



# Cutting Out the Whining

By Barry James

**You're sure to enjoy  
this insider's account  
of the development of  
Romax Technology's NVH  
breakthrough and benefits.**

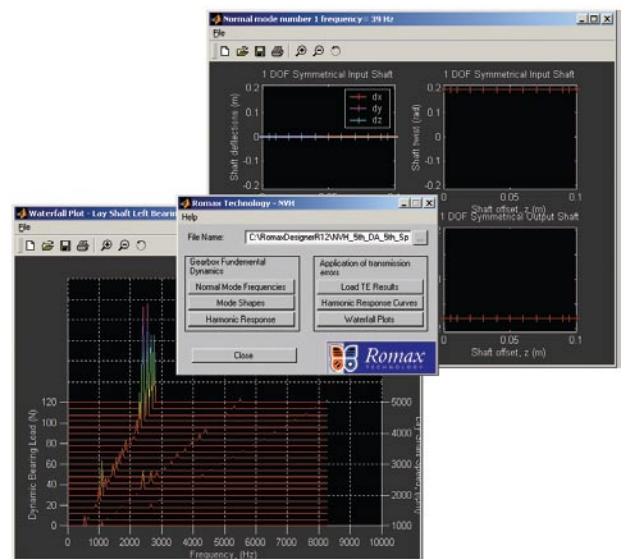
After celebrating the 20th anniversary of the founding of Romax Technology last year, long-time chief engineer Barry James recounts his experiences of noise, vibration, and harshness models and describes the exciting challenges that led to Romax's NVH breakthrough and completion of their award-winning technology.

My first experience of NVH models for transmissions came in 1993 when I was working for a UK-based consulting engineering company on an engine refinement project. My task involved carrying out the FE modelling and analysis, building each element by hand—no auto-meshed tetrahedral elements existed—defining each node and line one at a time. Since the focus was on engine firing noise, the transmission was relegated to a fairly simple model comprising shell elements for the casing and shafts defined as beam elements with the “rest of the transmission mass” evenly distributed along them. At the time, the client asked about noise from transmissions and if our model could be extended to deal with this. It was not the focus of the project, so we moved on and nothing more was said.

Three years later, having already completed a number of dynamics projects dealing with industrial machinery such as gas turbines and compressors, etc., I was working at Romax. We were interested in extending our well-developed RomaxDesigner static analysis models of geared systems to multiple shaft dynamics models, so we called in Dr. J. Derek Smith of Cambridge University: the man who literally wrote the book on “Gear Noise and Vibration.” He warned us of the complexity of what we were trying to do and concluded that our goal could not be achieved.

The difficulty of trying to predict transmission problems such as gear whine vibrations is that you need a complete, accurate dynamic model of the entire gearbox, including the effects of and interactions between all the internal components. As if this is not enough of a challenge, you also need an accurate estimate of the excitation causing the vibration, namely the transmission error. Of course, like most things in this world, a gearbox does not behave like a textbook linear structure. Its dynamic behavior is affected by the torque applied to it and, for automotive transmissions, which speed is selected. All of this had to be taken into account in our software tool.

Undeterred, we continued to develop our ideas further until in 2000 we achieved a major breakthrough. Following successful consultancy collaborations, a large Korean automotive OEM signed a deal to purchase our gearbox dynamic simulation tools. The static system model with shafts coupled via gear mesh stiffnesses in the line of action was extended to allow dynamic (modal) analyses. All six degrees of freedom were considered at each node in the system and the model could be excited by a predicted transmission error at the gear mesh. This allowed us to predict the dynamic forces at the bear-



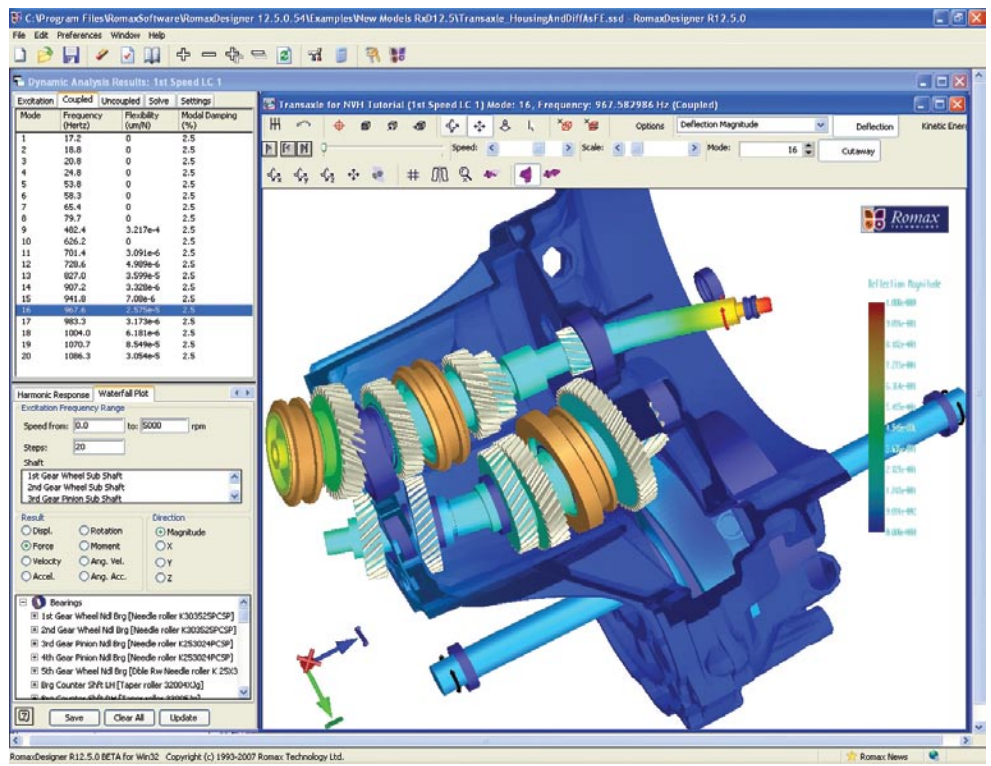
**Fig. 1: The first commercially available RomaxNVH software, a standalone post-processor to RomaxDesigner written in Matlab™ (2002).**



ic bearing forces that we were then able to predict. Essentially, they wanted to have a single source-path-receiver model from gear mesh to housing and beyond for gear whine noise which was fast enough to enable them to evaluate and optimize designs in the virtual world before cutting any expensive metal.

These requirements seemed daunting and, although at first there was some hesitation within Romax to commit to delivering them, our CEO, Dr. S.Y. Poon, had faith that we could accomplish this and so agreed a development project with our client to prove our capability.

Driven by our earlier successes, over the course of the next year we took up the challenge and worked hard to develop the two new technologies that would be required to satisfy our client. Predicting planetary gear transmission error is difficult and not just because there are more gear meshes to con-



**Fig. 3: RomaxNVH fully integrated into RomaxDesigner with full 3D animations (2008).**

## Romax as your NVH technology partner throughout the product lifecycle

The importance of noise and vibration performance on perceived customer quality can never be underestimated. It can easily make the difference between a "standard" and "premium" product. In fact, we have achieved many 'firsts' in the world on NVH - making the imaginative not only possible but now commercially available.

At Romax, we understand that NVH, durability and efficiency are not independent attributes. Our system level approach to transmission and driveline engineering allows us to optimize NVH quality without compromising other aspects of the design - a true design without compromise.

- Noise and vibration target setting
- Competitor benchmarking
- Design auditing
- Inherently quiet design
- Innovative design
- Component design for low noise
- Noise and vibration prediction
- Robust design optimization
- Driveline integration troubleshooting
- Rig and vehicle test design and methodology
- Manufacturing troubleshooting
- End-of-line test design
- Experience-based troubleshooting
- Analysis-based troubleshooting
- Design up-rating

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sider. In a planetary gear set the loads, misalignment and tooth contact behavior all change as the carrier rotates and every component interacts with every other component at the same time. Including the dynamics of the whole gearbox housing in the model is also challenging as the level of model detail required can make the analysis unacceptably slow.

The result of our endeavours was a vastly improved and infinitely more useful software tool (fig. 2). Our “Planetary Gear Transmission Error” prediction was the world’s first and only tool for the detailed system analysis of planetary gears with modelling and analysis runtimes suitable for optimisation and design purposes. Including the reduced mass, stiffness, and modal behavior of complex housings allowed us to predict vibrations anywhere on the gearbox surface. This had the added benefit of also allowing us to work with third party software tools to also predict radiated sound levels.

Our client concluded that “After evaluating several design and analysis tools and methods for the simulation of gear whine, we found that Romax best met the requirements of our Global Product Development System for decreasing time-to-market, saving us months of analysis time. Romax tools allowed us to transform the transmission NVH process from a test-based hardware iterative approach to a process focused on up-front design optimization. This new process not only provides cost savings by decreasing repetitive hardware testing, but most importantly makes it possible to design quiet transmissions more accurately than ever before. Furthermore, Romax provides the capability to perform structural analysis of an entire gear train system, including compound planetary gear sets of the transmission and hypoid gears of the axle. We believe Romax is the most efficient and effective tool for system gear whine analysis available on the market today.”

The software continues to develop (fig. 3) as we and our customers find more useful ways of exploiting this technology to produce better designs faster and at lower cost. This work gained us an honorable mention in the *Automotive News Pace Awards* in 2008, and was a significant contributing factor that helped Romax to win the Queens Award for a second time in 2009.

To date Romax has completed more than 40 consultancy projects in transmission NVH. Our capabilities have expanded and continue to expand, moving from gear whine to other transmission and driveline NVH phenomena. Gear rattle is another area where demand for better noise performance is growing, and Romax has already successfully used software tools that are in development to help solve real customer problems.

The desire for new capabilities continues to inspire us. This really is the Romax philosophy; we are always ready to embrace a challenge. Romax is a business, of course, and we are not here just to do difficult things for the sake of it. Making money is always the ultimate aim, but if we can enjoy ourselves through innovative technologies and by developing more “world-firsts” along the way, then I see no reason for us to stop now.

2009 marked the 20th anniversary of the founding of Romax Technology, Ltd. This kind of milestone is always an opportunity to reminisce about the past, and the spectacles at Romax are as rose-tinted as anywhere else. However, this is not solely an exercise in nostalgia—the future is just as interesting as the past. Taking the time to turn around and say “Look how far we have come” is usually followed by the response “Yes, but look how far we still have to go.”

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