TramLink und CityLink Familien – die neue Generation von Strassenbahnen und Stadtbahnen

43. Tagung – Moderne Schienenfahrzeuge. TU Graz
Mar Rivas, Stadler Rail Valencia S.A.
The Stadler Rail Group

Consolidated turnover 2016 (Budget): ca. CHF 2.2 billion
Number of employees (Budget, FTE): ~ 7000

DIVISION SWITZERLAND

Stadler Bussnang
1700 employees

Stadler Altenrhein
950 employees

DIVISION GERMANY

Stadler Pankow (Berlin)
1000 employees

Stadler Pankow (Velten)
40 employees

DIVISION CENTRAL EUROPE

Stadler Polska
800 employees

Stadler Praha
50 employees

DIVISION SPAIN

Stadler Valencia
900 employees

ERION Mantenimiento Ferroviario (Spain)
30 employees

ERION France
20 employees

DIVISION COMPONENTS

Stadler Winterthur
220 employees

Stadler Stahlguss
120 employees

DIVISION SERVICE

Stadler Algérie
100 employees

Stadler Niederlande
80 employees

Stadler Linz
20 employees

Stadler Meran
10 employees

Stadler Pusztaszabolcs
70 employees

Stadler Service
70 employees

Stadler Schweden
20 employees

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Stadler Rail Valencia - Site History

More than a century of experience putting visionary solutions on track.

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1897</td>
<td>Talleres Devis</td>
</tr>
<tr>
<td>1947</td>
<td>Material and Constructions S.A. MACOSA</td>
</tr>
<tr>
<td>1960</td>
<td>Start cooperation with EMD for DE locomotives</td>
</tr>
<tr>
<td>1989</td>
<td>Gec Alsthom S.A.</td>
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<tr>
<td>1993</td>
<td>1st. order of Metro Valencia</td>
</tr>
<tr>
<td>1997</td>
<td>New site</td>
</tr>
<tr>
<td>1997</td>
<td>1st. pass. Loc. for US market</td>
</tr>
<tr>
<td>2001</td>
<td>1st. pass. Loc. for US market</td>
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<tr>
<td>2005</td>
<td>Vossloh España S.A.</td>
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<tr>
<td>2006</td>
<td>EURO4000 and 1st. Tram Train</td>
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<tr>
<td>2007</td>
<td>ERION Mantenimiento Ferroviario</td>
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<tr>
<td>2007</td>
<td>ERION France</td>
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<tr>
<td>2009</td>
<td>Citylink NET 2012 starts operations</td>
</tr>
<tr>
<td>2013</td>
<td>1st. dual locos orders</td>
</tr>
<tr>
<td>2014</td>
<td>Citylink NET 2012 starts operations</td>
</tr>
<tr>
<td>2016</td>
<td>Stadler</td>
</tr>
</tbody>
</table>
Stadler Rail Valencia - Business snapshot

Converging engineering and production capabilities in ONE site.

- Design and manufacturing of locomotives, LRVs and bogies and after-sales services of rail vehicles
- Integral engineering and production facilities for car bodies and bogies on site.
- 900 multi-skilled employees with more than 150 engineers dedicated to product development.
- Facility completed in 1997 with almost 200,000m² distributed in several product-oriented workshops and installations. Flexible and full integrated plant which configuration allows to design, develop and test all vehicles in house.

<table>
<thead>
<tr>
<th>Main facility size (m²)</th>
<th>199,724</th>
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<tbody>
<tr>
<td>Total covered:</td>
<td>46,959</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Facility layout</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle workshop,</td>
</tr>
<tr>
<td>Bogies workshop,</td>
</tr>
<tr>
<td>Testing installations</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Certifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRIS2.0, ISO9001, ISO14001, OHSAS 18001, EMAS, EN 15085 (welding), DIN 7601 (bolding)</td>
</tr>
</tbody>
</table>
Stadler Product Portfolio: Urban Transport

- Metro
- Light railways: Citylink, Tango
- Trams: Variobahn, Tramlink

100% Low floor portion

STAV

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STAV LRVs for urban and suburban transport

Stadtbahn family
“One vehicle for two systems”

Strassenbahn family
100% LF multi-articulated tramway
TramLink and CityLink crosscheck

- **TramLink** is for urban environments, ~ 70km/h ➔ *Tramway / Streetcar application*
- **CityLink** covers from tramway applications up to a full railway operations at ~100km/h ➔ *Regional / LRT*

The key of the success of both families lies in:
- The innovative concept of TramLink bogie and CitiLink bogie
- Full integration bogie-carbody on both vehicles
- Optimised HS steel structure.
- Easy adaptation to customers’ needs.

Main differences are:
- Overall Performances
- Dynamic envelope and curve inscription
- Lower parts clearance
- Running comfort at high speeds
- Seat arrangement (capacity vs. seating comfort)
- Low floor and platform accessibility
- Crash safety resistance
- Weight in tare and weight per axle

*CityLink covers wider range of operational modes than TramLink.*
TramLink and CityLink crosscheck

- CityLink keeps the 100mm requirement for lower parts track clearance (EBO requirement 80mm)
- TramLink respect only urban lower parts clearance of 60mm (BOStrab minimum requirement among others)
- Even in a 900mm track gauge TramLink bogie still allows full low floor configuration, CityLink architecture needs inner steps
- TramLink allows down to 17m radii inscription (std.), CityLink minimum curve negotiation is 22m (standard configuration)
TramLink and CityLink: Structure and crash concept

- Collision scenarios = EN 15227 – 4

| Design collision scenario | Collision obstacle | Operational characteristics of requirement | Collision Speed - km/h | |---|--|--|--|--| |
|---|--|--|--|--| |
| 1 | Identical train unit | All systems | C-I | C-II | C-III | C-IV |
| 2 | 80 t wagon | Mixed traffic with vehicles equipped with side buffers. | 36 | 25 | 25 | 15 |
| 3 | 129 t regional train | Mixed traffic with vehicles with a central coupler | n.a. | n.a. | 10 | n.a. |
| 4 | 15 t deformable obstacle | TEN and similar operation with level crossings | vₜ = 50 | ≤ 110 | n.a. | n.a. |
| 4 | 3 t rigid obstacle | Urban line not isolated from the road traffic | n.a. | n.a. | n.a. | 25 |
| 4 | Small, low obstacle | Obstacle deflector requirements to be achieved | See Table 3 | n.a. | See Table 3 | n.a. |

Table 2 — Collision scenarios and collision obstacle

- Static loads = EN 12663 - 5.2.3

P.III: CityLink

P.IV: Tramlink

PV: Citylink Tramlink

Fuerzas de compresión en la zona de topes y/o gancho

Fuerza en kN

Carga máxima de operación

<table>
<thead>
<tr>
<th>Vagon de carga</th>
<th>Material de pasajeros</th>
</tr>
</thead>
<tbody>
<tr>
<td>Categoría F-I</td>
<td>Categoría F-II</td>
</tr>
<tr>
<td>0.00</td>
<td>1.200</td>
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</table>

<table>
<thead>
<tr>
<th>Categoría F-I</th>
<th>Categoría F-II</th>
<th>Categoría F-III</th>
<th>Categoría P-I</th>
<th>Categoría P-II</th>
<th>Categoría P-III</th>
<th>Categoría P-IV</th>
<th>Categoría P-V</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.95 × g × (m₁ + m₂)²</td>
<td>1.3 × g × (m₁ + m₂)²</td>
<td>1.2 × g × (m₁ + m₂)²</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Aceleraciones en la dirección x

<table>
<thead>
<tr>
<th>Vagon de carga</th>
<th>Material de pasajeros</th>
</tr>
</thead>
<tbody>
<tr>
<td>Categoría F-I</td>
<td>Categoría F-II</td>
</tr>
<tr>
<td>±5 × g</td>
<td>±5 × g³</td>
</tr>
</tbody>
</table>

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TramLink and CityLink crosscheck

Both, CityLink and TramLink, are modular and scalable platforms fitting in all, new or old rail nets.
CityLink Platform

• CityLink is the universal Tramway and Interurban LRV platform: Two systems in one train
• CityLink is modular, scalable and flexible. Barrier free, for urban & interurban operation
• CityLink LRV is within Stadler Rail Valencia portfolio the LRV with turning bogies (> 1’5° rotation)
• CityLink provides enhanced safety even at 110 km/h and in unpredictable urban environments
CityLink Platform – History of success

...becoming European leader manufacturer of TT with references in Spain, Germany, UK and Mexico with almost 125 units sold:

- Metric gauge Tram Trains to different Spanish customers:
- Citylink NET 2012 for Karlsruhe: 75 nits sold
- Hybrid Citylink for Chemnitz
- 1st. Tram Train in UK
- 1st. Tram Train in Latin America
CityLink Platform – Two systems in one train
CityLink Platform – Two systems in one train

- CityLink is a LRV with **turning bogies** able to operate not only as a tramway
- Providing a **very high comfort** at urban operational conditions and main line infrastructure
- Compliance with C-III and C-IV EN15227 together with visibility DIN 5566-3 (1200mm @300m)
- Certified according **BOS trab** and **EBO**.

<table>
<thead>
<tr>
<th>Tramway characteristics</th>
<th>Railway characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Impressive visibility from driver’s cab</td>
<td>- Excellent running dynamics</td>
</tr>
<tr>
<td>- Powerful brake system (effective hydraulic brakes)</td>
<td>- High comfort as in a regional train</td>
</tr>
<tr>
<td>- high acceleration</td>
<td>- Up to 110 km/h</td>
</tr>
<tr>
<td>- Easy access from street platforms</td>
<td>- Secondary pneumatic suspension</td>
</tr>
<tr>
<td>- Barrier free low floor LRV</td>
<td>- Heavy rail crash-energy management system</td>
</tr>
<tr>
<td>- Ready to cope with small curve radii and driving on sight</td>
<td>- Enhanced car body structure ready to deal with freight wagons and regional trains</td>
</tr>
</tbody>
</table>

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CityLink Platform – Vehicle architecture

Modularity and customization: Adapted to network requirements and customer’s needs

Power supply configurations:

- **750Vdc or 1500Vdc**
  - Alicante, Spain (metric)
  - Mallorca, Spain (metric)
  - Karlsruhe, Germany (int.)

- **Diesel**
  - FEVE, Spain (metric)
  - Puebla, Mexico (int.)

- **Diesel + 750Vdc (Hybrid)**
  - Chemnitz, Germany (int.)

- **750Vdc + 25KVa (Dual)**
  - Sheffield, UK (int.)
CityLink Platform – Vehicle architecture

Modularity and customization: Adapted to network requirements and customer’s needs

With the lowest access from its class, directly from platforms of 340mm up to 550mm. Allowing the use of existing infrastructures

- **Sheffield**
  - 235 pax

- **Chemnitz**
  - 228 pax

- **Karlsruhe**
  - 240 pax
CityLink Platform – Barrier free

CityLink standard track gauge allows low floor from the front to the back door with very smooth gentle longitudinal ramps <6%
CityLink Platform – Bogie architecture

- Main line bogie features in a tramway bogie size
  - Turning bogie with real-axle or conventional wheelset
  - up to 720mm diameter wheels
  - Horizontal curve inscription down to 22m radii
  - Lower parts 100mm clearance
  - Transversal motors
  - H frame structure
  - Resilient wheels
  - Secondary air suspension
  - Slewing ring steering
  - Fully suspended transmission

- CityLink bogie architecture is the lowest “conventional” truck of its class designed to provide good comfort values even up to 110km/h
- EBO & BOSTrab fully compliance
- UK certified also
- Low carbody interface
CityLink Platform – HS duplex steel

- Duplex stainless steel mix best properties from austenitic and ferritic stainless steel
- Provides the **best strength and protection with the lowest weight**
- Thanks to its high content in Chrome and Nitrogen, and the presence of Molybdenum, these steels provide **very good protection against corrosion**
- **Good protection against pitting and crevice corrosion** and good resistance against abrasion and erosion
- Micro-structure of duplex steels provide **high mechanical strength** and high strength against corrosion under stress and cracking
- Due to these advantages using duplex steels **design is optimized for strength, maintainability, durability** and long term cost efficiency, and reduce the life cycle cost
- High energy absorption with low thermal expansion and good welding properties
Crash management and visibility requirements in a low floor lightweight structure

Enhanced safety with passive measures and active equipment:

- Energy Absorbing crash elements,
- Anti-climbers,
- Powerful and quick reaction hydraulic brakes,
- Modular cab structure design,
- Survival area within driver’s seat, etc…
CityLink Platform – Principal characteristics

- **Typical configuration** 37m length in 2’65m width and around 220/250 pax @4ppm
- Capable of running on **urban networks** as well as on **railway lines**.
- **Allowing the use of existing infrastructures** → reduced infrastructure investments
- For speeds up to 110km/h with high acceleration and effective hydraulic brakes
- **Enhance safety**: Energy Absorbing crash elements, Anti-climbers, Powerful and quick reaction hydraulic brakes, Modular cab structure design, Survival area within driver’s seat, etc.
- **Compliance with** C-III and C-IV EN15227 together with visibility DIN 5566-3 (1200mm @300m)
- **Maintenance free structure**, full made of duplex high strength stainless steel
- **Real turning bogie with slewing ring bolster and secondary air suspension**
- CityLink has **low floor from back to front doors** with very smooth gentle longitudinal ramps <6%
- **Conventional wheel-set up to 720mm diameter wheels**
- With the **lowest access from its class**, directly from platforms of 340mm up to 550mm.
- **Mono / Dual / Hybrid / Diesel configurations**
Stadler TramLink
ALL ABOUT COMFORT

TramLink is the modular, scalable and flexible, full low floor, barrier free, multi-articulated tramway family.
TramLink platform - Principal characteristics

- Multi-articulated rail lightweight vehicle, 100% low floor, full barrier free (<6% ramps)
- Direct access from platforms from 240mm up to 350mm
- Best running dynamics and comfort thanks to a conventional turning bogie with real axel and big wheels diameter
- Top capacity of its class with up to 16 seats over running parts without steps or ramps
- Maintenance free structure, full made of duplex high strength stainless steel
- Compliance with C-IV EN15227 (& CIII-3 15T tank lorry @ 25km/h) and visibility DIN 5566-3 (1200mm @300mm)
- Updated to the new fire and smoke EN 45545
- Modular bogie concept (from 1435mm down to 900mm) same architecture for trailer and motor
- Designed for catenary wireless operation on demand
TramLink platform - Modularity

- Fits to all and every customer needs
- Length range from 18’5m up to 47’5m full low floor without any step from back to front
- Carbody widths from 2’3 up to 2’65m (including Rostock special one being 2’65 with 2’3 only for lower parts)
- Configurable door and seat arrangement. Interior modular concept

<table>
<thead>
<tr>
<th>Passengers</th>
<th>Length (min/max)</th>
<th>Doors (min/max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>115 / 135</td>
<td>18,5 / 23 m</td>
<td>4 / 8</td>
</tr>
<tr>
<td>200 / 215</td>
<td>28 / 35,2 m</td>
<td>6 / 12</td>
</tr>
<tr>
<td>255 / 300</td>
<td>37,8 / 47,5 m</td>
<td>8 / 16</td>
</tr>
</tbody>
</table>
TramLink platform - Modularity

- The interior of the TramLink has been designed based on modularity, for manufacturing and for our customers
- The *Halfen profiles* on the wall allow for multiple seat configurations without major changes on the interior lining
- Seat configurations can be varied not only in our plant but also in our customer’s depots throughout the vehicle life
- TramLink will always be able to fulfill our customer’s needs, no matter if they vary during the lifetime of the vehicle
TramLink platform - Modularity

Track width 1000 M
Track width 1435 UIC

GMUNDEN
3 Bogies (5 Cars)

VALENCIA
3 Bogies (5 Cars)

ROSTOCK
3 Bogies (5 Cars)

SANTOS
4 Bogies (7 Cars)

Length
28 m
30 m
32 m
40 m
43 m

Width
2'3 m
2'4 m
2'65 m

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Tramlink platform - Bogie concept

• Most of benefits and advantages of the TramLink, are possible because of the new bogie concept.
• The patented bogie design architecture consists on a turning bogie with real axle wheelset, transversal motors, H frame structure and resilient wheels.
• Conventional axle provides better curve guidance, strength and state-of-the-art proven solution easy to be homologated in all national normative frames.
• The suspension system is designed to provide good comfort values even up to 80km/h
• Modular bogie concept, even with different track gauge, same architecture, concept and solutions
• Low floor TramLink bogie fulfills all BOS trab criteria including 60mm clearance
Tramlink platform - Bogie integration

- Bogie and carbody were designed at the same time, with the same targets and requirements, etc.
- Highly integrated design, achieving a very low floor level entrance and allowing gently pass over axle mounting big diameter wheels.
- With the maximum seat capacity and comfort up to 16 seats per bogie area
- Ready for direct access from very low platforms, with a floor level over axle of 450mm achieved only with short 6% longitudinal ramps
- Big elastic ring wheels with 600mm diameter in a conventional axle wheelset
Treamlink platform - Bogie integration

• TramLink stand out from others thanks to its bogie-vehicle symbiosis allowing a very high capacity achieving up to 16 (4x4) comfort seats over bogie areas without any step or transversal ramp
• All 16 seats with the same comfort!!

Solutions of other tram manufacturers with steps, ramps or lower number of seats
Tramlink platform – Enhanced safety

Structure and crash concept

- Maintenance-free structure.
- The structure is basically made of DUPLEX® stainless steel and in certain areas also other steel grades are used.
- Structural requirements: EN12663 PIV & PV
- Reduction of the unfilled risk
- Absorption of the collision energy in a controlled manner
- Preservation of the residual space and vehicle structure where passengers and the driver can stay
- Crashworthiness requirements: EN 15227 C-IV & C-III scenario 3
Tramlink platform – Enhanced safety

Driver cab and exterior design.

- Impressive visibility
- **Maintenance** improved. Beams regulation could be made without dismounting any assembly.
- Easy-open mechanism to access the coupler.
- **Multi-mirror cams** installation is prepared.
- Full heated windows are possible.
- Lateral interior lining integrated in the exterior assembly increasing the quality of the finishing.
TramLink and CityLink - summary

CityLink:
- **Better comfort**, specially at higher speeds
- Designed for mix **urban and rail operation** (crash, coupling, signaling, etc.)
- More seats and room per seat
- Low floor from door to door
- Worst dynamic envelope

TramLink:
- **100% low floor** for any track gauge
- Designed for **urban operation** (or segregated tracks)
- Ready for **urban lower height platforms**
- Ready for **small curves negotiations** (twisted nets)
Thank you very much for your attention
Vielen Dank für Ihre Aufmerksamkeit