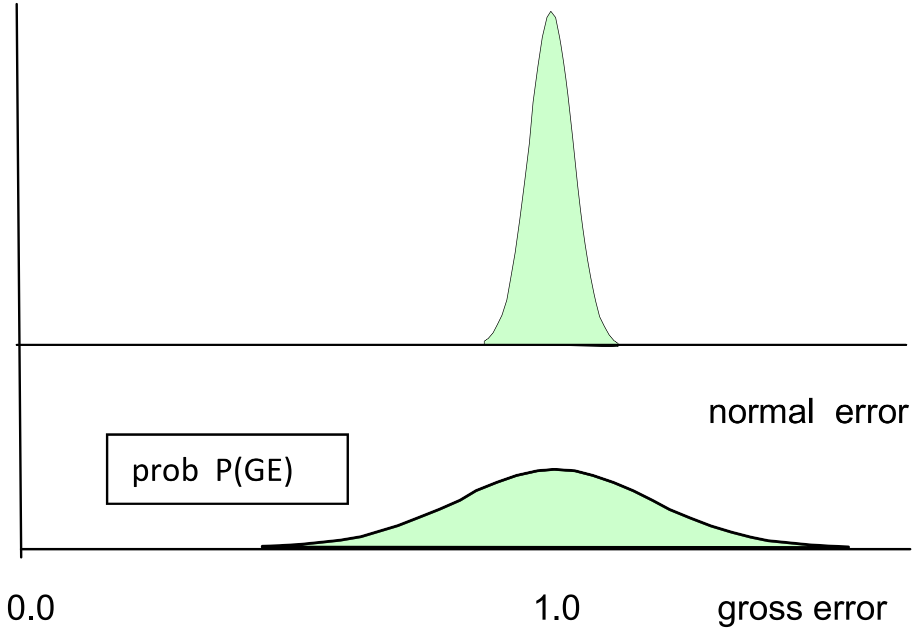
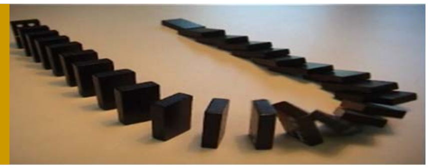


Figure 1: possible model for the effect of human error on resistance.



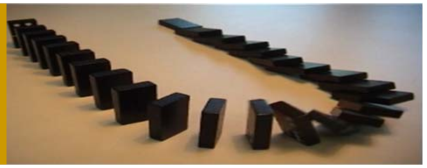
Data / Numerical values

Aspects

- ✓ Professional skill
- ✓ Complexity of the task, completeness or contradiction of information

- ✓ Physical and mental conditions, including stress and time pressure
- ✓ Adaptation of technology to human beings
- ✓ Social factors and organisation

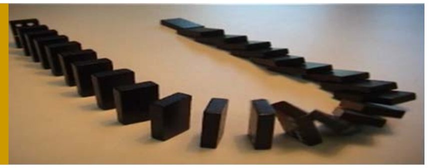
In some handbooks [e.g. Gutman and Swain, 1983] general estimates for the probability of making errors are given.



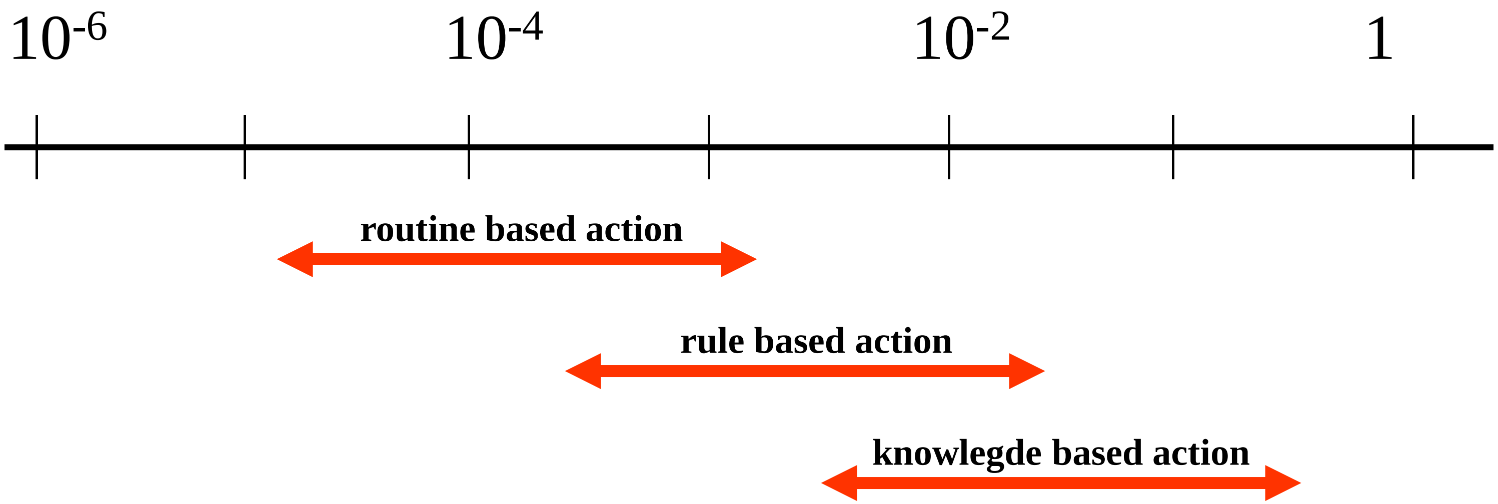
Gutman/Swain

- **Class 5 unbelievable**
- **Class 4 regular simple task, minimal stress**
- **Class 3 regular but more complex task, , some clues, less time**
- **Class 2 cues and memory necessary, distraction, little feed back**
- **Class 1 unfamiliar, complex, stress, no time**

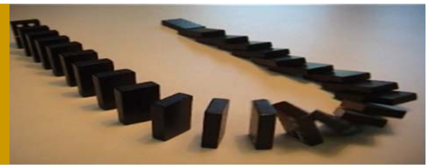
- **$P(error) \sim 10^{-class}$**



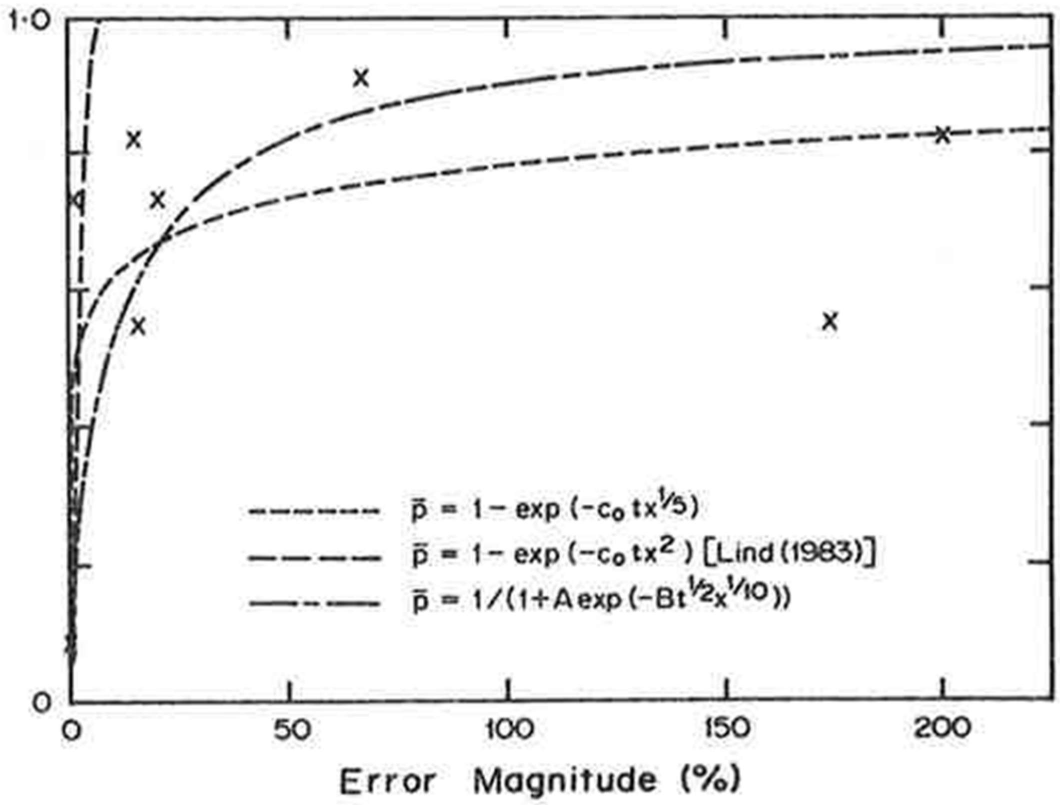
Quantification



Probability depends on training and mental circumstances (e.g.stress).



QA: Design checking



POD

Melchers / Stewart

1984

Time dependent

Checking Efficiency versus Error Magnitude at t = 20 minutes.

Conclusions

•Hazards are reviewed

•Focus on modelling and probabilistic description of explosion events

•Statistical modelling of human errors also discussed