Tessella
Technology & Consulting

Modelling and Simulation

Tessella's expertise in creating and implementing models in contexts ranging from clinical trials to satellite control systems means that we can solve your most complex technical and business problems in a highly cost-effective way.

Models are used to solve a huge variety of problems, from traffic management to crop growth predictions. Modelling and simulation of systems can provide low-cost solutions for product development, system performance assessment and interactive training.

Simulation provides a method for developing, analyzing, modifying and testing systems without physically building them, with the associated cost benefits. Problems in operation or performance can be identified earlier in a project, and potential solutions developed and verified rapidly.

We have worked with a range of customers over the last three decades in developing new models, and in making existing models and simulation tools more robust and easy to use. The breadth of clients that we work for enables us to 'cross-fertilize' and build on ideas from different businesses.

Our clients are world-leading scientific and engineering organizations with demanding and varied modelling and simulation needs.

Our experience includes model building and simulator development projects in diverse business sectors such as

- Life sciences
- Energy
- Public sector (including defence, space, transport and environment)
- Consumer industries

Tessella's expertise, wide-ranging experience, and certified Quality Management System mean we produce models and simulations you can rely on. All our consultants and software engineers have scientific and engineering backgrounds, so you get a team who can not only develop quality algorithms, models and simulations, but who can also talk your language and get to the bottom of your needs.

Life Sciences

Over the years, developments in the enabling sciences and technologies used by the life sciences sector have led to an exponential increase in the amount of data that is managed, processed and analyzed.

Tessella is a leading independent supplier of software solutions to the pharmaceutical, agrochemical, biotech and medical communities.

Our experience of modelling and simulation in the life science sector includes:

- Development of pharmacokinetic and pharmacodynamic (PK/PD) system models
- Correlation of models with clinical data
- Development of PK/PD simulation tools supporting Monte-Carlo simulation of patient populations
- Clinical trials simulation
- Software to support dosing selection for trials and 'what-if' analyses

Adaptive Clinical Trials Simulation

The drug development process is suffering from increasing costs and a decreasing success rate. Running clinical trials is the most expensive and time-consuming aspect of drug development. Developing better ways to run clinical trials that optimize the learning on those trials whilst minimizing the risk to patients and maintaining the statistical validity of the data is critical to improving the drug development process.

Since 1998, Tessella has been helping to drive innovation in drug development by enabling the deployment of adaptive clinical trials. Adaptive methods increase the efficiency of clinical trials by taking account of the data being gathered as the trial runs, leading to more effective use being made of the subjects treated in the trial and enabling better informed and quicker decisions to be made about the drug being developed.

Adapting the allocation towards the dose most likely to meet the target criteria (e.g. a dose which has a particular mean response), and modelling the dose response, increase the accuracy of the final estimate of the drug's dose response compared to conventional designs. Continuously monitoring the termination criteria allows failing trials to be stopped, preventing subjects being exposed to ineffective treatments and saving the sponsor company considerable wasted expenditure.

Tessella's Adaptive Trials Simulator is built around a flexible core design for phase 2 dose finding studies developed by Berry Consultants, the leading biostatisticians in the application of Bayesian statistics to clinical trial designs. The design includes options for a longitudinal model, used to predict patients' final outcomes from their early responses, and a dose response model, used to estimate the response across the range of doses being tested. The resulting Bayesian probability model is then used to estimate the probability that each dose conforms to the user's selected target criteria for the trial. These probabilities can be used to recommend which doses to favour when allocating the next patients, or, alternatively, terminating the trial when there is sufficient certainty that the desired target dose has been located, or when there is sufficient certainty that no dose is sufficiently effective.

In designing and optimizing a clinical trial protocol, it is necessary to predict how a proposed design will behave over a large range of possible drug behaviours. Significant numbers of simulations are required. Implementation of the models as Fortran executables and careful selection of numerical algorithms allow the simulations to be run as swiftly as possible. The time taken to run 1,000 simulations of a design on a standard laptop is typically 1-2 hours, for an average phase 2 dose finding design. To accurately determine the operating characteristics at the final stages of design, 10,000 simulations may be necessary for every combination of design and scenario being evaluated.

The user interface of the Tessella Adaptive Clinical Trials Simulator provides tools to manage all these simulations and integrates with computing grid software to allow large numbers of simulations to be run in parallel on a network of machines.

Energy

The world's energy businesses face new challenges from an ever-increasing demand for energy, together with dwindling natural reserves and a need to consider environmental and safety issues. Greater competition drives the need for consolidation and cost reduction, and the challenge for our energy sector clients is to stay ahead of the game by taking maximum advantage of advances in technology.

Tessella has been providing the energy sector with modelling expertise for many years. We can provide expertise in risk modelling, financial scenarios, pipeline network modelling, heat transfer simulation, asset models, dispersion simulation, statistical modelling (particularly using Bayesian statistics) and in many other areas.

Risk Modelling with Shell Global Solutions

Shell Global Solutions (UK) Health, Safety and Environment (HSE) Consultancy has gained worldwide recognition as an expert in the management of loss prevention and accident hazards on large chemical and industrial sites. The experimentally-validated software models used by the HSE Consultancy now form the basis of a number of commercial hazard analysis products. Shell Global Solutions (UK) approached Tessella to assist in the support and development of its hazard and risk model suite. They wanted to improve the Quality Assurance of their software development process to ensure high levels of quality and traceability, and thus reassure their customers that risk and hazard assessments are correct first time.

Tessella has extensive experience of writing scientific engineering programs within a rigorous quality system. We have managed the development and support of all commercial software sold by the HSE Consultancy since 2001. All Tessella activity is performed within our TickIT quality management system, accredited by the BSI to BS EN ISO 9001. Technical recommendations, based upon non-conformities against Tessella coding standards, were made to improve the long-term maintenance of the software.

Recommendations from the quality audits highlighted areas for improvement in maintenance processes and included a validation test strategy. This test strategy related experimental data to models within the software code, generating a series of test cases to ensure that each software release conformed to validated experimental data.

Financial Modelling for British Nuclear Group

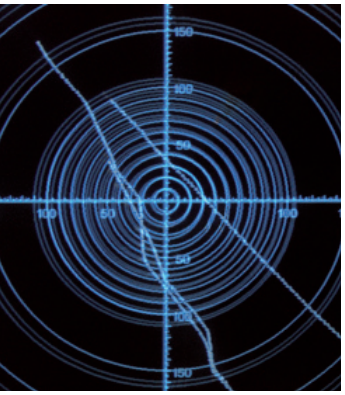
British Nuclear Group proposed a new hedging model to support their trading operations. In order to fine-tune and verify the model it was necessary to carry out a large number of Monte Carlo simulations. Because British Nuclear Group did not have the computing or human resources available to perform these simulations themselves, they turned to Tessella for help.

Tessella developed a wrapper for the new hedging model so that it could run in a Grid computing environment. Tessella used Condor, a shareware product, together with some of the technology behind the Tessella Grid Technology Infrastructure (GTI), which combines Condor technology with an ergonomic web-based user interface, allowing central control and user security.

Tessella's solution had to overcome a number of technical difficulties. Because the model was tied to a third party product based on Microsoft Excel, the simulations required Excel to be run within Condor. Furthermore, the model used input data from a central database, which meant that network access was also a requirement.

In order to demonstrate the validity of the model, over 50,000 Monte Carlo simulations were carried out over a period of three weeks. During this time the Grid approach ensured that all available CPUs were used to maximum effect, and that all results files were grouped together in a single location.

Following on from the success of this project, Tessella worked with the client to turn the hedging model into a robust and user-friendly application for use by energy traders as part of their daily activities.



Defence

Whether it be a guided weapons platform, a state-of-the art sensor system or a multi-function radar, today's defence solutions rely heavily on complex modern technology coupled with innovative and intricate algorithmic design. For these reasons, mathematical modelling and simulation play a key role in developing, tuning, analyzing and assessing such systems.

Tessella has extensive defence experience working both directly with the UK Ministry of Defence (MoD) and supporting prime contractors on major programmes. Our expertise covers radar target tracking, data fusion, guided weapon guidance, navigation and control (GNC), risk and cost-benefit analyses, and systems engineering.

Simulations have played a key role in many of these areas, in some cases essentially providing the reference model of system performance and operation against which the developed system is compared. Our capabilities and tools ideally equip us to support current and emerging military systems in order to meet ever more demanding specifications.

SAMPSON Radar Target Tracking Algorithms

The Type 45 Destroyer, for which BAE Systems are the prime contractor, will be a key part of the UK Royal Navy's air defences for the first half of the 21st century. When the first ship of the class enters service it will be one of the most advanced warships in the world. Crucial to the success of the Type 45 will be the SAMPSON radar, which will combine surveillance and dedicated tracking roles into a single system.

As an active array radar, SAMPSON can electronically shape and direct its beam, allowing multiple functions to be carried out simultaneously. SAMPSON is being designed, developed and delivered by BAE Systems Integrated System Technologies Limited (Insyte).

Automated tracking algorithms are necessary because of the large number of targets visible and to support the Principal Anti Air Missile System (PAAMS) fire control. Tessella developed tracking algorithms, and provided expertise in radar, complex systems design, and detailed mathematical modelling for the Type 45 project. Interesting and complex areas of development include plot-track association, development of tracking filters and analyzing the closed-loop system.

Algorithms have been developed by detailed mathematical understanding and investigation, supported by a complex simulation of the radar system and integrated tracking algorithms. This provides the capability to test algorithms in the closed loop environment. In addition, comprehensive and innovative output graphics are included to facilitate data analysis.

The expertise of BAE Systems (Insyte) with support from Tessella has enabled development of a system which represents a major technological advance in terms of surveillance and tracking performance.

Space

The complexity of any space mission presents unique technical challenges. Meeting these challenges typically requires extensive use of modelling and simulation. Tessella has expertise gained on a variety of missions across many applications, in areas including:

- Attitude and orbit control subsystems
- Descent and landing subsystems
- Systems engineering
- Mission analysis

Design, analysis and performance assessment within these areas make extensive use of mathematical modelling and simulation tools. This expertise provides a unique combination of skills that have been proven to deliver robust, compliant solutions to tightly-specified space platforms.

GIOVE-A Attitude Control

Tessella contributed to the prestigious European Space Agency contract to provide the first test satellite, GIOVE-A, for Europe's global navigation system, Galileo. The prime contractor for supply of the mission was Surrey Satellite Technology Ltd. This critical first step in a huge programme provided the first of a set of navigation satellites, to a demanding schedule, which had to be ready for launch in time to lay claim to the radio frequencies allocated to Galileo.

The GIOVE-A satellite requires a high degree of accuracy in Earth-pointing to enable the payload systems to operate successfully. Tessella supported SSTL in the design, analysis and performance assessment of all the attitude control mode algorithms. Final verification of the robustness of the solution was provided by performing a set of nominal, worst-case, and Monte-Carlo scenarios using a high-fidelity simulation of the system and the algorithms.

This simulation includes models of:

- The spacecraft itself, including flexible modes and fuel slosh effects
- Sensors and actuators, including delays, errors, misalignments and non-linearities
- Guidance and control algorithms
- Disturbing forces and torques

The project culminated in a successful launch for the GIOVE-A satellite. Tessella's attitude and orbit control algorithms have performed flawlessly in orbit, contributing to the successful mission outcome.

Transport

Finding effective transport solutions is becoming ever more important for governments and travellers as the growth in passenger and freight traffic continues. Increasing demand is putting more and more pressure on the existing infrastructure. Our expertise covers a wide spectrum of transport system solutions such as traffic modelling, decision support systems, asset condition monitoring, and rail track design.

Traffic Modelling with TRL

TRL Ltd, the UK's Transport Research Laboratory, provides research, advice and solutions on all transport issues. TRL works with governments, international funding institutions and private companies.

A number of factors can influence the flow of traffic on the roads: accidents, road works, and peak demand flow levels. Several strategies can be adopted to limit traffic congestion and reduce delays, but it is not always a simple task to decide which strategy would be most effective for a particular scenario.

TRL had developed a model for motorway traffic flow, called Simulation of Strategies for Traffic on Motorways (SISTM), to assess the effect of different road layouts, driver behaviour and increased traffic volume. The SISTM model is a microscopic real-time traffic model simulation that dynamically models ramp metering and variable speed limit systems, taking into account shockwaves and exit management. SISTM incorporates a model of drivers' psychological behaviour, such as aggressiveness and awareness, and different vehicle characteristics such as maximum speeds and acceleration capabilities. The UK Highways Agency owns the IPR of SISTM and funds other organizations to develop it further. TRL is the main user of the SISTM model.

Tessella helped TRL improve the simulation engine at the core of SISTM by updating the calculations to use real precision in standard units. Tessella also examined the use of incident detection algorithms to model statistical properties of traffic flow which could be calibrated to respond to flow breakdown. The model is used to dynamically impose speed restrictions on the M25 motorway in an attempt to improve the driving environment.

Environment

Public awareness of environmental issues, such as climate change, the depletion of the ozone layer, flooding, pollution, waste and habitat management, has increased over the past few years, leading to legislation, taxation and changing technologies that affect all businesses. Tessella has over fifteen years of experience working with environmental science organizations to implement cost-effective, reliable and innovative solutions. Our expertise is amply demonstrated through the broad range of environmental software we have worked on, ranging from hydrological information systems to using grid computing to model the future climate.

Groundwater modelling

For a number of years Tessella has worked to support the Environment Agency for England and Wales (EA) in groundwater modelling. Groundwater modelling involves modelling what water actually does in the ground, taking into account the geology and physics of each location, rainfall, rivers, streams, lakes and reservoirs and processes which remove water from the ground including boreholes and evaporation. The Environment Agency uses groundwater modelling to:

- Develop mitigation scenarios for possible droughts
- Assess the impact of abstracting large quantities of water
- Enable it to comply with the European Union's Habitats Directive

Groundwater models have been in use by the EA for many years. Numerous modellers were working in different parts of the EA, and within the UK water companies; however, it was difficult for good practice, models, systems or results to be shared and exploited for common good. The EA could see the potential benefits of bringing the groundwater modelling communities together.

Tessella had previously developed the EA's National Flood Forecasting System (NFFS), based on our previous work with Delft Hydraulics. The NFFS is now in use throughout England and Wales, and proved valuable during the July 2007 floods of the Humber, Severn and Thames rivers. A key aspect of the NFFS is that it allows models to run under a managed architecture, without the individual modeller needing to worry about how or where their model runs.

It was realized that the architecture underpinning the NFFS might be able to be adapted to support groundwater modelling. Building on the partnership delivering the NFFS, Tessella and Delft Hydraulics have supported the EA's investigations, working with them on a feasibility study, requirements collection, design, pilot and implementation of the National Groundwater Modelling System (NGMS) for England and Wales.

The NGMS provides a centralized managed run-time environment for the execution, storage and analysis, of models and results, based on standard IT hardware and infrastructure. Modellers can submit their jobs to run either immediately or at a pre-defined time, and can easily view input and results datasets, and extract subsets of data. There is central storage of model datasets, results, reports and configurations. The system includes good visualization facilities for input and results datasets. Due to the large input/output datasets, efficient data transfer and synchronization mechanisms have been expanded from their original implementation in the earlier Flood Forecasting System.

In parallel with the IT development, the EA's groundwater modellers have been refining their working practices to enable them to take full advantage of the new system, including developing standard nomenclatures, and standard GUI interfaces for their models.

The introduction of the National Groundwater Modelling System for England and Wales will ensure a greater standardization of future groundwater models within the UK, which promises to make them easier to keep up-to-date and ready for operational use. The wider availability of tried and tested models will enable more staff to use them to make key regulatory decisions.

Consumer Industries

The consumer industries sector is one of the fastest-moving and most competitive industrial areas. Uses of modelling and simulation range from the development of new or improved products, through optimizing the supply chain, to understanding the dynamics of the market itself.

Agent-Based Modelling with Unilever

Unilever is one of the world's leading manufacturers of consumer goods. There are many factors that affect the selection of goods by consumers, including their brand loyalty and the product's characteristics, price and availability. Using an Agent-Based Modelling approach, simulations can be created that provide insights into the effects of such factors on consumer choice.

An Agent-Based Model is a computational simulation of a group of autonomous individuals within a set environment. Each individual, or agent, performs actions using the information available from the environment and a set of rules unique to that agent. Using only a small number of a priori assumptions about the behaviour of each agent, macroscopic system behaviours can be observed during the simulation as emergent behaviour.

Tessella has aided Unilever in developing Agent-Based Modelling systems to understand the retail sector. This included development of a retail market simulation that models the competition between rival brands. The model consists of a set of firms each selling a product to a population of consumers. Each consumer agent is modelled individually and is unique in its tastes and preferences. Purchase decisions are made based on the match between their ideal product and those products actually available, the price, advertising and the necessity for a purchase due to their consumption rate.

Agents are also able to exchange information with each other using social networks, and in doing so become part of the feedback loop which affects and is affected by these interactions. In addition, every firm is an independent agent that adapts its strategy based on its beliefs about its rivals' strategies. This involves setting the product price and changing the product characteristics.

The market simulation model has revealed valuable insights into the dynamics of a competitive market. Tessella continues to work with Unilever on improving the model with additional market variables, and validating the model using retail data.

The benefits of modelling and simulation

Modelling and simulation can fulfil a variety of roles in enhancing the chances of project success, including:

- Establishing system worst-case performance
- Compliance verification
- What-if and sensitivity analysis
- System robustness and degradation under failure
- Performance tuning and optimization
- Solution trade-off analysis

Tackling the modelling of a process or an operation can involve many possible techniques, all of which may require mathematical and software development, including:

- Dynamical models of physical systems
- Algorithm simulation
- Statistical modelling
- System identification
- Monte-Carlo analysis (also known as ensemble modelling)
- Risk analysis

The accuracy, fidelity and precision of the simulation have to be balanced against its execution speed, development time, and role on the project. It is important to determine the level of detail appropriate to the modelled system and the simulation's purpose: too little and the results will be meaningless; too much and unnecessary effort will be expended.

Moreover, it is crucial that the model is correct. Validation, verification and calibration should be used to check that the theoretical model accurately describes the system being modelled, and that the software model conforms to the theoretical model.

The ability to archive model runs may be critical in some fields, for example where a model has been used to justify a decision that may undergo later legal scrutiny.

As well as the projects already described, some of our other modelling projects include:

- Aviation systems
- Gas pipelines
- Human eye modelling
- Climate prediction
- Radioactive waste
- Train services and rail condition monitoring
- Asset modelling
- Air bag sensors
- Medical devices
- Inflatable landing systems
- Precision instruments and devices

Contact Tessella to find out how we can use our unique blend of scientific, engineering and IT skills to solve your most complex technical and business problems.

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Tessella – successfully delivering IT and consulting services to world leaders in R&D, science and engineering.

For decades, Tessella has been successfully delivering IT and consulting services to world leaders in R&D, science, and engineering. Through the application of scientific methods and rigorous quality procedures, we enable clients in life sciences, energy, the public sector, and consumer industries to achieve a wide range of objectives, including, forecasting floods, developing fusion power, enhancing military sensor capability, improving drug discovery and development efficiency, and reducing risk to health and the environment in the extraction and production of oil and gas. With offices in Europe and North America, global companies rely on Tessella for business critical assignments.

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