Norwegian roundabouts
- design, capacity and level of service

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Outline of the presentation

- Introduction and background
- Capacity and level of service
- Models
- Design principles
- Some pictures
- Summary and conclusion

History of roundabouts in Norway

- The first modern roundabouts (with off-side priority, yield at entry) were established in England in 1966
- About 10 years later this idea was also adopted in Norway, and we started research on modern roundabouts at NTH / SINTEF
- Professor Ragnvald Sagen was the main pioneer of modern Norwegian roundabouts
- He invited Frank Blackmore from England and they managed to convince the Norwegian Public Roads Administration
- But a lot of people were sceptical; “this might work in England, but will it work in Norway?”

Development of roundabouts in Norway

- The first Norwegian roundabouts with off-side priority were established about 1980
- The first 6 roundabouts were closely examined in a large research project at NTH/SINTEF
- The project showed very good results for roundabouts regarding safety as well as capacity and level of service
- Drivers accepted the new type of intersection without large problems
- Some of the first roundabouts replaced priority intersections with very poor design, many accidents and capacity problems

Development of roundabouts in Norway

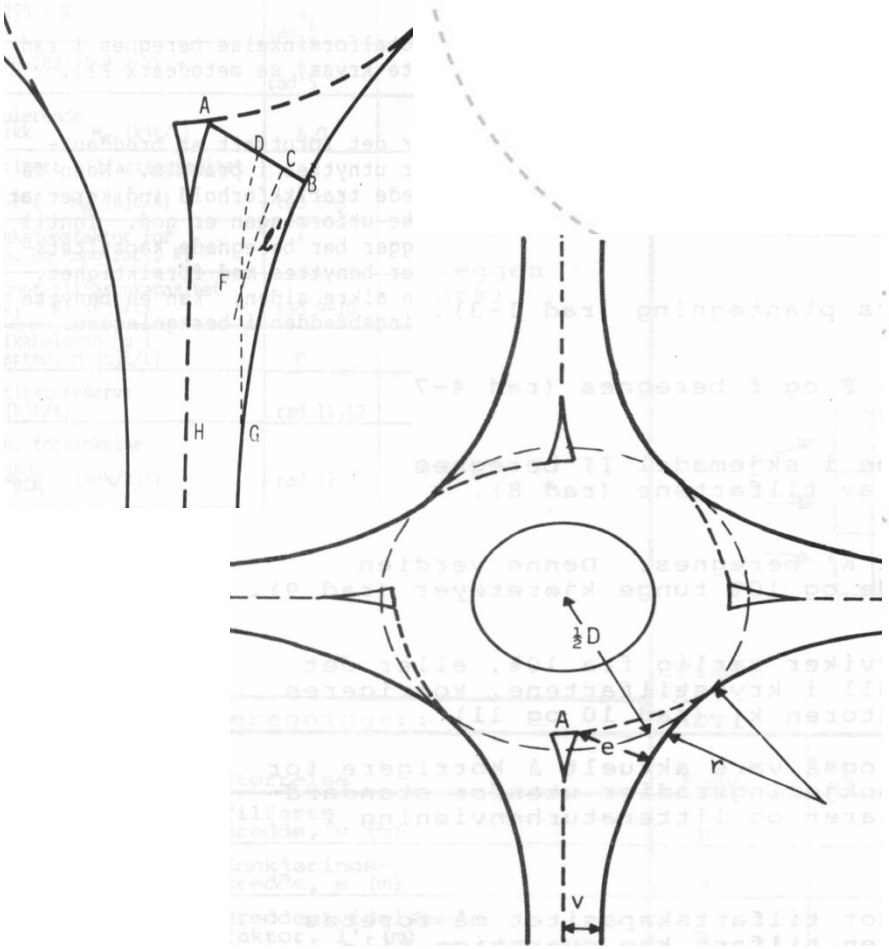
- Roundabouts were established all over Norway during the 1980's
- Today it is probably the most common type of intersection in Norway
- New intersections are often made as roundabouts
- We have lost counting, but we have probably about 2000 roundabouts in Norway today
- In general, roundabouts have been very successful in Norway

Based on English experience…

- The first 20 years (until about 2000) the Norwegian roundabouts were mainly based on English experience
- We adopted the English design as well as English capacity methods
- The roundabouts were quite small
- We did not care about lanes, but we were mainly looking at the width of the approaches
- The width extension was the important factor for capacity

Based on English experience…

- Approach width before extension (v)
- Entry width (e)
- Length of extension (l')
- Inscribed diameter (D)
- Entry radius (r)



TRL method for capacity and level of service

- We have mainly used the TRL method for capacity until about 2000
- This method was developed by TRL about 1980
  (Kimber, R.M., The Traffic Capacity of Roundabouts, TRL Laboratory Report LR942, 1980)
- Empirical method based on English data and driving behaviour
- Capacity is linear dependent on circulating traffic
- The linear relationship is found from geometric parameters (where approach width extension is most important)

$$K = K_{\max} - g * M_c$$

Norwegian experience with the TRL method

- The TRL method did usually overestimate capacity
- The main reason was probably that Norwegian drivers did not utilize the width extension
- We had lots of ”single lane roundabouts” with quite large entry width
- Drivers became confused when they were supposed to queue in two ”lanes” when it was less organized inside and after the roundabout
- Norwegian drivers were probably less flexible than English drivers
- Lack of rules and regulations for roundabouts were also a problem as well as insurance problems if an accident occured

Norwegian modification of the TRL method

- Some modifications to the TRL mehod were introduced
- The width extension got less importance
- But we did still use a linear empirical method based on the TRL method
- A Norwegian capacity handbook (HB127) was developed in 1985
- This handbook has not been replaced, but it is not used today

Some weaknesses with empirical methods

- The empirical methods are not ”logical”, but they are only based on experience and observations
- They do not explain driver behaviour
- It might be difficult to calibrate the empirical mehods to another country with different driving behaviour
- They are based on empirical (old) data, and it is not possible to evaluate new design principles
- The TRL method is based on approach capacity and lane utilization is not described

Entry capacity of roundabouts

- SINTEF made a comparison of different capacity methods in 2001 *(Aakre, Giæver: Tilfartskapasitet i rundkjøringer, STF22A01300)*

- Data for 14 roundabouts in Norway were collected and 6 different methods were evaluated:
  - TRL empirical
  - Norwegian empirical
  - German empirical
  - German gap acceptance
  - SIDRA
  - HCM

- SIDRA was found to give the best estimates of capacity compared to the observations

Computer models for roundabout capacity

- In the 1980's we mostly used ARCADY
- We also used Excel applications based on a modified Norwegian TRL empirical model
- The Swedish CAPCAL model and the US SYNCHRO model has also been used in Norway
- We had some use of SIDRA from about 1990
- But the last 10 years SIDRA has been the main tool for evaluating capacity, level of service and quality of traffic flow in Norwegian roundabouts
- Micro simulation models are also used (mainly AIMSUN and VISSIM)

Use of SIDRA in Norway

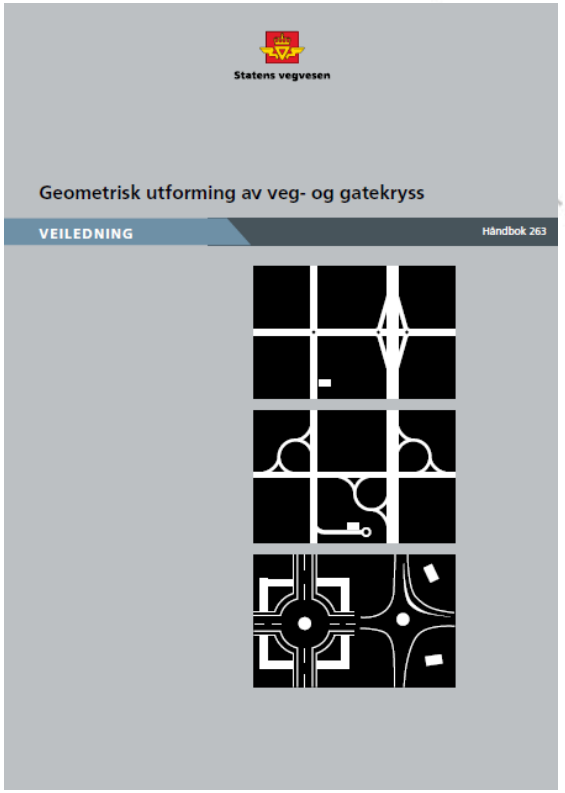
- The Norwegain Public Roads Administratrion has an Enterprise licence with unlimited number of users
- All consultants in Norway are using SIDRA
- The students are using SIDRA at the university
- Nearly all users have maintenance and latest version
- We have established a set of Norwegian deafult values and templates for different typical intersections
- SIDRA seems to give a very realistic description of traffic flow in Norwegian roundabouts

Current design principles in Norway

- We have left the ”width extension principle”, and Norwegian roundabouts are now more ”lane-based”
- The general rule is to limit the size and number of lanes to reduce speed and increase safety
- At many locations it is sufficient with 1 lane in each approach
- If this is not acceptable for capacity, we will introduce another lane
- But according to Norwegian guidelines safety should always be the most important factor

Handbooks for design of roundabouts

HB 017 (2008)
Road and street design



HB 263 (2008)
Geometric design of intersections

Roundabouts are always a possible solution, and it should be considered in most cases

Tabell 3.2: Kryssløsninger for ulike dimensjoneringsklasser

Dimensjone-ringsklasse (primærveg)	ÅDT	Farts-grense	T-kryss	X-kryss	Rund-kjøring	Planskilt
S1	0-12000	60	X	X	X	
S2	0-4000	80	X		X	
S3	0-4000	90	X		X	
S4	4000-8000	80	X		X	X
S5	8-12000	90				X
S6	>12000	60	X	X	X	X
S7	>12000	80				X
S8	12-20000	100				X
S9	>20000	100				X
H1	0-1500	80	X		X	
H2	1500-4000	80	X		X	
Sa1	<1500	50	X	X		
Sa2	>1500	50	X	X	X	
Sa3	<1500	80	X			

”Large” roundabout between two highways in a rural area

Example of road marking with two lanes

The central island might be used for heavy vehicles

Information sign ahead of the roundabout

Typical sign use at entry and exit

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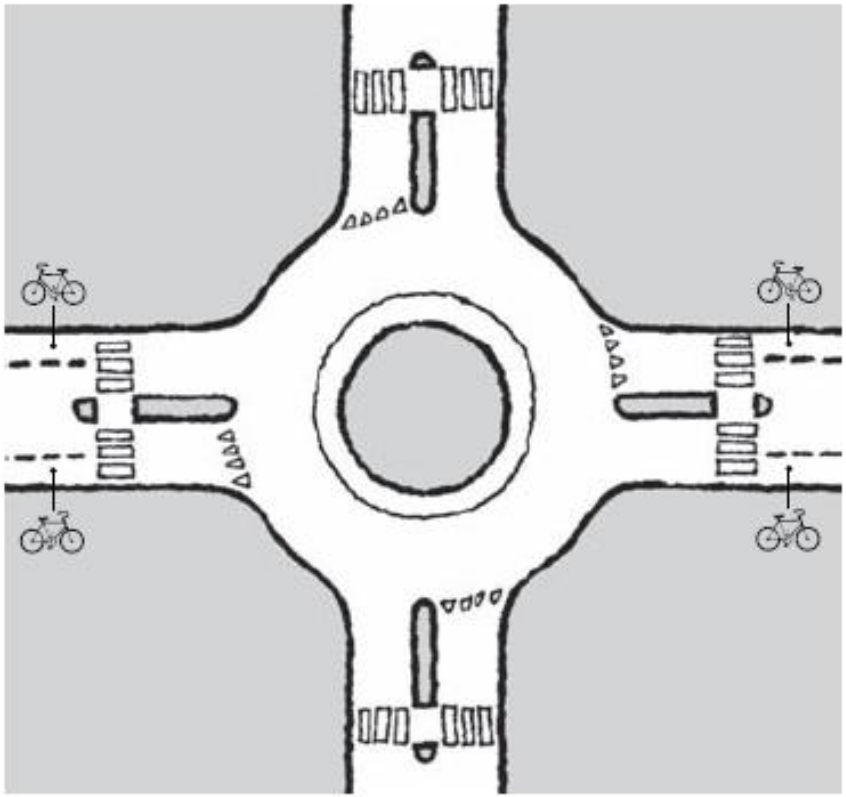
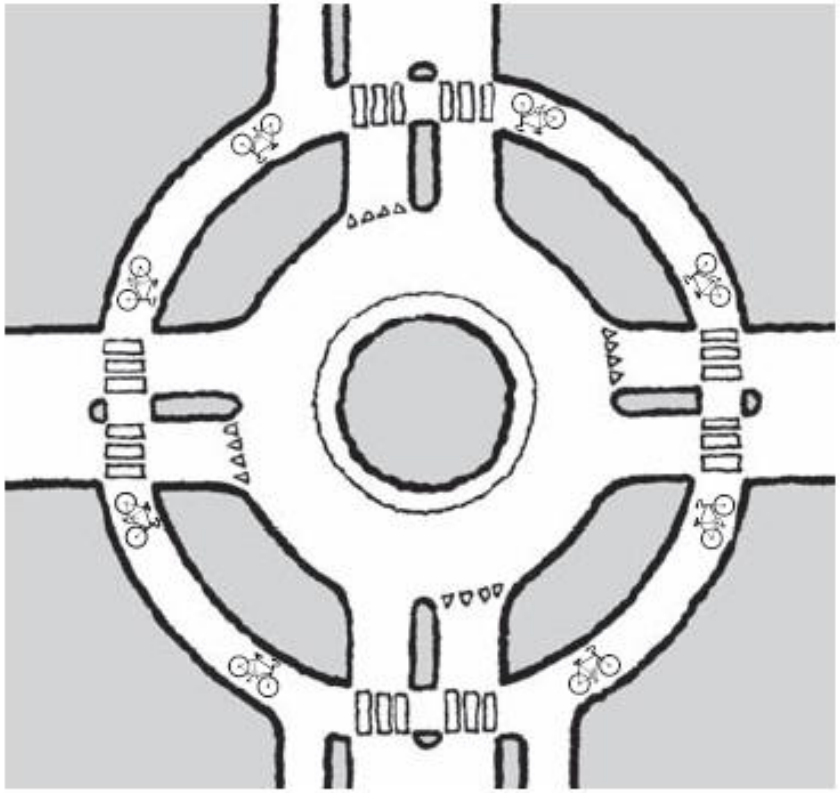
Sign on centre island (usually not used)

Solutions for bicycles in roundabouts





End of bicycle lane before the entry

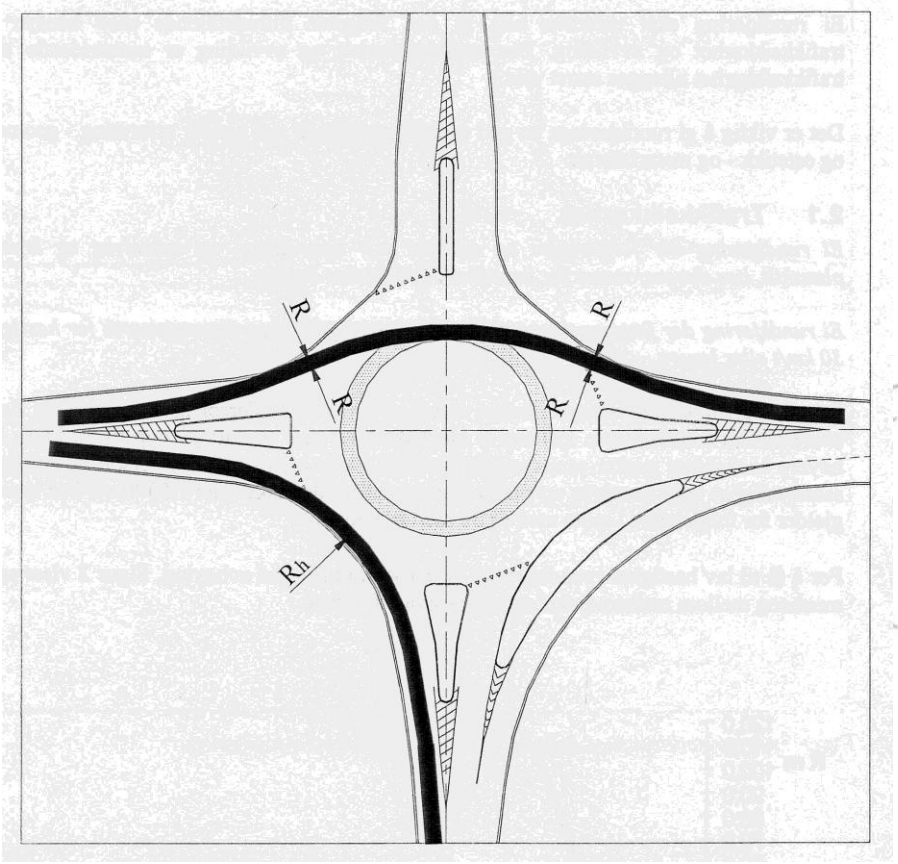
Bicycle lane

Pedestrian crossing and bicycle crossing

Space for at least one car waiting at the give-way line

Deflection

- Deflection is important to reduce speed and increase safety
- R<80 m for a typical driving movement
- R< 40 m if pedestrians
- Important discussion:
  At what point should speed be reduced?
  - Pedestrian crossing?
  - Entry / give-way line?
  - Inside the roundabout?
  - Exit?



Other roundabout discussions in Norway

- More roundabouts in the city centre
- Roundabouts and priority for public transport
- Roundabouts with metering signals
- Turbo roundabouts
  (but we need to adjust for winter conditions and maintenance)
- Large roundabouts
- The number of roundabouts on important main highways
- Use of lane markings and road signs

Summary / conclusions

- Roundabouts in Norway have been a great success
- Roundabouts have made significant improvement to both traffic flow and safety; benefit/cost ratio for roundabouts is very high
- A roundabout is probably the only “Vision zero intersection”
- We will continue using SIDRA for evaluation of capacity and quality of traffic flow
- We have probably not found the optimal design and solution for roundabouts – there are still quite a lot of improvements to make
- Environmental calculations will probably be more important in the future

Thank you for your attention!

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