Institution: University of Salford

Unit of Assessment: 11

Title of case study: Improving plant operations through innovative software products

Period when the underpinning research was undertaken: September 2015 – February 2019

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Dr Julian Bass	Senior Lecturer in Software Engineering	September 2015 – Present

Period when the claimed impact occurred: September 2015 – December 2020

Is this case study continued from a case study submitted in 2014? N

1. Summary of the impact

The operations director of any plant faces a daily dilemma: how to perform essential maintenance duties without adversely affecting production. By using a software development process defined by Salford's research, asset management and maintenance optimisation company, Add Energy Ltd., has established a dedicated research and development department, which has attracted GBP4,000,000 in revenue to date through exploitation of its software products, including the innovative AssetC software. While Add Energy Ltd. performs asset maintenance optimisation for major global clients, such as BP and Shell, in the energy and utility sectors, the AssetC software is used to create and enhance asset registers to implement design maintenance strategies for plants. AssetC has been utilised on projects with clients across Europe and Africa and is currently being used to create the asset register for the ExxonMobil-owned *Liza Unity,* a 300,000t floating production, storage and offloading vessel, resulting in a 30% time saving for the vessel's asset register production.

2. Underpinning research

Research undertaken by Bass at the University of Salford since 2015 comprises three areas: agile software development tailoring, agile innovation process and cloud-hosted application deployment technologies.

2.1. Agile software development tailoring

Software development methods must be tailored to their specific context, in terms of project scale, application domain and geographical configuration of team members and clients. Software development is a creative process in which abstract needs must be translated into a set of precise computer instructions. An effective approach is to perform software development in a discrete series of iterations, obtaining feedback from stakeholders and responding to changing circumstances as development progresses.

Bass's research has developed detailed taxonomies of two important aspects of agile tailoring: first, the scope and activities conducted within specialist job roles performed in software development teams (notably scrum masters and product owners) and second, the artefacts produced during the development process. For example, this research articulated the job scope and specific activities performed within the role that scrum masters play in mentoring and supporting software development teams using agile processes **[3.1]**.

Product owners play a critical role in agile methods by translating business needs into specific requirements. Bass's research has created, for the first time, the most detailed and authoritative

inventory produced to date of the activities that product owners perform in global software development projects **[3.2]**. Derived from a large, international data set comprising public- and commercial-sector project data, the research revealed that product owners exhibit several original behaviours **[3.3]**. These behaviours include: a relentless focus on key objectives, making time for reviewing products, understanding and trusting the agile software development process, understanding and minimising technical dependencies, effective communication, undertaking extensive networking and influencing, and focusing on the relationship between technology and people. Taken together, Bass's research **[3.2, 3.3]** provides insights into how product owners champion and prioritise needs and guide the teams who are creating software products.

Bass's research used a large international data set to create a detailed taxonomy of software development artefacts, such as source code, risk registers and release plans, produced in large scale agile software development projects, as described in **[3.4]**. This research identifies a novel range of artefacts produced by practitioners working across the full development lifecycle on large-scale international projects. The artefacts are produced to enable communication between stakeholders and to manage or control aspects of the software development process. Using this information, the research produced a pioneering inventory and detailed description of the range of artefacts produced during large agile projects.

2.2. Agile innovation process

Bass built on the findings from this research **[3.1** – **3.3, 3.5]** to develop an agile innovation process which was applied during two KTP projects with asset management and maintenance optimisation company, Add Energy Ltd., between April 2013 and September 2019 (KTP 9181, KTP 10789) to create the AssetC product. The agile innovation process integrated conventional research and development (R&D) and requirements elicitation activity with 3-month periods of agile development increments. This identified that R&D activities, such as product innovation workshops with key informants, served to drive feature prioritisation during subsequent software development iterations. A minimum viable product (MVP) was developed that provided an end-to-end data collection, analysis and visualisation solution in the AssetC product. The AssetC innovation process used the process first developed by the University of Salford for the AimHi product, a cloud-hosted software service that collects and displays data about maintenance operational performance, as reported in **[3.4]**. The two KTP projects have enabled collaboration where novel software development methods can be explored and evaluated while developing commercial software products.

2.3. Cloud-hosted application deployment technologies

Bass's research has also created new insights into the internal structuring of cloud-hosted applications delivered using internet technologies, known as software-as-a-service (SaaS), in a business-to-business (B2B) context. Cloud-hosting reduces software maintenance costs by collating executing code into a single server deployment. Cloud-hosted applications can also be scaled to ensure appropriate performance by varying numbers of users. By applying this research, Add Energy has been able to supply its applications to multinational corporate clients without those clients having to install Add Energy's applications within customer computer centres. Consequently, this has circumvented significant technical, organisational and business operational challenges, such as corporate IT departments profiling and estimating server centre capacity requirements in terms of disk throughput, disk storage space, network traffic, CPU usage and memory usage. Instead clients simply use a pre-installed web browser on their existing personal computers or laptops.

Bass's research developed the new concept of hierarchical multi-tenancy in B2B SaaS applications which was applied to the development of the AssetVoice product **[3.6]**. Tenants in consumer SaaS applications are independent of each other. However, in B2B SaaS, users – who are in the same business unit within a large multinational enterprise – are tenants who all require varying degrees of data sharing and data isolation. This research created a novel software reference architecture, employing a hierarchy of tenants at the level of individual users,

business units and multinationals for the first time. Subsequently, this reference architecture has been adopted in AssetC, reducing development cost and time to market for the new product.

3. References to the research

3.1. Noll, J., Razzak, M.A., **Bass, J.M.**, & Beecham, S. (2017). A study of the scrum master's role, *International Conference on Product-Focused Software Process Improvement*, pp. 307-323. https://doi.org/10.1007/978-3-319-69926-4_22
3.2. Bass, J.M., & Haxby, A. (2019). Tailoring product ownership in large-scale agile projects: Managing scale, distance, and governance, *IEEE Software*, 36(2), pp. 58-63. https://doi.org/10.1109/MS.2018.2885524
3.3. Bass, J.M., Beecham, S., Razzak, M.A., Canna, C.N., & Noll, J. (2018). An empirical study of the product owner role in scrum, *Proceedings of the ACM/IEEE 40th International Conference on Software Engineering (ICSE): Companion Proceedings*, pp. 123-124. https://doi.org/10.1145/3183440.3195066
3.4. Bass, J.M., Abdul, A.O., Ghavimi, H., MacRae, N. and Adam, P. (2018). Scrum for product innovation: a longitudinal embedded case study, *International Journal of Multimedia and Image Processing*, 8(2), pp. 414-424. https://doi.org/10.20533/ijmip.2042.4647.2018.0051
3.5. Bass, J.M. (2016). Artefacts and agile method tailoring in large-scale offshore software development programmes, *Information and Software Technology*, 75, pp. 1-16. https://doi.org/10.1016/j.infsof.2016.03.001 **(REF2)**
3.6. Abdul, A., & **Bass, J.M.** (2018). Hierarchical multi-tenancy in business to business software services. In *2018 44th Euromicro Conference on Software Engineering and Advanced Applications (SEAA),* pp. 494-501. https://doi.org/10.1109/SEAA.2018.00085

All references **3.1 – 3.6** have been subject to rigorous peer review. The average full research paper acceptance rate at ICSE **[see 3.3]** is 16.9%.

This research benefitted from funding from Add Energy Ltd. and Innovate UK through KTP 9181 for GBP139,730 (April 2013 – October 2017) and KTP 10789 for GBP95,187 (April 2017 – September 2019).

4. Details of the impact

Add Energy Ltd., which had a turnover of GBP12,000,000 in 2020, performs asset maintenance optimisation activities with clients in the energy and utility sectors and is a global top 10 competitor in its field **[5.1]**. Research carried out by the University of Salford has had a *'profound impact'* on the company's operations and business **[5.1]** and has **directly led to software innovation** at the company, resulting in **successive improvements in operational efficiency** for its clients **[5.1]**. Further, Salford's research and the long-standing collaboration has encouraged this company to **increase its own commitment and spending on R&D**. The trajectory of this activity and its subsequent impact is detailed as follows:

4.1. Achieving operational excellence through product innovation and development

Software product innovation at Add Energy
In order to exploit the understanding gained from engaging with Salford's research, Add Energy created a **dedicated software R&D department in 2015 [5.1]**, with its own budget, staff and leadership and reporting directly to the senior management team **[5.1]**. At this point, the company was still a consulting organisation focusing on asset maintenance optimisation, but as a result of the research the department has since been able to **create a portfolio of software products** that has attracted **GBP4,000,000 of revenue** for the company **[5.1]**.

AssetC product development
The AssetC software product was created by the R&D department, based on Salford's novel agile product innovation process **[3.4, 5.1]**. Conventional periods of agile software development were tailored to include product ideation and research activities. The application is implemented

as a cloud hosted software service and accessed using web browsers. Salford's hierarchical multi-tenancy reference architecture **[3.6]** allows **cost-effective centralised software maintenance** and **configurable data sharing** between different sites in the same enterprise but provides isolation of data from different clients to ensure confidentiality **[5.1]**.

Creating asset registers and achieving operational excellence
AssetC has since been used **to create plant asset registers for Add Energy's global clients** in the energy sector **[5.1]**. An asset register is a detailed inventory of the replaceable parts and their technical specifications and is used to populate a computerised maintenance management system. The quality of the maintenance management system affects plant maintenance costs, the safety of operator staff and continuity of operations. Asset registers typically list many replaceable parts: for example, the asset register for client ExxonMobil's *Liza Destiny*, a floating production, storage and offloading (FPSO) vessel, contains 24,000 component parts **[see 5.2]**.

SBM Offshore, which operates and maintains a fleet of FPSO vessels across the globe, contracted Add Energy in September 2019 to **create the asset register and maintenance process for ExxonMobil's 333m, 300,000t *Liza Unity* FPSO** using AssetC software **[5.2]**. *Liza Unity* will be the largest capacity FPSO delivered by SBM, eclipsing the *Liza Destiny*, with a **production capacity of 220,000 barrels of oil per day [5.2]**.

By December 2020 AssetC had been used by Add Energy on **9 projects with clients across Europe and Africa** and the **annual cost saving from deploying the software worldwide was estimated to be 30%** compared with manual approaches to asset register production **[5.1]**.

4.2. Optimising creation and enhancing quality of asset registers

There are four benefits to using AssetC software. Firstly, AssetC ensures that all the data is collated into a single store which **avoids the risks of data duplication and data loss [5.2]**. Secondly, the asset data stored in the repository is accessed through a web browser, using the cloud-hosted software service model, so it is **readily accessible to project stakeholders** without the need to install any software locally. Thirdly, the software allows a hierarchical visualisation of the asset component data such that equipment is **logically grouped around the subsystems** found on the vessel **[5.2]**. Consequently, using AssetC, clients are able **to visualise the way equipment is set out in the plant** and **easily find items in the register**. Finally, AssetC allows the status of asset data collection in the repository to be visualised, for example by managers. This is **useful for progress reporting during asset register population** and makes it **easier to keep stakeholders engaged** during the process. Taken together, Add Energy confirms that these features ***'accelerate the process for creating asset registers by 30%'*** compared with previous approaches **[5.1]**.

The quality of the asset register produced is also enhanced by AssetC, because it creates a single managed centralised data inventory, ensuring that Add Energy **continues to thrive within a highly competitive field** driven by pricing, whereby firms are operating on very thin margins [**5.1]**. An accurate asset register is important because missing items will not be included in the maintenance plan. The asset register also contains an assessment of criticality of each item. Some equipment items might have an impact on production, while others have an impact on safety too. The asset register is used to accurately capture the specification and criticality of each equipment item so that an appropriate maintenance plan can be devised for each part. Also included in the asset register is an assessment of business risk for each equipment item. The likely impact severity caused by failure of an equipment item influences the frequency and type of maintenance operation in the plan. A project engineer at SBM Offshore confirms that these features of AssetC *'help us **improve the quality of the asset register** we produce'* and consequently *'we can **ensure the quality of the maintenance plan** we offer our clients, which in turn helps **optimise maintenance costs** and **ensure safety and uptime of the vessel**'* **[5.2]**.

4.3. Enhancing the Add Energy product portfolio

As a result of working with Salford, Add Energy has been able to establish R&D processes which have enabled the company to **diversify into new markets with new products [5.1]**. The Executive Vice President confirms that in addition to AssetC, the company has applied Salford research on agile innovation and cloud technologies to create two other software products: AimHi and AssetVoice **[5.1]**.

The AimHi software product was launched to the public in March 2019 **[5.3]**. AimHi provides data calculation and graphical presentation on a dashboard for management of key performance indicators **[5.1]** and has been deployed by the company on 3 assets including a power generation plant, a mining and metals business and a gas processing terminal **[5.3]**. The AimHi software has helped maintenance teams to make **cost and time efficiencies** by accelerating the complex and lengthy process of preparing key performance indicator (KPI) data (compared with manual processes). Consequently, this has **reduced corrective maintenance by 8%** and **halved the amount of time spent on emergency work [5.3]**. Add Energy's Executive Vice President stated: '*We have combined years of experience with the intelligence of our consultants and the algorithms we use to create this KPI management solution. AimHi puts asset and maintenance managers back in control - helping them make better, more informed decisions, plan more effectively and address unexpected events efficiently*' **[5.3]**.

Further to the software development, Add Energy conducted multiple user group sessions with global energy company Uniper's combined cycle gas turbine power plant, located in the Isle of Grain, UK **[5.3]**. The maintenance team at this plant provided user feedback that enabled the AimHi tool to be tailored specifically to address the common issues relating to big data faced by maintenance teams **[5.3]**. One of the Business Solutions Architects at Uniper commented that *'Aim-Hi not only tells you how you are performing against your KPIs relating to maintenance, but, more importantly, it tells you the why behind them'* **[5.3]**.

AssetVoice is a set of software services for automated asset change management and was launched in June 2020 **[5.4]**. It received an ***'outstanding achievement of excellence'*** **award** from the KTP with Add Energy, considered a rare and prestigious recognition of the innovative development of an end-to-end solution for automated asset change management **[5.4]**. Regarding AssetVoice, the company confirms that '*by having accurate, real time visibility of equipment at their fingertips, companies can make their assets more self-aware, in effect giving them a voice. Enabling users to work smarter in this ever-challenging economic climate by effectively managing what you monitor*' **[5.4]**.

Red Ocelot Ltd., a software start-up associated with the University of Salford, was established in August 2020 to further exploit the team's agile software development and cloud hosted software service expertise and Add Energy are establishing a **Digital Innovation Laboratory** on campus at the University to further strengthen the relationship with Salford's researchers **[5.1]**. The Laboratory will accommodate iCASE and placement students as well as Add Energy R&D staff while acting as a launchpad for wider university collaboration.

5. Sources to corroborate the impact

5.1. Testimonial: Add Energy Ltd. (February 2021), on the establishment of an R&D department, exploitation of software products, creation of asset registers and improvements (4.1), enhancing the quality of the asset register (4.2) and demonstrating the wider product portfolio (4.3)
5.2. Testimonial: Asset Integrity Project Engineer, SBM Offshore (February 2021), on the use of AssetC software to build the asset register (4.1) and associated cost and time savings (4.2)
5.3. Launch Blog: AimHi Product, Add Energy Group (4 March 2019), available at: https://blog.addenergy.no/new-software-launched-to-optimise-maintenance-costs and in Figshare dataset https://doi.org/10.17866/rd.salford.7929749.v1 (4.3)
5.4. Launch Blog: AssetVoice Product, Add Energy Group (17 June 2020), available at: https://addenergy.no/news-article/add-energy-launches-smart-solution-to-give-assets-a-voice and in Figshare dataset https://doi.org/10.17866/rd.salford.12493064 (4.3)