THE TRUE COST OF POOR QUALITY

MARC BELL | AUGUST 2020

Project engineering organisations have embarked on a journey to tackle the high proportion of costs related to poor quality that originate in 'non-obvious' areas.

The quality battleground has extended beyond the manufacturing processes to eradicate margin erosion throughout the entire project lifecycle by the pragmatic automation of key processes and interfaces.

INTRODUCTION 3

COST OF QUALITY (COQ) AND COST OF POOR QUALITY (COPQ) DEFINITION 4

MEASURING COPQ WITHIN A PROJECT ENGINEERING ENVIRONMENT 5

WHY INVEST IN PROCESS AUTOMATION? 7

KEY FEATURES AND BENEFITS OF AN AUTOMATED PLATFORM 9

CONCLUSION 11

APPENDIX 12

ABOUT THE AUTHOR 15

INTRODUCTION

The world of **'quality' has been through something of a revolution in the last 25 years**. The automotive sector was at the forefront of this revolution as is often the case in the world of manufacturing. For car manufacturers, quality used to be a means of differentiation. In the 80's and 90's, there were 'good quality' cars and 'bad quality' cars, cars that worked reliably and others that did not. Since then, with widespread adoption of Japanese derived methodologies such as Lean to reduce waste & Motorola's Six Sigma to reduce variation, it is fair to say that today there are no 'bad quality' cars; they all work, they all get you where you need to be and they don't rust.

Within manufacturing businesses, the quality revolution has been raging even more fiercely and quality has been through a broadening of its definition. Most manufacturers now focus more on assuring quality rather than simply trying to control. In doing so, they have developed the ability to track the cost of Non-Conformance Reports (NCRs). **Understanding the price of failure has led to quality being used more and more as a business improvement and cost reduction tool**, balancing the cost of control and monitoring against the cost of rework and delay.

The **ultimate price of failure in extreme cases can lead to loss of life and environmental damage**. History is littered with organisational disasters caused by poor decision making and lack of a robust management system. Well known examples are NASA Challenger, BP Deepwater Horizon and the Toyota emergency recall. Subsequent incident investigations usually uncover that a relatively small amount of time and investment 'up-front' could have avoided the catastrophic event.

Within high-value bespoke project engineering and manufacturing industries such as oil & gas, products are often produced for a single project as a one-off or a first-off and will sometimes never be made to that same specification again. This makes investigation of quality issues challenging as there is no historical dataset to use as an audit trail. Engineers must use imperfect qualification data, modelling and extrapolation to simulate failure modes and then derive solutions.

Despite the lack of volume, **the price of failure in a project engineering environment can be extremely high** due to the product value and typically a very binary customer approach to product acceptance. Sometimes rework and repair are totally forbidden in the contract, or they require a full engineering justification prior to acceptance resulting in significant effort and schedule delays. Liquidated damages of up to 25% of the contact value are not uncommon for performance errors or late delivery, meaning the risk profile of these bespoke projects becomes palpable.

Many of the most successful project engineering businesses have followed what is effectively 'fast-track R&D with huge penalties for not getting it right first time' approach, by standardizing and qualifying products at the sub-component level. Even though their finished products may be highly 'bespoke', in reality, they are merely a unique combination of standard components that have been 'Configured-To-Order'.

COST OF QUALITY (COQ) AND COST OF POOR QUALITY (COPQ) DEFINITION

Cost of Quality (COQ) is defined as the sum of conformance and non-conformance costs, where the cost of conformance is the price paid for the prevention of poor quality (e.g. inspection and quality appraisal) and the cost of non-conformance is the price of any product and service failure (e.g. rework and returns); they are often referred to as 'internal' and 'external' failure costs. During the 1990's, IBM popularised the term Cost Of Poor Quality (COPQ) which is defined as the cost associated with providing poor quality products or services. COPQ is also often referred to as Poor Quality Cost (PQC), Cost Of Non Quality (CONQ) or Non Quality Costs (NQC).

Internal failure costs are those costs associated with product failure before delivery to the external customer. They include the net cost of scrap, rework, material wastage, labour wastage, overheads associated with engineering and production, failure and investigation analysis, supplier rework, re-inspection, re-test, delays due to quality problems, lost opportunity cost, or other product downgrades.

External failure costs emerge after delivery of the project to the customer within the warranty or the "defects liability period." Examples include deterioration of product, complaints of malfunctioning products, complaints associated with repair, replacement of nonconforming or defective parts, warranty charges, returned products, product recalls, allowances, direct and indirect labour associated with investigation and product liability costs.
Historically, companies have tended to focus on 'hard' manufacturing defects that occur in production, but as businesses learn to track issues back to their root cause, it has become apparent that **many quality issues and therefore a high proportion of the COPQ is rooted in front-end processes such as sales, tendering, costing, engineering and procurement**. Any defects incurred at this initial stage of a project tend to 'snowball' through a project, resulting in far higher levels of COPQ downstream if they are not addressed at source.

The iceberg analogy is commonly used, with the tip being the visible in-process production defects, but under the water lies a 'hidden factory' of tangible and intangible costs caused by cost estimation errors, drawing inaccuracies, human inputting errors and misaligned procurement specifications to name a few. Today, **many project engineering businesses take a holistic view to COPQ and see it as being any unexpected cost or cost variances to the as-sold position, no matter at which stage it occurs**.

MEASURING COPQ WITHIN A PROJECT ENGINEERING ENVIRONMENT

In a project engineering or manufacturing business, measuring COPQ is a challenge. Accounting systems were never designed to demonstrate the impact of quality performance on overall operating costs and that is why many of these costs remain hidden or invisible for so long. Research has shown that the COPQ across the entire cash-to-cash cycle can be huge and that the **COPQ typically equates to between 10-30% of the total sales revenue**.

> COPQ typically equates to between 10-30% of the total sales revenue.

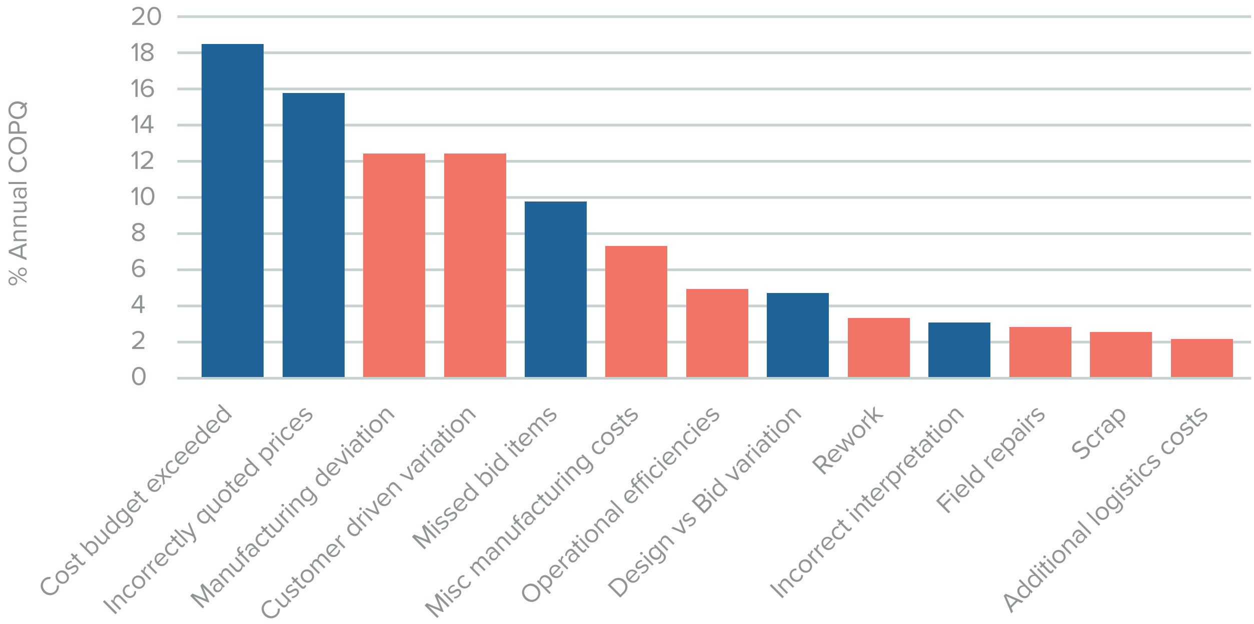
However, some commentators are concerned that hidden costs associated with external failure are not always reported in full. Lost opportunities, customer dissatisfaction, and negative customer referrals are certainly costs relating to poor quality and therefore the COPQ iceberg could be even larger beneath the surface and the actual cost could be even higher. To capitalise on the time invested in COPQ analysis and to understand its full extent, **organisations should ask themselves a series of questions as laid out in Appendix I**.

It is important to view COPQ proactively as a lost opportunity and to drive initiatives to find root causes and to implement robust preventative measures to reduce future errors and cost. **After all, how many other ways can businesses look to improve their bottom line by up to 30% with no increase in sales revenue?**

The distribution of COPQ across a project driven business will vary because there are many variables to consider. A recent study of project manufacturing organisations has shown that on average **50% of COPQ is rooted out with the manufacturing area in sales, tendering, engineering design and purchasing**. Figure 1 highlights (in blue) that approximately half the COPQ value is directly attributable to 'front-end' activities within the overall project lifecycle caused by cost budget exceeded (18%), incorrect pricing (16%), missed bid items (10%), design vs. bid variation (5%) and incorrect interpretation of requirements (3%). Whilst there are many specific reasons at the root of such failure costs, a common theme is the repeated breakdown in information flow between key functions and processes, largely due to the many fragmented and disconnected systems, databases and tools that are in use.

> 50% of COPQ is rooted out with the manufacturing area in sales, tendering, engineering design and purchasing.

TYPICAL COPQ DISTRIBUTION



After identifying these areas of cost, **many organisations struggle to tackle the softer issues** that often have human, cultural and behavioural elements, which are not necessarily predictable or consistent. It is common to find organisations stuck in a state of 'analysis paralysis' having revealed huge cost leakage, but frustratingly being unable to apply anything more than a containment 'sticky plaster' that simply leads to a high probability of reoccurrence.

The only real solution therefore is to reduce the human factor, not by banning mistakes or punishing those that make them, but by systematically removing human touch points. **This is achieved by joining up existing systems with an automation platform that will accurately and consistently transfer data, run calculations and check its own work to ensure its right first time, on time, every time.**

WHY INVEST IN PROCESS AUTOMATION?

Given the focus across multiple sectors towards lower cost delivered solutions and lead time sensitive project awards, it is paramount to have a standardised product configuration and an efficient process within the tender to engineering design cycle.

It seems strange then that it is commonly cited that half of the COPQ (the biggest opportunity to improve profitability) lies within the front-end business processes. So why is there such a disconnect between what is clearly needed and what happens in practise? To answer this, further exploration of typical 'symptoms' & 'causes' is necessary:

Sometimes **a process may not exist** or, as is more often the case, it may **not be clearly defined** in the first instance. Where processes do exist, it is not uncommon for individual behaviours to develop into customary practises resulting in the **process not being strictly adhered to in practise**. Unclear processes ultimately mean that too much interpretation is left to individual engineering judgement (rather than design rules) and there can be a **dangerous lack of traceability in terms of decision making**.

Moreover, **numerous 'tools' may already be in use, but have they been checked for accuracy and are they controlled for use**?

In an environment where tools often grow organically, there is usually limited or no integration between the different tools. This means that **changes made in one tool are not automatically carried over to the other**; data is transferred manually between tools, taking up valuable time and inducing a **high frequency of errors which may go undetected**.

In complex projects, engineering is often done at least twice; once to win the work in the first instance, then again to deliver the work after the order lands. Tenders often have a long gestation period, so there is likely to have been many bid iterations and changes in critical specifications and parameters. **Organisations often have to trade-off the efficiency of recycling bid engineering with the risk and cost of inaccuracy**. Most opt for the lowest risk option, that is to start the engineering again from scratch.

The low risk option inevitably results in bottlenecks appearing in the availability of suitably qualified & experienced personnel (SQEPs). Senior **Engineers are often consumed (and demotivated) with low value administrative tasks** that they shouldn't be doing and developing Engineers are not provided with the right tools to enable them to flourish and do more meaningful work. A vicious circle ensues. This reliance on key individuals means that too much core understanding resides 'in the heads' of too few and the **corporate memory is at serious risk of being lost should those people leave the business**.

Most of these typical ailments are hidden from view, but they generate **latent COPQ** that may not manifest itself until the project is further advanced, by which time their severity has often increased exponentially.

One KPI that acts as a clear indicator of the presence of these hidden issues is engineering On-Time

Delivery (OTD). Despite tracking the metric though, many Engineering Managers are at a loss to explain why engineering hours **routinely overrun and why Engineering always sits on the critical path**. This means that later stages in the project cycle such as procurement must be expedited at risk, then at the end of the project when latent defects are exposed, no one can explain why.

Despite the obvious need for accuracy, consistency and efficiency in 'front-end' processes, these facets are often not prevalent (for a number or reasons) and high COPQ is the outcome. Clearly, the thread of consistency that runs through all the causes is people and our bizarre and **unrealistic expectation for them not be 'human'**.

KEY FEATURES AND BENEFITS OF AN AUTOMATED PLATFORM

An automated platform will deliver a customised output to user requirements through a series of logical steps. The user will input project specific data. The platform will then utilise default configuration parameters to generate design solutions based on a background workflow of data validation, filtering, and process logic drawing upon reference data, standard engineering calculations, and intelligent machine learning. **Such a system can be applied to any complex transaction** and offers several key benefits within a project engineering environment:

An intelligent automation platform serves to join up the system dots and removes the grey areas in between tools. It captures and preserves the tacit knowledge that resides within your company; this **reduces your reliance on key individuals and provides a memory bank from which to train new recruits**.

Automation also allows you to create a set of standard design rules within a 'single source of truth'. This eliminates manual errors and costly re-work by adopting a consistent and validated approach from the start.

1 RETAIN KNOWLEDGE & REDUCE RISK

The use of an automation platform can create a **'smart system'** that enables critical knowledge to be captured, retained and distributed throughout the organization. This can be achieved without having to 'hand the keys' to the computer. In fact, the most reliable, error-proof and controlled systems **retain a strong human interface**. However, instead of doing time consuming and repetitive manual tasks, **talented engineers can work innovatively and creatively** to improve the quality and competitiveness of products and services.

Mistakes are expensive. Project liquidated damages are often in excess of 25% of the contract value and in-service failure can carry uncapped liability. **Automated software will drastically reduce the risk of costly mistakes** often caused by multiple manual points of data handling.

2 OPTIMISE PERFORMANCE & REDUCE COST

An automated platform will drive standardisation and cost reduction across the business.

It can create a powerful Configure-To-Order (CTO) capability and mandate a robust Engineer-To-Order (ETO) approach.

In its CTO form, the automated platform will allow you to create a bespoke solution for your client from a standard library of parts.

In its ETO form, the automated platform will perform an optimisation loop to produce a minimum viable, code compliant and cost-effective product.

Automation will increase the utilisation of your engineers too.

Checks and balances will be automated where possible. Junior engineers will be enabled to do more meaningful work and senior engineers can be allocated to more strategic and value-added tasks.

Automation will drive massive gains in engineering efficiency and capacity. Recent case studies from PDL sampling a range of clients in a number of different industries show that an automated platform can reduce the number of engineering hours to 1/10th of the original budgeted time.

3 SHORTEN LEADTIME

Gone are the days of doing the engineering twice; an automated platform will ensure that you only need to do the engineering once.

80% of the engineering it will be done prior to contract award and it will be done in an order of magnitude less time. This will provide cost certainty for you at the bid stage and provide for a more compelling bid.

With 80% of the engineering completed at the bid stage, only 20% of the engineering needs to be done after the order lands.

This will take engineering off the critical path when it comes to post-contract award delivery and provide an order of magnitude change in terms of delivery performance; it will create a valuable and much needed competitive advantage.

TYPICAL KEY AUTOMATION DELIVERABLES:

Drive the Cost of Poor Quality (COPQ) towards Zero

100% accuracy and 100% consistency

Order of magnitude reduction in engineering hours

100% increase in engineering capacity

CONCLUSION

> Eliminating the COPQ through automation can add up to 30% of your annual sales revenue to your bottom line

Low volume engineering projects in an industrial environment are very different to their higher volume automotive counterparts, however, the need to reduce the COPQ in the current industrial environment is as great, if not greater. There is also a need to focus business improvement initiatives at the right end of the pareto and tackle 'soft' process and systemic issues in addition to the 'hard' manufacturing defects.

Manufacturers are generally well-accustomed to making large investments in new machines, equipment and process control to reduce the COPQ.

It would seem logical to assume that the same mindset would apply to the comparatively small investment required to reduce the COPQ through automation.

Sadly, that logic does not always seem to apply, and some senior management teams often struggle to approve a business case that doesn't deliver a physical asset that can be paraded at board meetings.

An inaccurate, inconsistent and inefficient 'sales' process is known to introduce potentially catastrophic defects into a project that lie dormant until the latter stage. Many organisations mistakenly class this front-end COPQ as a 'people issue', satisfy themselves that it's down to 'human error' and then proceed to hope that it won't happen again in the future.

Hope is not a good strategy though. Given that the price of failure in the project engineering environment is so high, investment in process automation should be seen as an essential investment, rather than an unnecessary cost.

Eliminating the COPQ through automation can add up to 30% of your annual sales revenue to your bottom line, therefore;

> "..you should not worry about the price of doing it, you should worry about the cost if you don't.."

APPENDIX

APPENDIX I – HOW TO CALCULATE THE COPQ

In seeking to understand the true COPQ within your organisation, several fundamental questions should be asked with respect to appraisal and failure costs. These questions are listed below. The costs, if already tracked and known, can be directly used as actuals to develop a COPQ forecast. If the costs are not known, they can be forecast by risk assessment and weighting based on the severity and likelihood of occurrence, taking into account the existing controls and mitigation measures in place.

TYPICAL APPRAISAL COSTS

How much time and therefore cost is associated with:

- Engineering process, checking and approval
- Design, project and specific code review
- Inspecting and testing your process, product or service
- Auditing your internal systems and processes, suppliers and sub-suppliers
- Contract reviews, establishing quality goals/ objectives, gate release reviews
- Creating, reviewing, and updating quality plans

INTERNAL FAILURE COSTS

How much time and therefore cost is associated with:

- Process, product or service rework
- Retesting
- Redesigning or re-coding
- Remaking defective product
- Scrap cost
- Downtime and resulting overtime to catch-up
- Project delays & associated claims, e.g., liquidated damages
- Knock on effect to subsequent projects, re-planning exercise and reviews
- Claims management
- Failure analysis
- Crisis management, meetings, escalations, reporting

EXTERNAL FAILURE COSTS

How much time or cost is associated with:

- Grievances and complaints handling
- Engineering documents and product returns
- Replacement product
- Warranty returns and claims
- Product recalls, patches, repairs and service support
- Negotiations and sales reductions
- Loss of existing or future orders
- Reputational damage
- Company devaluation
- Legal disputes

APPENDIX II – A HYPOTHETICAL EXAMPLE

Company A is a project-driven, high-value design and manufacture organisation who had a particularly busy year with a record volume of sales and a high volume of fast turnaround projects.

Unfortunately, there were several exceptional issues within the tenders that were missed causing some unpleasant surprises during project execution.

In manufacturing, a series of product failures during testing led to a high volume of rework which subsequently delayed delivery.

Furthermore, they have been grappling with several high-profile field warranty issues due to inherent design failings.

The true Cost of Poor Quality might look something like this:

TOTAL ANNUAL SALES = £30M

APPRAISAL COSTS = £1.2M

Includes project check and approval cycles, regular inspections, audits, project and quality reviews.

INTERNAL FAILURE COSTS = £2.4M

Includes time and cost associated with omissions from tenders, misinterpretation of specifications and general costs associated with rework, remaking, retesting, scrap, downtime, analysis, and investigations.

EXTERNAL FAILURE COSTS = £3M

Includes time and costs associated with complaints handling, root cause analysis investigations, management time, travel costs, 3rd party validation, negotiations and legal fees.

COPQ = ∑Appraisal costs + ∑Internal failure costs + ∑External failure costs

COPQ = £6.6M (22% of Annual Sales)

Following root cause investigation, it was revealed that 50% of COPQ, or £3.3m, originated within the ‘front-end’ process primarily down to a lack of an integrated approach:

Cost budget exceeded	£1.1M
Incorrect pricing	£1.0M
Missed bid items	£0.7M
Design vs. bid variation	£0.3M
Incorrect spec. interpretation	£0.2M
TOTAL	£3.3M

Note: This hypothetical example assumes that all of the costs associated with appraisal, internal and external failure were known, tracked, financially accounted for and the root cause understood; this is difficult to do, hence these costs are often referred to as the ‘hidden factory’.

Whilst this is a hypothetical example, the figures shown are based on a real business that designs, manufactures and tests high value products for the offshore oil & gas industry.

ABOUT THE AUTHOR

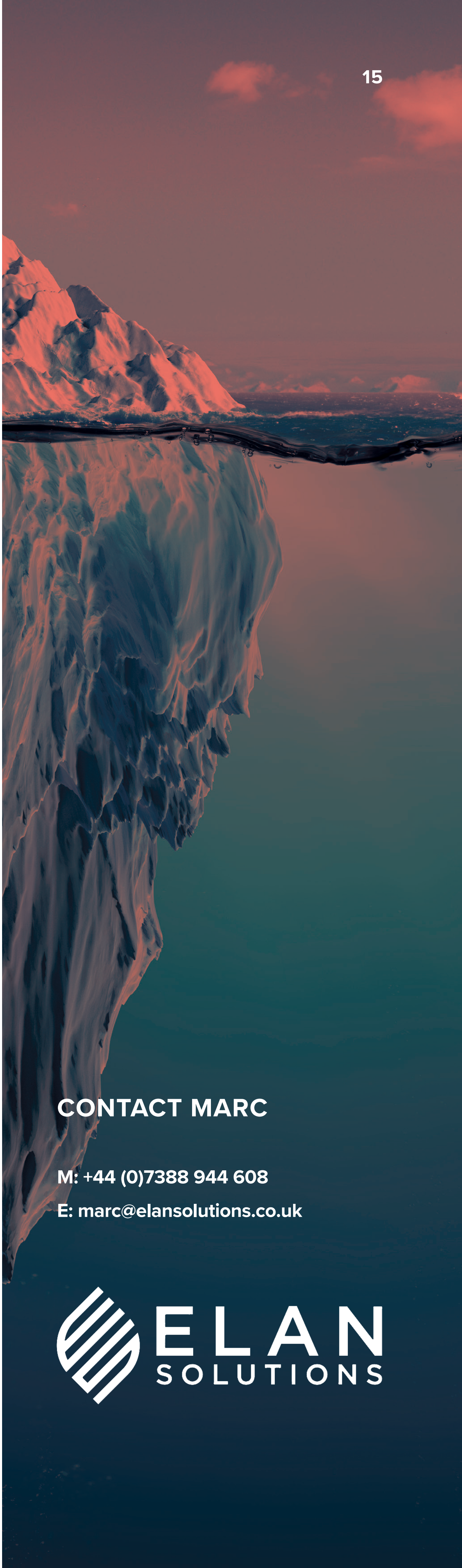
MARC BELL
BEng (Hons) MBA

ELAN SOLUTIONS
Consultant

Marc currently holds several Directorships and Associate Consultant positions within the Energy sector. He is a member of the Institute of Quality Management, holds a mechanical engineering degree from Sunderland University and a Master's in Business Administration from Durham University.

Before embarking on his portfolio career with Elan Solutions, Marc held the position of Director of Operations for JDR Cables, Head of Offshore Operations for Siemens Gamesa Service Division and Global Operations Manager for TechnipFMC. Over this period, he developed a wealth of experience within the Oil & Gas and Renewable Energy sectors working for and alongside Operators, Windfarm Developers, EPICs, O&M Operators, OEM's and supply chain manufacturers.

As a lean practitioner and certified six sigma black belt, Marc has over 25 years-experience delivering change programs via an integrated tripartite approach of lean, six-sigma and operational excellence methodologies.



CONTACT MARC

M: +44 (0)7388 944 608
E: marc@elansolutions.co.uk

ELAN SOLUTIONS