Vejdirektoratet

WORKSHOP ABOUT ROAD WORK ZONES ON MOTORWAYS, APRIL 2014

DANISH GUIDELINES AND RESEARCH PRESENTED BY KENNETH KJEMTRUP

THE DANISH GUIDELINES

- The Regulation for signing and marking of road work zones.
- The Guideline for signing and marking of road work zones
- Drawing examples for motorways
- Drawing examples for rural roads
- Drawing examples for urban roads
- Pocket Book for the people in the field

Vejdirektoratet

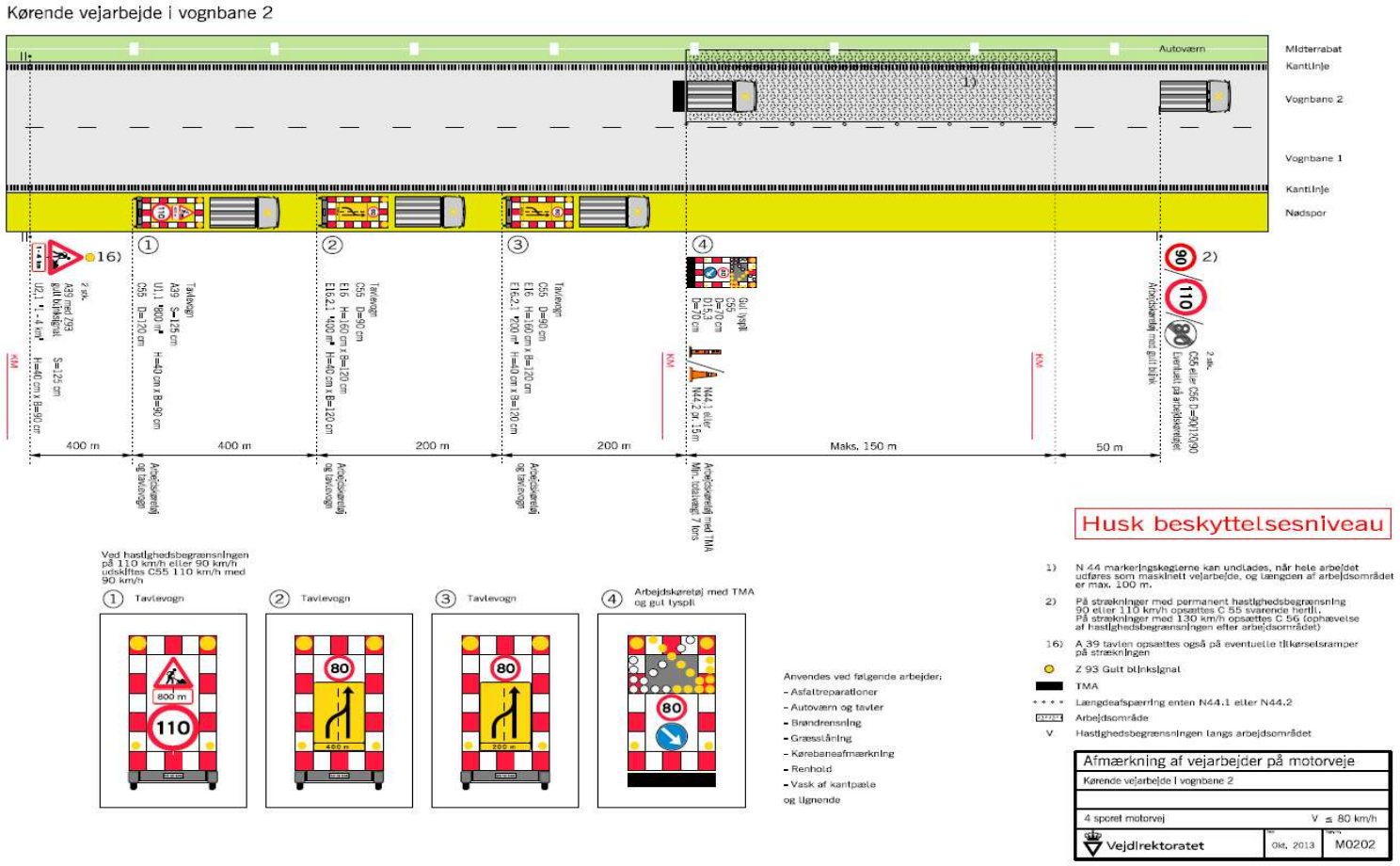
DRAWINGS FOR MOTORWAYS, LIST OF CONTENT

INDHOLDSFORTEGNELSE

GRUPPE 1: NØDSPOR OG RABATTER	
Tegningsnummer	**Titel**
M0101	Kørende vejarbejde i nødspor eller yderrabat
M0102	Kørende vejarbejde i nødspor eller yderrabat med tavlevogn
M0103	Akut vejservice i midterrabat, max. 15 min.
M0152	Kortvarigt vejarbejde i nødspor eller yderrabat
GRUPPE 2: 4-SPOREDE MOTORVEJE	
Tegningsnummer	**Titel**
M0201	Kørende vejarbejde i vognbane 1
M0202	Kørende vejarbejde i vognbane 2
M0203	Kørende vejarbejde i vognbane 1 på motorveje uden nødspor
M0204	Kørende vejarbejde i vognbane 2 på motorveje uden nødspor
M0251	Kortvarigt vejarbejde i vognbane 1 eller nødspor
M0252	Kortvarigt vejarbejde i vognbane 2 eller midterrabat (kun maskinelt vejarbejde)
M0254	Kortvarigt vejarbejde i vognbane 2 eller midterrabat i begge vejsider med portopstilling
M0255	Kortvarigt vejarbejde i vognbane 2 eller midterrabat med portopstilling
M0260 (4-fold og A3)	Overledning af 1 vognbane med begrænsningslinjer
M0261 (4-fold og A3)	Overledning af 1 vognbane med portopstilling
M0262 (4-fold og A3)	Overledning af 1 vognbane med nærtliggende frakørselsrampe
GRUPPE 3: 6-SPOREDE MOTORVEJE	
Tegningsnummer	**Titel**
M0300	Kørende vejarbejde i vognbane 1
M0303	Kørende vejarbejde i vognbane 3 eller midterrabat
M0350	Kortvarigt vejarbejde i vognbane 1 eller nødspor
M0351	Kortvarigt vejarbejde i vognbane 1 og 2
M0352	Kortvarigt vejarbejde i vognbane 2 og 3
M0353	Kortvarigt vejarbejde i vognbane 3 eller midterrabat
M0360 (5-fold og A3)	Overledning af 1 vognbane med begrænsningslinjer
M0361 (5-fold og A3)	Overledning af 1 vognbane med portopstilling
M0362 (5-fold og A3)	Overledning af 1 vognbane med nærtliggende frakørselsrampe
M0363 (5-fold og A3)	Overledning af 2 vognbaner med begrænsningslinjer
GRUPPE 4: 8-SPOREDE MOTORVEJE	
Tegningsnummer	**Titel**
M0450	Kortvarigt vejarbejde i vognbane 1 eller nødspor
M0451	Kortvarigt vejarbejde i vognbane 1 og 2
M0452	Kortvarigt vejarbejde i vognbane 3 og 4
M0453	Kortvarigt vejarbejde i vognbane 4 eller midterrabat

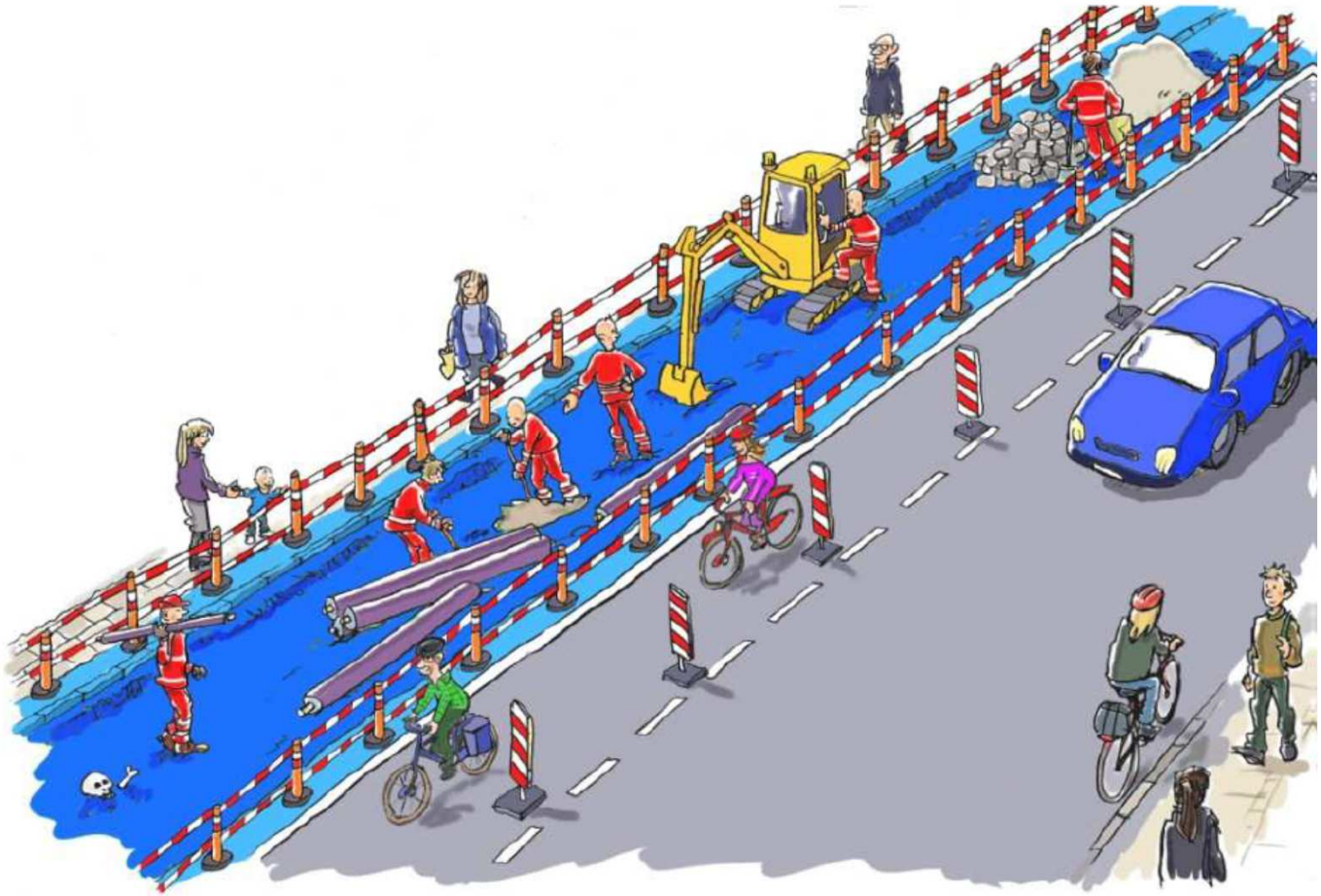
GRUPPE 5: DIVERSE	
Tegningsnummer	**Titel**
M0500	Trafikværn i nødspor med tilbageføring
M0501	Trafikværn i nødspor med påkørselsdæmper
M0502	Defekt autoværn eller gennemkørselsåbning i midterrabat
M0510	Affræsning og slidlagsudlægning
M0511	Tilkørselsrampe på overledningsstrækning
GRUPPE 6: INFORMATIONSTAVLER	
Tegningsnummer	**Titel**
M0600	Eksempler på informationstavler
GRUPPE 7: RAMPER	
Tegningsnummer	**Titel**
M0701	Bevægeligt vejarbejde på frakørselsrampe tæt på motorvejen
M0702	Bevægeligt vejarbejde på frakørselsrampe min. 100 m fra motorvejen
M0703	Kortvarigt vejarbejde ved spærreflade på frakørselsrampe
M0704	Kortvarigt vejarbejde i vognbane 1 ved frakørselsrampe
M0705	Spærring af frakørselsrampe med omkørsel før rampen
M0706	Spærring af frakørselsrampe med omkørsel efter rampen
M0707	Kortvarigt vejarbejde på spærreflade ved tilkørselsrampe

DRAWING EXAMPLE FOR MOTORWAYS



Vejdirektoratet

THE POCKET BOOK, EXAMPLE



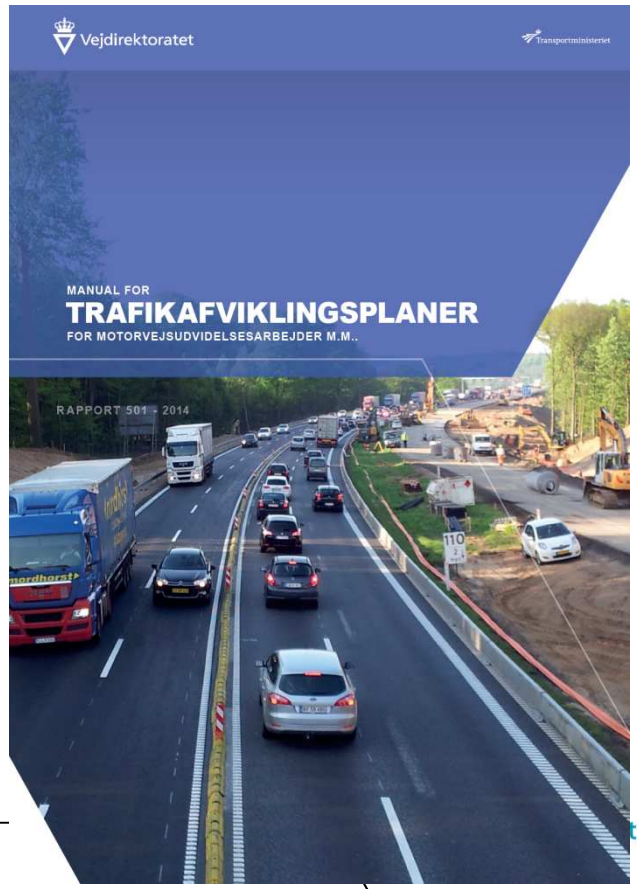
Vejdirektoratet

WHERE CAN YOU FIND THE DOCUMENTS?

- http://vejregler.lovportaler.dk/SearchResult.aspx?t=%2fV1%2fNavigation%2fTillidsmandssystemer%2fVejregler%2fAnlaegsplanlaegning%2fFaerdselsregulering%2fVejarbejder%2f

MANUAL FOR TRAFFIC MANAGEMENT AT ROAD WORKS ON MOTORWAYS

- Guideline for planning the traffic
- Guideline for excecuting the signing and marking
- Guideline for using the road equipment
- Guideline for signing detour routes
- Guideline for using guard rails
- Guideline for the geometric road design



THE BASIC PHILOSOPHY FOR THE TRAFFIC MANAGEMENT IN ROAD WORK ZONES ON MOTORWAYS

- Keep the number of lanes
- Speed limit is reduced to 80km/h
- Keep the traffic on the motorway
- Good passability, delay only caused by the reduced speed
- No increase in injury accidents
- No accidents between workers and the traffic
- 85% of the drivers are satisfied about our efforts in giving information and ensuring good passability.

HOW DO WE FULFILL OUR REQUIREMENTS

- We respect the drivers skills and behaviour
- We warn the driver by signs and markings
- We guide the driver through the road work zone
- We protect the driver and the worker, when accidents happen

RESPECTING THE DRIVERS SKILLS AND BEHAVIOUR.

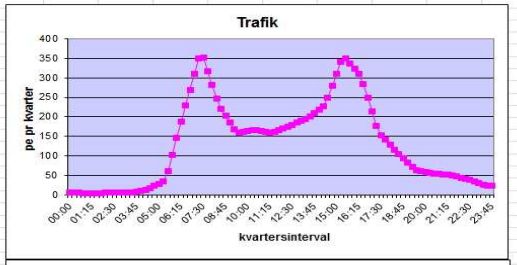
- The driver do not always respect the law
- The driver do not think like a civil engineer
- The driver use the information that suits him best
- The driver cannot read information placed after a bridge untill he has passed the bridge
- The driver cannot read more than 4 informations at a time
- The driver cannot see the road invironment in darkness
- The driver can only solve 1 problem at a time
- The drivers focus is long ahead of the vehicle
- The driver acts on the basis of experience and expectations

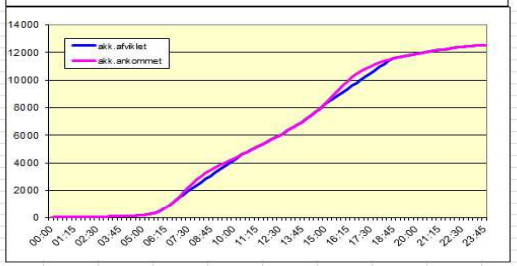
WARNING THE DRIVER, HOW

- Prewarning signs
- Rumble strips
- Speed limit signs 110-80km/h, normaly VMS signs
- Information signs, VMS
- Speed reducing measures, mostly visual speed reducers
- Narrowing the lanes
- Restricting the width of vehicles in lane 2 and 3 to 2,0m
- Qeue warning based on calculation or real time measurements (40km/h)

QUE CALCULATION

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	INDDATERET TRAFIK						TRAFIK			KAPACITET *			KØ		AKK. TRAFIK	
2	time	ktj/time				kvarter	ins.kvt.traf	kvttrafik	pe/kvt	pe/kvt	Demand	afviklet	kø	længde	akk.afviklet	ankommet
3	0,00	18	**Flaskehalsens kapacitet**			00:00	5	5	5	295	5	5	0	0	5	5
4	1,00	12		pe	pe	00:15	5	5	5	295	5	5	0	0	11	11
5	2,00	19	Kapacitet	pr. time	pr. kvarter	00:30	5	4	5	295	5	5	0	0	16	16
6	3,00	20	største:	1180	295	00:45	5	4	5	295	5	5	0	0	21	21
7	4,00	44	køafv.kap:	900	225	01:00	3	4	4	295	4	4	0	0	25	25
8	5,00	128				01:15	3	3	4	295	4	4	0	0	29	29
9	6,00	700				01:30	3	3	4	295	4	4	0	0	33	33
10	7,00	1.230	**Andel store køretøjer**			01:45	3	4	4	295	4	4	0	0	37	37
11	8,00	763	pct typ a:	8		02:00	5	4	5	295	5	5	0	0	42	42
12	9,00	529	pct typ b:	8		02:15	5	5	5	295	5	5	0	0	47	47
13	10,00	558	Faktor	1,20		02:30	5	5	6	295	6	6	0	0	53	53
14	11,00	531	(faktoren anvendes ti			02:45	5	5	6	295	6	6	0	0	59	59
15	12,00	591	beregn. af trafik i pe)			03:00	5	5	6	295	6	6	0	0	65	65
16	13,00	655				03:15	5	5	6	295	6	6	0	0	71	71
17	14,00	775				03:30	5	6	7	295	7	7	0	0	78	78
18	15,00	1.187	**Kømagasin**			03:45	5	7	9	295	9	9	0	0	86	86
19	16,00	1.009	antal sp:	1		04:00	11	9	11	295	11	11	0	0	97	97
20	17,00	531	meter/ktj	7		04:15	11	10	12	295	12	12	0	0	109	109
21	18,00	368				04:30	11	14	16	295	16	16	0	0	126	126
22	19,00	218				04:45	11	19	23	295	23	23	0	0	148	148
23	20,00	180	**Resultat af køberegning**			05:00	32	24	29	295	29	29	0	0	177	177
24	21,00	172	Størst kø:	**632**	pe	05:15	32	29	35	295	35	35	0	0	212	212
25	22,00	133	Længst kø	**4422**	meter	05:30	32	50	60	295	60	60	0	0	272	272
26	23,00	78	Forsink.	**2373**	pe-timer	05:45	32	86	103	295	103	103	0	0	375	375
27	sum:	10449				06:00	175	121	146	295	146	146	0	0	521	521
28						06:15	175	157	189	295	189	189	0	0	709	709
29	Inddatering i gule felter					06:30	175	192	230	295	230	230	0	0	939	939
30	Lyseblå felter beregnes eller inddateres					06:45	175	225	270	295	270	270	0	0	1209	1209
31						07:00	308	258	309	295	309	295	14	101	1504	1518
32	*Ved brug gemmes regnearket under et andet filnavn*					07:15	308	291	349	225	364	225	139	970	1729	1867
33						07:30	308	293	351	225	490	225	265	1855	1954	2219
34						07:45	308	264	316	225	581	225	356	2495	2179	2535
35						08:00	191	235	281	225	638	225	413	2890	2404	2817
36						08:15	191	205	246	225	659	225	434	3040	2629	3063
37						08:30	191	183	220	225	654	225	429	3006	2854	3283
38						08:45	191	169	203	225	632	225	407	2849	3079	3486
39						09:00	132	154	185	225	592	225	367	2569	3304	3671
40						09:15	132	140	167	225	535	225	310	2167	3529	3838
41						09:30	132	133	160	225	469	225	244	1710	3754	3998
42						09:45	132	135	162	225	406	225	181	1269	3979	4160
43						10:00	140	137	164	225	345	225	120	843	4204	4324
44						10:15	140	139	166	225	287	225	62	432	4429	4490
45						10:30	140	139	166	225	228	225	3	22	4654	4657
46						10:45	140	137	164	225	167	167	0	0	4821	4821
47						11:00	133	135	162	295	162	162	0	0	4983	4983
48						11:15	133	134	160	295	160	160	0	0	5144	5144
49						11:30	133	135	162	295	162	162	0	0	5305	5305
50						11:45	133	138	166	295	166	166	0	0	5471	5471
51						12:00	148	142	171	295	171	171	0	0	5642	5642
52						12:15	148	146	175	295	175	175	0	0	5817	5817
53						12:30	148	150	180	295	180	180	0	0	5997	5997
54						12:45	148	154	185	295	185	185	0	0	6181	6181
55						13:00	164	158	189	295	189	189	0	0	6371	6371
56						13:15	164	162	194	295	194	194	0	0	6565	6565
57						13:30	164	168	201	295	201	201	0	0	6766	6766
58						13:45	164	175	210	295	210	210	0	0	6976	6976
59						14:00	194	183	219	295	219	219	0	0	7195	7195
60						14:15	194	190	228	295	228	228	0	0	7423	7423
61						14:30	194	207	248	295	248	248	0	0	7671	7671
62						14:45	194	232	279	295	279	279	0	0	7949	7949
63						15:00	297	258	310	295	310	295	15	103	8244	8259
64						15:15	297	284	341	225	355	225	130	913	8469	8600
65						15:30	297	291	349	225	480	225	255	1784	8694	8949
66						15:45	297	280	336	225	591	225	366	2561	8919	9285
67						16:00	252	269	323	225	689	225	464	3245	9144	9608
68						16:15	252	258	309	225	773	225	548	3836	9369	9917
69						16:30	252	237	285	225	833	225	608	4254	9594	10202
70						16:45	252	207	249	225	857	225	632	4422	9819	10451
71						17:00	133	178	213	225	845	225	620	4338	10044	10664
72						17:15	133	148	177	225	797	225	572	4004	10269	10841
73						17:30	133	128	153	225	725	225	500	3501	10494	10995
74						17:45	133	117	141	225	641	225	416	2913	10719	11136
75						18:00	92	107	129	225	545	225	320	2239	10944	11264
76						18:15	92	97	117	225	436	225	211	1480	11169	11381
77						18:30	92	87	105	225	316	225	91	638	11394	11486
78						18:45	92	78	94	225	185	185	0	0	11579	11579
79						19:00	55	69	82	295	82	82	0	0	11661	11661
80						19:15	55	59	71	295	71	71	0	0	11732	11732
81						19:30	55	53	64	295	64	64	0	0	11796	11796
82						19:45	55	51	61	295	61	61	0	0	11858	11858
83						20:00	45	49	58	295	58	58	0	0	11916	11916





Vejdirektoratet

GUIDE THE DRIVER, HOW?

- High deliniater panels 145cm, low in sight areas 75cm
- White road markings, RL> 150mcd/lx
- Consistant road geometry designed for 80km/h:
  - Horizontal curves like s-curves at intersections(No transition curves)
  - Ramp and taper design at entries (For merging), 140m taper
  - Ramp design at exits
  - Lane drop design, 1:30
  - Narrow lanes with vehicle width restrictions (max 2,0m i lane 2/3)
  - Lane width: 2,75m (2,5m) in lane 2/3 and 3,0m (2,9m) in lane 1
- Supporting lane guidance signs
- Speed reducing measures
- Attention measures
- Emergency lay by´s for every 500m
- Detour guidance

PROTECTING THE DRIVER,HOW?

- Safety Zone as for permanent roads (6m for 80km/h)
- Guard rails, type T3, EN 1317 test and approved by RD
- Brake away constructions, EN 12767 and approved by RD
- Traffic Buffers (Crash Cushions)approved by RD
- TMA on vehicles working in lanes, tested NCHRP 350
- Speed limit 50km/h when working in the central reserve. VMS
- No entries or exits from the motorway to the working areas close to bridges and motorway exits/entries
- Protection against glare from warning lights
- Protection against glare from the working zone

PROTECTION AGAINST GLARE FROM THE WORKZONE

Hight above road surface	Max luminance
6 m	1500 cd
8 m	3000 cd
10 m	5000 cd
12 m	8000 cd
14 m	11000 cd
16 m	15000 cd

PROTECTING THE WORKER, HOW?

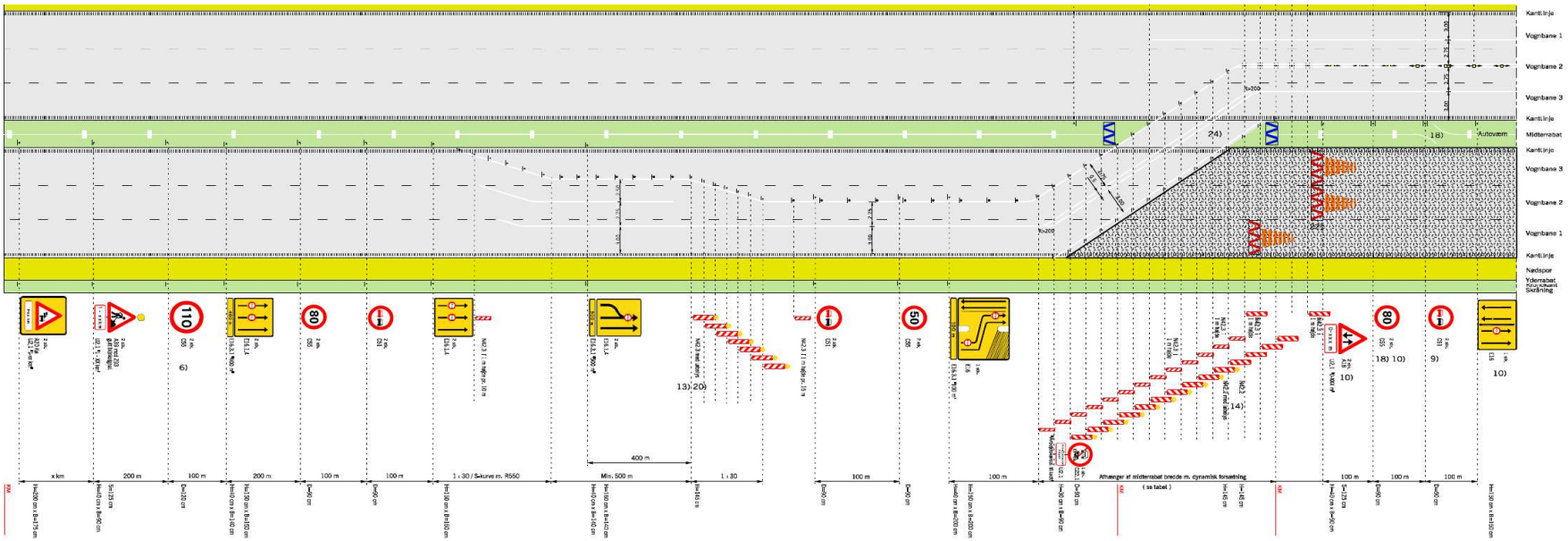
- 8 protecting levels used, only where work is ongoing:

1. Recommended speed 20km/h, Workers on the road
2. Delineator marking only
3. Working distance to traffic >1,0m
4. Protecting vehicle, weight>7t
5. Machine work, weight>1,5t
6. Guard rail
7. Secundary guard rail
8. Closing the road or road side

TYPICAL CROSS SECTIONS,

Vejdirektoratet

2-LANE TRANSITION, PRINCIP DRAWING WEEK-END WORK ONLY



Hældning 1:10

Rabatbredde i	3 m	4 m	6 m	12 m
Forsætningslængde	90	100	120	180

Tabel: Forsætningslængde ved 50km/h

2) På strækninger med permanent hastighedsbegrænsning 90 eller 110 km/h opsættes C 55 svarende hertil. På strækninger med 130 km/h opsættes C 56 (ophævelse af hastighedsbegrænsningen efter arbejdsområdet)

6) Udgår, hvis hastighedsbegrænsningen er mindre end 130 km/h

9) Tavler gentages pr. 500 m.

10) Tavler gentages pr. 1.000 m.

13) Begrænsningslinjen N 42,3 med løbelys kan erstattes med tavlevogn eller TMA.

14) Begrænsningslinjen opstilles 1:10 og N 42 udføres i størrelse 1,45 m

Husk beskyttelsesniveau

18) Hvor det ikke er muligt af fx pladsmæssige årsager at beskytte nødåbninger i midterrabatten med fx 1 stk. dæksæt, da sættes hastigheden ned til 50 km/h i en afstand af 100 m før nødåbningen. Tilsvarende, hvis der findes andre faste genstande, som det ikke er muligt at beskytte imod.

19) N 44,3 vognbanedelere placeres med 15 m mellemrum til adskillelse af modsat rettet trafik.

20) Begrænsningslinjen opstilles 1:30 og N 42,3 udføres i 1,45 m højde

22) Anvendes kun i de tilfælde, hvor trafikanten eller vejarbejderen skal beskyttes, fx. hvor der er dybe udgravninger

23) Hvis arbejdet varer under 24 timer erstattes N 44,3 med N 44,1 eller N 44,2.

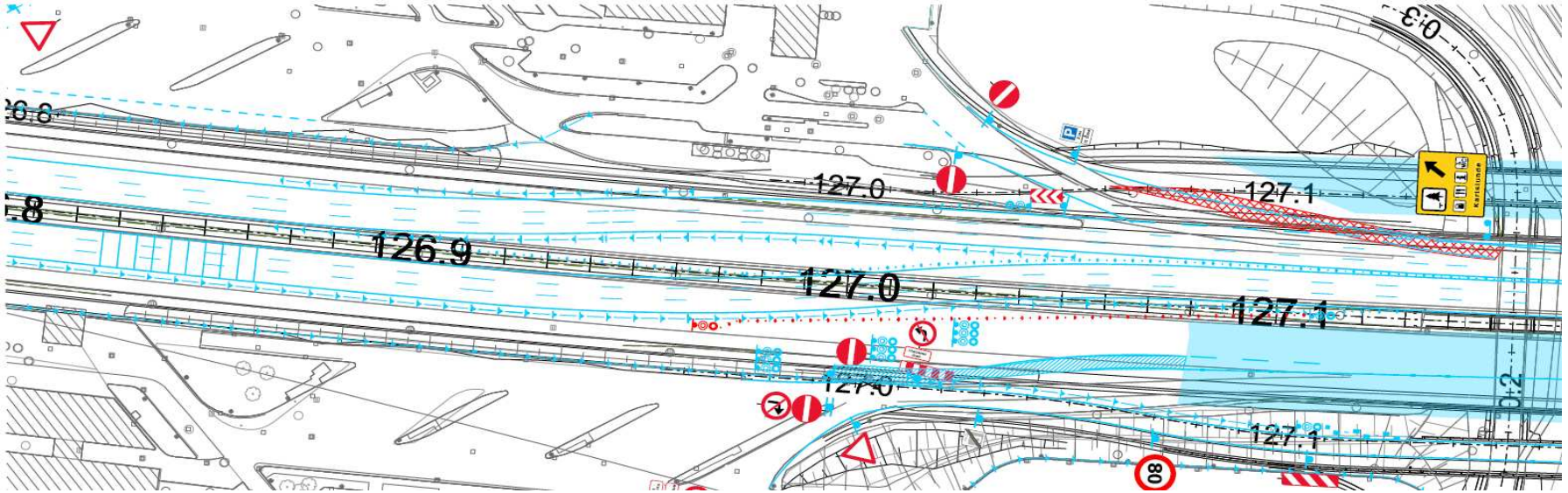
24) Autoværn, som midlertidigt fjernes i gennemkørselsåbningen skal enten køres bort eller lægges i bagkant af yderrabat uden for slikkerhedszonen. Når autoværnet er fjernet skal der ved autoværnsenderne opsættes energiabsorberende afspærring.

Q44 (0,15) afstribning
Bufferzone, tværgående sikring, længden afh. af produktet
Påkørselsdæmper som tværafspærring
Påkørselsdæmper foran autoværnsender
Z 93 Gult blinksignal
Arbejdsområde
V Hastighedsbegrænsningen langs arbejdsområdet

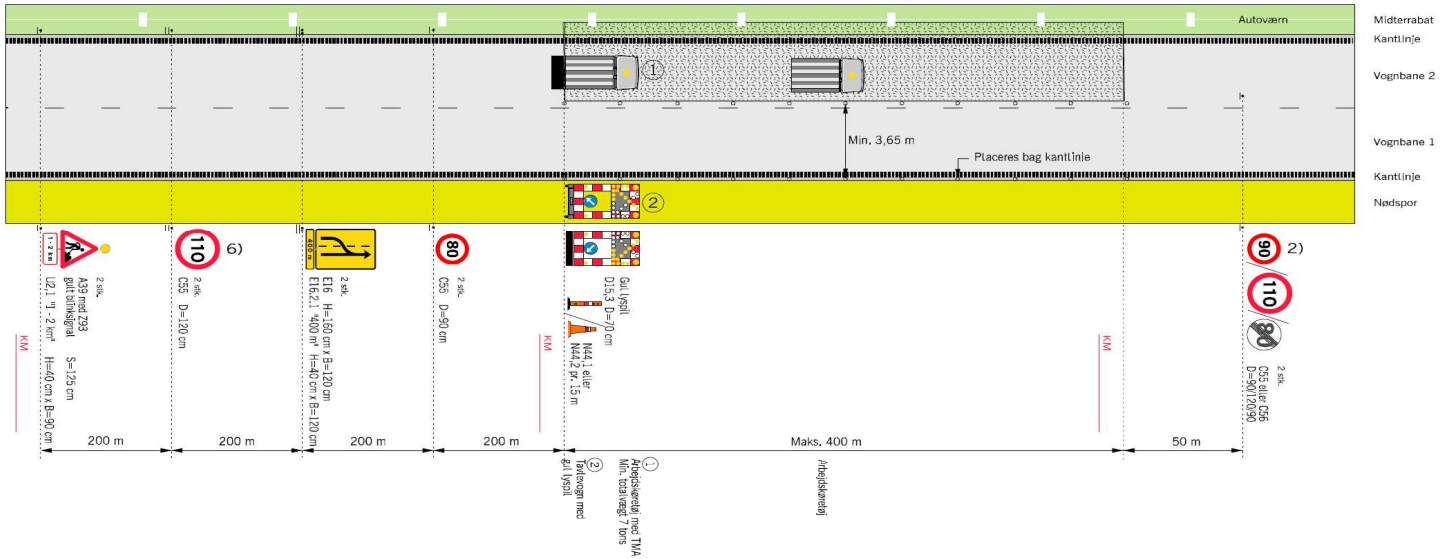
Afmærkning af vejarbejder på motorveje		
Overledning af 2 vognbaner (1. del af tegn. nr. M0363)		
Begrænsningslinjer		
6 sporet motorvej	V ≤ 50 km/t	
Vejdirektoratet	Okt. 2013	M0363-1

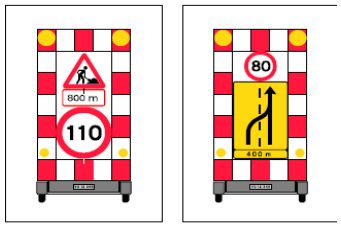
Vejdirektoratet

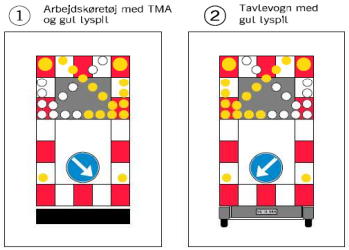
3-LANE TRANSITION, 80KM/H



LANE DROP, MOVING ROAD WORK







Anvendes ved følgende arbejder:
- Asfaltreparationer
- Autoværn og tavler
- Beplantning
- Kørebaneafmærkning
- Renhold
- Revneforsegling

og lignende

Husk beskyttelsesniveau

2) På strækninger med permanent hastighedsbegrænsning 90 eller 110 km/h opsættes C 55 svarende hertil. På strækninger med 130 km/h opsættes C 56 (ophævelse af hastighedsbegrænsningen efter arbejdsområdet)

6) Udgår, hvis hastighedsbegrænsningen er mindre end 130 km/h

Z 93 Gult blinksignal

TMA

Længdeafspærring enten N44.1 eller N44.2

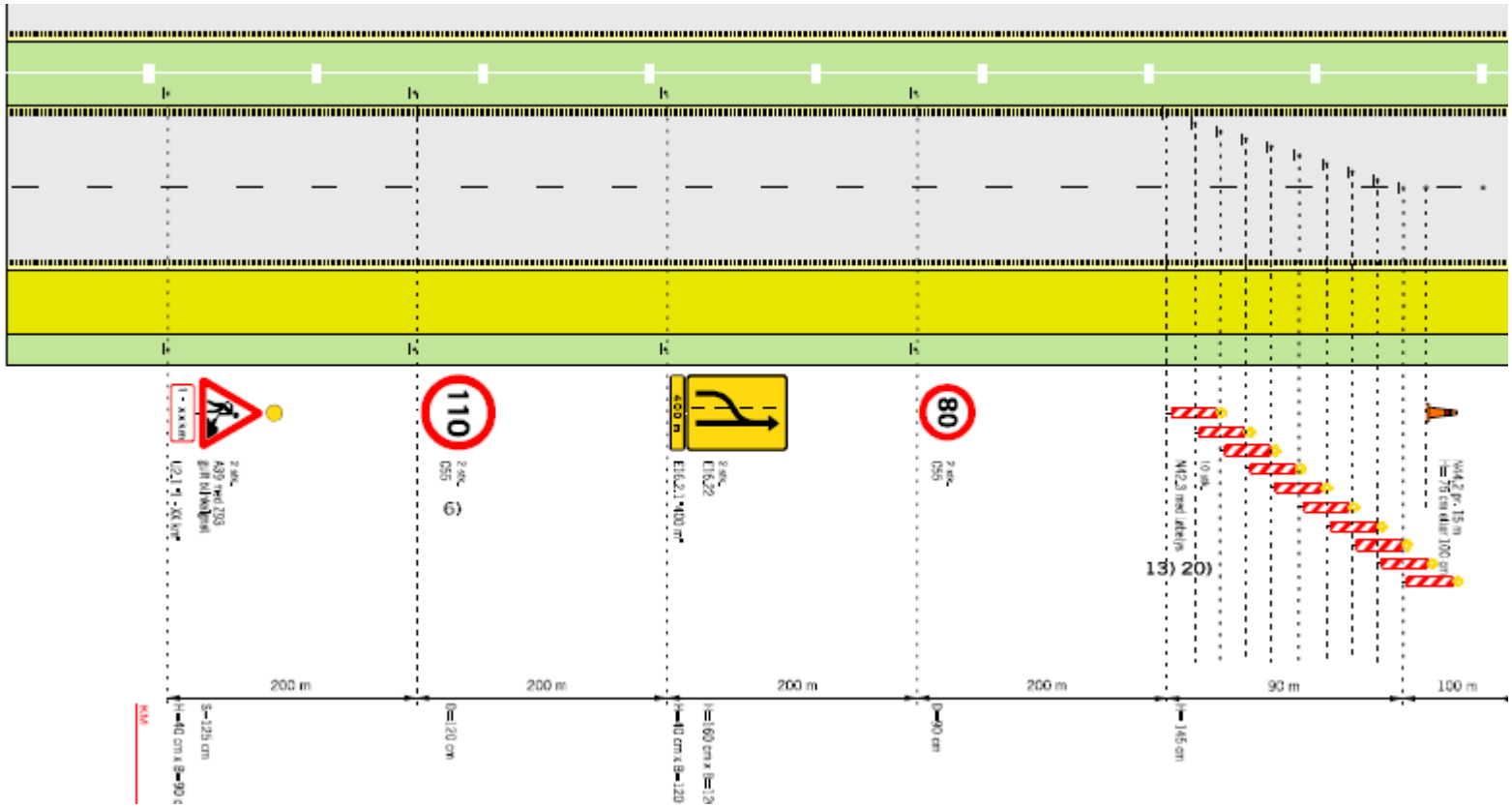
Arbejdsområde

V Hastighedsbegrænsningen langs arbejdsområdet

Afmærkning af vejarbejder på motorveje		
Kortvarigt vejarbejde i vognbane 2 eller midterrabat		
Portopstilling		
4 sporet motorvej	V ≤ 80 km/h	
Vejdirektoratet	Okt. 2013	M0255

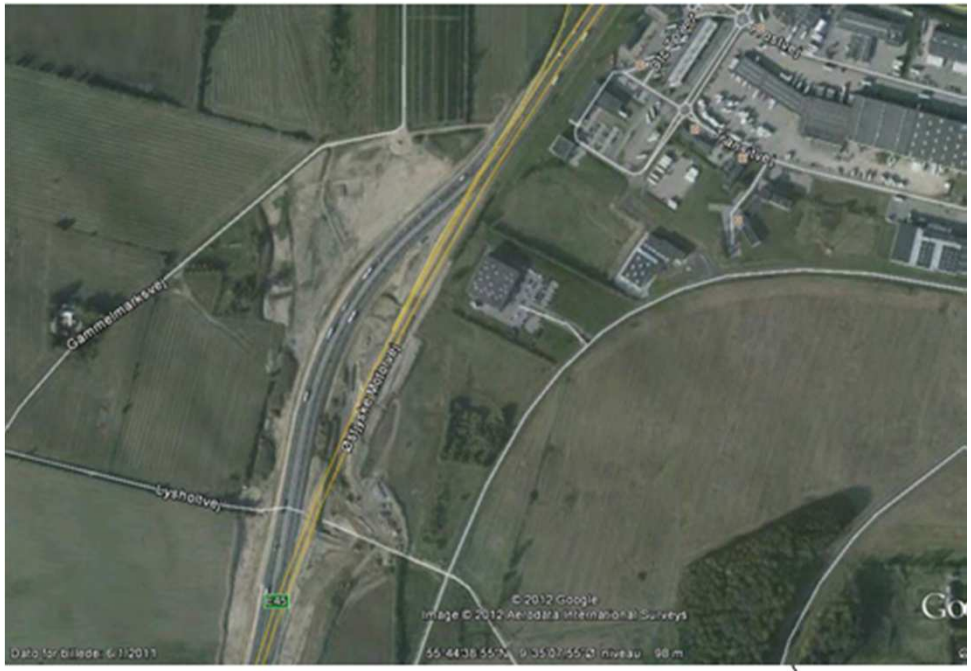
Vejdirektoratet

LANE DROP, ROAD WORK FOR A LONGER PERIODE



Vejdirektoratet

INTERIM MOTORWAY



Vejdirektoratet

INTERIM MOTORWAY

3 Slagelse retning vest.ts

Interim motorway – reduced standard

Interim motorway – high standard

Transition zone - reduced standard

Transition zone - high standard

The designs of interims

- The 2 interims have the same lenghts (1 km) and the same speed limit (80 km/h).
- The alignements and curvatures are very similar.

- Cross sections are different:
  - *The low standard interim* has reduced lane width (3m + 2,75m) and no emergency lanes
  - *The high standard interim* has the normal cross section profile for motorways

Evaluation results:

- Mean speed exceeds signed speed in all observation cross sections, and the 15 % highest speeds are more than 20 km/h higher than signed speed on both interims.

- The capacity is fine on both interims – no queue problems

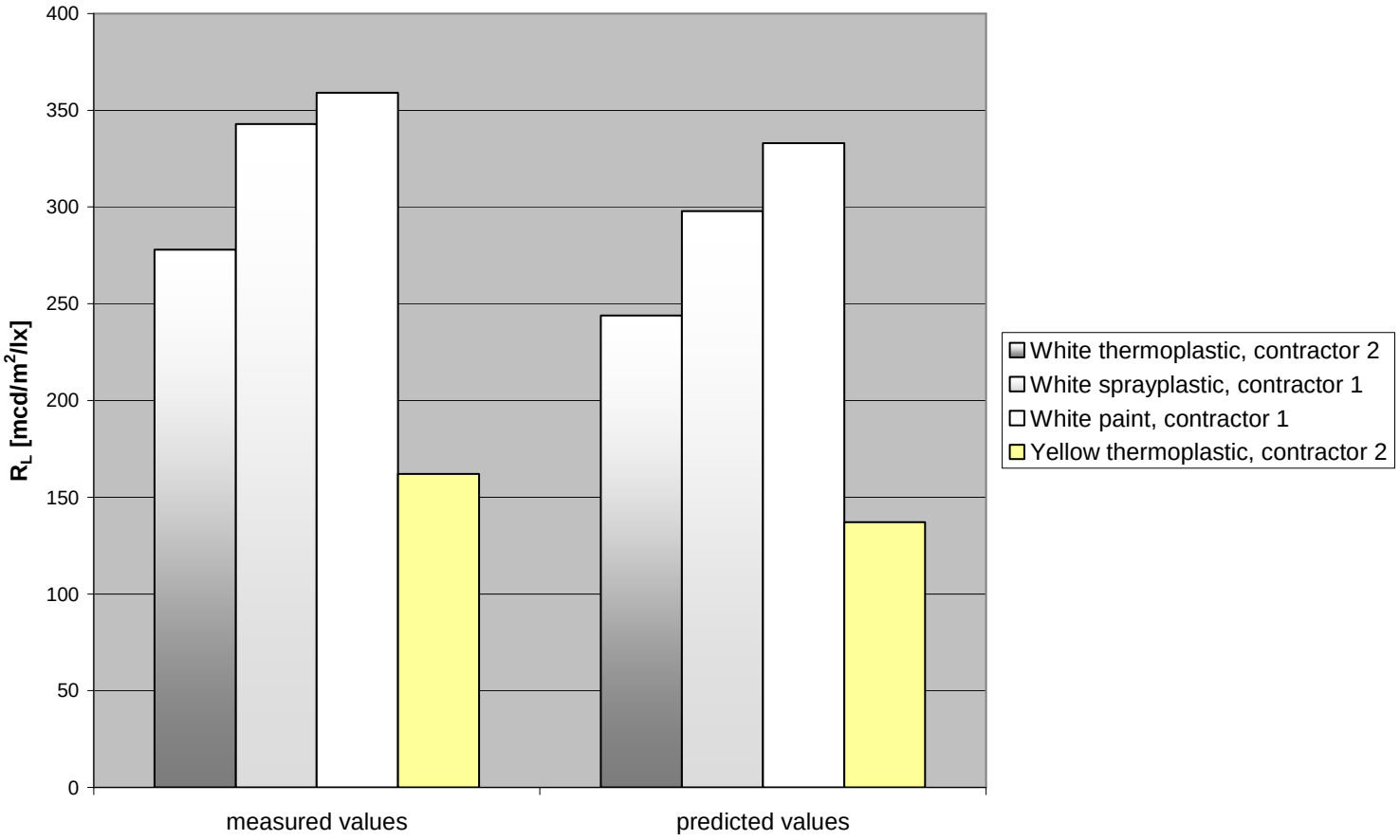
- Road users are very satisfied with both interims. A bit more positive for the high standard interim.

- Accident analyse indicates higher safety on the low standard interim compared to the high standard interim

INTERIM MOTORWAY

- Design and marking like a road work motorway
- Speed limit 80km/h (50km/h)
- Stop sight
- Lanewidth, lane 1: 3,0m, lane 2: 2,75
- Cross fall 80 km/h: 2,5%, 50km/h: - 2,5%
- Horizontal acceleration for articulated vehicles max 0,7g

ROAD MARKING VISIBILITY



PROTECTING AGAINST GLARE

Road works during night

Recommendations for the visual environment

Anita Ihs, VTI
Kai Sörensen, DELTA
Arve Augdal, SINTEF
Antti Tiensuu, LiCon-AT

REQUIREMENTS FOR WARNING LIGHTS

Type of warning light	Effective luminous intensity (cd) in relation to the ambient light level [1]				
	40.000 lx Full daylight	4.000 lx Weak daylight	400 lx Dusk or dawn	40 lx Road lighting	≤4 lx Darkness
Warning lights on road signs [2]	1280 ± 30 %	640 ± 30 %	320 ± 30 %	160 ± 30 %	80 ± 30 %
Running lights [3]	640 ± 30 %	320 ± 30 %	160 ± 30 %	80 ± 30 %	40 ± 30 %
Warning lights on barriers [4]	640 ± 30 %	320 ± 30 %	160 ± 30 %	80 ± 30 %	40 ± 30 %
Crosses and arrows on trailers or vehicles [5]	1280 ± 30 %	640 ± 30 %	320 ± 30 %	160 ± 30 %	80 ± 30 %
Lightbars and beacons on vehicles	In accordance with ”Bekendtgørelse om detailforskrifter for køretøjers indretning og udstyr”				

[1] The ambient light level is measured by the horizontal illuminance (lux, lx)

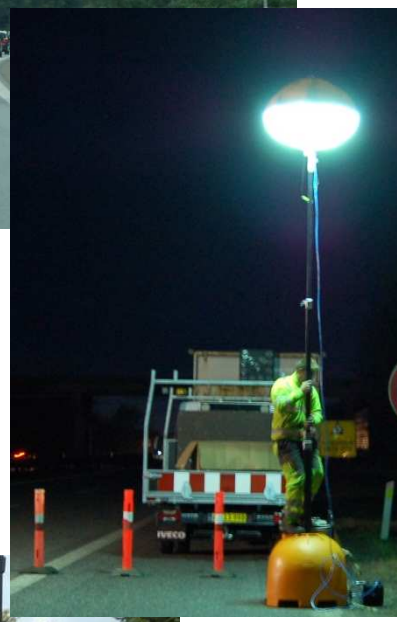
[2] Warning lights may be mounted only on A 39 “Road work”. The cycle period shall be 1 s and the on-time 0,2 s

[3] A cycle of running lights shall start each 1,5 s, during which the on-time of a warning light shall start 0,15 s after the start of the on-time of the previous warning light. The on-time shall be 0,2 s. Background light must not be used. This implies that there is an idle period between sequences, whenever the number of warning lights in a running light is less than 10

[4] Warning lights in pairs on O 43 – 45 Barriers shall have simultaneous on-times. The cycle period shall be 1 s and the on-time 0,2 s

[5] Warning lights forming crosses and arrows on trailers or vehicles shall have a cycle period of 1,5 s and an on-time of 0,6 s.

RoadWork Zones at Motorways – Speed Reducing Measures



- Mobile Road Quakes
- Mobile Road Quakes combined with ”Slow Down the Speed”
- Variable Message Signs
- ”Port and Cone”
- PowerMoon as Mobile Lighting
- Corridor of N42

Mobile rumble stripes (Mobile Road Quakes)

Tested at:

- Different spacing (1.5m , 4.0m)
- Speed limits (70 km/h, 50 km/h)

Results:

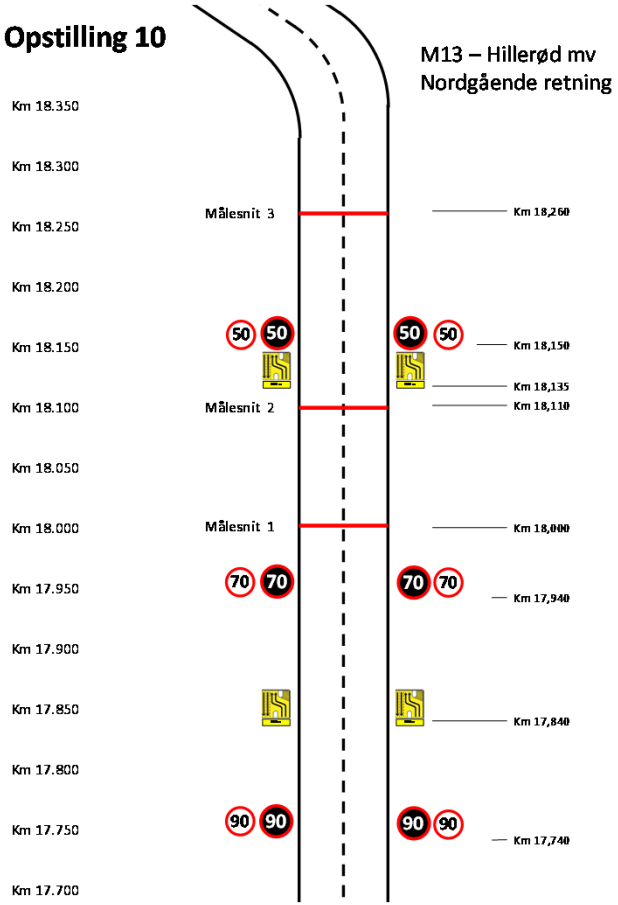
- Only in place for a few hours (moved by heavy vehicles passages)

- Speed reduction: 0-1 km/h
- Perhaps effect on driver attention ?

Use of electronic speed limit signs vs. ordinary speed limit sign.

Tested at workzone
110 km/h -> 90 km/h –> 70 km/h -> 50 km/h

Advantage: Electronic signs more visible ?



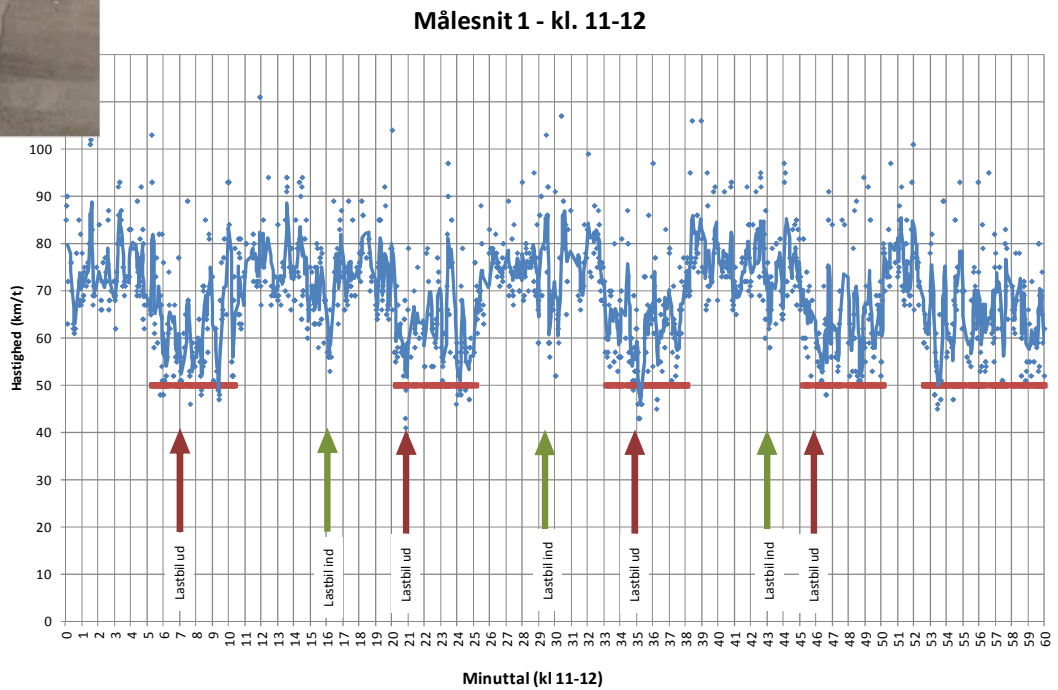
Reduction in average speed:
4- 11 km/h

Higher reduction at night

Temporary reduction in speed limit in work zone by use of VMS
(due to heavy vehicles entering left lane from center area)

Speed limit 80 km/h -> 50 km/h

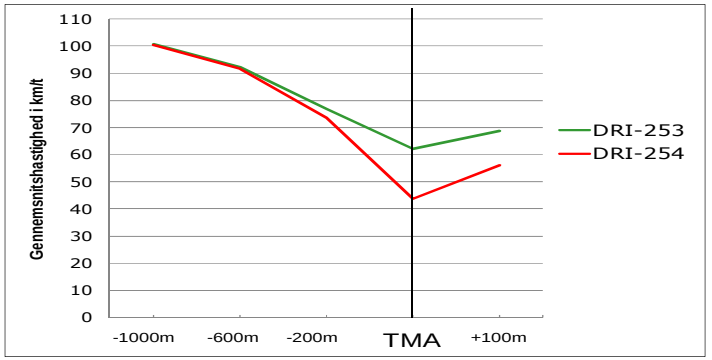
Effect:
Avg speed: - 13 km/h
85%: - 9 km/h



ROAD WORK ZONE MARKING BY NIGHT – ”PORT & CONE”

New marking DRI 254: ”Port & Cone”

Old marking DRI 253



Speed is significantly reduced

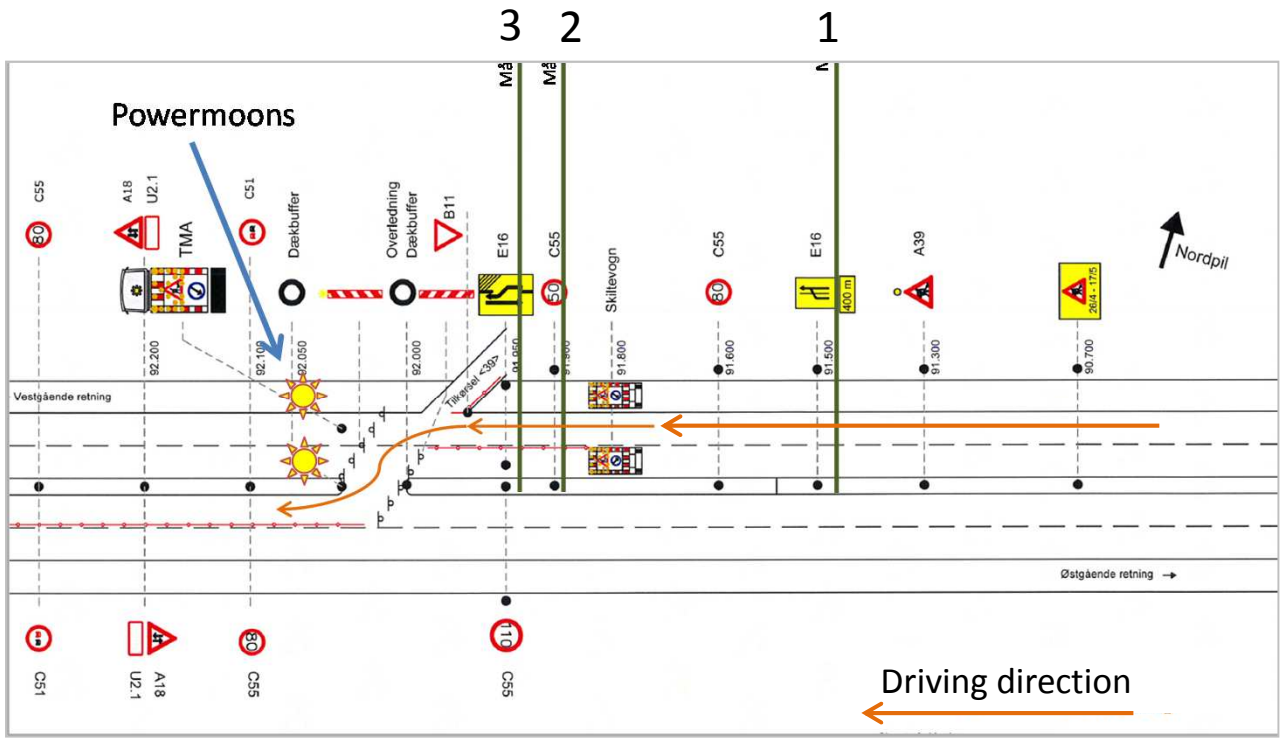
Vejdirektoratet

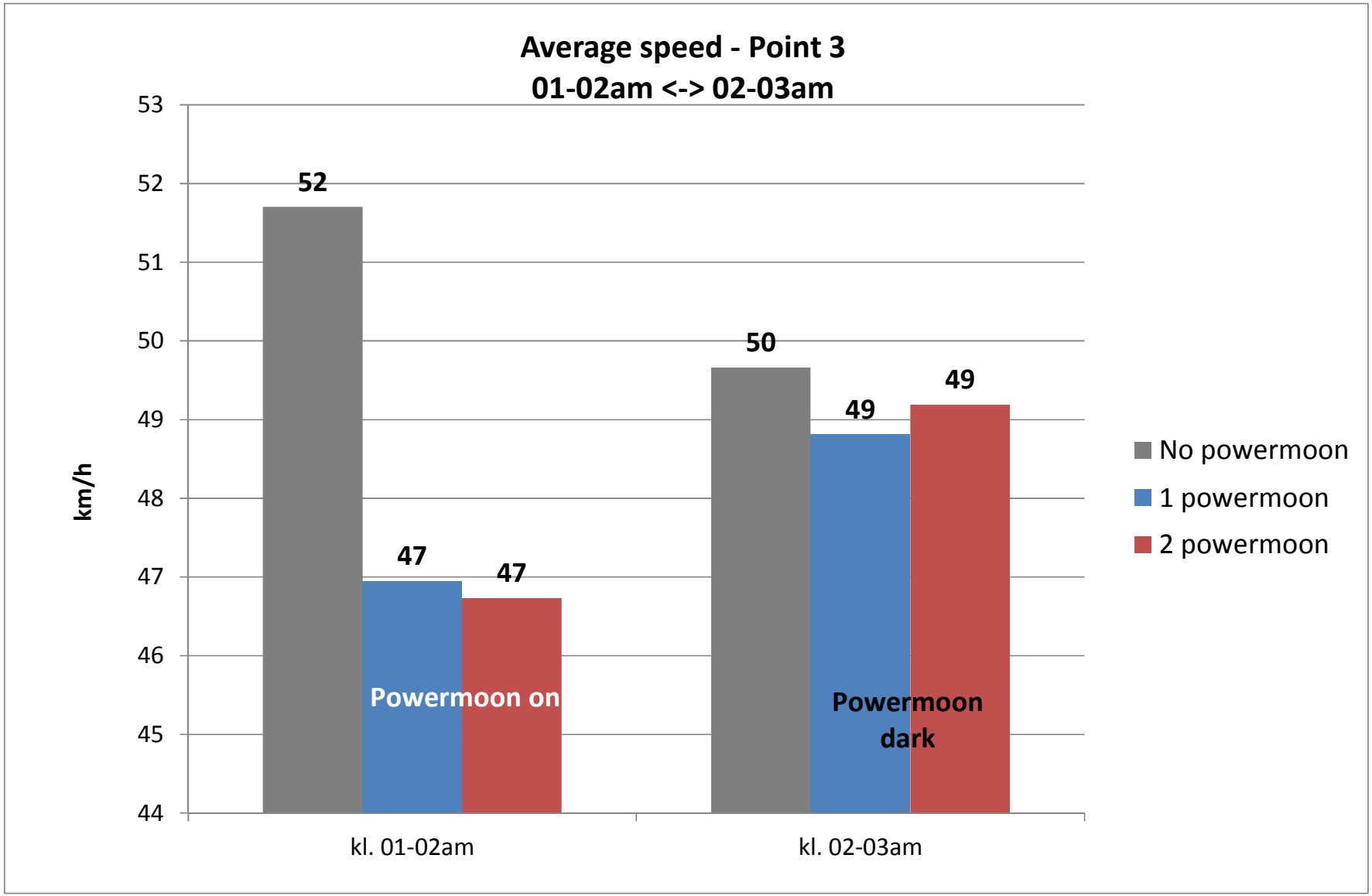
PowerMoon

Vest Motorway DRI-261

Speed limit on stretch:
1: 110 km/h
2: 80 km/h / 50 km/h
3: 50 km/h

Setup:
- No powermoon (ref)
- 2 powermoons
- 1 powermoon




Average speed - Point 3
01-02am <-> 02-03am
km/h
53
52
51
50
49
48
47
46
45
44
52
47
47
50
49
49
Powermoon on
Powermoon dark
kl. 01-02am
kl. 02-03am
No powermoon
1 powermoon
2 powermoon

Corridor of N42

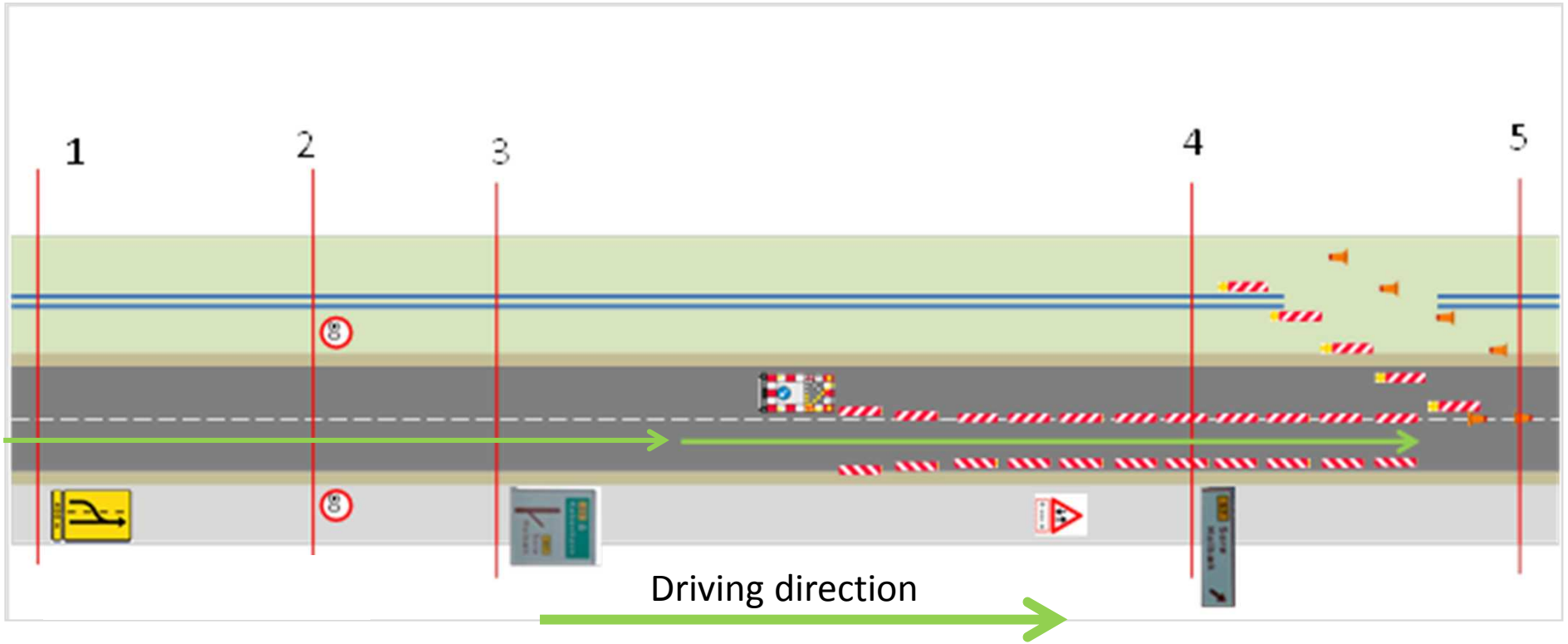
Highway (rute 23) – Modified DRI-261

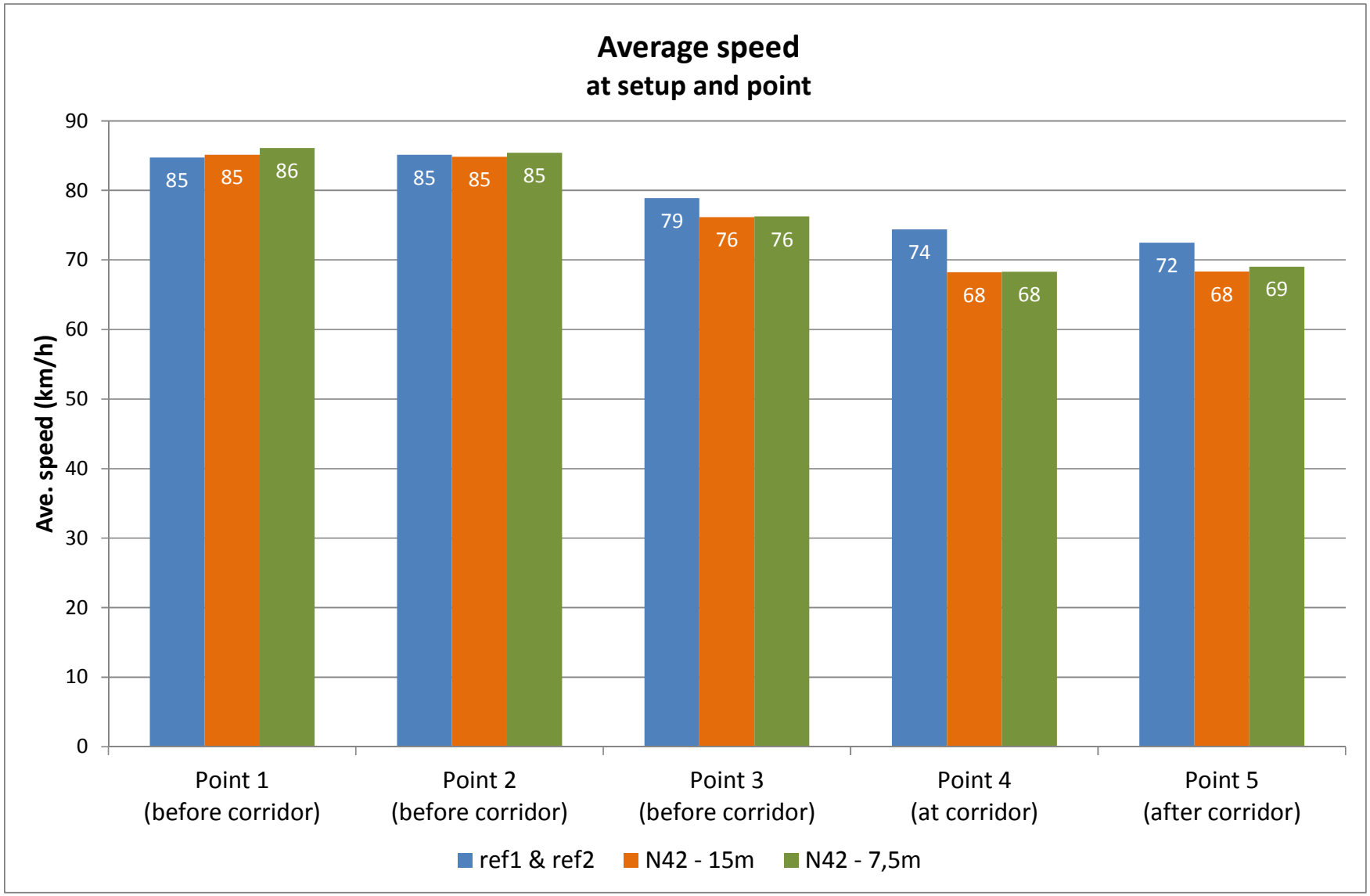
Speed limit on stretch: 80 km/h

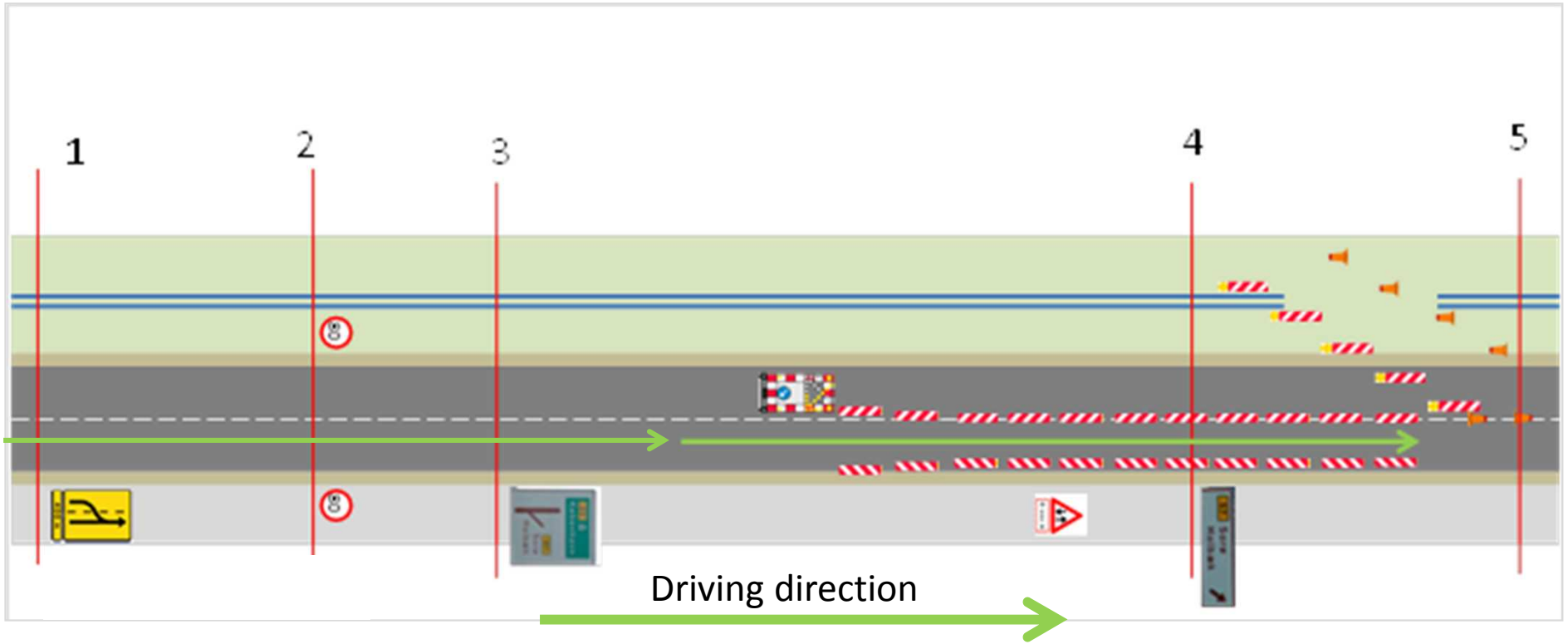
Setup:
- Reference stretch
- Test stretch N42 corridor, 7.5 m between N42
- Test stretch N42 corridor, 15 m between N42

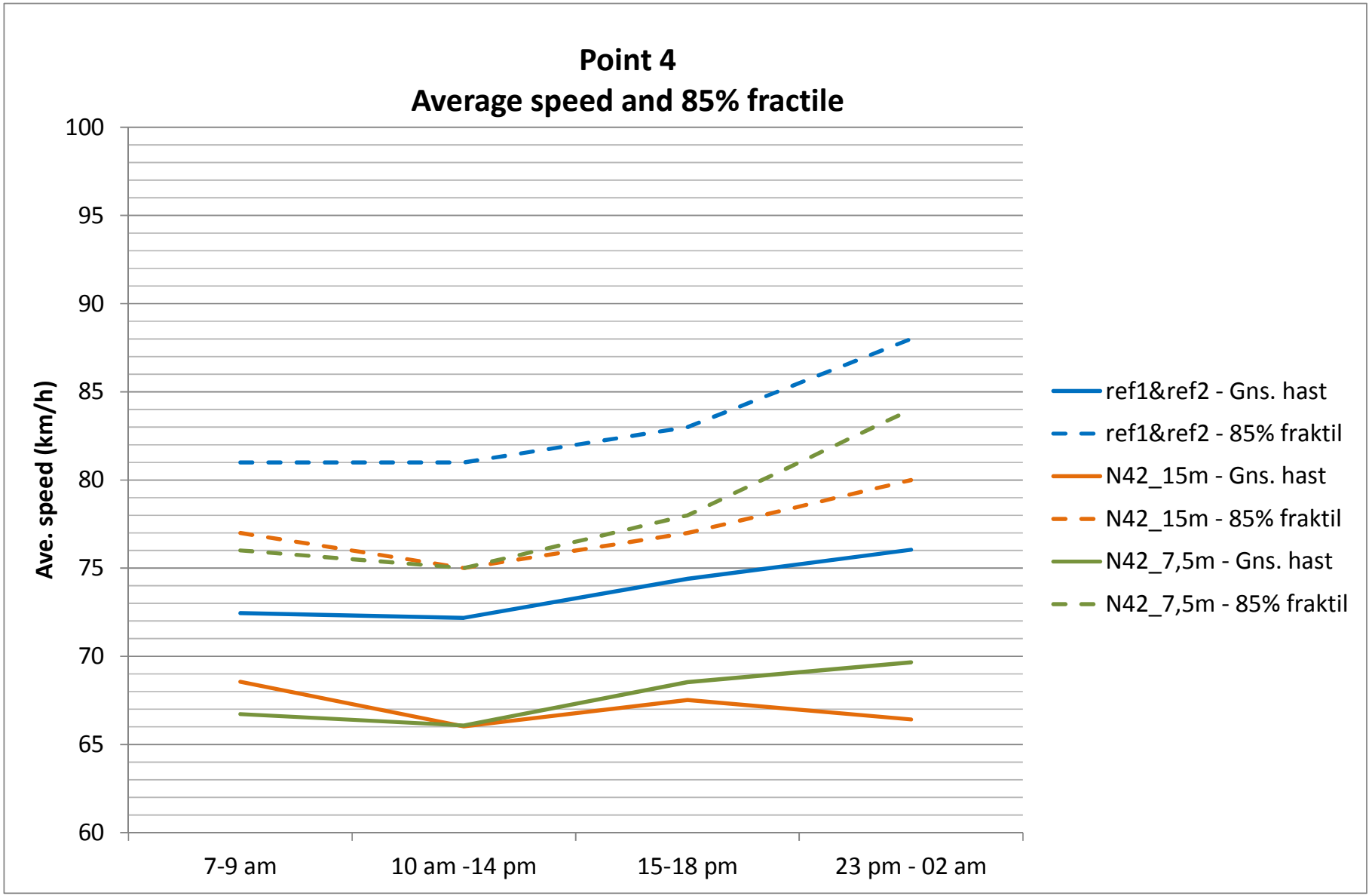
Delineators (N42): 2m high
Corridor length: 160 m
Corridor width: 3.65 m

Period:
- Reference stretch: 5 days and nights
- Each test stretch: 4 days and nights
  (not weekend)


1
2
3
4
5
Driving direction


Average speed
at setup and point
Ave. speed (km/h)
90
80
70
60
50
40
30
20
10
0
85
85
86
85
85
85
79
76
76
74
68
68
72
68
69
Point 1
(before corridor)
Point 2
(before corridor)
Point 3
(before corridor)
Point 4
(at corridor)
Point 5
(after corridor)
ref1 & ref2
N42 - 15m
N42 - 7,5m


1
2
3
4
5
Driving direction


Point 4
Average speed and 85% fractile
Ave. speed (km/h)
100
95
90
85
80
75
70
65
60
7-9 am
10 am -14 pm
15-18 pm
23 pm - 02 am
ref1&ref2 - Gns. hast
ref1&ref2 - 85% fraktil
N42_15m - Gns. hast
N42_15m - 85% fraktil
N42_7,5m - Gns. hast
N42_7,5m - 85% fraktil

Driving through a Roadwork Zone

- What are the road users looking at when driving through a roadwork zone?
- For how long do road users look at different roadwork related elements – and which?
- For how long do road users look at elements which are not related to roadwork?

Design of the trial

- Holbæk Motorway (M11) - 8 km - reconstruction 2->3 lanes in each direction - 2 ramps
- Instrumented car (eyetracker, GPS)
- 10 test drivers (age 21-69 years)
- June-September 2011

- Roadworks in both side of the motorway
- 80 km/t (50 km/t)
- Intensity of the roadwork varies along the roadwork stretch
- Intensity of the roadwork varies between test drivers

Elements related to roadwork

- ***Temporary signs*** used in relation to the roadwork
- ***Road side markings*** (edge marking, delineators/N42, temporary barrier)
- ***Working zone*** (roadworker, roadwork equipment, roadwork vehicles, crane and unspecified elements within the working zone)

Examples of Temporary signs

Periodic
Speed Control

Road side markings

Example of working zone

Elements *not* related to roadwork

- The road and other road users
- Traffic signal (located at the end of ramp)
- Glances at other elements (the sky, bridges etc.)

Results

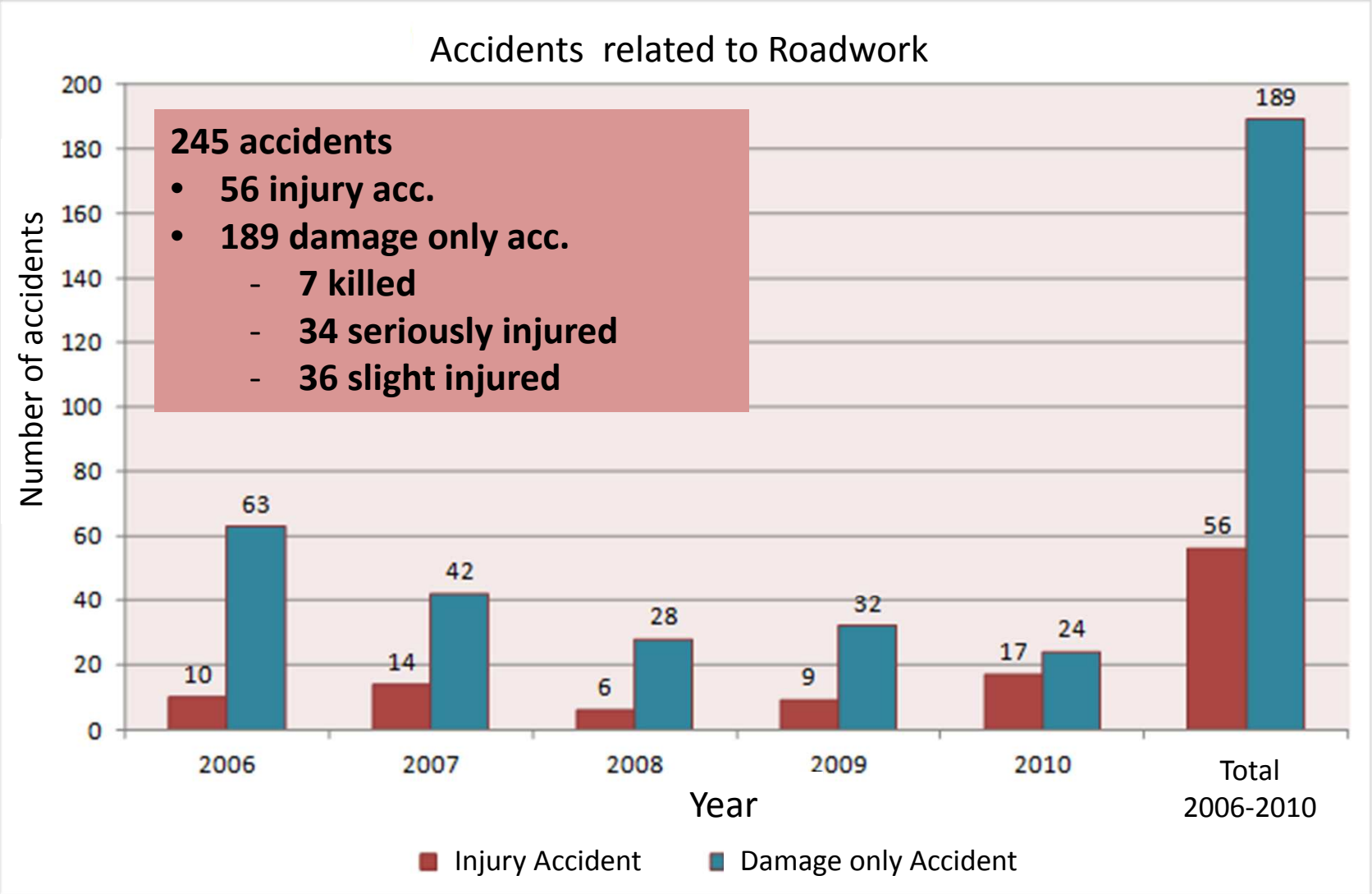
When driving on stretch

- 17% of the driving time: Glances at elements related to roadwork
  - Road side markings: 6% (most often barrier and tires)
  - Working Zone: 5% (most often unspecified)
  - Temporary signs: 6% (most often VMS and direction signs (Exits). Further, ‘km post’ and E16

- 67% of the driving time: Glances at elements *not* related to roadwork (other road users and the road)
- 16% of the driving time: Glances Left/right window, left/right mirror, instrumental board/car inside, center mirror etc.

Accidents Related to RoadWork on Motorways

7,3% of the total number of accidents on Motorways



Caracteristics of Roadwork accidents compared to other accidents (no roadwork)

Higher proportion of:

- Accidents involving **heavy vehicles**
- **Drunk-driving** accidents
- Drivers in the age group **35-44 years**
- Drivers who do *not* have **Danish citizenship**
- Accidents in **darkness** at stretches with lightning

Lower proportion of:

- **Seat belt use**
- Drivers in the age group **20-24 years**

Other caracteristics of Roadwork accidents

- Most frequent defined **accident situations** in relation to RW accidents:
  - 21% Rear end collisions
  - 13%: Merging and lane change to the left
  - 27% Single accidents
  - 14%: Accidents involvning roadwork barriers and other objects on road (are often single accidents)

- At least 12% of accidents are related to a **queue** situation

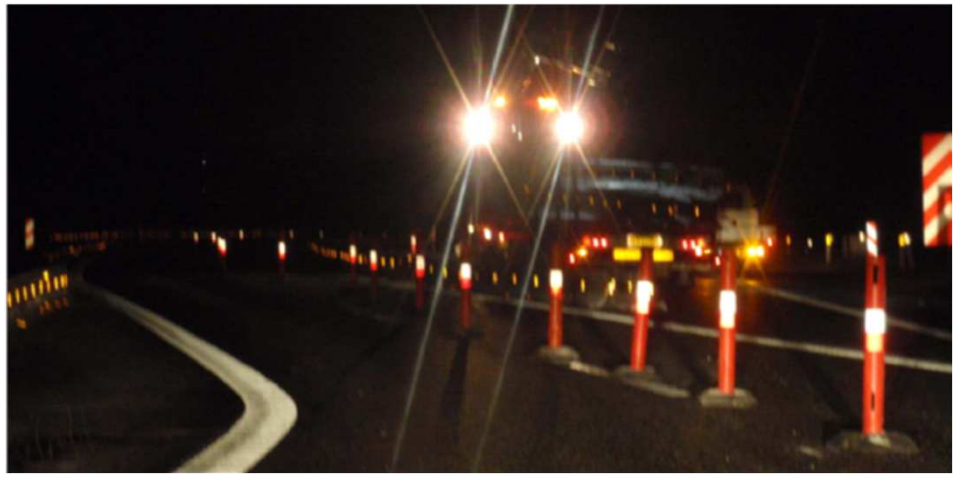
What goes wrong?

Descriptive parametres of the accident contributing drivers:

- Speeding – at least 26% of the RW accidents
- Influence of alcohol – 22%
- Inattention and fatigue - at least 13%

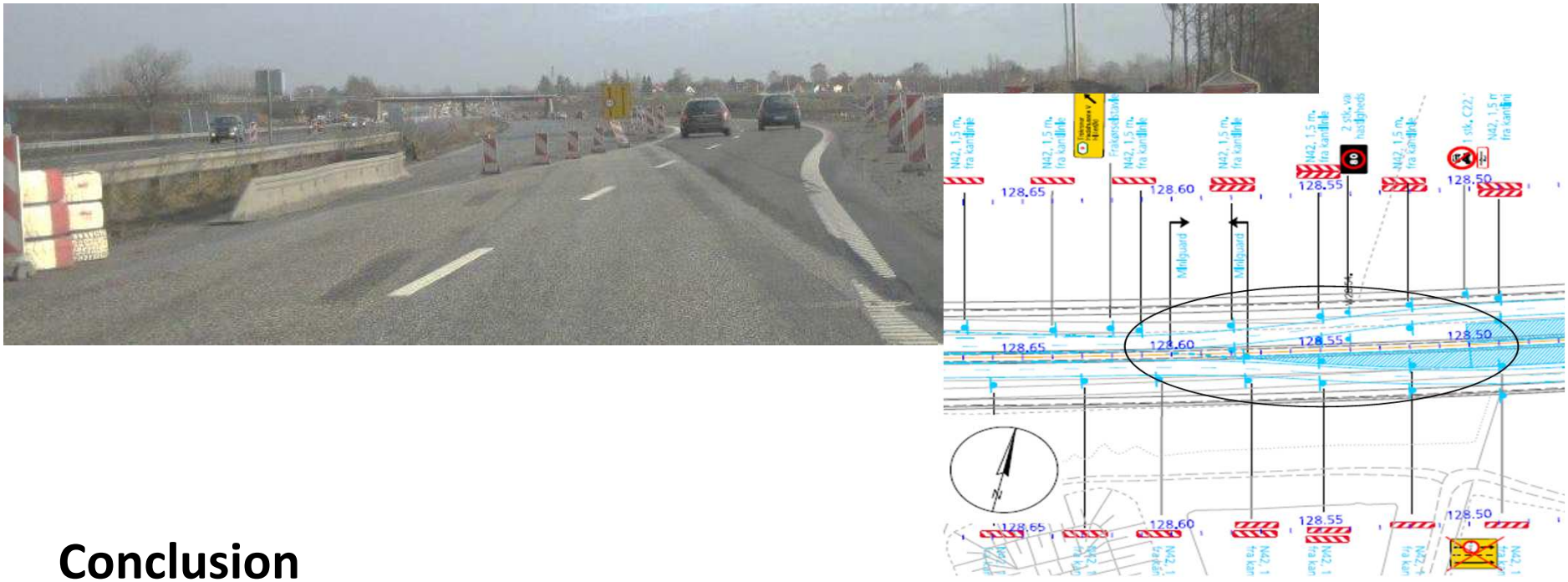
Speeding, influence of alcohol and inattention/fatigue are more pronounced for drivers involved in injury accidents.

- In 34% of the RW accidents the drivers collide to roadwork barrieres, roadwork vehicles or the like
- High speed and collision to roadwork barrieres, roadwork vehicles -> more serious accidents/more serious injury



Concentration of roadwork accidents

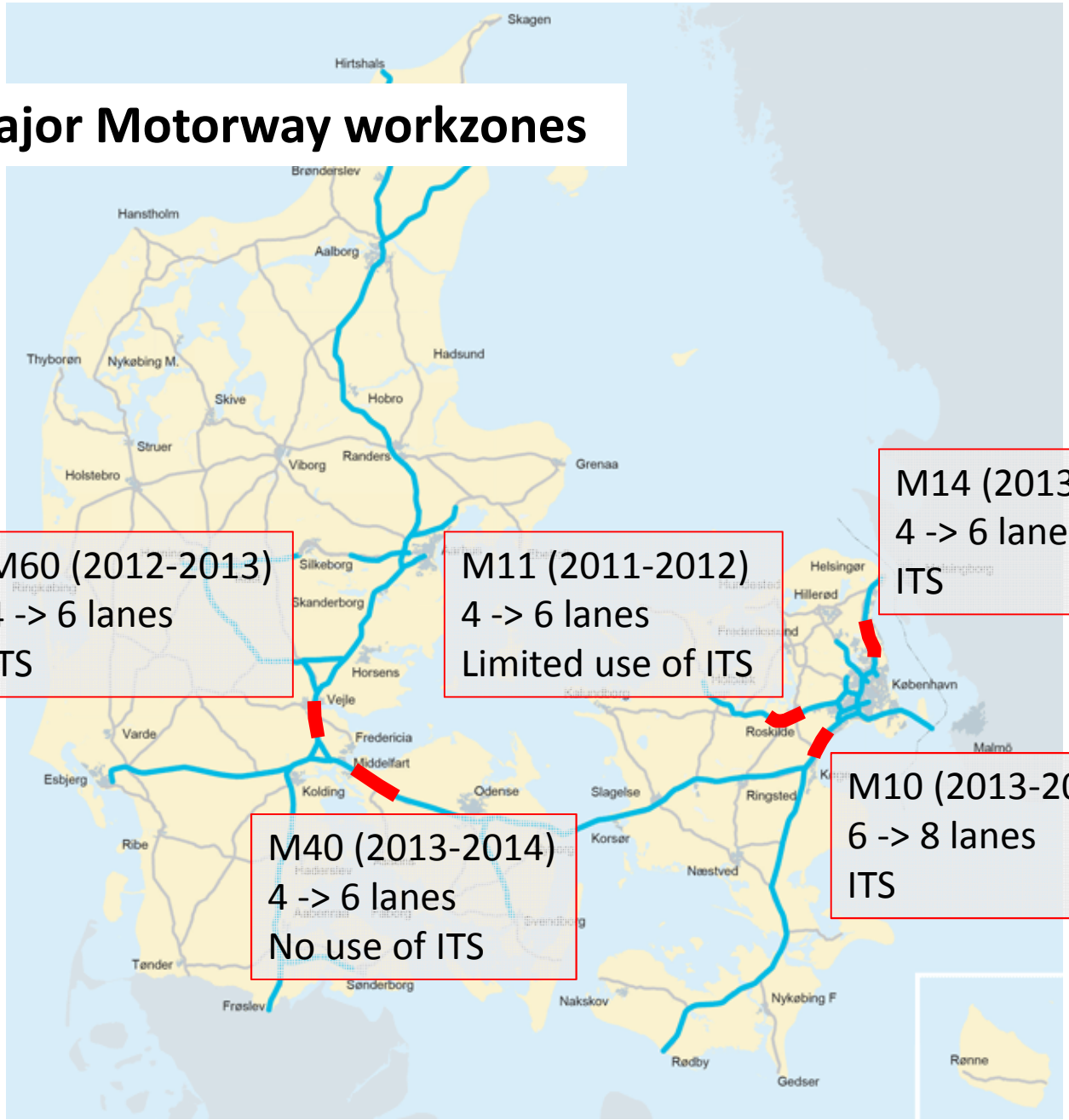
- Curves of ”S”shape



Conclusion

- Measures to reduce speed just before entering the roadwork stretch and at the roadwork stretch
- ”Wake-up call”

Major Motorway workzones



M60 – work zone

- 12 km motorway
- Widening from 4 lanes -> 6 lanes
- 3 on/off ramps
- 1.3 km bridges
- VMS on gantries (variable speed limit, travel time info, queue warning, incident warning)
- Different lane configurations (2+2, 3+1, 4+0) during construction period

M60 – Average traveling speed during road work
Direction south

Year / month

Period with road work

Time		2012											2013								
		1	2	3	4	5	6	8	9	10	11	12	1	2	3	4	5	6	8	9	10
	00:00	99	96	86	88	81	85	89	88	91	90	91	89	89	84	89	93	80	95	87	95
		92	92	85	87	81	86	89	88	91	90	90	88	90	84	88	94	76	92	92	92
	02:00	90	92	87	88	83	86	89	88	90	90	90	89	89	85	88	93	78	94	92	91
		92	91	87	88	83	87	89	89	91	91	89	88	89	85	89	94	79	94	93	92
	04:00	98	99	88	90	83	88	88	89	91	91	90	89	90	85	90	95	78	96	95	97
		106	106	89	90	81	87	89	89	92	92	90	90	91	87	91	96	93	96	95	98
	06:00	107	107	90	90	78	84	88	88	89	89	89	85	89	87	91	94	93	96	94	97
		91	100	86	79	66	75	80	77	77	81	83	66	76	74	78	83	81	91	85	86
	08:00	99	101	73	71	60	72	78	67	69	74	78	72	71	70	72	73	80	87	76	77
		106	105	78	81	65	73	84	69	80	84	86	84	76	81	81	86	88	92	87	85
	10:00	108	105	86	86	72	75	83	73	86	87	88	86	84	83	87	90	89	90	91	89
		106	105	86	86	73	76	82	80	86	86	88	87	87	83	87	88	88	90	91	94
	12:00	107	105	82	86	73	76	82	84	86	87	88	87	87	83	88	90	89	90	91	93
		106	105	87	86	73	76	81	84	85	87	88	87	87	84	82	88	88	88	91	95
	14:00	105	104	81	84	71	74	77	79	79	80	86	86	84	82	78	81	86	83	88	91
		103	101	76	82	67	70	76	71	73	68	84	83	81	74	79	77	84	78	82	84
	16:00	102	104	77	77	61	68	69	71	74	72	84	83	81	68	64	72	84	79	77	78
		107	106	85	84	66	73	71	77	79	77	87	87	87	65	79	83	91	84	86	86
	18:00	109	102	86	85	70	81	81	83	83	82	89	90	89	80	90	88	93	92	95	90
		112	103	83	86	78	85	88	89	88	86	90	91	89	85	93	93	89	96	95	95
	20:00	111	104	87	85	80	83	89	88	89	89	91	91	89	85	90	95	85	96	94	97
		112	105	88	84	80	86	88	89	91	91	92	91	89	86	85	96	85	96	95	100
	22:00	110	105	88	84	79	87	88	89	91	90	92	90	89	86	87	94	81	95	95	100
		109	103	89	88	80	86	89	90	92	92	92	91	90	84	90	95	81	96	95	99

M60 - Lane configurations - example

3+1

4+0

M60 - Traffic operation and lane configuration

Max observed traffic flow (2 lane)

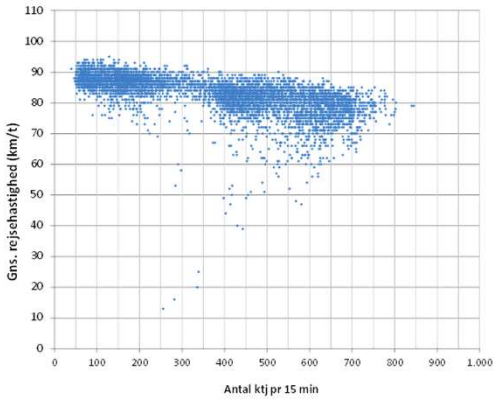
- 3+1: 3600 pcu/h
- 2+2: 3600 pcu/h (max flow not reached)
- 4+0: 4100 pcu/h

Main findings:
3+1 has

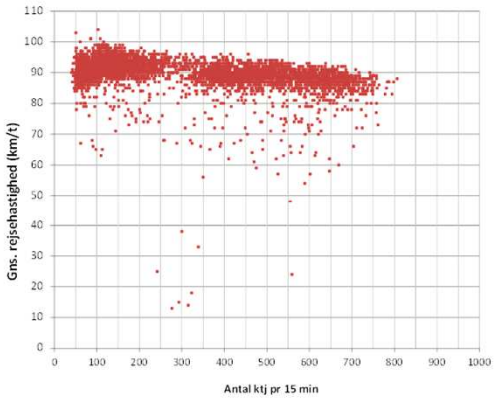
- Lower capacity
- Lower travel speed
- Greater variance in travel speed

- Main reason: Poor lane use

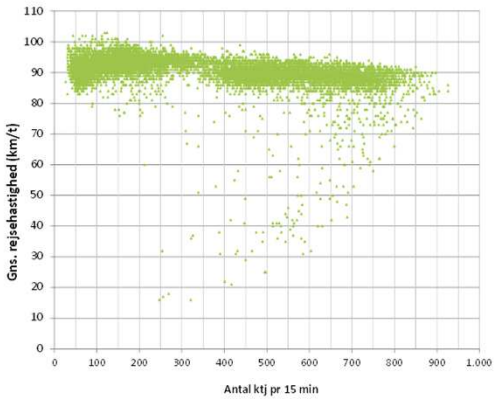
Speed- flow



3+1



2+2



4+0

General road user response to ITS/VMS at road works zones

VMS: (variable speed signs/estimated travel time/queue warning etc)

Road user feedback (based on interviews)

- Very satisfied with VMS
- Think VMS is useful
- Believe in safety effect / better traffic operation by use of VMS

However:

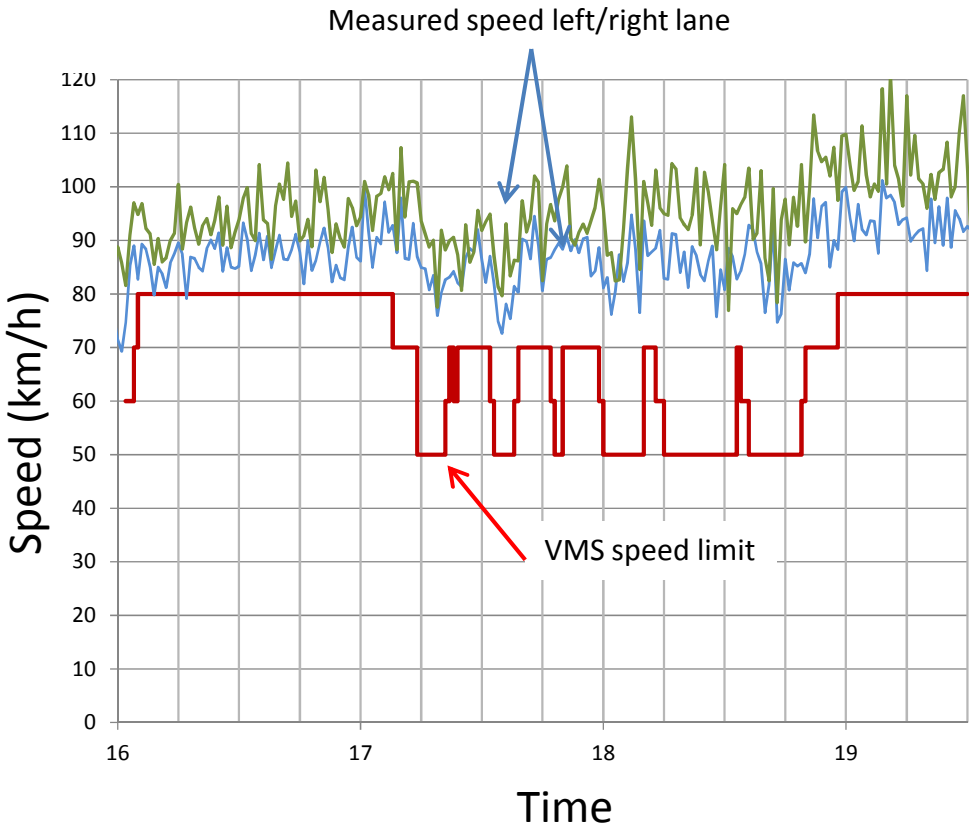
- 25-50% don’t think the variable speed limit is reasonable (to the current traffic situation)
- Divided views on the usefulness of the estimated travel times
- Divided views on the credibility of queue warnings

VMS speed limit compliance

- The compliance varies
- Greater effect on speed when reason for speed reduction is provided
- Often small effect on measured speed – but maybe on driver attention ?
- The measured speed seems to be more depending on traffic density than on VMS speed limits

Example from M60.

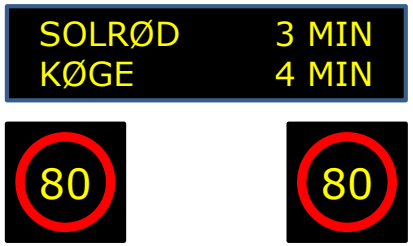
Accident/queue 5 km downstream



Speed limit (VMS)	Measured speed
80 km/h	92 km/h
70 km/h	91 km/h
60 km/h	87 km/h
50 km/h	87 km/h

Example from M10.

Warning: Pothole downstream / reduced speed limit (80 km/h -> 50 km/h)

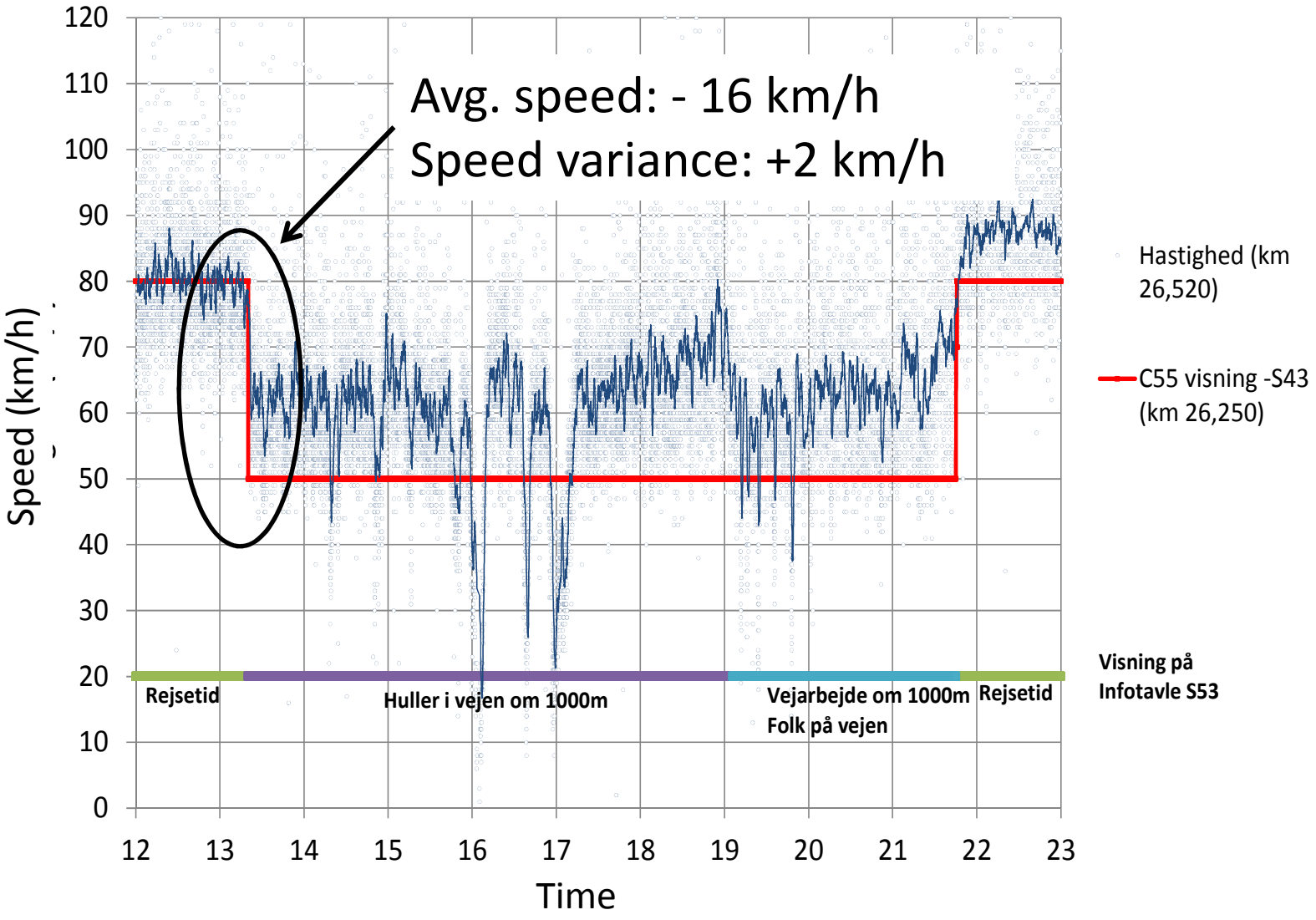


Estimated travel time
Speed limit 80 km/h

Pothole warning
Speed limit 50 km/h

Example from M10.

Warning: Pothole downstream / reduced speed limit (80 km/h -> 50 km/h)



Traffic operation on different freeway cross-sections

Basis

300cm 275cm

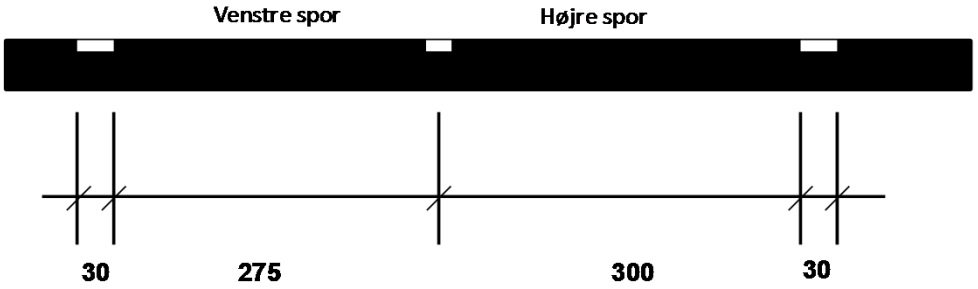
Afmærk 1

300cm 220cm

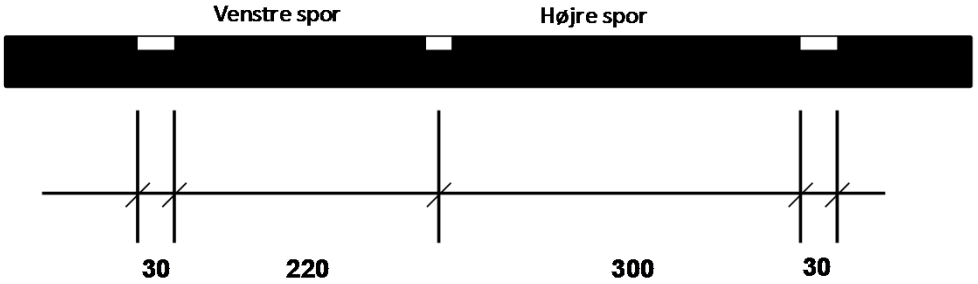
Afmærk 2

300cm 220cm

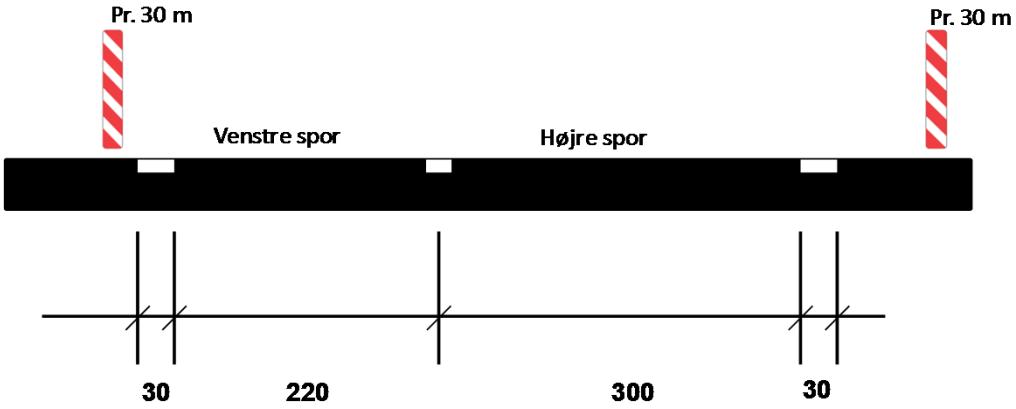
Basis

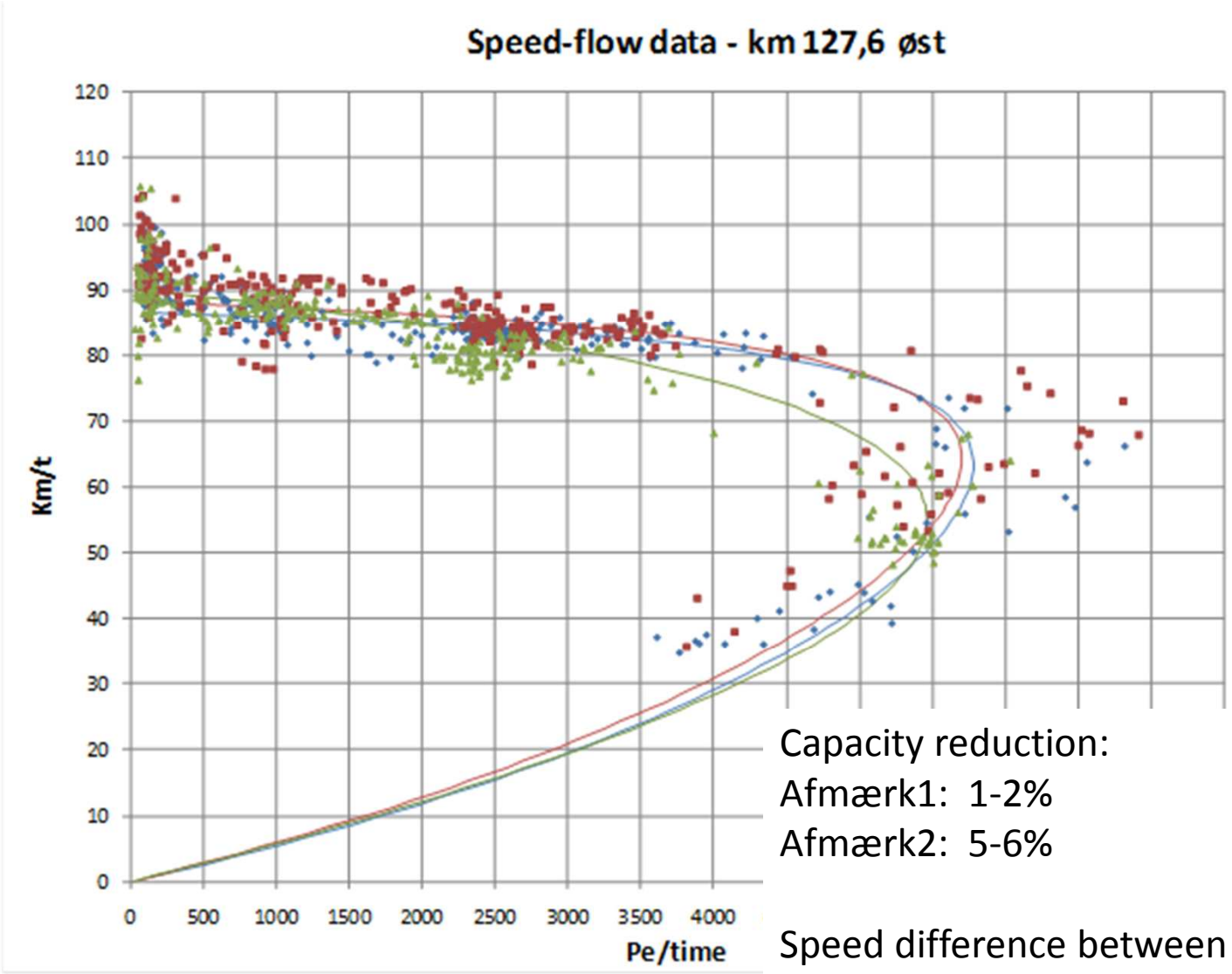


Afmærk 1



Afmærk 2





Capacity reduction:
Afmærk1: 1-2%
Afmærk2: 5-6%

Speed difference between left/right lane reduced

Higher share of vehicles in the right lane