Product and Service Quality Risk Design Considerations – Integration into Solution Architecture Methods

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Abstract. Enterprises have to find a way to ensure systematic quality in their IT solutions. However, there is no standard approach to the identification and consideration of quality risks and their inclusion in the solution development process. This work draws together two independent developed complementary quality risk-oriented approaches to solution ideation and architecture evaluation, developed by Volkswagen Group IT and Lefert Consulting respectively, and their integration with the solution development process at the Bank of England. The main added value is to form a more holistic view which incorporates quality risks. This has involved the development of training and education material to bring relevant professional communities involved in solution development, including consultants, business analysts, architects and software designers and (quality) engineers, to a shared understanding of how product and service quality risk lie at the heart of solution design and development.

Keywords: Quality management · Quality engineering · Service evaluation · Solution architecture · Design thinking

1 Introduction and Motivation

1.1 What is Missing Today

Many large enterprise and government organisations are in the process of adopting agile and nimble ways of working into their development procedures. To realise this, all involved people need to be trained about autonomous working – the key behind the agile approach. In IT projects, resources are limited [1]. However, the teams have to be adequately skilled to reach their goals – one approach is to have T-shaped professionals [2]. The vertical part of the T represents deep expert skills and the horizontal part of the T represents wide skills around the specialisation. To build this T-shaped professional capability, one also needs a holistic base of knowledge in a wide area around the core expertise domain. Furthermore, products and services are becoming more complex [3] and can form complex networks [4], and to have an expert for each topic becomes

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more difficult. It is fundamental that companies facilitate the development of T-shaped professionals with suitable training and education approaches to handle the growing complexity with limited professionals. This can be supported by trainings with a holistic view on a topic like solution architecture which brings in quality aspects such as product or service quality risks.

1.2 Why Quality Risk?

In many team forming phases during the start of an initiative, there exists a high level of enthusiasm and euphoria about the chances and opportunities. All the creativity is focused on developing new capabilities and features to realise the product or service vision of the initiative. This creative constructive momentum is good and needed. However, it can lead to a blind spot for risks. Risks are the other side of the coin, according to [5]. To ensure that the team has a realistic and balanced scope, it is useful to establish, as early as possible, a view of the product and service specific quality risks. With a holistic view of the capabilities and features it is possible to make the right prioritisation and design decisions. Also, it is possible to establish this balanced mindset of creative constructive and destructive thinking over the entire initiative and the product/service life-cycle. There are many existing approaches in literature about requirements ideation, such as [6, 7, 8], and development [9, 10], but these only lightly consider product and service quality risk ideation, and even less consider combining and balancing these two views in a systematic way. Volkswagen AG developed the Product Quality Risk (PQR) approach to address this. The openness of the PQR approach makes it possible to combine it with the Solution Architecture Review Method (SARM) approach of Lefert Consulting, which looks at architecture trade-off analysis from a quality risk perspective, to build a more holistic quality risk approach to solution architecture.

1.3 Why the Bank of England

In 2021, the Bank of England initiated a review of its solution architecture engagement model, with a view to achieving the following improvements:

1. Earlier engagement between the owner of an initiative and the architecture team. When engagement occurs too late in the process, initiative owners are often already fixed in their minds about the solution, and the opportunity to engage creatively in shaping requirements and considering alternative approaches, some of which might be more strategically aligned, or might lie outside the experience of the initiative owner, is severely limited. Earlier engagement, on the other hands, opens the opportunity for the facilitation of creative discussion with the possibility of radical options that might be quicker to implement, have greater benefits or lower costs.
2. Simpler decision governance, with greater autonomy for project teams. The Bank's past architecture governance involves the presentation of a complete "High Level Design" (HLD) document to a formal committee, the Architecture Review Board. Agile development methods involve an iterative design approach, and whilst many essential architectural decisions will likely be made early in the process, it is good

practice to delay architecture decisions where possible [11], taking them as necessary in later iteration of the Agile process. If the governance process demands a complete HLD, with an Agile process this will inevitably only become available at a late stage of development, defeating the value of sharing the design with a central design authority. The revised approach involves earlier presentation of a partial HLD, and devolution of authority, within agreed guardrail constraints, to a light-weight authority managed within the project team.

3. Improved quality of architecture decisions and solution designs, with the adoption of more rigorous methods for the development of architectures and a more innovative approach to design, taking advantage of the earlier engagement outlined in 1.
4. Improved consistency of architecture artefacts, with the adoption of standardised approaches, documents and models, such as ISO 25010 [12].
5. A stronger connection between architecture design and solution implementation, with the aim of ensuring that design documentation is an accurate reflection of the implementation, so that it can more successfully support continuous development of business technology solutions.

The Bank of England is the central bank of the United Kingdom with the mission of "promoting the good of the people of the United Kingdom by maintaining monetary and financial stability". Understandably, quality and risk are key perspectives that have a high priority in the way the Bank develops its products, services and business technology solutions. Given this, combined with the above aims for the review, both the PQR Method and the SARM were strong candidates for incorporation into a new solution architecture engagement model.

This paper presents a summary of the incorporation of the two models into the Bank of England's architecture approach motivated by the desire to bring together architecture methods that support design creativity with a focus on product quality, and a recognition that new training approaches are needed to bring these methods to life in today's multidisciplinary project teams.

2 Background and Literature

2.1 The PQR Method

The PQR approach was developed over time mostly within the Volkswagen AG Group IT. A first publication introduces the Identify-Plan-Do-Check-Act cycle [13] which make the risk ideation in the Identify phase explicit. Furthermore, this work presents a way to map the identified quality risks to capabilities, features or functions of products or services. In a more recent publication [14] the Identify phase is refined by a Design Thinking approach to facilitate workshops for the ideation of service and Product Quality Risks (PQR). Figure 1 shows the PQR approach. The ideation is realised with a lean Design Thinking flow with two facilitation methods in the Opening- and Focusing-Phase. Each method is facilitated with a poster which can be used during the ideation workshop. The methods are enhanced over time to ensure easy usage during the workshop. The Product Card is used to ensure that the scope of the deliverable is defined by the team. In particular, what is promised to sponsors, what are the constraints of the setting and what

is the "wow-effect" for the customer/user. With Reliable Fundament project stakeholders analyse the defined setup from the Product Card, exploring what is managed by the team, what is influenced by the team and what comes from outside. Especially, the influenced and outside areas are sources of risks. With Pre-Mortem, these product or service related risks are ideated. The focus is on identifying them and grouping them to orthogonal risks. With Risk Carousel, the identified risks are refined and classified to facilitate their handling during the life-cycle with adequate mitigation actions etc. Figure 2 presents an application example for a hypothetic "running group service". All four poster of the PRQ approach are presented with data based on the imagined service.

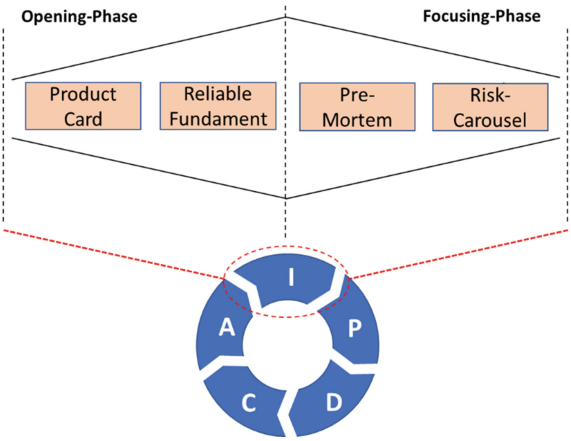

Fig. 1. The ideation flow of the PQR approach

The generic PQR approach can be used in different setups, such as the LoD [15] or evAIa [16] or as a building block of the efiS® framework [17]. The Level of Done (LoD) approach is used to address compliance and governance requirements of deliverables. The LoD makes the requirements of regulations and standards transparent to the teams. PQR complements the generic formal view of the LoD with the product or service specific risk view.

The evaluate Artificial Intelligence approach (evAIa) also uses PQR to identify the "critical" focus areas of the Machine Learning (ML) based product or Service. Another example is to use PQR as a building block in the efiS® framework, as a core element to focus on the deliverable of the value stream team which is applying efiS®.

2.2 The Solution Architecture Review Method

The Solution Architecture Review Method (SARM) is a trade-off analysis method for analysing solution architectures. It supports an analysis of an existing architecture, examining the extent to which it satisfies a set of potentially conflicting architecturally significant requirements. It can also be used to evaluate competing alternative solution architectures for a new or changed solution. It builds on the widely adopted Architecture Trade-off Analysis Method (ATAM) [18, 19] but introduces some key differences. The principal ones are that with SARM:

- trade-off analysis is conducted by comparing levels of risk (and not utility) using a standard Impact / Likelihood risk model [20]
- higher level views of trade-offs are obtained by associating architecturally significant requirements to a standard quality model

Fig. 2. Hypothetic example "running group service" as pre-filled workshop posters.

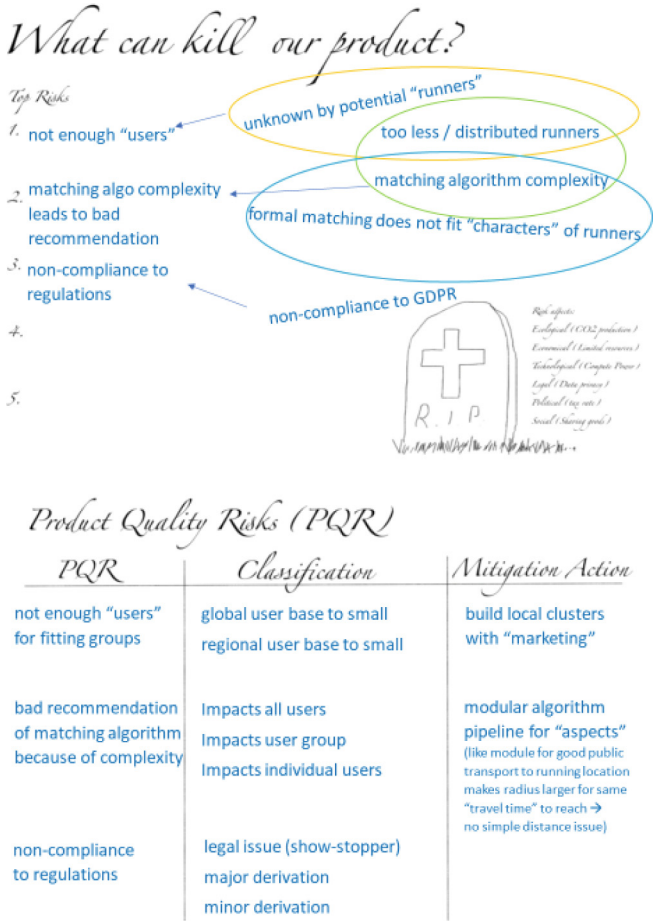

Fig. 2. continued

- trade-offs are examined from the perspectives of key stakeholders

Figure 3 illustrates the SARM process, which falls into two phases:

1. Creating the context: identifying key stakeholders, understanding the architecturally significant requirements, structuring them according to an agreed quality model, determining their impact, relating them to stakeholders, and quantifying benefits.
2. Evaluating the options: reviewing the proposed or existing architecture(s), agreeing solution risks for each requirement, analysing trade-offs, conducting a cost-benefit analysis, and interpreting the results of the analysis.

In the case where one or more new solution options are being developed for analysis, work must be undertaken between the two phases to develop those architectures to a level of detail which can come under the scrutiny of the analysis. This work might involve

the tendering of solution options by vendors in a procurement activity, or the creative design of one or more options by solution architects. These activities lie outside the scope of SARM, which assumes that one or more articulated architectures are available for analysis before the commencement of phase 2.

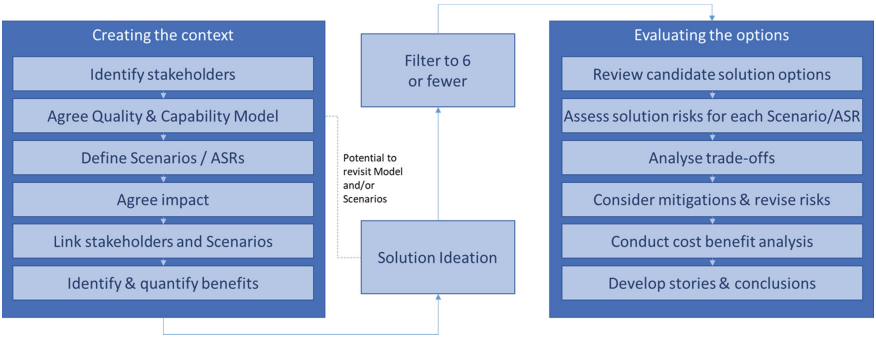

Fig. 3. The SARM process

Details of the SARM process have been published in full [21] and a software tool, based on Microsoft Excel, is available to support the process [22]. SARM was developed to address the need for a structured approach to the analysis of service designs [23, 24, 25], and has since been applied to the analysis of both services and business technology solutions in different organisations around the world.

2.3 Solution Architecture Process

Solution architecture has been defined as "a discipline concerned with the production and management of a blueprint for a comprehensive solution, that addresses a business need, problem or opportunity, and integrates with the business, in alignment with its strategy, while minimising negative impacts." [26]. Mark Lovatt proposes a solution architecture life cycle that is divided into eight phases: Initiation, Discovery, Solution outline definition, Analysis, Logical design, Validation, Roadmap development and Completion [Ibid. pp. 61–67]. A practical implementation of such a life cycle cannot stand alone, but must be integrated within the broader solution development lifecycle. Organisations that adopt an architecture-led approach to solution development are highly likely to engage in the activities described in the eight phases defined by Mark Lovatt, in the same sequence, though they may not necessarily have identified and named the architecture life cycle phases separately.

This life cycle mirrors the broader enterprise architecture development method, known as the ADM in the TOGAF Standard [27]. Whilst its eight phases are differently named, they follow a similar sequence starting with defining a vision and understanding the business architecture, before moving on to consider information systems and technology architecture and exploring opportunities and solutions prior to implementation and ongoing architecture change management. The TOGAF Standard also highlights the central role that requirements management fulfils for each of the phases.

Agile development approaches have become increasingly popular, with many organisations adopting enterprise agile frameworks such as Scaled Agile Framework (SAFe) [28], Disciplined Agile (DA) [29]. Both of these frameworks recognise the key role that solution architects / architecture owners play throughout the development life cycle, and the typical architecture process described above applies equally to both agile and traditional "waterfall" development methods [30].

3 Method Integration with Solution Architecture Process

3.1 Synergies Between PQR Method and SARM

The PQR Method and SARM both have quality and risk at their heart, and the motivation for the development of both was the improvement of the architectural quality of the resulting products or services. With PQR, the design thinking approach uses product quality risk to identify opportunities to improve a design and ensure that risks and corresponding mitigating actions are considered throughout the product or service development process. Furthermore, the risk profile of functions and features can be identified. In case of an unbalance between incorporated value and risks the functionality can be reprioritised for a more later release (when the risk-profile is "better"). These aspects are all driven by "establish quality by mitigate risks". This is a selective risk focussing view of PQR and does not open the solution space by finding other alternative options. SARM complements this by offering exactly this missing option view. With SARM, alternative architectures are evaluated using a risk trade-off analysis, and a quality model is used to provide a layer of abstraction, allowing the different trade-offs involved in each solution option to become more clearly visible. SARMs open trade-off view in combination with the quality risk view of PQR are balancing cooperative.

In addition to incorporating a similar "quality risk mind-set", the two methods complement each other in that PQR occupies the "Develop solution options" stage of the process outlined in Fig. 1, which is outside the scope of SARM. Together, they provide a quality risk lens support for much of the solution development life cycle.

3.2 Merging Them into the Bank of England Process

The Bank's proposed new solution architecture engagement model breaks the process into five distinct phases:

1. Solution Vision: a lightweight pre-project engagement that helps a business sponsor to articulate the vision, why the initiative is needed, for whom, and what information is involved.
2. Solution Outline: an initial exploration, focusing on articulating desired business outcomes, fleshing out the business case, understanding customer/user journeys, considering solution options, identifying relevant design patterns, and exploring operating model implications.
3. Emergent Design: the beginning of a delivery effort, which may adopt Agile methods, developing a deeper understanding of requirements and solution elements, including data and data flows, high level architectural decisions.

4. Design Refinement: More detailed solution and engineering design, with detailed understanding of data, security and deployment views.
5. Evaluation and Outlook: Architectural assurance and identification of acknowledged technical debt, leading to the creation of a forward-looking roadmap, the tracking of benefits and the possible identification of new design patterns for future sharing.

The model supports both traditional "waterfall" delivery approaches [31] and Agile methods. For Agile delivery, the Bank has adopted a version of the UK Government Agile approach, and phases 2 to 5 of the above engagement model take place during the Discovery, Alpha, Beta and Live phases respectively, as described in the Agile Delivery section of the UK Government Service Manual [32].

Whilst both the PQR method and SARM could be "dropped in" to this new engagement model, fitting quite well into phase 2, Solution Outline, it was recognised that a more integrated approach was possible. This involved breaking apart the different elements of both PQR and SARM and applying them at different phases while retaining their connection so that both methods retain their conceptual integrity.

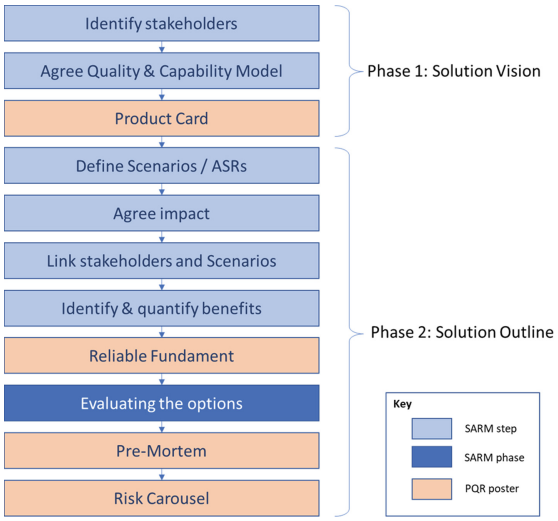

Fig. 4. PQR and SARM integration with engagement model

Figure 4 illustrates how the different elements of PQR and SARM were sequenced into the first two phases of the Bank's new engagement model. It should be noted that this figure only shows the elements of PQR and SARM; there are other activities in these phases of the engagement model that are not shown here. By bringing three activities into the earliest phase of the engagement, these were able to contribute to the initial conceptualisation of the solution as a whole. Had they taken place simply as later steps in the SARM and PQR processes, their value would have been reduced to a re-phrasing of material developed earlier. This would limit the potential innovation contribution of SARM and PQR, and introduce unnecessary duplication of effort.

Moving the last two posters of the PQR process (Pre-Mortem and Risk Carousel) beyond the second phase of SARM (Evaluating the options) ensures that these activities are only conducted for solution options that have been selected during the evaluation. The output of the Risk Carousel is then fed into the Emergent Design and Design Refinement phases of the architecture engagement model.

4 The Design of the Training Approach

4.1 The Need for a New Training Course

At the Bank, three distinct professional communities have been engaged in delivering the solution architecture engagement model: Consultants, who engage with the business sponsor to shape their initial thinking, Solution Architects who focus on the technical architecture, and Business Analysts, who lead the articulation of business requirements. The Bank's new engagement model demands a more integrated, multi-disciplinary approach, drawing together the skills of these professional communities and involving some new skills, such as service design.

Training and education were recognised as being central to the successful adoption of the new engagement model, and the Bank chose to develop a new course that can be delivered to staff from all the relevant professional communities to foster a common approach to architectural thinking and the recognition of the inter-connectedness of the elements of each of the five phases of the solution architecture engagement model.

The course does not attempt to cover every element of the solution architecture engagement model, as this would be too much ground to cover in a 2-day course. Its focus is on the PQR and SARM methods, and the broader concepts that they embody, including stakeholder analysis, quality and quality models, risk and risk models, architecturally significant requirements, design thinking and cost benefit analysis.

4.2 Course Design

The course consists of theoretical lectures and group exercises. In the beginning the authors lay the foundations with explanation e.g. what is architecture, how to describe architectures, why and how to compare architectures. The authors introduce the first elements of SARM and how it uses risk to qualify requirements and a quality model to classify them. These are combined to enable a comparison of the ways different architectures deal with them. Next, we introduce the stakeholders and their views on requirements and benefits.

In preparation for practical exercises, breakout groups develop their own simple service. A simple scenario guides the groups to create a service concept for a small student-run business to fund living costs during the summer vacation. This helps them to practise the methods involved in both PQR and SARM with a simple example without too much complexity while also being fully engaged, because it's their own creation.

For teaching the PQR method the authors show first the training kit and then the Self-Service Kit (SSK) with the posters. The breakout groups use the PQR method on their services with the help of the SSK. The SSK approach [33] is designed to facilitate

knowledge transfer in the context of autonomous teams. This also helps in the context of the training participants who are coming from different teams and initiatives across the organisation. By using the SSK as part of the training familiarisation, we seek to increase its later usage in the real world context.

In the next part of the course, the participants learn how to analyse architectures with SARM, and collectively use the SARM SSK (the evaluation spreadsheet tool) to analyse and compare their example services.

Having a number of breakout groups develop competing service propositions creates an element of friendly competition that runs across the two days of the course, introducing a degree of gamification in the learning process which encourages the level of innovation needed to apply design thinking creatively to address a business problem.

5 Experience, Evaluation and Improvement

5.1 Evaluation Setup

The evaluation and enhancement are based on Action Research [34, 35] methodology. Two phases of different evaluation approaches were defined with the dry run and user evaluation. As a final step of the training design the dry run of the training content and exercise was performed. The first training iteration was used for evaluation and observation of trainees during "lectures" and "exercises". The insights were used to enhance the lecture content and refine the exercises. After two iterations no further significant improvement indicators were identified – leading to a final version of the training setup, material and approach.

5.2 Feedback and Improvements

A number of improvements to the course were made between the first and second iterations, based on the feedback of the participants (both teachers and learners).

1. The topic of Stakeholder Analysis was moved from day 2 (after PQR) to day 1 (before PQR). The original SARM course introduced a simplified SARM process, leaving out optional aspects of SARM such as analysing stakeholder perspectives and conducting a cost benefit analysis. The basic concepts of SARM were introduced and applied through exercises before the optional aspects were explained. It was this original SARM course that was adopted with PQR incorporated for the first iteration. Feedback suggested that the stakeholder perspective is really valuable, and is a core element of the Bank's new engagement model. It was therefore decided to include stakeholder perspectives early in the course in the second iteration, before the introduction of the PQR method.
2. Feedback from the participants of the first iteration of the course suggested the inclusion of a worked example set of PQR posters in the initial presentation material. It was felt that this would bring the process to life, and make it easier for the groups to apply the posters to their service concepts. A simple service concept, facilitating the organisation of local running and jogging communities, was developed and used to populate all four PQR posters for use in the initial presentation of the PQR method.

3. During the first iteration, following the review of the completed PQR posters, it was noticed that several of the groups had some difficulty focusing on product/service risk, and their concerns ranged somewhat out of scope, into considering the risks associated with the service business model. For the second iteration, the trainer emphasised the value of focusing on product/service features and risks, as these can then be translated into product or service improvements through mitigating actions and design changes.
4. The original case study briefing focused on designing a service to provide refreshments (food or beverages) to people in the City of London. One innovative team stepped beyond this brief, with an umbrella sale or rental scheme, which added to the variety of services for evaluation. The brief has now been re-written to be more open to a wider variety of business services and business models, to encourage innovation by the participants.
5. With the emphasis in the course of covering the SARM and PQR methods, and their associated concepts, feedback from the first course participants indicated some uncertainty as to how these relate to the new architecture service engagement model, which was only introduced to the participants near the end of the course. The course content was amended to introduce the model near the beginning of the course, and then highlight during the course how each section of the course relates to the overall architecture service engagement model. This is then reviewed in the conclusion of the course.

It has not been possible to capture any precise data with which to measure the effects of these changes between the first and second cohorts of participants, the changes were judged to be successful by the teachers, and no further improvements were considered following the second iteration. There were fewer questions throughout the course that suggested confusion among the participants that might indicate further changes to the content or structure of the course.

Both iterations of the course took place at the Bank of England's premises in Threadneedle Street, London, with the exception of the PQR teacher who joined remotely from Germany. These were among the first face-to-face meetings that had been possible for employees following nearly two years of remote working during the COVID pandemic. Throughout both iterations, participants repeatedly confirmed their enjoyment of such an interactive learning experience which can only be delivered in a physical environment. The interaction was described by participants as "engaging", "good fun". There are no plans to adapt the course to be delivered to remote participants.

5.3 Outputs and Outcomes

One of the aims of the course, as outlined in Sect. 4.1 above, was to "foster a common approach to architectural thinking" among the relevant professional communities. Although it is too early to assess the success of this in participants' engagement in subsequent projects, the feedback that both PQR and SARM are "really good at visualising/abstracting risk aspects you would not otherwise see/consider/admit to" suggests that the course has triggered new ways of thinking.

At the Bank, two further courses offered in April and May have been over-subscribed, following recommendations from peers who attended the two initial offerings of the course. A further offering of the course has now been scheduled for June to manage the excess demand.

Early participants of the trainings have also initiated activities to link PQR and SARM more closely to other Bank standards and assets, such as the Bank's growing library of personas and its service classifications.

The success of the course and interest from beyond the architecture / business analyst / consultant community have triggered requests for participation from a much wider community of platform, software and business solution engineers and growing interest to involve the project and programme management community. This growth of interest suggests that the course is filling a gap in demand that is quite widespread across the professional communities who engage in business systems development and change.

Whilst the availability of teaching time is limited and acts as a constraint on the adoption of PQR, SARM and the new architecture engagement model, the availability of Self-Service Kits for both PQR and SARM encourages the organic growth of these methods once initial training has taken place.

The worked example of the PQR posters described in Sect. 5.2, developed for the Bank's training course, has now been incorporated into the self-service kit made available to staff engaged in product development and change at Volkswagen AG. This demonstrates the broad applicability of these methods in many environments, and the value of cross-fertilising methods and practices between organisations from very different industries.

6 Conclusion and Outlook

The presented training is based on establish approaches and de-facto standards which are defining the "what", as in TOGAF etc. We combined these approaches with new "methodology" and approaches – the "how" – to make it more applicable to current development approaches. The observed behaviour of the participants indicates that the proposed workshop method supports greater collaboration among the participants, which fosters the creation of better solutions.

Furthermore, the authors designed the training to give a holistic view to the trainees of the interface between architecture and quality management – both start early and accompany the entire life-cycle. This make them "strong partners", as long as they are thought together to reinforce and emphasise each other.

As the authors developed this training approach within a joined interdisciplinary team of enterprise architecture, solution architecture and quality engineering experts from different business domains we believe that we have created generic training material applicable to a wide range of IT organisation, especially those a focus on quality risks and their handling during the life-cycle. And for projects within quality critical situations, the approach can create the necessary sensitivity about the topic among a wider stakeholder circle. Neither PQR nor SARM is specific to a particular domain or industry, and whilst domain-specific quality models could be adopted, the Bank of England has used the generic quality model from ISO 25010. The only extension to this model that recognises

the specific nature of the Bank's business is the adoption of the Bank's business capability model to complement the Functional Suitability quality characteristic. We therefore see potential in domains beyond those of finance and automotive, for example in critical infrastructure or complex platforms.

Acknowledgement. Any views expressed are solely those of the authors and so cannot be taken to represent those of the Bank of England or to state Bank of England policy. This paper should therefore not be reported as representing the views of the Bank of England or members of the Monetary Policy Committee, Financial Policy Committee or Prudential Regulation Committee.

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