



An International Experience on the Safety Performance of 2+1 cross-section

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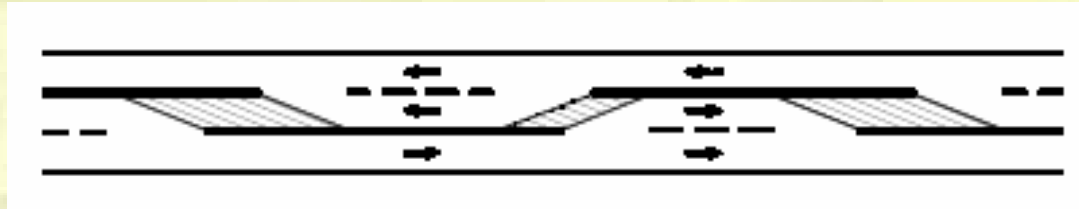
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What is a 2+1 cross-section?

- It's a 3 lane rural road
- It provides alternating passing lanes



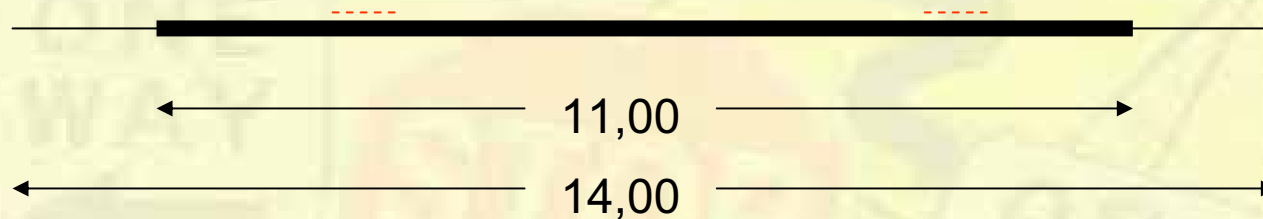
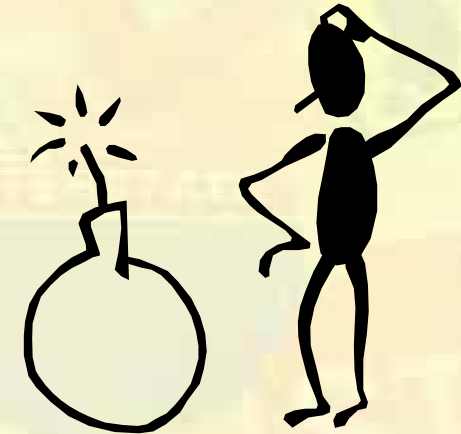
Why is it important?

- It can accommodate traffic volumes up to ca. 25.000 sometimes even 30.000 veh/day (**intermediate** cross-section between 2-lane and freeways)
- At least **two levels of service higher** than conventional 2 lane highways
- Most Important, it can resolve **safety** problems of 2-lane normal or wide lane width



Existing Wide Pavements

e.g.



**In General Two Times less Safe
than 2+1 cross sections**





Safety Ranking (D)

Roadway type	ADT (veh/day)	Accident rate (per 10 ⁶ veh-km)	
		Fatal and injury accidents	Fatal, injury, and serious PDO accidents
6-lane freeway	61,000	0.13	0.35
4-lane freeway	31,000	0.13	0.39
4-lane divided highway with wide shoulders	19,500	0.15	0.37
4-lane divided highway	16,600	0.19	0.39
4-lane undivided highway	12,100	0.21	0.39
2+1 roadway	14,100	0.16	0.28
2-lane highway with wide lanes	11,900	0.28	0.49
2-lane highway with wide shoulders ^a	9,800	0.19	0.35
2-lane highway (conventional)	10,300	0.25	0.39
2-lane highway (narrow lanes)	3,500–6,300	0.22–0.44	0.39–0.71

^a With paved shoulders wide enough that they can be used for passing.
PDO = property damage only.

Very Interesting!

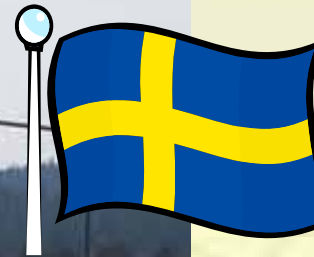


International Experience

GERMANY



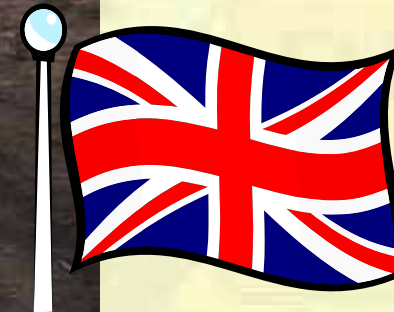
Sweden



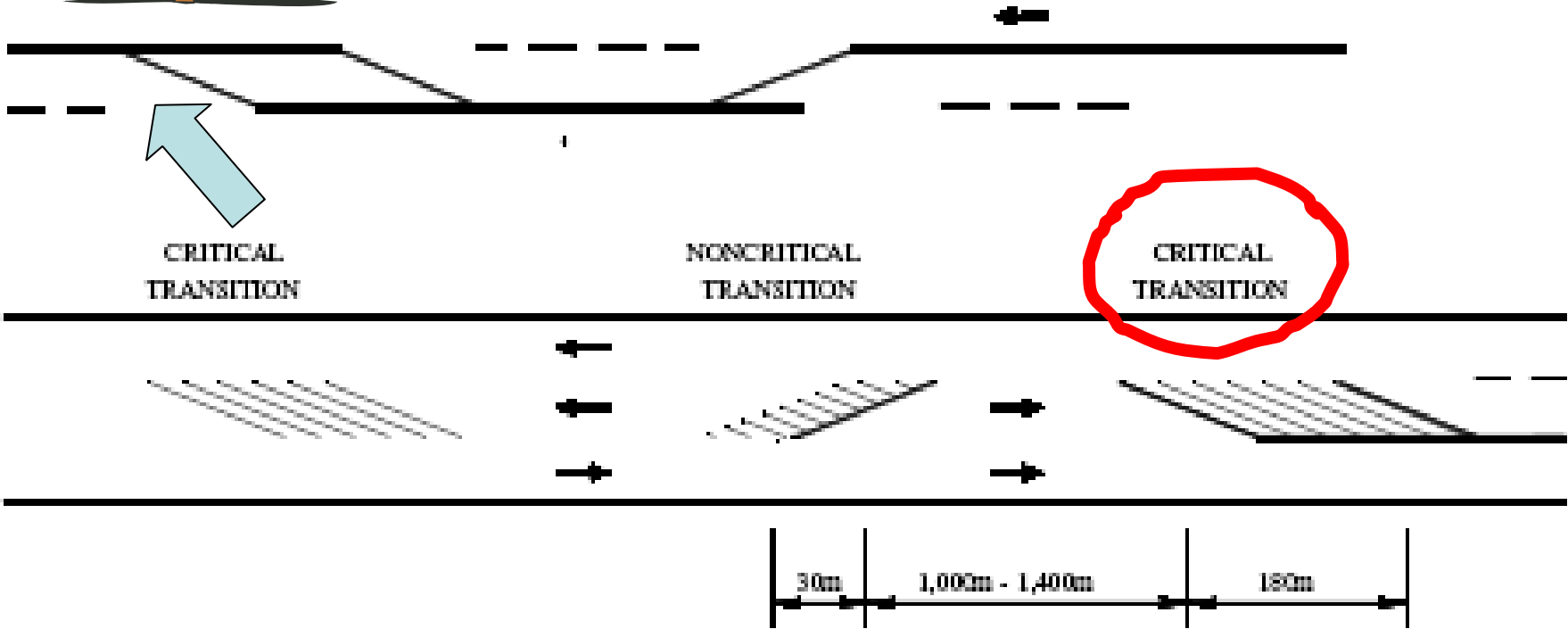
Finland



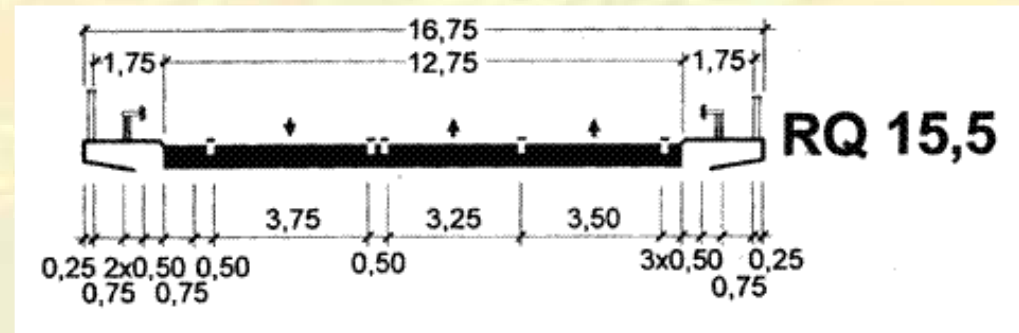
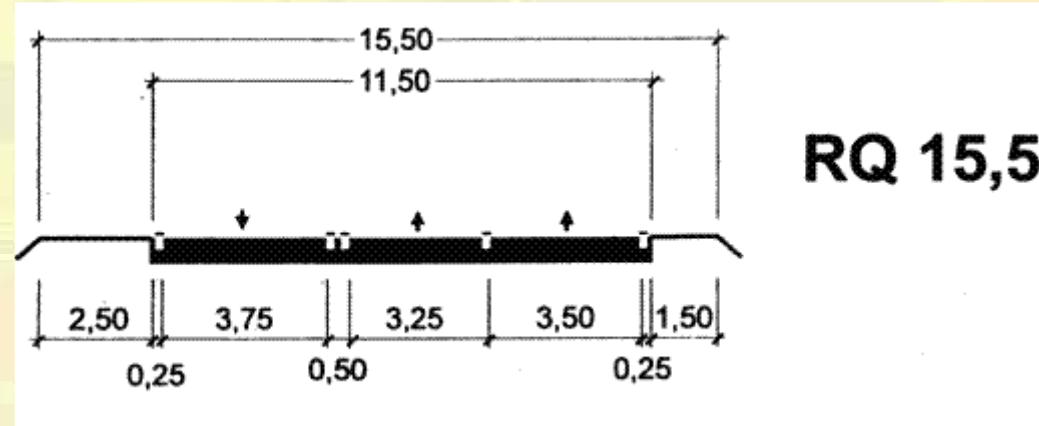
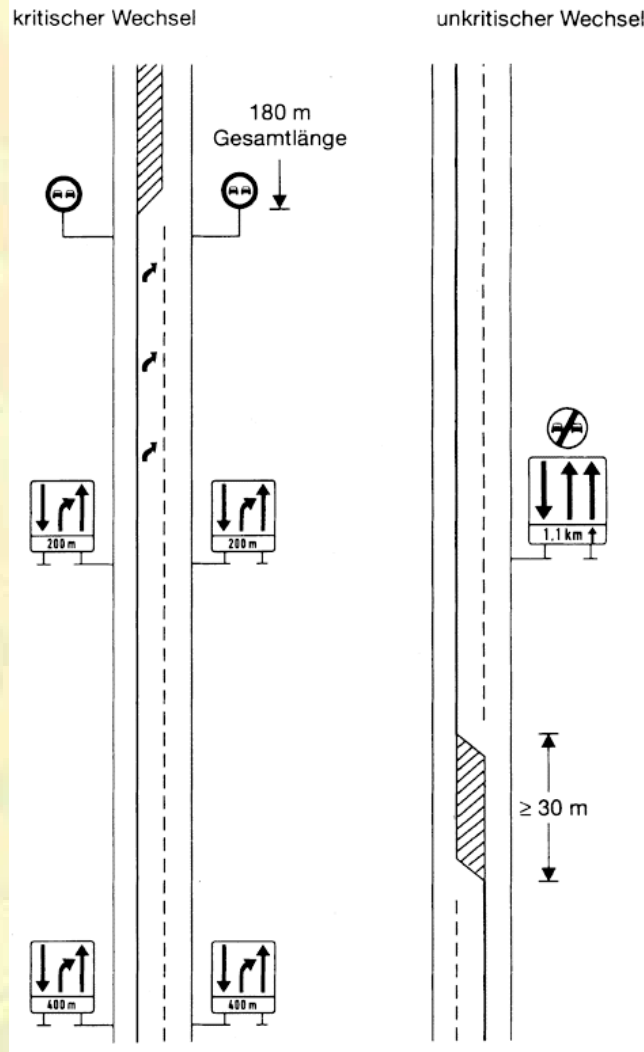
United
kingdom



Design Issues



Geometric Design



Geometric Design



- ~ up to 20000 veh/day
- 2-lane section at least 1000m long
- Critical Transition length >120 m
- Non-Critical Transition length ~ 30 m
- 1,5 m hard shoulder could be considered
- 0,5 m separation without barrier



Geometric Design Separation

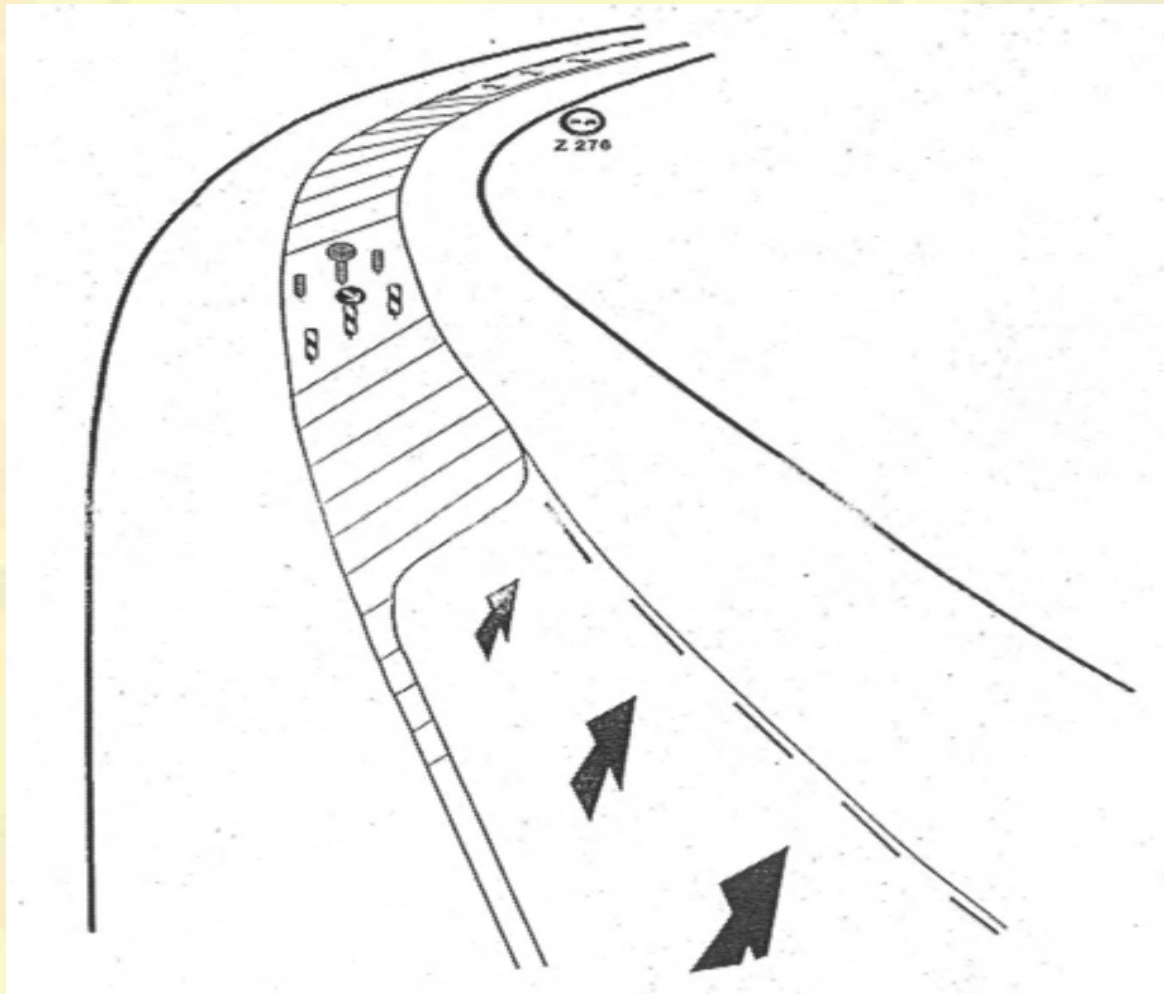


7 mm profiled
markings

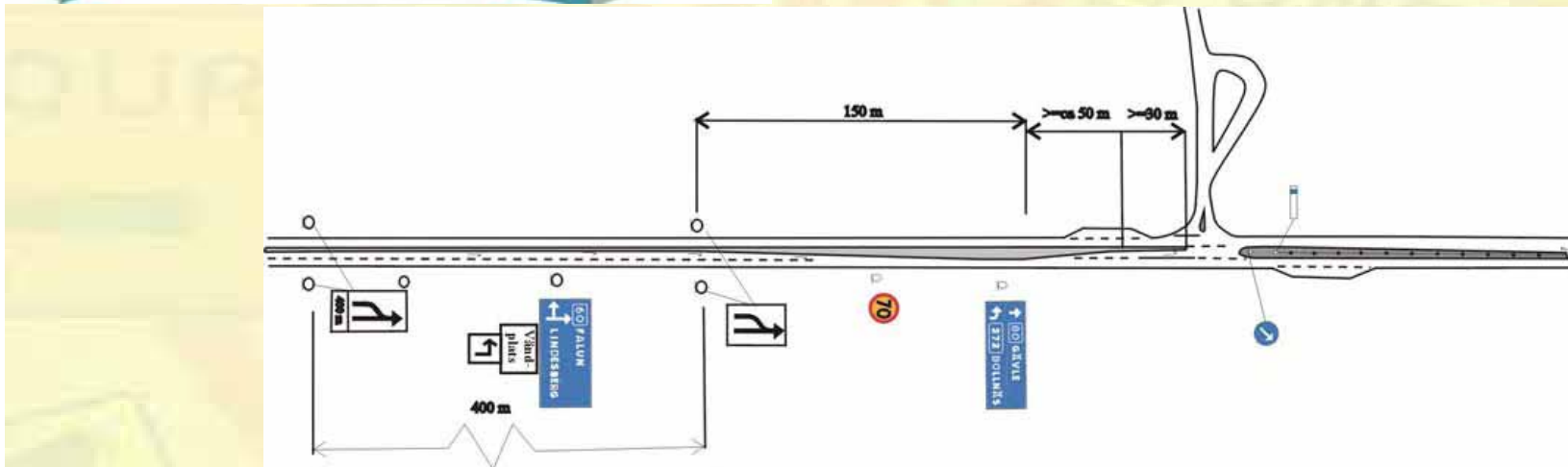
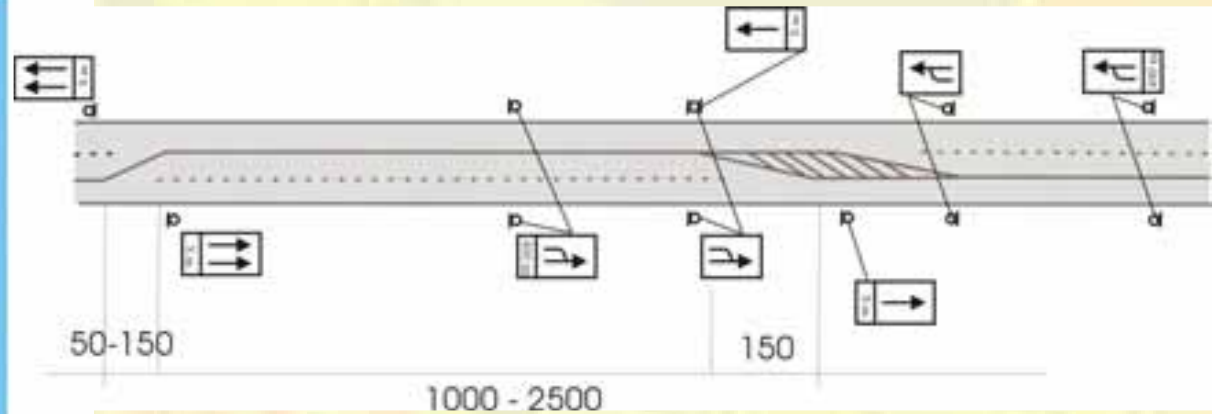
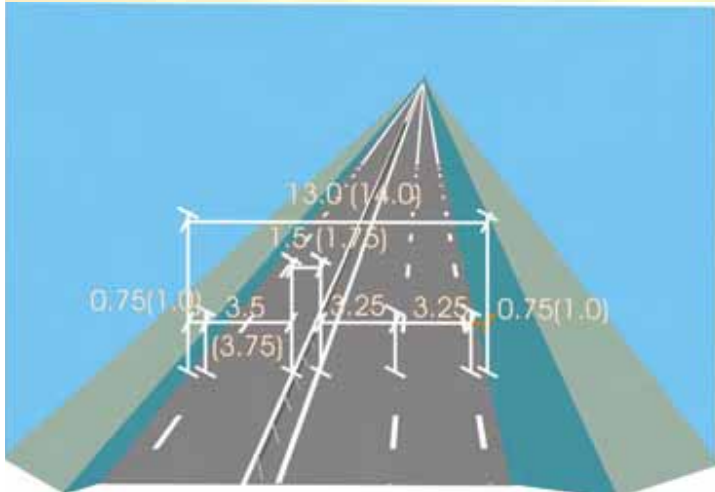


Geometric Design

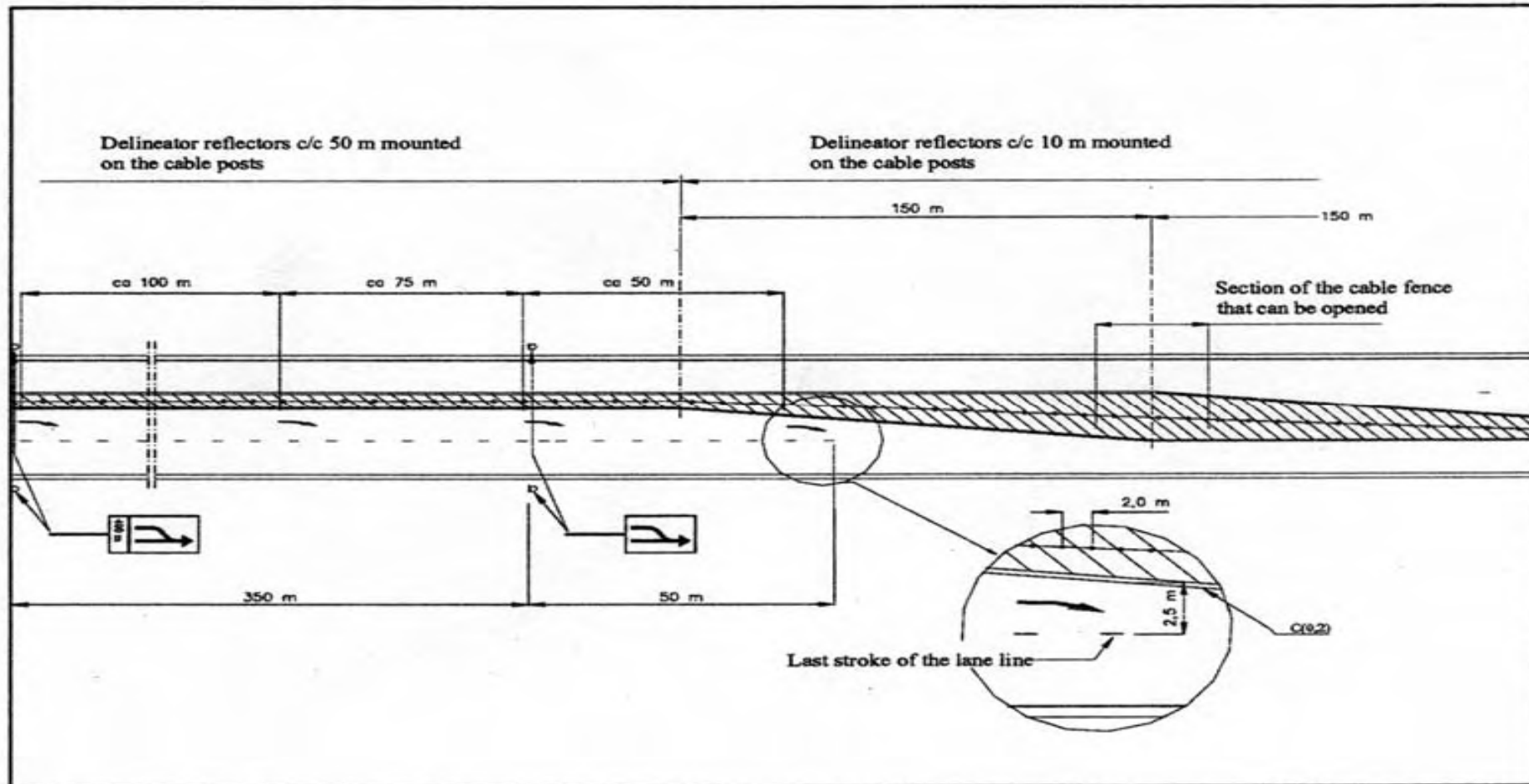
Critical Transition Warnings



Geometric Design



Geometric Design Transition Detail



Geometric Design Cable Barrier Separation



Geometric Design



Lane Widths: 3,4/3,4/3,2 m

Paved Shoulder: 1,0m



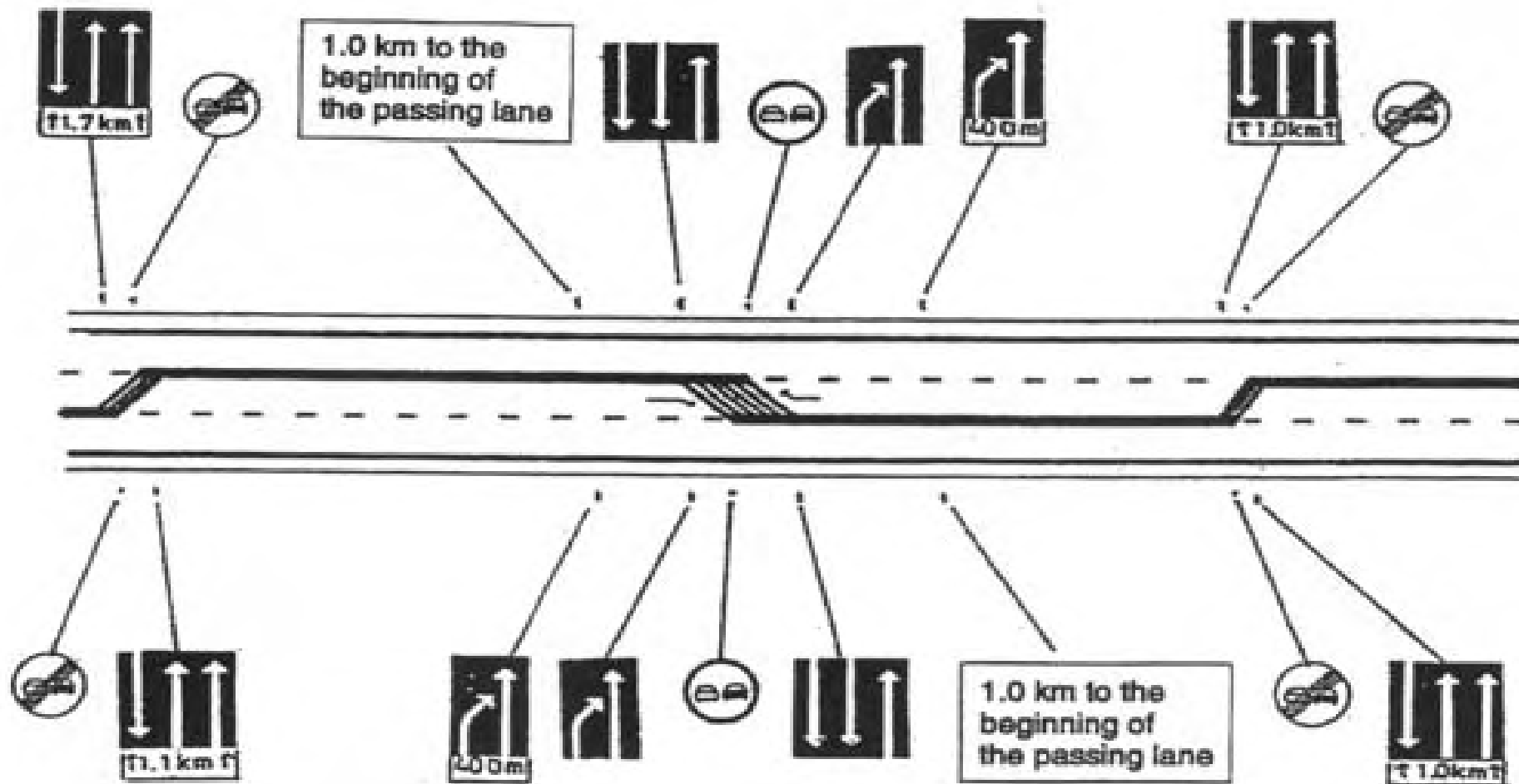
Geometric Design



**Climbing Lane
Standards**

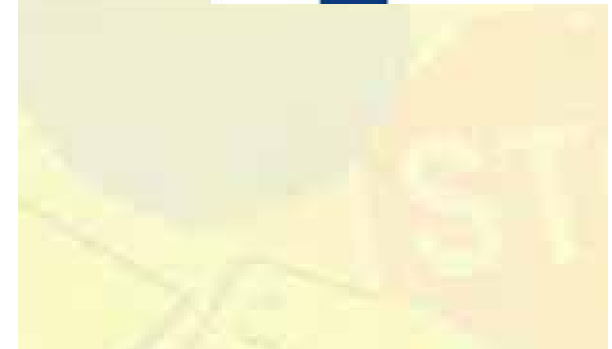
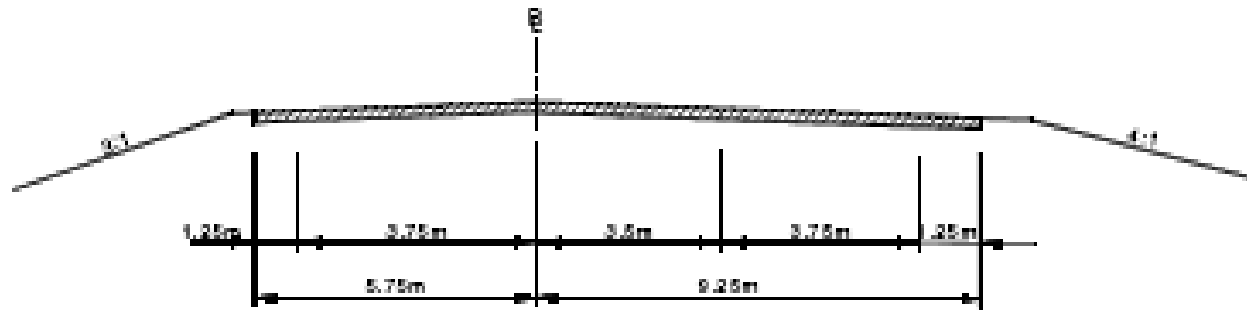


Geometric Design

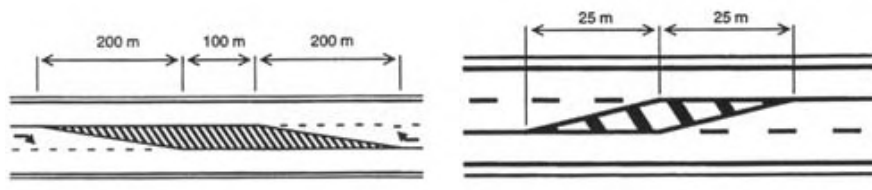
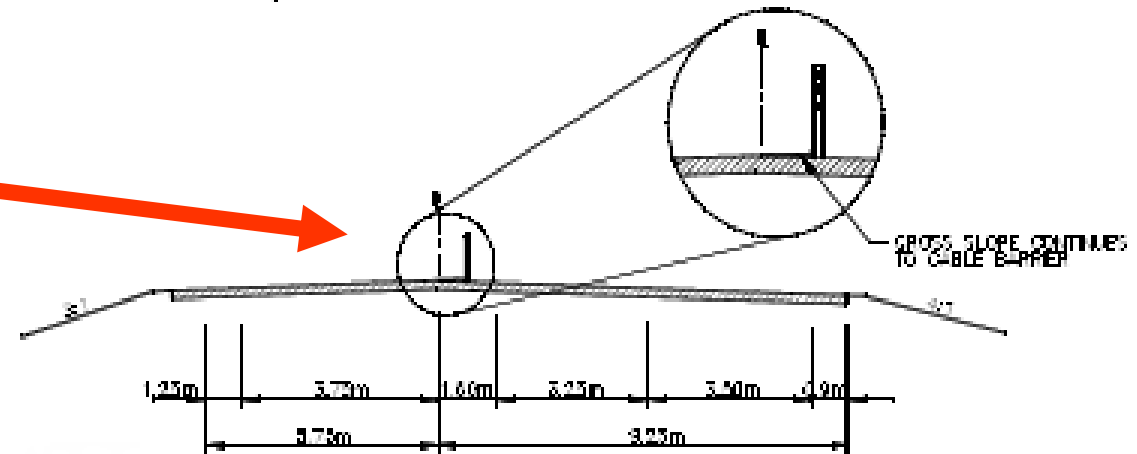


Geometric Design

Cross-Section



In some cases cable barriers are used



Safety Performance



- Frontal crashes are **2,5%** in **3** years on 2+1 roads. On 2-lane roads they are **15%** in **1** year
- Accident-Cost-Rate well above average safety level
- Poor **weather** and **sight** conditions worsen safety levels
- At **traffic peaks** **2+1** are safer than 2-lane roads
- Traffic Lights may **increase** the accident rate at at-grade intersections (may become black-spots)
- Grade-separated intersections have the **1/2 accidents** than at-grade intersections
- At grade-separated intersections severe injuries accounted **25%** ; at at-grade intersections **50%**



Safety Performance



- **Fatal** crashes reduce by **80%**
- **Severe injury** crashes reduce by **55%**
- **Run-off crashes** with severe consequences reduce by **40%**
- Speed limit of **90 km/h** result in **50%** less fatal + severe injury crash rates than of 110 km/h
- **65-70%** of barrier crashes occur on the one-lane segments



Safety Performance 2+1 at introductory phase



- Far fewer conflicts thus lower potential for crashes
- Slow-moving vehicles induce hazardous situations.
- Lay-bys need additional safety features than currently provided



Safety Performance



- **Not consistent** results (some 2+1 perform better some not)
- Median **barrier necessary** (50% of fatal crashes were head-on)
- Number of vehicle **passes decrease**
- Accepted and **preferred** by **drivers**



Safety Performance Overview



Country	Barrier	%reduction compared with 2-lane		
		Fatal	Injury	Fatal + Injury
Germany	NO	-	-	36
Sweden	Yes	45-55	-	30-50
	No	-	-	5-10
Finland	Yes	46	22	25
	No	0	13	11



CONCLUSIONS

- **General Consensus:** “2+1” cross-sections are the **safest cross sections** except for freeway cross-sections in terms of
 - Number of Accidents
 - Number of Conflicts
 - Other Safety Indices
- Slow moving vehicles may induce illegal passing maneuvers. Use



CONCLUSION

USE IT!



In Memory



Professor Rüdiger Lamm

