Computational methods have radically changed the way engineers design materials, products and manufacturing processes. Numerical simulations are used to save resources, e.g. by reducing the need for expensive experiments, to predict and optimize properties that cannot be measured directly, such as the microstructure of a material in a production process, and to explore new processes and parameter ranges in known processes that are not easily accessible experimentally, e.g. if this would require expensive new equipment. The industrial needs have been a steady driver for innovation in the numerical simulation of manufacturing engineering processes. In the automotive industry, for instance, it has become common practice to design metal parts and the corresponding manufacturing processes ‘virtually’ before building expensive tool sets. In materials science and engineering, the computer-aided development of new materials has started to replace the ‘alchemistic’ way of materials design.

With the availability of vast computing power, the development of parallel processing and robust numerical methods, it seems that not only individual manufacturing processes could be simulated but that the entire processing chain of a product ‘from the cradle to the grave’ could be designed virtually. This scenario is currently being pursued in the emerging field of ‘integrated computational materials engineering’ (ICME), which is an integrative approach for developing products, materials and the corresponding manufacturing processes by coupling of simulations across physical length scales and along the manufacturing process chain.

Matured numerical simulation, as well as experimental diagnosis in manufacturing and materials engineering create data sets that are difficult to interpret. The data sets are sparse in multi-dimensional parameter space since their generation is expensive. Using standard methods for data manipulation, like optimization criteria, supporting decision-making is difficult since the data are often discrete. Also, immense data streams created in the shop floor by sensors and computerized
quality management are not well suited since they tend to be unnecessarily dense. Model reduction, meta-modelling and visualization approaches are hence needed to prepare, explore and manipulate the raw data sets emerging from manufacturing metrology and virtual production.

This session deals with state-of-the-art methods of virtual production systems, which enable the planning of manufacturing and production processes, the handling of raw data sets and the development of new materials. Two key issues are addressed:

The paper “Meta-modelling techniques towards virtual production intelligence” addresses the problem of handling data sets and generation of information by means of meta-modelling techniques. In the example of laser sheet metal cutting it is shown how meta-models can be used to reduce complexity and allow decision-making.

The contribution “Designing new forging steels by ICMPE” envisions the next development step of ICME by achieving coupling to production engineering. The benefit of the resulting field of Integrated Computational Materials and Production Engineering (ICMPE) is shown with the aid of newly developed forging steels whose microstructure is designed by controlling precipitation kinetics and structural size using closely interacting alloying and processing concepts.