Wire Rope News & Sling Technology

December 2018
REPRINT

SERVING MANUFACTURERS, DISTRIBUTORS & RELATED SERVICE PROVIDERS FOR THE MATERIAL HANDLING INDUSTRY SINCE 1979

Designing the Nearly Impossible

The challenging projects of Jean-Marc Teissier

Jean-Marc Teissier: Designing the Nearly Impossible

by Barbara Spencer

Whether designing the first amusement ride to catapult passengers into "space," engineering the largest moving stadium roof in the world, or renovating the inclined lift of the Eiffel Tower - Jean-Marc Teissier, Managing Director/owner of DEP Engineering and President of OIPEEC, takes on projects with challenges that seem insurmountable.

Jean-Marc Teissier, Managing Director and owner of DEP Engineering, gazed intently at the green button on the remote control. In mere seconds, it would activate the maiden launch of a new amusement ride, Space Mountain, in Euro Disney.[1]

For months Teissier had played a major role in this engineering project. The results of his efforts rested on the next few moments.

The Space Mountain ride, once completed, would transport more than 8 million people a year. The overall cost of the project would be 120 million dollars.

And this was Teissier's catapult design, which had never been tried before.

A catapult to shoot humans

From the very beginning, when he'd first proposed the design, most thought it was preposterous.

"Yes, people thought I was mad," says Teissier. "First, I contacted a French rope manufacturer. We met in their office for about an hour, and they said, 'We don't want to waste time with this stupid thing. It will never work.' And it was the same with an Italian manufacturer, and the same with a British producer."

But after he contacted the German company Casar Drahtseilwerk Saar, Teissier says he received a curious call.

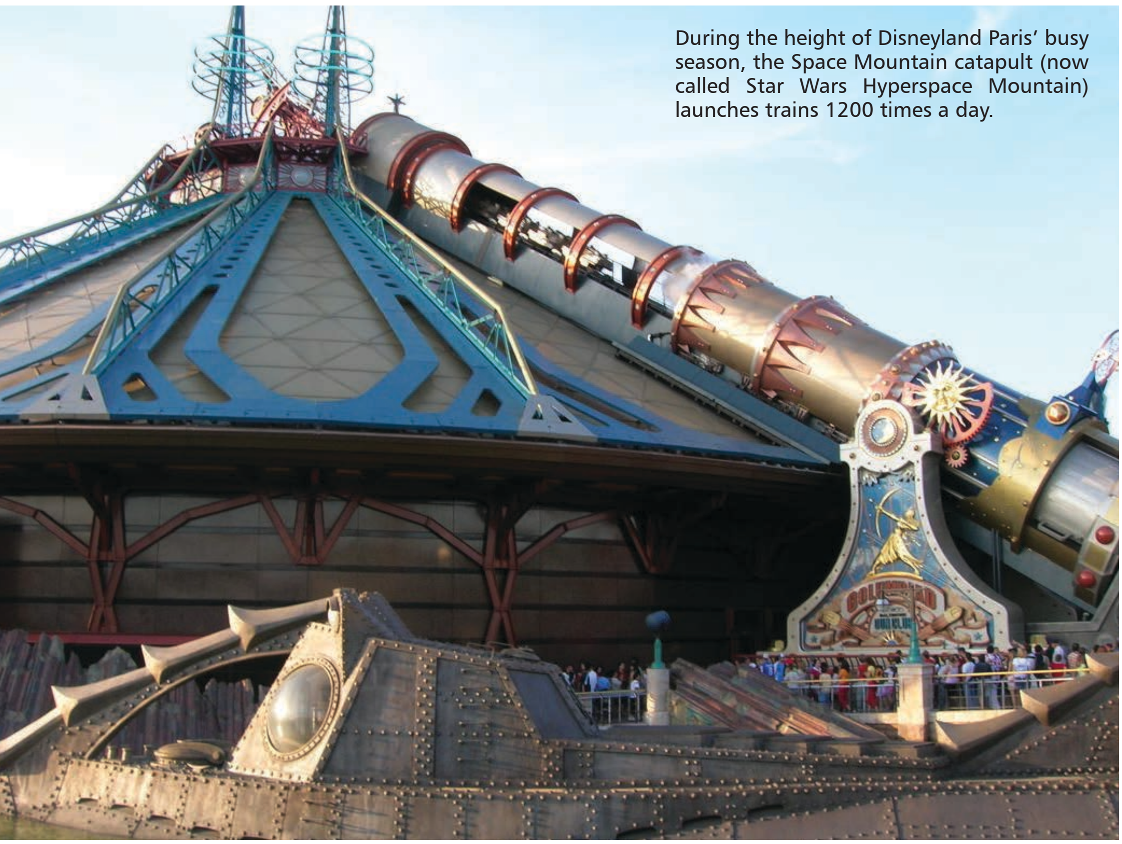
"Although he was German, the caller spoke French very well. It was Roland Verreet [often called 'The Rope Pope' because of the respect he has garnered worldwide as a wire rope designer, inspector, consultant and speaker[2]]. And he said, 'This project is very interesting. Please book me a hotel for when I arrive.' Then he drove 10 hours from his home in Aachen, Germany and we started working together." Teissier and Verreet have retained a close business relationship and friendship ever since.

When the two met, they discussed the daunting project. This unique catapult design would have to work dependably and flawlessly. During the height of the popular summer season, the Space Mountain train, filled with up to 24 people, would be launched every 36 seconds – 1,200 times a day.

"After I got the contract, I made my own calculations. I discussed it with people like Roland and Prof. Dr. Gabor Oplatka [a renowned ropeway expert]," remembers Teissier. And we concluded that it would never work. And this was a very, very hard discussion with the American team of engineers [who had already specified the project in great detail]. "I told them that if they wanted me to do it their way, it wouldn't work. And it took about three weeks or so before they came back and said, 'OK, you're right.' It was a challenge because the project had already advanced. The electrical motors had already been ordered. But, anyway, we combined all the things that were not possible and in the end we found a solution."

And now, as onlookers shivered on this cold, wet winter day in 1995, all watched expectantly.

"The instant the button was pushed, I remember one single thing as I watched the train launch," says Teissier. "I could see the huge acceleration." The train, filled with sand bags to model the weight of passengers, sped forward. "And because it was the first launch,



During the height of Disneyland Paris' busy season, the Space Mountain catapult (now called Star Wars Hyperspace Mountain) launches trains 1200 times a day.

we had no reference."

"The system worked! The train came back into the loading area, and everyone was applauding and so on."

Yet, something had gone terribly wrong. Almost immediately after the train stopped, Teissier and a colleague inspected the cable below the train. As they listened to the applause and clinking of champagne glasses above them, the two men discovered that the rope had slid inside the attachment. "If you have slippage it means the attachment is not strong enough. I can tell you that when we noticed this, it was a very difficult moment. And I thought, 'This is not good.'"

It wasn't until they investigated further that they realized the problem. The acceleration had been set incorrectly. The acceleration should have been set for .8G. Instead, the train had sped forward at 8G, which, of course, is 10 times the acceleration. "The train was launched at the maximum acceleration that the motors were able to do, and this was the reason why the attachment slipped."

Once that was corrected, the problem was solved.

Jean-Marc (left) works on the inclined lift of the Eiffel Tower.

When asked if he'd had any sleepless nights worrying if it would work, Teissier responded, "Yes. Plenty.

"The biggest challenge was the service life of the rope. The proposal was to change the rope only once a year. But that was never possible. So from the beginning it was two times a year. Doing our best to keep within the required constraints, we came up with the configuration of 145,000 cycles before the discard of the rope. At Disney in Paris you have a huge season in the summer and much activity for Christmas. So after one or two years, the decision was made to change the rope in June just before the summer season and then again in November just before the Christmas holidays." Inspections are performed daily, weekly, and monthly. "Every ten years they dismantle all the machinery for inspection and so on, and after the first 10

Understanding the Rope System that Powers the Space Mountain Catapult

"When the passengers are seated and secured, when the glasses have been taken off and the false teeth are stored in the pocket, the train moves down to the bottom of the canon slope by means of gravity."†

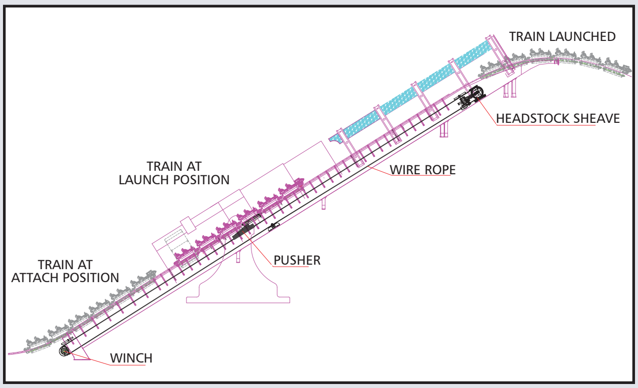
Unaware of the rope system that will power their ascent, riders excitedly anticipate the amusement ride in the dome above them, where they will travel in the dark at dizzying speeds.

But first, their train, which consists of six cars, each with four seats, will be literally catapulted into the dome.

The catapult pusher, which is a carriage fixed to the rope system below the train, moves the train into the departure position in the lower section of the track, which is 50m long and inclined by 32 degrees.

After a short waiting time, purposefully designed to increase the tension of the passengers, the canon is fired.

The rope reeving system rotates in a pretensioned, "closed loop" system, causing the pusher to launch the train.



"…The background music is interrupted by a loud bang, smoke comes out of the canon, and the train rapidly takes off. Under the acceleration of 1,3g the passengers are pressed into their seats and the train reaches a speed of more than 50km/h in less than 2 seconds." †

The steel wire rope is Casar Turboplast. It has a nominal diameter of 36mm with a wire grade of 1770 N/mm2, and consists of an independent steel wire rope core, a plastic layer and eight compacted outer strands.

"The rope ends are attached to the drum. As the drum rotates, one rope end is wound onto the drum and the other end is payed off. As a result, the rope length stored on the drum always remains the same: it corresponds to the length of the pusher stroke plus the required dead wraps. This configuration allowed the design of a very short drum with only one wrap empty, resulting in very small fleet angles for the wire rope."†

After the rope travels from the drum through the pusher, it is held by friction to the headstock sheave. There it is deflected by 180°.

Shortly before the summit of the slope is reached, the pusher decelerates. The train enters the dome, subjecting passengers to a short moment of weightless condition. Then it shoots forward to continue along the track.

The rope travels back to the drum via the mid-span supporting sheave. And the pusher resets to its starting position, ready to launch another train.

Meanwhile, passengers will experience the start of their breathtaking roller coaster trip. They will arrive 90 seconds later back at their point of departure.

†"Space Mountain at Euro Disney: A 120 million dollar wire rope test machine," by A. Arfa, A. Belleculée, G. Oplatka, J.-M. Teissier, Roland Verreet.

years, in 2005, they computed that 85 million people had ridden the Space Mountain train."

Another issue was estimating the wear of the winch drum. "The American team of engineers asked to have a removable lining for the drum. And I said, 'No, it's not good for the rope. We will provide the drum and you will face no problems with wear.' Finally, they said OK. But just in case, they purchased two spare drums. And it was really expensive. At the time it was more than one million francs. And when we dismantled the drum after 10 years, it was like brand new. So, they bought three instead of one."

The sole way to do what I wanted was to be on my own

Jean-Marc Teissier bought DEP Engineering in 1992. He was just 33 years old, but his business career had begun in high school. An avid skier from the time he was 10, Teissier says he applied for his first patent when he was 17. "I was on the national French racing team. I invented a machine for waxing skis and sharpening the edge."

After receiving a mechanical engineering degree at the University of Grenoble, France, Teissier worked first for Gimar-SA, which specialized in cable cars and ropeway systems. From 1988 to 1992 he worked for AKROS, another engineering firm, specializing in hoisting systems, cranes and inclined lifts for transporting people. "I had a huge level of responsibility because I was technical manager for the company and we were involved in the people transportation. But I did not have all the tools or engineers I needed when I wanted to make tests. I had to make do with the means given to me, not necessarily what I needed. I wanted to be able to make the final decision. And the sole way to do that was to be on my own."

"And I was very lucky at the time because at just about the same time we got involved in renovating a historical monument, the transporter bridge in Martrou, on the west coast of France. And because of our involvement in the renovation of the Martrou bridge, we got the contract for the catapult for Space Mountain. And this is the real significant project because thanks to this project I met Roland Verreet and Professor Oplatka and so on and so on.

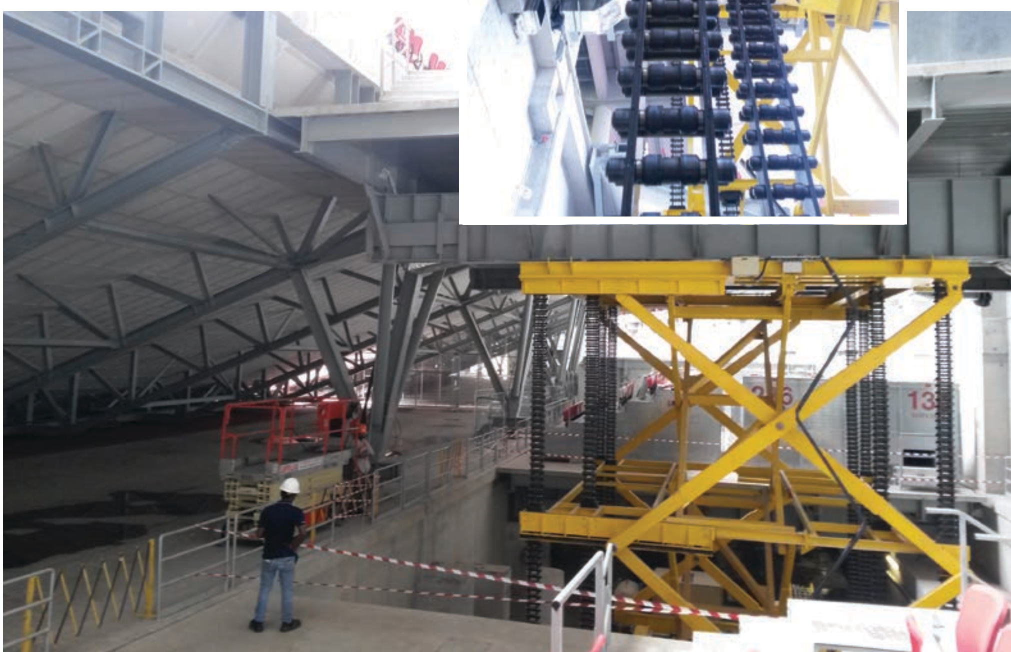
"Before that time, my knowledge regarding wire rope was limited to that of the field of cable cars and ropeway systems, i.e. almost nothing compared to what I learned when I entered the real world of wire rope and then the world of fiber rope."

Following the success of Space Mountain, DEP did a variety of design and engineering projects, including the inclined lift of the Eiffel Tower and the shaft sinking machine for an underground research laboratory.

Teissier says that the latter, which transported people to a 500-meter depth, was the most difficult. "But the moving roof of the Singapore Sport Hub is the most important" because of its unique design and tremendous size. In fact, it's the largest moving roof structure in the world.

This roof opens above a stadium full of 50,000 fans

In some aspects, says Teissier, "the roof was really an easy job. It is big, but it is much more difficult to make a very small load run very fast than a huge load run at a very low speed. Each roof panel would weigh 1,250 tons, but it would travel at a velocity of just 40mm



The monstrous Serapid machine, so-named because it uses Serapid "Rigid Chain Technology," moves a platform in the Singapore Stadium with a vertical lift of more than 5,390T.

A Glance into OIPEEC Today

by Jean-Marc Teissier, President

Q: What is the mission of The International Organization for the Study of Ropes (OIPEEC)?

A: The aim of OIPEEC is to collect, preserve and disseminate knowledge about a wide range of applications related to wire and fiber rope and lifting.

Q: What are your responsibilities as President?

A: Essentially, [chuckling] making the organization work.

Q: Has OIPEEC changed since it was created in 1963?

A: Formerly all the research for wire rope was financed by European public funding. Now it is a volunteer organization funded by private business. So, it's more difficult to get people involved because someone who is volunteering for OIPEEC is losing time from working on his or her own business. Also, more of the research is private.

Q: What are your goals for the future of OIPEEC?

A: Today we have about 100 members. We have to keep it on track. We are now involved in both wire and fiber rope. For the 2017 conference, more than 30% of the papers were related to fiber ropes.

Q: How can someone access information?

A: We just modified our website to make all the research papers accessible to our members. We've spent a lot of time doing that, but it's more or less a moral obligation. I hope this will be finished by the end of the year. We have about 700 published papers. I think so far we have digitized almost 600 of them.

per second. That's very slow."

Still, there were concerns that could contribute to sleepless nights – like the dire consequences of even one miscalculation. "If you made one mistake, you couldn't correct it because once the whole system was installed, you couldn't dismantle it. You would have to stand on the roof. And at that point the roof would no longer be accessible."

Safety was a major concern. The roof was designed to operate during events, which meant that it would be moving above as many as 50,000 people. The safety requirements would be the same as those used for transporting people. A safety brake was installed, which would lock the roof in place should a rope fail.

"There were different options for where to put the hoisting units, but the architects wanted it on the roof. For us, from a technical point of view, it was more complex. But we found solutions. For this project, we were involved in the early stages of the design, so it wasn't a problem."

To add to the attractiveness of the structure, the architects wanted almost nothing visible to the spectators when they looked up at the open roof. So, the supporting structure of the moving roof would need to be very light.

"Furthermore, this structure is curved in two directions. The biggest challenge was the design of a mechanism able to comply with these specificities. (See sidebar, "The Singapore Sports Hub Moving Roof: How Does it Work?")

"The hoisting system for moving the roof must accommodate the shape of the structure, the weight of the roof and the wind load.

"That means that the bogie wheels are not running on the same radius, thus not at the same velocity. So, we had to make provisions for that. We designed a very specific control unit for the winches because we had sixteen winches on the roof – (two moving panels, two groups of four winches on each), and the skew of the moving roof had to be limited in order not to damage its structure. From the beginning we had to make provisions so that we could adjust them on site."

The solution was to create what Teissier calls a "flexible" system. The roof runs on beams with tracks, supported by huge bogies, and is powered by wire ropes spooled onto winches. "Basically, the 1,250-ton roof is rolling on tracks that follow the line of the fixed roof. And depending on the wind and the weight, they can move up or down, and also laterally, up to half a meter of misalignment.

"And it is thanks to the specific sliding bearings installed on the bogies that we are able to move the roof in a straight direction with a track going sideways. And this is the first time for such a large roof. This is the biggest that has ever been done."

The Singapore Sports Hub Moving Roof: How Does it Work?

If you flew over the Sport Hub when the roof was open, you'd see two curved panels flanking a huge opening with five trusses arching across it. Each panel, 200m x 50m, 10,000m², and 1,250T, travels across five runway trusses via bogies – four bogies on each truss, travelling on tracks.

For safety, a storm brake is connected to the rear bogies of each truss. In case of a windstorm, for instance, the brake will clamp the roof panel onto the track. The brakes also have the same function as a track rope brake on an aerial ropeway - in case of lack of tension or over-tension on any rope, or overspeed of any panel, the storm brake will halt the roof.

To drive the roof panels, winches are located on the rear side of each panel. Driving lines are located on runway trusses RWT2 and RWT4, with four wire ropes and winches per line. Each winch is fitted with a 50mm high performance wire rope (eight strands, plastic infill, compacted outer and inner strands.) The driving force is 450T per roof panel. The distribution of the load among the wire ropes of the same driving line is very important. To see the video, go to www.wireropenews.com.

Intrepid Serapid moves stadium seats

While Teissier's company worked on the intricacies of the roof system above, they were also tasked with solving the problem of how to move the stadium seats below. The Sports Hub holds football, cricket and athletic events. The lower tiers would need to be reconfigured for each.

"We were on site," says Teissier, "and they asked us if we could do the project because we had diverse experience. And I said, 'Of course we can.'" The system first shifts the tiers like a waterfall and then hoists the concourse platforms (See photo on page 22).

"Just to give you an idea, when we change the configuration of the stadium, that means a vertical lift of more than 5,000 ton and horizontal shift of more than 10,000 ton.

(To understand how it works, see video link at wireropenews.com.)

"This is the machine that moves the concourse platforms," explains Teissier. "It uses Serapid chain. So we named this the Serapid machine."

Pointing to a diagram, he explains, "The machine transfers the concourse platform to the upper or lower position. It has to be safe, so we designed a locking system so that once the platform is in position it will be naturally locked and thus will never fall down. Here, on each platform, is a set of four locking arms."

For cost efficiency, the driving unit for the locking arms is located on the Serapid machine. So only one unit is required for the 49 platforms. Once the process begins, workers have 48 hours to change the configuration of the stadium. They work 12 hour shifts for four days straight.

A monstrous machine - 10m x 8m x (2m retracted/12m extended), 55T - the Serapid skids along the floor of the stadium on air skates, boosting the platforms up and down with ease. It is powered by eight driven chains.

"Serapid is the sole manufacturer of this kind of chain," says Teissier. "And

Curved in two directions, the Singapore Stadium roof moves with a hoisting system that must accommodate the shape of the structure, the weight of the roof and the wind load. This picture shows the roof closing for the first time on April 15, 2014. *Photo by Stanley Cheah*

we use this instead of rope because we require it to handle compression force. You cannot compress wire rope, and normally you cannot compress chain."

The Serapid company promotes their "rigid chain technology," explaining that the design is based on interlocking links. "When the chain is deployed it behaves as a true rigid pushing bar for the horizontal or vertical movement of heavy loads."[3]

On the horizon for DEP

Over the past 25 years, Teissier's company has grown and changed. Today DEP employs seven engineers, four technicians and an administrative assistant, but always with the same aim: "Not doing more, but doing even better at what we already do well."

Says Teissier, "When I bought this company, I transferred it into an engineering company. Then we moved toward production of safety components for lifts. And now we're also producing a twist/torque test stand and a bending fatigue test stand."

The latter, based on a concept by Roland Verreet, is unique. As Teissier and Verreet explained at the 2011 OIPEEC Conference, the bending fatigue test stand has five separate sheaves, rather than one. So, the rope is subjected to 10 bending cycles rather than two. This has a couple of major advantages. First, the machine mimics conditions on a crane, which typically has multiple sheaves. Also, different sections of the rope can be tested simultaneously rather than with multiple test runs – saving time and money while improving the accuracy.

"For me it's important because I really want this company to move from only providing services to a company that also provides products related to wire and fiber ropes and to machines using these ropes. My aim in the beginning was to do only design – no production. And then in about 2001 we had to design safety components for elevators and lifts. And in order to avoid being copied, we provided the full system. So, we moved from being only a design company to a company that could provide safety components. And now we've made another step since 2011. We've invested a lot in the production of our own wire rope products – bending fatigue systems, twist/torque systems. We design the machine, produce the machine, and sell the machine to the customer.

"DEP is also developing a new kind of rope termination which works well with both wire ropes and fiber ropes. The story of this development is interesting because this is typically the implementation of the process of creation as described in the book *'The Act of Creation,'* by Arthur Koestler. In this book, that I read in 1981, Arthur Koestler explains the logic of the creative process. He quotes Thomas Edison who said, 'Genius is 1% inspiration and 99% perspiration,' and Picasso who said, 'Creation is based on 10% inspiration and 90% perspiration.' Since I started working in the field of rope in 1981, I have questioned experts in order to understand the functioning of a conical socket, and I never got fully satisfactory answers. A few years ago I asked one of DEP's engineers to build a numerical model of such a system. We have worked on improving the model in order to get results in compliance with my past experiences. Maybe I reached the term of the 90% of perspiration, but then came an idea… the patenting process is on the way…"

At 59, Teissier is already planning for retirement. "We want to be more a manufacturer of products than just a provider of engineering services," he says. "I want to ensure the continuation of the company."

And what will he do when he eventually retires? Teissier says he is passionate about wire rope history and the lessons we can learn.

"Right now, I don't have the time to collect all the information, so I just discuss it with Donald Sayenga (an expert and historian of wire rope[4]). I owe him so much. And when I am retired – which will happen eventually – I will research rope history and maybe write about it.

"We have so much to learn from history, from the work of our predecessors. Their heritage is a very powerful tool. Using it, disseminating it, improving it is our duty." WRN

[1]Space Mountain at Disneyland Paris was refurbished in 2015, and is now called Star Wars Hyperspace Mountain.
[2]Roland Verreet was featured in our February 2018 issue.
[3]www.serapid.com
[4]Donald Sayenga, known as "Mr. Wire Rope," is a frequent contributor to Wire Rope News & Sling Technology.

Photos and illustrations courtesy of Jean-Marc Teissier, unless credited otherwise.

REPRINTED FROM
THE DECEMBER, 2018 ISSUE OF
Wire Rope News & Sling Technology