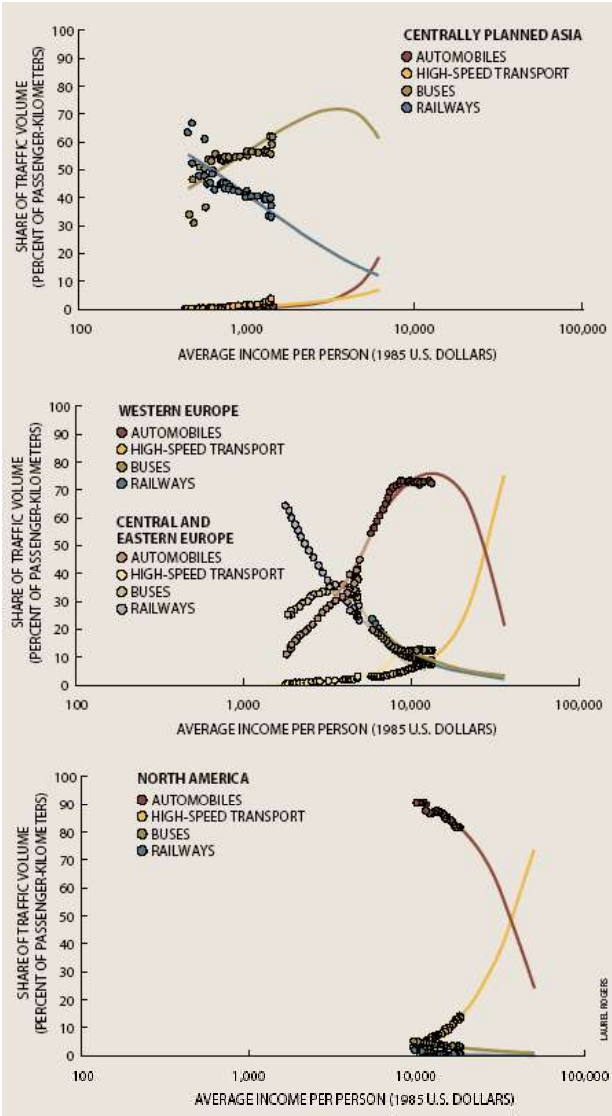

Figure 6: Modal split in transport as a function of average income (source: Schafer and Victor (1997))

The solution man found for his mobility problems has been towards transportation modes with higher speeds. These high speed transportation modes require their own infrastructure like airports and high speed rail roads but man has shown to be able to realize them. Therefore the most likely future development is a shift towards more high speed transport.

3. TRENDS IN ENERGY NEEDED FOR TRANSPORT

Nowadays there is an increasing awareness that the energy consumption of the World's population might have a detrimental influence on the climate. Especially the use of fossil fuels is expected to contribute significantly to global warming and climate change. The energy used in transport forms a considerable part of the World's energy consumption. It is therefore useful to consider what is the effect of the world wide trend of increasing speed in transport. Early research into this has been done by Gabrielli and Von Kármán (1950). They reported the specific resistance of vehicles as a function of their speeds. Specific resistance was expressed as the power required to propel the vehicle divided by its weight times speed. Figure 7 is a reproduction of their original diagram.

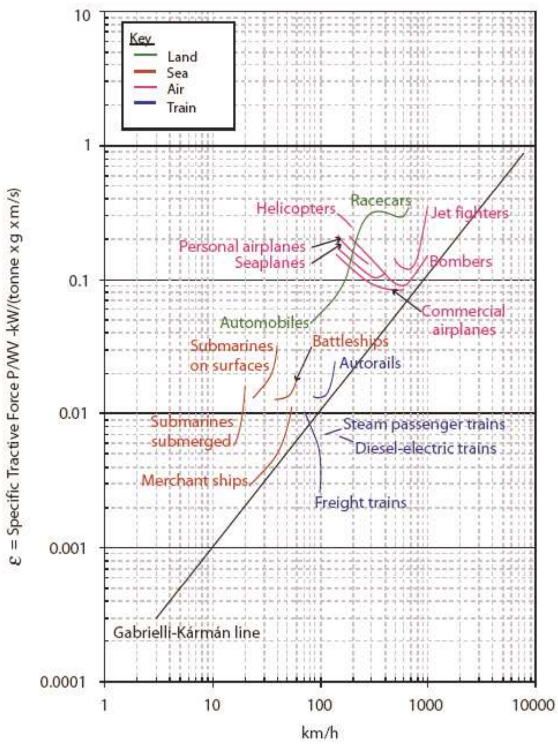

Figure 7: Specific resistance for various transport modes before 1950
(source: Yong et al (2005))

Gabrielli and Von Kármán discovered a lower limit in the specific resistance. Later this was called the Gabrielli – Kármán line. No vehicle was able to have a specific resistance/speed combination below this line. Only closely coupled combinations of vehicles like locomotives with a number of carriages or a series of cars were able to show a performance below this line. Over the years the performance of vehicles has improved. Yong et al. (2005) have shown that there is a trend in which vehicles are able to show the same performance in terms of speed but with a lower specific resistance. Figure 8 shows this development.

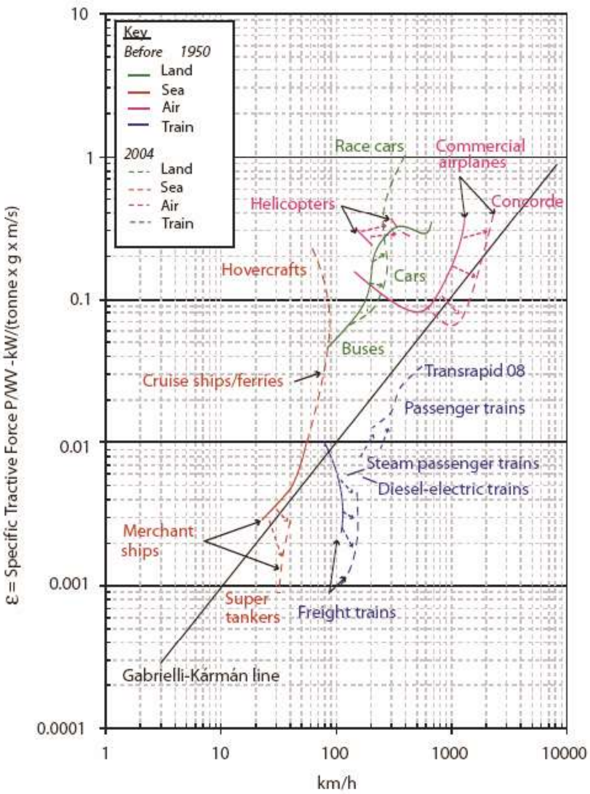

Figure 8: Trends in specific resistance for various transport modes (source: Yong et al (2005))

One can conclude that there is a trend towards a better energy performance but that the development over the period considered is relatively small.

4. LESSONS TO BE LEARNT FROM AEROSPACE TECHNOLOGY

Aircraft by their nature are required to maximize the fuel efficiency. The reason for this is the compounding effect of having to take too much fuel on board. If the aircraft is not efficient enough it has to carry additional fuel. This additional fuel requires the aircraft structure to be able to carry this. This will make the structure larger and thus heavier. A more heavy aircraft requires more lift. The price to be paid for generating more lift is more drag. More drag requires more powerful engines. These more powerful engines are more heavy and consume more fuel. Thus again additional fuel has to be carried, etc.

In aircraft design two major areas can be distinguished in which this compounding effect can be counteracted. The first area is the weight of the aircraft. Minimizing the aircraft weight will reduce the lift required to lift the aircraft. Less lift results in less fuel required. The second area is the aerodynamic drag. By minimizing the aerodynamic drag the propulsive force can be minimized. This then results in less powerful and thus less heavy engines which consume less fuel.