Jernbane-
direktoratet

railML2.4 Rollingstock

Rolling stock functional description for the Norwegian sector

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Summary

The following documents the Norwegian use of the railML2.4 Rollingstock (RS) schema. It contains information about the application of railML2.4 RS, general modelling rules and an example.

Content

1 General Information

1.1 What is railML2.4 RS

railML – Railway Markup Language – is an open-source XML based data exchange format, which shall enable an easy communication of heterogenous railway applications. Today, the connection of various railway software packages is beset with problems. The purpose of the railML.org initiative has been to find, discuss and present systematic, XML-based solutions for simplified and standardized data exchange between railway applications. The schema is developed by railML.org, a registered association in Germany since 2002, in close cooperation with all interested institutions and businesses of the railway sector across Europe. railml2.4 RS is the most recent version of the schema and is applicable for rolling stock (RS).[1]

1.2 Why do we need railML2.4 RS

With the fragmentation of the Norwegian sector, there is a great need to exchange data between the different stakeholders in a well defined, standardized way. This need can principally be met by using railML as data exchange format. The exact definition of how it should be used in the context of rolling stock (including the interaction with the schemes *timetable* and *infrastructure*) in the Norwegian sector will be given in this document.

1.3 What do we use railML2.4 RS for

railML2.4 was developed in accordance to the requirements of the use cases *operational simulation* and *traction power supply simulation*. The use cases of the Norwegian sector differ slightly and are listed below. railML2.4 RS shall be used as the general data exchange format in these areas. If available, information about the scope of the use cases is provided in the railML Wiki (links provided as hyperlink).

- Runtime calculations for operational simulation
- Passenger assets of rolling stock (e.g. for transport capacity planning)
- (Traction power supply simulation, currently not used in the Norwegian sector)

1.4 Reader information

This document is a documentation of the railML2.4 RS data exchange format. It contains general rules and definitions of how ambiguously defined core railML2.4 elements are interpreted and modelled in Norway.

Please note that this document is only a supplement to the documentation of the core railML schema. The documentation of the core railML schema is provided by railML.org and can be found in the following places:

- railML Wiki: Contains information about schema application
- railML Forum: Platform for discussions with railML users and the developer community
- railML Trac Ticket System: Platform to record and track all bugs and model enhancements
- railML.org website: Contains general information about the organisation of railML.org, the development of the schema, download of the schema and example data
- railML XSDs

In addition to the general modelling rules, this document provides an example of the usage of railML2.4 RS in the Norwegian sector.

Furthermore, the Norwegian sector provides an Excel sheet – "railML2.4 Rollingstock Use of Elements and Attributes in Norway Excel-list" - listing all railML2.4 elements that are used in Norway with their attributes,

[1] (railML.org, 2018)

values and specific definitions. Please additionally have a look at this Excel sheet, it is the complete overview of all elements, attributes and values of the Norwegian use of the railML2.4 RS schema.

1.5 Syntax guide

In the text, railML <elements> are put into XML specific brackets <>. railML @attributes can be recognized via the @ symbol before the attribute name. The combination of element and attribute is notated <element>@code. When specifying a parent- and a child-element, the syntax is <parent><child>. Attribute “values” are framed by quotation marks “”.

Source code examples are written in grey boxes:

```
<railml sourcecode="example">
   ...
</railml>
```

Some information in this document is written in *italic letters*. This means that the information is regarded as additional background information.

2 Norwegian use of railML2.4 RS on element level

The following hierarchy shows all railML2.4 RS elements that are used in Norway. It does not address attributes and values of these elements. Please note that the hierarchy is a simplification of the model and does not show container elements or elements from core railML that are not used in Norway. It is only meant to illustrate the content and does not display the correct syntax. A full list of all elements, attributes and values is given in the Excel sheet – "railML2.4 Rollingstock Use of Elements and Attributes in Norway Excel-list". Additionally, also view the example at the end of this document and the railML2.4 RS XSD.

The colours in which the rectangles in the hierarchy are coloured have the following meaning:

- Orange: These elements are railML2.4 core elements but are extended by Norway specific attributes or values.
- Blue: These elements are railML2.4 core elements, which are defined ambiguously by railML and thus were defined more precisely in accordance to Norwegian usage.
- Non-coloured: These elements are railML2.4 core elements, which are defined precisely by railML and thus do not need to be defined more precisely for railML2.4nor.

All elements that are coloured in the hierarchy are addressed in this document. A definition of all non-coloured elements is available in the railML Wiki. All elements are listed with their – for Norwegian use – relevant attributes and value sets in the Excel sheet.

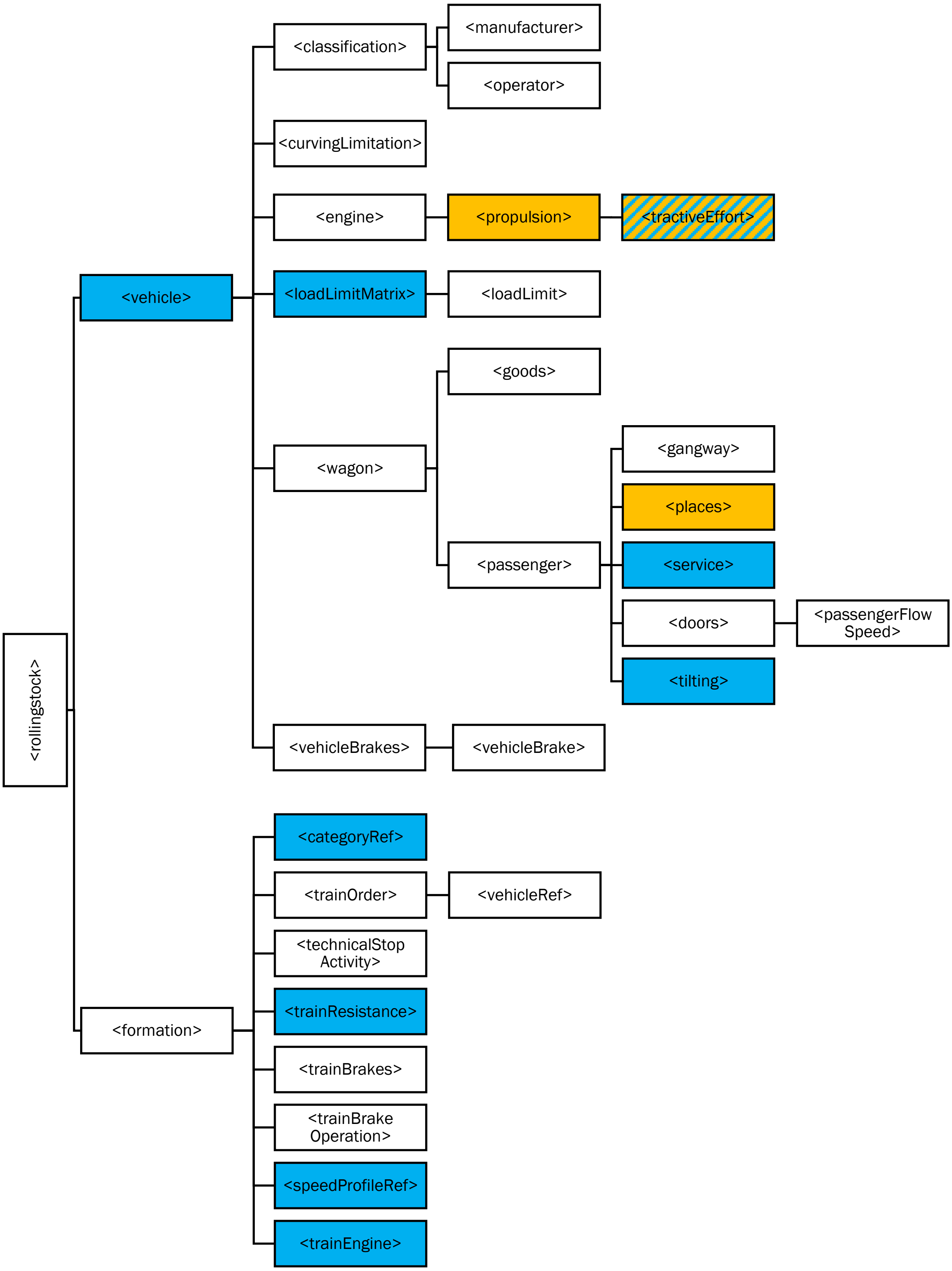

Figure 1: railML2.4 RS elements used in the Norwegian sector

3 General Modelling Rules

The following chapters explain general modelling rules that must be taken into account when working with railML2.4 RS data for Norwegian use.

3.1 Vehicles

A vehicle is the smallest unit that is modelled in the Norwegian use of railML2.4. This can be either a wagon for passengers or freight, a locomotive or an EMU/DMU (electric/diesel multiple unit). The attribute @vehicleCategory indicates what kind of vehicle it is. The information given for the vehicles are mostly the purely technical specifications which do not change. Only fully functional vehicles are modelled.

As the name suggests, an EMU/DMU comprises multiple carriages, which might have different characteristics (e.g. different amounts of places for passengers, driven or non-driven carriages). However, they are not modelled individually in the Norwegian use of the scheme. This is the case because during normal operations the configuration of that EMU will not change and it is therefore considered to be one unit.

If different variants of a vehicle exist, it needs to be checked if the the vehicle dynamics change significantly or not. If e.g. only the number of places vary slightly while the vehicle dynamics do not change, the variations can be considered to be the same vehicle. But if the tractive effort changes, these variations should be modelled as two different vehicles.

Figure 2 shows an example of how a train of type 75 (Stadler FLIRT) would be modelled. The vehicle consists of 5 more or less different carriages but they and their characteristics are combined into one vehicle. So e.g. the length, weight and number of places of the vehicle are the sums of the different lengths, weights and number of places of the carriages.

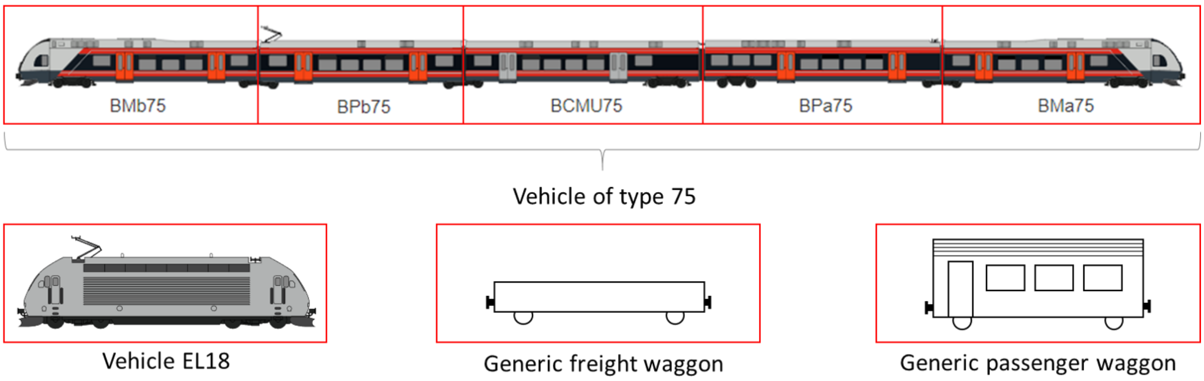

Figure 2: How an EMU is modelled as a vehicle. Image credit: Norske tog [www.norsketog.no]

For all other vehicles (locomotives, freight waggons and passenger waggons), each unit equals exactly one vehicle. Locomotives and EMUs in double heading need to be modelled as a formation, consisting of the same vehicle twice (or two different vehicles).

Currently, the Norwegian vehicle master database only contains EMUs/DMUs, locomotives and passenger waggons. If there is the need to model freight waggons, they can either be modelled as unknown vehicles (see Figure 3, length and weight for them given in <timetable>, see chapter 3.4) or as generic waggons (see Figure 2, length and weight for them given in the vehicle). Passenger waggons without detailed information can also be modelled as unknown vehicles or as a generic passenger waggon.

Refer to chapter 3.6.1 for naming rules of vehicles. Also, for each vehicle only one vehicle 'master' is modelled. All reading systems must be able to import those. Single instances of each vehicle could also be modelled if necessary for a certain use case (like asset management e.g.), but the reading systems are not required to import those.

3.2 Formations

A formation is considered to be an operational unit (colloquial: a train). A formation will usually be a locomotive with several wagons attached, two or more EMUs/DMUs coupled together, a single EMU/DMU or a single locomotive.

In Figure 3 there are some examples given of how a formation could be composed of different vehicles.

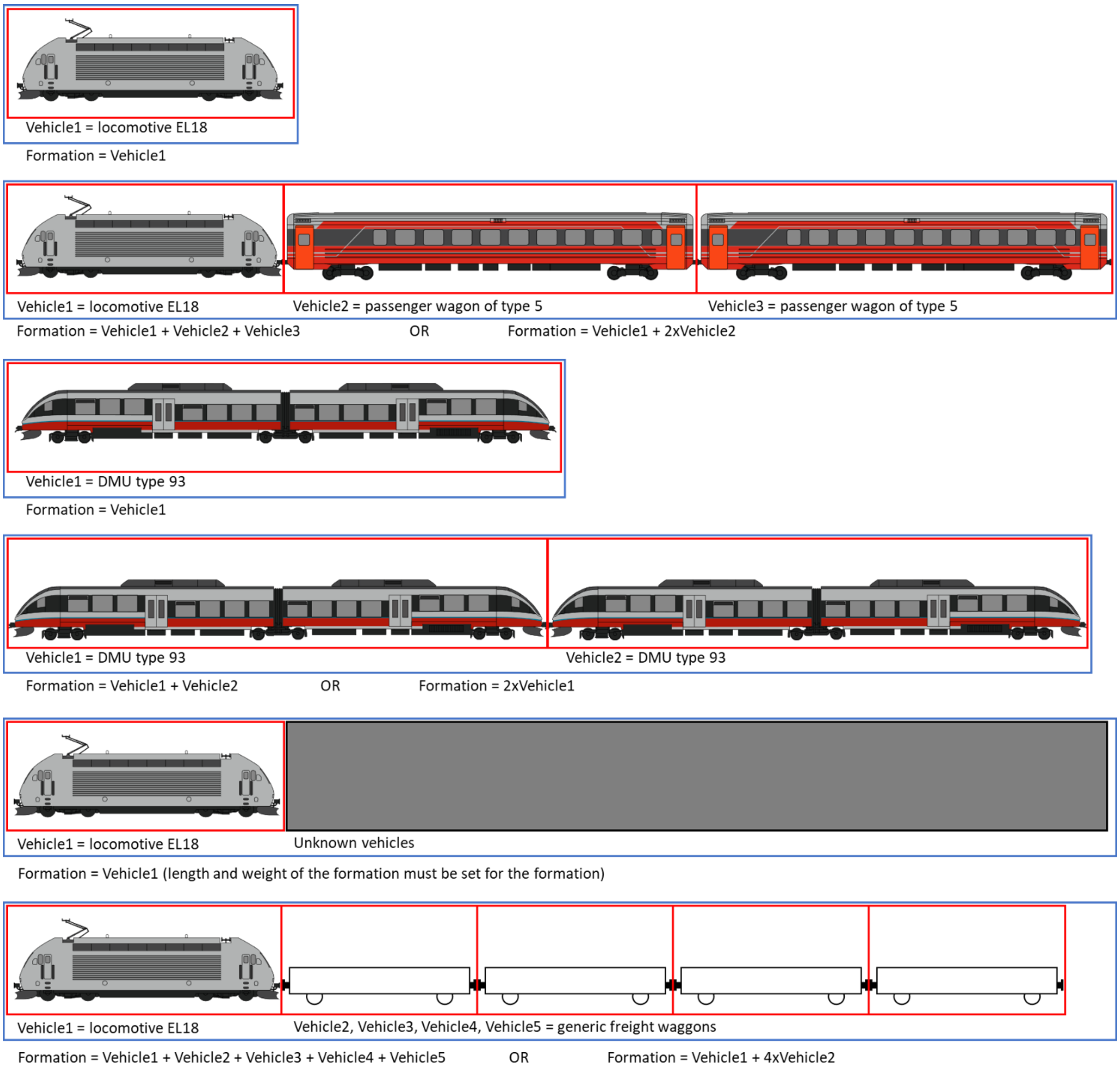

Figure 3: Different possibilities to build formations from vehicles. Image credit: Norske tog [www.norsketog.no]

A formation contains (mostly) operational abilities and limitations, like on which speed profiles the formation is allowed to run, how long it minimally takes to reverse the train and how the driver usually operates the brakes. Additionally, a formation contains technical information, which depend on the particular formation and can not be deducted from the vehicles used in the formation, e.g. the running resistance of the full train. The technical capabilities of the vehicles comprising a formation will be given for the vehicles and need to be extracted from there, if necessary.

For naming rules for formations, please see chapter 3.6.2.

3.3 Missing and conflicting information between formations and vehicles

Some attributes can be found both in <vehicle> and <formation>. The basic rule is that formation information overrides vehicle information, if there is a conflict between both of them. To avoid error, it is recommended that whenever it is possible to extract formation information from the vehicle information, the corresponding entries for the formation are left empty. Table 1 shows for which attributes this rule applies and how reading systems can extract the formation attributes from the vehicle attributes.

Table 1: Formation information that can be extracted from the vehicle information

Attribute or subelement of <formation>	Corresponding attribute on <vehicle>	If <formation> is empty…
@length	@length	<formation>@length = ∑<vehicle>@length
@bruttoWeight @nettoWeight	@bruttoWeight @nettoWeight	<formation>@bruttoWeight = ∑<vehicle>@bruttoWeight <formation>@nettoWeight = ∑<vehicle>@nettoWeight
@speed	@speed	<formation>@speed = min{<vehicle>@speed}
<trainBrakes> @regularBrakeMass	<vehicleBrakes> <vehicleBrake> @regularBrakeMass	<formation><trainBrakes>@regularBrakeMass = ∑<vehicle><vehicleBrakes><vehicleBrake> @regularBrakeMass (only if @brakeType and @airBrakeApplicationPosition match)

An exception for the rule are the resistance factors. Here the formation offers more detailed possibilities to enter. Therefore, the factors in <formation><trainResistance> shall be used and <vehicle>@resistanceFactor should not be used. This is because the running resistance of the formation can not be deducted by summing up the vehicles' resistance factors.

With the above mentioned rule, it is also possible to model formations that do not explicitly contain every vehicle in the formation. So if the characteristics of a vehicle are not known, the attributes of a formation can be used to step in. Please note that some information that are crucial for the use cases can only be given for a vehicle and not for a formation. They include:

- tractive effort for runtime calculations
- passenger capacity for transport capacity analyses

The user has to ensure that the needed information is given, even if not all other characteristics of the vehicles are known.

3.4 Interaction between <timetable> and <rollingstock>

Generally speaking, the information given in <timetable> is operational and the information given in <rollingstock> are the physical values. Together with the modelling principles mentioned in chapter 3.3, the hierarchy of possibly conflicting information is:

Information in <timetable> overrides information in <formation> overrides information in <vehicle>

3.4.1 Conflicting information

In many cases there can be redundant information between the data given in <rollingstock> and in <timetable>. For example: it is possible to set length, weight and speed for any <formationTT> in the <timetable> part of the file in addition to setting length, weight and speed for a formation in the <rollingstock> part. If this (and other) information is given in both parts, the information given in the timetable-part overrides the information given in the rollingstock-part.

If there is no further/concurring information given in the timetable part, the information of the formation (or extracted information from the vehicles) shall prevail.

Note: A tool that is importing rollingstock information shoud try to map the information to its existing dataset. But if the imported dataset differs from the mapped in any way, a new formation must be created.

3.4.2 The element <categoryRef>

One interaction between the Rollingstock and Timetable schemes is the element <categoryRef> given for formations in rollingstock. It references the categories given in <categories> under <timetable>. This reference states for which categories this formation can be used. This is intended to be a check of plausibility. However, not all <timetable>-writing systems are required to use the same list of <category>. Please note that it is possible to reference more than one category. Categories referenced from <rollingstock> do not distinguish between operational and product categories. If this is crucial, category information given in <timetable> have to be used.

For correct usage of <category> we refer to railML2.4nor Timetable Documentation.

If the element <categoryRef> is used, the referenced category has to be specified under the <categories>-element in the Timetable scheme within the same file.

3.4.3 Other information

Load of a train

The element <formation> has different weight attributes, but it is missing an attribute to specify the load of a train. The load is the brutto weight of the formation minus the weight of the locomotive. To indicate the planned load for the individual train, <formationTT>@timetableLoad under <timetable> can be used. On the other hand, the load of the train in operation can be specified with the <formationTT>@load.

Break percentage

The element <vehicle> has different brake weight attributes, but is missing an attribute to specify the brake percentage. To indicate the regular or emergency brake percentage for the individual train, <brakeUsage> @regularBrakePercentage or <brakeUsage>@emergencyBrakePercentage under <timetable> can be used.

3.5 Interaction between <infrastructure> and <rollingstock>

3.5.1 The element <speedProfileRef>

The most important interaction between the <rollingstock> and <infrastructure> parts is the element <speedProfileRef>. This reference specifies which speed profiles a train is allowed to use.

In railML2.4nor, the standardized Norwegian speed profiles must be used. The speed profiles and their railML specific values are given in railML2.4nor Infrastructure Documentation.

If the element <speedProfileRef> is used, the referenced speed profile has to be specified under the<speedProfiles>-element in the Infrastructure scheme within the same file.

3.5.2 Conflicting information

If the speed profiles of a formation do not match the speed profiles of the infrastructure it is running on, the reading software shall first try to identify the valid speed profiles for that formation by other means (e.g. the ETCS train category that can be given for speed changes in the infrastructure). If a formation and the speed profiles can not be matched at all, the formation shall always run on the speed profile with the lowest maximum speed at the current position.

For the speed profiles in Norway, there are defined fallback layers. Each train with <speedProfile>@name=”nor:krenge” is also allowed to run on @name=”nor:pluss” and the basis profile, @name=”basis”. Each train with profile @name=”nor:pluss” is also allowed to run on the basis profile.

3.6 Naming conventions

In order to ensure a smooth (machine readable) data transfer between external references, it is necessary to agree on a stable code list for current operational vehicles indepently from train operators, see chapter 3.6.1 below. As <vehicle>@name values are human-readable fields, there are only naming recommendations in railML2.4nor given in the attachment 7.1.

Different operators may name the same type of vehicle differently. In this case, <classification><operator>@operatorClass can be used additionally. Manufacturers can have their own marketing names. Those can be specified in <classification><manufacturer>@manufacturerType. For even further additional names the element <additionalName> can used.

3.6.1 Code list for vehicles

For the codelist entries we refer to the mandatory values listed in chapter 7.1 in this document. Code values listed here must be used for the applicable vehicles. Vehicles not listed shall have code values created according to the following guideline:

The code list is based on the national type names in the national vehicle registers (NVR) of the relevant national safety bodies or on the listing found for the national vehicle owner/keeper or othe formal lists of national or international railway sector authorities. Any use of [Space] is removed and type versions (series) are separated from the type with "-" e.g. "Type73-A". All letters are written with lower case.

Wagons

For the use of vehicles of type <vehicle>@vehicleCategory="coach" or "freightWagon", it is recommended to only map the locomotive (the vehicle with @vehicleCategory="motorVehicles") and add the weight and length generated by the passenger or freight wagons in the applicable attributes in formation.

3.6.2 Code values for formations

A formation must always refer to the vehicles it concists of. This with the exception of wagons, which are indicated with the usage of descriptive attributes like <formation>@bruttoWeight, @length etc. or in <formationTT>@load, @length etc.

3.6.3 Code example

```
<rollingstock id="rs-796796" name="Standard RS JDIR Rev02072020">
    <vehicles>
      <vehicle id="id-v1" code="type73-a" name="Type 73A"
vehicleCategory="motorCoach"/>
      <vehicle id="id-v2" code="el19-140" name="El19-140"
vehicleCategory="motorVehicles" tareWeight="85"/>
       <classification>
        <operator operatorClass="CE119"/>
       </classification>
    </vehicles>
    <formations>
      <formation id="fm-1" name="operational long distance double EMU with
tilt">
        <trainOrder>
          <vehicleRef orderNumber="1" vehicleRef="id-v1"/>
          <vehicleRef orderNumber="2" vehicleRef="id-v1"/>
        </trainOrder>
      </formation>
     <formation name="El19 loco with freight wagons" id="fm-2" speed="100"
length="600" bruttoWeight="885">
        <trainOrder>
          <vehicleRef orderNumber="1" vehicleRef="id-v2"/>
        </trainOrder>
     </formation>
    </formations>
 </rollingstock>
```

3.6.4 State of vehicles

It is recommended to use the railML2.4 core element <classification> under <vehicle>. Especially to distinguish vehicles and formations, which are not yet delivered or not used anymore from operational ones. In a correct and machine readable format, the attributes @startDate and @endDate of <vehicle><classification><operator> should be used.

Furthermore, it is recommended to indicate the operational status of a vehicle under <vehicle>@description. This attribute is only human readable. The description should use the values: “conceptual”, “planned”, “operational”, “disabled”, or “closed” (as used in <state>@status of the Infrastructure scheme).

3.7 Usage of deprecated attributes

No deprecated attributes are used.

3.8 Mandatory elements

Additionally to the mandatory elements in core railML, the following attributes are mandatory for the Norwegian use:

- <vehicle>@code
- <vehicle>@vehicleCategory

3.9 Common attributes

There are no attributes that all elements have in common.

4 Element Specific Definitions

4.1 The element <vehicle>

The Norwegian sector uses the <vehicle> element as defined in railML2.4. The following aspects are defined more precisely in accordance to Norwegian usage:

Table 2: Attributes of <vehicle> that are defined more precisely

Attribute of <vehicle>	Description	Type
@tareWeight	This is the weight of a fully functional vehicle without payload (passengers/goods). ‘Fully functional’ implies that the water and diesel tanks are half-filled. Given in metric tons [t].	xs:decimal
@bruttoWeight	This is the weight of a fully functional vehicle including full payload. For passenger trains ‘full payload’ implies that all seats (incl. folding seats) are in use including average luggage, but no passenger is standing. Given in metric tons [m].	xs:decimal

4.2 The element <propulsion>

Sub-element extension <tractiveEffort>

The tractive effort modelled in this element is considered to be the tractive effort that can be transferred on the rails under normal conditions (adhesion already considered).

Generally, there are different approaches to modelling the tractive effort. The three most commonly used approaches are listed below:

- Discrete values: the tractive effort diagram describes by discrete value pairs [speed|tractive effort]. The accuracy depends on the interval between the value pairs.
- Hyperbolic curve: the tractive effort can be described by a hyperbola of the form: $F = \frac{P}{v}$
- Quadratic curve: the tractive effort can be described by using a quadratic formula in the form of: $F = a \cdot v^2 + b \cdot v + c$. The arguments a, b and c may change for different speed intervals.

All three approaches can be summarized to:

$$F = \sum_{z} y_z \cdot v^z$$

This representation can then be entered into a <valueTable>. The tractive effort of a locomotive (in this case German BR 101) would be modelled as follows:

Discrete values:

Table 3: Example of tractive effort modelled as discrete values

Speed [km/h]	Tractive effort [kN]
0	300
…	…
78	271.7
…	…
100	212.4
…	…
120	177
…	…

This representation translates directly into a railML <valueTable> without any <columnHeader>/z values. The speed is the <xValue> and the tractive effort is the <yValue>.

Using a hyperbola and linear sections:

Table 4: Example of tractive effort modelled as hyperbola

Speed [km/h]	Tractive effort [kN]	Curve type connecting the points
0	300	Linear
78	217.7	Hyperbolic
220	96.5	

Written in the formula representation this would be:

$F\ [N] = 300000 + (-361.8) \cdot v$	for $0 \leq v < 78$
$F\ [N] = 21252700 \cdot v^{-1} + (-69.2)$	for $78 \leq v < 220$

This representation translates into a a railML <valueTable> as follows. Please note that the lower x-value of each interval is given.

Table 5: Example of tractrive effort modelled as hyperbola in a railML <valueTable>

	yValue		
xValue	z = -1	z = 0	z = 1
0	0	300000	-361.8
78	21252700	-69.2	0

Using quadratic segments:

Table 6: Example of tractive effort modelled as quadratic curve segments

Speed	a	b	c
0 ≤ v < 78	0.15	-373.8	30000
78 ≤ v < 100	30.19	-8095.9	720098
100 ≤ v < 120	16.1	-5312	582600
120 ≤ v < 160	7.9	-3319	461478
160 ≤ v < 200	3.69	-1991.2	356985
200 ≤ v < 220	2.31	-1450.9	304170

This representation translates into a a railML <valueTable> as follows. Please note that the lower x-value of each interval is given.

Table 7: Example of tractive effort modelled as quadratic curve segments in a railML <valueTable>

	yValues		
xValue	z = 0	z = 1	z = 2
0	300000	-373.8	0.15
78	720098	-8095.9	30.19
100	582600	-5312	16.1
120	461478	-3319	7.9
160	356950	-1991.2	3.69
200	304170	-1450.9	2.31

It is also be possible to combine the approaches in one <valueTable>. The code example shows the tractive effort of the given engine as a combination of discrete values and quadratic curves. If a reading system can not process the quadratic curves e.g., it can read the first column of y-values in the value table to extract the discrete values.

4.2.1 Code example

```
<tractiveEffort>
     <valueTable xValueName="Speed" xValueUnit="km/h" yValueName="Tractive
Effort" yValueUnit="N">
            <columnHeader zValue="-999"/>
            <columnHeader zValue="-1"/>
            <columnHeader zValue="0"/>
            <columnHeader zValue="1"/>
            <columnHeader zValue="2"/>
            <valueLine xValue="0.0">
              <values yValue="300000.0"/>
              <values yValue="0.0"/>
              <values yValue="300000.0"/>
              <values yValue="-373.533333333"/>
              <values yValue="0.15"/>
            </valueLine>
            <valueLine xValue="1.0">
              <values yValue="299627.0"/>
            </valueLine>
            <valueLine xValue="2.0">
              <values yValue="299254.0"/>
```

```
            </valueLine>

            <!-- ... -->

            <valueLine xValue="78.0">
              <values yValue="271777.0"/>
              <values yValue="0.0"/>
              <values yValue="720098"/>
              <values yValue="-8095.9"/>
              <values yValue="30.19"/>
            </valueLine>

            <!-- ... -->

            <valueLine xValue="100.0">
              <values yValue="212458.0"/>
              <values yValue="0.0"/>
              <values yValue="582600.0"/>
              <values yValue="-5312.0"/>
              <values yValue="16.1"/>
            </valueLine>

            <!-- ... -->

            <valueLine xValue="200.0">
              <values yValue="106194.0"/>
              <values yValue="0.0"/>
              <values yValue="304170.0"/>
              <values yValue="-1450.9"/>
              <values yValue="2.31"/>
            </valueLine>

            <!-- ... -->

            <valueLine xValue="220.0">
              <values yValue="96534.0"/>
            </valueLine>
      </valueTable>
</tractiveEffort>
```

4.3 The element <tilting>

The element <tilting> is used as intended and indicates the vehicles' physically ability and characteristics of the tilting system. In Norway, the tilting technology of a vehicle usually corresponds with the ability to use a certain speed profile (which can be referred to from a formation).

Table 8: Correspondence of tilting abilities and speed profiles

Attribute of <tilting>	Norwegian name	Corresponding speed profile
@actuation="active"	Krenge	<speedProfile id="spprf3" influence="increasing" name="nor:krenge"/> (with fallback level Pluss and Basis)
@actuation="passive"	Pluss	<speedProfile id=spprf2" influence="increasing" name="nor:pluss"/> (with fallback level Basis)
element <tilting> not used	Basis	<speedProfile id="spprf1" influence="increasing" name="basis">

4.4 The element <places>

In the following, the element <places> will be explained. The element contains data related to the planned regular transportation capacity and is used as intended in railML2.4. The categories are a defined more precisely and extended for the use in Norway.

Table 9: Description of used <places> for passenger trains

Value of @category	Description
class1	Seat category A. Defined as seats with high comfort, for which the operator may charge the passengers extra. (Also named as "first class" or "komfort")
class2	Seat category B. Defined as seats with normal comfort. The seat of a chair can be either fixed or folding.
class3	Seat category C. Defined as seats with lower comfort than the standard places in this vehicle. Can be fixed or folding seats.
standingArea	Number in @count should be interpreted as [m^2]. Total area that can be used for standing passengers, folding seats (class3) not in use.
wheelchair	Available number of wheel chair places in the vehicle.
bicycle	Available number of bycicle places in the vehicle.
couchette	Not used in Norway.
bed	Available number of beds in the vehicle.
sleepingCompartement	Available number of sleeping compartments in the vehicle.
chair	Not used in Norway.
bistro	Number of seats at tables with self-service.
restaurant	Number of seats at tables with service (waiter).
foldingSeat	Not used in Norway.
impairedToilet	Not used. Use in <services> instead.
toilet	Not used. Use in <services> instead.
business	Not used in Norway.
businessCompartement	Not used in Norway.
family	Number of seats in family compartements.
familyCompartement	Not used in Norway.
toddler	Not used in Norway.
toddlerCompartement	Not used in Norway.
other:standingCategoryA	Standing places in an area with sufficient possibilities for passengers to hold onto sth. Calculated with all seats in category A, B and C in use and 2 passengers per m^2.
other:standingCategoryB	Standing places in all areas that are accessible for passengers (without toilet). Calculated with seat categories A and B in use and 4 passengers per m^2.
other:standingCategoryC	The maximum standing capacity with seats in category A and B in use, before reaching a technical or safety limit.
other:strollers	Available number of stroller places in the vehicle.
other:*	

4.5 The element <service>

The element <service> can be used to refer to any additional services to the planned regular transportation capacity (as described in <places>). This can either be an offer of more places (e.g. toilets) or different kinds of amenities (like heating or WLAN). The services can be further specified by a count (e.g. number of toilets) or another value. If a service is either present or not present, it is considered to be present, when a <service> with the according @type is set. If the service is not present, no such element is written.

Table 10: Description of used <service> for passenger trains

@type	@value	@count	Description
mobileCatering	-	-	Not used, as this kind of service is not technically part of the train.
WLAN	-	-	If a <service> with @type="WLAN" is written, there is WLAN/WIFI available for the passengers on the train.
wheelchairLift	-	[total number of lifts]	The total number of lifts is specified by using @count. If a vehicle has one lift at each side of the vehicle, @count="2".
toiletClosed	-	[total number of applicable toilets]	@count specifies the total number of toilets (including any handicap toilets) with a closesd sewer system on board.
toiletOpen	-	[total number of applicable toilets]	@count specifies the total number of toilets (including any handicap toilets) with an open sewer system on board.
toiletHc	-	[total number of applicable toilets]	@count specifies the total number of handicap toilets on board. The kind of sewer system is usually the same as for the other available toilets. HC toilets are listed twice, once as @type="toiletHc" and once as @type="toiletOpen/Closed". To get the total number of toilets, only add @type="toiletOpen" and @type="toiletClosed".
Snack	-	-	If a <service> with @type="Snack" is written, a manned kiosk is on board. This kiosk doesn't have a seatng area.
SelfService	-	([total number of vending machines], if required)	Vending machine for food and drinks. Use @count for number of available vending machines. If you want to specify different types of vending machines, you may use more than one <service> with @type="selfService" and specify the type of vending machine in the name and/or description.
PIS	-	-	If a <service> with @type="PIS" is written, an Passenger Information System (PIS) is on board.
HVAC	-	-	If a <service> with @type="HVAC" is written, there is a system for Heating, Ventilation and Air-Conditioning (HVAC) is on board.
APC	-	-	If a <service> with @type="APC" is written, there is an Automatic Passenger Counting (APC) system on boaed.

SecurityCamera	-	([total number of security cameras], if required)	If a <service> with @type="SecurityCamera" is written, at least one security camera is in place. If no @count is given, this just states the general availability of security cameras. If the number of cameras is known, it can be entered in @count.

4.6 The element <categoryRef>

Please refer to chapter 3.4.

4.7 The element <speedProfileRef>

Please refer to chapter 3.5.

4.8 The element <trainResistance>

The use of <trainResistance> is preferred over the use of vehicles/vehicle/@resistanceFactor. Only if no <trainResistance> is given, the interpreting system may use @resistanceFactor of the vehicles which comprise the formation.

In principal, there are 3 different possibilities to model the train resistance:

- Using the formula from Strahl/Sauthoff
- Using the formula from Davis (mass dependent or mass independent)
- Using the value table

Even though it is possible to model all three approaches at once, it is highly suggested that only one of them is modelled for each formation. The approaches by Strahl/Sauthoff and Davis are preferred over the value table (which will therefore not be explained in this document.)

4.8.1 Train resistance according to Strahl/Sauthoff

The formulas developed by Strahl and Sauthoff are well used, especially within the German sector. The formula from Strahl is mostly used for freight trains and the formula from Sauthoff is mostly used for passenger trains consisting of individual wagons.[2]

Strahl formula:

$$r_W = c_0 + (0{,}007 + c_1) \cdot \left(\frac{v_{rel}}{10}\right)^2$$

with: r_W [‰] = specific train resistance

v_{rel} $[\frac{km}{h}]$ = relative speed (speed of vehicle + speed of wind)[3]

c_0 $[-]$ = Coefficient for bearing friction (1,4 for loaded wagons; 2,0 for empty wagons)

c_1 $[-]$ = Drag coefficient (to be given in @strahlFactor)

[2] (Pachl, 2013)

[3] Average speed of wind is assumed to be 15 km/h

Sauthoff formula:

$$r_W = 1{,}9 + c_1 \cdot v + 0{,}0048 \cdot (n + 2{,}7) \cdot A_f \cdot \frac{{v_{rel}}^2}{m}$$

with: r_W [‰] = specific train resistance

$v\ [\frac{km}{h}]$ = speed

$n\ [-]$ = number of wagons

$m\ [t]$ = train mass (brutto weight of the formation)

$A_f\ [m^2]$ = equivalent surface area of the vehicle (usually = 1,45 m^2)

$c_1\ [-]$ = drag coefficient (to be given in @strahlFactor)

Table 11: Guidelines on when to use Strahl or SauthoffTable 11 gives a few guidelines when to use which formula. If Strahl has to be used but it is unclear whether the train is loaded or empty, the default should be c_0=1,4.

Table 11: Guidelines on when to use Strahl or Sauthoff

Element/Attribute	Value	Formula
<timetable><categories><category>@trainUsage (referenced by <formation><categoryRef>)	"passenger"	Sauthoff
	"goods"	Strahl
<vehicle> (referenced by <formation><vehicleRef>)	contains <passenger>	Sauthoff
<vehicle> (referenced by <formation><vehicleRef>)	contains <goods>	Strahl
<timetable><categories><category>@code	"T" (=Tomtog/Empty train)	Strahl, c_0 = 2,0
AND <vehicle>	contains <goods>	

4.8.2 Train resistance according to Davis

The basic train resistance formula developed by Davis in another well established formula, especially in the English-speaking sectors. It is a quadratic formula and can be used either mass dependent or mass independent.

Mass dependent formula:

$$R = m \cdot g \cdot (A + B \cdot v + C \cdot\ v^2)$$

with: $R\ [N]$ = specific train resistance

$m\ [t]$ = train mass (brutto weight of the formation)

$g\ [\frac{m}{s}]$ = gravitational acceleration (=9,81)

v $[\frac{m}{s}]$ = speed

$A\ [N]$ = @daviesFactorA [sic]

$B\ [N\frac{s}{m}]$ = @daviesFactorB [sic]

$C\ [N\frac{s^2}{m^2}]$ = @daviesFactorC [sic]

Mass independent formula:

$$R = A + B \cdot v + C \cdot v^2$$

with: $R\ [N]$ = specific train resistance

$A\ [N]$ = @daviesFactorA [sic]

$B\ [N\frac{s}{m}]$ = @daviesFactorB [sic]

$C\ [N\frac{s^2}{m^2}]$ = @daviesFactorC [sic]

4.9 The element <trainEngine>

The element <trainEngine> includes information about the mean acceleration and maximum acceleration of a train (<formation>), as well as the train's minimum time to hold speed, i.e. the time the train driver should maintain the current speed before accelerating or decelerating again.

In Norway, these values depend on the (commercial) train category and not the formation. As one <formation> can belong to multiple train categories, the lowest applicable value should be given in this element. The values are given in the following table. E.g. if a vehicle can be used as Lokaltog or as Regiontog, the minimum time to hold speed would be 10 s and the max acceleration would be $0{,}65\frac{m}{s^2}$. If the reading system uses those values, it must allow the user to correct these values according to their train category.

Table 12: trainMaxAcceleration and trainMinTimeHoldSpeed per train category

Train category	Max acceleration	Minimum time to hold speed
Fjernekspresstog	$0{,}5\frac{m}{s^2}$	$30\ s$
Fjerntog	$0{,}5\frac{m}{s^2}$	$30\ s$
Regionekspresstog (Intercity)	$0{,}65\frac{m}{s^2}$	$30\ s$
Regiontog	$0{,}65\frac{m}{s^2}$	$20\ s$
Flytog	$0{,}65\frac{m}{s^2}$	$30\ s$
Regiontog i distriktene	$0{,}65\frac{m}{s^2}$	$20\ s$
Lokaltog	$1{,}0\frac{m}{s^2}$	$10\ s$
Storbytog	$1{,}0\frac{m}{s^2}$	$10\ s$
Godstog kobling maks 600 kN	-	$30\ s$

5 railML2.4nor Example

The Norwegian sector decided to attach one very simple example of railML2.4 RS to this documentation. This example is also available for viewing and exporting online in NorRailView – the Norwegian railML2.4 editor and viewer. To view the example, please click Navigate and then the Model “railML2.4 Rollingstock Example for Norwegian documentation”, to view the data in NRV. Click the -button to export to railML. In future also further examples and the public available operational rolling stock data set will be provided publicly accessible by the Norwegian sector in NorRailView.

The following example is only meant to illustrate the syntax and the use of railML2.4 RS. The contained data is only meant as exemplary information and Jernbanedirektoratet does not guarantee that the contained data is correct.

```
<?xml version="1.0" encoding="UTF-8"?><railml xmlns="https://www.railml.org/schemas/2018"
xmlns:nor="http://www.jernbanedirektoratet.no/railml" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
version="2.4" xsi:schemaLocation="https://www.railml.org/schemas/2018 https://schemas.railml.org/2018/railML-
2.4/schema/railML.xsd http://www.jernbanedirektoratet.no/railml
https://www.jernbanedirektoratet.no/globalassets/documenter/railml/norExtension.xsd">
  <metadata xmlns:dc="http://purl.org/dc/elements/1.1/">
    <dc:date>2020-11-30T15:05:37.776Z</dc:date>
    <dc:source>railOscope https://railoscope.com</dc:source>
    <dc:source>railML2.4 Rollingstock Example for Norwegian documentation rev6, last changed 2020-11-
30T15:04:53.729Z[Etc/UTC] by Torben Brand</dc:source>
    <dc:language>no-NO</dc:language>
   <dc:relation>norInfra.xsd_5.0</dc:relation>
<dc:source>https://railoscope.com/models/5d1dc59f72b32b08683bc7dc?modelId=5d1dc59f72b32b08683bc7dc&amp;branchId=&amp
;revision=6</dc:source>
    <dc:creator>Torben Brand</dc:creator>
    <organizationalUnits>
      <vehicleManufacturer id="id2" name="Stadler"/>
      <vehicleManufacturer id="id28" name="Bombardier Transportation"/>
      <vehicleOperator code="VY" description="Vygruppen AS, formerly NSB (before 28.04.2019)" id="id58"
name="Vygruppen AS"/>
      <vehicleOperator code="CN" id="id68" name="CargoNet"/>
    </organizationalUnits>
  </metadata>
  <infrastructure id="inf0" name="railML2.4 Rollingstock Example for Norwegian documentation">
    <speedProfiles>
      <speedProfile id="spprf1" influence="increasing" name="basis"/>
      <speedProfile id="spprf2" influence="increasing" name="nor:pluss"/>
```

```
      <speedProfile id="spprf3" influence="increasing" name="nor:krenge"/>
      <speedProfile id="spprf4" influence="decreasing" name="nor:local" verbalConstraint="SJN defined condition"/>
      <speedProfile id="spprf5" influence="decreasing" name="nor:temporary"/>
      <speedProfile id="spprf6" influence="decreasing" name="nor:conditional" verbalConstraint="SJN defined
condition"/>
      <speedProfile id="spprf7" influence="decreasing" name="nor:avalanche" verbalConstraint="SJN defined
condition"/>
    </speedProfiles>
  </infrastructure>
  <rollingstock id="rs0" name="railML2.4 Rollingstock Example for Norwegian documentation">
    <vehicles>
      <vehicle axleLoad="18.784" axleSequence="Bo´2´2´Bo´+2´2´Bo´" bruttoAdhesionWeight="360.0"
bruttoWeight="237.27" code="type74" description="Norske tog's Type74" id="id3" length="105.5" name="Type 74"
numberDrivenAxles="6" numberNonDrivenAxles="8" speed="200.0" tareWeight="218.07" towingSpeed="200.0"
trackGauge="1.435" vehicleCategory="motorCoach">
        <classification>
          <manufacturer manufacturerType="FLIRT" vehicleManufacturerRef="id2"/>
          <operator endDate="2019-04-24" operatorClass="74" startDate="2012-01-01" vehicleOperatorRef="id58"/>
        </classification>
        <engine>
          <propulsion id="id25" maxTractEffort="240000" power="4500000" powerType="electric"
rotationMassFactor="1.05" transmission="electric" wheelDiameter="0.92">
            <tractiveEffort>
              <valueTable xValueName="Speed" xValueUnit="km/h" yValueName="Tractive Effort" yValueUnit="N">
                <columnHeader zValue="-999"/>
                <columnHeader zValue="-1"/>
                <columnHeader zValue="0"/>
                <columnHeader zValue="1"/>
                <columnHeader zValue="2"/>
                <valueLine xValue="0.0">
                  <values yValue="212000.0"/>
                  <values yValue="0.0"/>
                  <values yValue="212000.0"/>
                  <values yValue="0.0"/>
                  <values yValue="0.0"/>
                </valueLine>
                <valueLine xValue="1.0">
                  <values yValue="212000.0"/>
                </valueLine>
                <valueLine xValue="2.0">
```

```
                <values yValue="212000.0"/>
              </valueLine>
              ...
              <valueLine xValue="200.0">
                <values yValue="72000.0"/>
              </valueLine>
            </valueTable>
          </tractiveEffort>
        </propulsion>
      </engine>
      <vehicleBrakes>
        <vehicleBrake airBrakeApplicationPosition="R" brakeType="compressedAir" emergencyBrakeMass="667.0"
regularBrakeMass="360.0"/>
      </vehicleBrakes>
      <curvingLimitation horizontalCurveRadius="120.0"/>
    </vehicle>
    <vehicle axleSequence="Bo'Bo" bruttoWeight="86.0" code="el19-140" description="Freight version" id="id48"
length="16.49" name="El19" numberDrivenAxles="4" numberNonDrivenAxles="0" speed="140.0" tareWeight="85.0"
trackGauge="1.435" vehicleCategory="motorVehicles">
      <classification>
        <manufacturer manufacturerType="TRAXX F140 AC2" vehicleManufacturerRef="id28"/>
        <operator operatorClass="CE 119" vehicleOperatorRef="id68"/>
      </classification>
      <engine>
        <propulsion id="id50" maxTractEffort="275000" power="3700000" powerType="electric"
rotationMassFactor="1.0" transmission="electric">
        </propulsion>
      </engine>
    </vehicle>
    <vehicle axleLoad="22.0" axleSequence="Bo'Bo'" bruttoWeight="96.0" code="el18" description="Norske tog's
locomotive EL18" id="id63" length="18.0" name="EL18" nettoWeight="88.0" numberDrivenAxles="4"
numberNonDrivenAxles="0" speed="200.0" towingSpeed="140.0" vehicleCategory="motorVehicles">
      <classification>
        <manufacturer manufacturerType="El18" vehicleManufacturerRef="id28"/>
        <operator operatorClass="El18" vehicleOperatorRef="id58"/>
      </classification>
      <engine>
        <propulsion id="id65" maxTractEffort="275000" power="5400000" powerType="electric"
rotationMassFactor="1.0" transmission="electric" wheelDiameter="1.0">
        </propulsion>
```

```
        </engine>
        <curvingLimitation horizontalCurveRadius="80.0"/>
      </vehicle>
    </vehicles>
    <formations>
      <formation bruttoWeight="317.0" description="Train consisting of EL18 locomotive and 5 passenger waggons."
id="id52" name="EL18+5xType5" speed="130.0" tareWeight="298.0">
        <trainOrder>
          <vehicleRef orderNumber="1" vehicleRef="id63"/>
        </trainOrder>
        <categoryRef ref="trcatFJ"/>
        <trainEngine trainMinTimeHoldSpeed="PT30S"/>
        <trainResistance daviesFactorA="1.67" daviesFactorB="0.00984" daviesFactorC="0.0285"
daviesMassDependent="true"/>
        <speedProfileRef name="basis" ref="spprf1"/>
        <speedProfileRef name="nor:local" ref="spprf4"/>
        <speedProfileRef name="nor:conditional" ref="spprf6"/>
        <speedProfileRef name="nor:temporary" ref="spprf5"/>
        <speedProfileRef name="nor:avalanche" ref="spprf7"/>
      </formation>
      <formation description="Dobbeltsett of Type 74" id="id53" name="2x74">
        <trainOrder>
          <vehicleRef orderNumber="1" vehicleRef="id3"/>
          <vehicleRef orderNumber="2" vehicleRef="id3"/>
        </trainOrder>
        <categoryRef ref="trcatR"/>
        <categoryRef ref="trcatRE"/>
        <trainBrakes airBrakeApplicationPosition="P" brakeType="compressedAir" regularBrakeMass="720.0"/>
        <trainBrakeOperation brakeSupervision="ATP" decelerationDelay="PT0S"/>
        <trainResistance/>
        <speedProfileRef name="basis" ref="spprf1"/>
        <speedProfileRef name="nor:pluss" ref="spprf2"/>
      </formation>
      <formation bruttoWeight="850.0" description="Freighttrain in combined traffic" id="id62" length="515.0"
name="Freighttrain" speed="120.0">
        <trainOrder>
          <vehicleRef orderNumber="1" vehicleRef="id48"/>
        </trainOrder>
        <categoryRef ref="trcatGK"/>
        <categoryRef ref="trcatGF"/>
```

```
        <categoryRef ref="trcatGS"/>
        <categoryRef ref="trcatGV"/>
        <categoryRef ref="trcatK"/>
        <trainResistance/>
      </formation>
    </formations>
  </rollingstock>
  <timetable id="tt0">
    <categories>
       <category code="R" id="trcatR" name="Regiontog" trainUsage="passenger">
        <additionalName name="Regional" xml:lang="en"/>
      </category>
      <category code="RE" id="trcatRE" name="Regionekspresstog (Intercity)" trainUsage="passenger">
        <additionalName name="Regional express, Intercity"/>
      </category>
      <category code="GS" id="trcatGS" name="Systemtog" trainUsage="goods">
        <additionalName name="System freight" xml:lang="en"/>
      </category>
      <category code="GK" id="trcatGK" name="Kombitog" trainUsage="goods">
        <additionalName name="Combined freight" xml:lang="en"/>
      </category>
      <category code="GF" id="trcatGF" name="Fleksitog" trainUsage="goods">
        <additionalName name="Mixed freight" xml:lang="en"/>
      </category>
      <category code="GV" id="trcatGV" name="Vognlasttog" trainUsage="goods">
        <additionalName name="Wagonload freight" xml:lang="en"/>
      </category>
      <category code="K" id="trcatK" name="Kipptog" trainUsage="goods"/>
    </categories>
  </timetable>
</railml>
```

6 References

Pachl, J. (2013). *Systemtechnik des Schienenverkehrs.*

railML.org. (2018, 09 12). Retrieved from The railML.org initiative: https://www.railml.org/en/introduction/background.html

Open access national vehicle register of Sweden: https://jvportalen.transportstyrelsen.se/fordon.wp/Startsida/Startsida.aspx

Unofficial and for the moment not updated overview page of Norwegian types by national safety body SJT:

https://www.sjt.no/jernbane/tillatelser/kjoretoy/nasjonalt-koyretoyregister-snvr/oppbygging-av-evn-for-trekkraftkjoretoy-siffer-5-8/

Tips for an unofficial support page: https://forsk.njk.no/mdb/mdbp.php?aid=2&aut=

7 Attachments

7.1 List of commonly used vehicles in Norway

This is the normative codelist to be used in the Norwegian railway sector for the value of vehicle@code in railML2.4nor.
White part of the table is mandatory with fixed values. The grey part is optional with example values.

<vehicle> @code	<vehicle> @vehicleCategory	<vehicle> @name	<operator> @operatorClass	<manufacturer> @manufacturerType
type69-c	motorCoach	Type 69CII	69C	
type69-d	motorCoach	Type 69D	69D	
type69-h	motorCoach	Type 69H	69H	
type70	motorCoach	Type 70		
type71	motorCoach	Type 71	[link]	
type72	motorCoach	Type 72		
type73-a	motorCoach	Type 73A		
type73-b	motorCoach	Type 73B		
type74	motorCoach	Type 74		
type75	motorCoach	Type 75	[link]	
type75-2	motorCoach	Type 75-2	[link]	
type78	motorCoach	Type 78	[link]	
x2	motorCoach		[link]	
x50	motorCoach			Regina
X60	motorCoach		[link]	
type92	motorCoach	Type 92		
type93	motorCoach	Type 93		
type76	motorCoach		[link]	
di4	motorVehicles	Di 4	Di4	
di6	motorVehicles		ME26	
di7	motorVehicles		T44	
di8	motorVehicles		[link]	
di9	motorVehicles		T66, CD66	
di10	motorVehicles		T43	
di11	motorVehicles		MZ, TMZ	
di12	motorVehicles		T68, CD312	Euro 4000
el14	motorVehicles			
el16	motorVehicles			
el17	motorVehicles			
el18	motorVehicles	EL18	EL18	
el19-140	motorVehicles		BR185, BR241, CE119	TRAXX F140 AC2
el19-160	motorVehicles		BR187	TRAXX F160 AC3
iore	motorVehicles	IORE	IORE	
rc2	motorVehicles		Rc2	
rc4	motorVehicles		Rc4	
rc6	motorVehicles		Rc6	
skd224	motorVehicles			
skd226	motorVehicles		Z66	
skd227	motorVehicles		Z70, Z71	
skd228	motorVehicles		ME05	
skd229	motorVehicles		BR214	
br193	motorVehicles		BR193	Vectron
br941	motorVehicles		BR941	G2000
a5-1	coach	A5-1	A5-1	Type5
b5	coach	B5	B5-3,B5-5	Type5
bc5	coach	BC5	BC5-3	Type5
fr5	coach	FR5	FR5-1	Type5
a7	coach	A7	A7-1	Type7

<vehicle> @code	<vehicle> @vehicleCategory	<vehicle> @name	<operator> @operatorClass	<manufacturer> @manufacturerType
b7	coach	B7	B7-4, B7-5, B7-6	Type7
bc7	coach	BC7	BC7-1	Type7
f7	coach	F7	F7-1	Type7
fr7	coach	FR7	FR7-3	Type7
wlab2	coach	WLAB2	WLAB2	WLAB2
[No normative code values]	freightWagon			