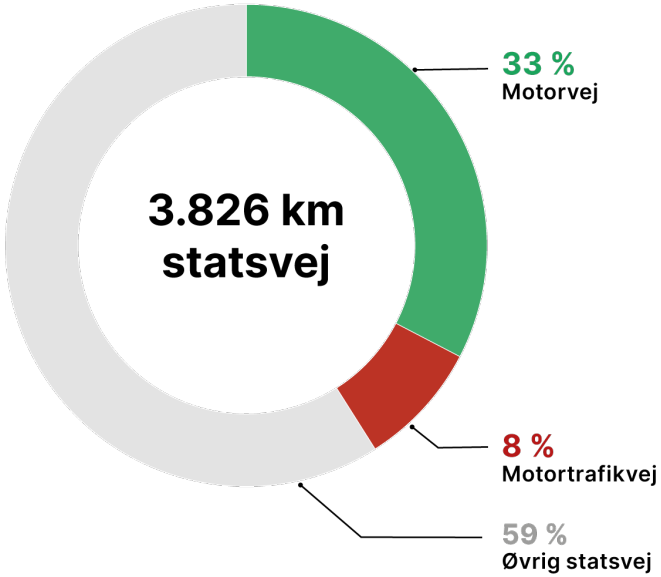
Experience with AI condition measurements and implementation in pavement management – part 2

Niels Dujardin, Danish Road Directorate - TRB International Partnership Meeting 2026

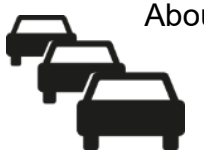
Vejdirektoratet

Danish Road Directorate's responsibility

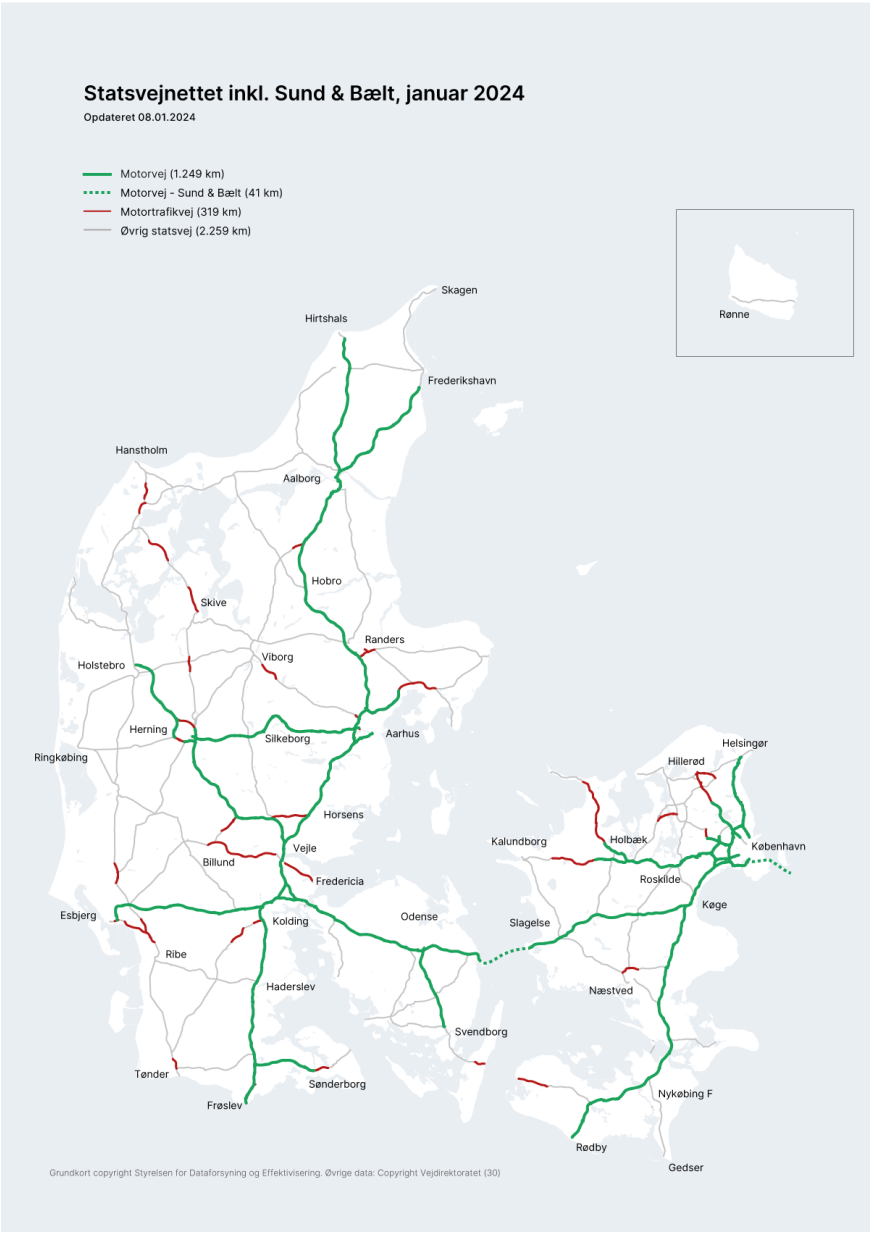
We are responsible for the national roads, which are motorways, dual carriageways, a large part of the main roads and many of the bridges across the country. A total of 3,800 kilometres. We are also responsible for maintaining around 2,500 bridges and tunnels.



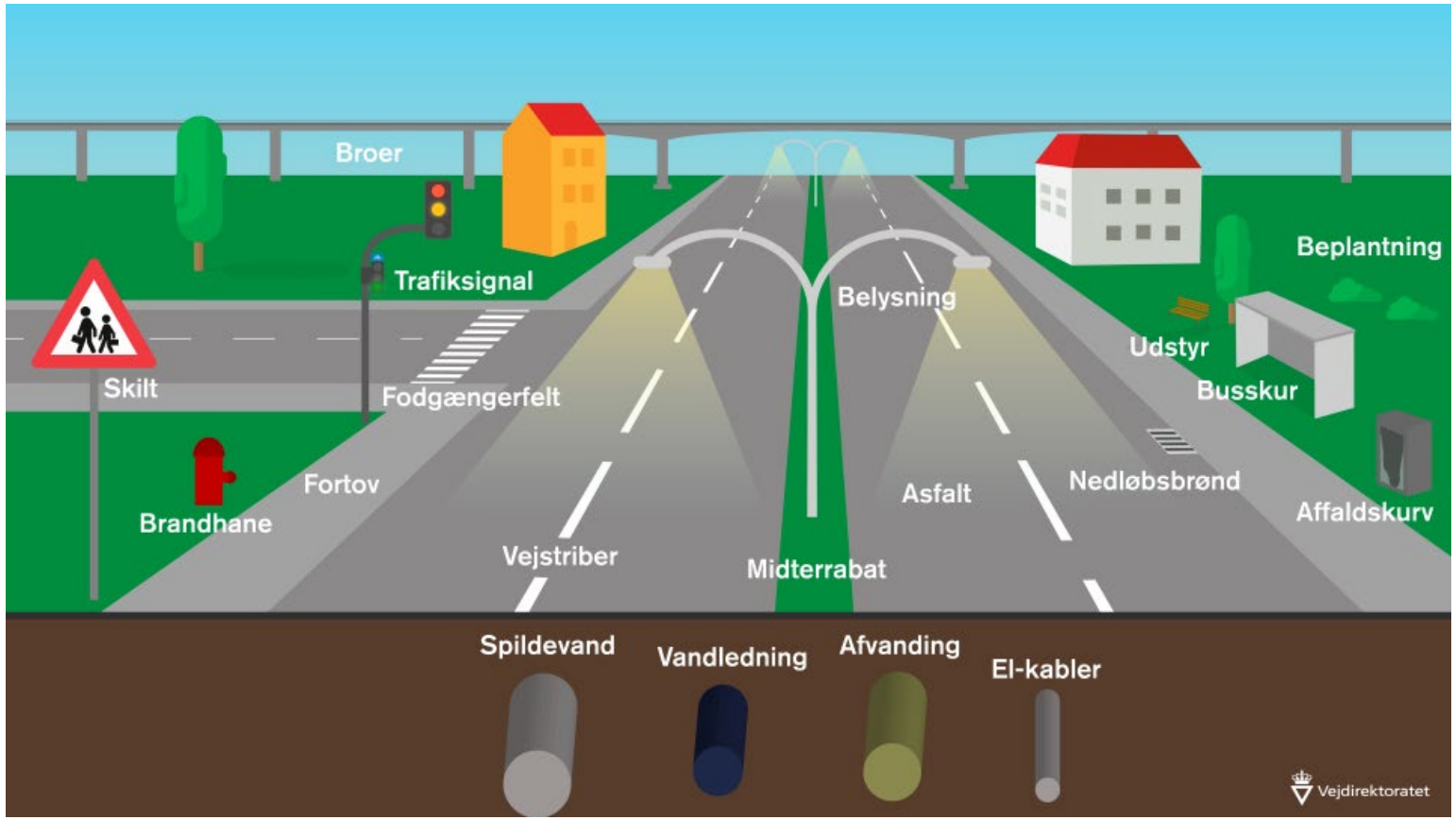
The national trunk road network accounts for about **5%** of the total public road network in Denmark



About **48%** of road traffic travels on national roads



Asset management – optimum operation and maintenance I



Asset Management supports the goal of **safe, functional and economically optimal road maintenance** in accordance with politically determined wishes and priorities.

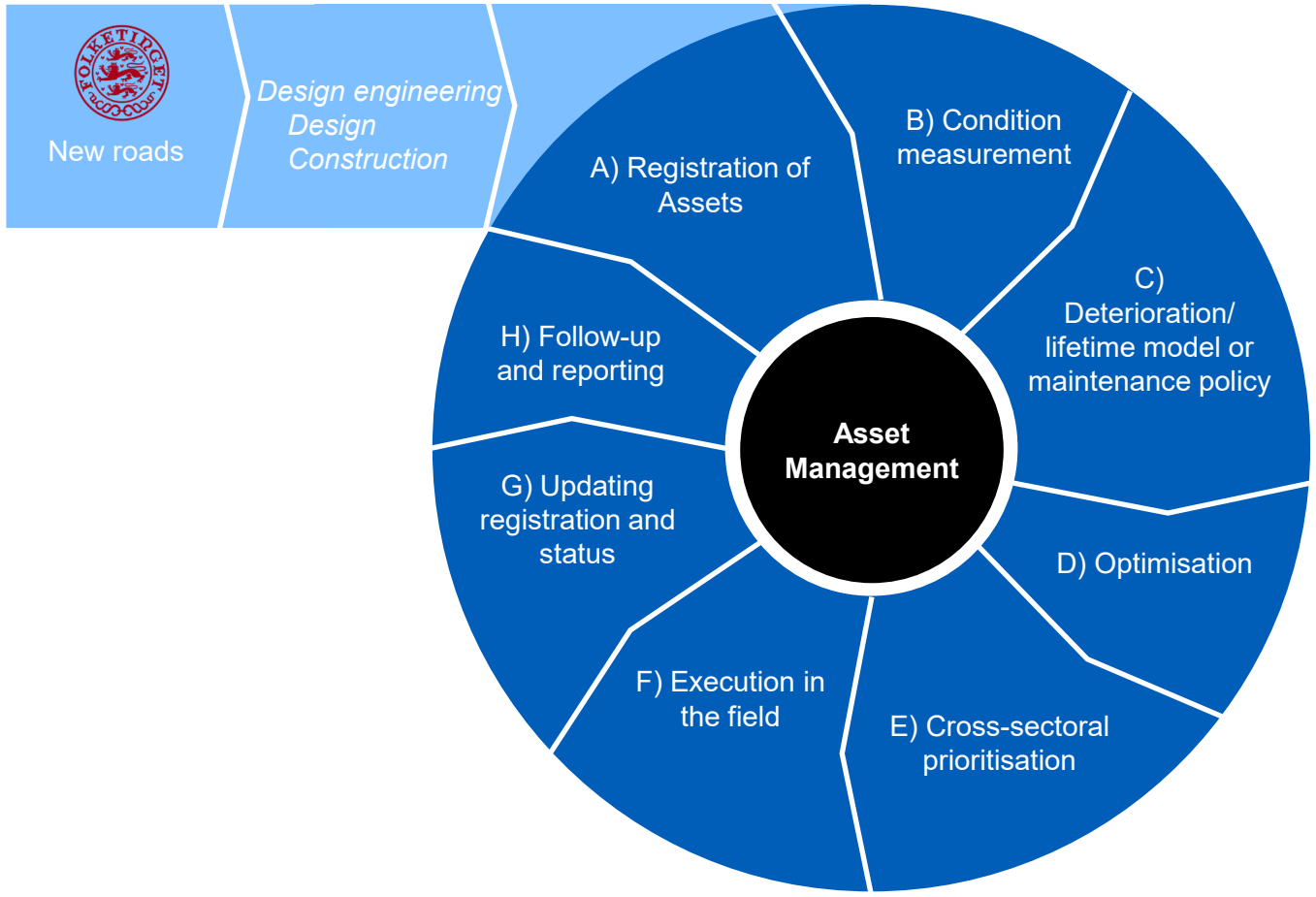
Asset management is built around strategies and processes that must be supported by data and IT-systems

Asset management – optimum operation and maintenance II

Within the given framework, the goal is to minimise the total life cycle costs of the road network while maintaining the agreed service level.

To achieve this goal, we need to:

- get an overview of what we have, i.e. unambiguous registration of assets
- know the condition and need for operation and maintenance based on fixed criteria
- prioritise and plan our efforts
- carry out and document operation and maintenance
- report the status of the overall condition



ASSESSMENT OF QUALITY AND CONDITION OF ROAD NETWORK

COMPLETE OVERWIEV – CONDITION OF THE ROAD PAVEMENTS ON THE DANISH STATE ROADS (2024)

Roads are safe and functional

Global indicator (0-100 scale)

Global condition

Motorways	88,7 - God
Other Roads	89,3 - God

Combined indicators (0-100 scale)

Structural condition

Motorways	92,2 - Good
Other Roads	88,9 - Good

Functional condition

Motorways	85,3 - Good
Other Roads	89,7 - Good

Lifetime

Motorways	92,2 - Good
Other Roads	88,9 - Good

Safety

Motorways	86,6 - Good
Other Roads	90,5 - Good

Comfort

Motorways	80,0 - Good
Other Roads	86.1 - Good

Single indicators (0-100 scale)

Bearing capacity

Motorways	95,0 - Good
Other Roads	85,4 - Good

Evenness

Motorways	78,9 – Acceptable
Other Roads	85,4 – Good

Rutting

Motorways	99,8 - Good
Other Roads	99,2 - Good

Texture

Motorways	100,0 - Good
Other Roads	99,6 - Good

Road Markings

Motorways	62,5 - Acceptable
Other Roads	74,4 - Good

Monitored condition (divided in categories from good to critical, % of complete road network)

	Bearing capacity					Evenness					Rutting					Texture					Road Markings				
Motorways	87,0	8,7	2,4	1,4	0,6	27,2	64,1	6,6	1,3	0,8	99,1	0,9	0,0	0,0	0,0	99,8	0,1	0,0	0,0	0,0	33,2	18,2	27,5	4,3	13,4
Other Roads	64,7	20,4	8,6	4,4	1,9	51,8	41,0	5,1	1,3	0,9	97,0	2,9	0,1	0,0	0,0	98,8	0,9	0,3	0,0	0,0	51,0	16,4	20,1	4,3	8,3

Signature Explanation

Good | Acceptable | Becoming poor | Poor | Critical

ASSESSMENT OF QUALITY AND CONDITION OF ROAD NETWORK

	GOOD	ACCEPTABEL	TOWARDS POOR CONDITION	POOR	CHRITICAL
	Common maintenance action	**Follow up recommended**	**Parts of the road network requires intensified maintenance action**	**Extensive actions required**	**Acute actions required**
Bearing capacity (Estimated RLT based on TSD screening	30 years	10 – 29 years	5 – 9 years	2 – 4 years	Under 2 years
	No structural problems.	No requirements for reinforcement.	Reinforcement needs to be considered	Moderate to high risk of structural failure and the need for reinforcement.	High risk of structural failure and the need for reinforcement. v.
EVENNESS (IRI, m/km)	0,8 and under (motorways) 1,0 and under (other state roads)	0,9 – 1,6 (motorways) 1,1 – 2,0 (other state roads)	1,7 – 2,4 (motorways) 2,1 – 3,0 (other state roads)	2,5 – 3,2 (motorways) 3,1 – 4,0 (other state roads)	Over 3,2 (motorways) 4,1 – 5,0 (other state roads)
	Good driving comfort No or very few unevenness.	Average driving comfort. Unevenness can occur due to surface defects, patches etc.	Several uneven parts. Can be noticed when driving. The road is considered uneven	Poor driving comfort – can result in safety issues.	Poor driving comfort high influence on safety.
RUTTING (rut depth, mm)	5 mm and under	6 – 10 mm	11 – 15 mm	16 – 20 mm	Over 20 mm
	No rutting problems and no risk of aquaplaning	Discomfort noticeable when changing lanes. Low risk of aquaplaning	Risk of aquaplaning at heavy rainfall and high speeds.	Risk of aquaplaning and possible indication of poor bearing capacity. The condition can be of hazard for motorists.	High risk of aquaplaning and an indication possible poor bearing capacity.
TEXSTUR (MPD, mm)	0,5 and over	0,40 – 0,49	0,30 – 0,39	0,20 – 0,29	Under 0,20
	Very low risk of friction problems	Low risk of friction problems	Moderate risk of friction problems	High risk of friction problems	Very high risk of friction problems.
ROAD MARKINGS VISIBILITY (mcd/m²/lux)	150 and over	130 - 149	100 - 129	90 - 99	Under 90
	Road marking appears as new.	Road marking is visible, and no major safety risk is foreseen	Road marking is visible but requires extra concentration from the motorist. The visibility is problematic in wet weather or at night.	Visibility very poor in dependently of the conditions. The condition contributes to a higher safety risk.	The road marking is not visible and requires immediate action

Roads are safe and functional

Economically optimal road maintenance

- Remaining life is the central parameter
- The remaining life is determined through visual assessment, where the cost of continued repairs exceeds the cost of replacing the surface layer
- The objective with AI-condition measurement is to replace the visually assessed remaining life

Market dialogue and testing of different AI-solutions

- Clarifications of which assets should be included in the tender
- Clarifications of which technical requirements can be imposed on the suppliers
- Clarifications of IT security, phone/camera types, and GDPR handling
- Clarifications of practical aspects in vehicles – power on/off, calibration, power supply, internet connection
- 50+ participants, 6 suppliers, plenary sessions, individual conversations, system testing

Procurement and implementation

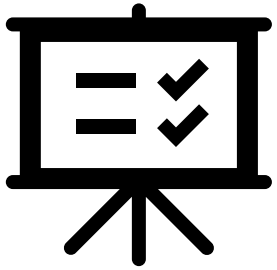
Procurement

- We received six offers from suppliers based in Australia, the United States, and Europe
- Four of these offers met the conditions outlined in the tender material
- The initially announced winner withdrew their offer during the clarification phase
- The second announced winner successfully passed the delivery test, and the contract has now been signed

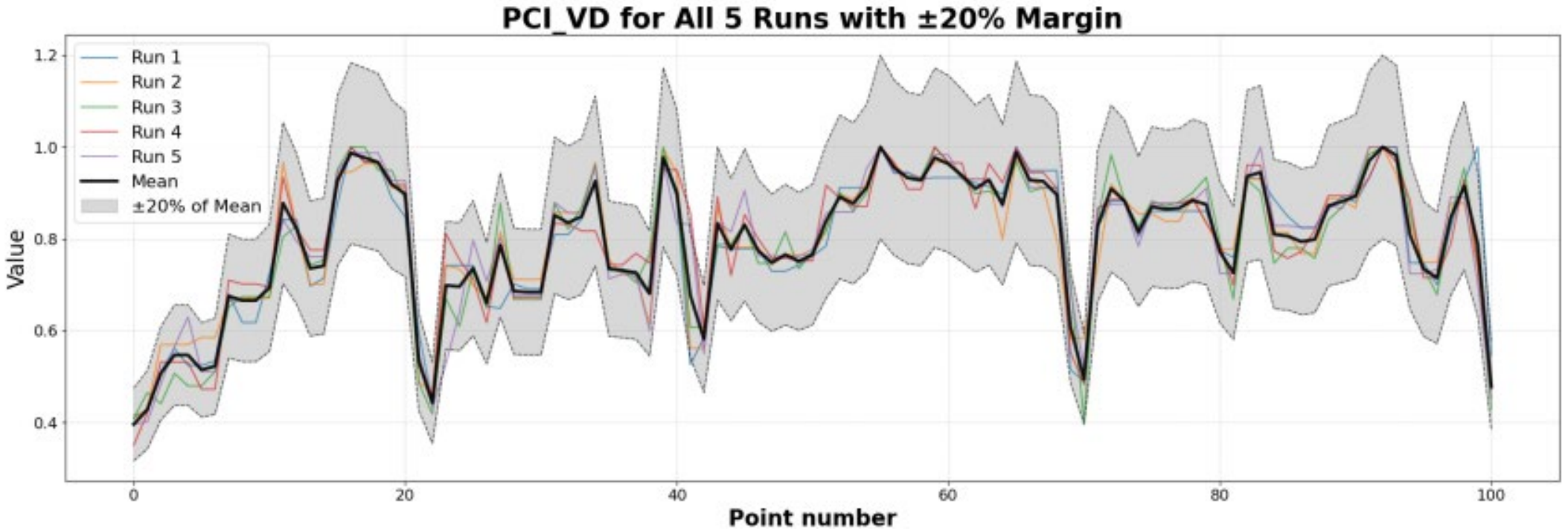
Implementation

- The current road model used by the Danish Road Directorate is insufficient to handle data measured at random roads
- The vehicles used for the measurement process must be van-sized
- The measurement vehicles must be equipped with Wi-Fi connectivity
- The current IT setup in the Danish Road Directorate must be optimized to support daily data updates

Repeatability and classification



Test section	Road class	Road Name	Section length	Total damage index	Classification based on reference	Classification based on VAISALA
2	Motorway	11-0-H-VB1	1000 m	0,0495	Best	Best
3	Motorway	11-0-H-VB1	1000 m	0,101	Good	Good
4	Motorway	11-0-H-VB1	1000 m	0,417	Worst	Worst
5	Motorway	11-0-H-VB1	1000 m	0,114	Fair	Fair
6	Highway	119-0-H-VB1	1000 m	0,289	Poor	Poor



Cross-element register and pavement register

Cross-element

A register, that contain the cross-elements of the road. (”How wide are the carriageway, number of lanes etc.”).

Pavement

A register, that contains all pavement information from the base to the friction course.

Tværprofil

Data for strækning « ‹ 13/0000 - 13/0004 › » Vej 13−0 KØBENHAVN−HELSINGE (HILLERØDMOTORVEJEN) kmt 13/0000−13/0010

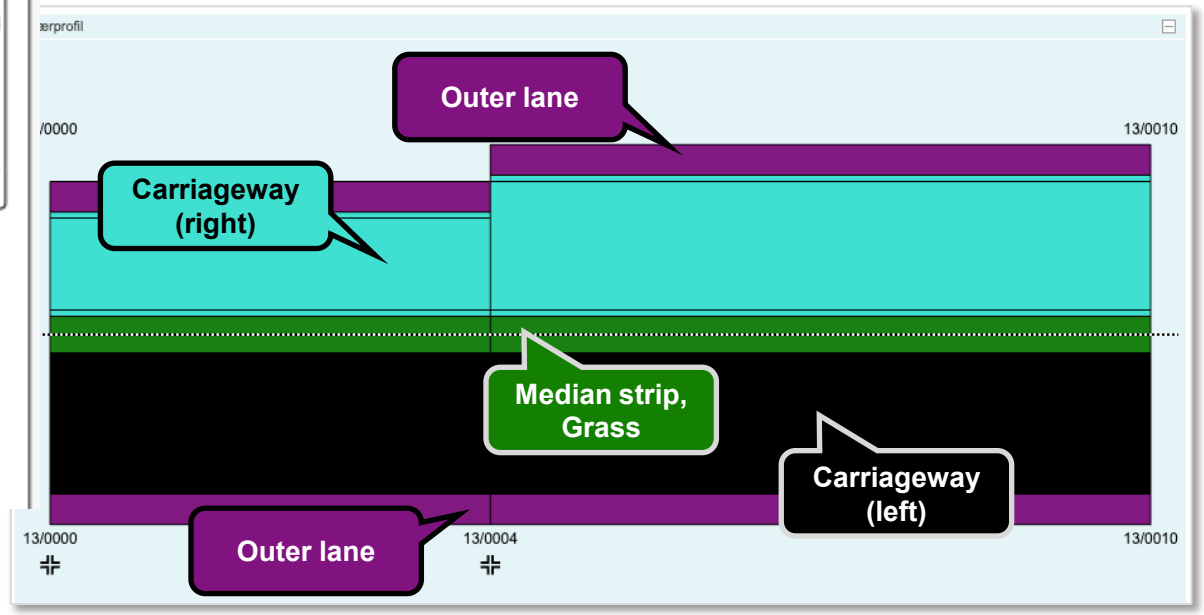
Tværprofil | Justeringsarealer | Kryds | Tegn m | PDF-udskrift | Gem data | Opret delepunkt | Nedlæg delepunkt | Normalprofil

Ny	Tværprofilelement	Vejside	Bredde Start	Bredde Slut	Kile	Funktion	Antal spor	Antal minusspor	Overflade
	63 Sti	Venstre	2,50			Anden bestyrer, eget tra			Asfalt
	56 Yderkantbane	Venstre	0,50			Kant -alm.			
	4 Kørebane	Venstre	7,50				2		
	58 Midtkantbane	Venstre	0,50			Kant -alm.			
	1 Midterrabat	Midt	3,00						Græs
	58 Midtkantbane	Højre	0,50			Kant -alm.			
	4 Kørebane	Højre	10,50				3	1	
	56 Yderkantbane	Højre	0,50			Kant -alm.			
	63 Sti	Højre	2,50			Anden bestyrer, eget tracé			Asfalt

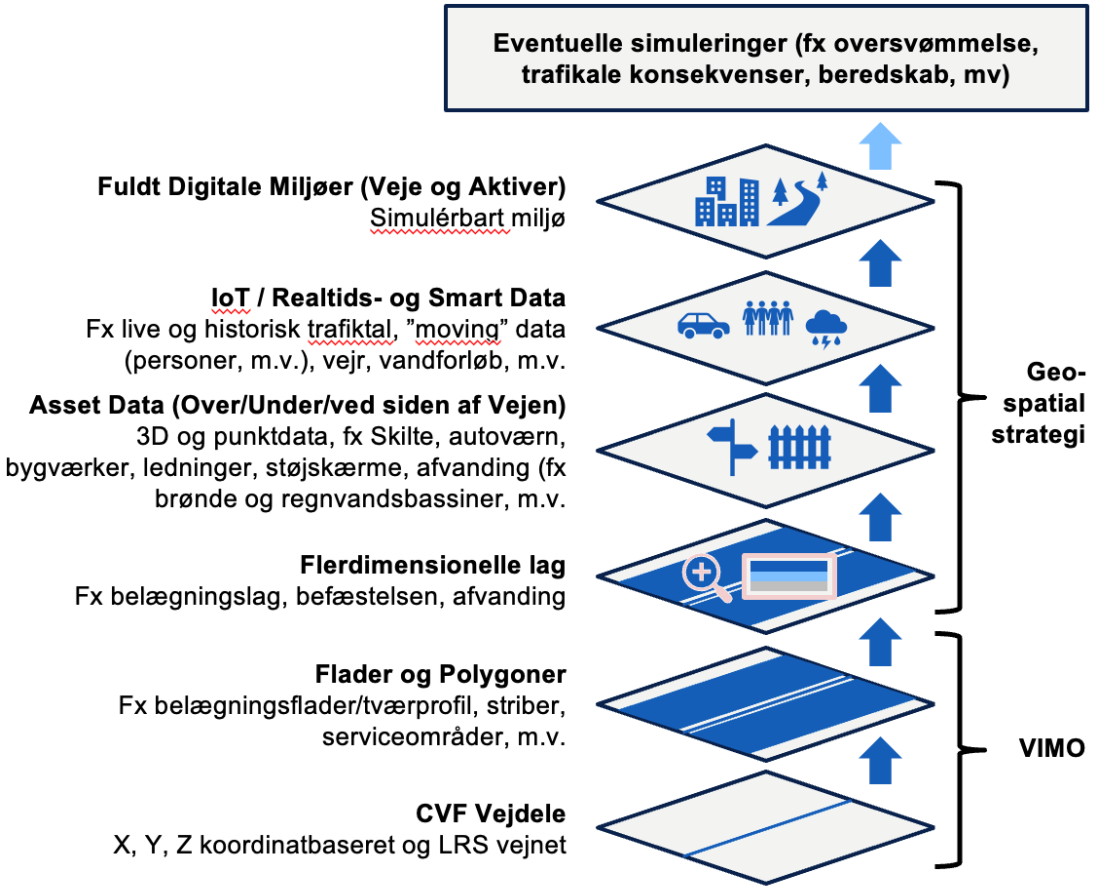
Søgeresultat

Opret ny

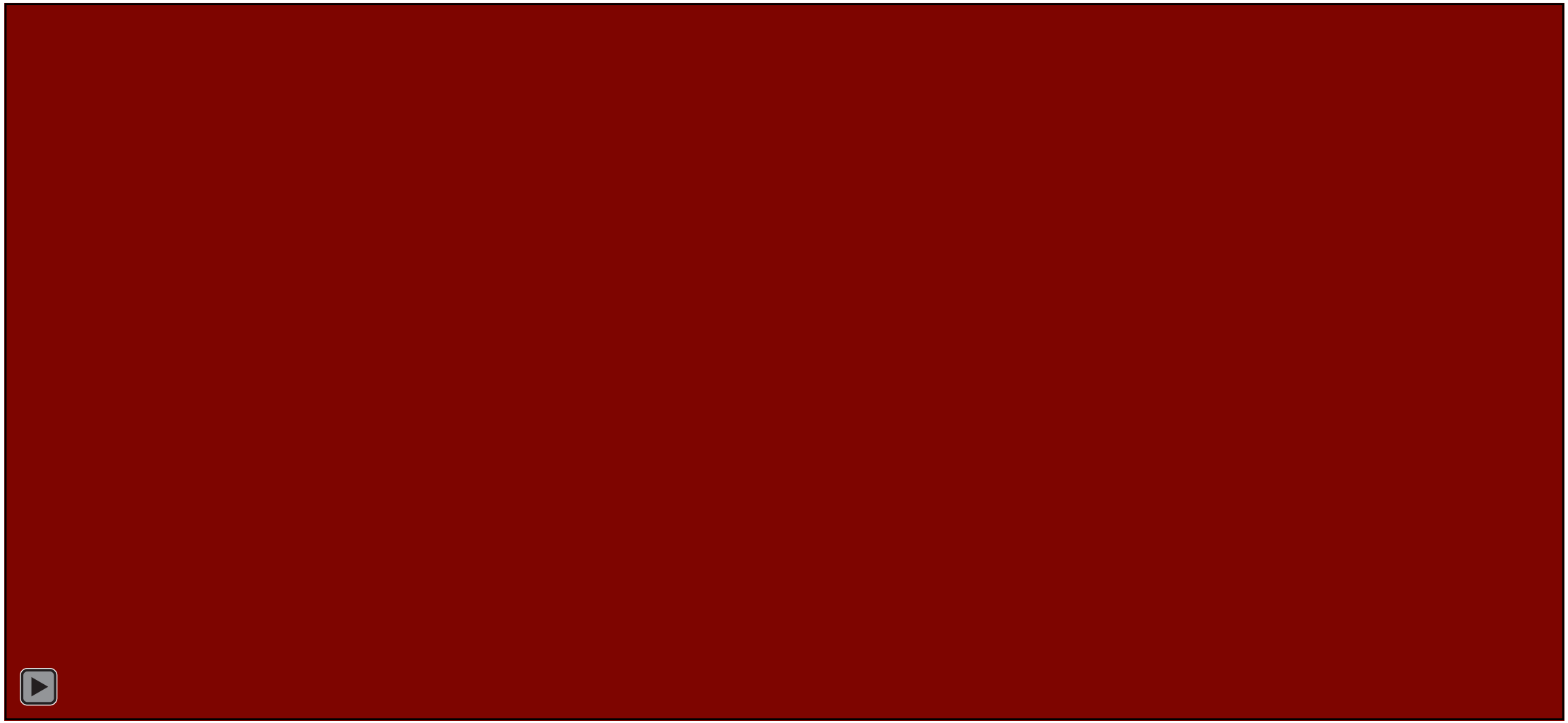
Admvejnr	Admvejdel	Frakm	Fram	Tilkm	Tilm	Belarb id	Vejside	Tværprofilelement	Mængde kg/m2	Tykkelse mm.	Affræst tykkelse mm.	Type	Udlægn slut dato	Senest rettet	Bru
13	0	13	0	13	10	21887210	Højre	Kørebane		300		BG	02-01-1974	11-12-2023	stla
13	0	13	0	13	10	21887207	Højre	Kørebane		150		SG2	03-01-1974	11-12-2023	stla
13	0	13	0	13	10	21887206	Højre	Kørebane	518	230		GAB2	07-01-1974	11-12-2023	stla
13	0	13	0	13	10	21887205	Højre	Kørebane	135	60		GAB1	08-01-1974	11-12-2023	stla
13	0	13	0	13	10	21887204	Højre	Kørebane	86	38		ABS	13-01-1974	11-12-2023	stla
13	0	13	0	13	10	21898989	Højre	Kørebane	90	38		ABS	31-12-1974	28-10-2003	SS
13	0	13	0	13	10	21902085	Højre	Kørebane	-78,75		35	AFFR	01-09-2010	14-12-2010	sok
13	0	13	0	13	10	21902087	Højre	Kørebane	55	23		SMA	02-09-2010	14-12-2010	sok
13	0	13	0	13	10	99058752	Højre	Kørebane			30	AFFR	30-10-2020	30-10-2020	pja
13	0	13	0	13	10	68490033	Højre	Kørebane	70	30		KVS	31-10-2020	30-10-2020	pja
13	0	13	0	13	10	21898998	Venstre	Kørebane	90	38		ABS	31-12-1974	28-10-2003	SS
13	0	13	0	13	10	99057636	Venstre	Kørebane			34	AFFR	30-07-2012	22-07-2014	pja
13	0	13	0	13	10	32614305	Venstre	Kørebane	80	34		SMA	31-07-2012	22-07-2014	pja



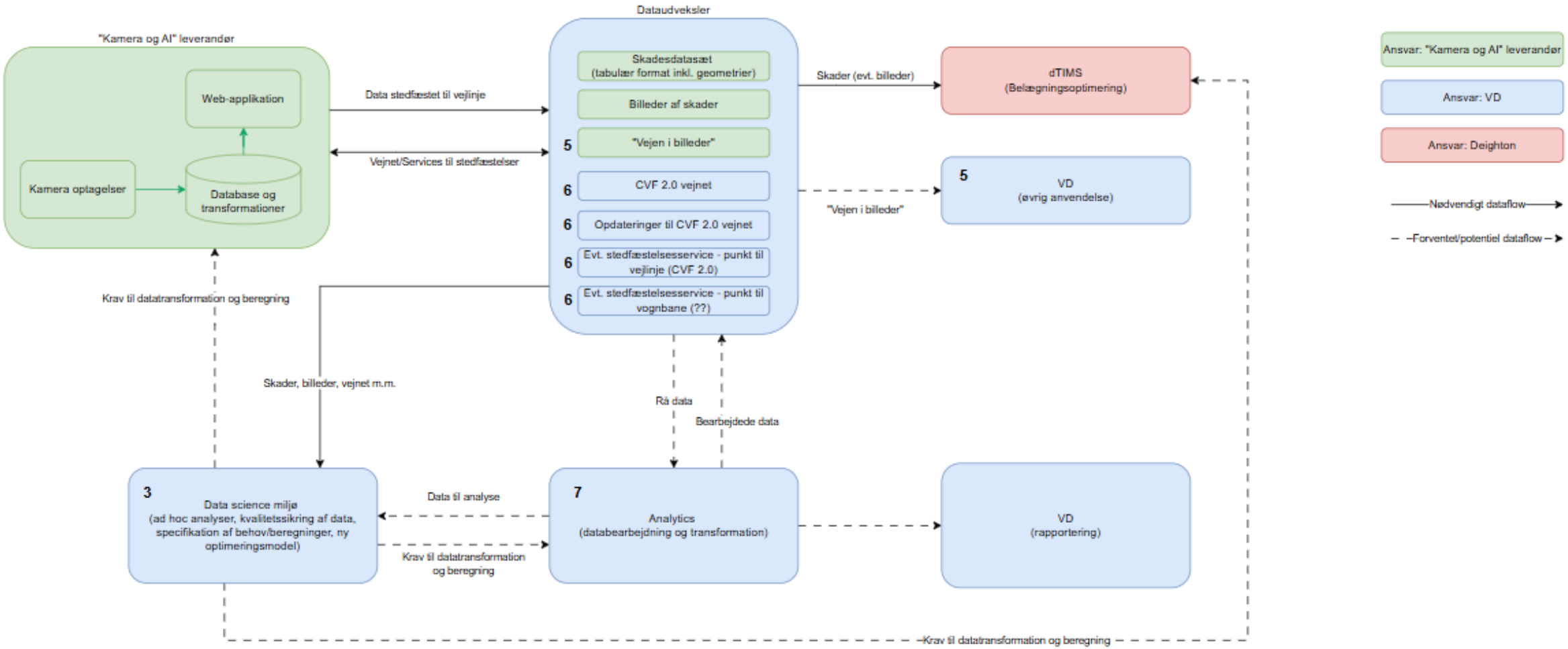
Transition to geospatial domain



Example of Vaisalas AI solution



Målarkitektur



Further work (I will present a part 3 next year ☺)

To perform economically optimal pavement maintenance based on AI condition measurements we have to:

- Perform GIS-based registration of all state roads
- Define a maintenance policy aligned with the new objective condition data
- Optimize maintenance effort based on the new maintenance policy
- Execute and document operations and maintenance activities, including associated cost
- Report on overall pavement condition and cost levels for maintenance