Introduction

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Biographical notes: Christos Spitas is a Professor of Machine Design at the Nazarbayev University, Leader of the Space Technology Research Group and Leader of the Space, Industry and Transportation (SIT) Cluster. Prior to joining Nazarbayev University in 2015, he was a Full Professor and Head of the Product Engineering Section at the Delft University of Technology, Leader of the Design Cluster of the Delft Centre for Materials (DCMat), Leader of the Design Cluster of the European Platform for Sports Innovation (EPSI), and Founder of the European Academic Network of Product Engineering (including TU Delft, ETHZ, KIT, NTUA). Since 2006, he has led over ten applied research and technology development projects funded by the European Commission (FP6-7), the ESA, Toyota, and Kawasaki.

The transmission is a critical part of any vehicle powertrain. Selectable ratio transmissions are very much at the centre of current ongoing research and technology development, with the trend being to move towards a replacement of manual transmissions with ATs, DCTs and CVTs not only in sports and luxury vehicles, but throughout the entire range of vehicle roles and prices. Gear macro and micro-geometry and mechanical behaviour are in this context strongly coupled, with a particular focus on error and misalignment tolerance, as are clutch systems and bearings. The role of compliance, friction and thermo-mechanical interactions and their coupling to efficiency is gradually being better understood as several studies continuously provide more and deeper understanding of what used to be modelled as a single degree of freedom spring and damper system. Adding to the already significant complexity of a single gear mesh is the fact that several power transmitting and idling meshes interact at any time within a transmission system, producing complex and to some extent self-exciting dynamical phenomena.

In new electrical and hybrid vehicles the DC electric motor characteristics are very different from those of the traditional IC engines, able to supply near-constant torque over a range of speeds, so that the need for shifting and selectable ratio transmissions is diminished or eliminated and even direct drive systems, with the help of a central transmission or with a motor at each wheel, are by now an established possibility. However, this benefit comes at a cost due to the much larger weight of DC motors of sufficiently high torque to perform this role. There is therefore a strong incentive to move towards lightweight high-speed low-torque DC motors, coupled with high ratio planetary gearboxes. High speed ratio and high efficiency have always been difficult to reconcile and this dilemma once more becomes very relevant, with ratios between 30–100 and input speeds above 100,000 rpm challenging what current technology can deliver. Once

again, therefore, new transmission innovations become important, in order to increase the efficiency, speed and load rating of planetary gearboxes. Dynamical modelling, topological optimisation, and novel stronger more efficient tooth forms and bearing configurations is key emerging directions in the upcoming innovation.

Such were the discussions at the 3rd ICAVP in Hangzhou, China. Following that, a number of participating experts were asked to elaborate on the latest developments in their related research, giving birth to the present special issue on ‘Vehicle transmissions’, which I hope will be a good reference on the way forward towards the vehicle powertrain technologies of the next five years.