3* A In 2008, two solutions can be chosen: synchronous motor with permanent magnets or asynchronous motor with squirrel-cage. In both cases, a frequency converter with direct voltage intermediate circuit has to be installed. The intermediate circuit is designed to be supplied from direct voltage catenary (first 1200V= later 1500V=) through LC-filter (voltage can vary between 800V= and 1800V=).
The line profile is hard. So we can install independent traction line for each motor, included the secondary of transformer, preferably as one single line pro bogie, with two motors in parallel: we can think more about this point in **B**. In such a case, both intermediate circuits can be connected in parallel, note only under continuous voltage, but also in case of defect of one network converter.

B One critical case is a full load start-up on 70 ‰ ramp. The motors have to counteract slope-force, frictional force and give certain acceleration, for example 0,3 m/s^2 until 40 km/h. Mass is estimated at full load at 147 [t] (75 kg for each passenger) and the corrected mass at 153 [t] (see doc. FLIRT40). Frictional force F_f is also estimated from this document.

$$F_f = (735+10\cdot 40+0{,}18\cdot 40^2)\ 10^{-3} = 1{,}5\ \text{kN} \qquad (13.11)$$
$$F_{acc} = m^*\cdot a = 153\cdot 0{,}3 = 46\ \text{kN} \qquad (13.12)$$
$$F_d = m\cdot g\cdot i\cdot 10^{-3} = 147\cdot 9{,}81\cdot 0{,}07 = 101\ \text{kN} \qquad (13.13)$$

The total drive has to develop 150 kN until 40 km/h: a power of 1650 kW.

A second case is to hold the top speed of 70 km/h on the 70 ‰ ramp: we count a frictional force of 2,3 kN, a total force 103,3 kN. At this speed, the necessary power reaches 2 MW.

For the acceleration of 1 m/s^2, until 60 km/h, we count a force of 153 kN. The drive has to develop shortly 2,55 MW. To hold 140 km/h, it needs 5,5 kN, a power of 220 kW.

Conclusion : The nominal power of 2 MW, which can reach shortly 2,6 MW, as installed on *Flirt* vehicle, is also good for this application.

We cannot simply take the *Flirt*-equipment : we have first to test if the currents under continuous-voltage catenary can be supported by motor converter components. In this case, it is interesting to take this equipment "as ever built" and to put away the idea of independent drive pro motor instead of pro bogie. So a part of equipment is standard with other trains which are already on work in the same region.

C The load for adherence is 64,4 [t]; in normal conditions (μ_r = 0,35), the train can use a traction force of 220 kN at wheel-rail contact. This is sufficient for the requirement calculated on B. If very bad conditions are often encountered, another wheel-arrangement has to be chosen, with more traction wheels.

The Jacobs-bogies can be motorised, but the floor of the aisle will be higher over the bogies. In order not to have a too high floor, we choose littler motors (4 motors at 250 kW instead of 2 at 500 kW pro drive), with wheel-arrangement B_o'-B_o'-2'-B_o'-B_o'. A variant is to choose 5 motors at 200 kW, with the advantage of only two types of bogies for a total-adherence-train. Also if the trains are ordered by the same supplier as *Flirt*, the bodies cannot be realised "as built": the design of both ends has to be modified for higher floor. In this case, it is interesting to choose synchronous motors – 30% littler as asynchronous of same power – in order to reduce the high of the aisle floor.

It seems that no additional electric equipment is required: it can take place in the same roof box as the equipment of a Flirt. Also 5 converters of 200 kW can probably take the same space as one of 1 MW.