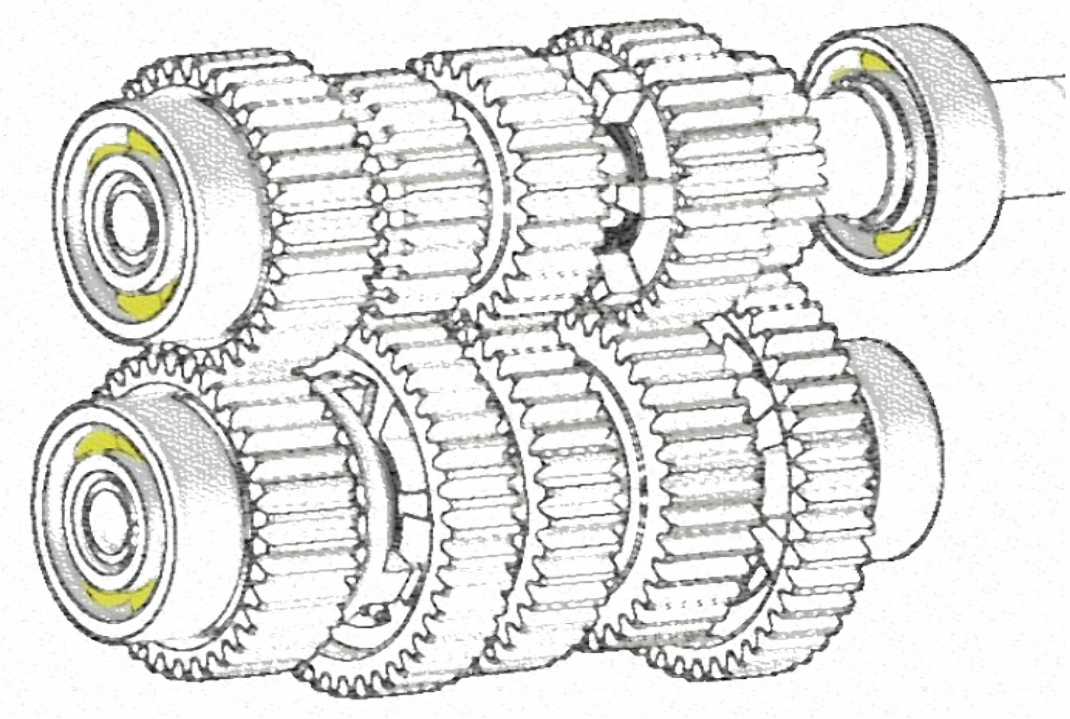
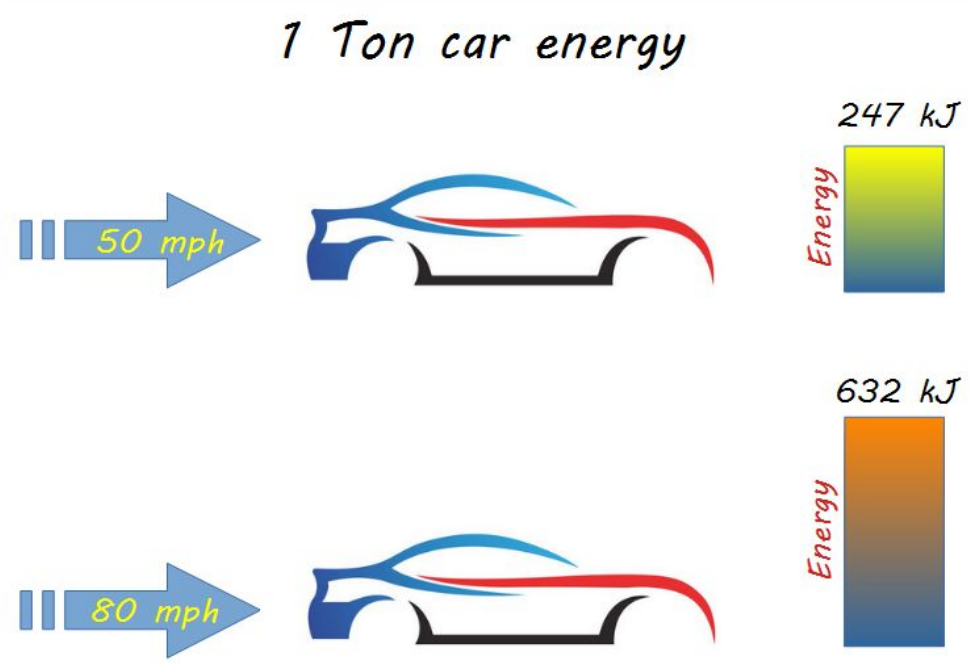


How to increase power using the gearbox?

Abstract :
Everybody knows that a close-ratio gearbox makes the car faster. If the car is faster, it means that more power is transmitted to the wheels. But a gearbox does not produce power. So what is going on ?! More power without producing power ?! That sounds silly but it is actually the case. Let's have a look at how it works...

What is the power?

« How powerful is this engine? » That might be the most common question you can hear when talking to motorsport amateurs. Let's first try to understand what is the power.
The power is simply the speed rate at which you can provide energy to something. Considering a car, energy is basically the speed. In the international system, the energy unit is the **Joule** (J). Here are some figures :



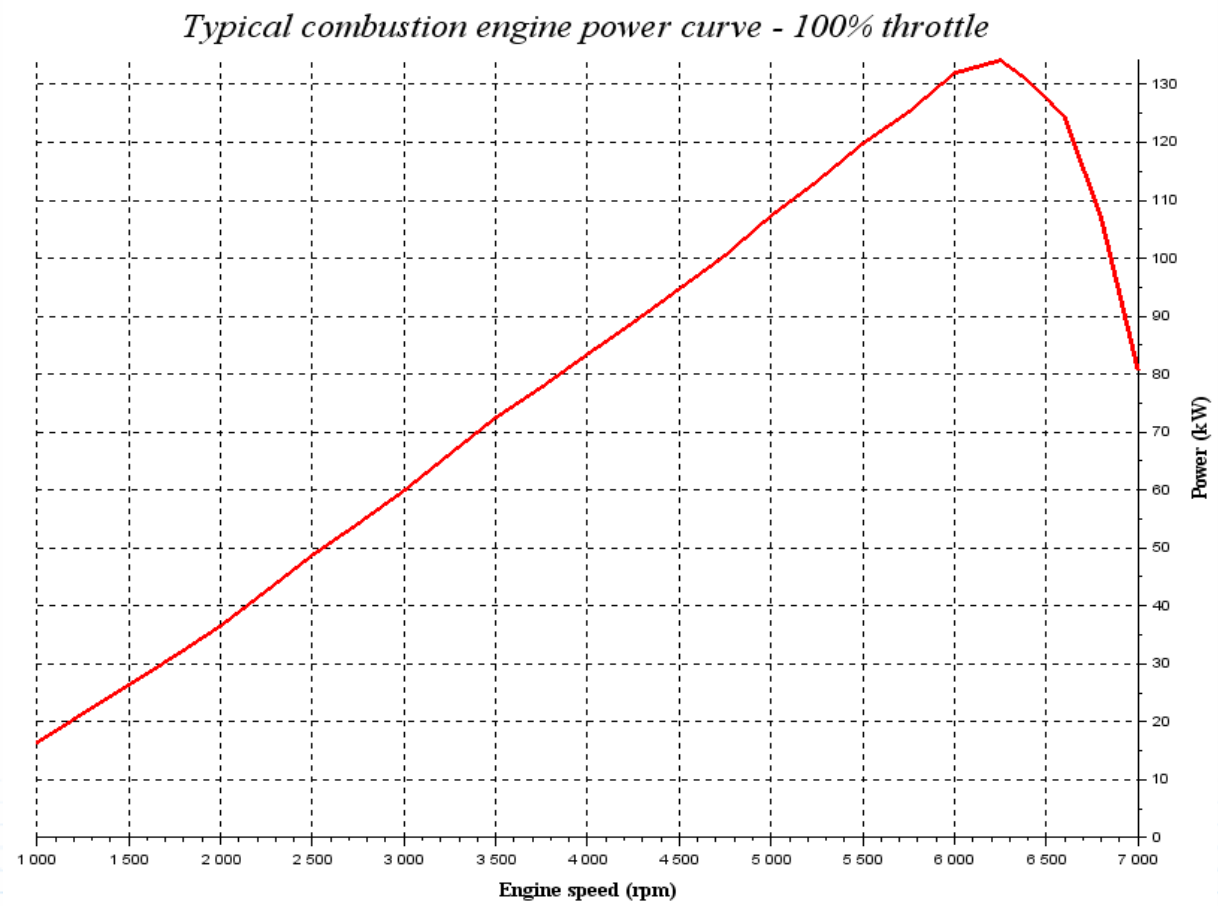
Because the energy owned by a car is big, the unit used is the kilo Joule (kJ) which is equal to 1000 Joule. As a comparison, a large calibre gun bullet has got an energy of roughly 700J.

Given that power is the speed rate at which you can provide energy to the car, more power means less time to get to 80mph for our car**. Hence more power means more acceleration.**

NB : Because of the friction, not only the acceleration but also the maximum speed is related to power. Let's simplify and consider only that power means acceleration.

The engine: mechanical power source

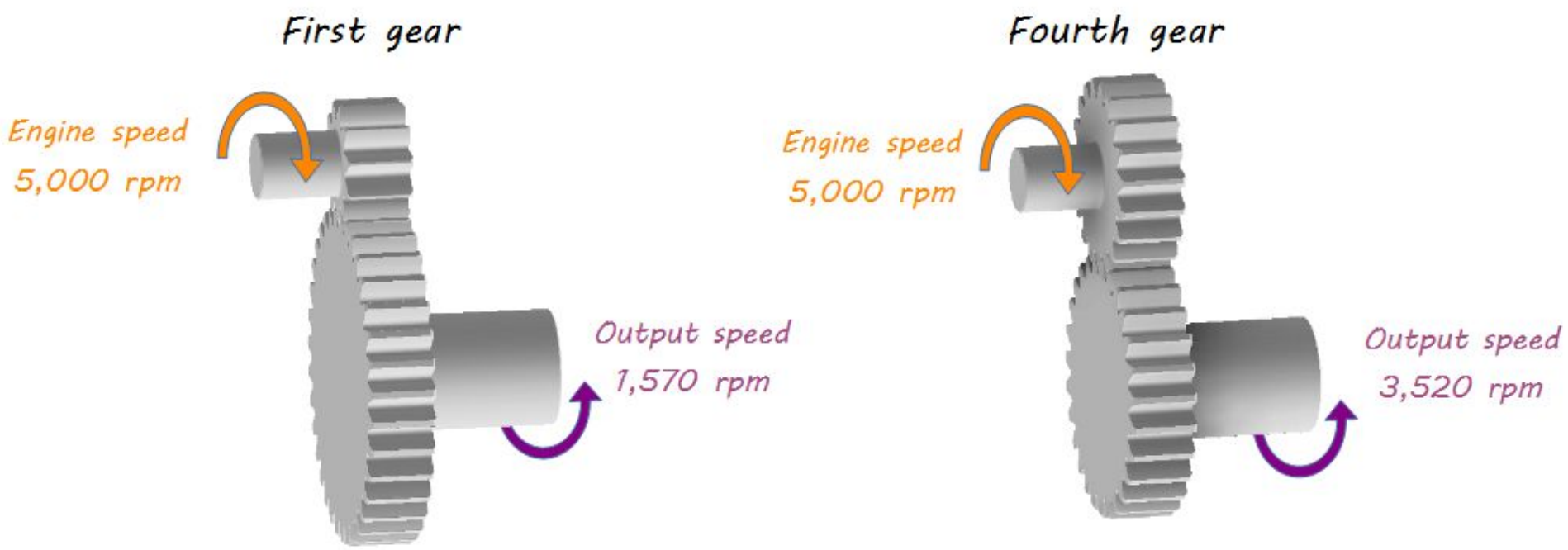
The engine is the device which provides power to the car. Nowadays, both electrical motors or combustion engines are used in cars but let's consider only the combustion engine. The most important feature of the combustion engine is that **the power delivered depends on the engine speed**. To convince ourselves, here is an actual power curve measured on the test bench :



This engine can deliver 134kW (180 bhp) at 6,250 rpm at full throttle. However, **this engine will deliver only 36kW (48 bhp) at 2,000rpm** even at full throttle ! This can be easily felt in your car. To do so, just put the fourth gear at 30mph and full throttle. You can hardly feel any acceleration. On the contrary if you put the first gear, you will feel a strong acceleration. This is only due to the engine speed difference.

The gearbox: power transmission

The previous example showed that the **engine speed must be adapted to the speed of the car in order to get power**. The device which adapts the engine speed is the gearbox.
The mission of the gearbox is to transmit the power from the engine to the wheels while changing the rotating speed. This is done by gears:



The output speed is directly related to the car speed. The ratio between the engine speed and the output speed is called the « gear ratio ». Each gearbox speed has its own gear ratio.

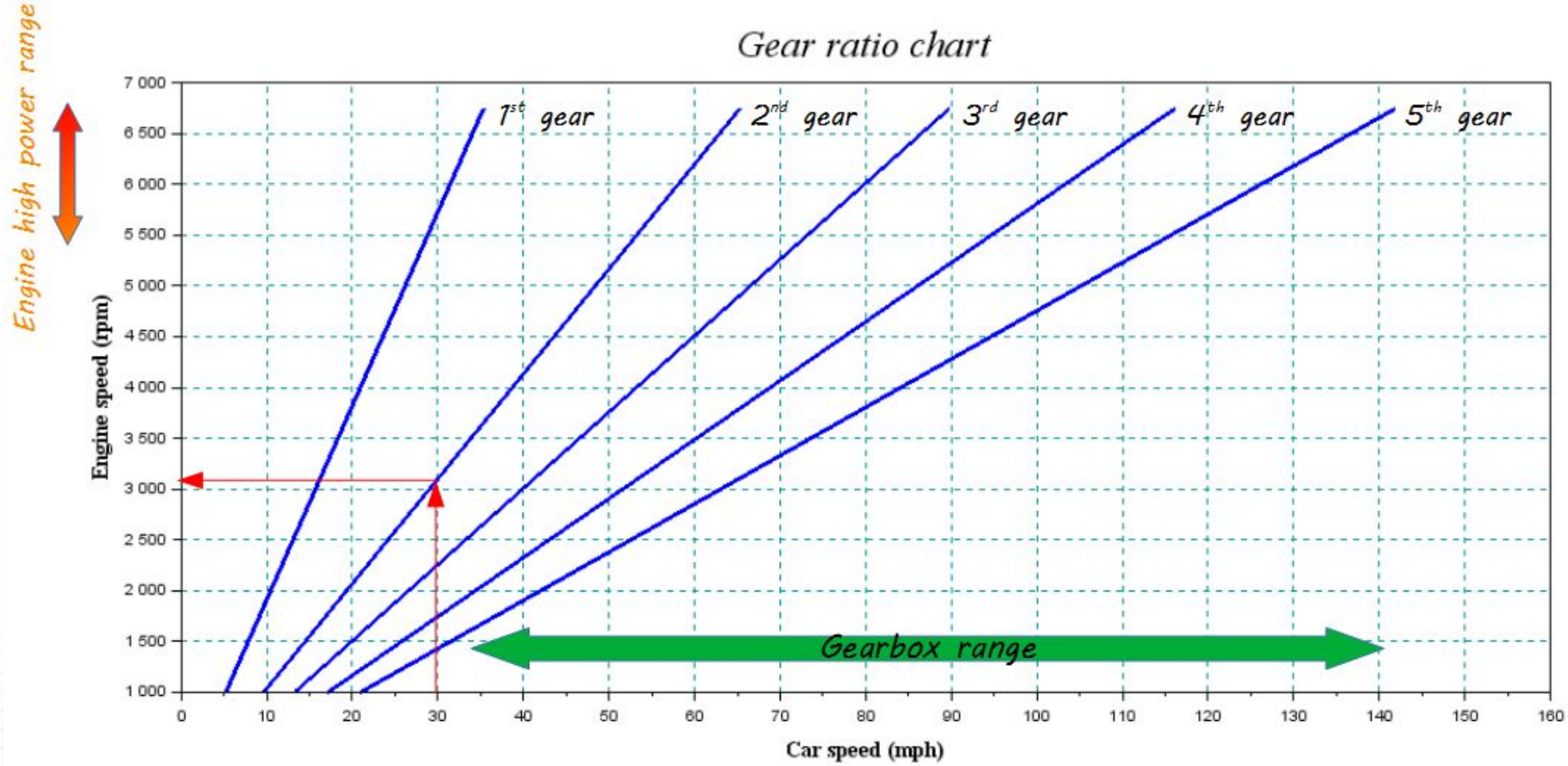
These are the importants features of the gearbox :

- **Gearbox does not produce power**
- **Gearbox transmits the power from the engine to the wheels while adapting the speed**

Gear ratio optimisation

If we want to increase the power transmitted from the engine to the car, we need to make sure that **the engine speed is as close as possible to the max power engine speed in every gear**. This means that the gear ratios have to be optimized depending on the engine power curve and car usage.

The universal design tool for gear ratio optimisation is the following chart:



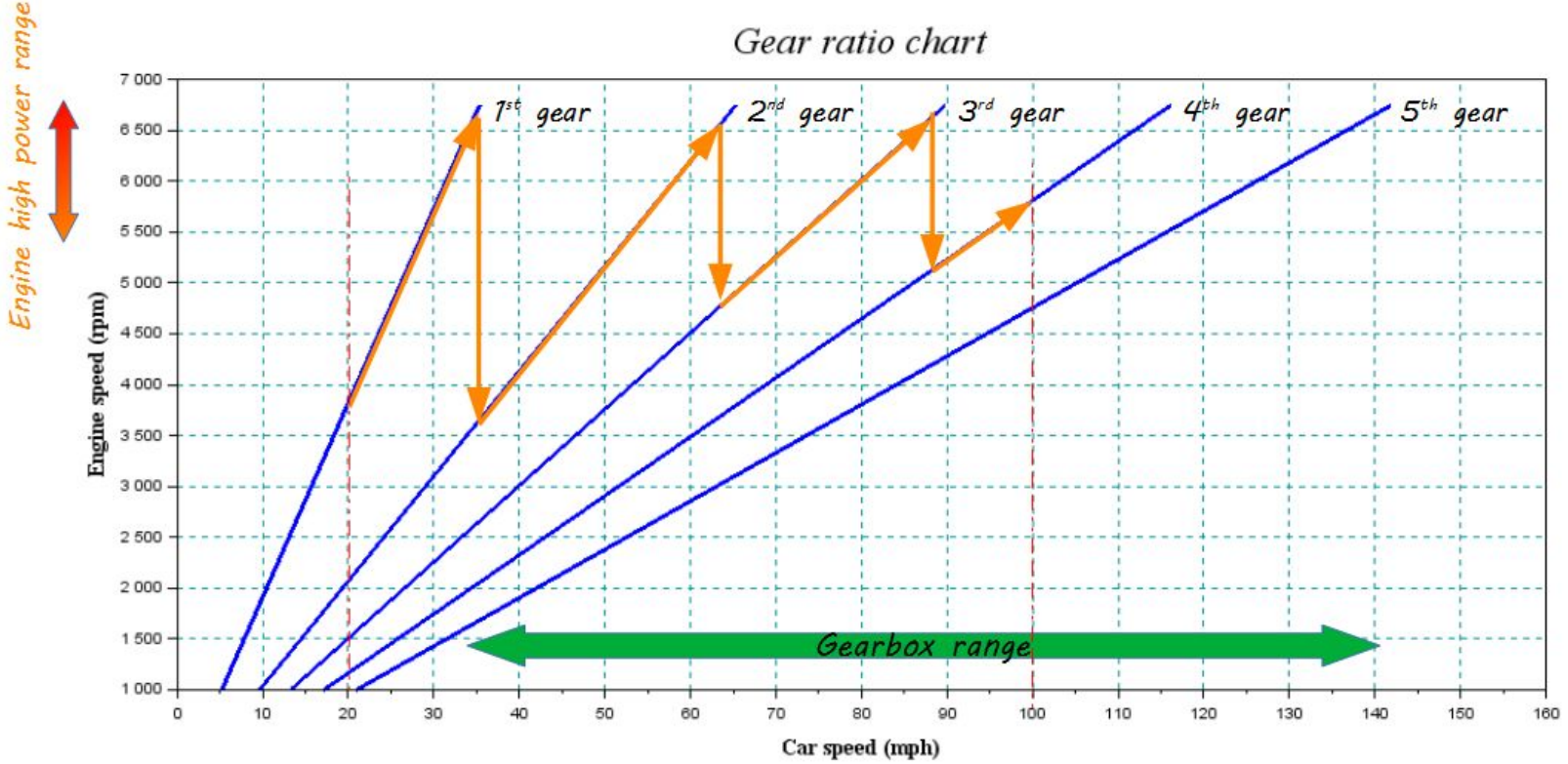
This chart shows **engine speed versus car speed** for every gear. Let's say you want to know the engine speed at 30mph in 2nd gear. Just follow the red arrows which lead to 3,150rpm.

Gearbox designers are used to this graph and can tell a lot about the car behaviour just by looking at it. The above chart shows a standard-ratio gearbox which cannot optimise the power delivered by our engine. We will demonstrate why below. First, let's explain some very important features:

- **Gearbox range:** The gearbox range is the difference between max theoretical speed in 5th gear and max theoretical speed in 1st gear. The wider the gearbox range, the better the adaptability of the gearbox. Indeed, wide range allows for short 1st gear which is good for car start in steep road and wide range allows also for long 5th gear which is good for fuel consumption, low engine noise and max speed.

- **Engine high power range:** This is the speed range where the engine needs to operate if the maximum power is needed.

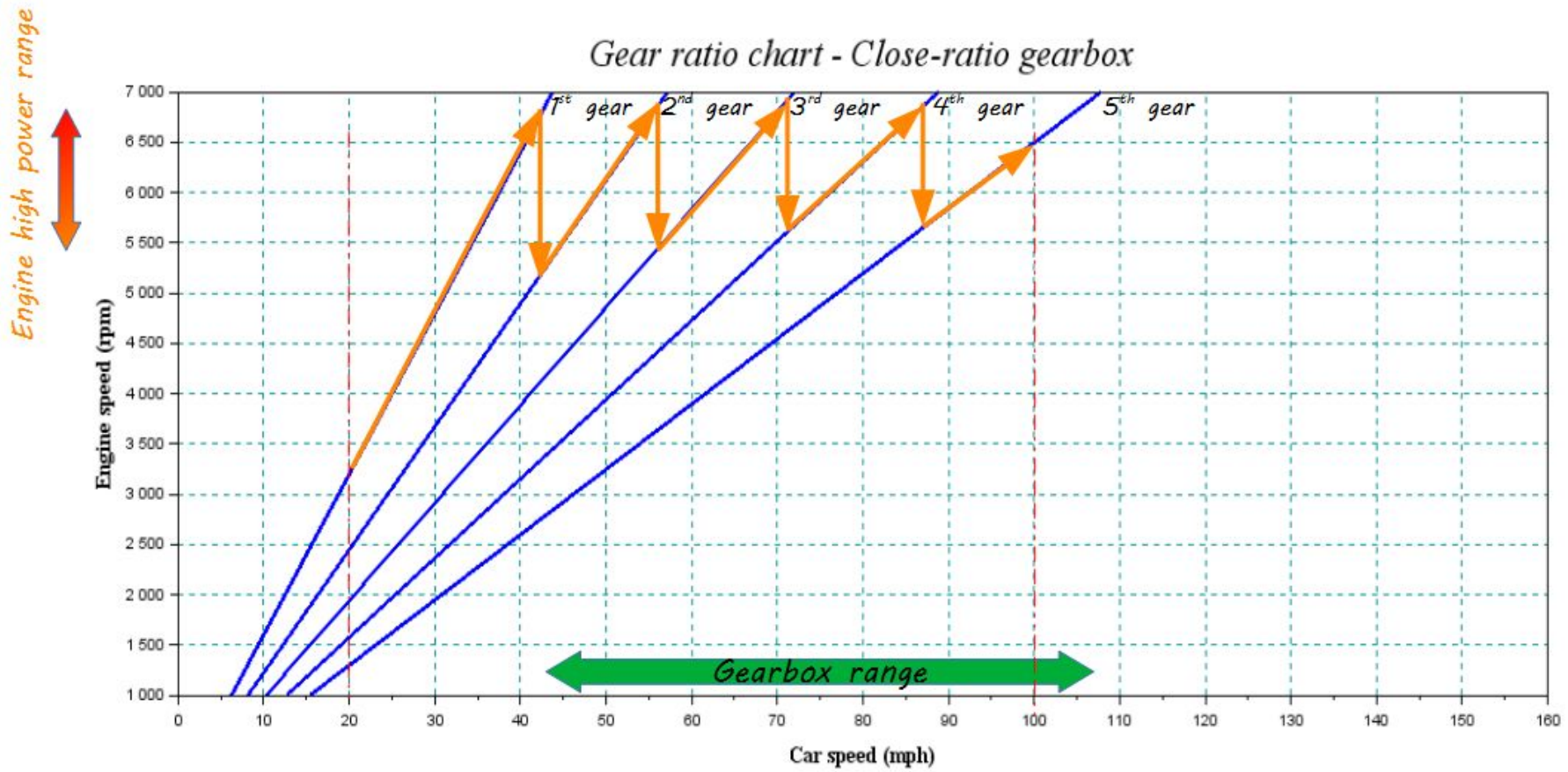
For a given number a gears, there is a strong relationship between gearbox range and car performances. Let's show it by considering our car cruising at 20mph in 1st gear. Suddenly, the driver goes flat out until 100mph, the engine speed will follow the orange path below:



At every gear change, the engine speed slows below the high power range. For instance, when changing from 1st to 2nd gear, the engine slows down from 6,800 rpm to 3,600rpm. But at 3,600rpm, the engine power is only 74kW (99bhp) instead of 120kW (161bhp) at 6,800rpm. **To conclude, the car has lost 62bhp by changing from 1st to 2nd gear.**

Close-ratio gearbox

A close-ratio gearbox is basically a gearbox where gear ratios are optimised to keep the engine speed in the high power range at every gear change. This is a close-ratio gearbox optimised for our engine power curve. We have plotted the orange path from 20mph to 100mph:

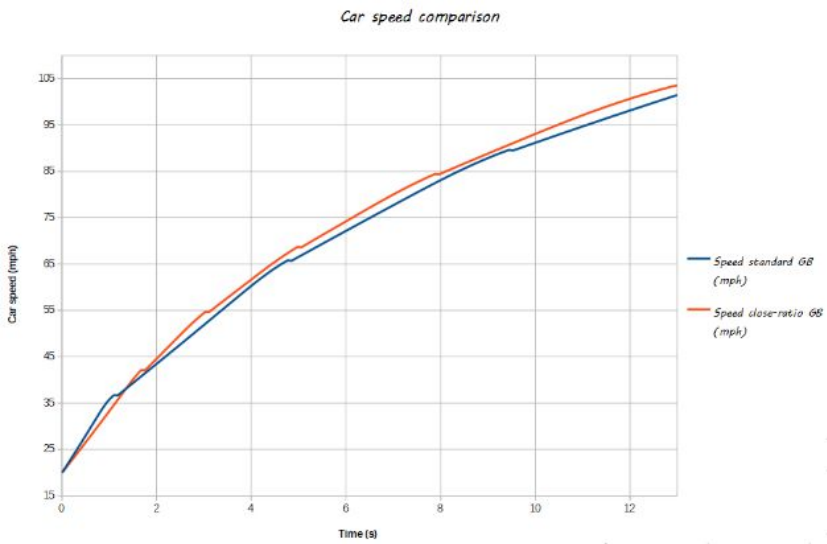


We can see that the engine speed is always in the high power range. This gearbox will give much more performances to the car. However, there is a major drawback of using a close-ratio gearbox: **the gearbox range is much lower**. It means that a compromise must be found between having a long 1st gear or a low max speed.

The most common way of increasing the gearbox range is to add more gear ratios (6th, 7th, ...).

Performances comparison

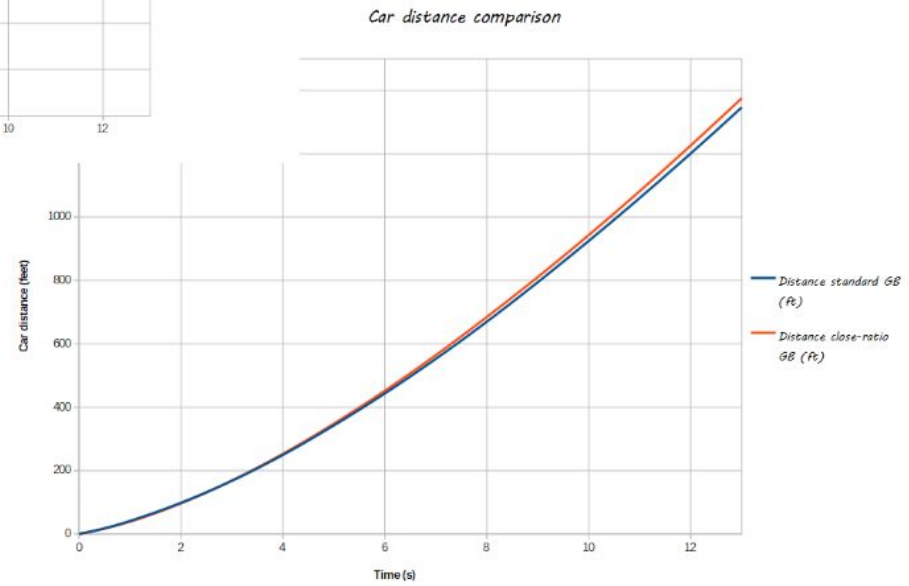
In order to understand the concepts shown above, we have simulated the acceleration of the car from 20mph to 100mph with both gearboxes. Here are the results:



20mph to 100mph results

Standard GB : 12,6s

Close-ratio GB : 11,8s



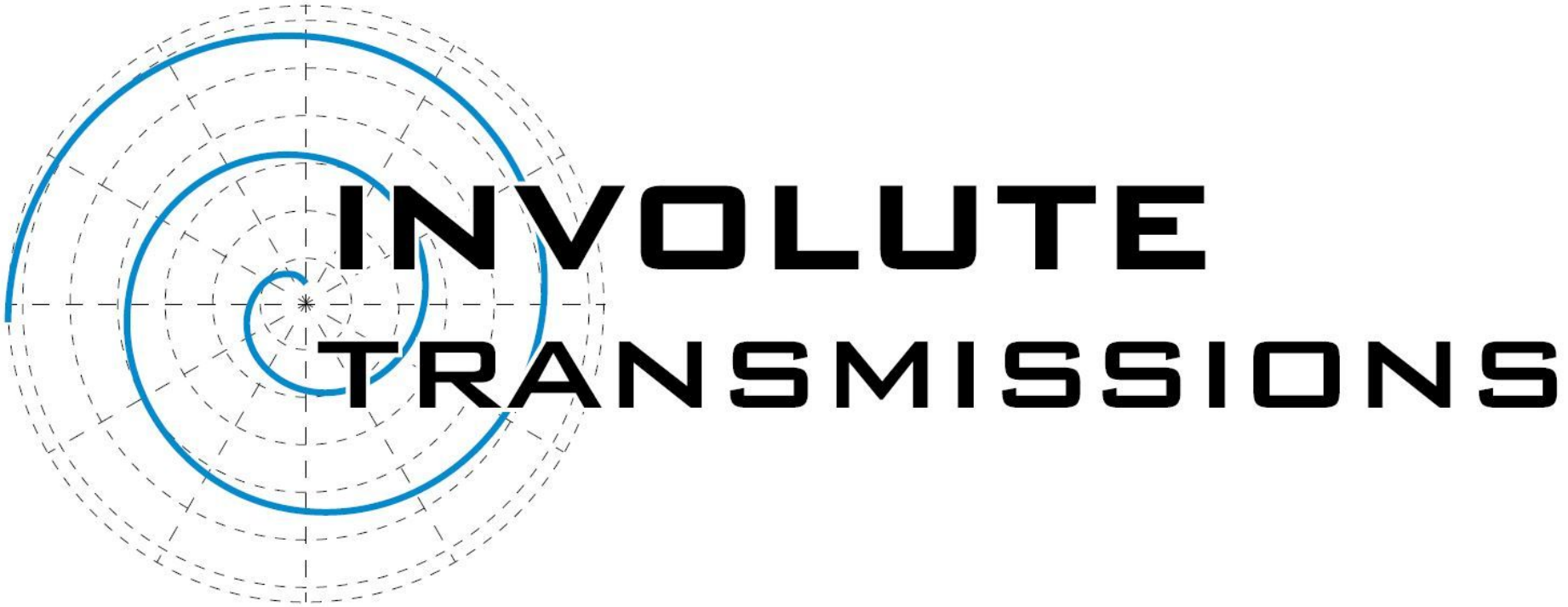
Distance after 12s

Standard GB : 1200ft

Close-ratio GB : 1227ft

The close-ratio gearbox leads to better acceleration which means more power transmitted to the car. In fact, the average power transmitted during this acceleration is 114kW (153 bhp) with the standard gearbox and 121,5kW(163bhp) with the close-ratio gearbox. **Therefore, the close-ratio gearbox has increased the average power transmitted to the car by 10bhp. Q.E.D**

Written by Lionel Bauduin on behalf of:



Visit our website at https://involutetransmissions.com/