New Diverging Diamond Interchange at Junction 52 Odense SV

Presentation of Road Safety Audits 2016-2018 by
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- NVF Lillehammer, September 2019

Vejdirektoratet

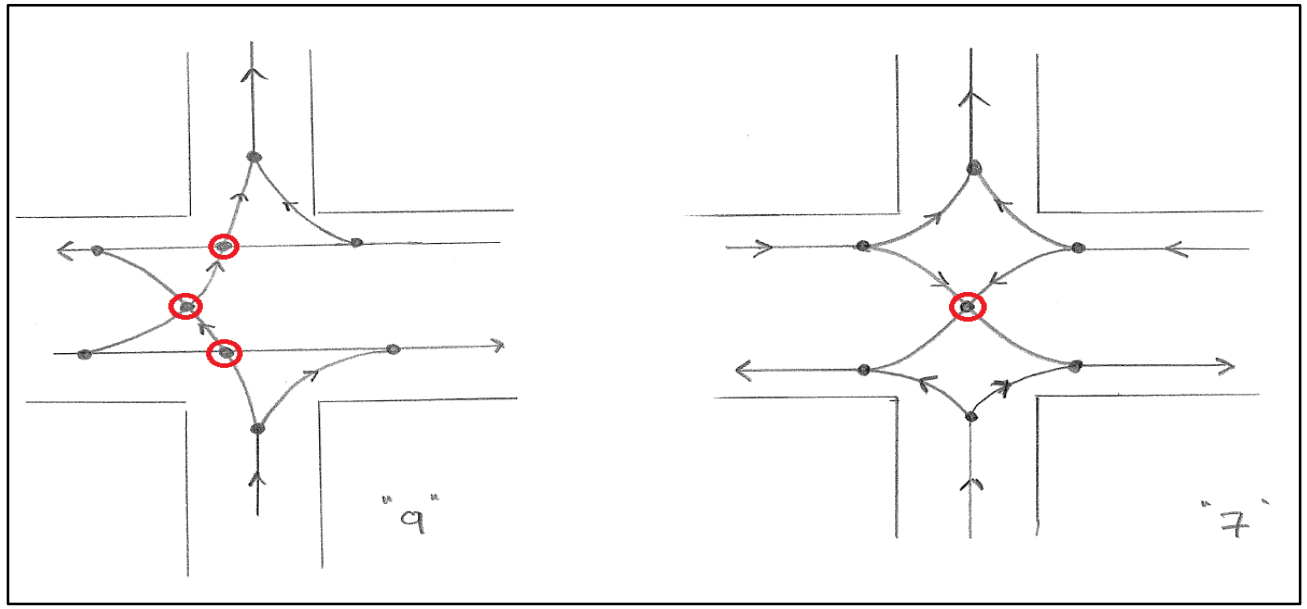
Background for project

- Congestion at Motorway Junction 52 Odense SV
- Narrow motorway bridge on Assensvej prevents adding-on extra lanes
- Interest in new solutions to reducing congestion problem at a confined space
- From USA we knew of Diverging Diamond Interchanges (DDI)

Principle for the

Diverging Diamond Interchange

- A ramp system where motorists swap ground to eliminate conflicts between left- and straight-ahead traffic
- Advantages: Greater capacity and fewer accidents as crossings between left- and straight-ahead are removed



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A new motorway junction at 52 Odense SV

- The project at Odense has its own website https://www.vejdirektoratet.dk/side/dynamisk-ruderanlaeg-odense-sv

- The website includes an online presentation of the project idea
- The language is Danish here, I hope it will be understandable for most ☺

- https://www.youtube.com/watch?v=SH0drvyCqwk&feature=youtu.be

Professional visit to USA

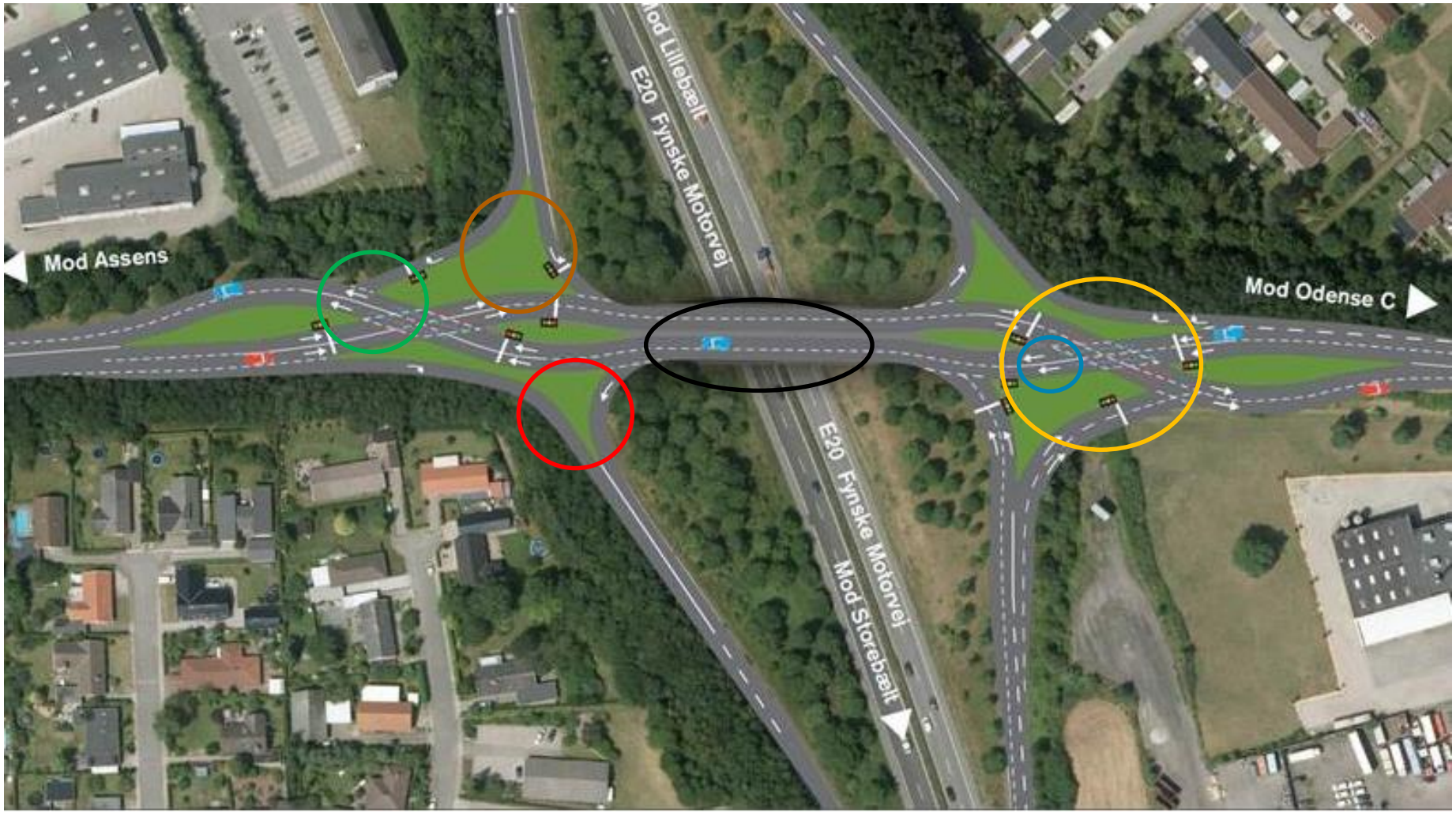
- The Missouri Department of Transportation was visited in late 2015 by different VD professionals to learn more about the design and use of DDIs

- In 10 site visits the focus was e.g. on:

  - Traffic islands
  - Signals and signs
  - Road markings
  - Optical guidance
  - Glare

Expected road safety challenges in the resulting project proposal – as outlined by project team

- Curve radii
- Connecting Assensvej to and from junction
- Road markings
- Junctions, signals and signs
- Traffic islands
- Glare



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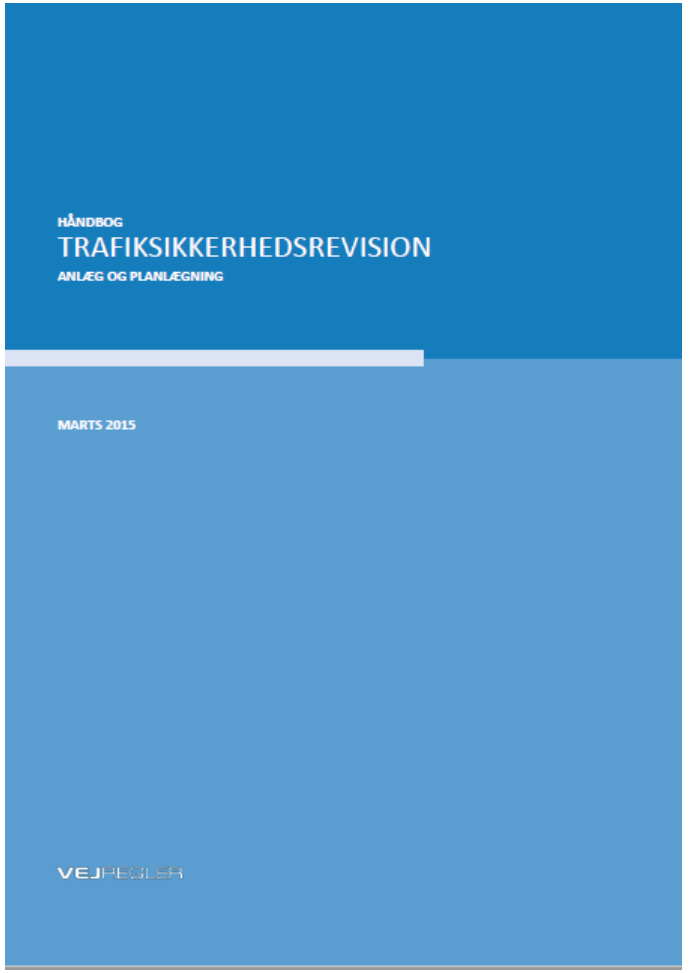
The road safety audit

- The road safety audit is performed by an examined road safety auditor, who is independent of the project
- The road safety audit is a systematic and critical examination of the project, performed according to a validated and agreed procedure
- The road safety audit is not a quality control whether a project complies with all rules and road regulations
- The focus of the audit is only on identifying and describing the conditions that give rise to road safety concerns, and on providing practical proposals to remedy the problems



- I should mention that it is not required that the project team (represented by the project designer and project leader) needs to agree with the road safety auditor on all identified problems and recommended remedies.
- It is only required that the formal audit procedure is followed. And it has been ☺.

- I should also mention that there are no cyclists or pedestrians in the new junction at Odense. Access is prohibited by signage on Assensvej.
- The planning of a new DDI at Aalborg has been started. This junction will provide access for vulnerable road users. Next week I start the step 2 audit of the preliminary design.

This was the site before reconstruction

17 June 2016

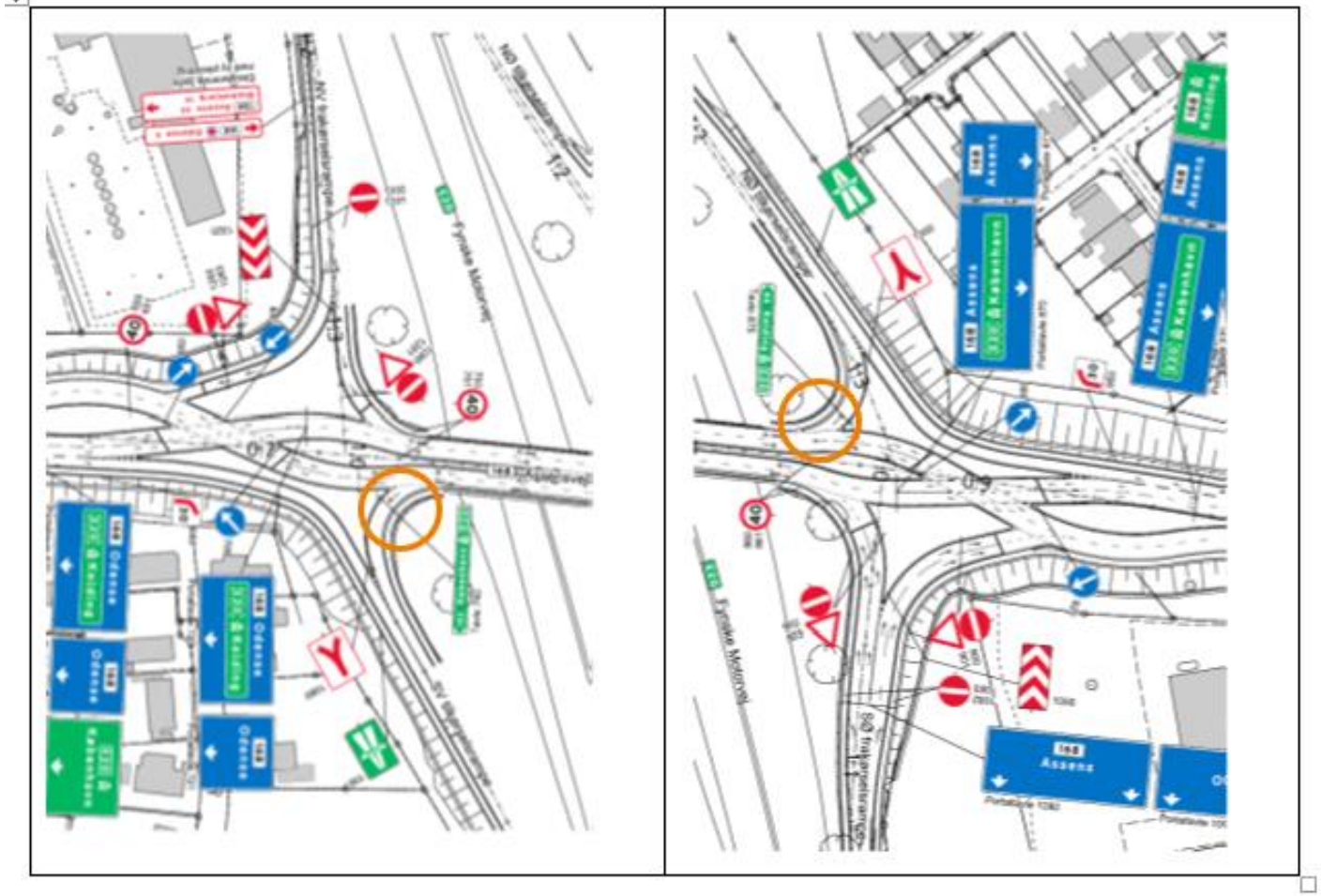
Road Safety Audit, Step 3 Detailed design

- What were my main findings in the audit?

  - Sharp curve radii on exit ramps and at left turns from motorway bridge towards entry ramps
  - Local lack of stop sight due to combination of sharp curve radii and side crash barriers
  - Inadequate invervening periods between certain traffic flows, long clearing distances on Assensvej, and limited sight between stop positions in traffic lights – latter also partly due to the planned glare screen
  - Risk of unintentional right turns on Assensvej against oncoming traffic in traffic lights, missing marking of right of way on Assensvej in traffic lights (in the case of signal failure)
  - Missing marking of certain traffic islands, inadequate guidance of roadway on Assensvej, inappropriate placement of marking against ghost drivers on exit ramps and need for increasing marking of speed limit
  - Design and placement of crash barriers and street lighting, use of high curbs, area need of heavy vehicles

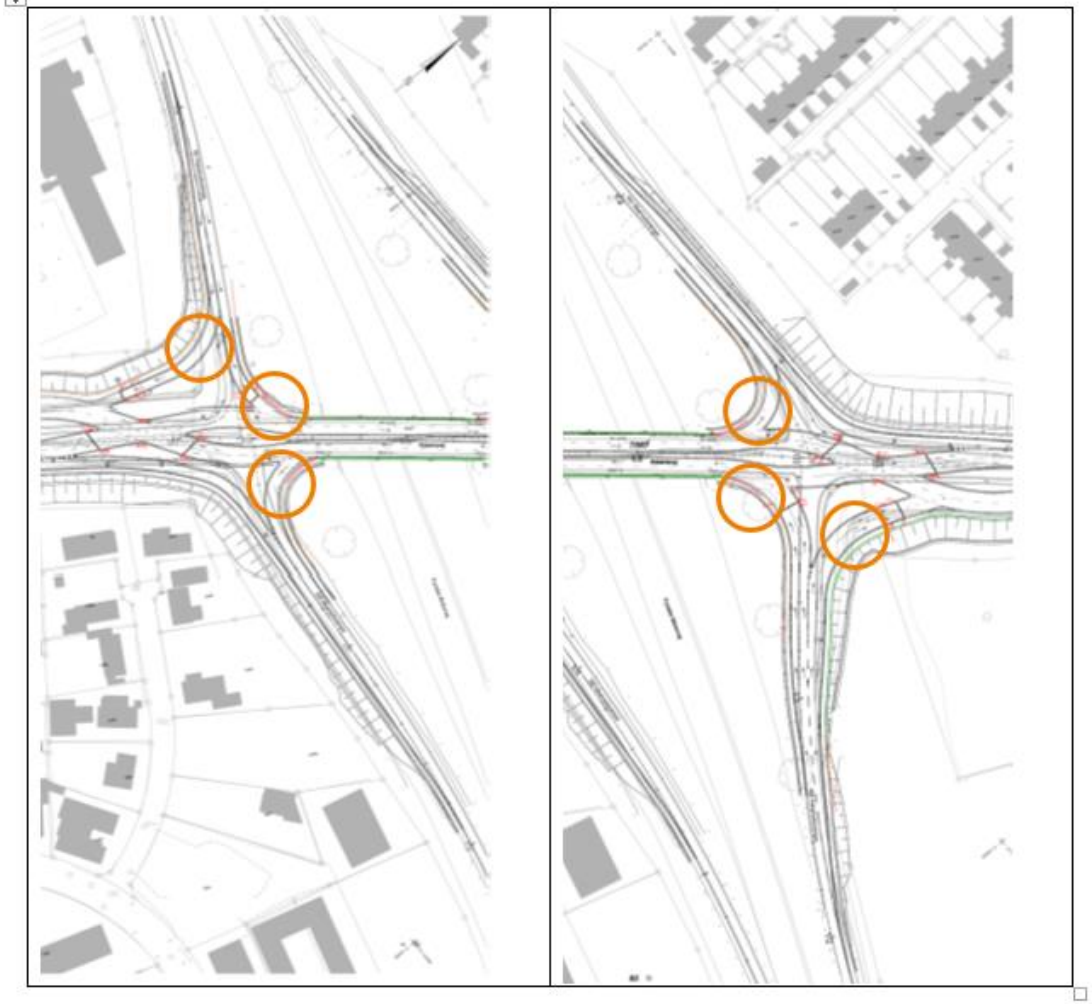
  - Furthermore I had no details on the longitudinal profile and on expected traffic flow versus capacity. It was therefore not possible to assess the required queue, deceleration and accelerations lengths before stop lines and on entry and exit ramps in general. These lengths are relevant for safety too.

Sharp left turns from motorway bridge



- Problem
  - Sharp horisontal curve radii for left turning towards entry ramps at end of the motorway bridge, max. speed of 30 km/h possible, no left turning lane, risk of too high approach speeds, especially in non-peak hours. This increases the risk of rear-end collisions and single vehicle accidents.
- Recommendation
  - Increase curve radii, preferably to allow for 40 km/h turning speeds.

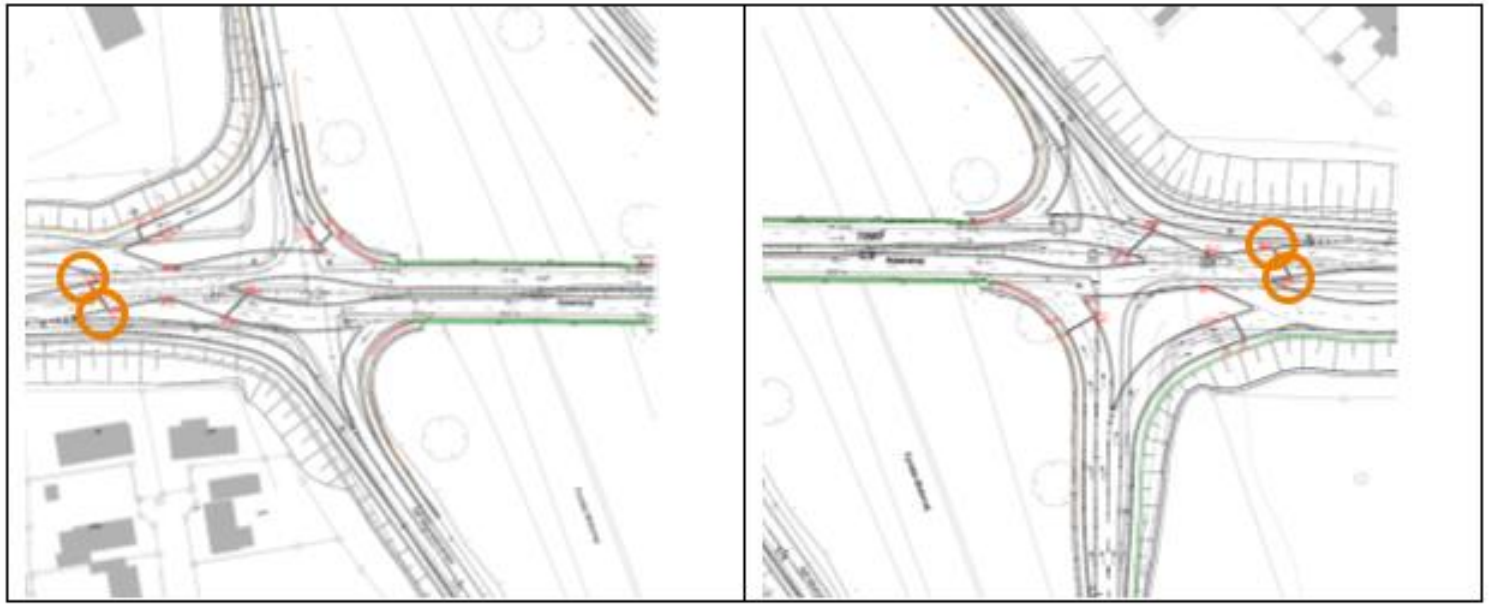
Lack of stop sight in sharp curves



- Problem
  - In a number of sharp horisontal curves there is insufficient stop sight at the planned 40 km/h speed limit, due to combination of curve radii and new crash barriers. Especially on the exit ramps from the motorway there is a risk of much higher approach speeds. The lack of stop sight increases the risk of rear-end collisions and collisions with lost goods, etc.

- Recommendation
  - The project should provide stop sight at the design speed, as minimum the planned 40 km/h speed limit. Otherwise the speed limit should be lowered accordingly.

Unintentional right turns in traffic lights



- Problem
  - Despite planned 3-arrow signals, markings and refuges there is a risk that traffic makes ”normal” but here unwanted right turns on approach to motorway bridge on Assensvej – against the oncoming traffic from bridge.
- Recommendation
  - Set up right-turn prohibition signs in approaches to traffic lights, direction towards bridge.

16 October 2017

Road Safety Audit, Step 4 Commissioning

- What were my main findings in the audit (performed 1 month after opening)?

  - Missing background markings in sharp right turning curves on exit ramps
  - Missing marker posts along multiple parts of the new junction
  - Locally a high edge between carriageway and shoulder
  - Changed and misleading use of arrow road markings on bridge on Assensvej
  - Use of red light in front of green light at new stop positions on Assensvej
  - Inadequate separation between right shunts and straight through lanes on Assensvej
  - Signal lanterns and road signs placed too near carriageway
  - Road directions not visible on exit ramp due to planting
  - Area need and use of shoulder in inside of right shunt to entry ramp

  - Besides these problems I had comments to the safety zone, to the extent of and road lighting times, to the placement of service markings and to different other bits and bobs

Missing background markings

Fotos hhv. 20. september og 4. oktober 2017 af frakørselsramper (SV til venstre og NØ til højre).

- Problem
  - The exit ramps end in sharp left and right turning curves at the traffic light on Assensvej. The right turning curves are long, with limited sight, regulated with a recommended speed limit of 30 km/h.
  - There is a risk of high approach speeds and of underestimating the right curve and overlooking the following traffic lights, especially in the 2 lane right curve.
- Recommendation
  - Set up background markings with directional arrow signs.

Misleading arrow markings on bridge

Fotos 20. september 2017 af vognbanepile på motorvejsbro på Assensvej, hhv. mod nord og syd.

- Problem
  - From project step 3 to 4 the planned arrow road markings on the motorway bridge were changed. The left lane of the dual carriageway is now marked with alternately left and straight through arrows. This can be misleading, and cause sudden braking and lane shifting at exits to the entry ramps as the left lane is a combined through-left turning lane.

- Recommendation
  - Change the arrow road markings to the previously planned combined arrows.

Placement of lanterns and signs

Fotos 20. september 2017 med eksempler på signallanterner (og B11 tavler) for tæt på kørebanen.

Fotos 4. oktober 2017 med eksempler på B15 flettetavle og N43 Spidsmarkering for tæt på kørebanen.

- Problem
  - Certain signal lanterns and road signs are placed too near the carriageway. This partly increases the risk of traffic colliding with the equipment, partly - after damages to the equipment - increases the risk of causing more severe accidents due to missing or misleading traffic regulation.
- Recommendation
  - Review and adjust the placement of signal lanterns and road signs in accordance with the road marking standards, both horisontally and vertically.

This was how the junction looked in 2018

Developments since opening

- The project was evaluated late in 2018
- The new DDI has improved traffic flow considerably and reduced delays without any major issues – besides some continueing peak hour congestion in the neighbouring signalized junctions on Assensvej, primarily south of the DDI at Hvidkærvej
- There have been very few police reported accidents and to my knowledge also only few road user complaints after commissioning
    - As of late August 2019 there are still no injury accidents in the new DDI !

- In the period since commissioning by the Transport Minister on 17 September 2017 https://www.vejdirektoratet.dk/node/940 until the road safety audit step 5 ¾ years later only a few changes to the final project design had been implemented in the DDI.

- Thank you for your attention ☺