

Associazione Liutaria Italiana

Unveiling the secrets of violins

Products

Simcenter, NX

Business challenges

Understand the acoustic performance of antique string music instruments

Identify the main performance contributors

Provide violin makers with engineering insights on how to improve current instrument production

Keys to success

Collect acoustic data precisely and perform detailed acoustic analysis

Work with integrated software solutions and support the digital twin concept

Use versatile testing solutions enabling customized setups

Results

Provided data to explore and optimize new music instruments designs

Delivered information to help recreate instruments precisely with the same acoustic performance

Conducted acoustic measurements onsite

How Simcenter testing solutions and digital twins help reveal the data behind the sound

Every single violin – from a priceless Stradivarius to the violin a beginner plays in the school orchestra – has a unique personality. Besides subtle differences in the instrument itself, such as shape and form, varnish, age, wood types and manufacturing processes, string instruments are influenced by the musician's individual technique as well.

What is the secret to creating a stellar sound? What makes priceless violins so

exceptional that virtuosos clamber to play them? Genoa, Italy is the home of Il Cannone, a heritage violin dating from 1743, and an unusual team of violin researchers.

Professor Enrico Ravina and engineer Paolo Sivistri have been researching the acoustic performance of violins and string instruments for more than a decade, using a variety of Simcenter™ software simulation and testing tools to explore the data behind the sound. To gain insight into the construction process, Pio Montanari, master violin maker, joined the research project as did Pier Domenico Sommati, second principal



violinist at the Genoa Opera. Although not researchers, both Montanari and Sommati provide the hands-on experience and expertise required to help pinpoint what this novel research work will mean for the future of violinmaking and violinists around the world.

Art or science?

Although Sommati normally plays a violin dating from 1781 from Vincenzo Carcassi from Florence, he was more than eager to play one of Montanari's latest models for the test run. Using a customized sound array running Simcenter™ SCADAS hardware, test expert Sivestri collected unique acoustic data from Montanari's new handcrafted violin as well as heritage data from a 1781 violin.

"Very old violins are very different in the way they are constructed," Sommati explains. "It is quite a different world. New violins have their own positive acoustic effects. A new instrument is not necessarily going to sound worse than an antique one. You just have to get used to the instrument that you play."

"The goal of our project is not necessarily to reproduce classic violins, but rather to learn the secrets behind a certain type of acoustic performance," says Ravina, a full professor at the Polytechnic School of the University of Genoa and a member of the governing council of Associazione Liutaria Italiana (ALI - the Italian Association of Stringed Instrument Makers). "This might be the wood, the way it is constructed, the way it was repaired, the layers of different varnishes over the centuries, or how it was stored or used. The number of possibilities that affect a certain type of violin sound isn't necessarily a science. It is more of an art, and we are trying to discover the engineering behind this art to help violin makers create the best possible instruments today as well as offering a pool of research information for future restoration purposes."



“It is important to know the characteristics of a historical instrument to construct a good replica. This is why our work with Simcenter and Siemens is so useful.”

Professor Enrico Ravina
Polytechnic School, Università di Genova
ALI Associazione Liutaria Italiana

The data behind the sound

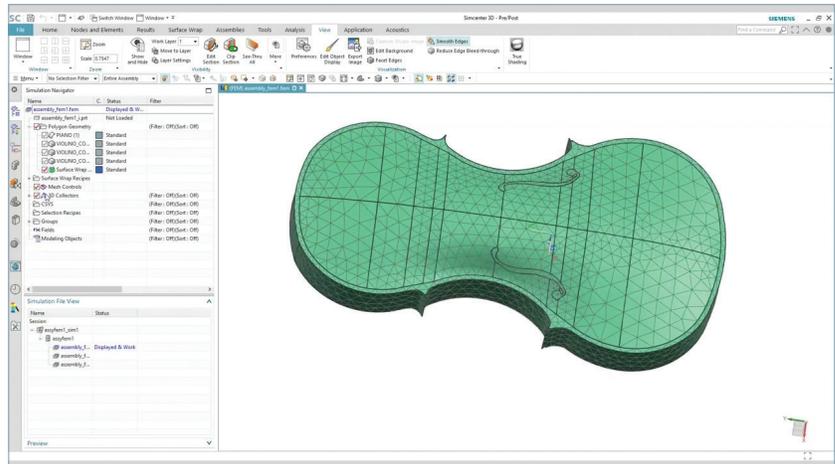
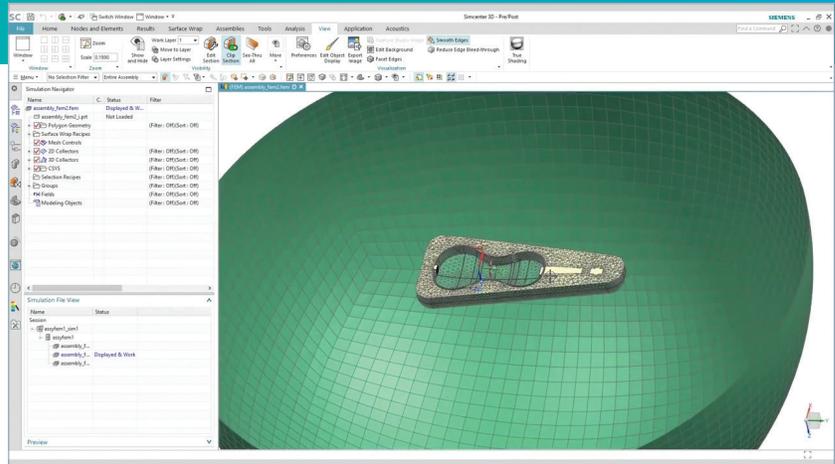
As the testing team and Montanari looked on, there was a tremor of magic in the air as soon as Sommati's bow struck the strings of Montanari's violin. Where did this magic come from? Where is the science behind the sound?

"I try to put something new into every instrument I make," says Montanari. "We have been working with Professor Ravina for over ten years and I have really focused on precise elements of the acoustics." Typically, it takes Montanari one month to finish a violin and several more weeks to varnish. He has made more than 100 violins in his career although he quickly notes that he spends a lot of his time repairing and adjusting instruments as well. At the moment, he has a special signature technique that includes varnishing with his fingers, which means, he quips, that he can save money not buying brushes.

"A master violin maker like Pio Montanari has to consider many different shapes today," says Professor Ravina. "Not every violin is going to be a Guarneri or Stradivari. It is important to test different types of shapes and learn what effects they can have on the overall sound. With a scientific project like this, you see the data behind the sound."

From MUSICOS to ALI

This research project did not evolve overnight. With the subject close to his heart, Professor Ravina started working on this topic more than a decade ago as part of the former MUSICOS organization, the Multidisciplinary Research Centre for Choral and Instrumental Music, at the University of Genoa. The activity of the former MUSICOS center ended in 2013, but Professor Ravina continued the research project at ALI which is based in Cremona, the home city of Guarneri and Stradivari, among others. ALI is directed by Professor Lucia Maramotti, a restoration expert. Within the ALI organization, there are several groups of researchers studying



different issues of stringed instruments. The project that Professor Ravina leads is oriented towards testing the vibrations and acoustical responses of instruments.

"For more than a decade, tools like Simcenter Testlab software and Simcenter SCADAS hardware have been very useful to study an instrument's behavior to gain information from a vibrational and an acoustic point of view," adds Ravina.

One of the key aspects that the researchers still appreciate is the high-quality analysis capability of Simcenter™ testing solutions. For more than a decade, the team has been gathering quality data by performing modal analysis using Simcenter™ SCADAS hardware and analyzing it in Simcenter™ Testlab™ software. Using this seamless setup, the team can dive into the data and investigate the optimal design and performance of violins

“With Simcenter 3D, we can quickly validate the importance of a test setup and explore other acoustic possibilities that we might not have thought about in a traditional setup. Technology like Simcenter testing solutions and Simcenter 3D simulation can play a significant role in understanding the sound patterns and real behavior of musical instruments in general, and in particular the violin family.”

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Polytechnic School, Università
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ALI Associazione Liutaria
Italiana



and other stringed instruments to improve the acoustics of future instruments and help restore ancient violins.

“To create a methodology that supports quality string instrument manufacturing is a huge advantage for the high-end market,” says Professor Ravina. “The fact that our work covers the restoration of classic instruments also makes our partnership with Siemens even more rewarding.”

The digital twin and the violin

More than a decade later, the project has progressed from modal analysis using the Simcenter testing solutions to a complete digital twin study. The team links the valuable data sets that they have accumulated over the years seamlessly into digital

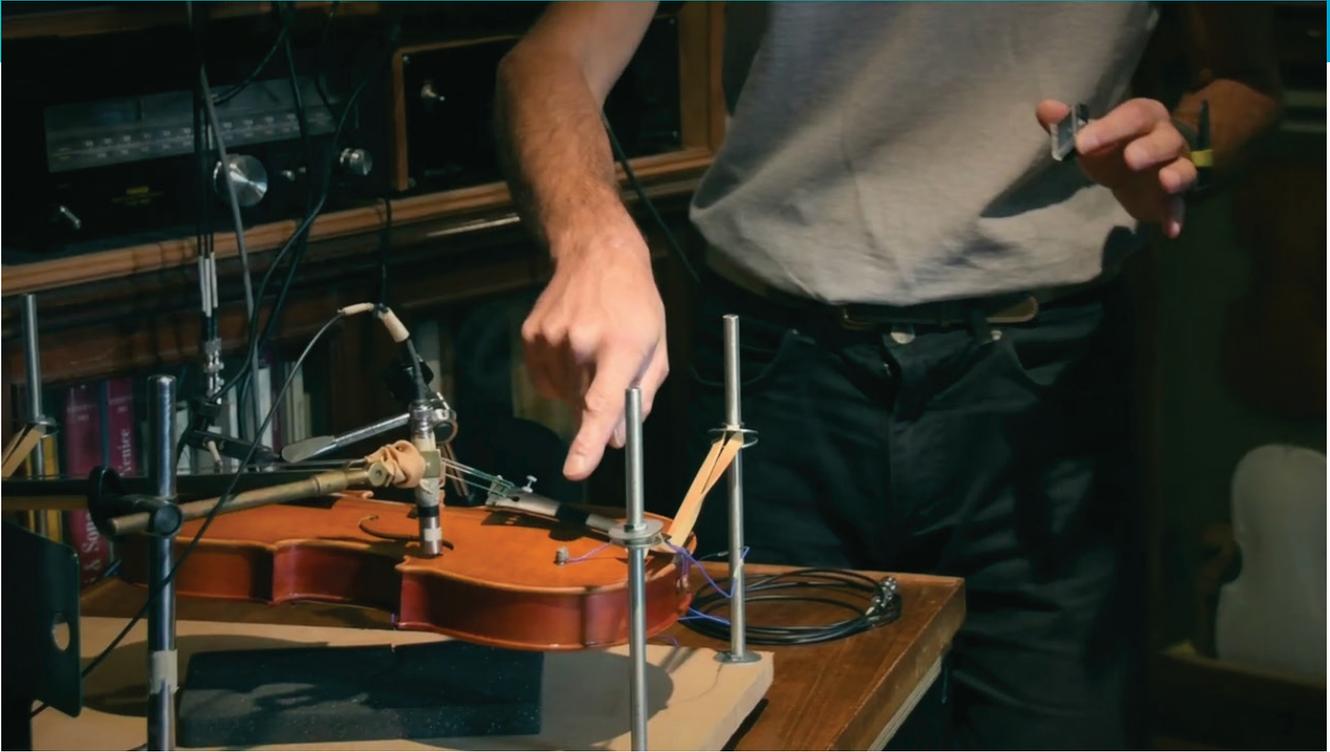
twin models for further analysis work. The latest digital twin is a model of a Montanari violin, created in NX™ CAD software, which can be further studied in Simcenter™ 3D simulation software to explore the effects of the various acoustic data sets. Potentially, it may be possible to create digital twins of priceless heritage violins for research purposes.

“With Simcenter 3D, we can quickly validate the importance of a test setup and explore other acoustic possibilities that we might not have thought about in a traditional setup,” Professor Ravina says. “Technology like Simcenter testing solutions and Simcenter 3D simulation can play a significant role in understanding the sound patterns and real behavior of musical instruments in general, and in particular the violin family. We have done some of our own innovating on the test setup side as well.”

A customized sound array

One example is a customized sound array in which the musician is surrounded by 10 distributed microphones on an arch. This setup is used to create a sound map of the acoustics created by the instrument in Simcenter Testlab. From there, Simcenter Testlab software can easily create a spherical mapping, giving information not only about the sound power of the instrument but also the directivity.





“Our low-cost sonic arch system is really purpose-built,” adds Professor Ravina. “The idea is to have the violinist in the best possible position to correctly map the sound generated by the instrument.”

Streamlined test setup

Besides built-for-purpose arches, another key factor to the success of the test setup is the ease and portability of Simcenter SCADAS hardware. Testing experts like Sivestri can simply take the 16-channel Simcenter SCADAS data acquisition system out of its carrying case and set it up. This makes it easy to install a test setup offsite in workshops or perform tests on historical instruments in museums.

“It is important to know the characteristics of a historical instrument to construct a good replica. This is why our work with Simcenter and Siemens is so useful,” explains Professor Ravina. “It is easier to move the software and test instrumentation than to move a famous violin like Il Cannone.”

The beginning of the digital journey

Both Professor Ravina and Montanari are quick to point out that this is just the beginning of the digital journey for the ancient profession of violin making. Both experts are certain the research work will have an impact on both traditional hand-crafted models and more mass-produced string instruments.



Solutions/Services

Simcenter Testlab
Simcenter SCADAS
[siemens.com/simcenter](https://www.siemens.com/simcenter)

Simcenter 3D
[siemens.com/simcenter3d](https://www.siemens.com/simcenter3d)

NX
[siemens.com/nx](https://www.siemens.com/nx)

Customer's primary business

Associazione Liutaria Italiana is a cultural association that binds together musical instrument makers, researchers and musicians to provide cultural and technical assistance to preserve the musical instruments' heritage and advance future development.

Customer location

Genoa
Italy

"You need to define the characteristics of old and famous instruments to make good replicas," Professor Ravina explains. "Our methodology supports the construction of the replica step-by-step using experimental and theoretical analysis. Our research is important because the violin maker requires specific information and many times this information is not available. This is why it is so important to have portable instrumentation like Simcenter SCADAS hardware and Simcenter software. They are easy tools to manage to have a prompt response for the violin maker during the construction of an instrument."

"It is very difficult to imagine what will happen in the future of violin making because of this technology helping us today," Montanari adds. "Even as technology becomes more available, we have to

maintain a sensibility that violin making is about personal construction. We don't want to forget that we have fingers and the ability to listen to a sound."

In the future, Professor Ravina hopes to continue to share his work with other experts on an international level. "As researchers, we don't have the knowledge of the construction or techniques," Professor Ravina says. "Our long-term partnership between the university researchers, the violin makers, the violinists, and Siemens Digital Industries Software has been very important, interesting and exciting. Looking forward, we are part of several international projects and I hope this will continue as well. It is very important and useful to compare results with other researchers and experts on an international scale."

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