Soaring by Design

The Mechanics of Launching

Narrator:
In order to start flying a glider must first be launched, that is, it must be given an initial store of energy. One traditional method of launching is to use an elastic bungee rope. The launch crew store energy in the rope by stretching it. When the glider is released this energy is transferred to the glider as a combination of Kinetic Energy for speed and Potential Energy for height. Even a large launching crew can't provide much energy. So for modern heavier gliders, or for a higher launch, some other method is needed. Winch launching involves one or two steel cables, each attached to a motor-driven drum on the winch lorry. Pay out the cables from the winch and hook them to a waiting glider. Once hooked up the glider is ready for the winch operator to reel in perhaps one kilometre length of cable. Just as a kite will soar up into the sky as its string is tugged so too will the glider once airborne. The only constraint to the height at release is the decreasing length of the cable and the angle that the cable makes with the horizontal. Once released the cable is pulled in to the winch ready for another launch. Although there have been various modifications over time, winch launches have remained pretty much the same for many years. In an effort to understand the process of winching better, a team of engineering students in Karlsruhe set out in the mid-'90's to gather data about the forces involved in a launch. They fitted various meters, including one on the drive shaft which measured the tension in the cable, and a detector which would record the speed of the drum, two parameters which were incorporated into a model of the launch. One of the engineers on the project was Tobias Hoffstetter.

Ian Johnston: (The Open University)
Tobias, we've seen the winch in action. You were project leader of a group here at Karlsruhe looking at more detail of winch launches. What was the real world problem you were modelling?

Tobias Hoffstetter:
First of all we are interested to find out more about winch launches. Our purpose is to find weight for organisation and optimisation of winch launches, know more about forces curing the winch launches, and maybe we will find a way to calculate and design much more easily new winches.

Ian Johnston:
So where is this information about forces collected?

Tobias Hoffstetter:
I will show you. Please follow me to the cabin.

Ian Johnston:
It's unusual to find a computer in a lorry. What does it do?

Tobias Hoffstetter:
We need a computer here inside because we have to collect a lot of datas and we would like to see the whole process on the screen, and we need the datas afterwards for our simulation, and it is done on the computer too.

Ian Johnston:
So what data do you collect?

Tobias Hoffstetter:

I would like to show you here first the data with these numbers. These numbers here are the force in the cable.

Ian Johnston:
And the larger the number, the larger the force in the cable?

Tobias Hoffstetter:
Yes, that's the point. So right now we'll see the curve. The first curve you see, that's the first in the rope or in the cable, and with this curve you can see the behaviour of the whole launching process.

Ian Johnston:
So how does the graph of the force relate to the stages of a typical winch launch?

Tobias Hoffstetter:
The graph of force you see here, it begins when the cable is tight, and then you accelerate the glider which is still on the ground, and you need a lot of energy and force to do this. Then the glider begins to fly and you have no more friction between the glider and the ground, which means the force will decrease. And then you really begin to start which means the glider climbs into the sky – that's this spirit here – and after this the glider launched the cable. Then we throw the cable without the glider very fast to the winch.

Ian Johnston:
And the speed increases?

Tobias Hoffstetter:
The speed increases, yes.

Ian Johnston:
At that point.

Tobias Hoffstetter:
That's what you can see from these curves here. This is a very characteristic curve, almost every start looks like this.

Narrator:
Once you've collected the data you can include them in the model and compare to reality.

Ian Johnston:
Arno, you worked with Tobias on the Winch Launch Project in Karlsruhe. He's shown us how the information was collected in the winch. What did you do with it then?

Gerhard Arnold Seiler:
We use this data for the calculation of the winch launch. We see here the input data for the calculation: the horizontal scale has the time in seconds; vertical scale is force in Newton; and this blue curve is the collected measurement data from the winch launch.

Ian Johnston:
So now that you've filtered the data, what do you do with it?

Gerhard Arnold Seiler:
Now we are calculating from this input data the interesting data. We have now calculated the energy balance – the energy in the vertical scale in kilojoules versus the time in seconds on the horizontal scale. The blue curve here shows us the work of the launch. The green one here is the Kinetic Energy of the glider and cable. The blue one here is the resistance energy of the cable, and the red one here is the resistance energy of the glider. And this energy is the most interesting one – it's the Potential Energy of the glider as a function of its height and with the mass of the glider we can calculate from this resolving energy the height of the glider.

Ian Johnston:

So you were able to work out the height of the glider despite not having taken any direct measurements of that?

Gerhard Arnold Seiler:
Yes, and we can compare with measured data from the photographs.

Ian Johnston:
So what path through the air does this model predict for the glider during the launch?

Gerhard Arnold Seiler:
OK. Another screen shows us now the calculated movement of the glider, the horizontal movement and the vertical movement as a function of the time. You see starting the glider, moving straight to the height and then reaching his ending points of 330 metres, we've found out that this curve is a simply cosine function.

Ian Johnston:
Was that something you expected before starting?

Gerhard Arnold Seiler:
No, we did not expect such a result.