Institution:	**The University of Manchester**
Unit of Assessment:	UoA12a Chemical Engineering
Title of case study:	BRITEST – Best Route Innovative Technology Evaluation and Selection Techniques

1. Summary of the impact

BRITEST is a global leader in the development of innovative process solutions for the chemical processing sector with > £500m of value being realized since 2008. Research in Manchester (1997–2000) generated a set of novel tools and methodologies which analyse chemical processes to identify where and how process improvements could be made. BRITEST was established in 2001 as a not-for-profit company to manage the technology transfer and effective deployment of these tools and methodologies into industry. Manchester holds the IP arising from the underpinning research and has granted an exclusive license to BRITEST for use and exploitation of the toolkit.

2. Underpinning research

The impact relates to research carried out in collaboration with Imperial College, University of Leeds and industry between 1997 and 2009.

Key researchers at Manchester were:

Professor Paul Sharratt (1991 – 2008, Principal Investigator)
Dr Kevin Wall (1998 – 2011, Research Fellow)
Professor John Garside (1982 – 2004, Professor)
Professor Roger Davey (1991 – present, Professor)
Dr Naheed Sadr Kazemi (1997 – 2000, PDRA)
Dr Aruna Manipura (2008 – 2009, PDRA)

Dr. Jorge Arizmendi-Sánchez (2003 – 2007, PhD Student) , Dr. Tinoush Sheikhzeinoddin (2005 – 2009, PhD Student).

The main aim of the research was to deliver a methodology, models and a suite of decision support tools designed to sustain and improve the new product development (NPD) process in the fine chemicals industry.

The research project aimed to
(a) halve the time to product launch,
(b) halve capital costs and
(c) substantially improve manufacturing flexibility.

The key findings were:

1. That process tools could be used to help companies understand the design of the chemical process [1, 2].

2. That the convenient capture and analysis of critical information, both numerical and non-numerical, with the developed methodologies opened up clear, effective communication channels between the multi-disciplinary groups involved in the development and operation of a complex industrial process [3].

3. That the early identification of processing options allows timely development of experimental programmes to evaluate the options and allows controlling phenomena (for example, chemical reaction rates, phases of matter and minimum data requirements) to be reviewed by engineers and chemists in a common language that will ultimately lead to processes being scaled-up much more easily [3].

The BRITEST toolkit was successfully used to develop multi-scale approaches and performance enhancement for chemical and pharmaceutical production. Further examples of continued research include:

- Using the BRITEST whole process design concept for high throughput experimental design [4,5]
- Developing a design strategy to adapt the process to the chemical reaction (process intensification) [6].

3. References to the research

The research was published in leading chemical engineering journals, including *Organic Process Research & Development* (American Chemical Society) and the *Chemical Engineering Journal*. Sharratt was awarded a Royal Academy of Engineering/EPSRC Chair in Innovative Manufacturing for the period of 2001-2006 based on the strength of his BRITEST research work in support of innovation in the pharmaceutical and chemical industries. This led to the award of the IChemE/AMEC award for Innovation and Excellence in SMEs in 2006.

Key Publications

1. Wall K, Sharratt PN, Sadr-Kazemi N and Borland JN (2000) "Plant-independent Process Representation", In: Sauro Pierucci (Ed.) *Computer Aided Chemical Engineering*, Elsevier, Volume 8, 721-726. DOI 10.1016/S1570-7946(00)80122-4
2. Wall K, Sharratt PN, Sadr-Kazemi N and Borland JN (2001) "Plant-independent Process Representation", *Org Proc Res & Dev*, 5 (4): 434-437 Jul-Aug 2001 DOI 10.1021/op010002j
3. Sharratt PN, Wall K and Borland JN (2003) "Generating innovative process designs using limited data", *J. Chem Tech and Biotech*, 78, 156-160 DOI 10.1002/jctb.718

Other Relevant Publications

4. Obenndip D.A. and Sharratt P.N. (2005) "Enhancing Fine Chemicals Process Chemistry: A Practical Approach", *Chemical Engineering Research and Design*, 83(6), 655-661. DOI 10.1205/cherd.04358
5. Obenndip D.A. and Sharratt P.N. (2006) "Towards an information-rich process development – part I: Interfacing experimentation with qualitative / semi quantitative models", *Org Proc Res & Dev*, 10 (3), pp430-440 DOI 10.1021/op050236t
6. Arizmendi-Sánchez, JA and Sharratt PN (2007) "Phenomena-based modularisation of chemical process models to approach intensive options", *Chem Eng J*, 135(1-2), 83-94 DOI 10.1016/j.cej.2007.02.017

4. Details of the impact

Context

Chemical processes are highly complex, multi-stage operations where traditional thinking is focused on the effective process design of each stage. The BRITEST tools and methodologies that resulted from the research are highly innovative in promoting a whole process analysis approach, with input from both scientists and engineers. This novel approach is necessary to fully understand the complexity of processes within the high-value manufacturing sector.

Pathways to Impact

The underpinning research was conducted in collaboration with industry and the resultant tools and methodologies continue to be effectively used across high value chemical manufacturing sectors. The active engagement of industry throughout the research and development stage, and the establishment of BRITEST Ltd in 2001 to provide an effective route to market, has ensured that the original research has gone from strength to strength with the full backing of industry through membership subscription and continuing in-kind support. Manchester holds the IP arising from the initial research and has granted an exclusive license for use and exploitation of the tools and methodologies to BRITEST Ltd. Further investment in BRITEST, via increased membership and collaborative research projects, has ensured the continued development and expansion of the toolkit over the last 12 years. BRITEST Ltd is a not-for profit global organisation, owned and

directed by its members, both industrial (19 companies) and academic (5 institutions). Currently the company has 8 staff and a turnover of £800k in 2012-13 [i].

Reach and Significance of Impact

Process design is fundamental to chemistry-using industries including pharmaceuticals, agrochemicals, electronics, food and consumer products generating an estimated £195bn GVA each year in the UK alone, with processing activity accounting for 40 % of the product cost. The BRITEST tools and methodologies enable companies to understand complex process chemistry, and develop innovative process solutions.

An intensifying focus on the environment and climate change is driving industry to challenge the sustainability of its manufacturing processes, to ensure that products are produced in the most sustainable manner. BRITEST is helping its members meet this challenge and remains active in the development and implementation of sustainable process design solutions to deliver improved process efficiency including energy savings, reduced waste and lower solvent usage. Furthermore products must meet strict government legalisation and Christine Moore, the U.S. Food and Drug Administration Acting Director of New Drug Quality Assessment, has recognised BRITEST as one approach for product understanding in the drive for quality and design as companies *"seek a systematic process for the assessment, control, communication and review of risks to the quality of the drug product*" [ii].

Members of BRITEST report significant benefits including increased throughput, reduced capital expenditure and improved asset utilisation. One member was considering commissioning a new plant but after evaluating the manufacturing process using BRITEST tools & methodologies, substantial improvements were made to the existing process and investment in a new plant was no longer considered necessary. In 2012 Mark A. Phillips, a Process Expert with GSK, submitted written evidence to the House of Commons Science and Technology Select Committee, describing BRITEST Ltd as "*one of the most successful translations of research from academia to the development of tools and techniques within industry to improve the introduction of new products in the chemical and pharmaceutical sectors*" [iii].

The reach of BRITEST encompasses the UK, Europe, the United States and South East Asia with a wide range of industrial sectors from mining and consumer goods to pharmaceuticals. Examples of industrial members are Pfizer, Johnson Matthey and Procter & Gamble. Academic members include Newcastle, Nottingham, Limerick and Purdue (USA). *Sue Fleet, BRITEST CEO, says "a typical BRITEST process study realises a saving of £250k. With more than 2000 such studies performed since 2008, BRITEST has delivered economic impact in excess of £500m"* [i]. Below we provide several illustrative examples.

Illustrative Case Studies:

1. Company A is an international organisation {text removed for publication}. Over the last 5 years, the company has used the BRITEST toolkit to evaluate and optimise their chemical processes {text removed for publication}. During this time *"substantial benefits have been achieved including, a reduction in processing costs, improved yield, and reduced solvent usage as well as significant process optimisation benefits. In one particular process study, the company* {text removed for publication} *using the BRITEST tools to identify where the process could be optimised. In implementing changes identified through the study a reduction in cycle time from 41 to 35 days was achieved, yield was improved by 5% and a financial gain of £80k per campaign*[1] *resulted*" [iv].

2. Company B {text removed for publication} uses BRITEST tools & methodologies to routinely evaluate its {text removed for publication} development processes and has been actively engaged in the BRITEST innovation programme during this time. In 2011, the company used the BRITEST toolkit to address a problem they had been experiencing for some time on {text removed for publication}. The BRITEST study *"helped them analyse the problem from first principles and*

[1] Campaign, in this context, refers to a set of batch production runs carried out over a period of time (in this case 35 days).

generated an action list which ultimately identified the root cause of the problem. A multi-disciplinary approach using several of the BRITEST tools and methodologies enabled the company to find a permanent solution to the problem resulting in a GBP 500k annual saving to the company" [v].

3. Company C {text removed for publication}. In 2012, it employed a BRITEST study methodology to evaluate an established production system they had been operating for over 25 years. The BRITEST tools enabled them *"to gain a clear understanding of each stage of the process and identified ways in which they could optimise the whole process. The resulting action plan and laboratory trials enabled them to remove two process stages and streamline the whole process resulting in an improvement in product yield from 76 – 81%; a 60% reduction in production cycle time and a 15% reduction in production costs. The process optimisation achieved as a result of the BRITEST study has generated a value of £160k per production year"* [vi].

4. Company D {text removed for publication}. Using the BRITEST tools and methodology {text removed for publication} has been able to deliver step-change advances in manufacturing that has enabled them to compete effectively in the global market. The company's Managing Director states that "*use of the BRITEST tools and methodologies, together with our active participation in the on-going development of the toolkit, enables us to contribute to, and benefit from, a sustainable, competitive industry that offers better science and innovative processes. A project undertaken recently involved producing a new product for a new customer.* {text removed for publication}*. Using the BRITEST study approach throughout, the company was able to understand the process better, identify the problems, discover the solutions and fully optimise the process as it moved from laboratory to pilot-plant and onto full scale production. In using the BRITEST tools, the company realised a 5% increase in product yield, a 10% increase in margin and zero off-site disposal costs*" [vii].

Note: *The identification of individual companies referred to in this section, together with some of the information relating to particular impact statements, has been genericised in line with the BRITEST Company Rules regarding information disclosure. The identification and data relating to each example given above can be audited and verified through BRITEST under an appropriate CDA should that be necessary.*

5. Sources to corroborate the impact (indicative maximum of 10 references)

[i] Letter from CEO BRITEST Limited corroborating factual information presented in this case.
[ii] 17th International Process Development Conference. "FDA Perspective on Quality by Design (QbD) in Pharmaceutical Development." Presentation by U.S. Food and Drug Administration (Christine Moore) 19 May 2010
[iii] Written Evidence submitted to the Science and Technology Select Committee Inquiry: Bridging the "Valley of Death": improving the commercialisation of research. Quote from Process expert, GlaxoSmithKline (Mark A Phillips) February 2012
http://www.publications.parliament.uk/pa/cm201012/cmselect/cmsctech/writev/valley/valley14.htm
[iv] Company A paper presented at BRITEST Members Day 20 October 2011. "Tool-kit to success"
[v] Company B paper presented at BRITEST Members Day 20 October 2011. "Oh No! It has all gone horribly wrong (Using Britest tools to aid communication and problem solving)"
[vi] Company C paper presented at BRITEST Members Day 25 October 2012. "Challenge your neurons to kill false ideas and generate value."
[vii] Company D paper presented at BRITEST Members Day 20 October 2011. "It Smells Like Money"