# The Sukhoi SU-37

*Departed greatness Russian style*

*By Jeroen Ottens*

## The tragic history

Aviation has always stirred the imagination of the people. The freedom of flight. The elevation above the ordinary. It had a ring of romance to it as well. Not only the Casablanca-like romance, but also the engineering romance of pushing the boundaries further than ever thought possible. The development of airplanes is one of the most advanced developments in the human history. Almost all our technological fields have been stretched immensely by the airplane: electronics, mechanics, (aero-)dynamics, material science, etc.
As is typical for our species most developments were driven through our perpetual wish to fight. During the cold war era fighters on both sides of the iron curtain were constantly evolving to counter the perceived threats posed by the other side. And then the Berlin wall fell.
In the years following the fall the Russians opened up and started to show off what was previously shrouded in layers of mist and secrecy. They attended airshows with their latest fighters and stunned the world with their impossible aerobatic manoeuvrings.
Where the Americans had chosen to go stealth, the Russians had chosen to go super-maneuverable. Planes that could fly with their nose pointing backwards or that could make a looping around their own axis. Planes with engine nozzles that could swivel to enhance the steering capabilities. Planes with engines that had more power than the weight of the plane itself so that it could fly straight up like a rocket. If ever a war was fought in dog-fights like World War I these planes would win hands-down.
And to top it all they looked stunningly beautiful.

But in the battlefield missiles are king nowadays. Planes fight against each other out of sight. By the time a dog-fight would ensue most planes will have been shot out of sky. And the grand Russian industry is falling apart. Knowledge drains away faster than gas from the leaking pipes in the tundras. Only two SU-37's were ever built. The Russian fighters are departed greatness.

## The building process

To be honest it was the looks that prompted me to build this plane in the first place. It was only during the research phase that I found out about its bittersweet history. I decided to build it studless, which was sort of a first for me (I was never a big fan of the studless technique because of the inherent weakness of the structures you could make, but with the advent of the 5x7 and 5x11 frames this issue is more manageable). I must say that I am almost convinced now. Especially for airplanes where smooth curves mean everything studless building gives a much better finishing (the smooth curved panels help a lot as well :). Furthermore the function density can be higher than with the old studded techniques. In figure 1 a good example of the high function density is given.

In total the whole building process took just over seven weeks. The first week I used to gather information from the internet. At www.the-blueprints.com I got hold of a decent set of drawings which I plotted at the scale I wanted to build the plane in. In

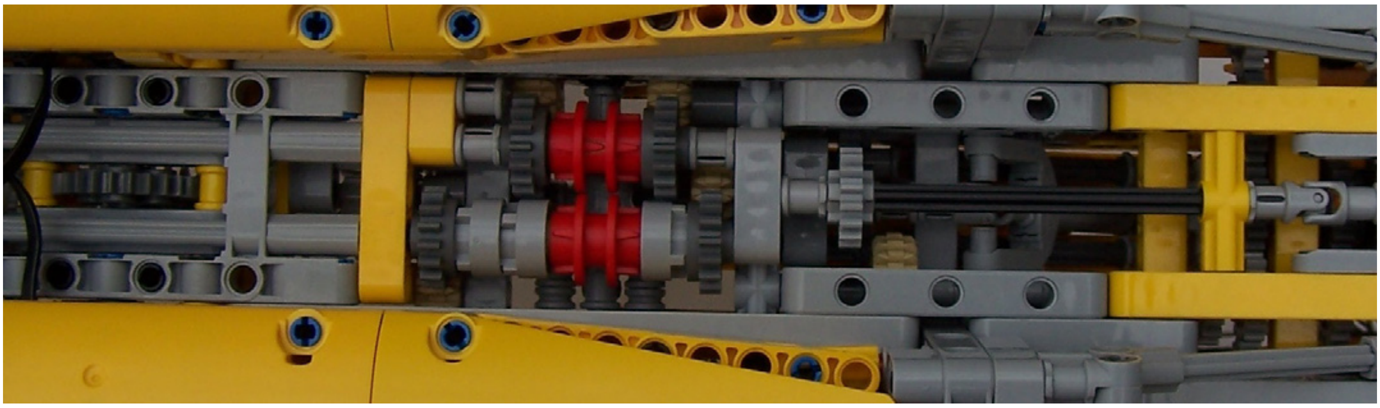


Figure 1: A look from the bottom: the function switch mechanics controlling the landing gears, the landing gear bay doors, airbrake and canopy. From left to right the following functions are visible: main landing gear (24 tooth gear), the switching mechanism, the mini-LA controlling the air brake and the mini-LA for the front landing gear.

figure 2 and 4 you can see this printout lying below the model. In the first stage I just built the outline of the plane. Almost no functions were incorporated, only the basic pivot points of the landing gears, canopy, etc were present. With studless building about one third of the structure is needed for stiffness, one-third is needed for the finishing and the last third is needed to guide the axles and gears. Once I had about half a plane (the other half is mirrored) I put that aside and started anew. This time I started with the functions in mind. Obviously the model should be motorized, so the first question was were to put the motor(s). In my F14A I had filled the engine nacelles with removable jet-engine replicas and at first I wanted to do the same thing with this plane, but despite its size (almost 90 cm long) it has very little internal volume. In fact there are only three areas with some substantial volume: the two engine nacelles and the mid part of the fuselage. This plane really is just a wing with motors attached to it.

So I skipped the removable jet-engines from the list of wanted features and put two PF-M motors in. In figure 3 you can see one of the motors sitting snugly inside the nacelle.

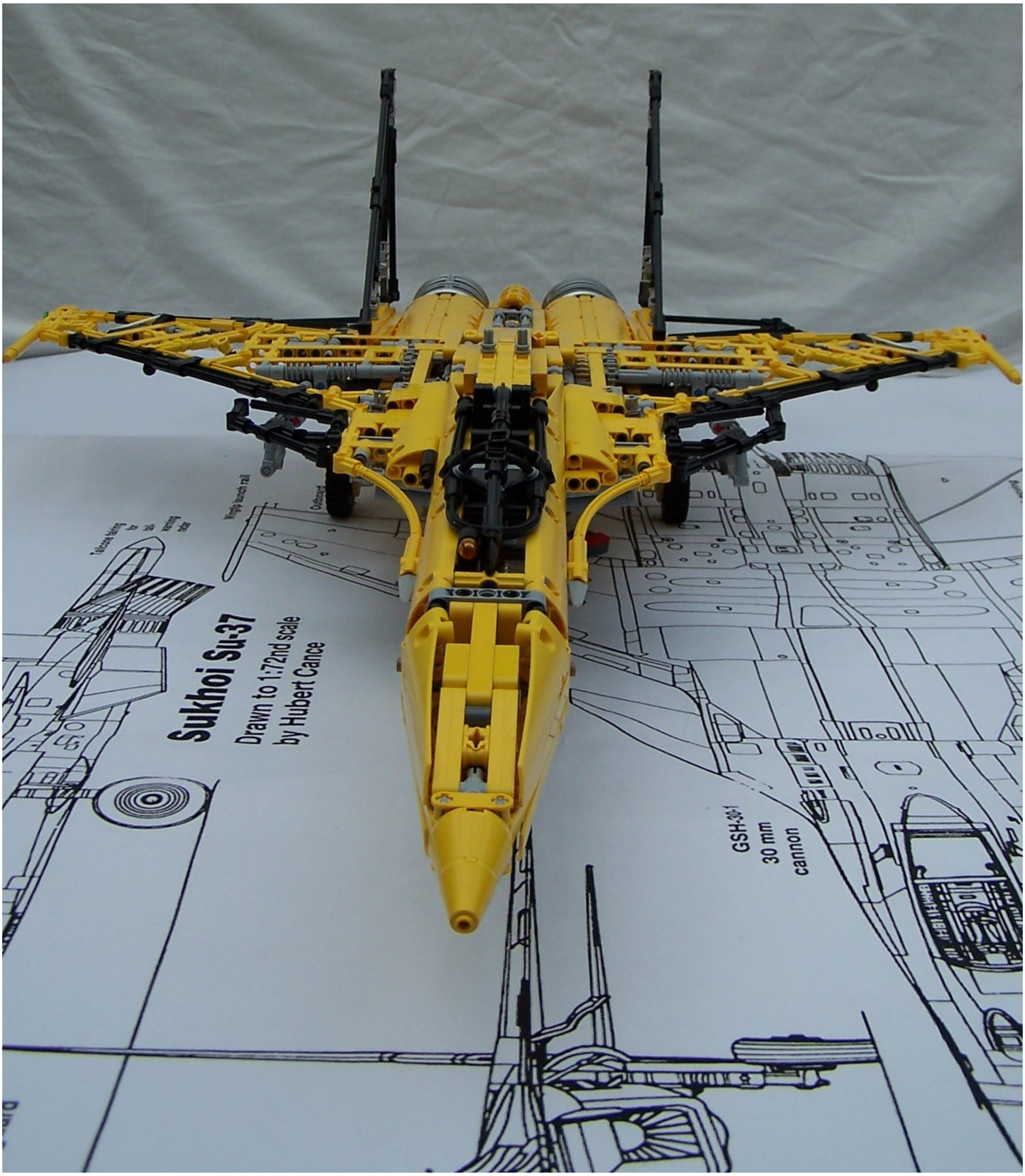
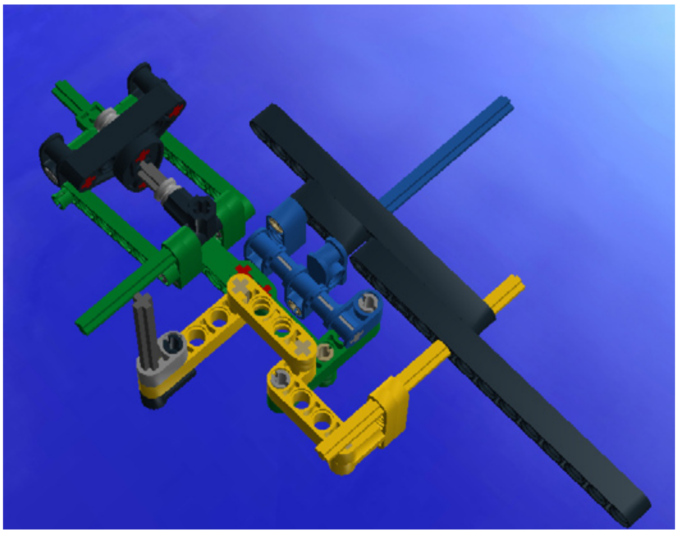



Figure 2: Front view of plane with the 1:1 scale drawing below it. The model rests on its own landing gear.

Figure 3: The inside of the right nacelle. The PF-M motors drives also the inlet fan. Behind it is the mechanical adder used to differentially control the tailplane and engine nozzle.

## The flight control surfaces

The second functional challenge were the flight control surfaces. The tail planes are controlled differentially. That means that they can move up and down together to steer the plane up or down (pitch control), but they can also move up and down against each other to put the plane on its side (roll control). The engine nozzles are steered in the same way. The vertical tail fins move left and right together to steer the plane left and right (yaw control). In practice most fighters fly through a bend with a combination of yaw and roll, so I decided to combine these two controls. I devised a mechanical adder to combine the input of roll and pitch. In the next figure this mechanical adder is shown.



The black parts are part of the rigid structure. Blue is the pitch control, yellow is the roll control. The combined input of both determines the position of the green parts. The green axle is connected to the tail plane. The dark gray axle controls the vertical tail fin surface. On the other side of the plane the same mechanism is mirrored. The blue parts move in the same direction, but the yellow axle has the opposite direction at the other side (in figure 3 two tan 12-tooth bevel gears and one black 12-tooth double bevel gear are visible that do this). This configuration combines the roll and jaw control in such a way that if the plane turns left it also rolls on his left side.
Before the main wings are two little canard wings. In the real plane these are controlled by fly-by-wire systems to keep the plane maneuverable at (extreme) high angles of attack. In this plane I have chosen to couple it to the roll control. In the figure 4 you can see that the canards are in their extreme position, while the tail planes are angled in opposite direction and the vertical fins are angled as well.

## Structural details

As I mentioned earlier I am not too fond of studless building because of the inherent weakness of the structure. Technic beam connections can easily be reinforced with plates on top and bottom, but studless beams can only connect to other beams through their holes. And that gives just that tiny little bit more play or less stiffness. Especially for a model this large it is not easy to prevent it from bending under its own weight. One of the tricks to keep a structure straight is by pre-stressing it in the other direction than the nominal load would do. The rear part of the fuselage is such a pre-stressed structure. In figure 6 you can see the framework that carries most of the weight. It is a triangle with a base of 34 studs and a height of 3 studs (see the drawn triangle in the figure). Pythagoras tells us that the sloped section should than be 34.13 studs. But it is only 34 studs. Consequently the backside is bended upwards slightly. The weight of the plane bends it downwards again so the net result is a relatively straight underside.

## The landing gear

The main landing gear has to rotate around its axis when it is raised to fit in the wing well. There are multiple ways of doing

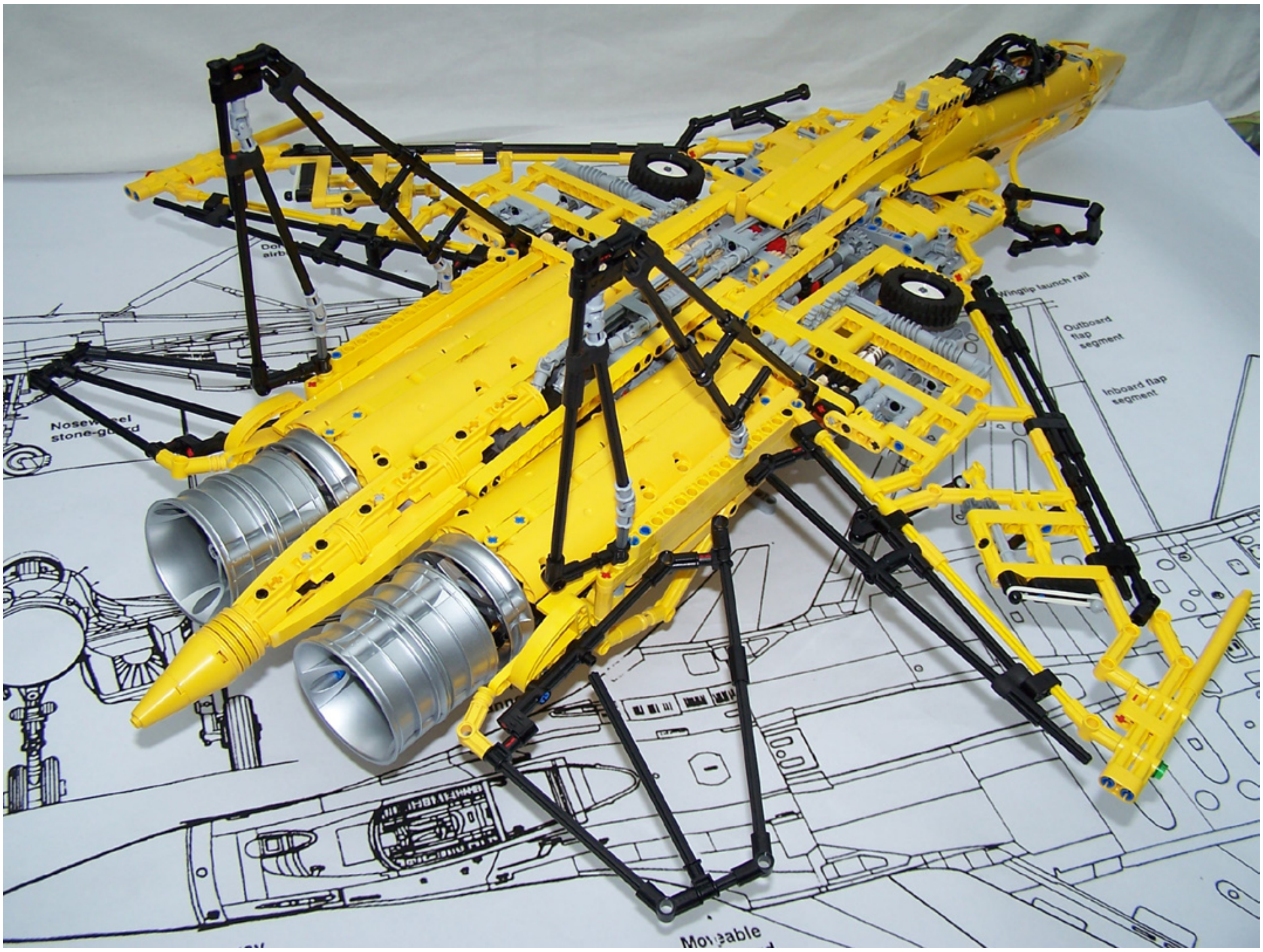



Figure 4: The plane has its control surfaces positioned for a left turn. The vertical fins turn left, the right tail plane pushes that side of the aircraft up, while the other one pushes it down. The engine nozzles enlarge that effect. The canards are also in quite extreme positions which normally would only be used when the plane is flying with his nose pointing upwards (or even slightly backwards).

this. For this model I have chosen to do it using a fixed gear. In figure 6 the mechanism is shown. The red gear is fixed with a long technic pin with stop bush, the yellow gears are used to drive the landing gear. The white gear will rotate along the red gear making it turn 90º around its axis while it is raised.

The front landing gear is much simpler. Because of the limited volume in the fuselage I had to compromise on the functionality. One of the compromises is that the nose gear has no steering functionality. It simply moves up and down. It is actuated with a mini linear actuator.

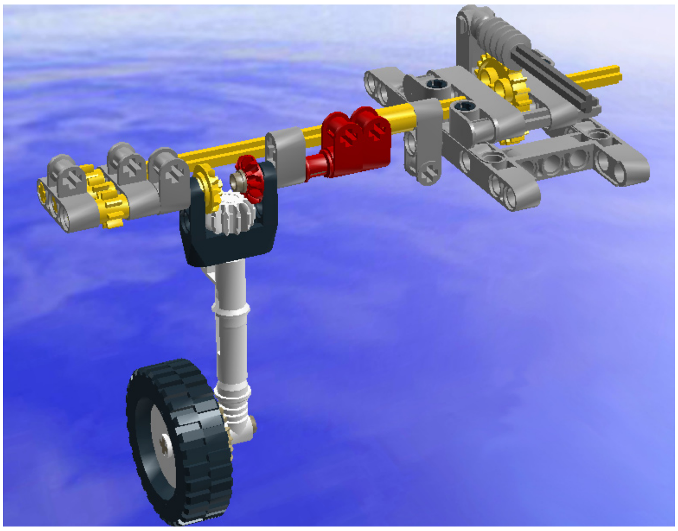


Figure 6 The main landing gear. The red part is fixed, the yellow part is the driving mechanism

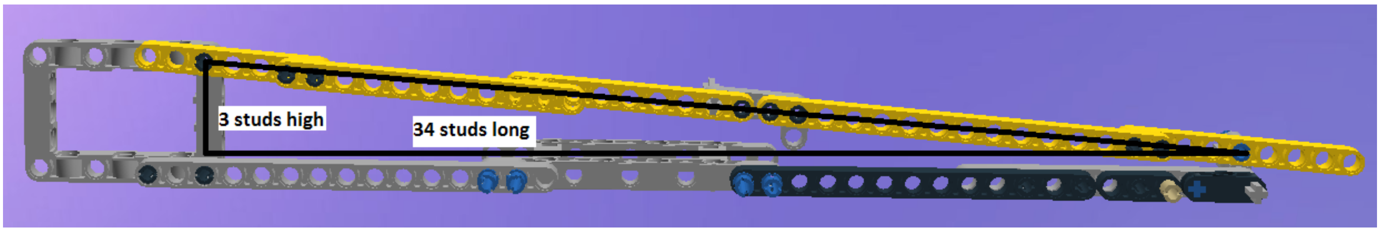



Figure 5: the pre-stressed frame in the rear of the fuselage to compensate the weight of the plane

## Building is compromising

Building with LEGO® is all about making compromises. Looks, structural integrity and functionality all have to fit in the same space. All in all I am pretty happy with this fighter as it turned out. It is quite strong and stiff. It is swooshable albeit the weight is significant.

It has the following functions:

Electrically controlled:
- Landing gear
- Landing gear bay doors
- Airbrake
- Canopy

Manually controlled
- Flight control surfaces
- Leading & trail edge flaps on the main wings

Functions that I wanted to incorporate but where I didn't find the space for:
- Ejection seat (including a mechanism to open the canopy a split second before the seat ejects)
- Nose gear that can steer
- Properly working bleed doors in the air intakes (they are actually there, but they move only a minimal amount)
- Functional control stick
- Nozzle outlets that can change diameter (afterburner mimicry)

As for the looks I'll leave that up to you to decide.

More pictures (and a video showing its functions) can be found on my Flickr page (http://www.flickr.com/photos/jeroen_ottens/). Sadly the Sukhoi SU-37 will never fly the skies again to stun us with its agility. Only the romantic tales of its spectacular appearance will remain.
Leg godt,
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