



Modelling explosive risks

Tessella's experience in risk modelling and hazard assessment ranges from creating new models of the consequences of an accidental explosion in a weapons storage facility, to developing sophisticated software tools to model the effects of an explosion on an offshore oil platform.

Tessella have developed, implemented and tested consequence models, and developed sophisticated software tools to support the risk assessment process. Specific examples of our experience include:

- Implementation and verification of explosives consequence models for the MOD's Defence Ordnance Safety Group.
- Development of a weapon fragments consequence model for a new weapon type.
- Development of software tools to support quantitative risk assessments, including for sites where explosives are stored and for major oil drilling projects.
- Development of software tools to model and assess major accident hazards in offshore oil and gas facilities.
- Consultancy for the oil and gas industry to improve the existing software tools.
- Development of a tool to help visualise the relative importance of different hazards.

Explosives site risk assessment

Tessella's work on the analysis of consequence models and development of tools for site risk assessment has been performed for the MOD's Defence Ordnance Safety Group (DOSG), part of Defence Equipment and Support (DE&S).

Verification of consequence models

Tessella have performed work to verify explosives consequence models. The key features of the explosives models are:

- The models include the effects of blast, thermal effects, building debris and weapons fragments (for above- and underground storehouses), considering people out in the open and in buildings.
- The models consider fatalities due to:
 - Primary effects: thermal models: direct heat injury; blast models: effects such as lung haemorrhage; weapon fragment models: impact by weapon fragments

- Secondary effects: thermal models: death or injury due to fires ignited by the heat, particularly for people in buildings; debris models: being struck by debris, usually the brick or concrete of the explosives storehouse or the rock and soil overlayer of an underground storehouse; blast models: long range effects such as laceration by broken glass
 - Tertiary effects: blast models: injury following bodily displacement
- Some of the models used are based on theoretical considerations (e.g. modelling of combustion and heat flux as a function of position; scaling blast effects as a function of distance and amount of explosives), whilst others are empirical or semi-empirical (e.g. observed casualties from secondary effects of a blast at longer distances, distributions of fragment mass, and velocity based on experimental trials).
- Some of the models and research documents discuss the probability of serious or minor injury as well as of fatality, though currently the focus is on fatalities.

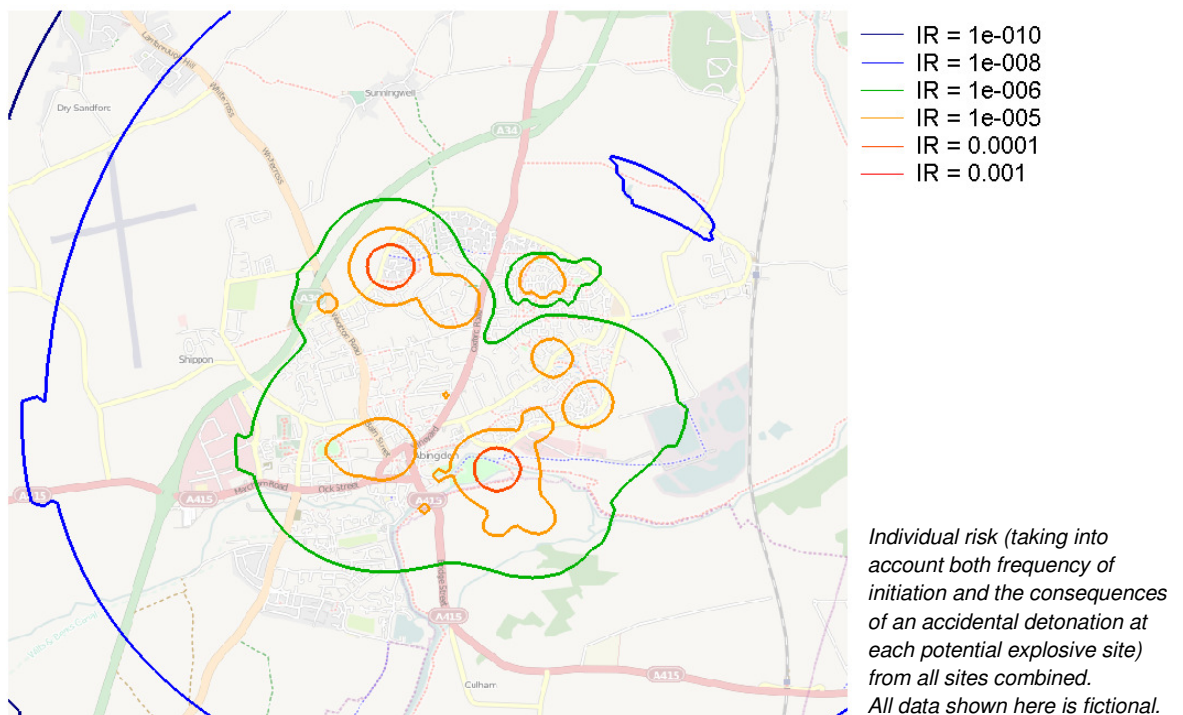
Tessella's contributions to verification of the models include:

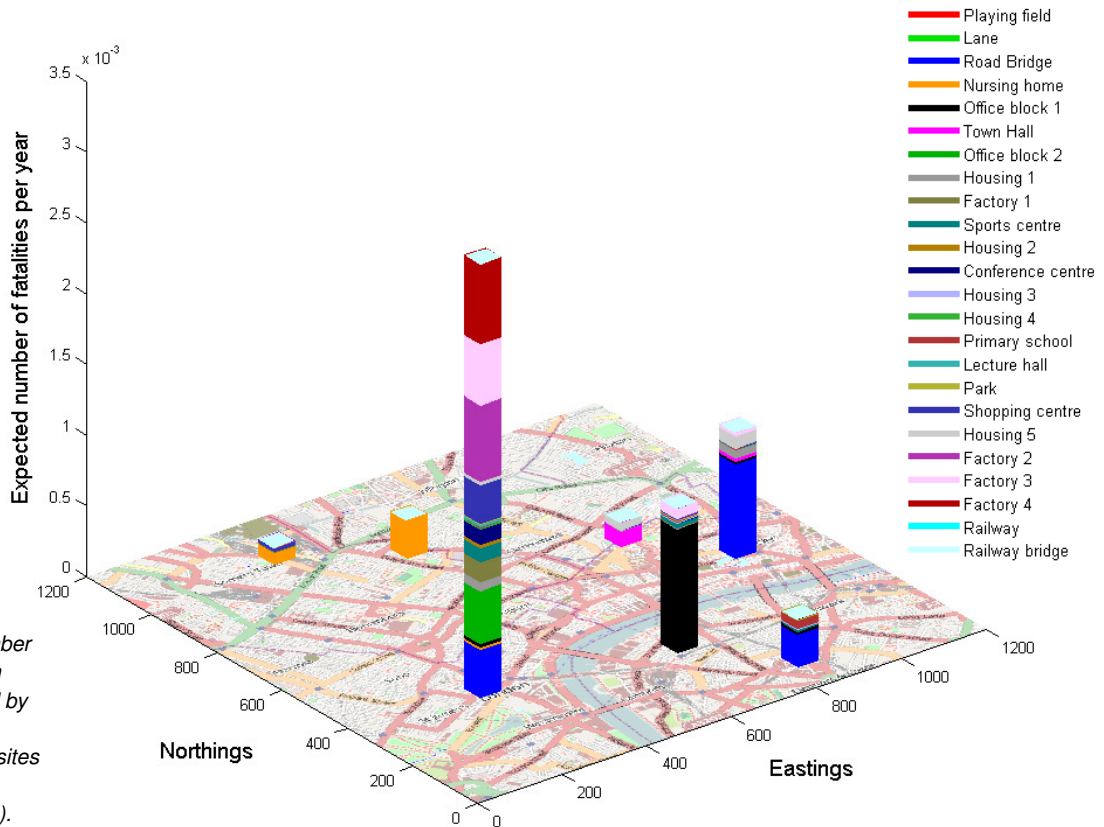
- Comparing the results of existing software models with the original documentation to identify errors in implementation.
- Re-implementing selected consequence models in MATLAB.
- Identifying potential improvements in the model and the areas where additional experimental data would be most valuable.

Software tools to support risk assessments

Tessella have developed several software tools to support risk assessments:

- Sophisticated tools which use the consequence models in support of a Quantitative Risk Assessment process. Features of the tools include:
 - Graphical user interfaces to input parameters efficiently.
 - Importing geographical data (location of buildings etc) generated by the ArcGIS tool, to facilitate site definition.
 - Data can be imported from external population database.
 - Detailed representation of time-varying populations, which can be sub-divided by category in the database, to distinguish workers and residents etc., and specified by times of the day, days of the week or the days of the year that they are present. Only the populations that coincide in time with the potential for an explosive event need be included in the risk calculation, leading to more accurate estimates of risk.
 - Calculating the probability of fatality for all potential explosive events as a function of location (conditional risk), the consequences of an individual accidental detonation event, individual risk and societal risk.
 - Visualisation: risk contours, graphical representation of societal risk, etc.





Societal risk: expected number of fatalities per year at each populated site (represented by the different colours) due to various potential explosive sites (the towers, shown at their actual locations on the map). All data shown here is fictional

- A software tool to quantify the effect of uncertainty in input parameters on the outputs from the consequence models:
 - Range analysis: to visualise the effect of varying a single parameter between its minimum and maximum values.
 - Sensitivity analysis: to determine the sensitivity of the results to uncertainties in the model parameters.
 - Monte Carlo analysis: to visualise the effect of statistical distributions applied to selected input parameters.
- A generic hazard assessment tool to compare and rank a collection of hazards by risk. Consequences are expressed as “equivalent number of fatalities”, where an injury is considered to be equivalent to some fraction of a fatality.

Weapons fragment modelling

Tessella have developed a weapons fragment consequence model for a new weapon type:

- Fragment trajectory calculations, including ballistics and the effect of air resistance.
- Calculating probability of fatality using an 80 J fatality criterion.
- Evaluating the sensitivity of the fatality probability distribution to the 80 J criterion.

Risk analysis in the oil and gas industry

Tessella have supported risk modelling and analysis for a number of clients in the oil and gas industry, including oil majors BP and Shell. The work has included improvements to the quality of existing software as well as the development of new software tools.

Risk analysis software tools

Tessella have developed tools for clients in the oil and gas industry:

- Development of Offshore Major Accident Risk (OMAR) software tool for use in assessing and modelling the major accident hazards associated with BP’s offshore facilities:
 - Capturing the 3D structure of an offshore oil platform using a sophisticated GUI to allow the user to graphically construct the model.
 - Modelling the distribution of people for different operations and times of day.
 - Event-tree modelling: an initial event leads to consequences, population movement, and subsequent events. This leads to many end-points of the tree, each with its own frequency of occurrence.
 - Complex models of fire and explosion propagation were distilled into a suitable form for use in the tool.

- Development of a bespoke Quantitative Risk Assessment system for the Kashagan oil field consortium
 - The Kashagan field suffers from extreme conditions, including temperatures which can range from -35° to 40° C, and a large amount of highly toxic and corrosive hydrogen sulphide gas in the oil.
 - The consortium turned to Risktec Solutions, an independent specialist in risk management consulting. Tessella helped Risktec to develop solutions for Quantitative Risk Assessment.
 - A bespoke solution was chosen as a more cost-effective and flexible alternative to an off-the-shelf package.
 - Tessella's solution, based around an SQL database, is fully transparent and flexible, down to control over all of the variables used in the algorithms. It has enabled a more sophisticated, tailored and comprehensive risk analysis compared to off-the-shelf packages. The solution is very reliable and easily shared by users in different locations. The software allows complex "what if" analyses, produces plots of risk levels and supports risk-based decisions.
 - The tool supports more informed planning and design for safety, especially for plant layout, manning and protection of workers. Overall this innovative approach to quantitative risk assessment will help the consortium achieve their challenging field development programme, while enabling higher levels of safety.
- Development of a software tool to perform a transparent quantitative risk assessment for offshore oil drilling facilities:
 - Event tree analysis: the original fault may lead to a range of outcomes. Each outcome's associated consequence model generates a spatial distribution of a physical quantity.
 - Vulnerability models convert these spatial distributions into fatality spatial distributions.
 - Calculates Location Specific Individual Risk (LSIR), Individual Risk Per Annum (IRPA), Potential Loss of Life (PLL) and F-N curves.
 - Outputs include charts, breakdown reports, exports to Excel, etc.

Software quality

Tessella has extensive experience of writing scientific engineering programs within a rigorous quality system. All Tessella activity is performed within our TickIt quality management system, accredited by the BSI to BS EN ISO 9001. This experience has been used in the following cases:

- Software development process support for a hazard and risk software suite for Shell Global Solutions (UK) Health, Safety and Environment (HSE) Consultancy:
 - A series of quality and technical audits resulted in recommendations for changes in processes to improve the long-term maintenance of the software.
 - Tessella set up a validation test strategy that relates experimental data to models within the software code, generating a series of test cases to ensure that each software release conforms to validated experimental data.
- Support to the maintainability of software for a client in the oil and gas industry.
 - Code rationalization to improve the interface and architecture of a model.
 - Implementation of an automated standard test rig to exercise new versions of consequence models using defined test cases. The test rig also performs regression tests against previous tests.

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