Design and creativity
Folding bike re-invented

Narrator
Mark Sanders is an Engineer and Industrial Designer, who's best known for his creative design of folding bikes. His first bike originated as a postgraduate design project.

Mark Sanders
I'd gone back to college to study industrial design engineering as a postgraduate and I needed a project and I also commuted from Windsor into London and so something that combined cycling with other forms of transport seemed ideal.

Narrator
To get started, he drew up a specification of how he wanted his bike to perform. And then made a detailed review of the state of the art in folding bikes.

Mark Sanders
There are lots of folding bikes, but they all try and be as small as possible.

Narrator
Seeking a new and simpler concept, he was inspired by another folding transport device, the baby buggy.

Mark Sanders
The key thing about the Maclaren Baby Buggy is when it's folded up, it's not actually as small as possible, but it's long and thin. And it's like a walking stick with wheels on the end. I thought well why not apply that concept to a folding bike. Instead of trying to fold it really small, make it long and thin, with the wheels together at one end.

(Screen ident: EXPLORING POSSIBLE STRUCTURES)

Narrator
Sketching played the crucial role in Mark's exploration of how to turn his basic idea into a concept design.

Mark Sanders
Like the process before, I immersed myself in the problem, and really tried to think of every possible way of making a structure that could fold up into a long formed thin shape. And this is why I used the sketching as a sort of dialogue with myself to try and have an idea, and sketch it, to then refine it between my head and the sketchbook. And I really, didn't really worry about which ideas were good, and which ideas were bad. I just got down as many ideas as possible at this stage to really try and cover the whole of the area.

Narrator
To decide which of his many concepts might work, he needed to categorise them and narrow them down using the criteria in his specification.

Mark Sanders
It boiled down to basically two shapes. The triangular shape and an 'x' type configuration. And so what I did here was to put the different drive arrangements, along the different frame arrangements and check back that they all must fold into a long thin shape.

Narrator
There were also practical and engineering factors to consider.

Mark Sanders
For example, we can't have a chain, which crosses a joint, or a belt which crosses the joint and so some ideas were automatically thrown out, due to these practical considerations.

Narrator
The next step was to make some very simple models.

Mark Sanders
Sketches for something very three dimensional, like a bicycle, have their limitations and the only way to really explore how for example three tubes might be realigned into a long thin stick is to make models. And so the little wire models were an ideal way of exploring, very quickly, these three dimensional shapes.

Narrator
Mark decided that the triangular frame was the way to go.

(Screen ident: DEVELOPING THE TRIANGULAR SHAPE)

Mark Sanders
I really wanted to have something, which hadn't been done before. Because one of the ideas was to patent the design and try to put it into production myself and so I didn't want to infringe anybody else's patent.

Narrator
It had technical advantages too.

Mark Sanders
A triangle is inherently stiff and is basically just three tubes and three joints and so it really stood head and shoulders above the rest.

Narrator
Getting from sketches and wire models to the real thing, involves some engineering science. He started doing very rough calculations on bending moments and weight distribution on the triangle just to see that it was feasible. As the project progressed, the calculations became more and more sophisticated, looking at the actual materials proposed, and wall thicknesses and other details. A key element of the original specification was that folding and unfolding the bike was as easy as possible. This required creative ideas for components, like the front joint.

Mark Sanders
The front joint is the first thing that disconnects on the bike and so I tried to think of other things in the world which disconnect, and are obvious to use so that people wouldn't have to have a long learning time on using the bike. And then it struck me that a car seat belt joint is just the sort of mechanism I would like for the joint on the bike. And in fact more than that, I thought maybe I could actually use an existing car seat belt mechanism, when I could find one the right size, and one that fitted in with the action of lifting up the front tube. I used a car seat belt for the first prototype.

Narrator:
To make sure that the bike was actually going to be rideable, the next stage was to make a full sized mock-up cobbled together out of bits of old bicycle. The fully adjustable joints and fittings helped Mark to come up with a final design. The first triangular framed folding bike. Eventually he found someone prepared to set up a company. And manufacture a commercial version of the bike called 'The Strida'. Its great strength was the simplicity of its folding mechanism. It was a considerable commercial success. With some 25,000 sold worldwide.

Mark Sanders
As a folding bicycle design it won on simplicity but it didn't win on long distance ability and I think that was the main criticism of it. They pointed out that it wasn't good for tall people; that it wasn't as stiff as some of the mountain bikes they're used to riding and that its handling wasn't as secure as a mountain bike.

(Screen ident: IMPROVING THE DESIGN)

Mark Sanders
The feedback we got back from users, from the Mark I, was that people wanted a bike which they could use for longer distances, more like a conventional bike. They wanted something that was stiffer, handled more like a conventional bike and also had more knee room and so the changes between the Mark I and the Mark II are basically an increase in frame length, which gives the knee clearance and at the same time the steering geometry was altered to make the handling a bit more predictable, like a conventional bike.
The other feedback we got from users, was they wanted a much flatter package which could fit into the overhead lockers on trains and buses, particularly on trains and so we had some folding handlebars added, which makes the whole thing very narrow in this plane.

Narrator
After a spell away from the company that made his bikes, Mark was invited back to help design the next generation of Stridas.

Mark Sanders
Well moving from the Mark II to Mark III was a fantastic opportunity. Because the production was going to be moved from the UK to Taiwan and they asked me to see if I could redesign it and take out all the user feedback problems that they'd been having. And the top of the list were making the bike handle like a regular bike and also making it as stiff as a regular bike.

Narrator
The move to Taiwan has made lighter and stiffer all metal construction economically viable.

Mark Sanders
The major thing I think was moving a lot of the parts, which were previously plastic to aluminium and welded construction, which is actually as cost effective in Taiwan as plastic construction is in the UK.

Narrator
Mark still uses sketching to create and develop his basic ideas and concepts.

Mark Sanders
Sketching is still my main way of generating ideas. I still fill loads and loads of pieces of paper with sketching. I can't refine an idea unless I've sketched it down, and thought it through and added.

Narrator
He now makes much greater user of computer aided design.

Mark Sanders
I've used CAD in a big way now and after the initial stage of sketching, I find it's a way of refining down to which prototypes to make. Rather than having to make ten prototypes, the CAD system helps me decide which ones are worth making and then maybe just make one. I also like to make physical models, and that can either be hand made models out of wood. Just to check how things feel and how you hold them, for example. Or also, parts made out of solid aluminium, for example, which need to take loads. Now these parts are made directly from the CAD data, using a computer numerically controlled machine, to actually mill them out of solid aluminium and then they can be tested with real live loads. Now that technology has been hugely helpful in this development process.

Narrator
Even with CAD there's still a need for physical test rigs.

Mark Sanders
The full size test rigs are absolutely vital because handling is such a subjective thing. There's no way a computer could simulate what a bicycle feels like to ride. No way. It may be able to work out the stiffness but it doesn't give you the feel of a bicycle. And so the only way is to make a test rig. And I particularly like fully adjustable test rigs where things can be subtly changed to see the effect on the handling. This is the adjustable test rig that was used to optimise the frame geometry, to make the handing really good for the Mark III. Every aspect of the frame is completely adjustable, from the steering axis to the length of the tubes and also the height of the handlebars. And using this, and lots and lots of hours of testing, using riders who hadn't ridden the Strida before, we found the optimum steering geometry. And in fact it was quite different from what all the theory suggested.

Narrator
The production version of the Mark III incorporates all the optimum features from the test rig. As far as the ride goes, it feels much more like a non-folding bike. It's still really fast to fold. And now a magnet has been added to pull the wheels firmly together when the bike is being wheeled along. But the Mark III is far from the end of the line for the Strida.

Mark Sanders
There are several improvements that are still in the pipeline for the Strida. And that includes gears, electric power versions, even lighter versions, maybe even different materials. My personal ultimate goal is not actually to make it more complicated, but to keep it as simple as possible, and ideally make it as light as possible. One of my driving philosophies is to make design affordable, in other words, design within reach. And so one ideal thing for the Strida would be to keep the costs down so that it is an affordable useful product, that a lot of people can get benefit from. I obviously totally believe in it, and believe in its advantages and being able to link other forms of transport. But I'd like to be able to offer that to as many people as possible.