Light railway with tramways in Aarhus, DK

ELENA Mobility
Aarhus – second largest city in DK

- 1.2 million people in the greater Aarhus city area
- Aarhus and Copenhagen are the two major growth centres in Denmark
- Home to 55,000 students and a university ranked top 100 in the world and top 20 in Europe
Municipality of Aarhus – Climate action plan

• Climate Action Plan → CO2 neutral and no use of fossil fuels in 2030

• Energy efficient transport is one strategic focus area

• The establishing of Denmark's first light rail is one mean to reach the goal
Aarhus LRT – The first light rail in Denmark

- Upgrading and integration of two older railway lines (95 km total)
- Keep rail freight capacity on old Grenaa Railway Line
- 12 km of new double light rail track
- Full electrification
- a new control and maintenance center
- 23 new light rail vehicles
New 12 kilometer central light rail corridor

Axis of knowledge:
- Aarhus Central Station
- New Public Library (DOKK1)
- School of Engineering
- Aarhus University
- Royal Nation Library
- Danish Broadcasting Corporation
- Aarhus University hospital
- Office Park Skejby
- Agro Food Park

New Urban developments:
- New town Lisbjerg (10-15,000 inhabitants)
- New town Nye (8-12,000 inhabitants)
Central facts: New urban line

New Urban line:
- “Classic tram”
- Drive on sight
- Max speed: 80 km/h
- Infrastructure owner: Aarhus Light Rail
Central facts: Grenaa Railway Line

Grenaa line:
- Drive on signals
- Max speed: 100 km/h
- Owner of infrastructure: Rail Net Denmark
- Rail Freight Capacity

Aarhus Central Station
- New stop
- Building owned by (owned by Danish national rail company)
- Rail Net Denmark's signalling system not prepare for electrification
Central facts: Odder Railway Line

- Drive on signals
- Max speed: 80 km/h
- Infrastructure owner: Midtjyske Jernbaner (handover to Aarhus Light Rail)
Several complex challenges to overcome

**Technical:**
- First in Denmark (no norms or rules)
- Dual system network (80 and 100 km/h)
- Prepare for rail freight capacity
- Prepare signalling system at central station for electrification
- Several energy supply companies

**Stakeholder management:**
- Infrastructure management contract to integrate and maintain a new stop at Aarhus central station (owned by Danish national rail company)
- Infrastructure management contracts to operate on other owners infrastructure
- Run through 4 municipality

**Energy efficiency:**
- Energy efficient dual system
- Several energy supply companies
The ELENA funded activities

Help to secure a coordinate approach to the integration of the existing railway lines into light rail operation.

Two work packages:

1. Preparation for technical integration for freight and light rail

2. Studies and integration of innovative solutions for energy efficiency and power supply

PDS contributed to establishing an overview of the conversion works and identification of possible solutions.
Projects undertaken

**WP1: Preparation for technical integration for freight and light rail:**

1. **Innovative platform fronts** and the rebuilding of the harbour front junction
2. **Smart solutions to immunisation of legacy signalling assets**
3. Operational rules and CSM for Aarhus Light Rail
4. **Infrastructure Management Contracts**
5. Smart interlocking

**WP2: Studies and integration of innovative solutions for energy efficiency and power supply**

1. Energy efficient power supply and OCS
2. **Energy storage and conservation**
3. **Sustainable CMC**
Time schedule

2012
- Tender preparation
- Aarhus Light Rail ACT
- Construction Company is founded

2013
- Civil Works – Bridges and utilities
- LRT System tender
- Start ELENA programme

2014
- Civil Works
- Contract on LRT System

2015 - 2016
- Civil Works on LRT System and CMC
- Tram and Tram Train production
- Test og Trial Operation
- End ELENA programme

2017
- Trial run and safety approval
- December: Operation of new urban line

2018
- Operation of entire Network
1. Technical integration of the existing railway lines
Innovative platform fronts

Contents of work:
- 30 existing platforms
- Platform - train interface not acceptable:
  - Safety
  - Accessibility
- Structural gauge: both tram and freight
- Dual ownership of platforms
- No norm existed

The proces:
- Study report (requirements, solutions, cost)
- Define new norm
- Hazard workshops
Innovative platform fronts

Results:
• Solution with "gap bridging device"
• Project tendered out
• All platform rebuild in 2017

Lessons learned:
- Finding an ideal solution was difficult
- Maintenance concept in focus by owners
Smart solutions to immunise legacy signalling assets

Contents of work

Letbane DC electrification shall use its running rails as part of the earth return (via the tram wheels) of the power supply.

The current Track Circuits used in Aarhus H. are the simplest DC type.

The Lightrail DC return current could interfere with DC track circuits in parallel Rail Net Denmark tracks, in worst case scenario turning red signals green.

- 120 77hz track circuits
- Old norm: Estimated budget 10 MEUR + time consuming
- Alternative solution: more efficient and lower cost
Smart solutions to immunise legacy signalling assets

The process
• Project coordination group with Rail Net Denmark initiated
• Study of alternative solutions in the rest of Europa
• A new “FETR” track circuit approved by Rail Net Danmark

Results
• All FETR tracks circuits installed
• Saving 5,4 MEUR (40% cost reduction)
• New FETR norm to be use by other rail and light rail project

Lessons learned:
• Introducing new approach from the beginning” successful
• Use of experience from other EU countries effectfull
• Highly specialized study. Technical assistance was hard to find
Infrastructure Management Contracts

Contents of work
• Process, manage and deliver various agreements with stakeholders prior to operation.

The process
• A project manager was hired to perform the work
• Several project and work groups
• Success - most of the agreements closed

Lessons learned
• Same contact person – important
• Huge job to initiate and afterwards implement in the organization

<table>
<thead>
<tr>
<th>Agreements</th>
<th>Status</th>
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<tbody>
<tr>
<td>Rail Net Denmark – Grenaa line</td>
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<td>Odder line maintenance centre</td>
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General lessons learned

- Standardisation of the conversion of infrastructure more complex than expected

- Numerous technical solutions for integration and conversion were identified, and included in the technical design for the system

- Some solutions led to savings in construction costs

- Highly skilled specialist are hard to find
2. Integration of innovative solutions for energy efficiency and power supply
Traction power: From diesel to electricity

Figure 1 Scenario 1-3. Baseline scenario is index 100

Short description of the scenarios:

- **Baseline**  
  Current Operation with Desiro MQ diesel

- **Scenario 1**  
  Tango Tram-Train with Current Timetable

- **Scenario 2**  
  Tango and Vario Trams with New Timetable

- **Scenario 3**  
  Tango and Vario Trams with New Timetable and GreenSpeed DAS Coasting
Energy storage and conservation

- Mapping the energy consumption
- Traction power: 75% of total consumption
- Idea catalogue
Detailed studies initiated

• Three studies initiated to investigate potential savings in energy consumption and emissions.

  1. Energy Storage Systems (ESS)
  2. Driver Advisory Systems (DAS)
  3. Mobility model

Lessons learned:
• Potentials found but studies came to late in the process (design of the LRT system was ongoing) →
• unacceptable high costs related to deployment and installation
• reevaluated after a period of time with operations experience
• Had to change focus to the ongoing design process to gain results
Design focus: tram and tramways

Bought standard trams and tram train with some additions:

- Regeneration of brake energy
- Excess brake energy is transformed into other vehicles
- Double layer thermal glass
- LED (inside and out)
- Intelligent heating - three configurations (remote control, clock or auto in outdoor temperature)
Design focus:
Sustainable Construction and maintenance centre (CMC)

Building
• Low energy building
• Green Roofs: Increases biodiversity in the area
• Lessnox roof: Captures NOX particles
• Covering of stabling area

Rainwater management:
• Green roof reduces the risk of flooding in the area
• Collects rainwater for tram wash
Thank you