ETH zürich

Forest Road Network and Pavement Engineering Revisited

FORMEC '15
Linz (AUT)

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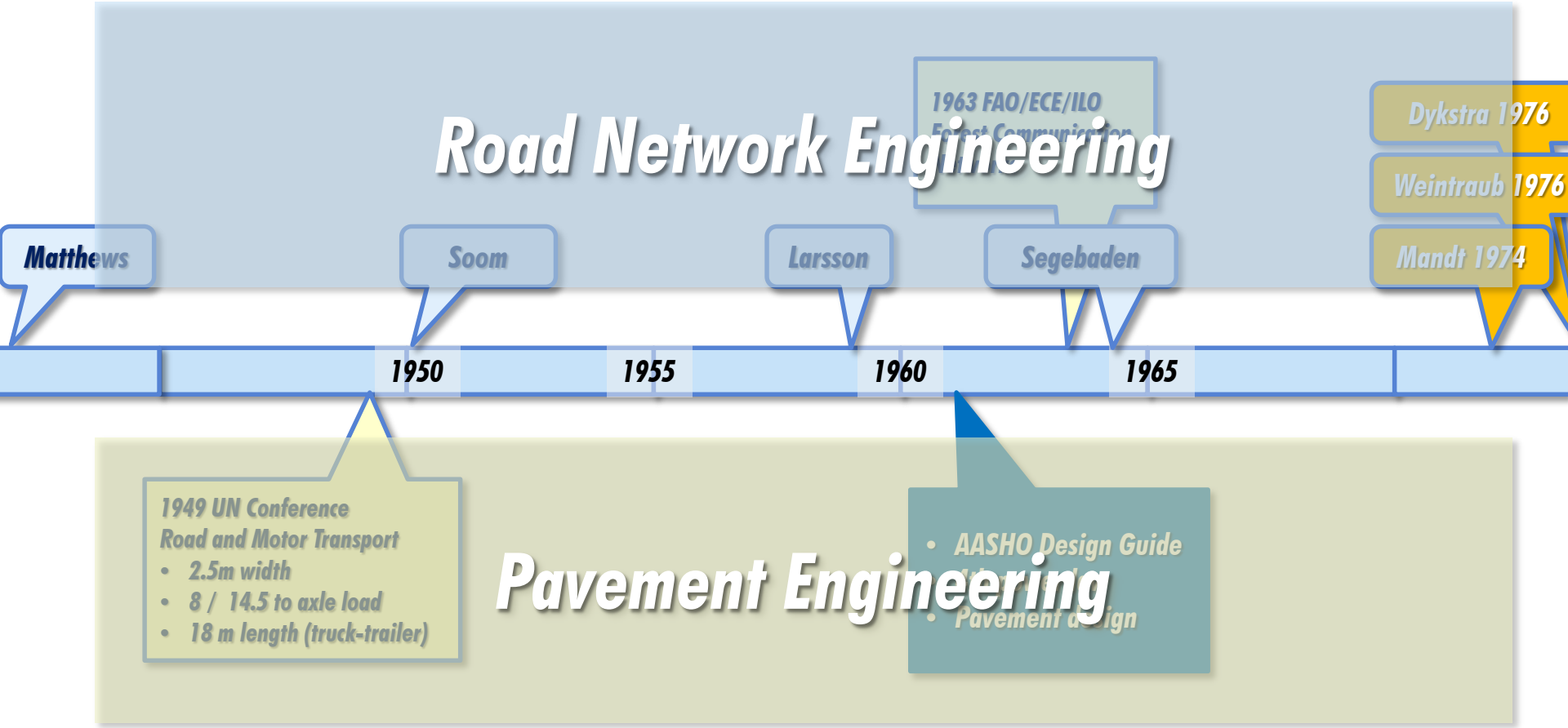
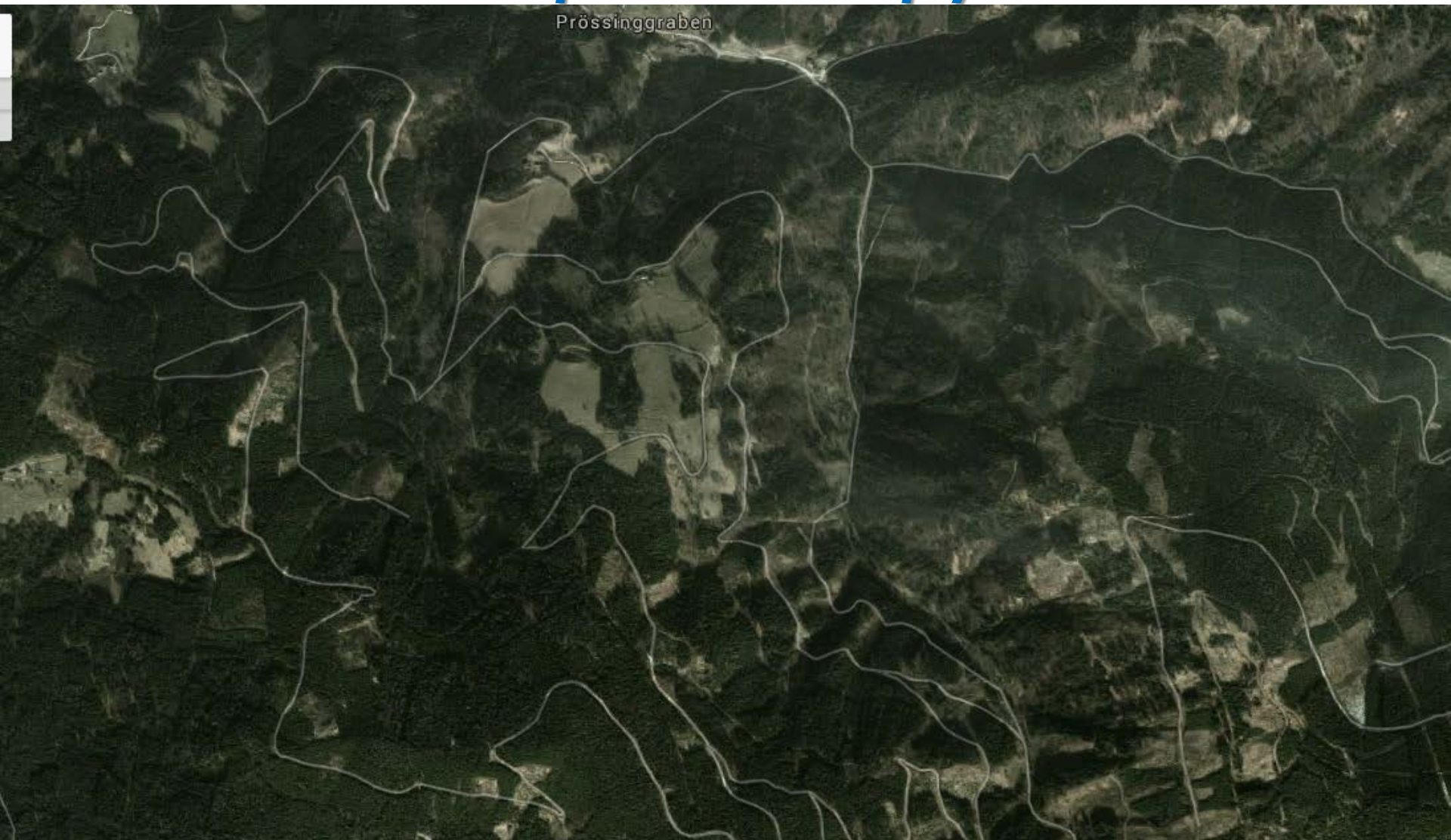
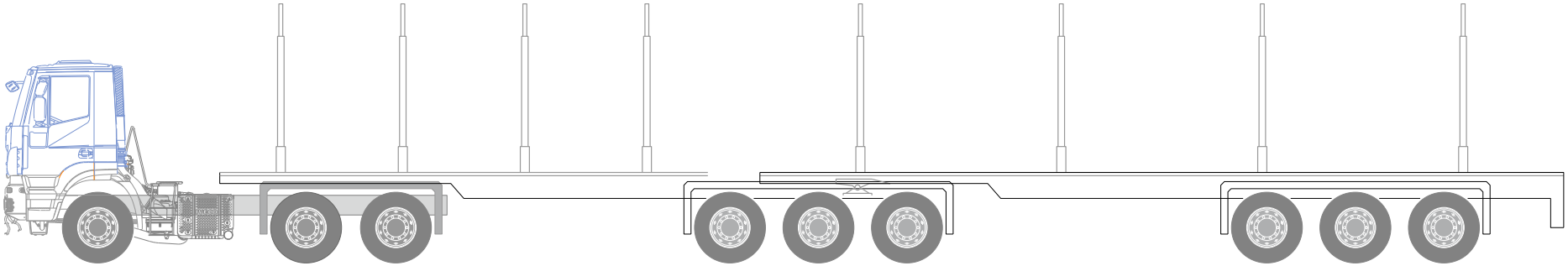
Network and Pavement Design Origins



Road Networks – Built upon 1960 Philosophy?



B-Double Configuration (70to)

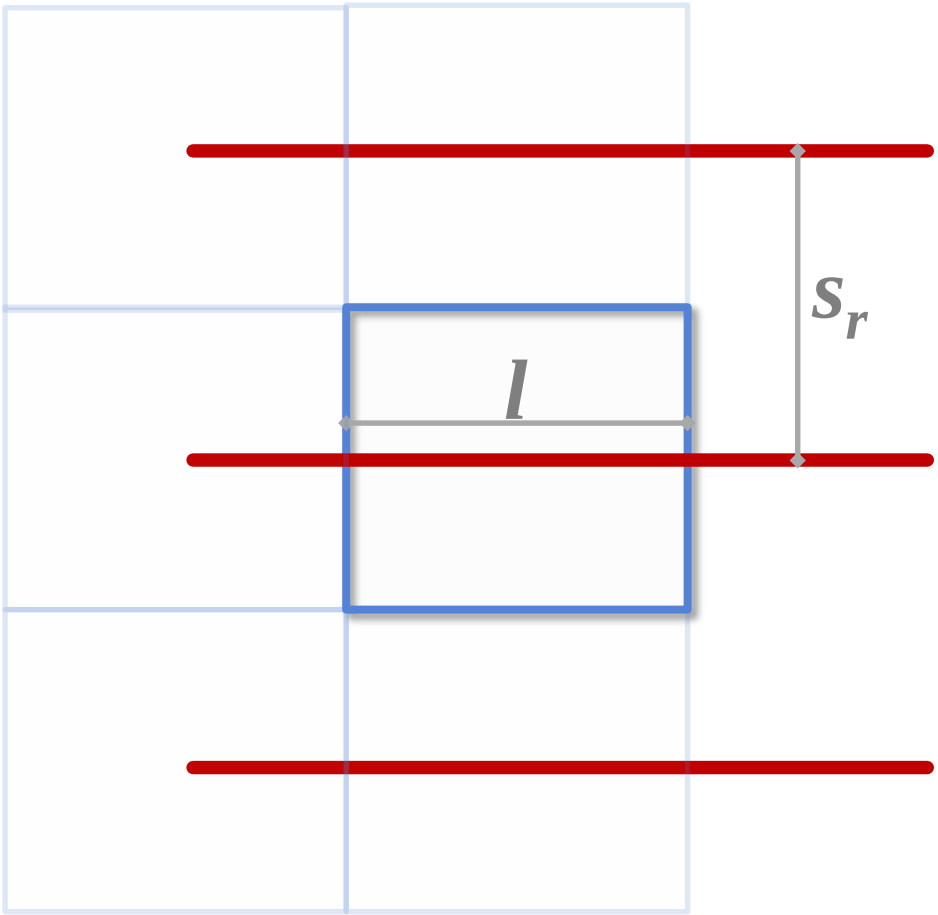


90t Configuration SWE (ab 2009)

Key Questions

- Take part of network out of service?
- Extend the existing network?
- Upgrade existing roads?
- Adapt pavement structure to traffic and vehicle requirements?

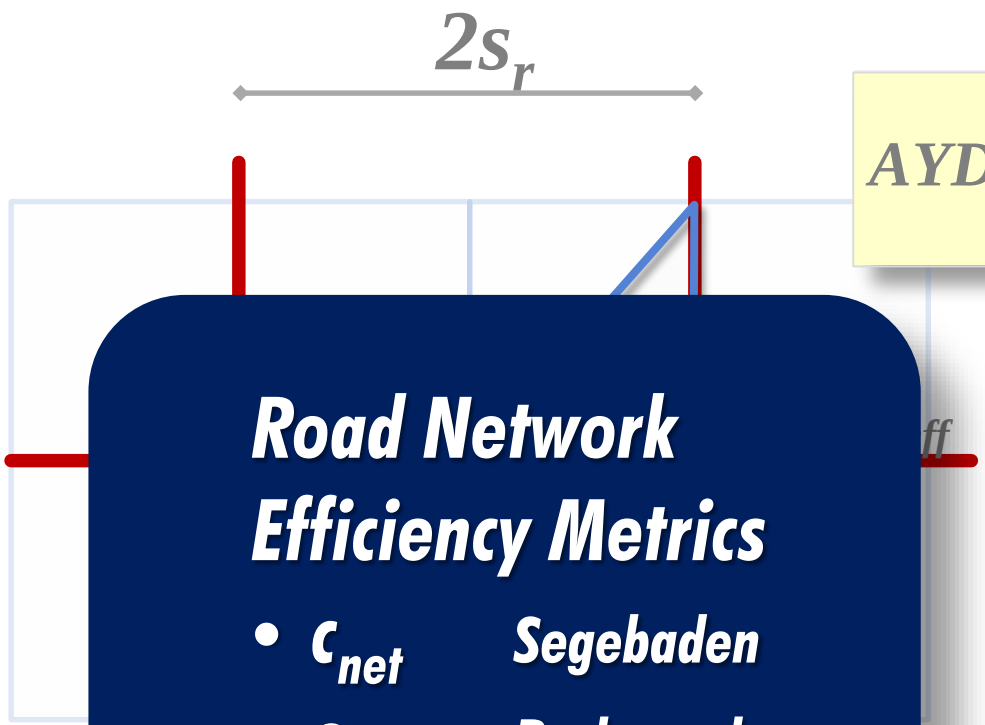
Road Network Geometry – Matthew's World



$$RD_r = \frac{l}{l \cdot s_r} = \frac{1}{s_r}$$

$$AYD_{theor} = \frac{s_r}{4} = \frac{1}{4 \cdot RD_r}$$

Non-parallel Road Networks – Segebaden's World



$$AYD_{theor} = \frac{1}{4 \cdot RD_r} = \frac{4 \cdot s_r^2}{4 \cdot 4 \cdot s_r} = \frac{s_r}{4}$$

$$AYD_{eff} = \frac{s_r}{3}$$

Road Network Efficiency Metrics

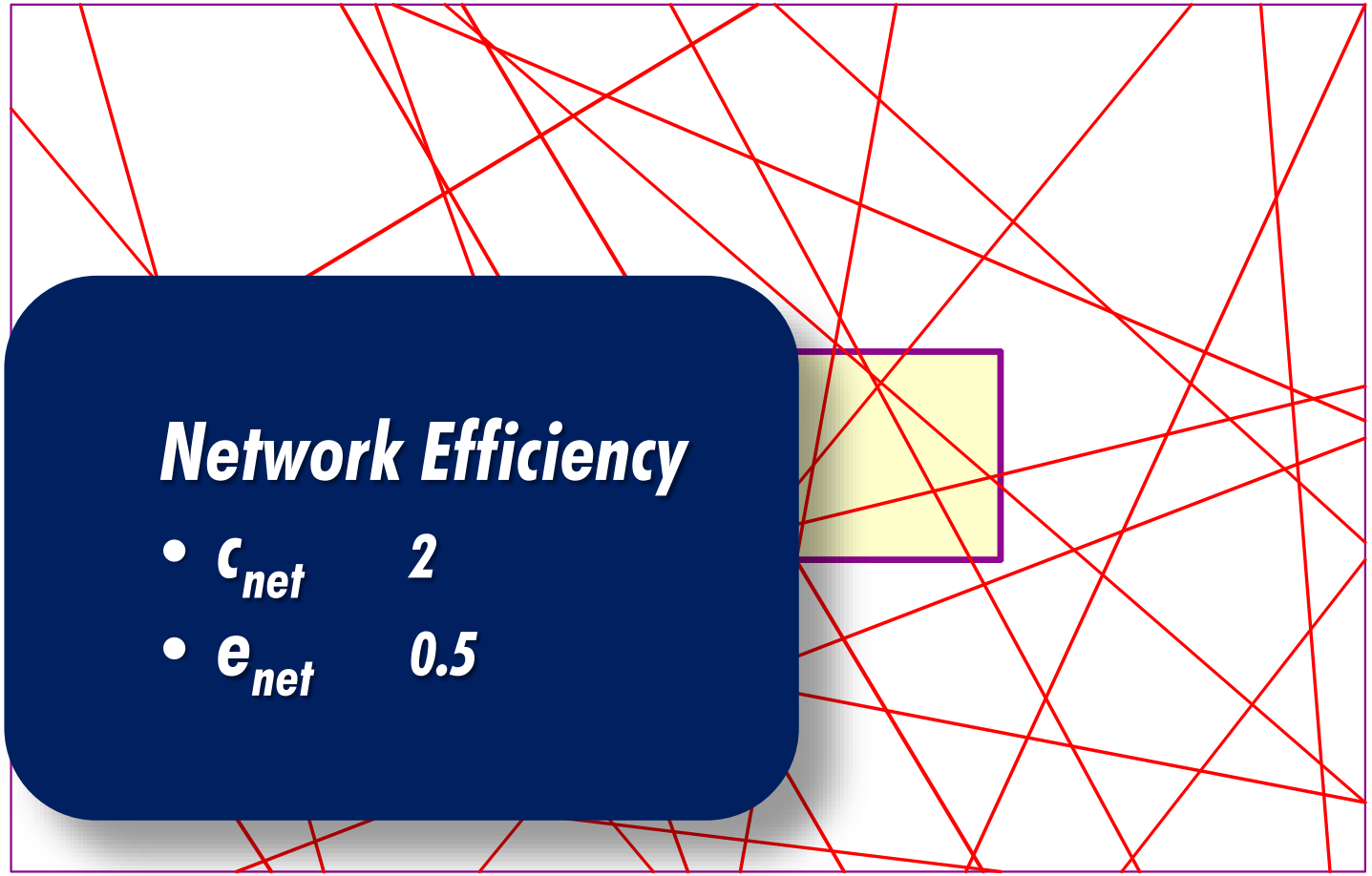
- c_{net} Segebaden
- e_{net} Backmund

$$c_{net} = \frac{AYD_{eff}}{AYD_{theor}} = \frac{s_r \cdot 4}{3 \cdot s_r} = 1\frac{1}{3}$$

$$e_{net} = \frac{AYD_{theor}}{AYD_{eff}} = \frac{3}{4}$$

Backmund

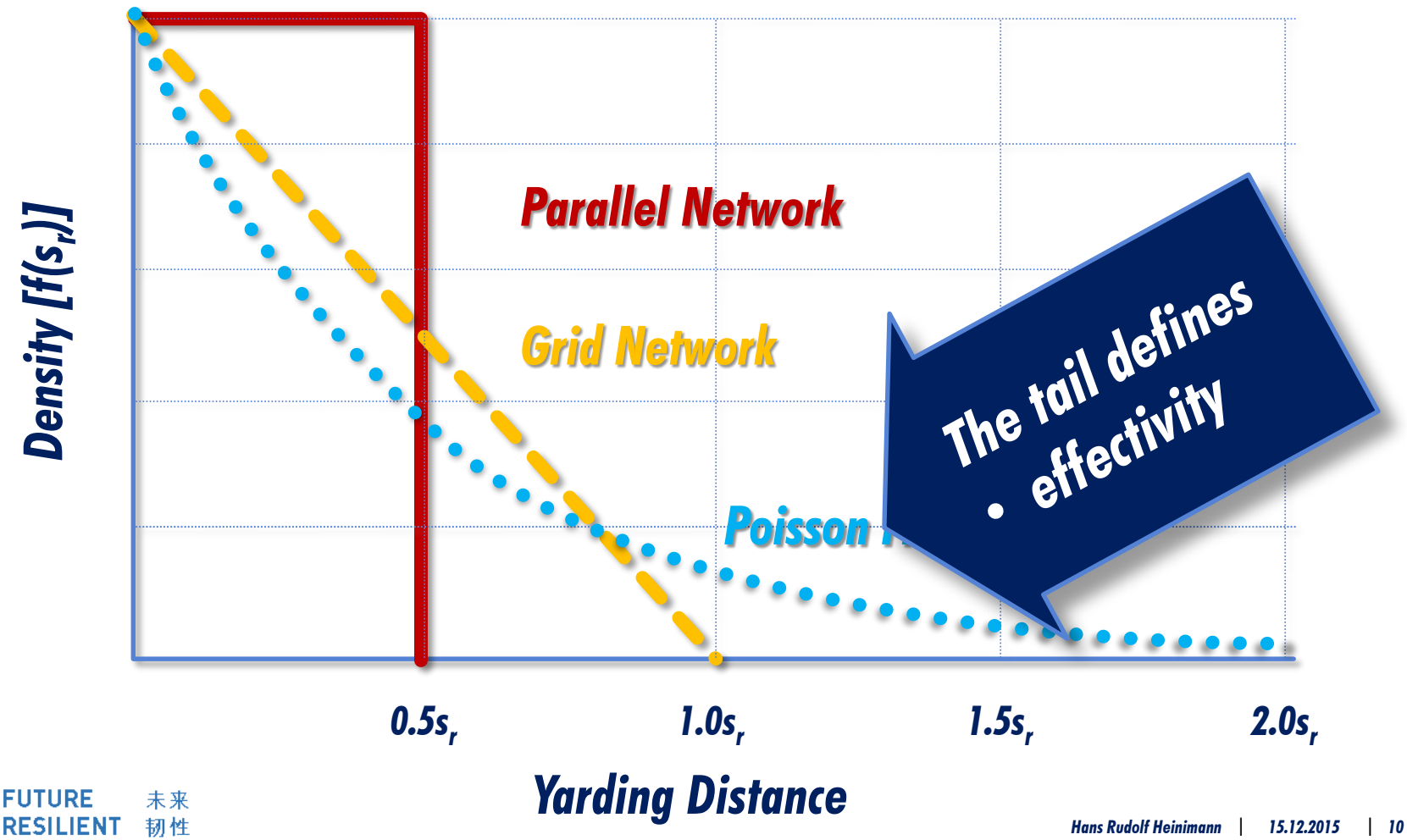
Non-Parallel Road Networks – Poisson World



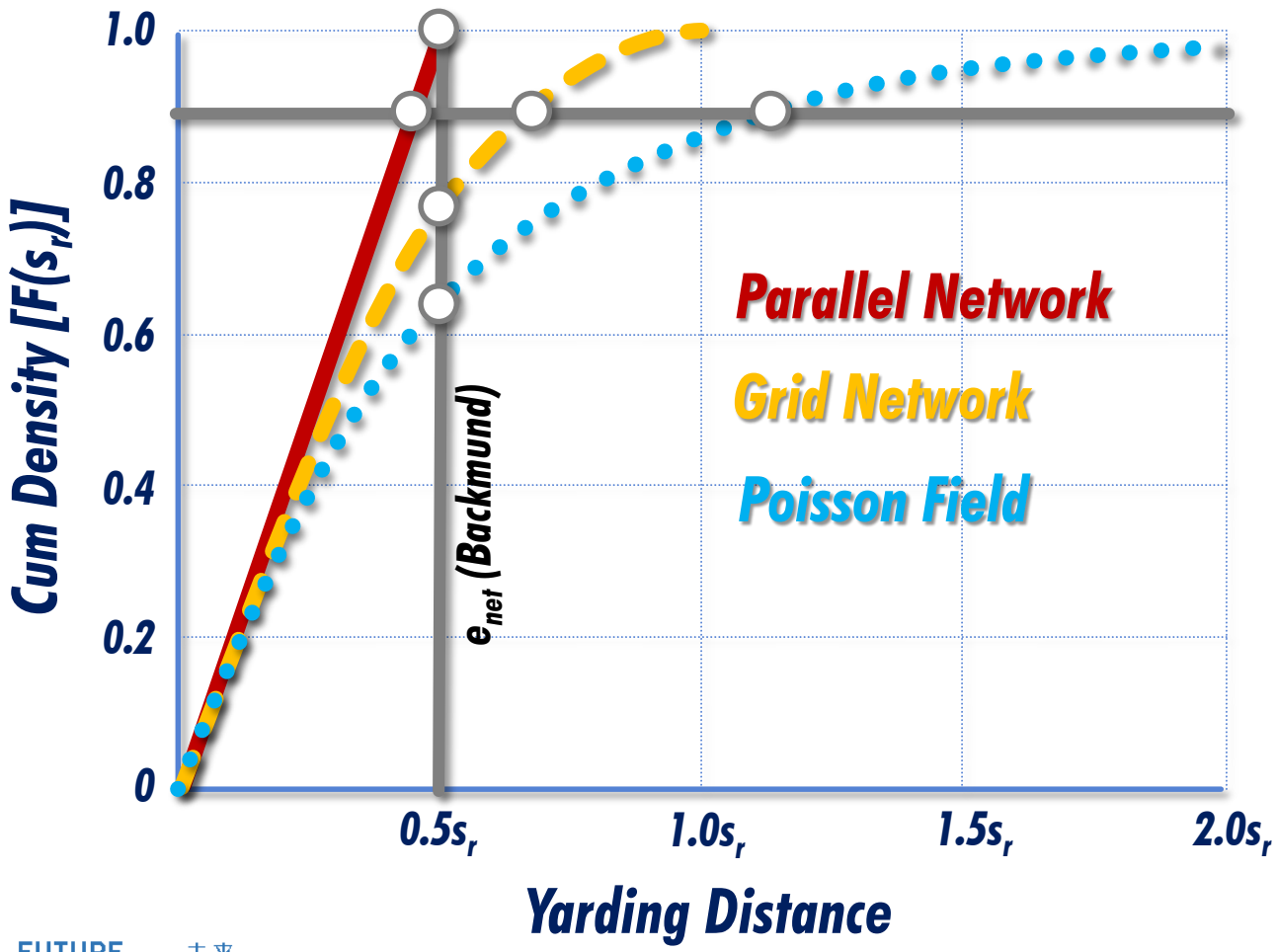
Network Efficiency

- c_{net} 2
- e_{net} 0.5

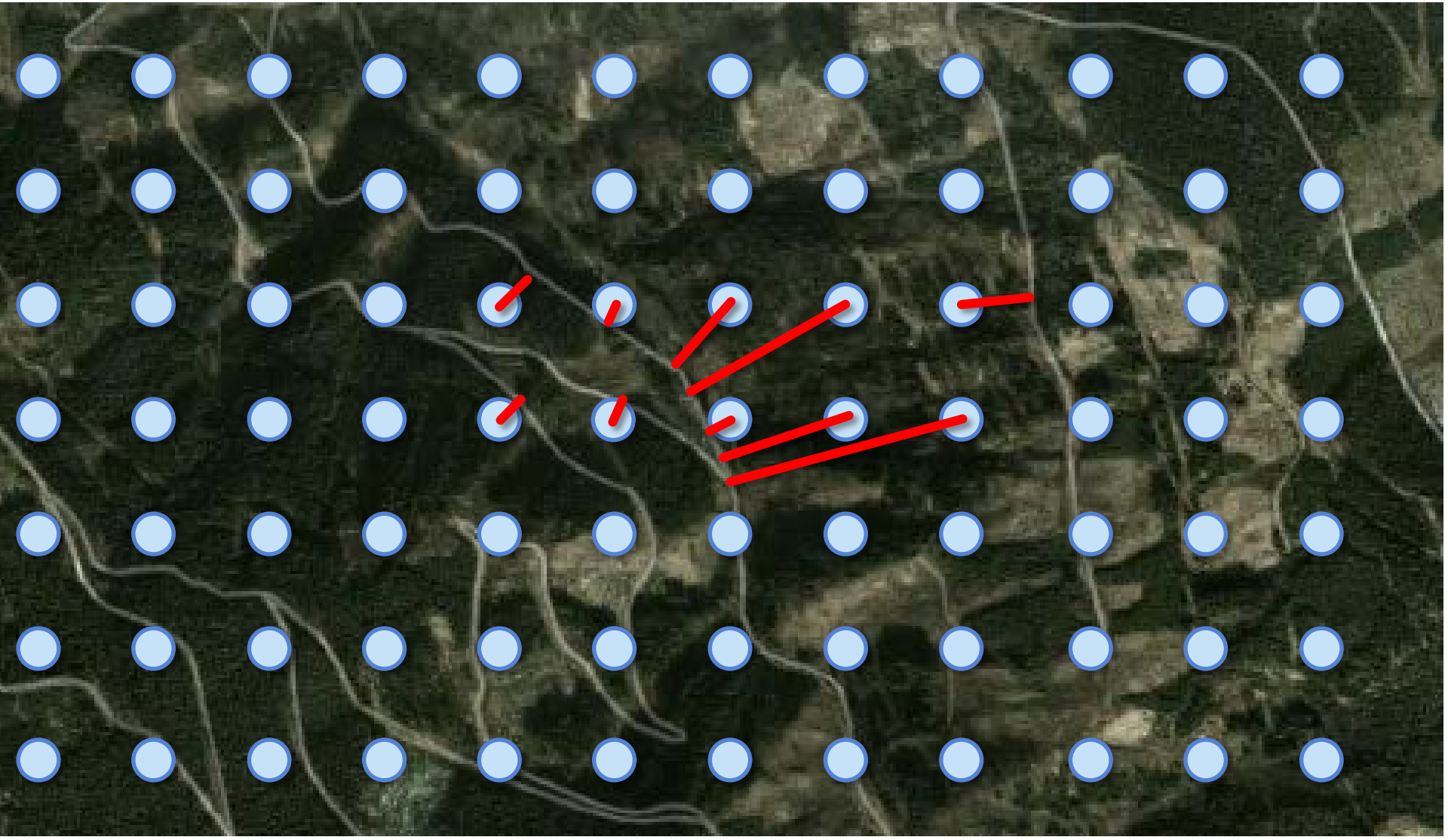
YD - From Mean Values to Distributions



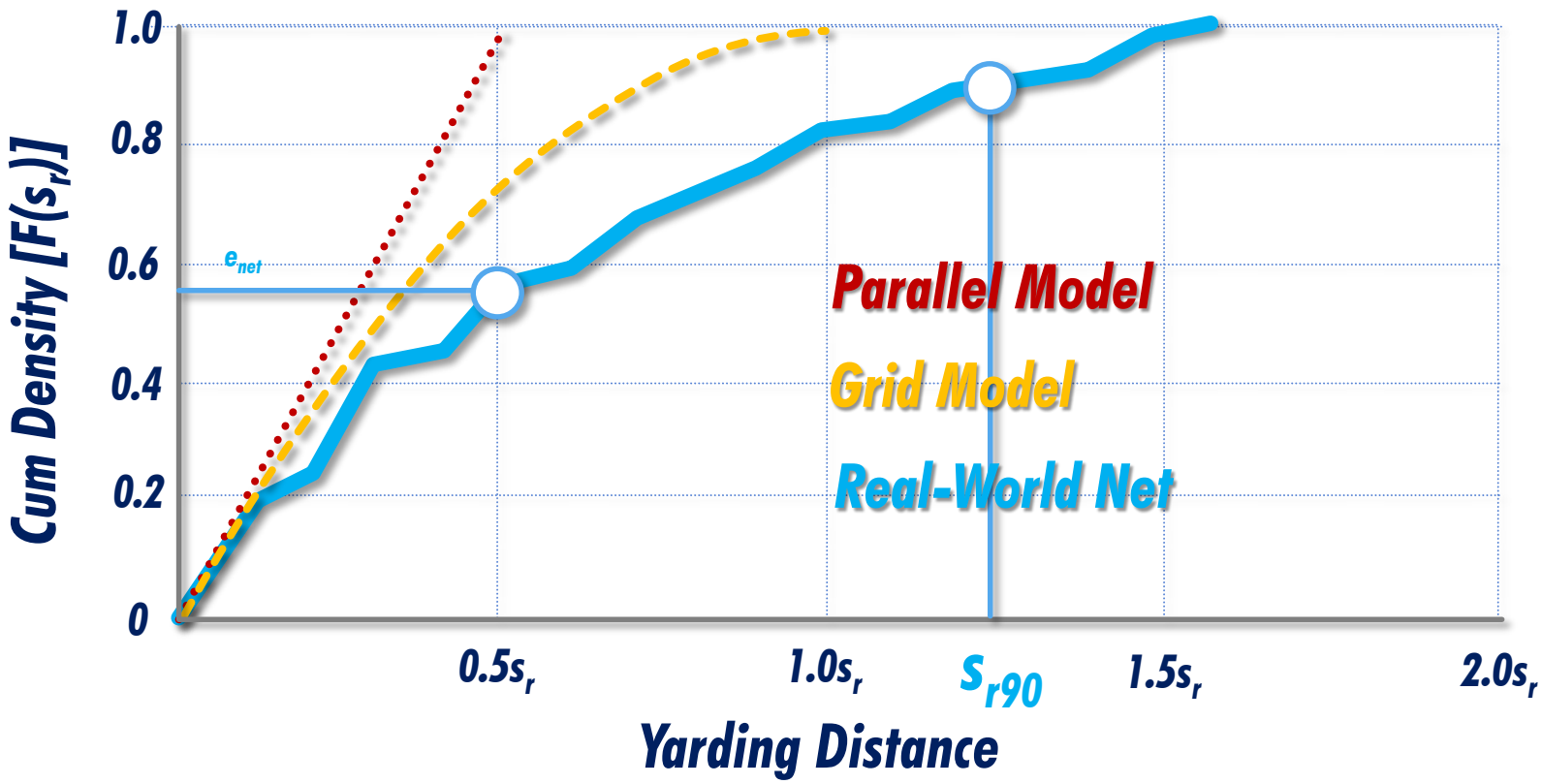
YD – Distribution Functions



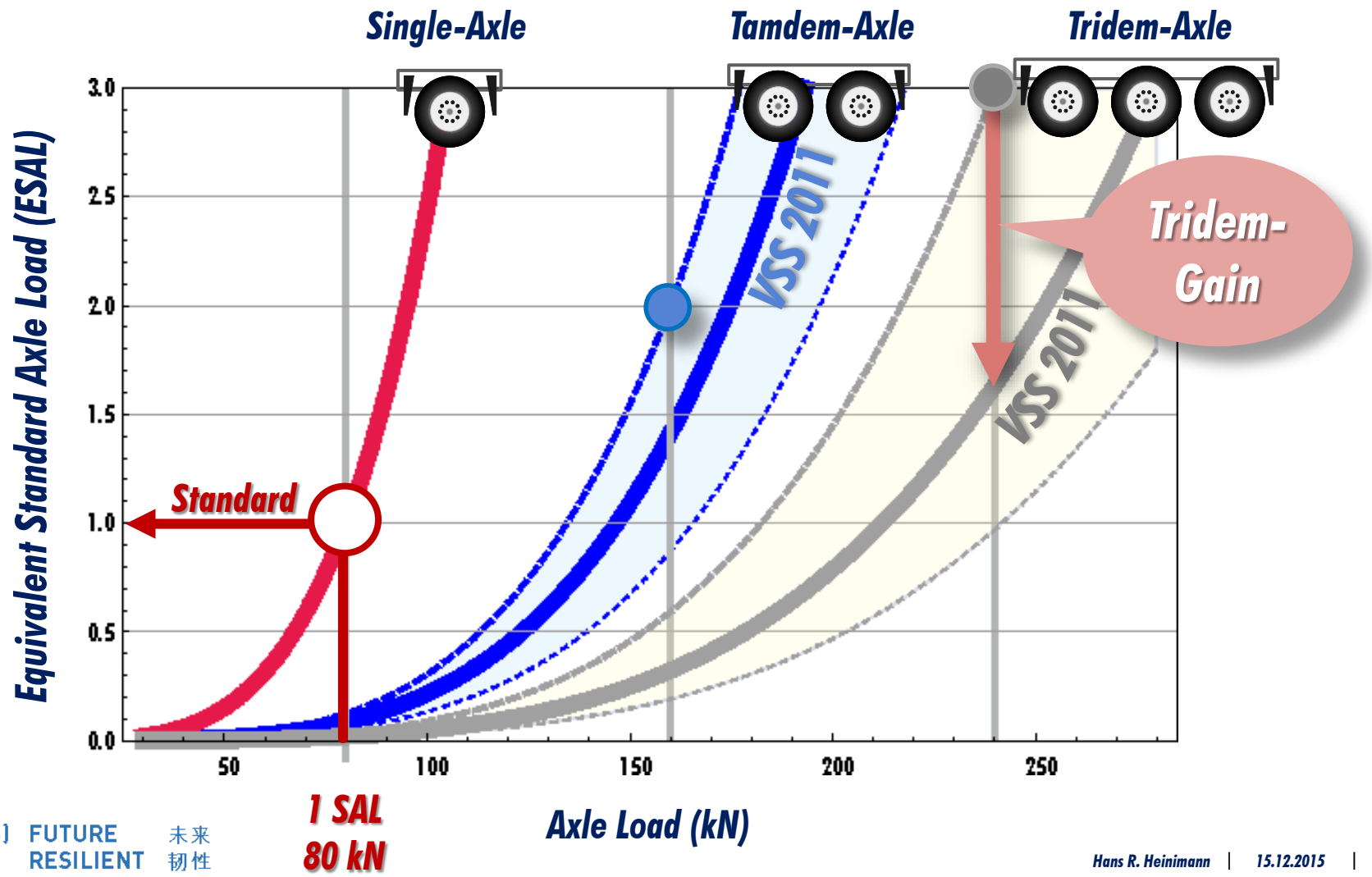
Road Networks Assessment?



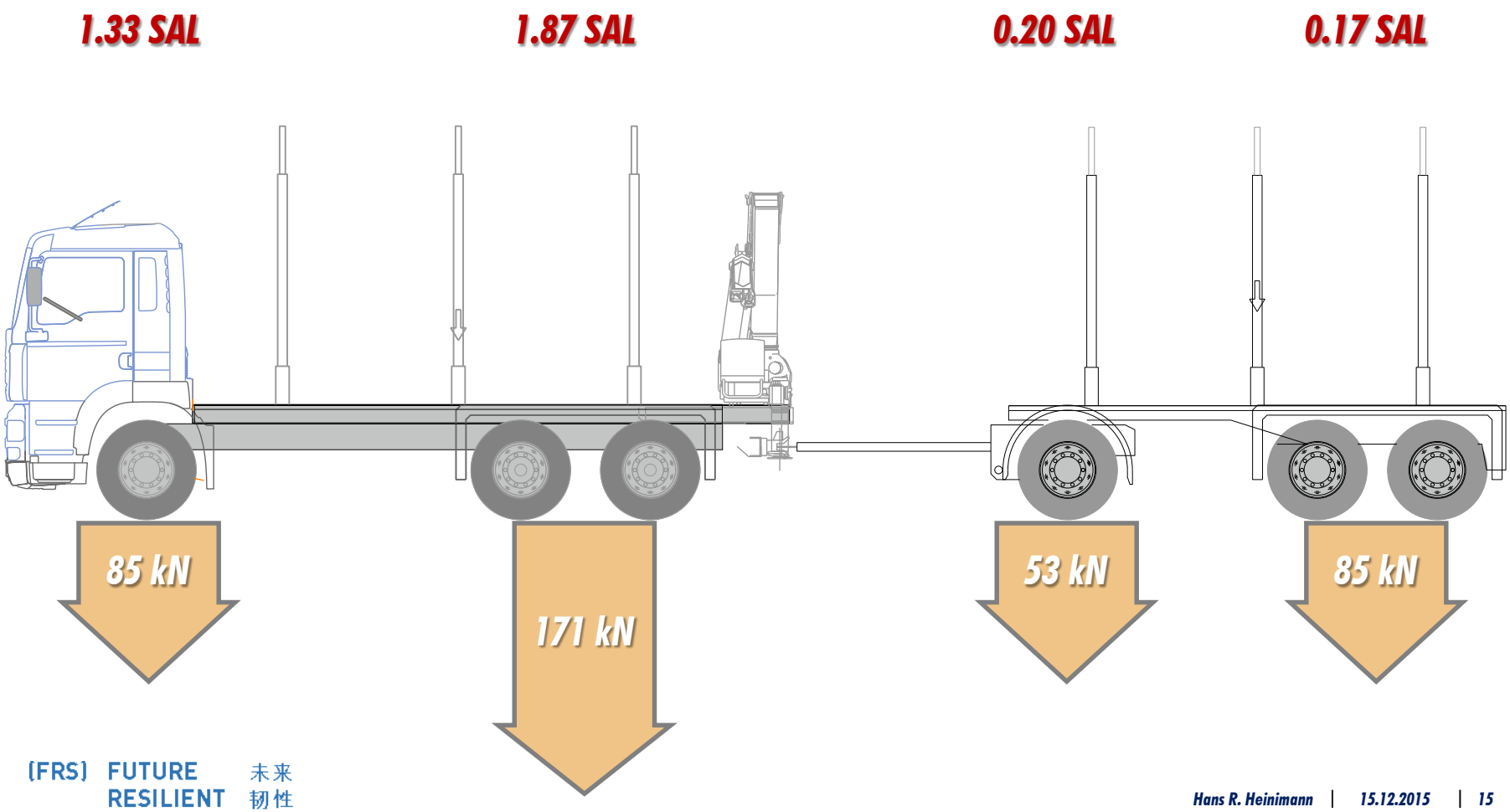
Real-World Example



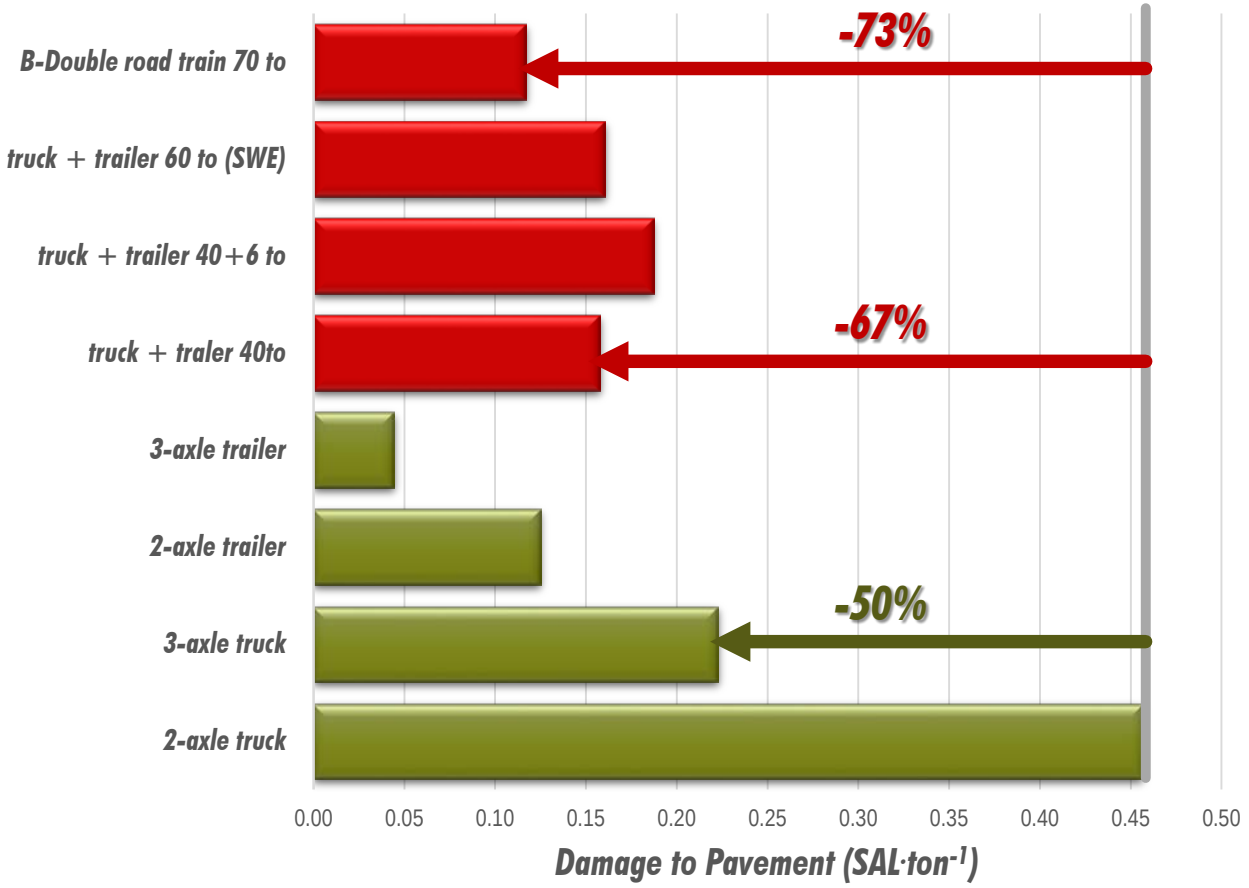
4th-Power Law



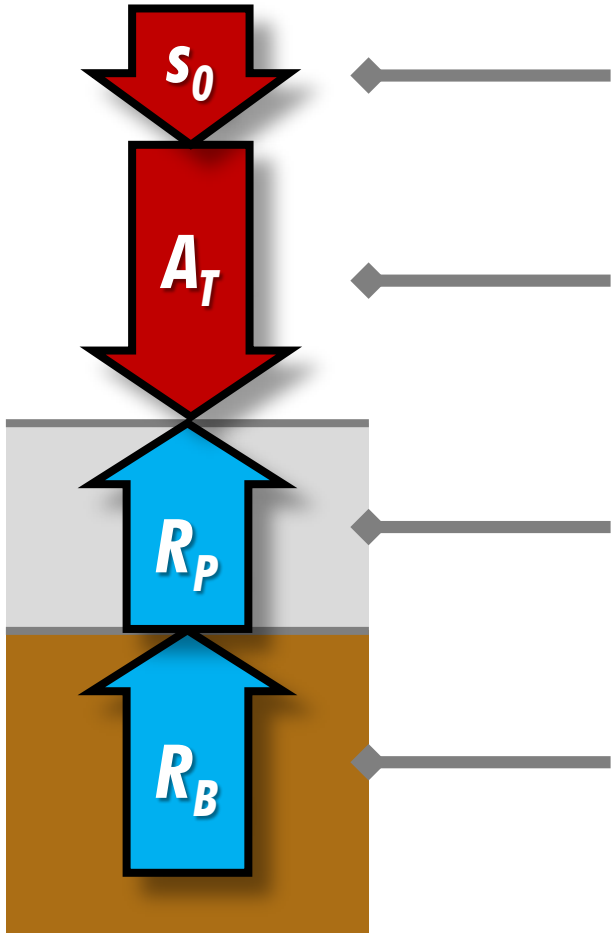
40to Truck-Trailer System



Damage to Pavement Effects of Different Vehicle Configurations



AASHTO Pavement Design Aproach



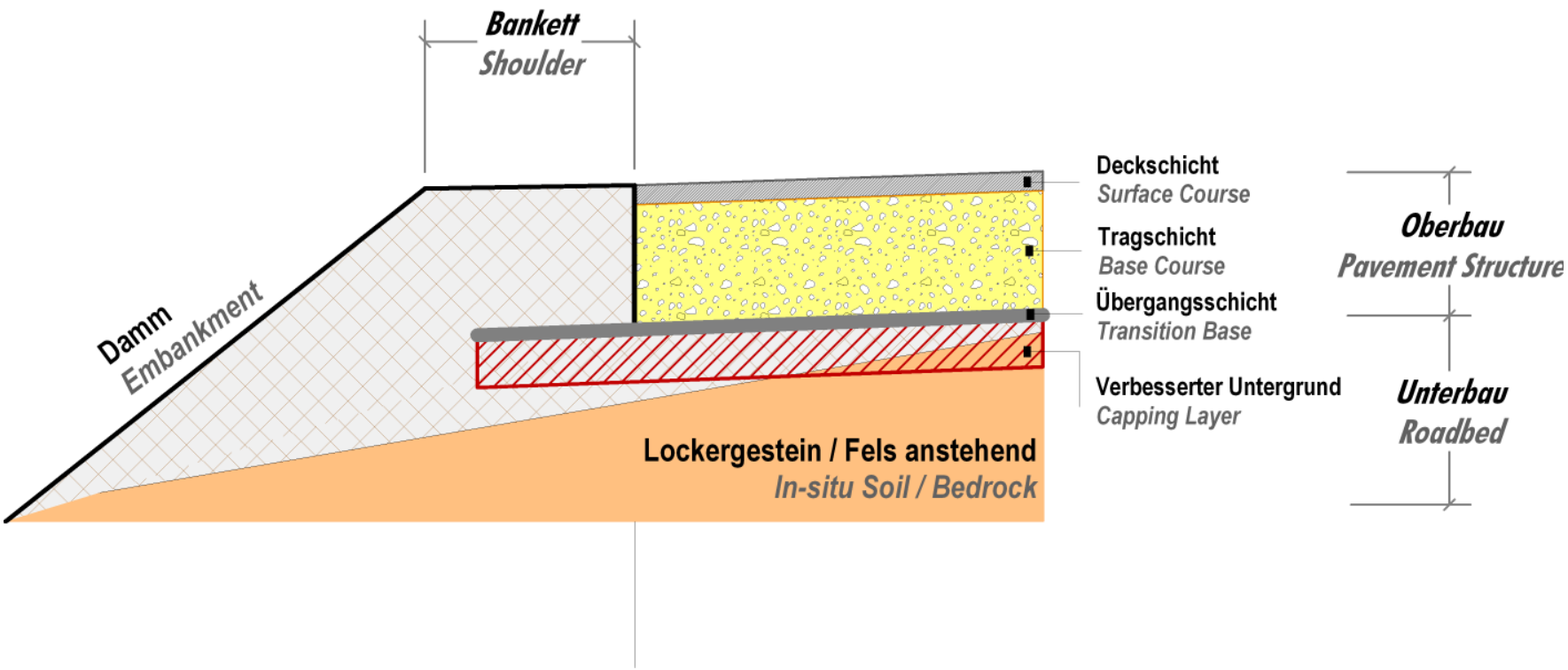
Uncertainties	$s_0 \cdot z_R$	Error (ESAL + Perf)
Traffic	ESAL	Equivalent Standard Axle Load
Pavement Bearing Resistance	SN	Structural Number
Soil Bearing Resistance	M_r	Resilient Modulus
	CBR	California Bearing Ratio

LVR Pavement Design [AASHO Guide 1973, simplified]

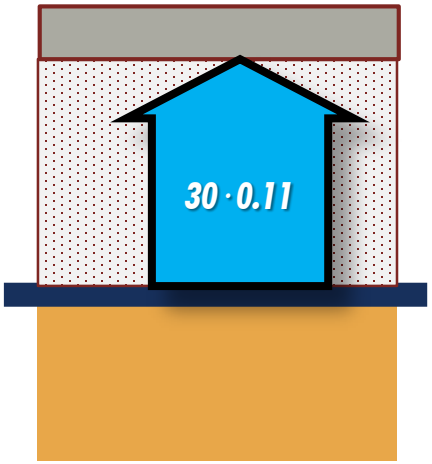
$$SN = \frac{12.04 \cdot e^{-0.24 \cdot s_0 \cdot z_R} \cdot ESAL^{0.11}}{M_r^{0.25}} - 2.54$$

Where	$ESAL$	=	Characteristic value of traffic actions
	M_r	=	Resilient Modulus (kPa)
	s_0	=	standard normal derivate
	z_R	=	Error (ESAL + Performance)

Pavement – Structural Elements

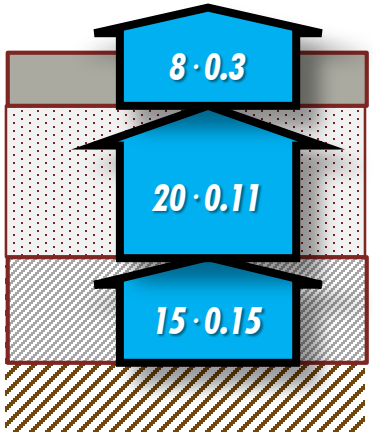


Pavement Design



8 cm	SC	Unbound Aggregate UG 0/22	0
30 cm	BC	Unbound Aggregate UG 0/63	3.3
	TB	Geotextile, if CBR < 3%	0

SN = 3.3



8 cm	SC-BC AB 16 TDS L		2.4
20 cm	TS	Unbound Aggregate UG 0/63	2.2
15 cm	TB	Lime Stabilization	2.2

SN = 6.8

Conclusions

- Characterization of Road Networks
  - From means to distributions
  - The tail of YD distributions defines network effectivity and efficiency
  - Assessment GIS-based, yielding the CDF
- 4th-power law
  - Vehicle configurations with tandem and tridem axles!
  - ESAL metric
- Pavement design
  - AASHTO 1993 Guide
  - Standardization of aggregate materials