The BUGATTI 100P Replica Propeller(s)

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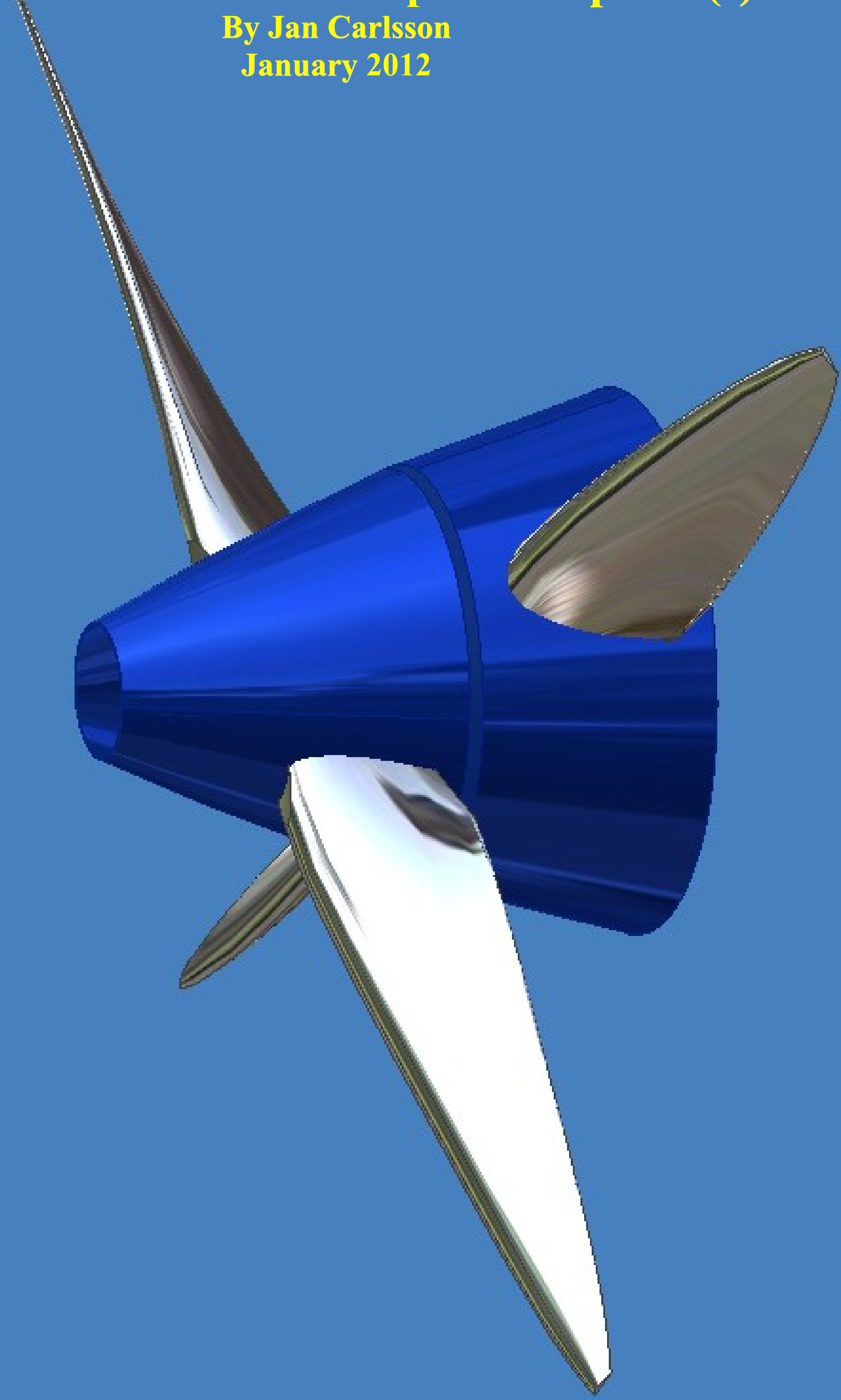


At the end of November 2011, I got an e-mail from a Scotty Wilson, asking:

“Would you consider helping us to design a custom prop(s) for a reproduction of the most extraordinary aero plane ever built?”

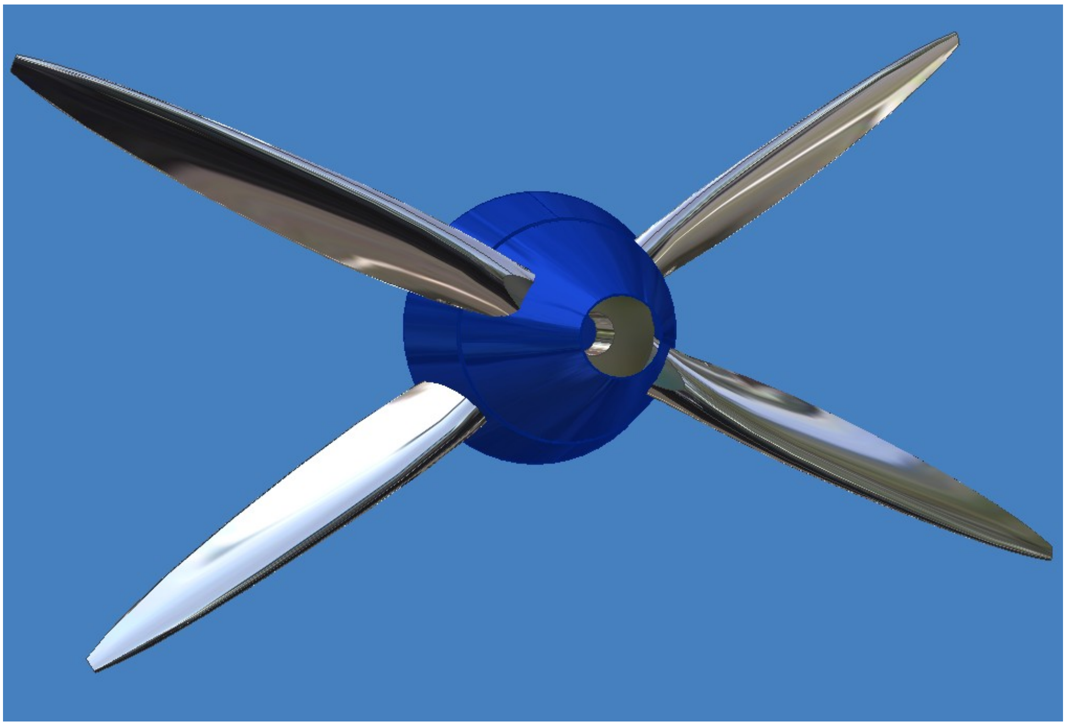
In my reply I asked if that was the Bugatti 100P, so…

That request sounded like an interesting, fun but demanding task, two problems to solve, first, I don’t make propellers, but have hand-carved propellers in the past. Second, I don’t have the needed software for counter- or dual-rotating propellers.

But I know a great guy in UK that makes great propellers, Rupert Wasey of Hercules Propellers that use my propeller software, the “JC Propeller Design” for normal propellers, So I asked him if he was interested to team up for this project, we discussed the pros and cons of being part of a big project like this construction of a pre world war II design that never have flown.

I had just finished programming a new propeller program for optimal propellers, this “HSOP” software is partly based on Theodore Theodorsen’s book “THEORY OF PROPELLERS” from1948, and a lot of insight from Jack Norris interesting book “PROPELLERS The First, and Final Explanation” a book I can recommend to all that want to know more.

That software took me a year of spare time to perfect. So how could I now create this new software for counter-rotating propellers in a very limited time? Well a good thing, I had it in fresh memory and some of it was possible to use for this application, even if all the formulas for mass flow, losses and blade angles is completely different, the part with airplane drag and performance, (without that part, a propeller calculation software is pretty useless) could be used as it was. This time of the year is also the slowest at my ordinary work, so two good things that cooperated.



Scotty Wilson presented us for John R. Lawson, the Bugatti team Engineering Director, also in UK. After some thinking about the original thought of having and making ground adjustable propellers that will hold a number of new untested designs, and costs of manufacturing, it was decided to make the propellers fixed pitch, with a “slight” redesign of the propeller hubs and shafts, but a overall easier and faster route to travel to a finished product, John Lawson did a great job in redesigning the hub and flanges.

It was my job to do the aero-dynamical and strength calculations of the counter-rotating propellers, I have got one or two requests in the past about counter-rotating propellers, but that have always been to some goofy aircrafts, so I always politely declined. There aren’t many aircrafts out there that use counter- or dual-rotating propellers so no big market on those. That’s one good reason I had, to not even think about making the special propeller software it require.

The Bugatti 100P replica, on the other hand is very interesting, as a historical airplane, almost mythical, mostly, I guess because it never have flown, and the exotic look.
The replica team with Scotty Wilson in charge, and people spread over half the globe, do have the driving force to make it happen. So that’s why I accepted to “run the numbers” and help the team reach the goal to get the plane in the air.

Counter-rotating propellers is very different from normal propellers, we can not just use two normal propellers calculated for the same speed and total power. Counter-rotating propellers interact with each other, the forward propeller need to have more pitch, and the rear less pitch then a normal, single-rotating propeller would have. The forward propeller will also have little more area then the rear propeller.

They also absorb more power then single rotating propellers, with the result that they will have less area, be narrower, if diameter and all other settings are kept the same.
The positive thing with dual-rotating propellers is that the efficiency is higher, the air stream over the fuselage, wings and tail is more axial than rotating so trim losses is less, and compeered to a normal twin engine the tail feathers can be made smaller. It will go straighter on take off, and no rudder input is needed during climb out to compensate the propeller factor. They will probably make more noise than single rotating propeller, but that at the time of writing that still remains to be heard.

With the software ready and tested, it is just a question of collecting and insert the correct data, press the “calculate now button” and see if output make sense.

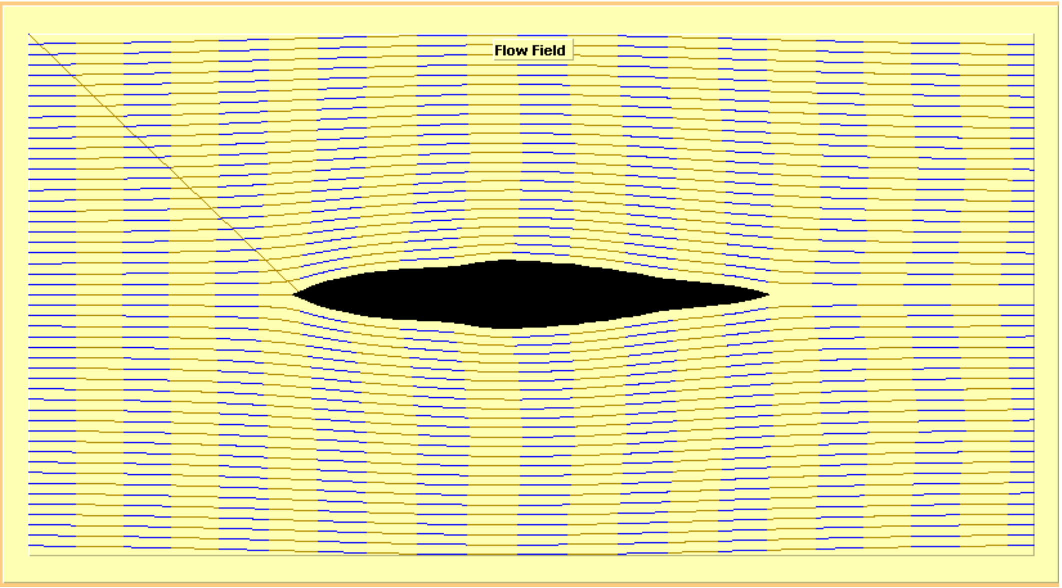
The big benefit with computer software is that different settings easily can be tested, instead of making hand calculations, where you have to start all over for every change.
But as with all computer programs they are just dumb and do what we tell them to do, so it is garbage in – garbage out.

We face two small problem, we don’t have the same power as the original, and the wish to have propellers that look like the original propellers.

But “luckily” Scotty Wilson picked a lower RPM then original, and wants to have good climb propellers, a climb propeller have bigger diameter and/or blade chord than a cruise propeller will have, and the physical law that make slower airplane propeller larger than faster one. And with less HP at the propeller the plane will naturally be slower. So with some tweaking at the input numbers and settings, the output, the physical propeller, look almost as the original. It all played along with the goals.

By running the numbers from the original Bugatti 100P, and using settings for a cruise/speed propeller we still get about the same looks, the same diameter and chord lengths, but of course steeper blade angles/pitch. So it is easy to see that Count Pierre *Louis de Monge* de Franeau, that was a propeller designer during WW1, and/or? the Ratier propeller company had don there homework.

All objects that travel in a fluid, like water or air, push the fluid in front of them, that fluid then try to get around the object, forcing it outboard at the front of the object.

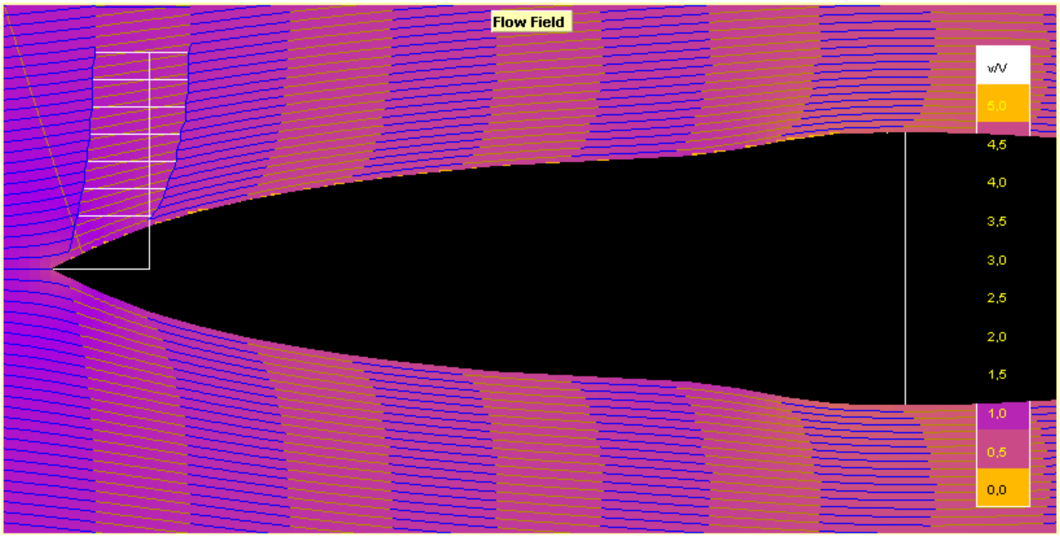


So also with aircrafts, the air is slowed down in front of, and <u>at</u> the front of the aircraft

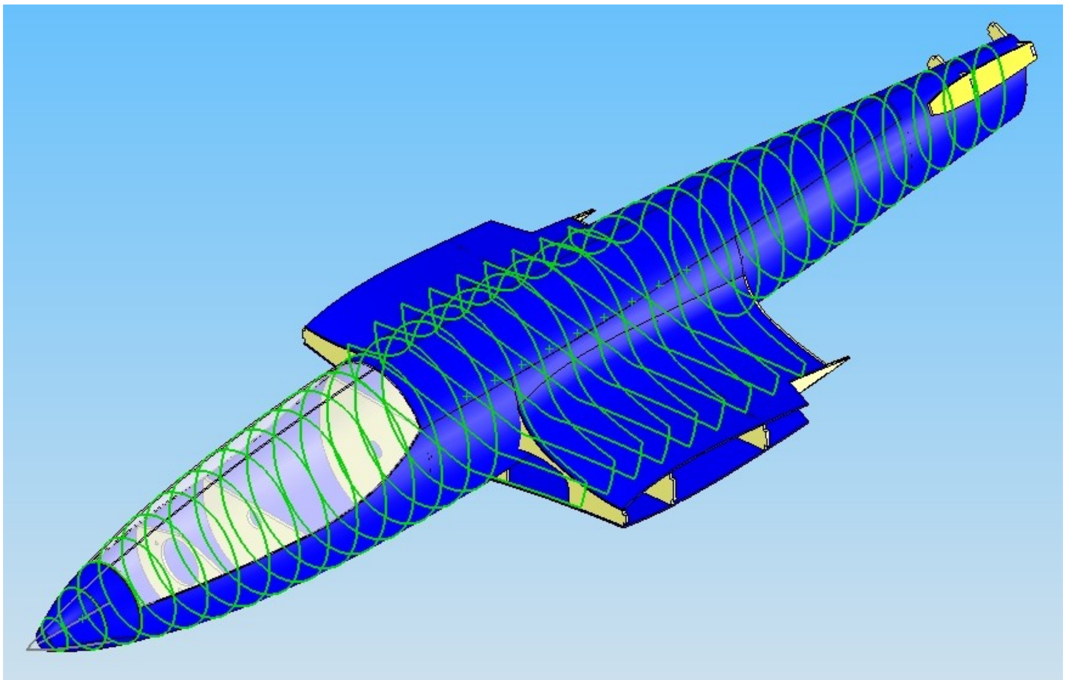
(if the aircraft is stationary and the air is moving)

or pushed forward/outward, this lead to a situation that make the propeller “see” different airspeeds (and air-stream angles) along the radii of the propeller blade, on most aircrafts the propeller will also see a variation of slowdown as it rotate due to non circular form of the cowling/airframe, so a average of slowdown have to be calculated for each aircraft type.

See the picture below of the fuselage of the Bugatti as a “body of rotation” within the propeller-wash covered part of the wing and wing fairing.



The Bugatti have an almost circular front and elliptical fuselage, so we can make the assumption that the slowdown is constant around the propeller path, which will probably help the efficiency and reduce noise. The absence of cylinders and air intake behind the propeller make it very streamlined, reducing the slowdown. But this has to be calculated just because it is very different from other tractor airplanes. To do this I got the fuselage dimensions from the Swedish model plane builder Staffan Månsson that just happened to be modelling the Bugatti in a CAD program, from that model I could get the cross sections needed to make an average cylindrical model, so I could calculate the slowdown factors.



Along the propeller radii, the closer to the spinner we come the slower the air stream will be, here where the blade angle is greatest too, we don't want the blade to be stalled during take off and climb, and we don't want the angle to be to shallow either making negative thrust at cruise. Just perfect is OK.