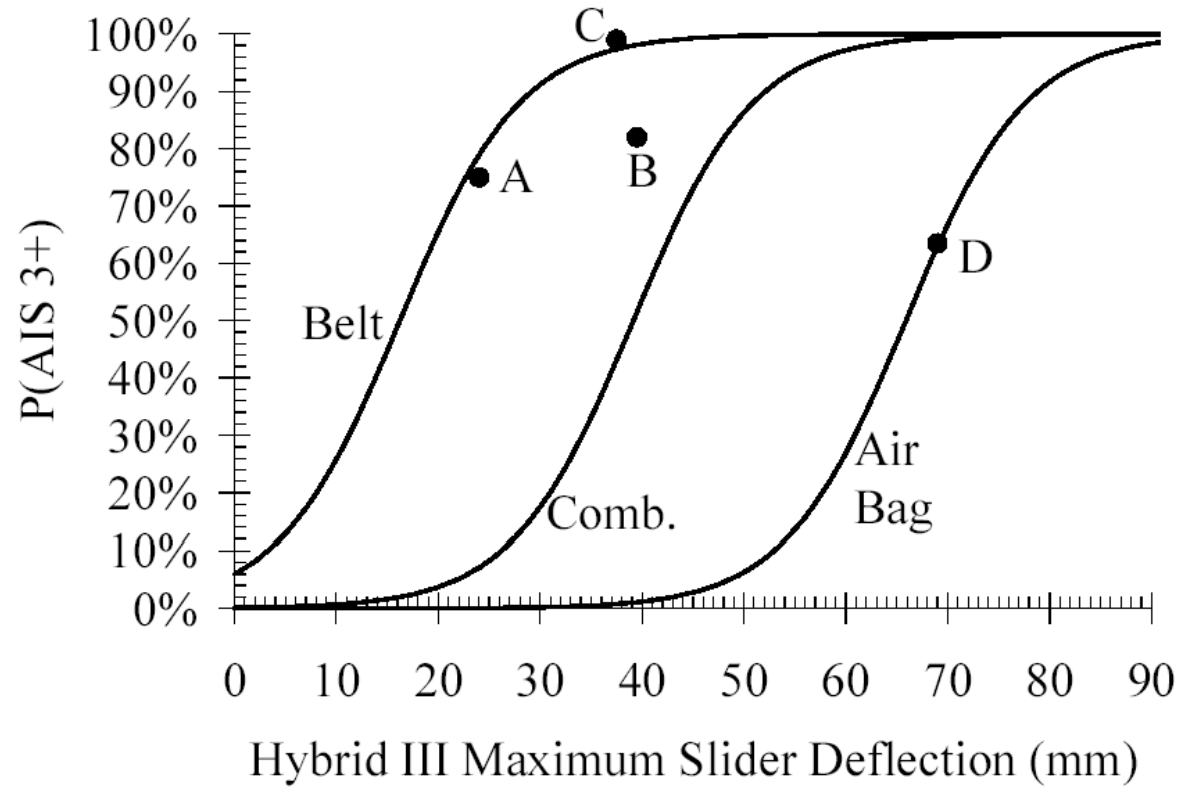# Equivalent Deflection (Deq)

ↈ Developed to address an inconsistency between

  ↈ Accident investigation: a restraining system with a belt load limitation at 4kN and an AB is much more efficient than a belt with a load limitation at 6kN.

  ↈ Crash tests: the deflections measured on an HIII were higher with the 4kN+AB system compared to the 6kN.

  ➢ The increase of deflection due to the airbag loading was higher than the decrease of deflection associated to the decrease of belt load.

  ➢ This would not have been an issue if the risks associated to the deflection were the same for the belt and the airbag

Kent et al. (2003)

Equivalent Deflection (Deq)

$2\ Fz$

Fx $\qquad$ Fx

Fz $\qquad$ Fz

l

$Ftot = Fx + Fz$
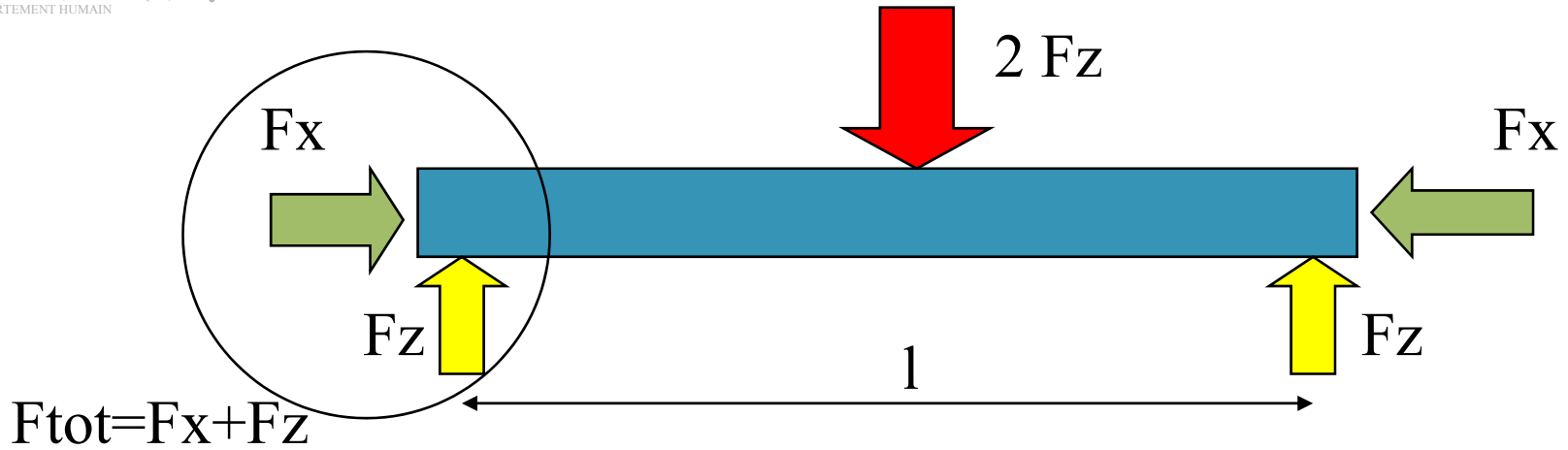
$$\sigma\max = Mf\max/(I/v) + Fc/s$$
$$Mf\max = Fz*(l/2)$$
$$\sigma\max = Fz*l/2.(I/v) + Fx/s$$
$$\boxed{\sigma\max = \alpha(Fz/Fzcritical + Fx/Fxcritical)}$$
$$\textit{If Fzcritical} \neq \textit{Fxcitical then}$$
$$\sigma\max \neq \beta\ Ftot$$

Fz

Fz_{crit} $\quad$ $\sigma max = cst$

Fx

Fx_{crit}

Equivalent Deflection (Deq)
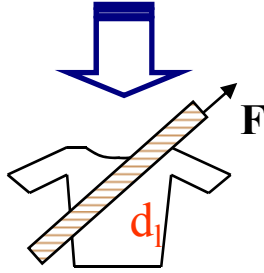
% risk

belt   airbag
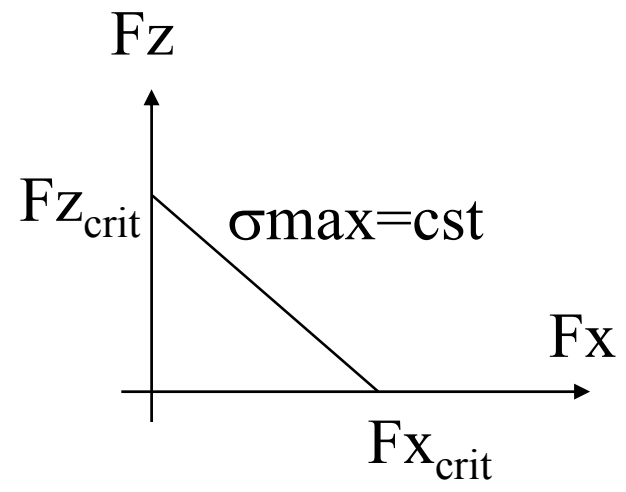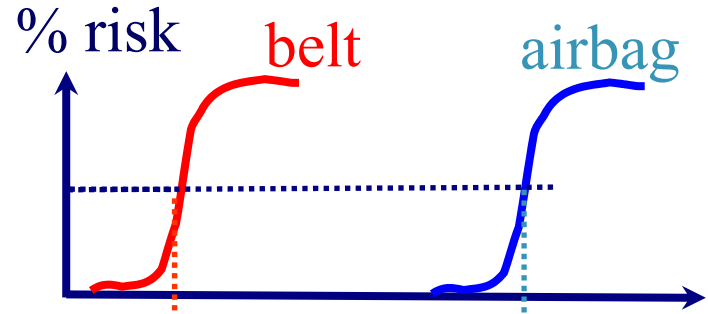
Hybrid III deflection

d localized   d distributed   evaluated separately

d_l F

d_d = X_d - d_l F

from shoulder belt load
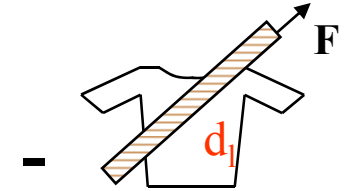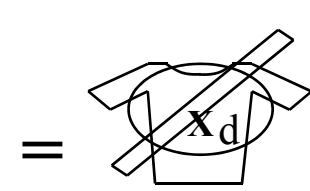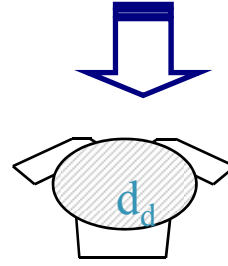
subtracting the localized deflection from the total deflection

combination (d localized, d distributed)
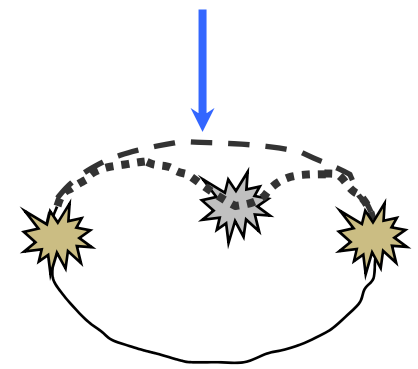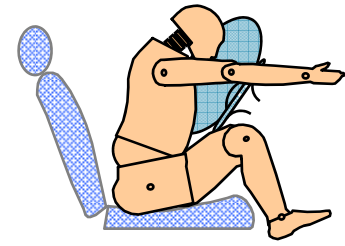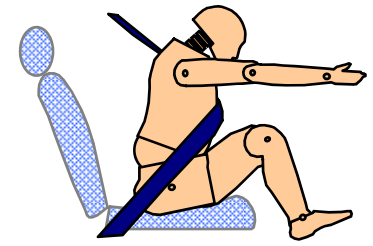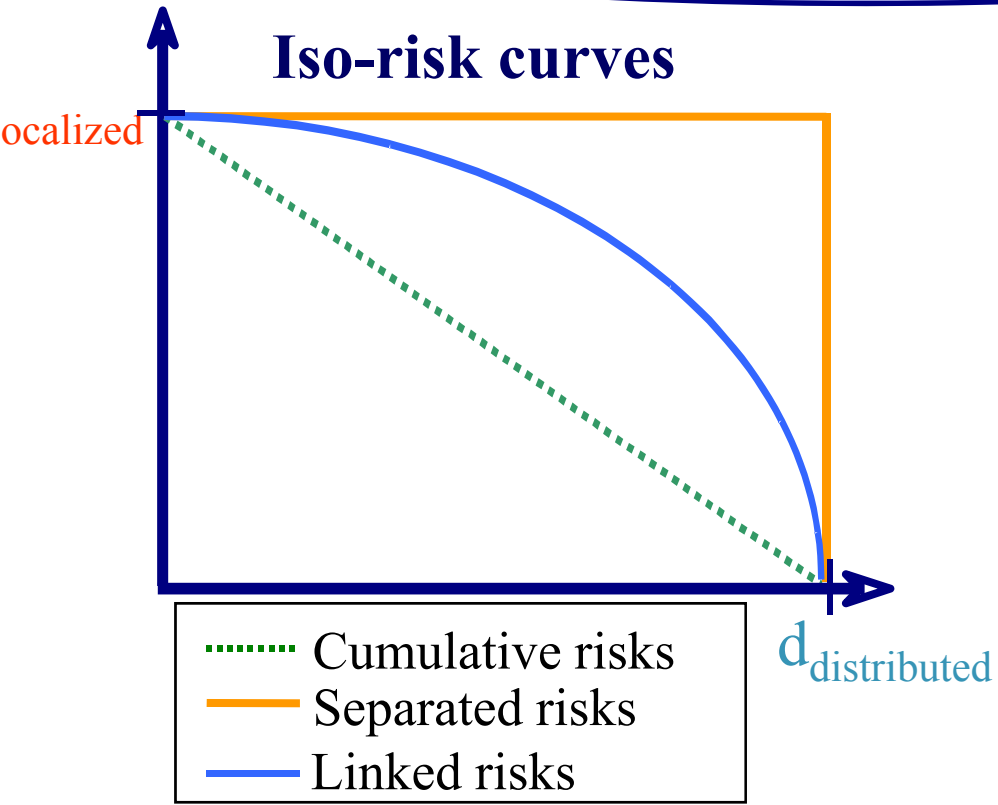
Equivalent Deflection (Deq)

combination (d localized, d distributed) ?

Iso-risk curves

localized

$d_{distributed}$

········ Cumulative risks
──── Separated risks
──── Linked risks
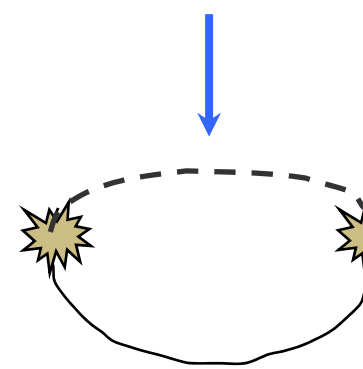
☞ quadratic combination form of localized and distributed deflections

F

d_l

d_d

F

k   c

Mass

$F_{shoulder}(t) = k*d_l(t) + c*v_l(t)$

$d_{localized}(t)$

$d_{distributed}(t)$
$=$
$d_{total}(t)$
$-$
$d_{localized}(t)$

$d_{distributed}(t)$

Equivalent Deflection (Deq)

% risk   belt   airbag

Hybrid III
deflection

$d_{localized}$ $d_{distributed}$

% risk   belt
airbag
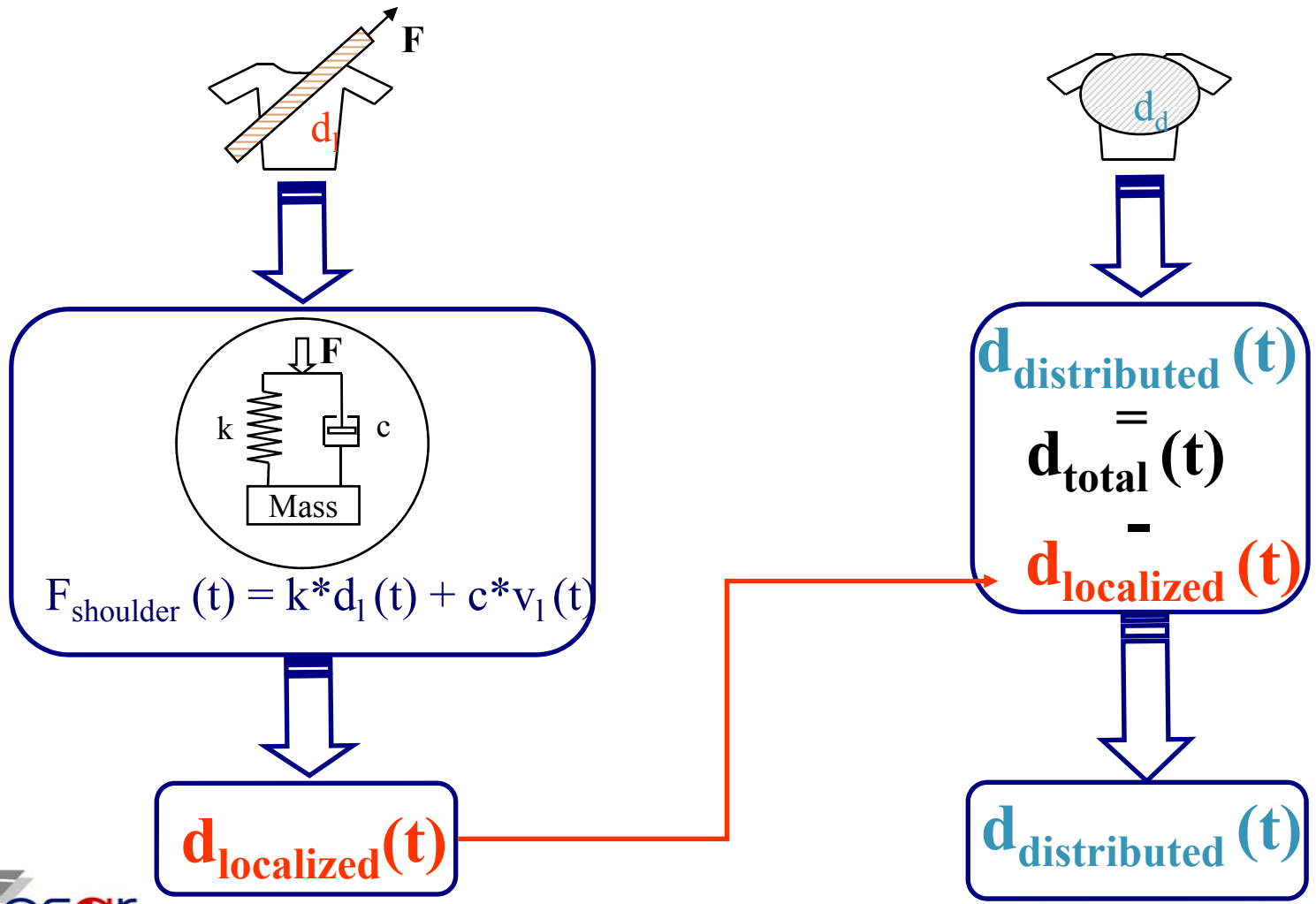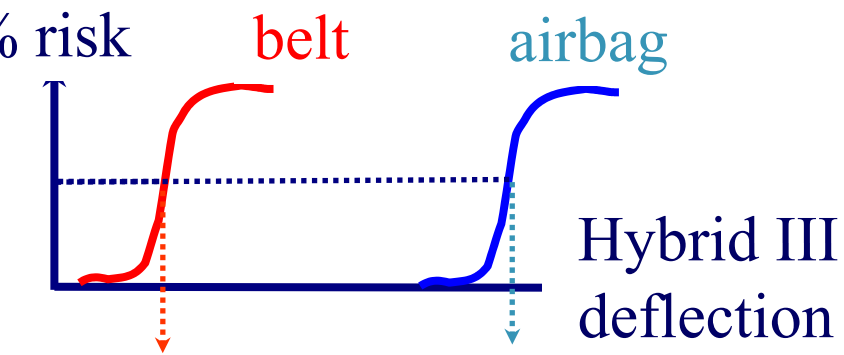
equivalent
deflection
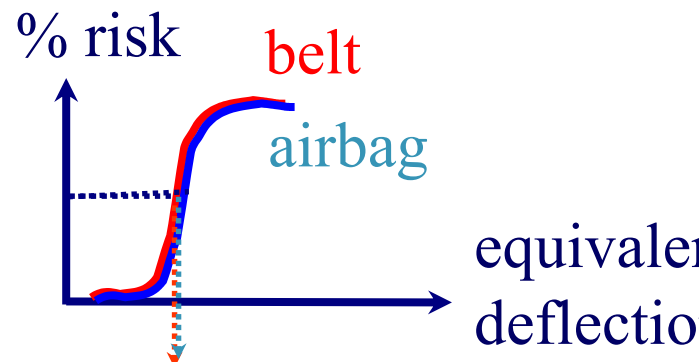
$f_n * d_{localized}$
$d_{distributed}$

$d_{localized}$

$f_n * d_{distributed}$

$$d_{equivalent}(t)^2 = d_{localized}(t)^2 + (f_n * d_{distributed}(t))^2$$

Equivalent Deflection (Deq)

⇖Equivalent deflection criterion was evaluated against 48 paired HIII and PMHS tests

⇖An injury risk curve was proposed based on accident investigations

Equivalent Deflection (Deq)

↳ probability of AIS3+ risk for 45 years

|	Current laboratory study		Accidentological study 📖
	Sternal deflection criterion	Equivalent deflection criterion	Shoulder belt criterion
4 kN belt + airbag	27 %	1 %	1 %
6 kN belt	13 %	11 %	18 %

☞ equivalent deflection criterion predicts risk consistent with accidentological study results

📖Foret-Bruno et al. (2001)

Equivalent Deflection (Deq)

Equivalent Deflection Criterion improves the injury prediction for combined loadings

↳ better than the sternal deflection criterion for the data sample used

↳ using Hybrid III available measurements
　　↳ application in short term
　　↳ potential improvement of its reliability with several thoracic deflection measurements

↳ predicting risk consistent with accidentological study results
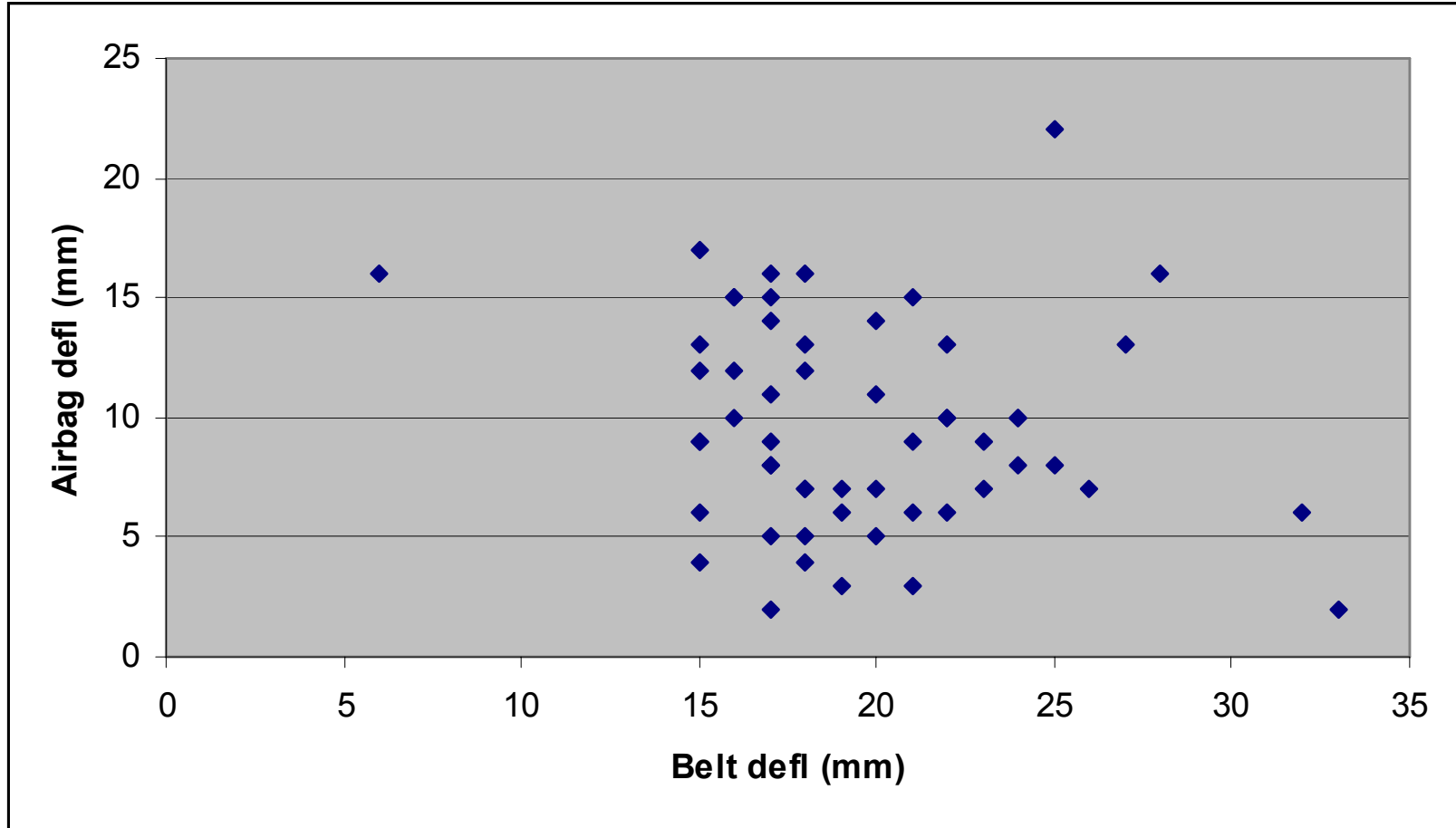　　↳ better protection with 4 kN load-limiting belt plus airbag than with 6 kN load-limiting belt

Equivalent Deflection (Deq)
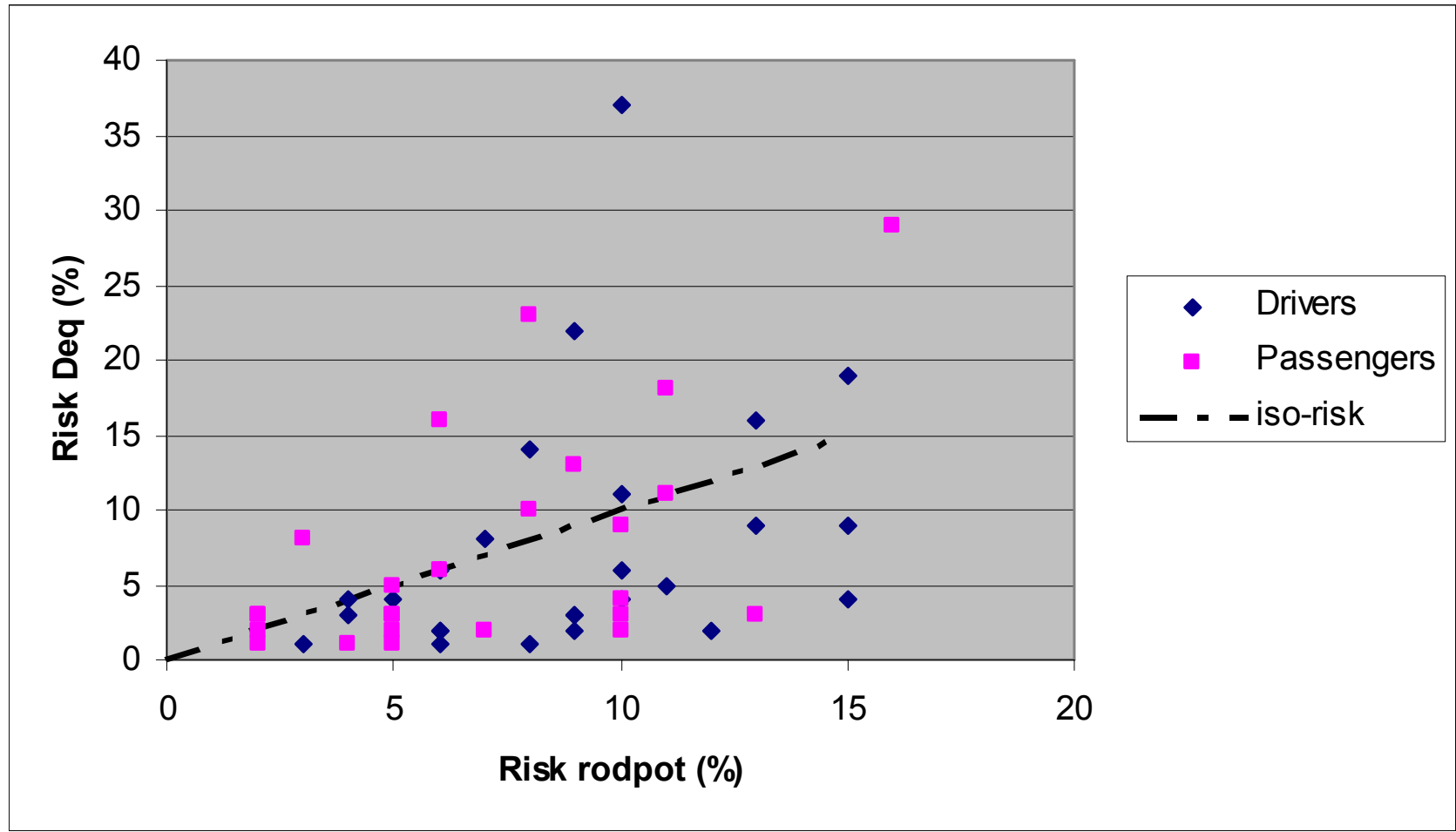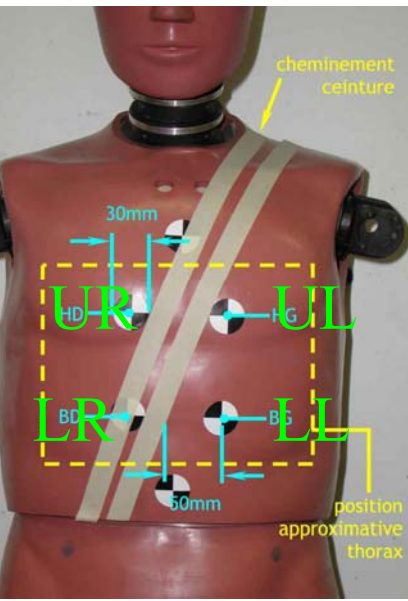
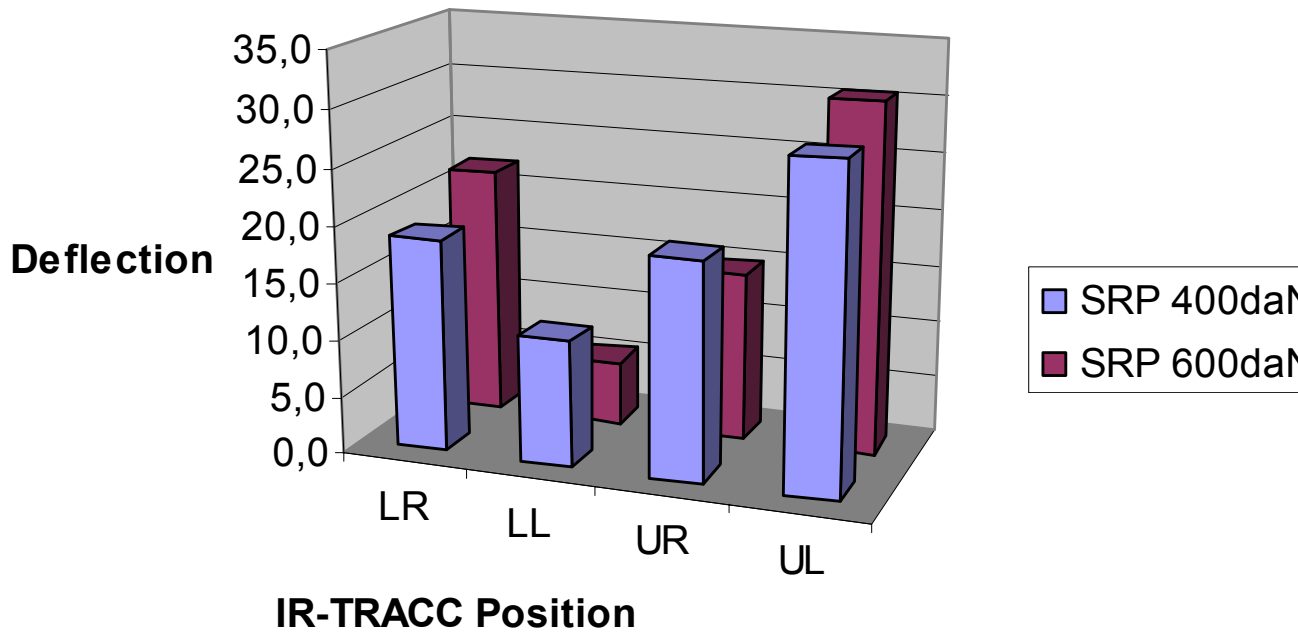# Equivalent Deflection (Deq)
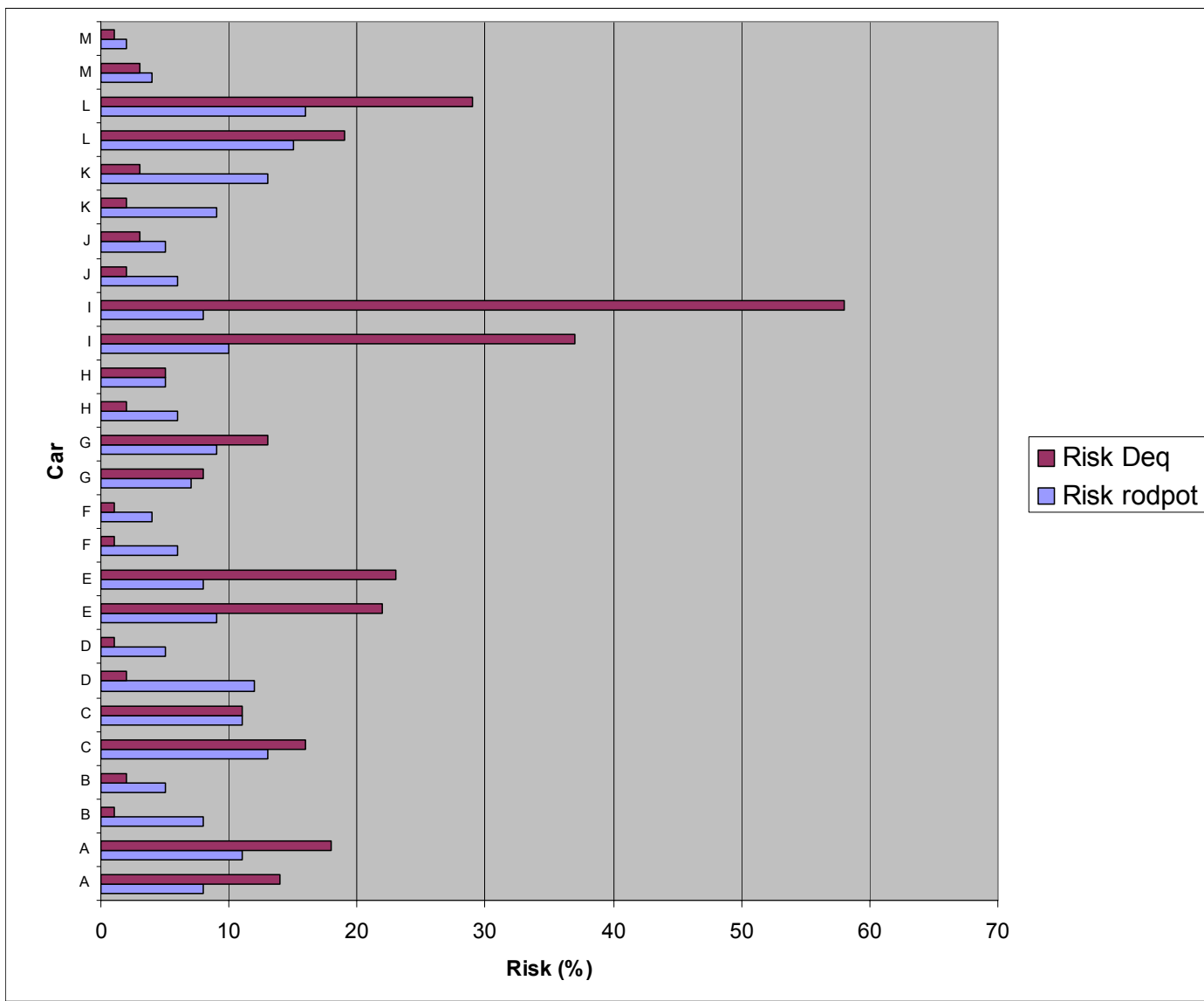
Equivalent Deflection (Deq)

Further analysis

↪ Check hypothesis with updated Human Body Model
↪ Check coefficients with updated data/methods
   ↪ Risque curves from PMHS Airbag loading
   ↪ Relative risk using HBM
↪ Use of THMPHR to better evaluate the real deflection and therefore the accuracy of the Equivalent deflection.
   ↪ The maximum deflection itself does not discriminate belt/Airbag loading
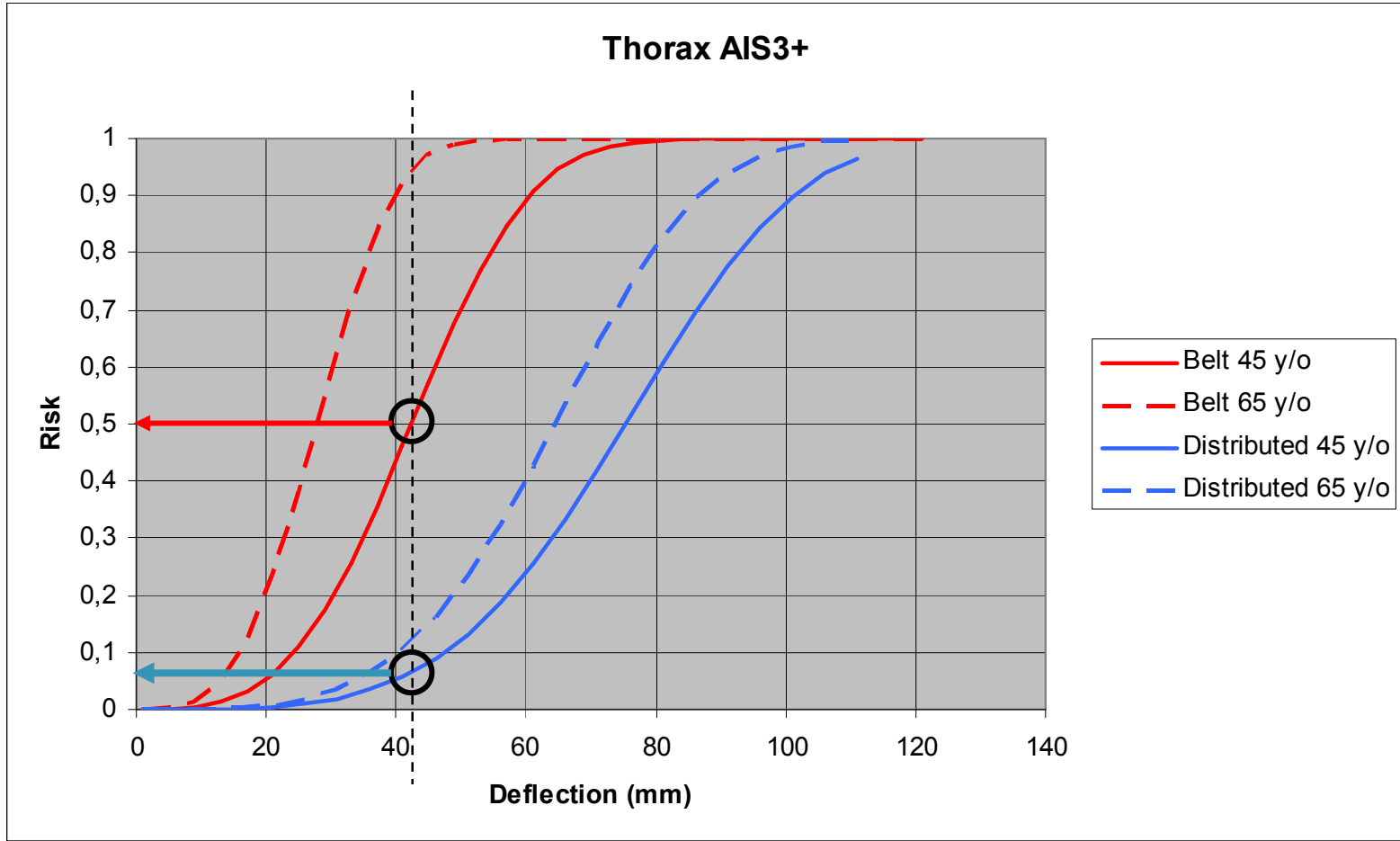   ↪ The THMPHR is complementary to the Equivalent deflection

Equivalent Deflection (Deq)

Variation of deflection versus SRP - THMPHR

Deflection

IR-TRACC Position

SRP 400daN
SRP 600daN

Equivalent Deflection (Deq)

Equivalent Deflection (Deq)

Thorax AIS3+