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Requirements Management: **The Complete Guide**

How to improve your product quality, and reduce development costs & cycle times.

White Paper

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January 2014

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01 Introduction

This document presents the business case for the introduction of effective requirements management supported by the Visure Requirements toolset. There is strong evidence to support the case that reducing requirement errors and omission may be the single most effective action that developers of complex systems can take to improve project outcomes and assist in our goal of delivering quality systems, on time and within budget. This document highlights some of the empirical evidence and demonstrates that an investment in more effect requirements management can produce substantial and quantifiable rewards.

The examples given are generated from data collated from existing customers, consultants and published research data from the Standish Group and IDC.

An area not specifically covered by this document is the visible and invisible project costs associated with requirements error and omission. Requirements that get missed or overlooked, where this omission is not realized until system integration or beyond, can involve huge costs. From the Standish report published in 2009 requirement errors and omissions detected late in the postdelivery and maintenance phase can cost up to 200 times more to resolve than those detected during the early requirements analysis phase. Capturing each requirement in a Visure Requirements database as an item that must be acted upon (in terms of design and testable compliance criteria) will significantly reduce the probability of such omission.

02 Engineering Product Quality Improvement

It has become clear from all companies who have formalized their requirements management process through the introduction of Visure Requirements that there is an immediate improvement in the quality of the engineering product and documentation, which is derived from its application during the system definition and development process.

This quality improvement is inherently difficult to measure; however, we know from numerous discussions with existing customers that the lack of redundancy in the Visure Requirements information model is a key contributing factor to improved quality.

2.1. Information Traceability

There are two kinds of “traceability” which most project engineers are concerned with in their day-today activities:

2.1.1. Ad Hoc Traces

The first is what we call “navigational” traceability in which, for example, an engineer is tasked to find all of the system design elements, which may be affected when a given requirement is changed. This type of ad hoc enquiry is handled very quickly and easily in Visure Requirements, simply by using the impact and traceability view or the traceability report. Assuming the database contains all the relevant information, this kind of trace can be performed in seconds, using just a few mouse clicks to highlight and track the relevant information.

2.1.2. Traceability Matrices

The other kind of traceability is the production of elaborate “traceability matrices” for requirements reviews and deliverable system documentation. The information gathering and production of such a matrix can be a labour intensive and daunting task for even the smallest program. On many projects complex databases are set up to record and allocate all of the mandatory “shall” requirements from the original specifications. This type of traceability often demands a great deal of commitment to online maintenance, to ensure that all the customer requirements are being met. When links are established between requirements in the Visure Requirements database, traceability matrices are automatically created as a bye product of using the tool. This information is then available for real time on-line review and can be used for the production of project progress metrics reports and deliverable documentation.

03 Project Cost and Time Savings

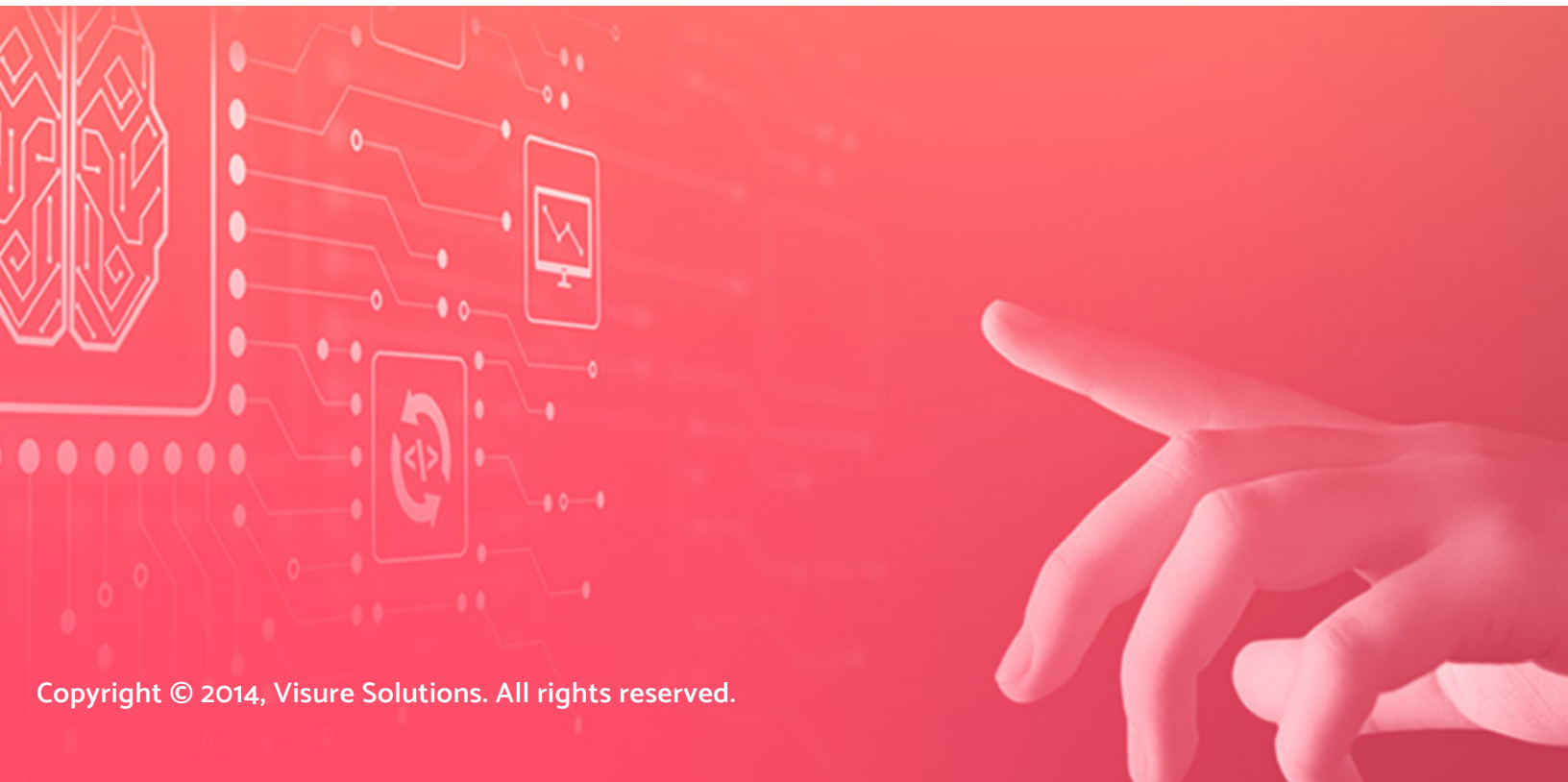
Even if we discount the quality increase attained when using Visure Requirements, there are genuine savings in both cost and time, which accrue with knowledgeable use of the tool. In this section, we attempt to qualify the savings, which would be associated with the various phases of the project lifecycle, as detailed below:

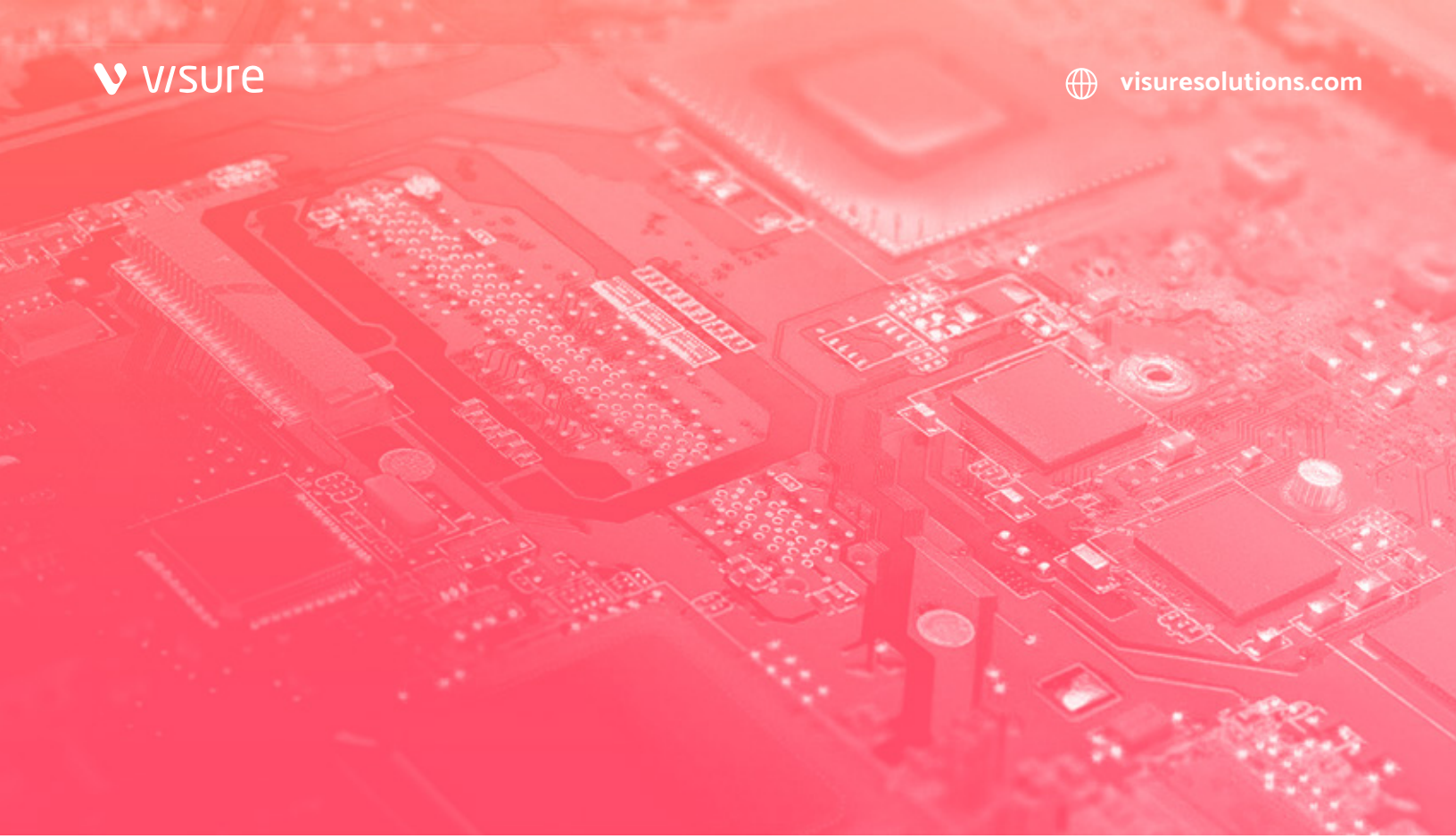
- A **Engineering information access**
- B **System Requirements Re-use**
- C **Requirements traceability**
- D **Information Version Management**
- E **Traceability matrix production**
- F **Test planning**
- G **Risk Management**
- H **Engineering report production**
- I **Production of contract deliverable specification documents**
- J **Capturing and Maintaining your Intellectual Property (IP)**

For the purposes of this exercise the statistical information on cost savings are based on an assumed pricing rate of £30 per hour.

3.1. Engineering Information Access

One of the most daunting tasks facing any engineer joining an existing project, is finding out just where the information exists. This can be a time-wasting and counter-productive activity for even the most seasoned and capable of engineering professionals. Very often project information is held in various unconnected documents and “islands of information” where more than one version of duplicated or overlapping data can exist. Visure Requirements simplifies this process by making all the relevant project information available in a single, integrated central database that can be accessed by anyone within the project who needs to see it. With the use of Visure Requirements the project engineers are able to capture, maintain and share one instance and version of current project information, which promotes significant productivity and quality improvements.





3.2. System Requirements Re-use

Increasingly organizations are looking more towards large scale reuse as a way of improving productivity, raising quality and reducing project delivery timescales. It is recognized however that this can only be achieved through the introduction of systems engineering best practice rather than ad-hoc reuse of data held in project archives. Planning for reuse needs to happen during the early stages of the project and captured in a central repository in a form which is easily accessible by the project engineers. Capturing this reusable data in bounded MS Word and Excel documents is often not good enough to promote and encourage effective reuse of information. Effective and flexible reuse needs to occur at individual requirement statement or item level rather than whole document level. Capturing reusable artifacts in Visure Requirements allows this reuse to be managed and controlled at individual requirement statement level, and because it is captured in a central repository, the information is available to the whole project team.

3.2. System Requirements Re-use

Industrial case studies have been completed in the aircraft engine control domain where reuse of common platform data and international standards information has been successfully captured and reused on the next generation system. This provided a solid and consistent foundation on which to start the new project, where compliance with known and stable information could be reused. The effective reuse of this data increased quality and consistency between projects and help to ensure that unnecessary omissions could easily be avoided. At the start of the new projects, the cost and time savings of effective information reuse were found to be significant and over the life of the whole project activities associated with the reuse of standards and common platform information represented savings in time and effort of about 25%.

Information Reuse	Saving	Year 1	Year 2	Year 3	Total	Your Project
Number Hours spent/year		1,440	1,008	806	3,254	
Reduction in time using Visure Requirements	25%					
Hours saved using Visure Requirements		360	252	202	814	
Information Reuse Savings		£10,800	£7,560t	£6,045	£24,405	

Table 1 – Information Reuse Time Savings

One study concluded that reuse allows organizations to use personnel more effectively because it leverages expertise and moves the focus to the new customer requirements rather than the ones already covered by the common platform and customer specified standards.

3.3. . Requirements Traceability

Engineers typically maintain traceability information independent of the actual requirements and design data, either in the form of a spreadsheet, a simple database, or even on paper using a manual process. This information may take from several minutes to several hours to identify for each entity being traced. If the engineer must also refer to base lined specifications in addition to the raw engineering data, this trace activity can be even more protracted.

Requirements Traceability	Hours	Year 1	Year 2	Year 3	Total	Your Project
Number of requirements traced		1,050	0 750	806	3,254	
Number of Hours/Object (Manually)	1.5	1,575	1,125	900	3,600	
Number of Hours/Object in Visure	0.1	158	113	90	361	
Requirements Traceability Savings		£42,510	£30,360	£24,300	£97,170	

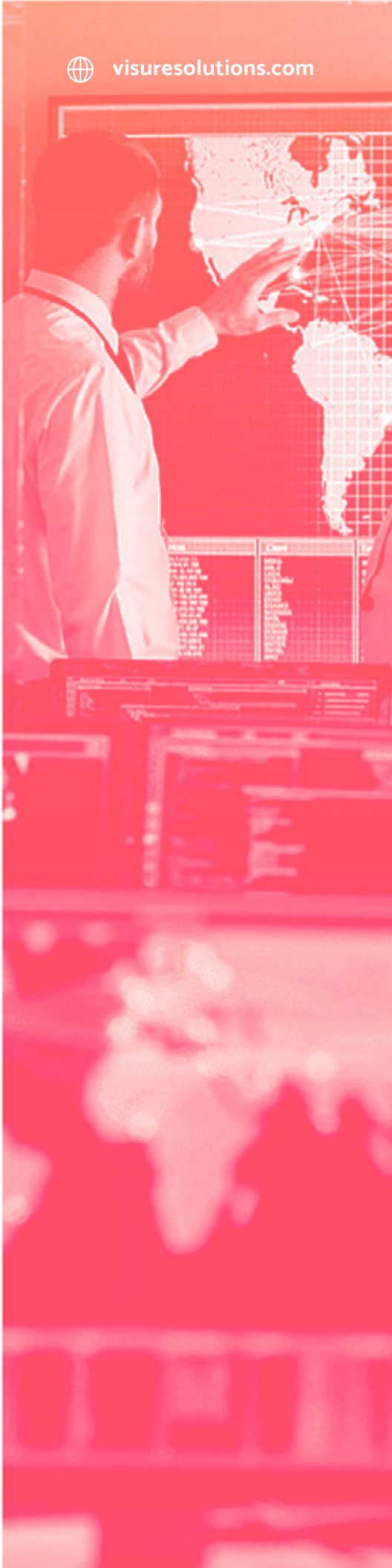
Table 2 – Requirements Traceability

By using Visure Requirements, an engineer is assured of automatic traceability once the data is entered and the appropriate relationships are established. Consider the following example: An engineering manager asks a System Engineer to ascertain the impact of changing a particular requirement or system performance index. Done manually, this is usually a time-consuming and tedious task, involving document searches and possibly meetings with people no longer involved with the project. Visure Requirements ability to capture project history and rationales for design decisions, coupled with its extensive traceability capabilities, makes this kind of query a simple bye product of capturing and linking requirements in the database.

3.4. Information Version Management

The other challenge that many projects faced was ensuring that everyone who is working on the project is working on the correct version of the project information. Working on out of date information can consume unnecessary time and effort which could so easily be avoided. Maintaining one instance and one version of the project data in a central repository which everyone in the project team can access, significantly improves the quality and consistency of the resulting project deliverables. Also, maintaining a record of who changed which individual requirement statement and when provides useful history and context of why changes occurred. It also allows projects to monitor and assess requirement volatility, which for information held in Visure Requirements can be reported on at any time. Requirements which are subject to a lot of change over time could be the subject of other underlying issues that need to be analyzed and resolved at source rather than perpetuated into future projects.

Metrics and cost savings motivated by effective version management have been more difficult for organizations to assess and quantify, but our customers have confirmed that the business benefit is real. Historically version management has been performed at document level rather than individual requirement statement level, which increases the management and control of these documents and the effective recording of these changes.



3.5. Traceability Matrix Production

Project managers frequently request traceability matrices as a program evolves, especially for major reviews and milestones. Another reason than traceability matrices are created is to document system compliance with standards, regulations and the customer's original statement of need.Typically this matrix is produced by manually compiling diverse engineering information during the latter design phases of a program, as a prelude to system integration and test activities. For a moderate-sized system database, containing roughly 1000 requirements, an equal number of functions and components to which functions have been allocated, this matrix may take from 50 to 500 staff-hours to compile and publish.

Trace Matrix Production	Hours	Year 1	Year 2	Year 3	Total	Your Project
No. Matrices:		11	8	6	25	
No. Hours/Matrix (Manually)	150	1,650	1,200	900	3,750	
No. Hours/Matrix	1	11	8	6	25	
Trace Matrix Savings		£49,170	£35,760	£26,820	£111,750	

Table 3 – Traceability Matrix Production

Using Visure Requirements, a single engineer can effortlessly produce traceability reports and matrices in a fraction of the time spent producing them manually.

3.6. Test Planning

Traditionally test planning has been accommodated has been has been performed as part of the systems engineering process and passed to the test team through requirements traceability matrices and reports. Since Visure Requirements automates the generation of these reports, the needs of test planners can be easily met. More importantly, Visure Requirements can be easily extended to explicitly accommodate test plans, procedures and criteria within the Visure Requirements data repository, thus encouraging early substantive participation of the integration and test team in the requirements analysis, design and specification process. It is estimated that time savings of about 60% in using the tool to accomplish test planning and publish the collateral test material (including developing the appropriate report templates) is the norm. This significant saving is achieved because of the re-use of the verification criteria associated with the re-use of requirements standards and common system/product requirements.

Test Planning	Saving	Year 1	Year 2	Year 3	Total	Your Project
Number Hours spent/year		2,520	1,800	1,440	5,760	
Reduction in time using Visure Requirements	60%					
Hours saved using Visure Requirements		1,512	1,080	864	3,456	
Information Reuse Savings		£45,360	£32,00	£25,920	£103,68	

Table 1 – Information Reuse Time Savings

The production of the test specification documents is no longer a separate exercise, which runs in parallel with the design activities. The test specification documents are automatically produced from the Visure Requirements database, with data that is supplied from an integral part of the design process.

3.7. Risk Management

Project risks can also be recorded and maintained with Visure Requirements, where risks can be motivated by requirements from any of the project documents and activities. Identified risks can also be directly linked to risk mitigation information, which everyone within the project team can have visibility of. So risk management becomes an integral part of the project management process which is controlled throughout the project management lifecycle. Risk management reports can be produced at any time during the project on demand.

3.8. Engineering Report Production

There are many instances where a project engineer is tasked with producing a report or metrics for internal peer or management review. This generally involves the tedium of extracting the relevant information from various sources, organizing it and then arranging for a professionally appealing production of the document. Usually by the time the document reaches its target audience, there are some inconsistencies, out of date or incorrect information contained within it. The problem often stems from the gap between the engineering data and the production of the document. This gap can be eliminated with Visure Requirements. There are numerous engineering reports which Visure Requirements produces at any time during the requirements analysis, functional design or functional allocation phases. These ad-hoc reports are frequently demanded by a number of key stakeholders including the customer, the project manager or senior management and often cause significant disruption to project activities when requested.

Ad Hoc Reporting	Saving	Year 1	Year 2	Year 3	Total	Your Project
Number Hours Spent/Year		1,260	900	720	2,880	
Reduction in time using Visure Requirements	20%					
Hours saved using Visure Requirements		252	180	144	576	
Ad Hoc Reporting Savings		£7,560	£5,400	£4,320	£17,280	

Table 5 – 20% Time Savings in Ad hoc Reporting

Our customers agree that the ability to produce these reports on demand out of Visure Requirements database is a great time and cost saver. It is estimated that in general, savings of up to 20% of the systems engineering staff's time can be accrued during a project.

3.9. Production of Contract Deliverable Specification Documents

During the life cycle of most systems, there is an ongoing need to produce specification documents to satisfy the needs of the various customers, subcontractors and other organizations participating in the system development process. All too often, these activities (since they usually carry the label "deliverable", and hence, generate revenue) take precedence over the engineering of the system. Since staffing is usually fixed for most contracts, this means that valuable and expensive engineering talent is consumed producing paper. Visure Requirements eliminates this waste by providing easily modified templates and functions for automated report and specification production.

Ad Hoc Reporting	Saving	Year 1	Year 2	Year 3	Total	Your Project
Specification Production		2,940	2,100	1,680	6,720	
Reduction in time using Visure Requirements	40%					
Hours saved using Visure Requirements		1,176	840	672	2,688	
Ad Hoc Reporting Savings		£35,280	£25,200	£20,160	£80,64	

Table 6 – 40% Time Savings in Specification Production

3.10. Capturing and Maintaining your Intellectual Property (IP)

Product and system development experts leave project teams frequently and with their departure intellectual capital often leaves with them. Capturing the inputs and contributions from these experts and maintaining this information in a central requirements repository, collectively provides one of your most valuable business assets, your Intellectual Property (IP). Storing this information in a structured environment which is both accessible and most importantly, re-usable, is vital to the continued success of all businesses. Allowing this IP to walk away from your project or your business where their vital contribution has not been properly captured and recorded for future use, can consume significant time, effort and cost to re-produce. In some instances critical information cannot be reverse engineered or reproduced, particularly where it was only stored in the departing chief designers head. Like insurance it is not easy to estimate the true value of properly capturing this “IP” through the effective application of a requirements management tool supported by repeatable processes and best practice, but there is no doubt that the value is real. The true value is often only realized when the source of the original IP is no longer available.disruption to project activities when requested.

04 Conclusions

As you can see from the analysis above there are many areas where the introduction of a formal requirements management environment would bring quantifiable improvements to the management of projects. There are many areas where time and cost savings would be achieved by the introduction of Visure Requirements to enforce repeatable requirements engineering processes and best practice. Depending on the customer's circumstances, we believe that it is possible to construct a clear and justifiable business case for introducing effective requirements management supported by Visure Requirements.
The introduction of the central Visure Requirements repository will allow you to maintain a complete record of the "as built" system rather than the as "specified system", ensuring that all of the support documentation reflects the system as delivered. By collating the information presented in this document, the table below provides a summary of the possible savings that could be achieved by the introduction of Visure Requirements. The figures are based on an average engineering cost of £30 per hour with the estimates of savings being derived from customer interviews and published analysis that has been produced during the last 15-years.

Phase	Saving	Year 1	Year 2	Year 3	Total	Your Project
Information Reuse Savings	25%	£10,800	£7,560	£6,045	£24,405	
Requirements Traceability Savings		£42,510	£30,360	£24,300	£97,170	
Trace Matrix Savings		£49,170	£35,760	£26,820	£111,750	
Test Planning Savings	£35,280	£45,360	£32,400	£25,920	£103,680	
Ad Hoc Reporting Savings	£35,280	£7,560	£5,400	£4,320	£17,280	
Specification Production Savings	£35,280	£35,280	£25,200	£20,160	£80,640	
Total		£190,680	£136,680	£107,565	£434,925	

Table 7 – Estimate of Total Savings

The re-use of existing information on known standards and common system requirements provides a consistent foundation for all new projects. This will motivate repeatable processes and support significant improvements in product quality, at the same time as reducing the time to market. Customer satisfaction also improves because key information becomes more accessible, so you can become more responsive to queries or requests for change. The use of an integrated design environment will provide significant benefits in ensuring full traceability of your customer expectations throughout the design and implementation lifecycle. It allows your most valuable engineering resource to focus on the system design rather than the administration, document production and performance metrics reporting activities that are normally associated with projects. The Visure Requirements environment also encourages more integration across engineering disciplines, where people share common design information but with different viewpoints. As the requirements are directly linked to the physical and functional views of the design solution, the impact of design change can be more quickly and clearly understood. This allows project engineers to make informed design decisions based on connected and current information. The cost of dealing with missed or errored requirements retrospectively during system integration or beyond has been proven in a Standish report to be up to 200 times higher than addressing them at the early analysis phase of the project.The capturing and maintenance of product and project information also allows you to protect your most valuable re-usable asset, your company IP. Although the true value of this is difficult to estimate, the value in collecting this information through effective requirements management is real.

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