# Scaling Tutorial for Vehicles (II)

*Last part of this tutorial that covers the rules for choosing a scale and calculate the dimensions for LEGO® models on wheeled or tracked vehicles, plus some general tips on models.*

*Text & pictures by Paul Ian Kmiec*

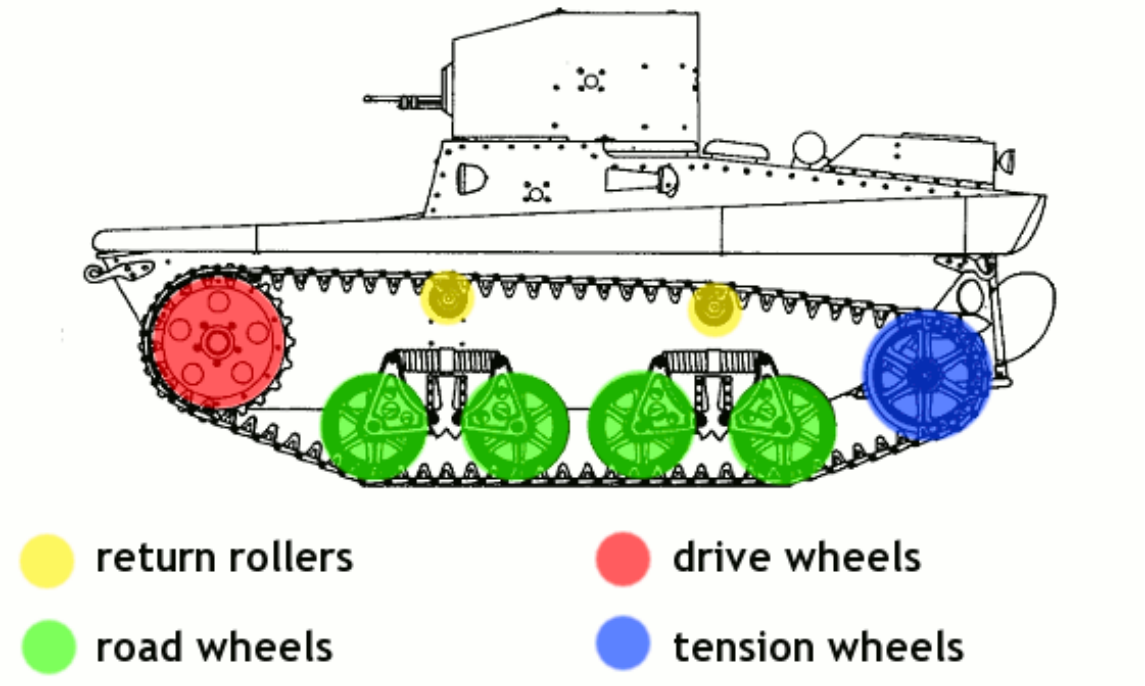
### 4 Tracked vehicles

Tracked vehicles are an exceptional case when there is no determined scale and you are seeking to set one. This is because of three reasons:

- the size of the road / tension wheels doesn't impact the general proportions of the model as much as it does with wheeled vehicles
- the width of both old & new tracks is fixed (although it can be modified to a certain degree; more on this in the section 5)
- the minimal width of a tracked model is usually larger than in case of the wheeled vehicles

First, let's clarify the wheels' issue. It's kind of ironic, but a typical tracked vehicle can have up to 4 types of wheels:

- road wheels (wheels that the vehicle basically stands on; they are separated from the ground only by the tracks, usually have suspension and are not driven)
- tension wheels (the first and last wheels that extend the tracks to their maximum length; they are usually located above the ground and have no suspension, but in some set-ups they act as the first & last road wheels too)
- drive wheels (all the wheels that the drive is directly transferred to; usually the last or the first pair of the tension wheels act as drive wheels, but sometimes a single wheel can act as a tension, drive & road wheel at the same time)
- return rollers (the usually small wheels that support the upper section of the track and keep it from hanging down; they are never driven, they are almost never suspended, and many tracked vehicles don't use them at all)



Let's consider a LEGO® model of a tank to see the importance of these factors. We obviously want our tank to be able to turn as well as to drive straight, so we have to use more than a single motor to drive it (we can use a subtractor too, but it does almost no difference in terms of width. Since tanks tend to have relatively wide hulls, and we want the drivetrain to use as little space as possible, the best solution is to locate the motors transversely, back-to-back, so that their output axles can go straight into the drive wheels (but there can be some gears in between too). In case of the PF motors which are 6 studs long (both Medium and XL ones) it means that the space inside the hull has to be at least 12 studs wide, plus 2 more studs for the sides of the hull, plus the width of two, sometimes more tracks (2×3 studs for older tracks and 2×5 studs for the newer ones), and eventually plus the width of the side skirts, if present. If we want to build a large model of a modern tank, we will need to use the newer tracks (the older ones look bad with large models) and most likely include the side skirts. Which means: 12 studs (internal hull space) + 2 studs (two sides of the hull) + 10 studs (2 sets of newer tracks) + 1 or 2 studs (depending on how thick we want the side skirts to be) = 25 or 26 studs. Therefore we can safely assume that a large model with newer tracks has to be at least 24 studs wide, not including the side skirts. This is exactly the assumption that determined the scale of my recent tank models, e.g. the Abrams M1A2 and the Leclerc T6. At this scale the newer tracks are usually just as wide as needed, at least for modern tanks, while the diameter of the road wheels should be usually between 3 or 4 studs according to the scale, and even making it 3 studs instead of 4 in my Abrams model still resulted in a successful construction. Which means that out of the three factors mentioned at the beginning of this section, the most important one is usually the minimum width that complies with technical requirements, and the least important one is usually the size of the road wheels.

Side view of my Abrams M1A2 model, with road wheels 25% smaller than they should be.

Things get a bit different with some other types of the tracked vehicles. The category of construction equipment is particularly filled with diverse tracked vehicles. For instance the tracked bulldozers often have narrow hull – sometimes constituting to less than half of the vehicle's total width. To build a motorized model of such a machine with the older tracks would be nearly impossible, and to build it with the newer tracks would require placing the drive motors side-to-side. In case of PF Medium motors (in most cases well fit to drive a model of this size) it means 6 studs of minimum internal hull width. I went even further with my Caterpillar D9T model – it had small openings in the sides of the hull, so that the motors would fit into a 6-studs wide hull with just 4 studs of internal width. It was somewhat extreme approach, but again proved successful – and in this model the width of the tracks and the road wheels' diameter have been crucial to determining the scale.

There are many other types of tracked vehicles that we will not consider here – for instance the crawler cranes, the tracked excavators, tractors and loaders – and each of these types has its own specific proportions. While the three aforementioned factors remain essential to determining the model's scale, their individual importance should be considered separately for each type of the vehicle.

Caterpillar D9T model with just 6-studs wide hull. Some viewers are still surprised that it housed 5 motors, a regular battery box and two IR receivers. It had more functions than the legendary LEGO 8275 bulldozer, while being roughly 50% smaller.

## 5 Tips & tricks

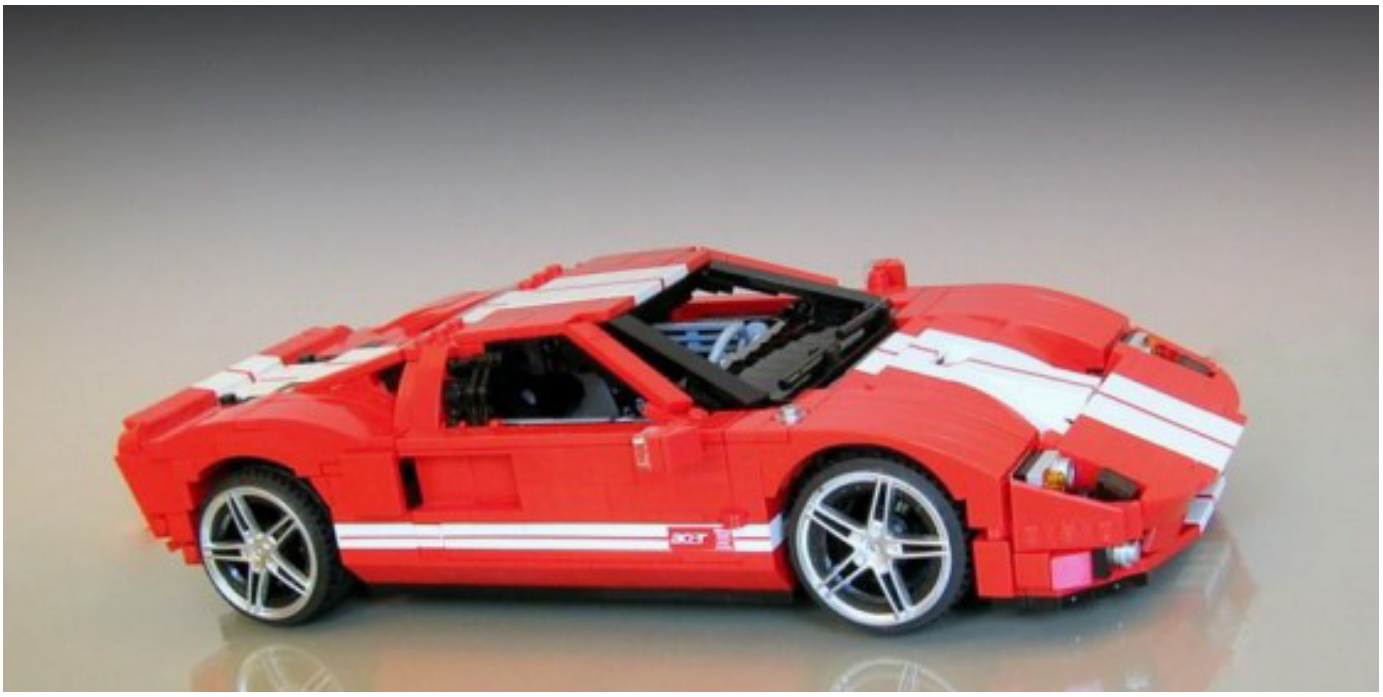
**• Including the specificity of the LEGO bricks into the scaling process.**

LEGO bricks are very universal and provide great possibilities to explore, but they have their limitations too. For instance some details have to be discarded as to small, because it's difficult to model something smaller than a single stud. Some model-builders cross this border quite successfully, but it usually requires truly masterful skills. LEGO bricks are also generally inaccurate when it comes to modeling some round and oval and irregular shapes. Many builders tend to approximate the challenging shapes with available LEGO bricks rather than try to model them with a perfect accuracy. A number of issues with possible solutions

is listed below.

The steered wheels in LEGO® models rarely have realistic steering geometry. In the real world the steered wheels usually rotate around a vertical axis that goes through their center. In the LEGO world this is possible almost exclusively with the wheels & suspension components from the 8448 set, so most of the wheels usually rotate around the axle located at their side. It means that they need more space to rotate than the real wheels, and thus their mudguards have to be more spacious than their real counterparts. Note the front mudguards of my Tow Truck built around steered & suspended wheels: even though their shape was carefully modeled with multiple small pieces, they are still much larger and more massive than the mudguards of the real trucks.

This beautiful, small model of the Ford GT by a renown model-builder Firas uses custom stickers to separate the white stripes in half, because there are no LEGO parts thin enough. Note the extremely tight mudguards, only present in models that have no steering system nor suspension.



The round shapes of the body of one of my hotrods have been only conventionally marked with flexible axles. Even though this technique has been sanctioned by some of the official LEGO® sets, it remains controversial among the model-builders' community.


**Many of the existing LEGO wheels have different diameter-to-width ratio than the real wheels; namely, they tend to be wider. It is particularly troublesome for small models and results in some uneasy concessions. This is why these models of trucks built for the Hard Truck Contest held in Russia have two wheels on rear axles while the real trucks have four.**

**• Modifying the width of the tracks.**

The standard LEGO® tracks, both older & newer ones, are compliant with many other LEGO parts. Both types can have additional parts added outside to appear wider and larger. The older, 3-studs wide tracks work best with thin plates, while the newer, 5-studs wide tracks work best with Technic bricks.

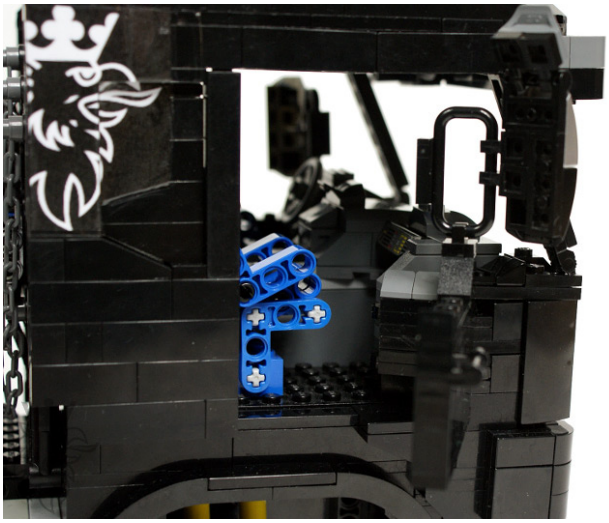
This acclaimed tractor built by Noddy uses 1x4s plates to make the older tracks slightly wider and more massive. Note that the size of the tracks' treads allows to add plates on every second tread only.

Close view of my Snowgroomer shows the newer tracks with 1x8s Technic bricks attached to every tread. It results in a very strong and robust set-up.

**• Adapting shape of PF elements to save space.**

Some PF elements come in shapes that can be often adapted as parts of the model. For instance the round shape of the PF motors makes them adaptable as side fuel tanks is some vehicles (especially trucks), while the new rechargeable battery can be easily integrated into some brick-built elements where its shape doesn't stand out. Moreover, almost all the PF elements share a common, simple color theme which can be used to make them match the rest of the model.

My Scania dump truck model was driven by two PF XL motors. Having a very limited amount of space to use, I decided to locate these motor in such a manner that they resembled side fuel tanks.

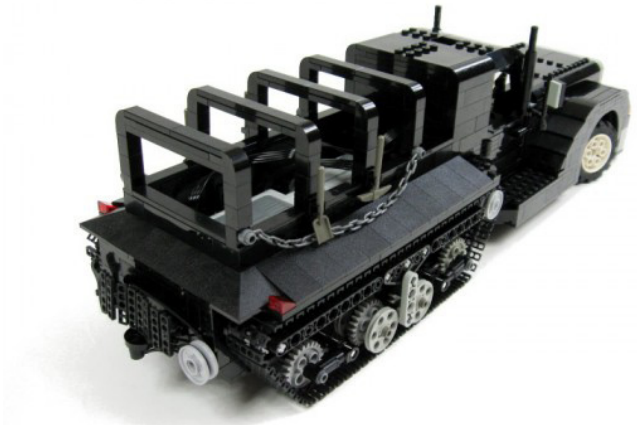


The same Scania model had a PF rechargeable battery located between the seats inside the cabin and fully integrated into the cabin interior, with a matching color theme used.

My PF Forklift was intended to have a naked, raw Technic look, but the use of a matching color theme and putting the PF elements in carefully considered places made them look like integral parts of the model.

**• Using optical tricks.**

This is actually much simpler than it sounds. There are few simple rules: for instance dark colors make models appear more massive. Dark colors also come in handy in those parts of the model where some gaps are difficult to avoid: using black parts in such a place makes the gaps almost invisible. Sometimes you have to choose whether to make a certain part of the model larger or smaller than the scale implies; when doing so, try to estimate what impression will a viewer get from both versions, and pick the more desired one. Example: I have built two models of similar tanks at a similar scale, and with both tanks the diameter of the main gun's barrel implied by the scale was 1.5 stud. It's difficult to make a long, smooth-looking object 1.5 stud thick, so I made the barrel slightly thinner in one tank, and slightly thicker in another. Many people complained about the thinner barrel, but no one complained about the thicker one – this is because it made a threatening impression on the viewers, and this is the kind of impression that is generally expected from tanks.

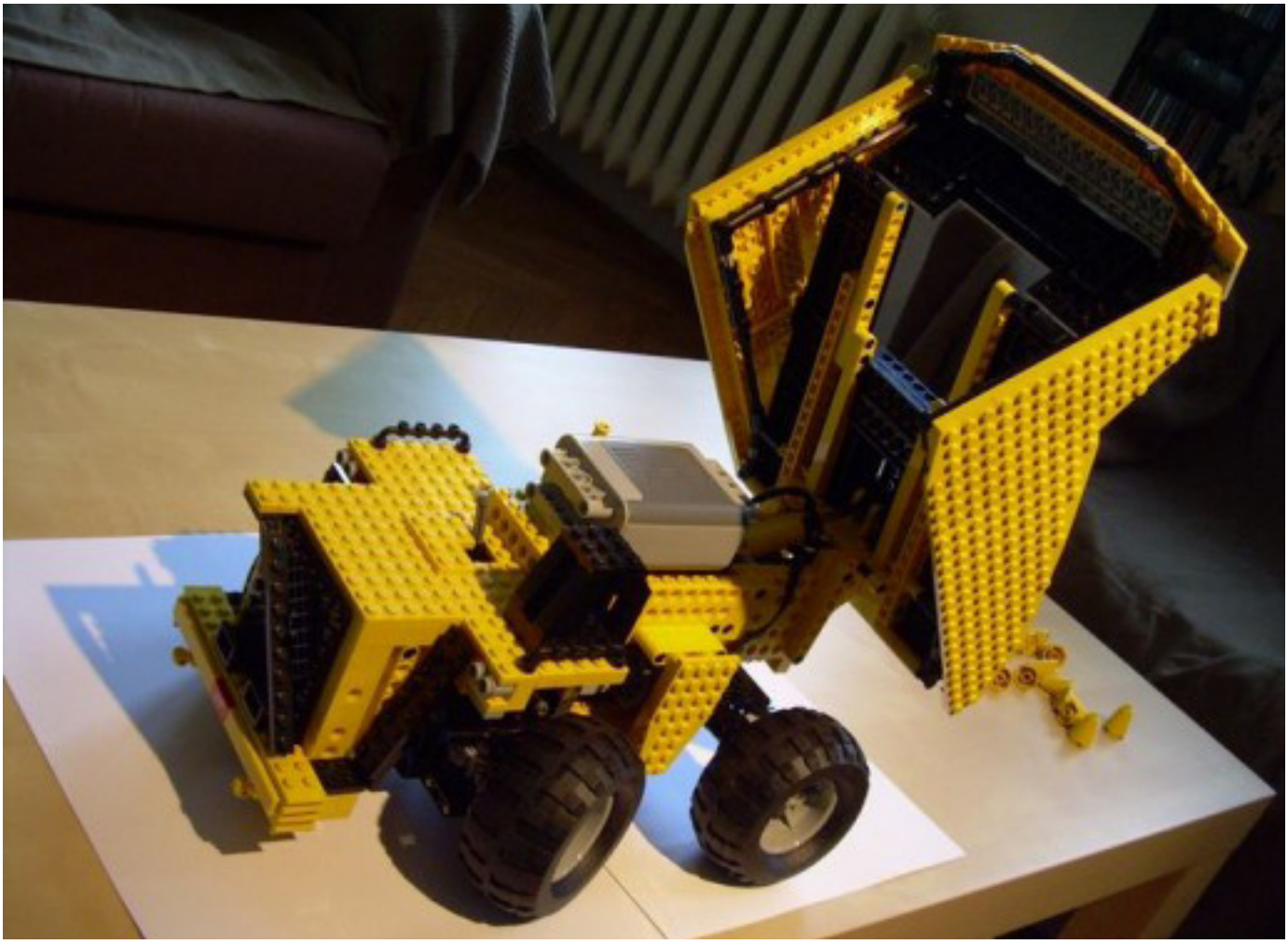


Sometimes a simple trick can make a big difference. My Crusader, a simple half-track truck, was so small that its motors and its battery box could be only located inside its cargo case. When I tried to cover these elements up with some plates, it didn't look like a cargo case at all – in fact, it looked pretty weird. Eventually I left them uncovered on a purpose, so that they would look like an actual cargo being transported by the model, and it had a much better effect.

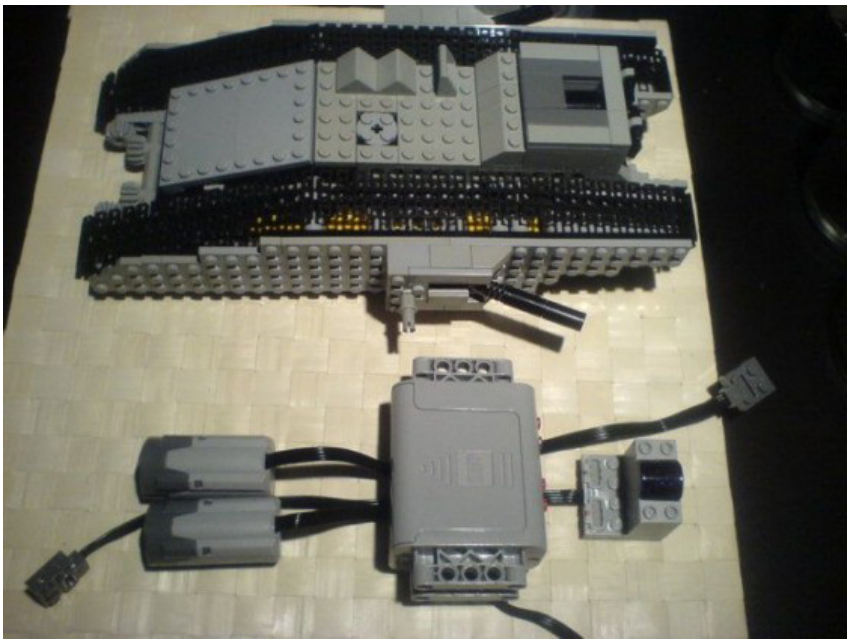
**• Knowing what to sacrifice**

This is probably the most crucial skill when it comes to really challenging or feature-packed models. In most cases there are two aspects of a model that have to be balanced: its aesthetics and functionality. Some models are built only for one of these two aspect and ignore the other, but the real art of model-building is to blend these two aspects together seamlessly. Some models, however, require the builder to sacrifice some of one aspect for the sake of another because of e.g. the scale chosen or some technical limitations. The final choice of what is the most important in a given model is up to you, and here are some examples.

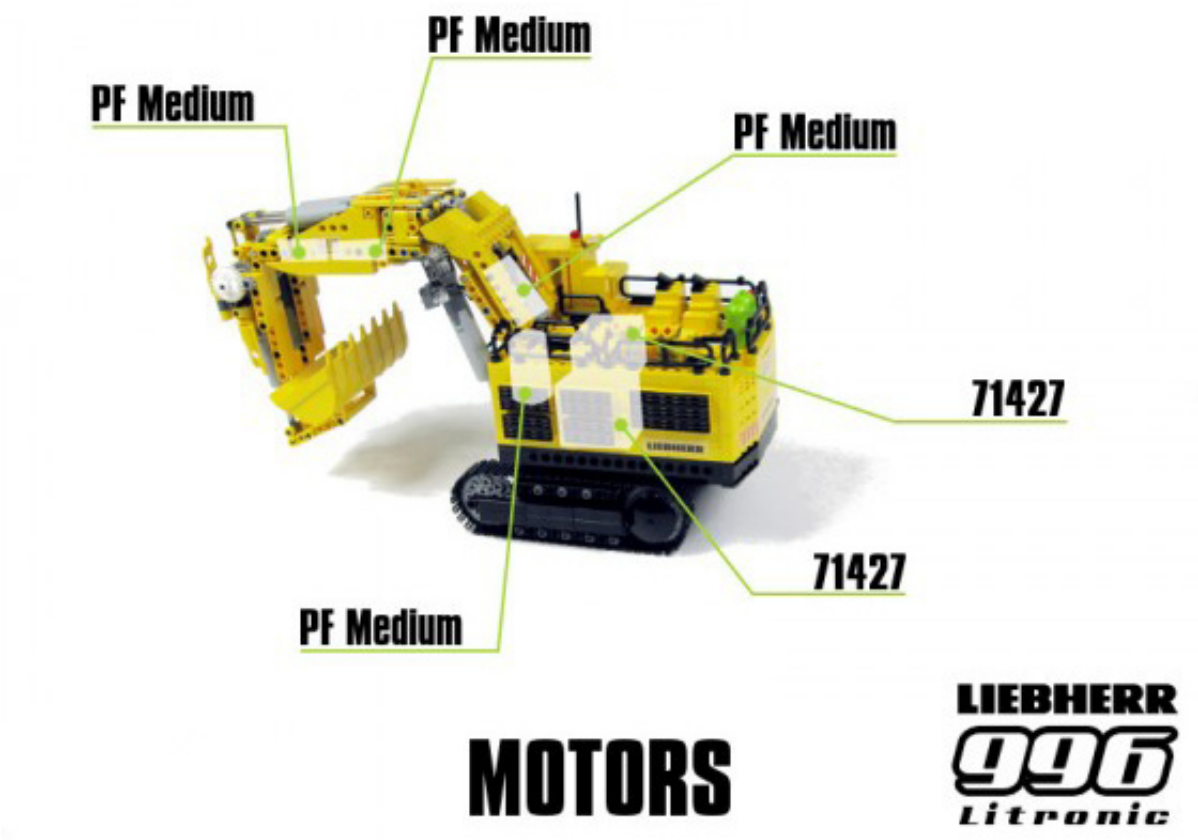
My first own model, the LiebherrT282B, didn't look pretty but had a long list of features including a full suspension, 4×4 drive, rear differential lock and even a manual gearbox. To include all of it into a relatively small construction, I decided to make a somewhat funny compromise: the battery box was located inside the cargo case. The case looked fine from the outside and still could be pneumatically elevated, but it was useless because its inside was shallow and had a central opening to fit the battery box in.



The first model I've ever built, the Mark I tank, was based on a static model created by pepik. It was extremely small and literally built around a battery box. There was no place for any substantial gear reduction, so the model worked fine except it ran at incredible speed. It looked well and maintained the proper proportions, but its functionality was more suited for a F1 car than for a tank.



My model of the Liebherr R996 Litronic excavator was small, had no motors in the chassis and half of the hull's inside taken by a battery box. Still, I managed to fit 6 motors in it by placing 3 of them inside its arm. It degraded the look of the arm, but at this scale I could have a bad-looking arm or a completely static arm. Moreover, since the model used linear actuators instead of pneumatics, it has severely simplified the transmission system in the arm.




I hope this tutorial was helpful to you. As mentioned at the beginning, there are dozens of model-builders much better than I am, so while the rules explained in this tutorial remain more or less universal, feel encouraged to seek inspiration in the work of other builders. If you have suggestions, corrections etc., please include them in comments.
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