T802 Research Project – TMA30

MSc Computing for Commerce and Industry

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13th September 2015

IPv6: Identifying the critical factors to assist in building a successful business case for adoption

Word Count: 15814 *(Additional word count approved by module team)*

Extended Abstract Word Count: 1247

This dissertation is submitted in partial fulfilment of the requirements of the MSc in Computing for Commerce and Industry.

Abstract

The adoption of the IPv6 (Internet Protocol version 6) protocol within organisational IT networks and the wider Internet continues to remain stubbornly low. Most of today's networks and internets still make use of the IPv4 protocol to allow connected computers and devices to communicate. IPv4 however was not designed to scale to the size of today's Internet with the huge number of devices it currently accommodates.

The lack of a wide scale transition to IPv6 is beginning to pose problems for organisations (both public and private), with insufficient numbers of IPv4 addresses being available for all users and devices, without using invasive and troublesome workarounds.

In spite of these implications, IT practitioners and business leaders are struggling to *connect* the benefits, advantages and new applications that IPv6 can bring to their organisation's business goals well enough to garner the support needed to build a successful business case. Little literature exists to describe what is needed in building a successful case for and subsequent IPv6 implementation.

This research addresses this knowledge gap, by identifying the most important elements needed and provides practical recommendations, generalisable across a range of organisations drawn from the views and opinions of IT engineers and IT/business managers working in UK FE (Further Education) Colleges. By making use of the Systems Failures Approach as a framework to investigate the information system failure, using two methods. The Delphi method a process of iterative questionnaires designed to converge the views of a panel of experts toward consensus on a subjective or speculative topic, coupled with semi-structured interviews. An approach that has revealed the lack of IPv6 adoption no longer focuses technical barriers in isolation, but instead a wider organisational state unconducive to adoption, requiring holistic and inclusive remediation techniques to tackle effectively.

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Glossary

CIO (Chief Information Officer): A person with the responsibility within an organisation for the information technology systems used by the organisation.

Emic Codes: A description of a culture based on an "insider" view of the situation being studied, i.e. by those within the situation *Lett (1990)*.

Etic Codes: A description of a culture that is based on an objective or "outsider" view of the situation being studied *Lett (1990)*.

FE (Further Education) College: A college of further education, providing education below degree level for young and mature students.

Formal System Model (FSM): A model of an (information) system developed by *Checkland (1981)*, that provides a framework into which a system may be placed to examine its function or dysfunction relative to an ideal model system.

Information System: An information system is any system that collects, processes, distributes and/or uses information as a core component of its functions. An example would be an email system or a database driven system that has been developed/purchased and implemented to support business operations *(Fortune and Peters, 2005)*.

Internet: The global communications network of interconnected IT (computer) networks to allow the flow of information between connected devices that is based on the internet protocol suite.

Internet Protocol (IP): A generic term for the suite of protocols used to transfer information across the Internet between the connected devices.

internets: A term used to describe (note the lowercase 'i') an IT (computer) network that is made up of interconnected networks, that does not mean the Internet specifically, rather groups of networks belonging to different organisations who have agreed to join them for the purposes of commerce, research, business etc.

IP Address: A generic term for the address of a node/device that is connected to the Internet or an IT network, used by the IP protocol suite to direct traffic to and from the node/device.

Internet Protocol version 4 (IPv4): The current and most widely deployed version of the Internet Protocol suite used on the Internet at this time.

Internet Protocol version 6 (IPv6): The successor protocol to IPv4, currently not widely deployed.

IP TV (Internet Protocol Television): Services that provide television programmes via the transmitted over computer networks such as the Internet.

IT: Acronym of Information Technology, a term pertaining to the technologies used for information processing, communication, storage and dissemination.

IT (Information Technology) Infrastructure: IT infrastructure refers to the various components that make up the backbone of communication in a modern organisation, typically this includes the un-seen components such as hardware, software, cabling, disk storage and network components that *glues* together the people (end-users) and information systems facilitating the flow of information around an organisation. IT infrastructure may also be considered an Information System in its own right.

IT Network: Information Technology network, a general term for a computer based communications network, which links nodes (desktop/laptop computers, servers) with other computers inside or outside the boundary of the organisation.

JISC: Previously called the Joint Information Systems Committee, JISC is a public body that promotes the use of information and communication technology for teaching, education and research. More recently it has become merged with JANET (Joint Academic Network) to provide its services and Internet connectivity.

LAN (Local Area Network): An IT computer network that covers a small area, such as within a building or small campus.

Network Address Translation (NAT): The method of translating and rewriting one IP address to another for various purposes, the most prevalent being to minimise IP address usage by hiding multiple devices behind one address.

Project Specific Form of the Formal System Model (PSFFSM): A model devised by *White (2003)* that is based on *Checkland's (1981)* Formal System Model (FSM) except is focussed on a project treated as a system to allow the proposed or in progress project to be examined against an ideal model system to identify potential or actual failings.

Protocol: Within this context, a protocol is an agreed method with which to communicate between nodes on an IT network or the Internet.

Return on Investment (ROI): A way to measure the benefits (in monetary or other terms) the beneficial effect of making an investment in a project, system or some other endeavour.

Server(s): A device connected to an IT network or the Internet that serves information to client computers or devices also connected to that network.

Voice over IP (VoIP): A generic term for transmitting voice (telephone calls) across an IT network or the Internet using the Internet Protocol suite.

WAN (Wide Area Network): An IT or computer network spanning a large area, often through public communications providers. An example of a large scale WAN would be the Internet.

Acknowledgements

I would like to thank my wife Naomi and our daughter Aoife, who have been very loving, patient and supportive. I would also like to thank my tutor Dr Tina Wilson for her guidance and advice throughout the process.

Additionally, a thank you to all the participants of the primary research whose time, expertise, knowledge and opinions have made this research possible.

Chapter 1 (Introduction)

1.1 Background to the problem/issue

IPv6 (Internet Protocol Version 6) is widely regarded as the future protocol of the Internet and IT network connectivity *(Reddy et al., 2014; Onuora, 2010)*. It was developed in 1995 by the Internet Task Force to replace the incumbent IPv4 (Internet Protocol Version 4) in response to accelerating growth of the Internet.

However twenty years later, IPv6 uptake remains stubbornly low, only 4.75% Internet traffic *Google Inc. (2015)*; with adoption climbing slowly *Sridevi (2013)*. A situation that is becoming more concerning as the available pool of IPv4 addresses became depleted in 2012 *RIPE NCC (2012).* Instead organisations are choosing to deploy Network Address Translation (NAT) workarounds rather than IPv6 to grow their networks, creating issues for law enforcement, support/configuration and end-to-end communications *(Che & Lewis, 2010)*.

Organisations are aware of the benefits of IPv6: vastly more addresses, improved quality of service and routing, auto-configuration, better handling of mobile devices and no longer needing NAT *(Reddy et al., 2012)*. In spite of this, justification in the form of a strong business case is still needed to show Return on Investment (ROI) *BT Plc. (2012)* or alternatively a justification for proceeding without it.

To ensure IT practitioners can create this case; they need understanding of: inhibiting/promoting factors for IPv6, their organisation's perceptions of IT, the role/support government has in encouraging IPv6 adoption, stakeholder support and the most suitable IPv6 transition method. When these elements are understood, they may be combined to make a successful (IPv6) project and therefore avoiding system failure *(Fortune and Peters, 2005; Sauer, 1993)*. In this case, a failure is defined as an organisation's IT network not adapting to use IPv6, potentially resulting in: connectivity problems, loss of business/competitiveness *(Kaur et al., 2013; Dell, 2010)*, increased transition costs *Palet (2007)* etc.

Authors' existing works attempt to explain the current state of IPv6 adoption using methods/theories such as: Resource Based View *(Singh & Tan, 2013)* that identifies three key IT assets that are needed for a sustained business advantage to be obtained from technology adoption. Or *(Kaur et al., 2013)* Network Externalities, where the external drivers of partner or peer influence organisations might compel other organisations toward adoption. Or additionally the application of older theories, such as Institutional Theory *(DiMaggio & Powell, 1983; 1991)*; that explains how the characteristics of organisations and the decisions made within them tend toward homogenisation overall. Whereby an organisation implementing a technology may encourage other organisations to do the same within its

environment, or conversely be compelled not too (thus maintaining the status quo) by those same organisations.

However, these methods/theories fail to give a complete and holistic understanding of what elements are needed, or where to find the support needed to build a successful case for IPv6. An investigation into the adoption of a global communications protocol, will by its nature affect anyone using IT networks or the Internet (and its associated protocols) either directly or indirectly.

1.2 Justification for the research

It has become apparent that the problem of limited IPv6 adoption is common to many organisations and factors inhibiting IPv6 adoption now and in the future will focus less on the technical factors as seen in *Waterworth's (2006)* research and more on the inability of IT practitioners to build an acceptable business case for adoption. This is highlighted by *BT Plc.'s (2012)* survey where 22% of IT professionals questioned cited this as the top response impeding their organisation's adoption, where additionally a majority agreed that IPv6 does not yet offer a strong enough ROI, even though many organisations are currently considering IPv6 implementation. The benefits of IPv6 are widely publicised and the reviewed literature had much to explain the current state of IPv6 adoption, but little (such as *Chiniah's (2014)* "Hybrid IPv6 Adoption Strategy") to explain what is actually needed to build a successful IPv6 business case.

Therefore the principle justification for this research is to determine the key success and failure factors to building a business case for IPv6. So as to identify reasons (failures) for the current low rate of adoption, but more importantly contributing to the development of knowledge of what is required for IT practitioners to build a successful case for IPv6. Showing where they can garner support (internally and externally) and what elements are needed for a successful IPv6 implementation project, drawn from state of the art knowledge of an ideal model (project) system. Or in other words, this research's practical benefits are to determine what is needed to build a successful case for IPv6 through identifying, understanding and therefore avoiding failure. In an endeavour to avoid time and money being wasted attempting to start an IPv6 implementation without the correct elements, stakeholder support or resources in place. The lack of IPv6 adoption globally, in spite of the protocol being over 15 years old, provides motivation for this research. Firstly understanding the elements needed for the preparation of a successful business case and secondly define them so they may be amalgamated easily into an organisation's IT strategy in future.

UK FE Colleges have been selected as the vector for the primary research, being analogous of organisations in the wider world and constructed like any modern organisation of technological/human components *(Checkland and Holwell, 1998)*. This focused context is justified

when coupled with secondary research of existing literature to examine the wider implications of the situation, with an aim to obtain from those "at the coal face" the pertinent elements (factors/drivers, government support, relevant stakeholders etc.) that can be synthesised by this research into possible solutions to the practical problem. This justification also extends to educating an organisation's IT strategy; raising the profile of IPv6 so IT and business leaders can make 'IPv6 friendly' decisions to ensure purchasing, software development or deployment decisions are made with IPv6 in mind, so when IPv6 deployment starts, the costs and time of implementation can be reduced by not having to redo work or repurchase equipment.

1.3 Scope of the research

This research is concerned with examining the key elements required in the building of a successful case for IPv6 implementation within a modern technology dependent organisation. To do this the research consulted IT engineers (practitioners) and IT/business managers within publicly funded UK Further Education (FE) Colleges as a source of primary research data, using semi-structured interviews and 3 rounds of the Delphi method.

This research works on the premise that an organisation's IT network and systems (i.e. its IT infrastructure) is an 'information system', made up of interacting human an technological components that when combined allow work to be done. This premise allows the problem of limited IPv6 adoption to be framed as an information systems failure, allows the Systems Failures Approach *(Fortune and Peters, 2005)* to be used to investigate why IT practitioners are having problems building a successful case and identifying the elements needed for success in doing so.

The primary research was conducted as a cross-sectional investigation, between February 2015 and June 2015; consisting of three interviews conducted between 13th February and 20th February 2015. This was followed by three rounds of a Delphi method questionnaire conducted from 25th April 2015 to 3rd May 2015 (round 1), 4th May 2015 to 10th May 2015 (round 2) and 13th May 2015 until 20th May 2015 (round 3).

1.4 Outline of the dissertation

This dissertation begins with an ‘abstract’ providing a high level summary of the research approach and findings, followed by the main body of the dissertation, split into five sections, concluding with a ‘references’ section, an ‘extended abstract’ and ‘appendices’. The dissertation has been written to be as accessible as possible to the non-technical reader, but due to the nature of the subject some technical terms and abbreviations remain, but explained within the ‘glossary’. The dissertation also frames the issue of limited IPv6 adoption as an information systems failure, the implications to the research scope are highlighted in section 1.3.

Chapter 1 (Introduction) describes the background to the problems organisations are experiencing building a successful case for IPv6 adoption, what issues this is causing, the benefits of resolving this problem and who might benefit from the information this research has uncovered. It also justifies why this problem should be researched within the context of an information systems failure and the benefits that emerge from doing so.

Chapter 2 (Research Definition) details the specific practical problem this research focussed on, with an extensive literature review of existing state of the art knowledge around IPv6 adoption and the building of a successful business case. The section also states the aim and objectives of the research and then goes on to describe at a high-level the research process used to achieve these.

Chapter 3 (Methodology) provides firstly a summary of the research methods and techniques selected, followed by a justification of their applicability to supporting the research aim and objectives. These tasks coupled with a detailed explanation of the ethics and application of the methodology used to collect the primary research data.

Chapter 4 (Analysis and Interpretation) presents the data collected from the semi-structured interviews and Delphi method, showing analysis of the data, using graphs, tables, diagrammatical form (rich picture and Project Specific Form of the Formal Systems Model) and discusses these in relation to the research questions and aim.

Chapter 5 (Conclusions) summarises the conclusions drawn in relation to the research’s aims and objectives, followed by an identification of any further work that could be undertaken to develop this research further. The chapter concludes by discussing the implications of this research in other contexts outside of the UK FE sector scope of study and provides reflection on the research process undertaken.

Chapter 2 (Research Definition)

2.1 The practical problem

A review of the literature revealed that IT practitioners are not making the case for IPv6 adoption well enough because they are failing to align their proposed adoption projects sufficiently well with their organisation's goals.

The inability to exhibit sufficient relevance to current business circumstances *Dell (2012)*, and therefore as *(Robert et al., 2009)* promote, an inability to show the proposed technology's synergy with the organisation's goals, will give rise to an environment unconducive for IPv6 adoption. The IT practitioners attempting to build a case for IPv6 implementation will find success difficult or impossible, if they are unable to present either a strong business case *(BT Plc., 2012; Clark, 2011; Robert et al., 2009)* or demonstrate acceptable ROI (return on investment) *(BT Plc., 2012; Ofcom, 2012)*.

Chiniah (2014) asserts that aligning the case for IPv6 sufficiently well with business goals (moving beyond just the technical argument) will provide IT practitioners with the knowledge to assist them in building a successful case for their own organisation. Within his hybrid adoption strategy he identified three key themes below to assist in the development of a case for IPv6 and subsequent adoption, that have been written into questions for the purposes of this research to:

1. The factors, drivers or perceptions are affecting business decisions to adopt IPv6?

2. Is there a contemporary (business) case for IPv6?

3. Who in the organisation can support a case for IPv6 (i.e. which stakeholders)?

These themes may be contextualised by a fourth theme that *(Robert et al., 2009)* promotes:

4. Where and in what context are the interactions that may determine the success or failure of technology adoption?

2.2 Existing relevant knowledge

A review of relevant existing literature was conducted to determine state of the art thinking on how to build a successful business case for IPv6 adoption.

2.2.1. What factors, drivers or perceptions are affecting business decisions to adopt IPv6?

Cost of implementation was identified by *Waterworth (2006)* in her Delphi method survey and *Bons (2011)* as *cost, time, business case* as most discouraging to IPv6 adoption, such concerns of an organisation over technology implementation costs and success are understandable, when IS failures are so prevalent *(Fortune and Peters, 2005).*

A key component of successful systems implementation is a *legitimised area of operation Checkland (1981)*; implying an organisation needs a strong business case to successfully adopt IPv6. *Bons (2011)* and *BT Plc.'s (2012)* found *a lack of a strong business case* as discouraging to adoption, yet this goes beyond mere concerns over *implementation costs* that *Waterworth (2006)* purports impede adoption. One might conclude therefore that cost alone isn't the issue stopping a successful case being made for adoption, rather its making the expenditure on IPv6 without a sufficiently strong business case that demostrates an acceptable return on investment (ROI) is *(BT Plc, 2012; Chiniah, 2014).*

Although authors agreed the lack of a valid business case would be discouraging to IPv6 adoption, only *Chiniah (2014)* explained why, concluding the *lack of synergy with business goals* was responsible in limiting an IPv6 business case's success; appearing to stem from a lack of understanding of IPv6. *Chiniah (2014)* found 56% of organisations had little or no knowledge of IPv6, and 16% identified a *lack of IPv6 trained staff* as impeding adoption, also supported in *Waterworth's (2006)* survey findings.

Clark's (2011) interviews identified common factors of *lack of a business driver*, *lack of internal champion* and *uncertainty of costs and approach* that would discourage adoption, but didn't identify staff training as a common factor where *BT Plc. (2012)* and *Chiniah (2014)* did. The benefit of staff training or knowledge of IPv6 in assisting building a case should not be underestimated; *(Singh and Tan's, 2013)* Institutional Theory shows how *normative isomorphism* can support technological change from within the organisation, through pressure exerted from employees who have had IPv6 training.

Promoting factors like *inevitability* identified by *Waterworth's (2006)* survey and *Oxley (2014)* coupled with *new services support* like IPTV or VOIP *Bons (2011)* being important in supporting IPv6 adoption could be called into question. Many new services already work with IPv4 NAT

workarounds today *(Che & Lewis's, 2010)* without the need for IPv6. The increased IPv6 address scope as (*Waterworth 2006*; *Bons, 2011)* assert being a promoting factor, may not in the short term at least be as appealing as the IPv4 NAT workarounds that have a more appealing ROI than IPv6.

Chiniah (2014) found 86% of organisations surveyed have inadequate knowledge of IPv6, it would be reasonable to conclude that identifying the factors/drivers/failures an IT practitioner must be aware of in building a case for IPv6 would be beneficial. To create the primary research questions below seed with the identified factors/derivers (table 2-1) in need of further investigation.

Table 2-1 – Identified factors/drivers encouraging or discouraging IPv6 adoption

Encouraging Factors/Drivers	Discouraging Factors/Drivers
• inevitability *Waterworth (2006)*, • lack of IPv4 addresses (more IPv6 addresses) (*Waterworth, 2006; Che & Lewis, 2010)*, • government policies and assistance *(Yadav et al., 2012)*, • software/hardware support from vendors *(Clark, 2011; Gallaher & Rowe, 2005; Kaur et al., 2013)*, • access to IPv6 trained staff *(Leavitt, 2011; Onuora, 2010)*, • IPv6 standard and product maturity *(Che & Lewis, 2010)*, • new applications (mobile IPv6, VOIP or IoT) (*Oxley, 2014; Che & Lewis, 2010)*, • negating need for NAT (and its associated costs) *(Bons, 2011; Chandra et al., 2013; Gallaher & Rowe, 2006; Limoncelli & Cerf, 2011; Che & Lewis, 2010)*, • auto-configuration *(Che & Lewis, 2010; Hovav et al., 2004)*, • network externalities - pressure from suppliers, customers etc. *(Hovav et al., 2004; Kaur & Singh, 2014)*, • studies showing competitive advantage from IPv6 adoption *BT Plc. (2014)*, • competitive advantage *Ghobakhloo (2012)*.	• unclear return of investment (ROI) *BT Plc. (2014)*, • high transition cost *Waterworth (2006)*, • IPv6 skills shortages *(Dell et al., 2008; Hilson, 2012; BT Plc. 2014)*, • inertia (of the organisation or change to technology) *(BT Plc., 2012; Dell, 2010; Waterworth, 2006)*, • prevalence of NAT *(Che & Lewis, 2010)*, • business need (not relevant to business goals) *(BT Plc., 2014; Chiniah, 2014)*, • lack of ISP support *(Dell, 2010; Chiniah, 2014)*, • seen as an immature standard *(Dell et al., 2008)*, • lack of software/hardware support *(Chittimaneni, 2011; Mason and Mahindra, 2011; Che & Lewis 2010)*, • lack of compatibility to IPv4 services *(Hovav et al., 2004)*, • no critical mass of users *(Huston & Michaelson, 2008; Huston, 2008;Dell, 2012; Oxley, 2014; Sridevi, 2013)*, • no "killer" application *(Bons, 2011; Geer, 2008)*.

Primary Research Question: What are the key factors that will assist or inhibit an organisation in making a successful case for IPv6?

2.2.2. Is there a contemporary (business) case for IPv6?

The literature identifies reasons for and against the contemporary case for IPv6 adoption. *BT Plc.'s (2012)* survey, found 22% of respondents citing "lack of compelling business reasons" for a lack of IPv6 adoption so far. *Clark (2011, p.1)* interview results concluded a similar result: "lack of clarity of

business case (costs vs benefits)". Further to this *BT Plc. (2012)* survey found another key issue: "IPv6 has value but does not link to business drivers". Such findings might imply there are compelling business and technical reasons (table 2-2) but IT practitioners have yet to "connect" these effectively to their organisation's goals to allow creation of an acceptable business case.

Table 2-2 – The benefits of using IPv6

- Removing the complexity and costs of using NAT *(Bons, 2011; Dell, 2012)* which is estimated by industry stakeholders to be 20% of IT expenditure *(Gallaher & Rowe, 2006)*.
- Sufficient addresses for each device to have a unique IP address, allowing end-to-end connectivity and new applications/services *(Che & Lewis, 2010; Jara et al., 2013; Reddy et al., 2012)*.
- Auto-configuration removes need for DHCP (Dynamic Host Configuration Protocol), saving costs, management overhead, and improving the user experience *Bons (2011)*.
- Increased security built into the IPv6 protocol *(Reddy et al., 2012; Bons, 2011; Chandra et al., 2013; Yadav et al., 2012);*
- Better mobile device support (*Yadav et al., 2012; Oxley, 2014; Chandra et al., 2013; Che & Lewis (2010),*
- Longer term cost savings from cheaper network equipment due to lower overheads of better protocol design *Dell (2012)*.

Clark (2011, p. 1) determined a *lack of clarity of business case (costs vs benefits)*, echoed in BT Plc.'s (2014) survey where 27% citied "inability to demonstrate a strong business case" as an important factor. Results, that when coupled with a *lack of IPv6 business champions (Kaur & Singh, 2014; Bons, 2011)*, would appear to show an environment unconducive of successful adoption.

IPv6 differs from other emerging technologies in lacking short term benefits to the adopter *(Bohlin & Lindmark, 2002)*. However *Chiniah (2014)* found 66% of companies surveyed said IPv6 would give them competitive advantage, a view further contested by *Dell's (2012)* and *BT Plc.'s (2012)* surveys where almost a quarter and 26% respectively said IPv6 wasn't being used because it was irrelevant to their circumstances.

As *(Katz & Shapiro, 1986; Zhu, 2004)* assert, organisations use new technology to gain competitive advantage, but in the case of IPv6, these "early adopter" rewards are missing *Bons (2011)*. An argument, when joined with BT Plc. (2012) assertion that "IPv6 has value but does not link to business drivers", may explain *Dell's (2012)* seemingly paradoxical survey findings: 75% of CIOs or

equivalents surveyed believe IPv6 was necessary for their organisation's future, yet 52% of CIO believing it is not urgent.

Four main approaches for a transition from IPv4 to IPv6 are identified by *(Che & Lewis, 2010)*: Dual-Stack (coexistence of IPv4 and IPv6), Translation (joining IPv4 networks to IPv6), Tunnelling (encapsulating IPv6 over IPv4 networks) or IPv6 over WAN Links. *Geer (2008)* alleges translation is the best method, a view supported by (*Zhai et al,. 2011)*. However this is contested by both *BT Plc.'s (2012, p. 11)* survey findings and *(Quynh et al., 2012)* interviews where *BT Plc.'s (2012, p.11)* results showed 28% of respondents who saw dual-stack as most favourable by mitigating many transition risks *(Reddy et al., 2012).*

It would appear the literature shows conflicting views, if a contemporary business case is possible, it would be prudent therefore to clarify through a primary research activity the apparent consensus of the literature that the dual-stack approach would be the best for a transition to IPv6

Primary Research Question(s):

- Do the benefits of IPv6 support the goals of an organisation well enough to allow a successful business case to be made today?
- Which transition approach would be most favourable to building a successful case for IPv6?

2.2.3. Who in the organisation can support a case for IPv6 (i.e. which stakeholders)?

Successful adoption of new technology relies on identifying and including pertinent stakeholders (table 2-3) both inside *(Burnett & Youker, 1980)* and outside the organisation. The Resource Based View (RBV) *(Singh & Tan, 2013)* shows the human aspects by identifying 3 types of IT assets: human (IPv6 skills and knowledge of staff), technology (hardware/software support), relationship (management and vendor support). The assets that when the business and IT department share risk and responsibility, allow a technology to become an asset to the organisation *(Ross et al., 1996).*

Table 2-3 – Identified stakeholders (and their support) needed for success in technology implementation projects (such as IPv6)

- government *(Waterworth, 2006; Bons, 2011; Che & Lewis, 2010; Yadav et al., 2013),*
- users (inside/outside the organisation) and their demand *(Bons, 2011; Gallaher & Rowe, 2005; NRO, 2013),*
- vendors (manufacturers) of software and hardware *(Waterworth, 2006; NRO, 2013; Bons, 2011; Ghobakhloo, 2012; Kaur and Singh, 2014; Kaur et al., 2013; Oxley, 2014)*

- customers *(Alafouzos, 2006; Bons, 2011; NRO, 2013; Chiniah, 2014),*
- senior management *(Clark, 2011; Robert et al., 2009; Kaur et al., 2013; White, 2003),*
- project champions *(Clark, 2011; White, 2003),*
- project manager White (2003),
- IPv6 project monitoring/steering group *Chiniah (2014),*
- (IPv6) project team *(Quynh et al., 2012).*

Clark (2011) discovered successful IPv6 adoption in organisations requires support of *senior management* and *project champions*, i.e. (*Singh & Tan's, 2013)* human and relationship assets. *Clark's (2011)* assertions about management support for success draws parallels with *(Fortune & Peters', 2005)* Formal System Model (FSM) and *White's (2003)* Project Specific Form FSM. Their ideal model system encapsulates *(Ross et al.'s, 1996)* suggestions: that successful projects need engaged stakeholders to as *White (2003)* purports: 'make known expectations' and 'provide resources and legitimate the area of operation'.

The authors *(Ross et al., 1996; Singh & Tan, 2013)* show internal stakeholders as important in adoption of IT infrastructure technologies, a view contested by *(Kaur et al., 2013),* who place more importance on external partner/peer "network externalities", (e.g. government, vendors etc.). While *White's (2003)* model shows actions and stakeholders needed for a successful project environment, further research could identify those most useful in supporting a case for IPv6.

Government assistance in encouraging IPv6 adoption was shown by *Waterworth (2006)* Delphi method results as important, supported by more contemporary studies *(Singh & Tan, 2013; Cisco Systems Inc., 2010).* Where *(Yadav et al., 2012)* showed practically how *government policies* and *financial subsidies* in Japan and China have increased IPv6 adoption; although contention still remains around the form government assistance should take. BT Plc. (2012) survey findings appear to support this assertion: 16% of surveyed experts saw government involvement as helpful, contradicting (Gallaher & Rowe, 2006) findings where 63% of consulted Internet stakeholders/experts said government should *support research* and *participate in IPv6 equipment markets* (i.e. acting like a consumer). Their view agreed with *Bons (2011)* results, purporting *government playing the role of a consumer*, but leaving organisations to develop a business case and adoption plans themselves, but did not going as far as *(Gallaher et al., 2006)* Department of Commerce survey where 47% of Internet stakeholders/experts wanted government to provide *technical guidance*.

The findings described above seemingly supports *Cisco Systems Inc. (2010)* 2 of 3 key roles for government: "setting policies" and "facilitating market solutions". Where the third: "building

infrastructure to support private sector adoption" (i.e. the "how much" help to provide) requires as *Dell (2012)* asserts additional research; canvassing views of actions from experts to determine the practical steps governments (table 2-4) could take to assist IT practitioners building their case.

Table 2-4 – Possible roles and actions of government to support a case for technology adoption (such as IPv6) and its subsequent adoption

- government policies *(Dell et al., 2008; Oxley, 2014; Waterworth, 2006; Yadav et al., 2012; Cisco Systems Inc., 2010)*
- financial support (subsidies, tax breaks or grants) *(Ghobakloo, 2012; Oxley, 2014; Gallaher et al., 2006; Yadav et al., 2012)*
- sponsorship *(Bons, 2011; Hovav and Schuff, 2005; Hovav et al., 2011)*
- acting as a consumer *(Bons, 2011; Gallaher et al., 2006)*
- training and information (e.g. template adoption plan) *(Rowe & Gallaher, 2006; Chiniah, 2014)*
- building infrastructure to support adoption *Cisco Systems Inc. (2010).*

Primary Research Questions:

- Which stakeholders will be most important in building a successful case for IPv6?
- What role does government have in assisting an organisation to formulate a successful case for IPv6?

2.2.4. Where and in what context are the interactions that may determine the success or failure of technology adoption?

Modern Information Systems (IS) (e.g. an IT network) are embedded within a host organisation; changes to the technology mean complementary organisational changes too *(Fortune & Peters, 2005)*. *Sauer (1993)* defines IS failure when its operation and/or development cease, i.e. IPv6 is an example of this. It is available but transition to support future needs of the stakeholders is not occurring.

The authors *(Ghobakhloo, 2012; Agarwal & Prasad, 1998)* show technological innovation needs "compatibility" with the values, needs, goals and past experiences of the adopter for success. *BT Plc. (2014)* and *NRO (2013)* show us this practically for IPv6 where: *lack of compatibility to business goals* was a key inhibiting factor. An element that may explain Dell (2012) survey where most Chief Information Officers (CIO) believed IPv6 necessary, yet only a quarter had actually taken action; appearing to show *compatibility with business goals* and *influence of stakeholders* are key to success, while avoiding the elements that would contribute to failure:

- Limited or no alignment to business goals, linking to business drivers *(BT Plc., 2014; NRO, 2013; Ghobakhloo, 2012; Agarwal & Prasad, 1998)*
- Lack of an internal champion *Clark (2011).*
- Insufficiently strong ROI to deploy IPv6 *BT Plc. (2014).*
- IT infrastructure (like IPv6) has an embedded nature, making change difficult, as the organisation must change too *(Singh & Tan, 2013).*
- The absence of senior management support or inclusion of users/staff, their presence is seen as a cornerstone of successful IT technology adoption *Ghobakhloo (2012).*

The authors *(DiMaggio & Powell, 1991; 1983)* and *(Kaur et al., 2013)* focused on the external factors to try to define success, drawing parallels between the Institutional Theory's: coercive and mimetic isomorphism where an organisation seeks legitimacy within its environment, through influencing and being influenced. A theory showing overlap with (*Kaur et al., 2014)* Network Externalities, where the Partner Influence and Peer influence are synonymous with external influences that isomorphic pressures impose to encourage adoption of a technology (such as IPv6).

Further comparing (*Kaur et al.'s, 2014)* findings with *(DiMaggio & Powell, 1991; 1983)* Institutional Theory, that says an organisation's actions (toward new technology) can't be explained by collective explanations of the actors within, or by the consequences of their action or inaction. Their view appears short-sighted, ignoring the benefits of reductionism in the understanding of the whole situation is not suitable when investigating IS failure. The Formal System Model (FSM) *(Fortune & Peters, 2005)* (Appendix 10 - Figure A10-1) specifically shows the opposite, overall success or failure of a project (such as IPv6 adoption) can be explained by these individual actions, inactions of stakeholders (actors) in the form of missing or invalid communication. That when put in terms of *Churchman's (1971)* work purporting the investigation of "wholes", means using a tool like the Systems Failures Approach *(Fortune and Peters, 2005)* is apt for abstracting, modelling and synthesis for the complete understanding needed to explain and remediate the issues IT practitioners have building a successful case.

Primary Research Questions:

- Do organisations take interest in the implementation of IT infrastructure technologies like IPv6?
- Where are and in what context are the interactions (communications) that may determine the success or failure of IPv6 technology adoption?

2.2.5. Literature Review Summary

The literature review revealed that IPv6 adoption is low because IT practitioners are failing to align IPv6's benefits with their organisation's goals to make a successful case. Issues seemingly borne out of a lack of consensus of: the role of government, the most important stakeholders and which drivers, factors or perceptions are most inhibiting or promoting to an IT practitioner's case creation. The discovered elements tables 2-1, 2-2, 2-3 and 2-4; elements that led to the research questions needed to remediate the gaps in the existing knowledge are visualised in figure 2-1. Whereby the lack of IPv6 adoption and the difficulty IT practitioners have building a successful case investigated not as merely a technical problem, but as a more holistic failure of the organisation and it IS to respond and adapt to the changing circumstances of IT use, now and in the future.

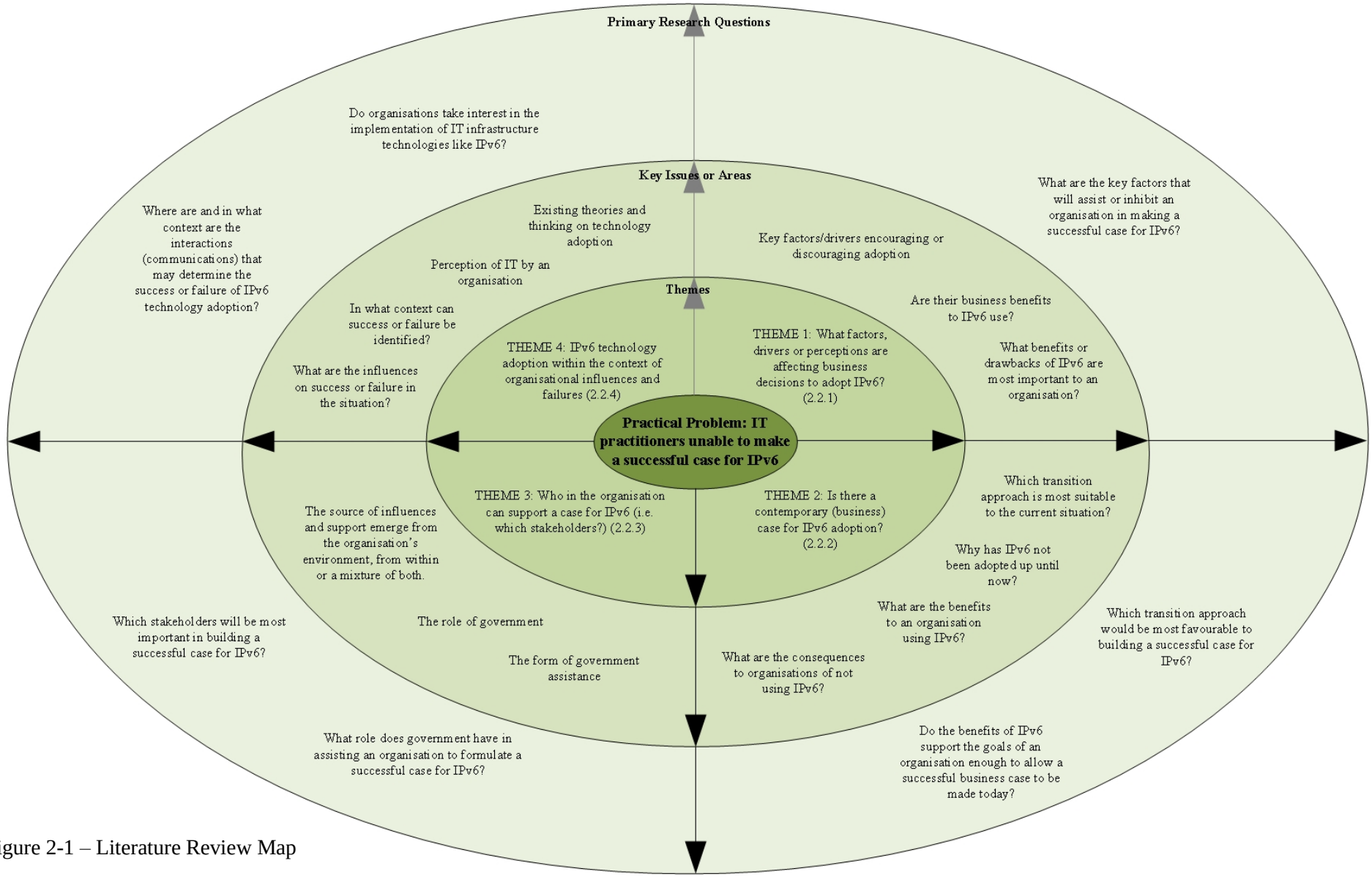


Figure 2-1 – Literature Review Map

2.3 Aim, objectives, methods, tasks and deliverables

2.3.1 Research aim

The aim of this research was to identify the most important elements needed in building a business case for IPv6, to develop recommendations that will increase the likelihood of success both in project approval and any subsequent implementation.

The aim was supported and recommendations developed, through objectives that explored the various aspects of what constitutes success or failure within a fledgling IPv6 project environment, using views collected from both IT/Business practitioners in the UK FE College sector and a literature review conducted before the primary research activities.

2.3.2. Research objectives, questions, methods, tasks and deliverables

Objective 1: Prepare semi-structured interview questions and Delphi method survey questions

Data Required:

i. Key elements and themes of the past and present state of IPv6 adoption drawn from a literature review.

Tasks:

i. Prepare, then pilot (on 2 people, not taking part in full survey) semi-structured interview questions verifying clarity of the questions and adjust as needed.
ii. Prepare then pilot (on 2 people, not in full survey) the first round of the Delphi method questionnaire questions developed using results of literature review and semi-structured interviews; adjusted as required.
iii. Adapt (where needed) subsequent round Delphi method questionnaire questions, collating and re-presenting results to the panel.

Deliverables:

i. Semi-structured interview questions.
ii. Three rounds of Delphi method questionnaire questions.

Objective 2: Produce ranked lists of the most important factors encouraging or discouraging IPv6 adoption

Research Question(s):

i. What are the key factors that will assist or inhibit an organisation in making a successful case for IPv6?

Data Required:

i. Lists of encouraging or discouraging factors.

Methods:

i. Semi-structured interviews.
ii. Survey of an expert panel using the Delphi method.

Tasks:

i. Conduct semi-structured interviews of 3 persons.
ii. Conduct 3 rounds of Delphi method (web based questionnaire).
iii. Collate results of Delphi method, identifying (possible) consensus and rank results by order of importance.

Deliverables:

i. Ranked lists of the most important factors encouraging or discouraging IPv6 adoption.

Objective 3: Identify the most appropriate approach an organisation should take to adopt IPv6 on its IT networks and internets

Research Question(s):

i. Which transition approach would be most favourable to building a successful case for IPv6?

Data Required:

i. List of possible transition approaches and which are most favourable.

Methods:

i. Semi-structured interviews.
ii. Survey of an expert panel using the Delphi method.

Tasks:

i. Conduct semi-structured interviews of 3 persons.
ii. Conduct 3 rounds of Delphi method.
iii. Collate results of Delphi method, identifying (possible) consensus and rank results by order of importance.

Deliverables:

i. The most favourable transition approach as identified by the panel of experts.

Objective 4: Identify which and what government actions would be most important and useful to support an organisation building a case for IPv6

Research Question(s):

i. What role does government have in assisting an organisation to formulate a successful case for IPv6?

Data Required:

i. Views of possible government actions.

Methods:

i. Semi-structured interviews.
ii. Survey of an expert panel using the Delphi method.

Tasks:

i. Conduct semi-structured interviews of 3 persons.
ii. Conduct 3 rounds of Delphi method.
iii. Collate results of Delphi method identifying (possible) consensus and rank results by order of importance.

Deliverables:

i. Ranked list most important and useful government actions as identified by the panel of experts.

Objective 5: Determine if a contemporary business case for IPv6 currently exists, borne out of the benefits of IPv6 and the perceptions of IT by the organisation

Research Question(s):

i. Do organisations take an interest in the implementation of IT infrastructure technologies like IPv6? (i.e. how IT is perceived by the organisation.)
ii. Do the benefits of IPv6 support the goals of an organisation well enough to allow a successful business case to be made today?

Data Required:

i. Views on how IT infrastructure technologies (like IPv6) are perceived within the organisation and how this affects their adoption.
ii. The benefits to an organisation from using IPv6.

Methods:

i. Semi-structured interviews.
ii. Survey of an expert panel using the Delphi method.

Tasks:

i. Conduct semi-structured interviews of 3 persons.
ii. Conduct 3 rounds of Delphi method.
iii. Collate results of Delphi method identifying (possible) consensus and rank results by order of importance.

Deliverables:

i. A view of how IT infrastructure technologies are perceived by an organisation's staff and management, as identified by the panel of experts.
ii. An evaluation of if a contemporary business case for IPv6 exists (as identified by the panel of experts).

Objective 6: Identify the important stakeholders, actions and communications that contribute to a successful case for IPv6

Research Question(s):

i. Where are and in what context are the interactions (communications) that may determine the success or failure of IPv6 technology adoption?
ii. Which stakeholders will be most important in building a successful case for IPv6?

Data Required:

i. List of the important actions, stakeholders and communications of a modern organisation within the IPv6 project environment.

Methods:

i. Semi-structured interviews.
ii. Survey of an expert panel using the Delphi method.

Tasks:

i. Conduct semi-structured interviews of 3 persons.
ii. Conduct 3 rounds of Delphi method.
iii. Collate results of Delphi method identifying (possible) consensus and rank results by order of importance.

Deliverables:

i. Ranked list of the most important stakeholders.
ii. Ranked lists of the most important interactions (communications) and actors that may determine success or failure of IPv6 technology adoption.

Objective 7: Summarise, model and compare results to provide recommendations of the actors (stakeholders), actions and communications needed to build a successful case for IPv6 adoption

Data Required:

i. Ranked List and Rich Picture of key drivers, factors, perceptions and failures within the situation.
ii. List of the important actions, stakeholders and communications of a modern organisation within the IPv6 project environment.

Method(s):

i. Summarise and model the situation in a Rich Picture Fortune & Peters (2005) to visualise the key elements discovered from the primary and secondary research activities.
ii. Synthesise key elements from the situation drawn from primary and secondary research sources and model them in the Project Specific Form of Formal Systems Model (PSFFSM) *White (2003)* and compare with an ideal model system.

Tasks:

i. Prepare Rich Picture diagram.

ii. Prepare “emic” *Lett (1990)* codes based on results of the semi-structured interview.
iii. Prepare PSFFSM within the context developed from the research and analysis completed from objective 2.
iv. Compare PSFFSM with ranked lists and ideal PSFFSM to draw out key drivers, factors, perceptions and failures within the context.
v. Evaluate and explain key findings to prepare recommendations for building a successful case for IPv6.

Deliverables:

i. Rich picture diagram of the situation.
ii. Diagram of Project Specific Form of the Formal Systems Model.
iii. A list of key success and failure factors to building a case for IPv6.
iv. Recommended actions, communications and stakeholders needed to build a successful case for IPv6.

Chapter 3 (Methodology)

3.1 Methods and techniques selected

The Systems Failures Approach *(Fortune & Peters, 2005)* was selected as a framework for the primary research methodology to address the practical problem that IT practitioners are unable to build a successful case for IPv6. A problem that was reframed as an Information Systems failure which allowed the application of the Systems Failures Approach to investigate what elements are needed to build a successful case for the IPv6 protocol within an organisation's IT networks whilst avoiding the elements that cause failure.

To collect the data needed to meet the objectives, semi-structured interviews of 3 IT engineers and IT/Business managers were conducted, followed by a Delphi method survey *Gordon (1994)* in the form of a 3 round questionnaire of 20 panellists from UK FE Colleges. These methods when coupled with the literature review fulfilled the 'pre-analysis' component of the Systems Failures Approach (appendix 8 - figure A8-1) providing the data to answer the research questions shown in table 3-1, with the question numbers and codes used, linking to questions shown in appendix 1 and appendix 5.

Table 3-1 – Table of methods used to support the data requirements of the research questions and aim

Research question	Data required	Methods supporting data collection	
		Semi-structured interview questions:	Delphi method questions:
1. What are the key factors that will assist or inhibit an organisation in making a successful case for IPv6?	Key factors and drivers affecting the building of a successful case.	B1 to B5 C1 to C6	1 and 2
2. Which transition approach would be most favourable to building a successful case for IPv6?	Most favourable transition approach.	n/a	3
3. What role does government have in assisting an organisation to formulate a successful case for IPv6?	Assistive actions to organisations by the UK government.	D1, D2 and D3	4
4. Do organisations take an interest in the implementation of IT infrastructure technologies like IPv6? (i.e. the perceptions of IT by the organisation.)	The perception of IT infrastructure technologies (like IPv6) by the users (staff and management) of the organisation.	A2, E1, E2, G2 and G3	5 and 6
5. Do the benefits of IPv6 support the goals of an organisation enough to allow a successful	A view of if IPv6's benefits support a contemporary business case within a modern organisation.	E2	1 and 7

business case to be made today?			
6. Which stakeholders will be most important in building a successful case for IPv6?	Most important stakeholders of an FE College to support an IPv6 case.	A2, A3, A4, B6 and C6.	6, 8, 9 and 10
7. Where are and in what context are the interactions (communications) that may determine the success or failure of IPv6 technology adoption?	The important actions, stakeholders and communications of a modern organisation within the IPv6 project environment as identified by IT practitioners and management within UK FE College organisations.	A3, E1, G1, G2 and G3.	8, 9 and 10

The identification of success and failures within the situation was supported by collected data that was analysed and presented in both numerical terms (including bar graphs and pie charts) and diagrammatically. The modelling of the findings in the form of a Rich Picture *(Fortune & Peters, 2005)* and the Project Specific Form of the Formal Systems Model *(Fortune & Peters, 2005; White, 2003)* made up analysis and system modelling steps of the Systems Failures Approach, ahead of the final 'synthesis' and conclusions to complete the research aim and objectives.

3.2 Justification

The research used the naturalistic research paradigm with a composite (contingency) approach in common with *(Singh & Tan, 2013; Waterworth, 2006)* being suited to the investigation of subjective phenomena manifesting within the context of social interactions. Technology adoption is a phenomena with these traits*(Fortune & Peters, 2005, p. 19*), where existing literature about IPv6 technology adoption has yet to explain the problem with the positivist paradigm using only technical factors and systematically indefinable causal links*(Yadav et al., 2012; Guerin & Hosanagar, 2010)*.

Use of the Delphi method and semi-structured interviews (open questioning) as cross-sectional investigations was justified, firstly due to time constraints, secondly research of past factors and their changes over time already exists, and thirdly as the research questions require qualitative systemic holistic analysis of the interacting human and technological components *(Checkland & Holwell, 1998)*.

Other methods considered were: 'experimental procedures', not suitable because the phenomena existed in the context of social interactions, a method more suited to quantitative research and therefore not allowing research with sufficient rigor. A 'case study' allowing investigation of a contemporary phenomenon in the place it manifests itself *Yin, (2003)*, was not suitable because there were insufficient organisations displaying the phenomena in question (i.e. actively IPv6 case building)

to be consulted. Additionally generalising the limited results (from one or two organisations) would not provide sufficient results to make generalisations needed to achieve research aim. The use of a 'theoretical' or 're-interpretive review' were also not suitable, because insufficient existing relevant literature existing to make a fruitful research project.

3.2.1 The Systems Failures Approach

The Systems Failures Approach *(Fortune & Peters, 2005)* fitted the situation, providing techniques and a framework to structure primary and secondary research activities, obtaining as *Geertz (1973)* describes; a "thick description" of the qualitative soft aspects of the situation to model the system(s) and determine key success and failure factors.

The approach used pre-analysis to, as *Churchman (1971)* advocated, collect information from a variety of viewpoints to gain a holistic understanding of the situation. Qualitative methods, focussed on the environment "in situ" *Silverman (2002)* to allow the knowledge of the current IPv6 adoption decision making process and environment that *Dell (2010)* asserts is lacking, to be obtained. The interviews and surveys collected different viewpoints, that were collated (in pre-analysis), conceptualised and compared with an ideal model system (Formal Systems Model) to identify discrepancies that could be causing the failure state *Taylor (2010).*

3.2.2 Semi-Structured Interviews

A complementary technique to the Delphi method allowing deeper investigation into specific issues *Gordon (1994),* although time restrictions of this research made it infeasible *McKenna's (1994)* assertions to use interviews in the first round of the Delphi method could be advantageous.

The use of semi-structured interviews was justified to condense and focus the key research questions (of the Delphi method), to obtain the answers required more precisely by giving "context". It also formed part of the "stakeholder mapping" process *Newcombe (2003)* and as *(Flowerdew & Martin, 1997; Archibald, 1992)* assert; supporting the early stages of primary research collection where complex ideas were expressed and "emic" codes *Lett (1990)* identified. These elements being beneficial to identifying key actors of the situation and providing data to assist the formulation of Delphi method questions, result analysis, modelling and key factors.

3.2.3 Delphi Method Survey

A method, suited to identifying key drivers, factors/failures and perceptions of IT, by converging subjective opinions of a panel of experts into a useful quantifiable answer *Ludwig (1994)*; to obtain current knowledge and perceptions *(Jairath and Weinstein, 1994)*. The use of FE Colleges as a vector is justified, because they employ sufficiently informed people who can make up a panel of experts

whose views and results will be transferable to the wider world. The method used a panel of 20 experts, where *Ludwig (1997, p. 2)* states: 15 to 20 is suitable to provide quality results in a limited time frame. It also used a structured questionnaire for the first round (differing from the pure form of the Delphi method) but *(Hsu & Sandford, 2007)* state is acceptable, if an extensive literature review has first been conducted.

The method also offsets the problems of other opinion pooling techniques such as noise, group pressure or dominant individuals *Dalkey (1972),* while allowing "group thinking" to investigate subjective topics, prediction of future events or characteristics in a structured way *(Hsu & Sandford, 2007).*

3.2.4 Research methodology validity

To ensure validity, bias was mitigated by selecting experts unknown to the researcher *(Murphy et al., 1998)* and interviewees were not involved in the subsequent Delphi method. Anonymity was protected by replacing names with numbers therefore maintaining impartiality from the findings suggested by the participants.

3.3 Research procedures

3.3.1 The Systems Failures Approach

The Systems Failures Approach *(Fortune and Peters, 2005)* figure 3-1 (augmented from Appendix 8 Figure A8-1), provided a methodology for data collection and analysis that suited the holistic analysis of systems failures within Information Systems *Drevin (2008)*. The various inputs/outputs are superimposed on to the approach, to show how these primary and secondary research methods were used collect information for analysis later in the process.

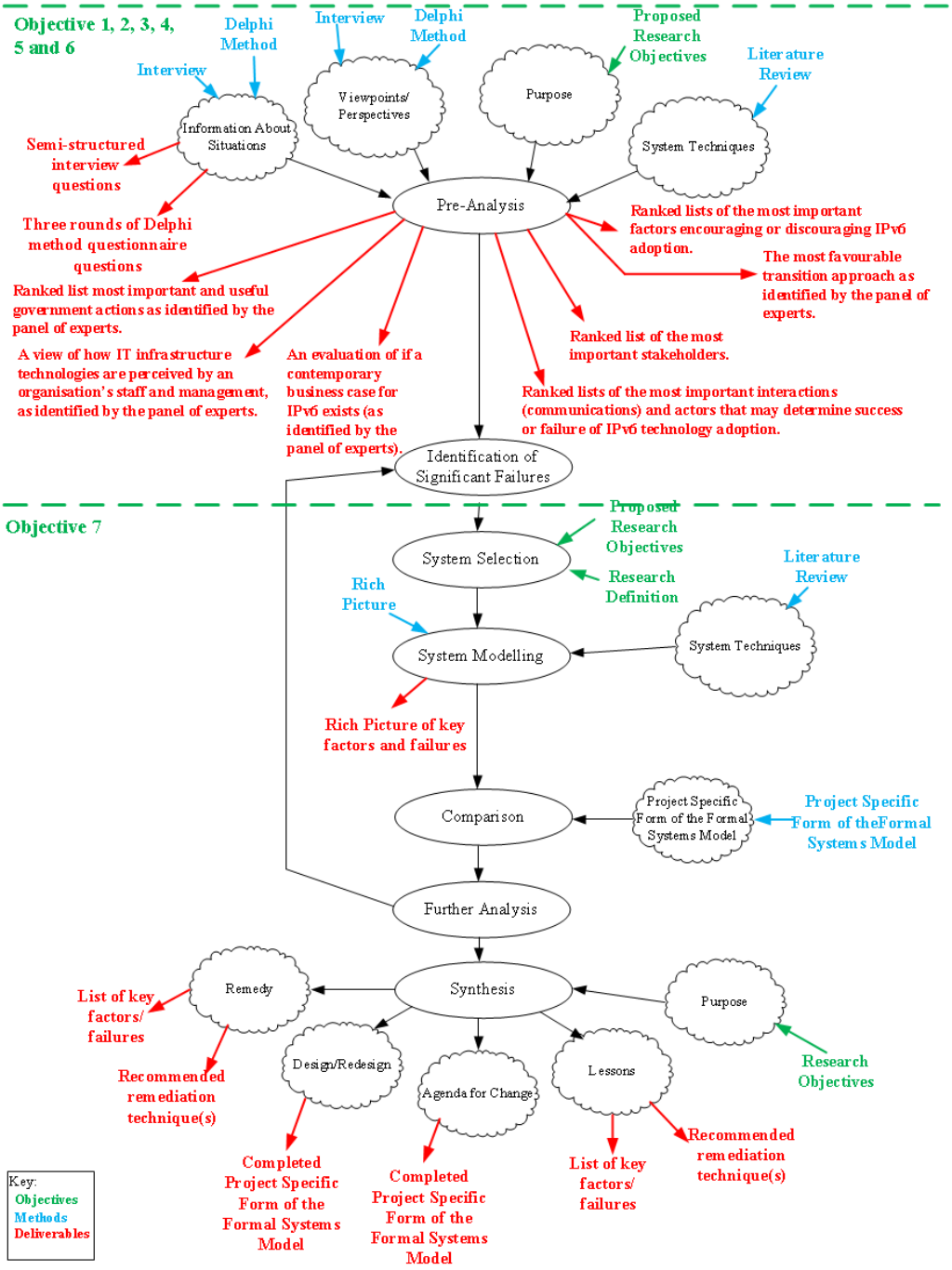


Figure 3-1 The Systems Failures Approach
Adapted from (Fortune & Peters, 2005)

3.3.2 Semi-Structured Interview

A round of semi-structured interviews were conducted using:

- 3 participants (not in the Delphi method).
- 2 IT engineers and 1 business/IT manager (separate FE Colleges).
- Selected using the convenience sampling technique *Biggam (2011)* suitable for "context building" in preparation of the Delphi Method.
- Participants recruited in advance via email, explaining study and to arrange a mutually agreeable time (appendix 12), not known to researcher to reduce bias.
- Participants might have been consulted for follow-up interviews, but this was not necessary for this research.

The developed interview questions and responses are shown in appendix 1 and appendix 2 (tables A2-1 to A2-7) and were:

- Developed using key themes from relevant literature *Denscombe (1998).*
- Piloted on (non) technical colleagues before use to confirm suitability *(Stone et al., 2005; Birley & Moreland, 1998).*
- Delivered using standardised open-ended model *Turner (2010).*
- Asked identically to each participant *(Gall et al., 2003).*
- Used "think-aloud" verbal proving to extract deeper understanding from the situation *Willis (1999).*
- Split into themes (identified from the literature review) to focus questioning and aid the later analysis *Biggam (2011).*

All interviews were 30 – 45 minutes in duration, prepared in advance, conducted in person, documented with contemporaneous hand written notes (and voice recordings on a hand held recorder). The results were fully transcribed as *Davies (2007, p. 191)* recommends, (appendix 2 – tables A2-1 to A2-7) with a clearer narrative assisted by paraphrasing *Weiss (1995)*

The qualitative nature of the interview results makes for difficult analysis *(Bryman & Bell, 2011)* used "emic" encoding (appendix 3) (i.e. language used in participants' responses) *Lett (1990)* to analyse the interviewee's responses for comparison, but also identifying meaningful language (to the participants) to be used in the subsequent Delphi Method. The results were also analysed visually in a Rich Picture *Checkland (1972)* to show salient features/factors for easier assimilation. The literature review used an "etic" approach by identifying the (external) language *Lett (1990)* and categories of study *Boyatzis (1998).* This encoding was then used, coupled with key themes (discovered from the literature review) to search for pertinent elements or patterns *(Bogdan and Biklen, 1982: p145)* within

the interview and Delphi Method results, assisting effectiveness and analysability through highlighting key factors/comparators *Biggam (2011)*.

3.3.3 Delphi Method

A survey was conducted using the Delphi Method *(Dalkey and Helmer, 1963)*, with three rounds of questionnaire, sufficient to investigate enterprise systems issues (e.g. technology adoption) *(Skulmoski and Hartman, 2007; Timbrell and Chan, 2003)*. A panel of 20 experts were consulted where *Gordon (1994)* shows a panel of 15 to 35 is sufficient for valid results when:

- there were some dropouts in later rounds*(Skulmoski and Hartman, 2007);*
- a homogeneous group *Gordon (1994)* is used, i.e. in this case participants from only the UK FE sector.

Participants were recruited randomly from UK FE colleges (maximum 3 from any particular FE College) via the JISCMail forums and/or direct email. The study was introduced and an Internet hyperlink to the first round of the questionnaire supplied. Participants were categorised half and half (10 and 10) at recruitment, as IT (IT engineers) or business managers or IT managers depending on their role.

The questionnaire was piloted on 2 individuals (not participating in the full survey) to ensure its content and readability were sound *(Stone et al., 2005; Gordon, 1994; Birley & Moreland, 1998)* and conducted using *(Okoli and Pawlowski's, 2004)* procedure (figure 3-2).

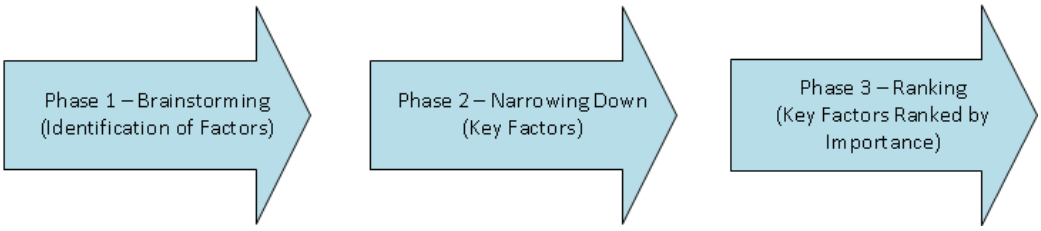


Figure 3-2 – Delphi Administration Process
(Okoli and Pawlowski, 2004)

The results of each round were fed into the next, assisting the participants in reaching consensus by highlighting areas of agreement/disagreement *Ludwig (1994)*. A stopping rule was implemented as *(Hsu & Sandford, 2007)* and *(Pare et al., 2013)* suggest; that gave participants an indication of their time requirement and avoiding diminishing returns of increasing consensus when using more rounds *(Jacobs, 1996; Anglin, 1991; Weaver, 1971; Dalkey & Rourke, 1972)*.

As per *(Gill et al., 2013)*, a web based survey tool (SurveyMonkey – http://www.surveymonkey.com) was used, allowing simple distribution and collection of the iterations, efficiently and in a user-

friendly manner, increasing respondent rates and validity through built-in auditing *(Rodgers & Cowles, 1993)*.

Round 1: The respondents were asked 10 questions (appendix 5 – table A5-1). Respondents could suggest options via a text box, this suggestion made up the results of that round (and an option in subsequent rounds). For validity respondents were prompted automatically if they made a mistake by the web survey itself.

Round two's questions (appendix 5 – table A5-2) were for the most part identical to the first; encouraging the experts to reassess their opinion in light of the other respondent's comments. *Schmidt (1997)* suggests those with extreme positions may reassess to increase consensus. Unknown to the respondents they were split into two groups "IT engineers" and "IT/business managers" that provided two *streams* of data to allow a comparison (objective 7 requirement).

Round 3: The final round was adjusted slightly (appendix 5 – table A5-3); respondents were asked to pick and rank their selections in descending order of preference. To analyse, each answer was assigned a value based on its position that was multiplied by the number of participants selecting it, to find the 3 most important and the single most important of these 3.

The Delphi method intended to elicit consensus rather than forcing it *(Shields et al., 1987)*. Therefore did not mandate 3 responses if the participant only agreed with 1 or none (they had the option to suggest their own), otherwise this could invalidate results by creating apparent consensus *(Rowe & Wright, 1999)*.

The process followed from qualitative questioning (within the semi-structured interview) seeking subjective opinion (with the Likert scale) in a form amenable to quantitative analysis, so the most popular responses could be counted from each round. To create ranked lists, a weighted average was calculated (appendix 6), by multiplying the frequency of an element by a ranking factor, 3 for 1st, 2 for 2nd and 1 for 3rd most important; the most highly valued being the most important as identified by the panel. Ranking analysis was not used on the Likert questions (3, 5 and 7) due to the discrete categorical nature of the responses.

Consensus was determined by this research using a combination of two measures:

1. *(Loughlin & Moore, 1979)* measure of 51% or more respondents selecting the same response.
2. *(Scheibe et al., 1975)* measure of stability of a particular response in each successive round of questioning.

3.3.4 Rich Picture

Successful analysis will require visualisation of a complicated and interrelated environment. Using holistic tools such as the Rich Picture (appendix 11 - figure A11-1) to visualise an Information System in context, pertinent information was displayed along with the interactions between the various actors.

3.3.5 Formal System Model

The Systems Failures Approach *(Fortune & Peters, 2005)* introduced the FSM *Checkland (1981)*; a model to aid the understanding of this (failure) situation by providing a method to compare the current situation with an idealised version of the FSM as shown in appendix 9 and 10, figures A9-1 and A10-1 respectively with *White's (2003)* PSFFSM.

3.3.6 Risk Identification and Mitigation

To ensure research success the risks to the research methodology were assessed by use of a FMEA (Failure Modes and Effects Analysis) appendix 7 - table A7-1. Key risks identified were R10, R13, R14 and R22, a RRF (Residual Risk Factor) being over a value of 5.0, the preventative measures described were sufficient to prevent problems, so no contingency plan was required.

3.4 Ethical considerations

All research was conducted in accordance with each participant's organisation's policies/procedures and the Open University's T802 ethical research guidelines. Any ethical issues identified, were managed to protect participants from physical, physiological or financial harm to themselves, their organisation or other stakeholders.

Informed Consent and Compliance - All participants were asked to sign consent forms before taking part, ensuring they understood and agreed to the terms: research purpose, approximate duration, confidentiality/anonymity protection, how their information will be used, stored and collected was explained in person, email or online (as applicable).

Openness - All participants were given access to the research results and their contribution, facilitated by emailing all participants upon completion of the research.

Integrity and Anonymity - No participants' comments or opinions were misrepresented from how they were collected, anonymised so only identifiable by a unique number, their form only changed (paraphrased) to fit the narrative of the dissertation. Participants were treated honestly and respectfully.

Data Protection (Confidentiality) - No personal information was stored; other than to facilitate conducting the research. Data was not printed or stored on mobile devices/media, stored separately from data that may identify a person and destroyed at the end of its usefulness (i.e. research completion) according to principle 5 *Data Protection Act 1998 (1998)*.

References and Plagiarism – Any other author's work used, was fully cited to ensure credit is correctly assigned.

The threats, their impact and likelihood were assessed and it was concluded there were no significant risks to those involved by conducting the research. A conclusion reached by conducting a risk assessment using *Health Safety Executive HSE (2014)* and "Health and Safety – Advice for T802 Students" *The Open University (2014)* to determine the impact and likelihood of an event and the actions required to remediate it.

Chapter 4 (Analysis and interpretation)

4.1 Summary of data collected

In addition to the literature review, primary research data was collected by semi-structured interviews followed by a three round Delphi Method survey of a panel of experts from UK FE Colleges, during February 2015 to June 2015. Follow-up interviews were not conducted, as interviewees felt their comments were complete, the Delphi Method did not deviate from the method described in section 3.

4.1.1 Semi-Structured Interviews

The semi-structured interviews posed questions (appendix 1) to the interviewees, their responses were transcribed (appendix 2 tables A2-1 to A2-7) from contemporaneous written notes and voice recordings made by the researcher after interview completion. These responses created qualitative data, in the form of written notes, voice recordings of the interviewee's opinions, that although based on answers to structured questions, was not directly amenable to analysis in that raw form.

To resolve this, an 'open coding' process *Crang (1997)* based on Grounded Theory *(Glaser and Strauss, 1967)* was used, to identify keywords (codes) akin to *Thematic Analysis* and in doing so derived data into a form amenable for use in formulating the subsequent Delphi method questions.

The 'open coding' process *Strauss (1987, p. 32)* involved iteratively reading the transcripts to identify and categorise the important elements of the text, identifying 'emic' codes (terms the interviewee had introduced themselves) from data using *Crang's (1997)* in *(Flowerdew and Martin (eds.), 2005, p. 222)* method. The process analysed the collected raw data by first asking the questions like: "*What is the interviewee talking about?", "What is important in what they are saying?"* This first sweep provided verbs and nouns from the text (Appendix A4-1) "emic" codes, a label or phrase (e.g. "senior management") interviewees had identified from the situation, providing language representing common parlance of the experts of the sector *Pike (1967, p. 37).*

The next step of the process asked a further question of: "*how does the interviewee describe what they have identified?",* identifying adjectives to describe the label or phrase; so relating to the example label; 'necessary' was a word used to describe the interviewees' view of the senior management label. Therefore it could be surmised from the interviewee's responses that: senior management support is needed for IPv6 adoption to be successful.

The processes' goal was to: first identify the concepts, develop them and finally relate them to each other, to discover the meaning within data collected *(Strauss and Corbin, 1990)*. An approach that provides analysis of qualitative data systematically, although potentially biased by being influenced by the personal experiences of the researcher *Denscombe (2003)*.

These 'emic' codes were obtained on multiple readings of the interviewees' results, in order to build a list of codes (appendix 3 table A3-1) most representative of their responses. This 'emic' thematic coding contrasted with that of the literature review (tables 2-1 to 2-4), where 'etic' codes were identified and outsider's views like scientific observers with accounts expressed as concepts *Lett (1990)*. The findings were not absolute and based on the comparison, interpretation and perception of the "etic" codes by the researcher.

Appendix 4 table A4-1 shows the 'etic' codes (identified from the literature review) synergised with 'emic' codes identified from the interviews to produce key themes, words and phrases common to both the 'etic' and 'emic' datasets. Although not exact matches, they were synonyms or terms the researcher decided were similar enough to represent the interviewees' responses. Whereby the 'emic' codes identified and the grouping of questions into sections (themes) *Crang (1997),* allowed the use of relatable language achieve more effective responses from the respondents of the subsequent Delphi method. Finally, the results gained were triangulated with Delphi method and literature review results to corroborate the findings and improve the accuracy of the interpretations *Padgett (2008, p. 95-96)*.

4.1.2 Delphi Method

The Delphi method questionnaire was put before a panel of 20 experts from the UK FE sector. In each round the participants were invited to give their views, as expected some experts of the panel did not respond in the second or third rounds, falling to 17 experts by the final round.

The raw data returned from each round of the Delphi method (appendix 6, tables A6-1 to A6-18) was copied from the SurveyMonkey website into a Microsoft Excel spreadsheet. The questionnaire allowed the answers, although qualitative in nature, to be derived into a form amenable to quantitative techniques such as frequency analysis; subsequent presentation in bar graphs (option selection questions) and pie charts for the Likert scale questions (appendix 6).

The frequency analysis method was used because it supported answering research questions and suited the characteristics of the data *(Tabachnick and Fidell, 1989)*, i.e. the tables contained the numbers of responses for each element, against the total number of responses. The optional comment section proved difficult to analyse, due to the free text answers; however these for the most part were

short phrases (some suggesting additional elements/factors that were transcribed into the next round's question options.)

Throughout the analysis the Bivariate Analysis *(Bryman and Bell, 2011)* was used to determine if a relationship existed between the views of IT engineers and IT/Business managers; to support objective 7, identifying if a particular element was more important to IT engineers or IT/Business managers.

The Delphi Method attempts to reach a consensus. This research used the measure of 51% or more agreement of the panel on a particular element *(Loughlin & Moore, 1979)* coupled with a second measure the stability of a particular response in each successive round of questioning *(Scheibe et al., 1975)* to identify consensus. A second measure was used because the researcher felt that although 51% may seem low compared with the measures of *Sumsion (1998)* at 70% or *(Green et al., 1999)* at 80%; the large number of options (for participants to choose) and a comparably small sample size could lead to insufficient clarity of the results toward a consensus.

4.2 Data analysis

4.2.1. Semi-Structured Interviews

The semi-structured interviews assisted "context building" ahead of the Delphi method. Three interviews were conducted (2 IT engineers and 1 IT/Business manager). The transcribed responses were analysed by thematic coding, following *Crang's (1997)* in *(Flowerdew and Martin (eds.), 2005)* process where 'emic' codes were identified (Appendix 3 – Table A3-1) using the interview question results (Appendix 4 – table A4-1). The analysis appeared to indicate: *senior management support* and *support from the organisation* would be key to a successful case and highlighted the difficulty IT practitioners have aligning the benefits of IPv6 with their organisation's goals to enable acceptance.

4.2.2. Delphi Method

A response rate of 85% (figure 4-1 and table A6-1) was maintained across the three rounds of the Delphi method, not falling below the 70% threshold *Sumsion (1998)* asserts as the minimum needed to provide a sufficiently rigorous response.

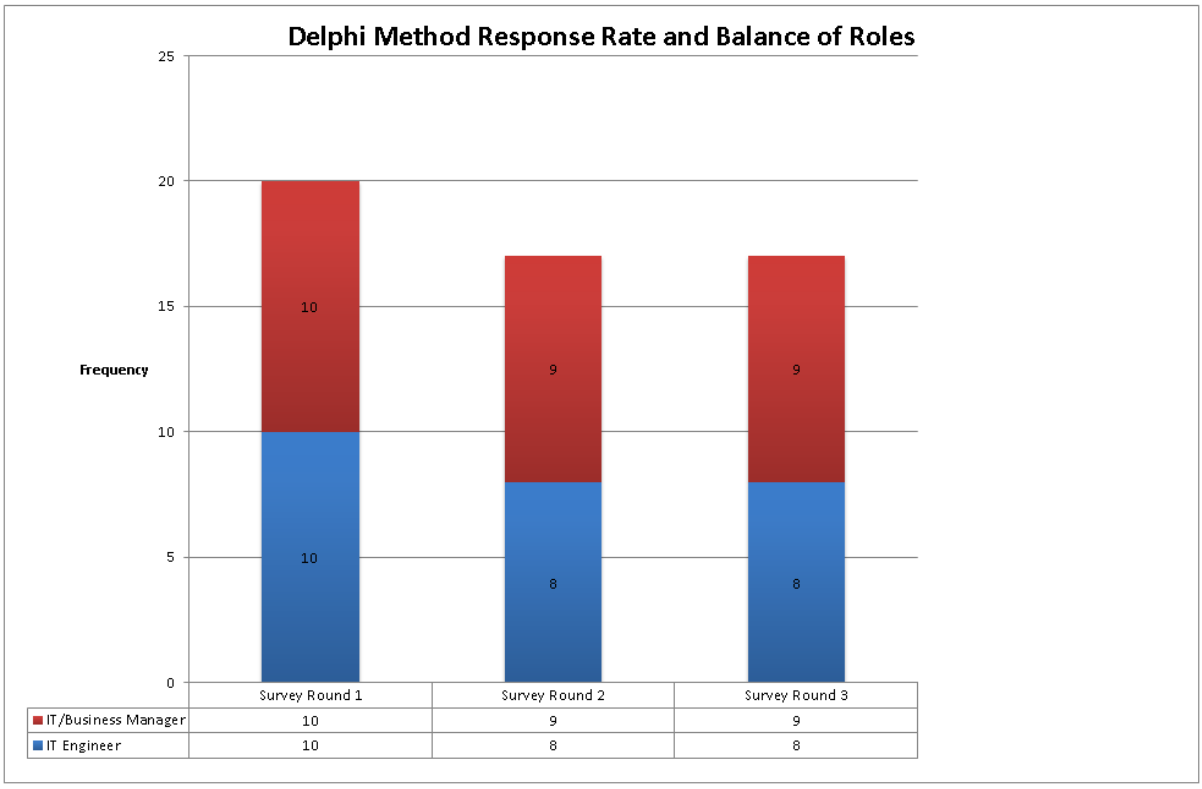


Figure 4-1 – Table and graph of number of experts' responses, and balance of roles
Raw Data: Appendix 6 - Table A6-1

The sample was split 8 IT engineers to 9 (IT/Business managers), a split as close to 50/50 as possible was needed to ensure a fair comparison could be made between the responses of participants for each role.

There are limitations to these results and conclusions as they are fundamentally dependent on the interpretation of questions by the experts at the time of collection, which may have been different if a different panel of experts were consulted. Time limitations meant limited windows for each round, restricting the range of responses or confirmation of a stronger consensus.

Qualitative research is prone to ambiguity *(Ely et al. 1991)*, this was minimised by:

1. The use of the Delphi method with multiple iterations to refine the respondents' thinking toward an answer.
2. Using 'emic' and 'etic' codes (appendix 4 table A4-1) discovered in both the literature review and semi-structured interviews to formulate the questions using language used by those within the IT sector.

The results did show consensus of the thinking of the group of experts around certain elements of building a case for IPv6. However it does not show causality, i.e. an IT practitioner who uses a key success factors determined by the experts, would not necessarily be able to build a successful case for IPv6 within their own organisation.

4.2.2.1. Key factors/drivers encouraging or discouraging adoption

Questions 1 and 2 (appendix 6.2 and 6.3) asked the questions: *In your opinion, what are the 3 most important factors encouraging/discouraging adoption of IPv6?* A consensus for question 1 (figure 4-2) showed "IPv4 address depletion" (64%), "access to new functionality…." (58%) and "inevitability" (58%) as most encouraging factors to the case for IPv6 (table A6-2). The ranked list (table A6-3 and figure A6-1) showed the same 3 highest factors in the order of "access to new functionality…"(1st), "inevitability" (2nd), "IPv4 address depletion" (3rd) and an even balance between the roles in comparison (figure A6-1).

Question 2's results showed a consensus on the inhibiting factors of: "no business need…" (70%), "IPv6 skills shortages" (58%) and a "lack of short term benefits" (52%) (figure 4-3 and table A6-4). The ranked list (table A6-5 and figure A6-2) showed the same 3 key factors, but "lack of clear ROI…" ranked 3rd rather than 4th and all factors roughly equally balanced (figure A6-2) except "lack of clear ROI (return on investment)" was seen as more important by IT/Business managers.

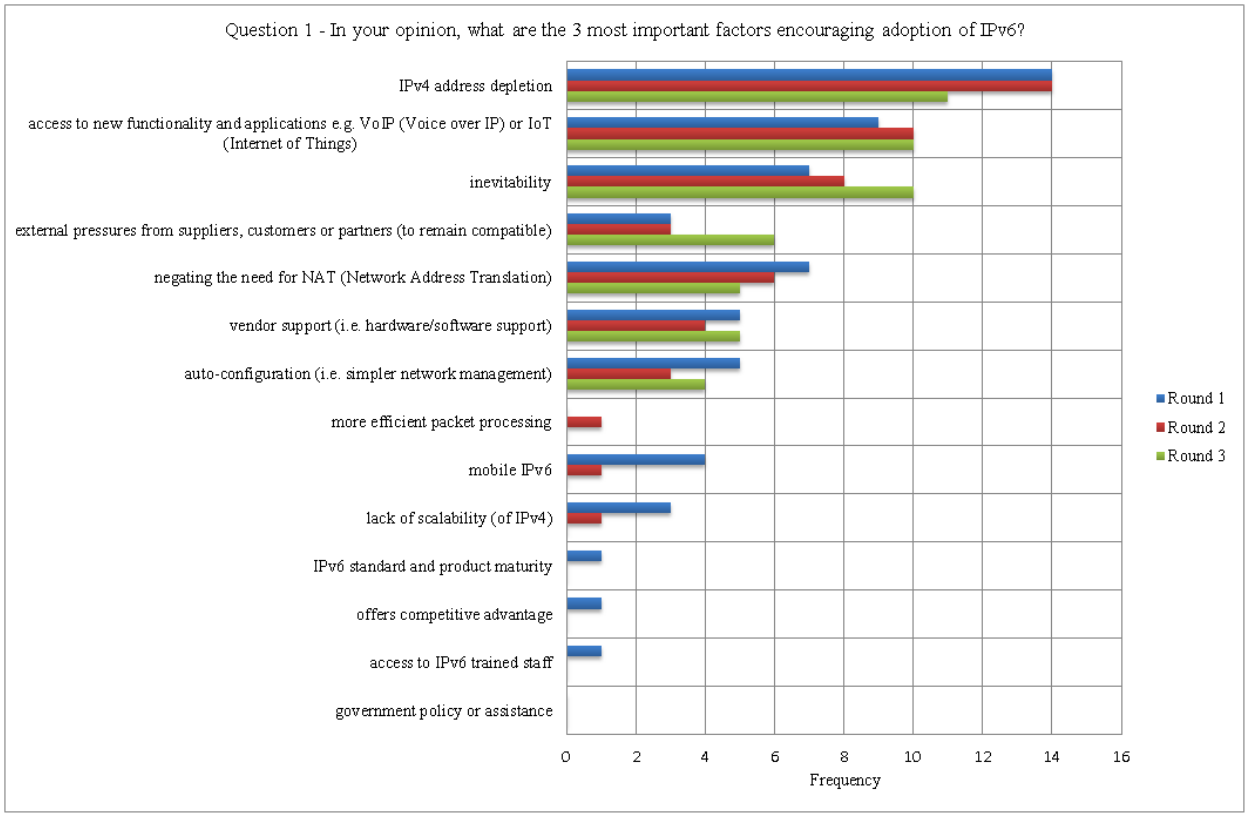


Figure 4-2 –Bar Graph of Delphi Method Responses for Question 1 over Rounds 1, 2 and 3
Raw data: Appendix 6 – Table A6-2

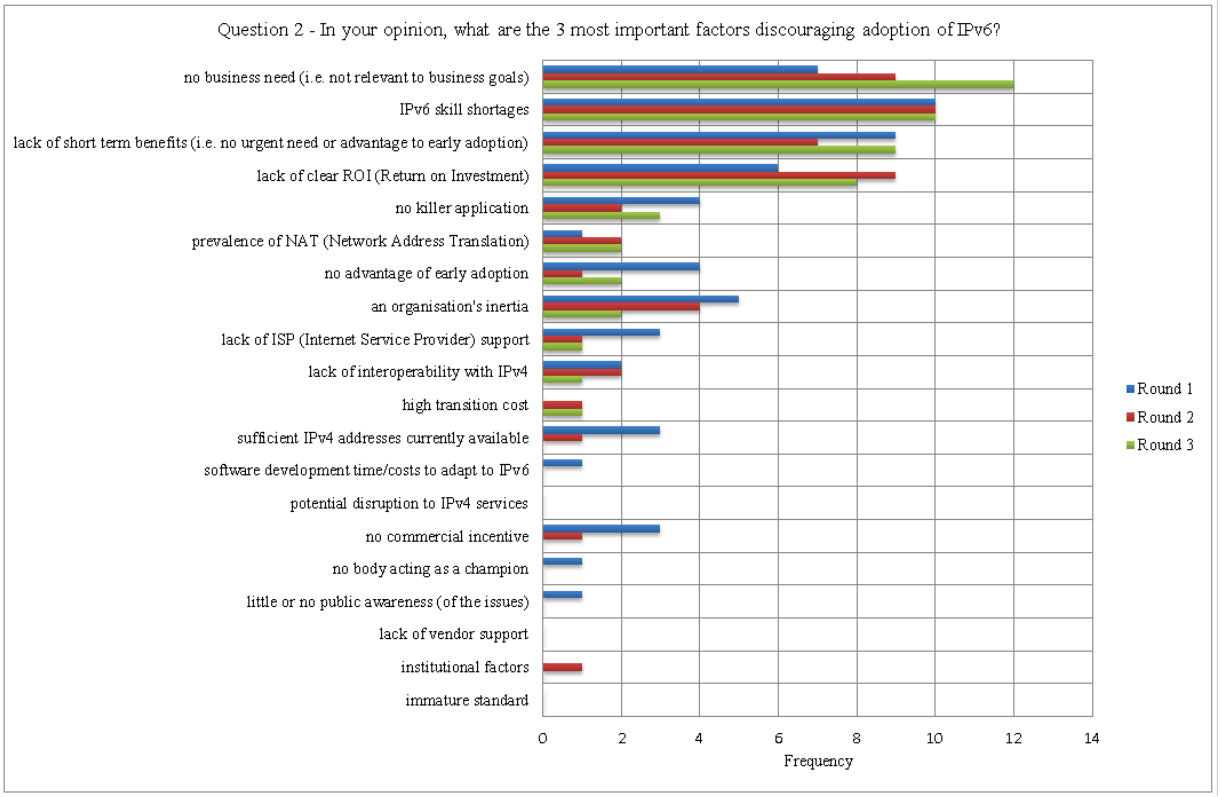


Figure 4-3 –Bar Graph of Delphi Method Responses for Question 2 over Rounds 1, 2 and 3
Raw data: Appendix 6 – Table A6-4

4.2.2.2. The lack of a holistic view in identifying the approaches for IPv6 adoption

The panel were asked in question 3 (with a short explanation of each approach for clarity): *"What would be your most favourable approach to the transition to IPv6 for your organisation that would allow a successful case for IPv6 adoption to be built?"*

The results showed 88% of respondents identified 'dual-stack' as most suitable by round 3 (figure 4-4), showing consensus and demonstrating how the Delphi method can use other panellists' influences to hone in on consensus; 25% in round 1 saying 'don't know' falling to only 12% by round 3.

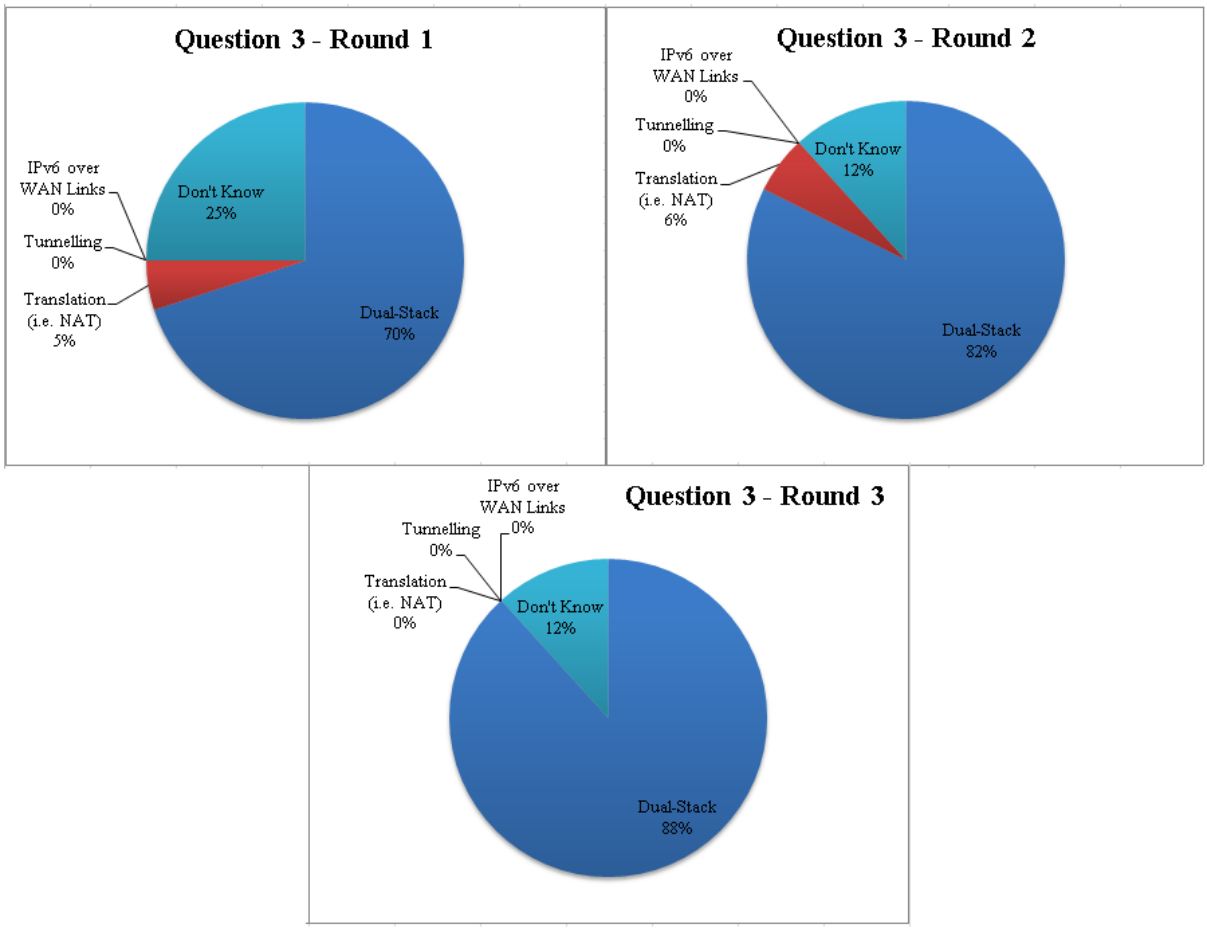


Figure 4-4 –Pie Charts of Delphi Method Responses for Question 3 over Rounds 1, 2 and 3
Raw data: Appendix 6 – Table A6-6

4.2.2.3. Psychological factors affecting perception of IT by the organisation

Question 5 asked the panel for their opinion of the statement: *"My organisation's staff and management take an active interest in the development and implementation of Information Technology infrastructure technologies such as IPv6"* using the Likert scale. Figure 4-5 showed the panellists' consensus of 59%, that appeared to show an organisation's staff or management were typically not interested in the development of IT infrastructure technologies like IPv6.

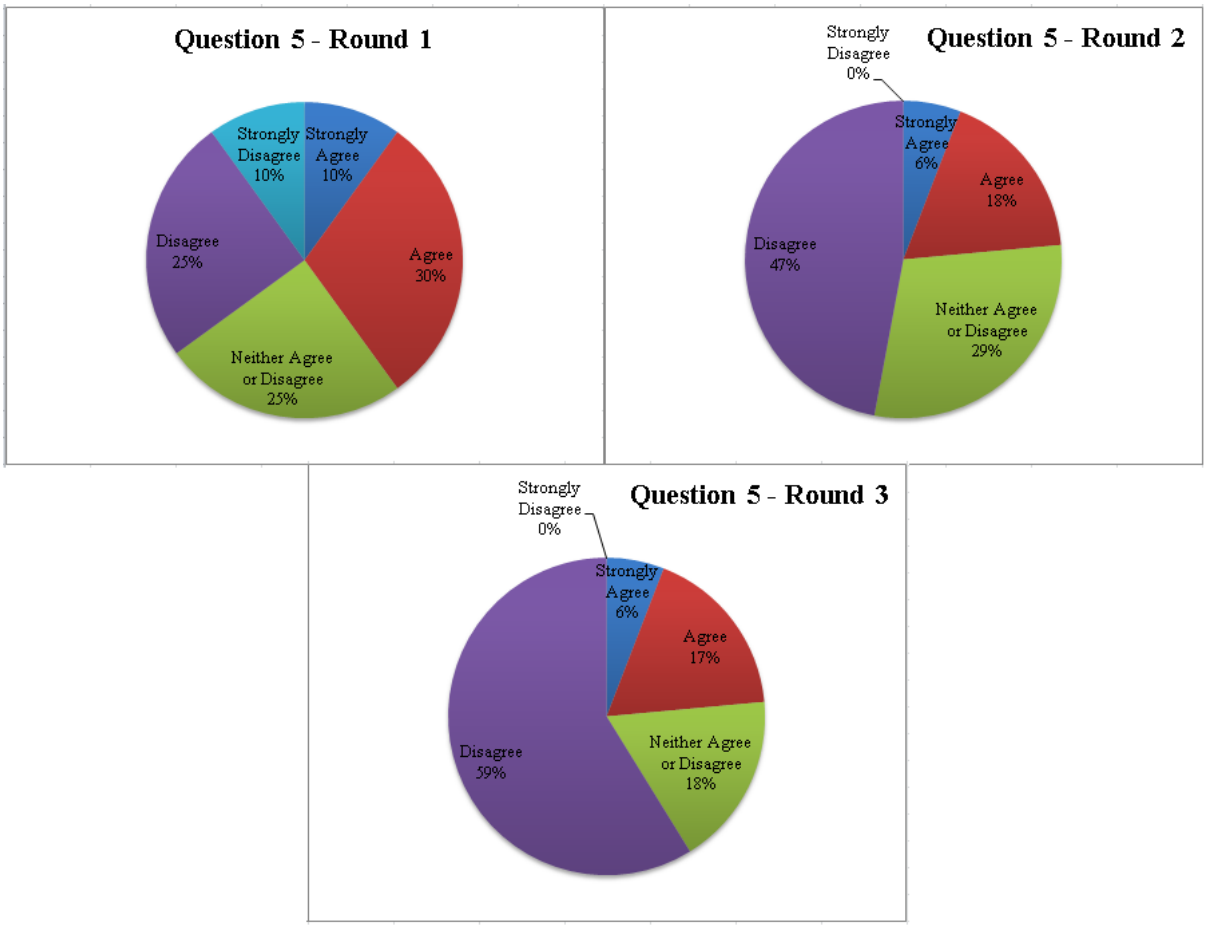


Figure 4-5 –Pie Charts of Delphi Method Responses for Question 5 over Rounds 1, 2 and 3

Raw data: Appendix 6 – Table A6-9

4.2.2.4. Is there a contemporary (business) case for IPv6 adoption?

The literature appeared to suggest IPv6's benefits could be used to support a successful case for adoption, if synergy could be shown with the organisation's goals. Question 7 (appendix 6.8) explored this by asking the panel for their opinion of the statement: *"The benefits of IPv6 have synergy with my organisation's goals and therefore support the building of a contemporary business case for IPv6."* The results (figure 4-6) failed to reveal a discernible consensus either way, but did reveal 65% being unable to choose, appearing to show significant doubt in a contemporary business case for IPv6 existing in today's organisations.

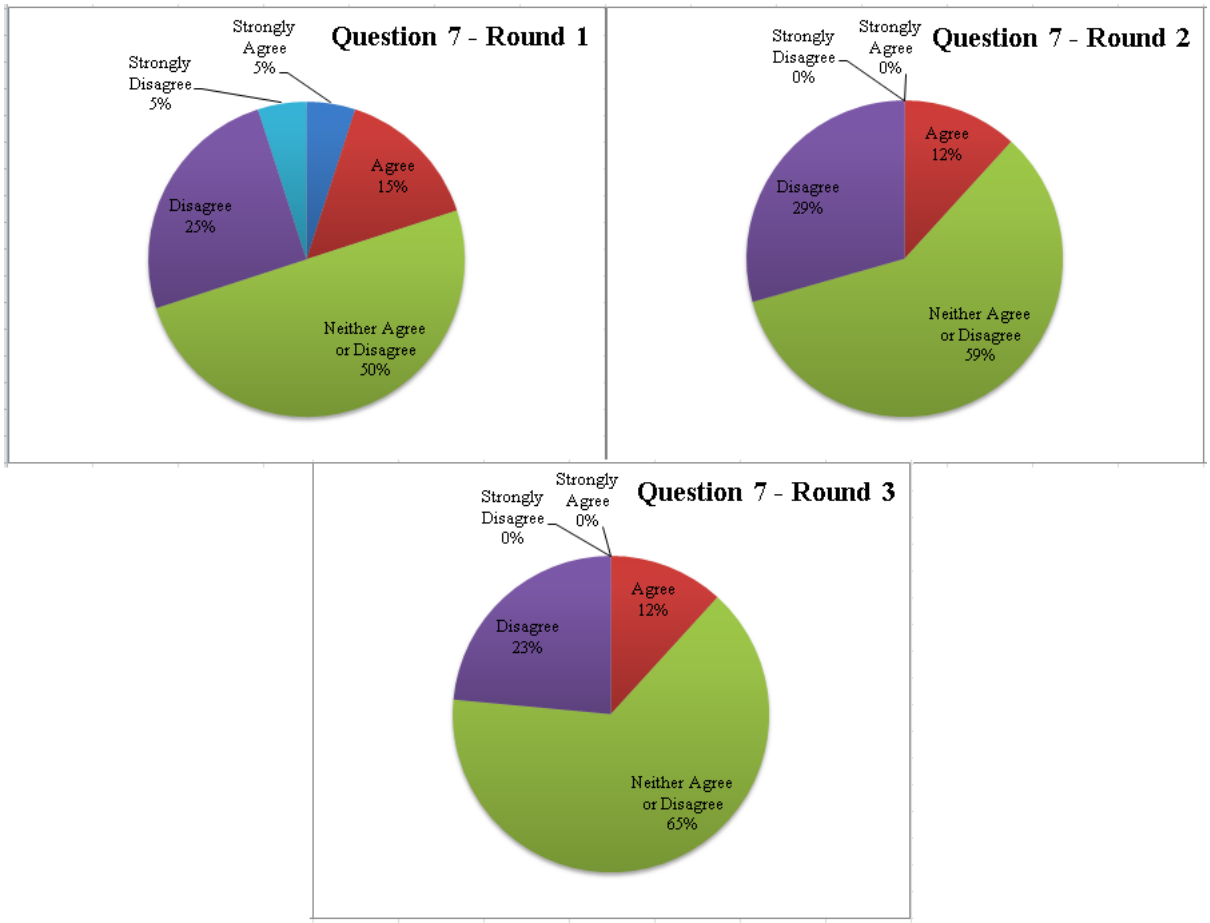


Figure 4-6 –Pie Charts of Delphi Method Responses for Question 7 over Rounds 1, 2 and 3
Raw data: Appendix 6 – Table A6-12

4.2.2.5. Which stakeholders within the organisation can support a case for IPv6?

Questions 4 and 6 tackled this topic, asking in question 4: *"What the 3 most important actions the UK government could take to encourage/support IPv6 adoption within your organisation?"* In question 6: *"Which 3 stakeholders will be most important supporting a successful business case for IPv6 within your organisation?"*

The panellists' results to question 6 (figure 4-7), showed 'senior management' (94%), 'government' and 'vendors' (58%) as most important, where the ranking of the results (table A6-11 and figure A6-4) revealed the same order (as figure 4-7) for the most important of the 3 top stakeholders.

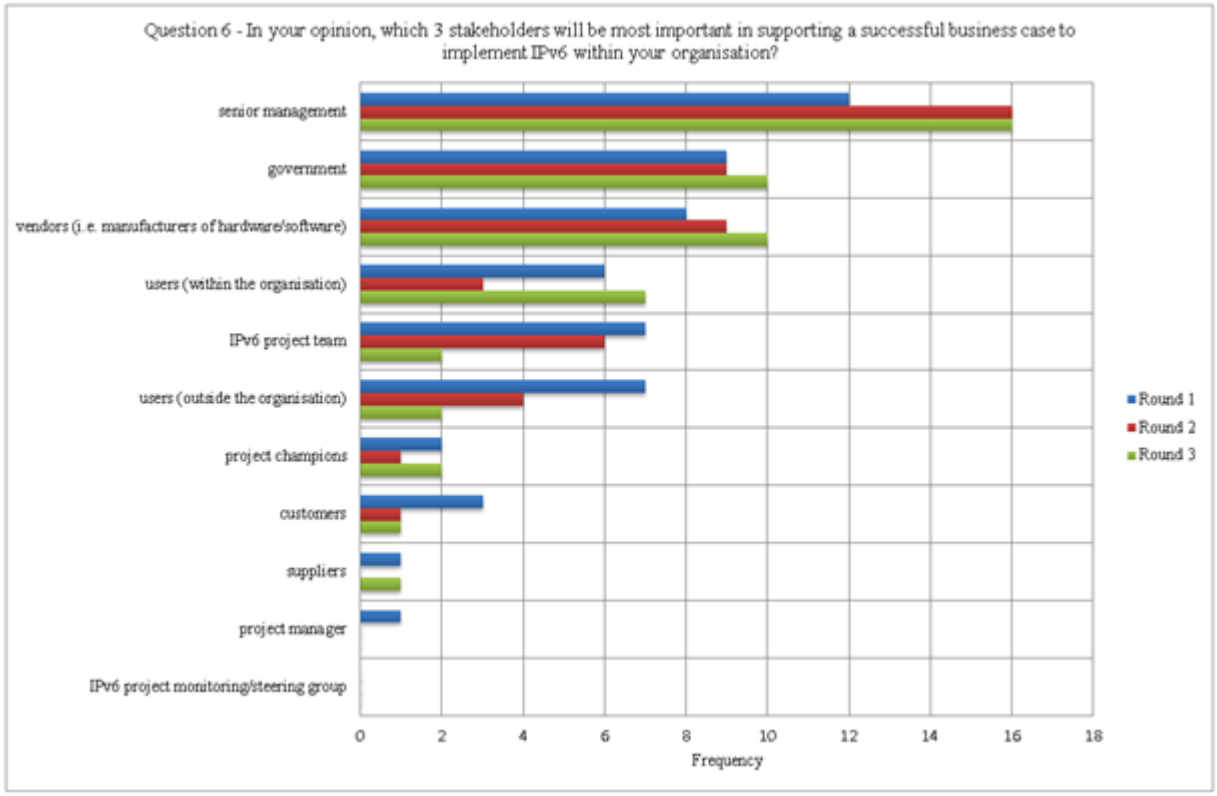


Figure 4-7 –Bar Graph of Delphi Method Responses for Question 6 over Rounds 1, 2 and 3
Raw data: Appendix 6 – Table A6-10

Question 4 investigated government support more specifically, because the literature review revealed this has been instrumental in successful IPv6 adoption elsewhere in the world. Figure 4-7 shows consensus around 'financial support (grants)' (94%) and 'training for IT staff' (82%) as the most important actions of government in assisting an organisation; IT/Business Managers saw 'financial support' as almost twice as important (figure A6-3) than their 'IT Engineer' colleagues in this endeavour.

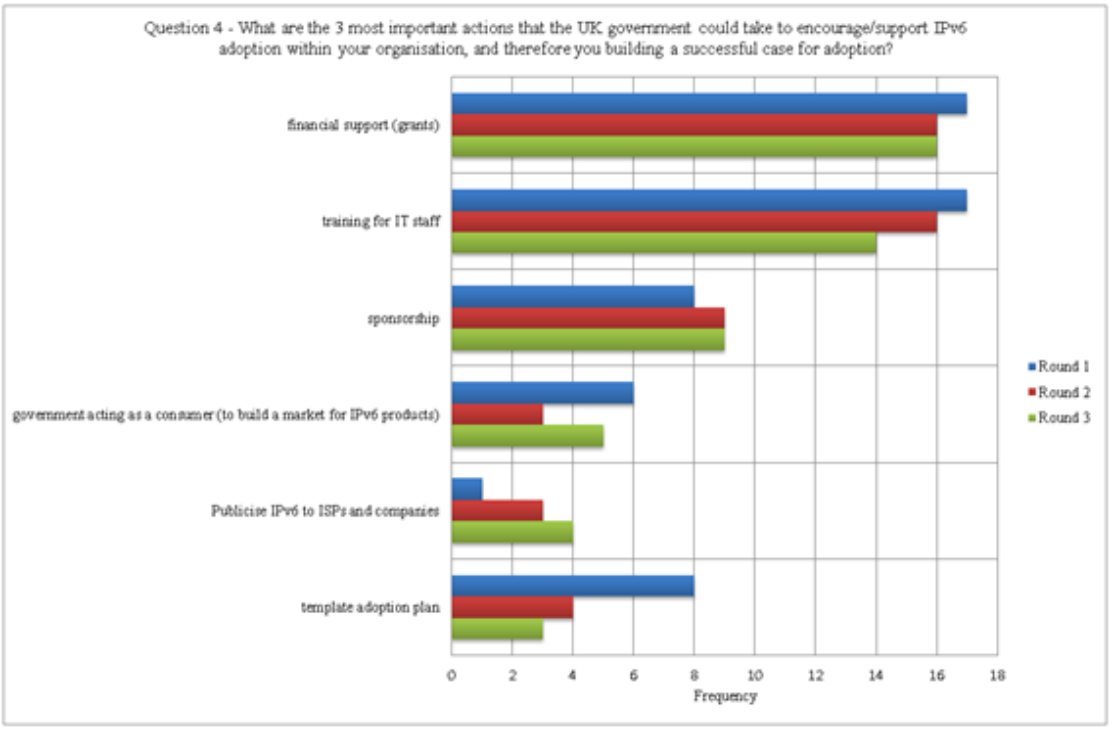


Figure 4-8 –Bar Graph of Delphi Method Responses for Question 4 over Rounds 1, 2 and 3
Raw data: Appendix 6 – Table A6-7

4.2.2.6. IPv6 technology adoption within the context of organisational influence and failure

The problem IT practitioners' have in building a successful business case, contextualised as an information systems failure, was explored in questions 8, 9 and 10 shown below, each question's focus was changed, directing respondent's thinking toward different areas of an organisation's situation. The organisation's environment, the organisation itself, or within the organisation's IPv6 project team; akin to the: *environment*, *wider system* and *system* of *White's (2003)* Project Specific Form of the Formal Systems Model.

"In your opinion, what are the 3 most important actions, communications or influences that stakeholders within your organisation's environment (question 8)/organisation (question 9)/IPv6 project team (question 10)?"

The question 8 results (figure 4-9 and table A6-13) showed a consensus that the environment would need to supply: 'identifiable motives for change' (94%) coupled with a favourable 'project context (in relation to business goals)' (70%) to the IPv6 project system to support a successful case.

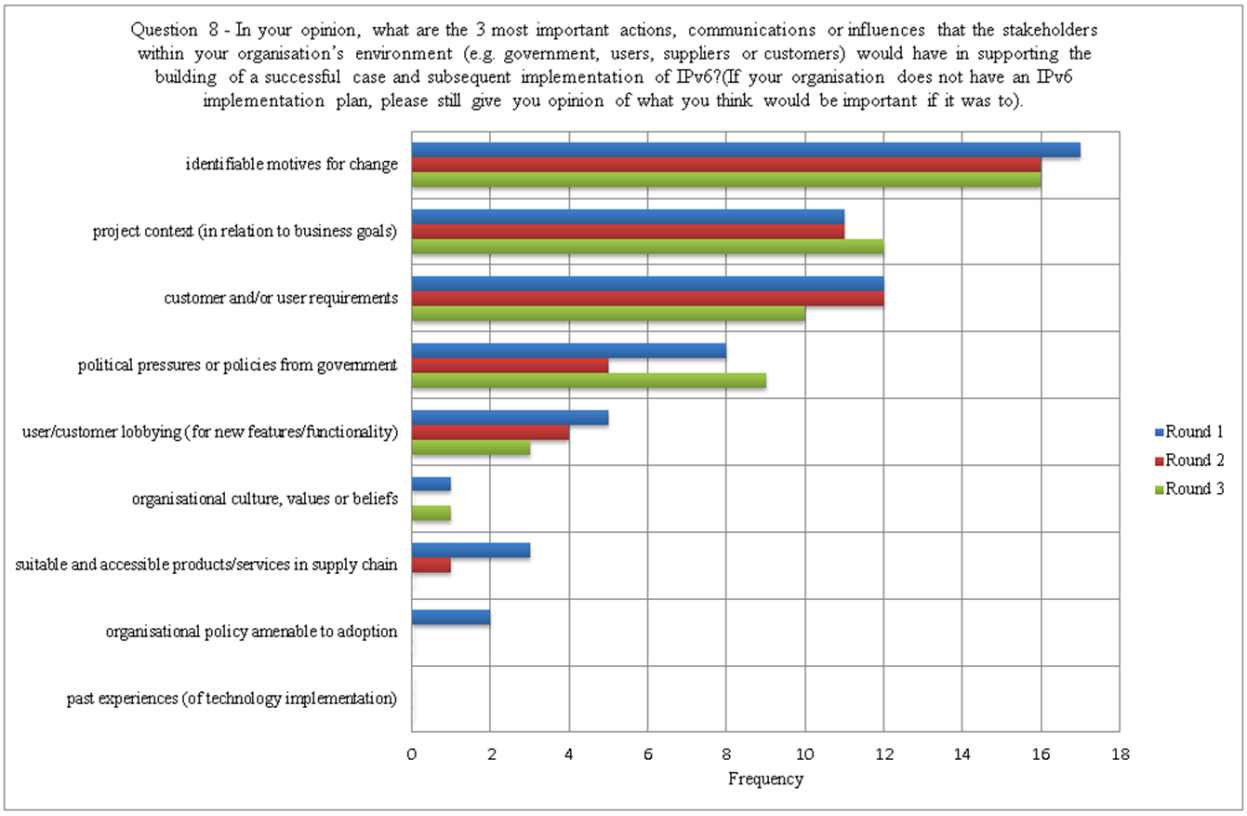


Figure 4-9 –Bar Graph of Delphi Method Responses for Question 8 over Rounds 1, 2 and 3
Raw data: Appendix 6 – Table A6-13

Question 9 (figure 4-10) explored the organisation context, where the panel appears to reach consensus on the two most important actions, communications or influences were: ‘creation of clear objectives, goals and success criteria’ (100%) and ‘senior management support’ (88%), where a weaker consensus was seen in: ‘providing sufficient budget’ (58%) as an important action in building a successful case.

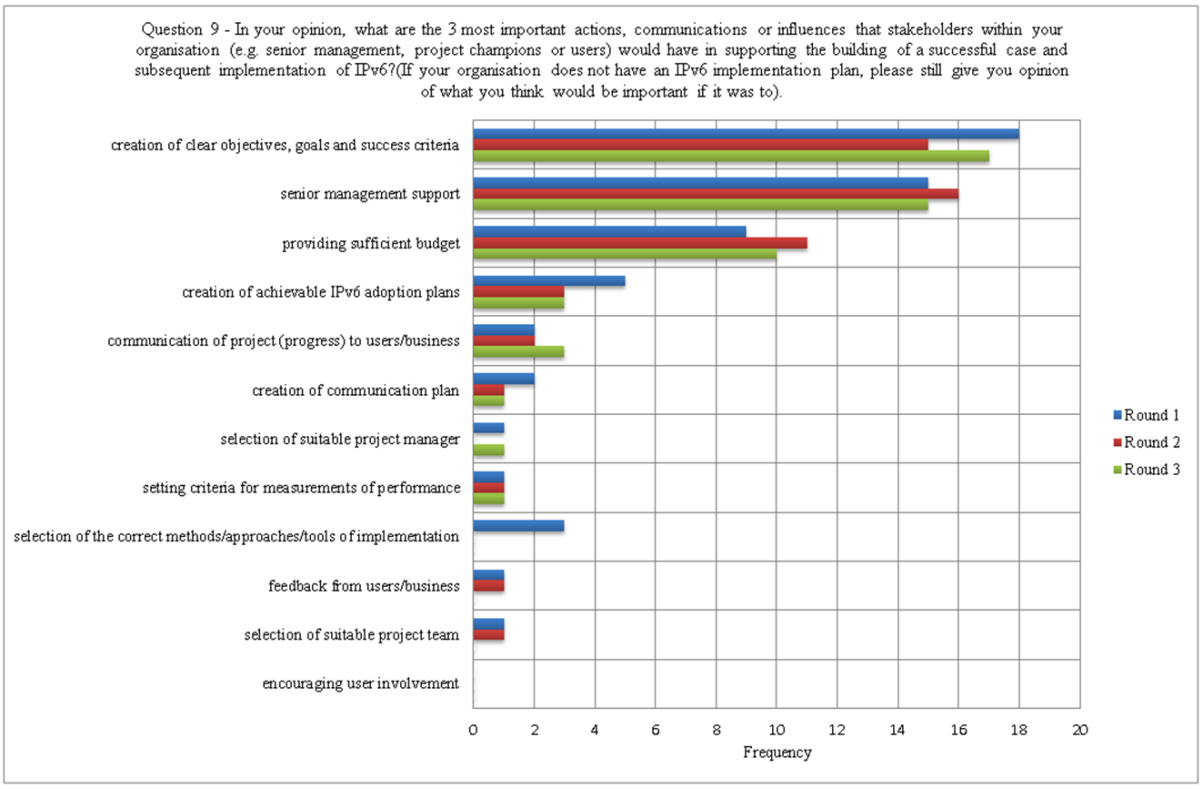


Figure 4-10 –Bar Graph of Delphi Method Responses for Question 9 over Rounds 1, 2 and 3
Raw data: Appendix 6 – Table A6-15

Question 10 (figure 4-11 and table A6-17) focused the panellists’ thinking toward the potential IPv6 project team and what key actions, communications or influences would shape a successful case. A consensus appeared to emerge around: ‘adequate and clear planning of project tasks’ (76%), and ‘providing suitable budget’ (70%), actions that an IPv6 implementation team would need both clear guidance and suitable resources to be successful.

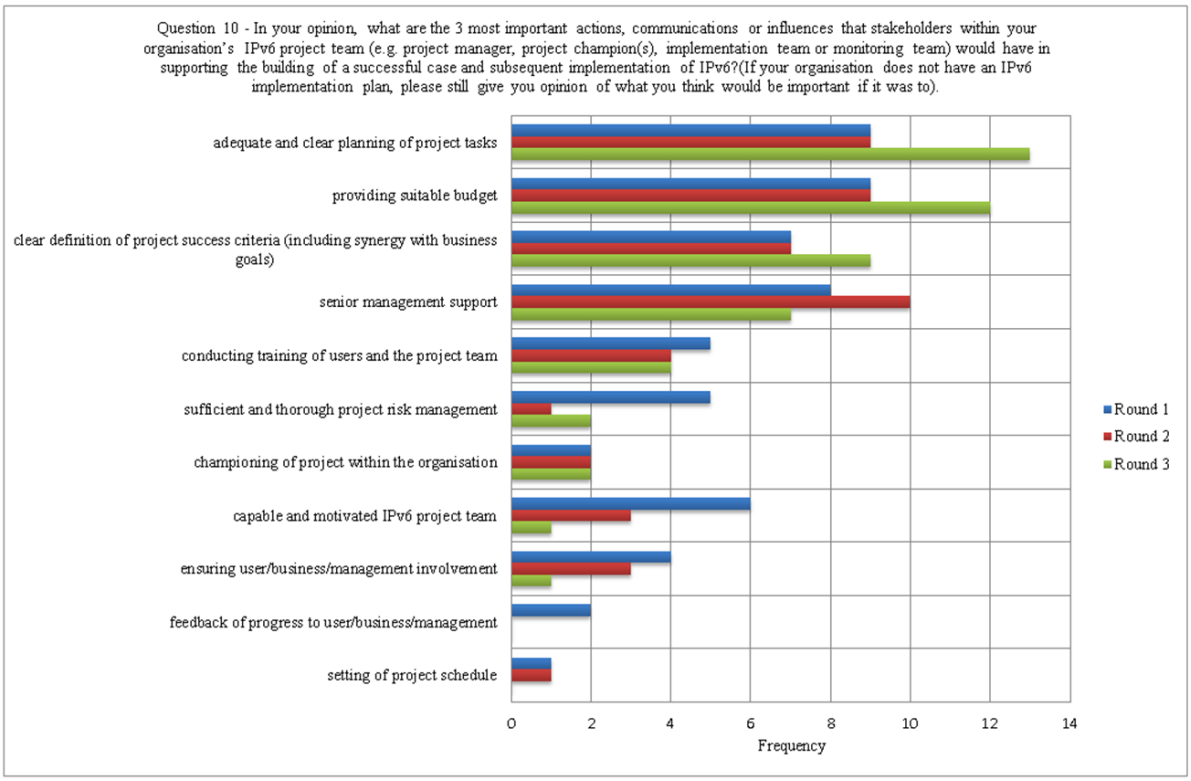


Figure 4-11 –Bar Graph of Delphi Method Responses for Question 10 over Rounds 1, 2 and 3
Raw data: Appendix 6 – Table A6-17

4.2.3. Holistic Situation Analysis and Modelling

The Systems Failures Approach provided the tools to visualize the collected primary and secondary research data (drawn from section 2's research questions) in the form of a data rich picture (figure 4-12). From which the Rich Picture and semi-structured interview and Delphi method results were modelled in the PSFFSM White (2003) (figure 4-13), allowing a comparison with an ideal project system (appendix 10 - figure A10-1) in the form of a table (table A10-1). This comparison then gave sufficient information to interpret the results and draw the conclusions shown in section 4.3, 4.4 and section 5.

This examined each aspect of this research's PSSFSM against the ideal to identify discrepancies within the modelling process *(Fortune and Peters, 2005, p. 126)*. The goal being to synthesise the research results to provide the information needed to support the research aim through identifying the critical elements and providing recommendations of how to build a successful case for IPv6 adoption.

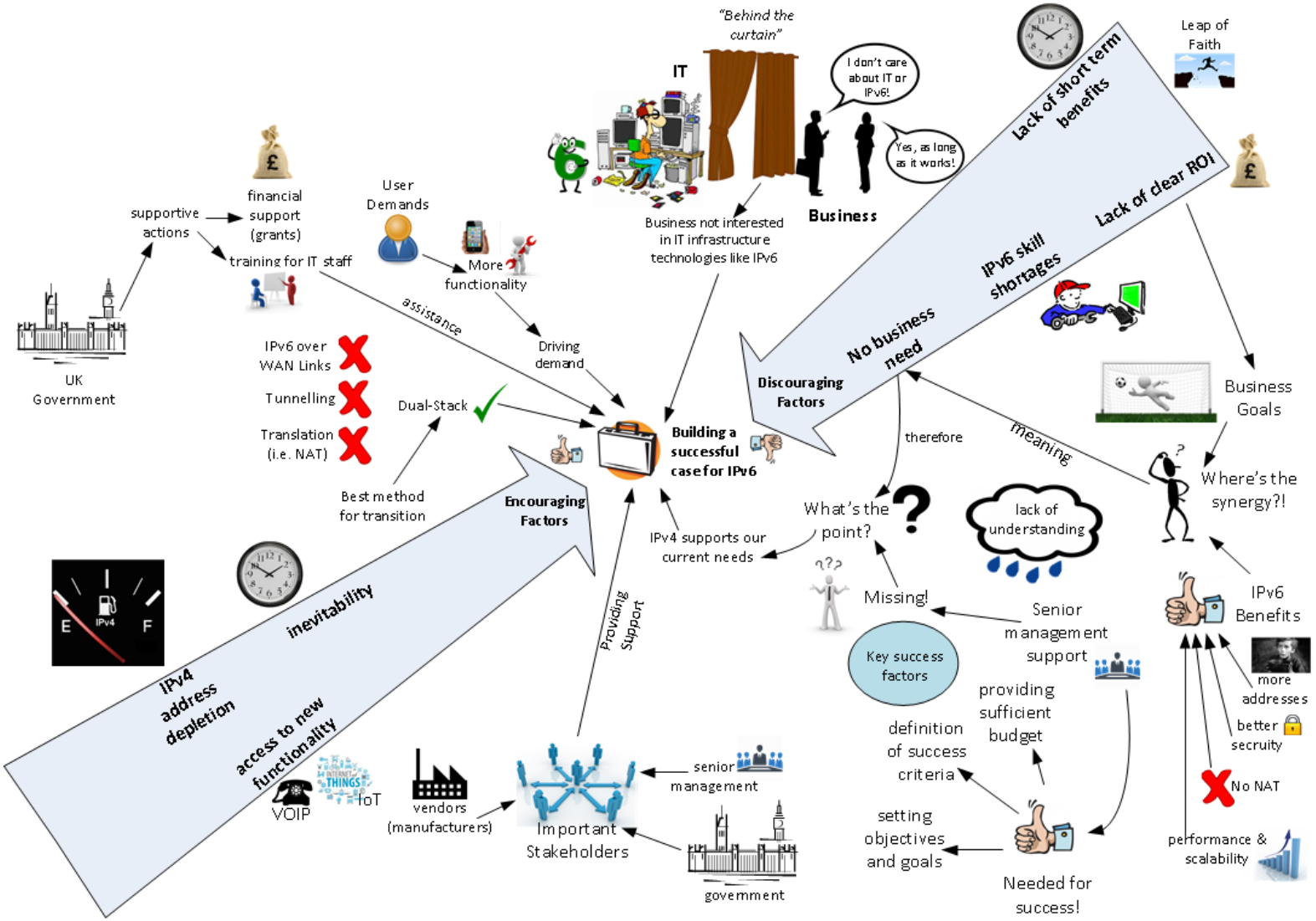


Figure 4-12 – Rich Picture of Primary Research Results
Adapted from: *(Fortune & Peters, 2005, p. 101)* drawn from *Checkland (1992)*

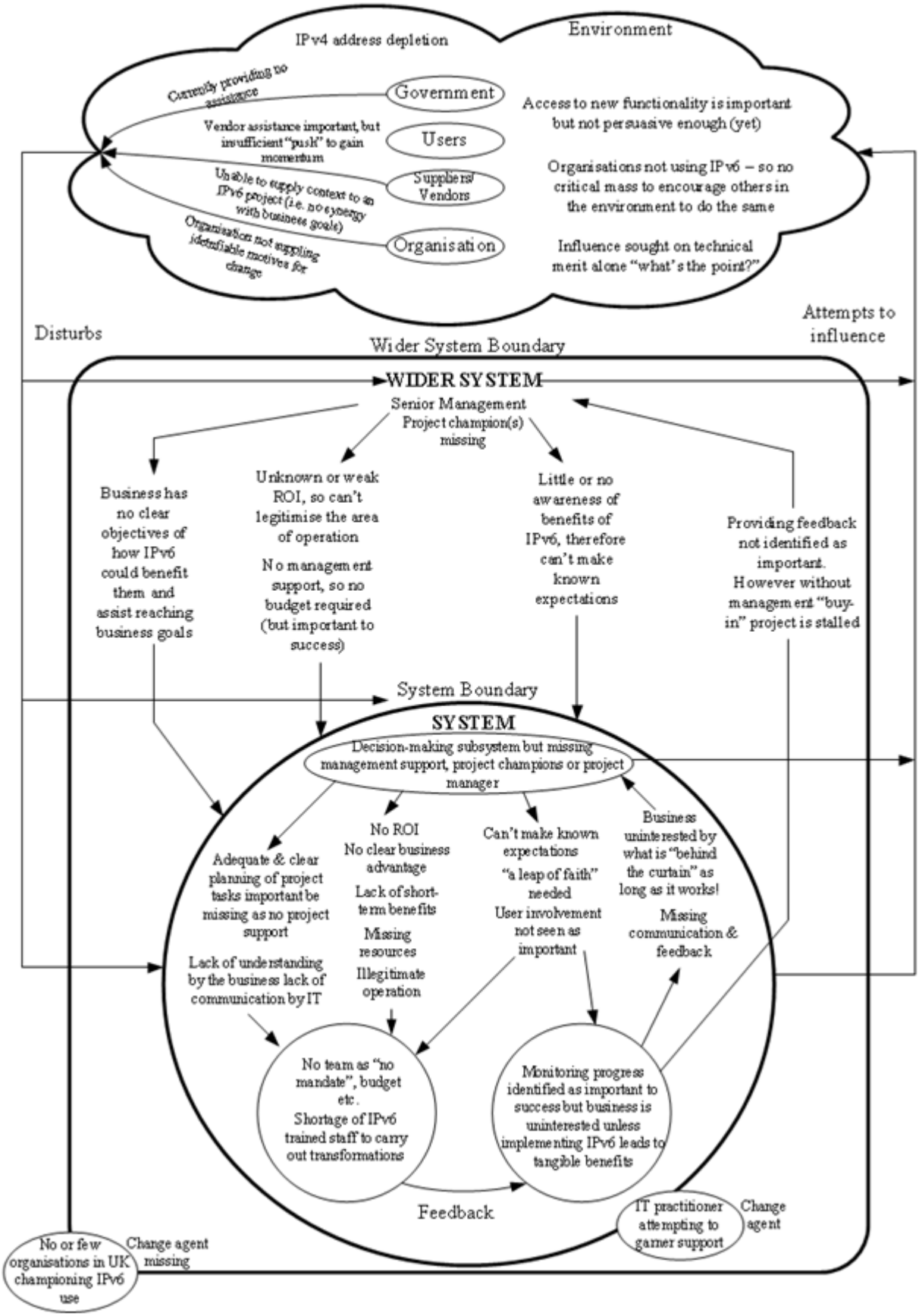


Figure 4-13 – Project Specific Form of the Formal Systems Model of the Situation
Adapted from: *White (2003)*

4.3 Interpretation in relation to the objectives

Section 4.3 and 4.4 discuss how and to what extent the primary research results answer the research questions posed and meets the research objectives, with the aim of using the deliverables as a measure of success. The full descriptions of each objective are listed in section 2.3.

4.3.1. Objective 1

This objective was successfully achieved, the questions for the semi-structured interview (appendix 1) and Delphi method (appendix 5 tables A5-1, A5-2 and A5-3) were prepared based on themes and content from the literature review and delivered as per the research methodology.

4.3.2. Objective 2

The research delivered the panel's views on the most important factors affecting IPv6 adoption (table 4-1); complied from the analysis: figure A6-1 and figure A6-2; showing only 2 of the 6 factors (table 4-1) were technical, showing a softening of factors toward human or business factors that was alluded to within reviewed literature.

Table 4-1 – Summary table of 3 most important factors encouraging or discouraging IPv6 adoption

Encouraging	Discouraging
1. IPv4 address depletion	1. No business need (not relevant to business goals)
2. Inevitability	2. IPv6 skills shortages
3. Access to new functionality and applications	3. Lack of clear ROI

4.3.3. Objective 3

The objective was achieved by creating the deliverable where the panel of experts provided a strong consensus that *dual-stack* would be the most appropriate IPv6 implementation approach (figure 4-4), however, some respondents commented the actual method would need to be customised to the organisation's needs.

4.3.4. Objective 4

Objective 4's deliverable was successfully completed: a ranked list of the most important and useful government actions to building a successful case for IPv6 (table 4-2). Results (appendix 6 – table A6-7 and A6-8) appearing to support *(Yadav et al.'s, 2012)* findings, that successful IPv6 business case acceptance (and therefore adoption) requires government financial and training incentives.

Table 4-2 - Table of 3 most important government actions to support an organisation's case for IPv6

1. financial support (grants)
2. training for IT staff
3. sponsorship

4.3.5. Objective 5

The results allowed successful creation of the deliverable to determine how IPv6 is perceived by the organisation (figure 4-5), 59% of the panel disagreed with the statement posed in question 5 showing that outside IT, the organisation's staff and management are uninterested in IPv6. The other deliverable supporting objective 5 revealed there is insufficient clarity in the benefits of IPv6 to support a business case; with only 12% (figure 4-5) agreeing it supported a successful case for IPv6 today.

4.3.6. Objective 6

Objective 6 was successfully supported by the deliverables of the Delphi method questions 6 (figure 4-7), 8 (figure 4-9), 9 (figure 4-10) and 10 (figure 4-11) allowing identification of the most important stakeholders (actors) (table 4-3) and communications (table 4-4) needed to satisfy the objective's deliverables.

Table 4-3 - Ranked list of the 3 most important stakeholders

1. Senior management
2. government
3. vendors (hardware/software manufacturers)

Table 4-4 - Ranked list of most important components within each area of the IPv6 project environment

Environment (outside the organisation)	Organisation (inside the organisation (i.e. the wider system))	IPv6 Project Team (those conducting the IPv6 implementation (i.e. the system))
1. identifiable motives for change	1. Creation of clear objectives, goals and success criteria	1. adequate and clear planning of project tasks
2. project context (in relation to business goals)	2. senior management support	2. providing suitable budget
3. customer and/or user requirements	3. providing sufficient budget	3. clear definition of project success criteria (including synergy with business goals)

4.3.7. Objective 7

Objective 7 was successfully completed by the deliverables of Rich Picture (figure 4-12) and Project Specific Form of the Formal System Model (figure 4-13). A comparison of *White's (2003)* ideal PSFFSM and a PSFFSM developed from the results of this research (appendix 10 - table A10-1) provided the deliverables of: recommended actions (table 4-5) and key success/failure factors (table 4-6).

Table 4-5 – Recommended actions, communications and stakeholders in building successful case for IPv6

Recommended Actions	Recommended Communications	Recommended Stakeholders
1. Link business goals with the benefits of IPv6 adoption to allow a clear plan to be developed. 2. Instigate training of IT staff in IPv6 installation, configuration and support. 3. Gain buy-in at senior management level to secure both budget and a mandate for support.	1. Improve understanding by communicating the benefits of IPv6 and importance of IT infrastructure to the organisation to improve understanding. 2. Communicate effectively future problems of not migrating to IPv6. 3. Identify and communicate to the management when competitors or peers within the sector start to use IPv6 creating identifiable motives for change.	1. Senior management 2. Government. 3. Vendors (i.e. manufacturers of hardware/software). 4. IPv6 project champions (within IT, staff and management).

Table 4-6 – Key success and failure factors to building a successful case for IPv6

Key Success Factors	Key Failure Factors
1. Obtaining "buy-in" of senior management, by gaining a commitment to provide resources and setting objectives and expectations.	1. Attempting to build a case without senior management support; without increasing understanding of the short and long term benefits of adoption.
2. Successfully displaying how the organisation's goals could be supported by the adoption of IPv6; i.e. providing resources and legitimising area of operations.	2. Failing to show how IPv6 now or in future supports the organisation's goals, expecting the organisation to take a 'leap of faith' without ROI.
3. Identifying and reducing the barriers to adoption within the organisation. These might be technical (software/hardware support, or process of adoption), human (training or understanding) or relationship (support, commitment of the organisation to provide resources) based.	3. Seeking support for adoption, based on IPv6's technical merit alone, or linking the technology with how it could improve the organisation and its services/products.
4. Making use of external influences such as government, vendors or customers to support the building of the case for IPv6 adoption.	4. Failing to acknowledge or make use of support from internal or external stakeholders (government, vendors or customers) in building a case. Not using staff within the organisation that have been influenced by other organisations, skills and viewpoints obtained during training or media influences.
5. Proposing to use a staged implementation approach (e.g. *dual-stack*) for a period of co-existence to reduce risk, upfront costs and disruption of the implementation.	5. Proposing an implementation plan that shows insufficient synergy with the needs of the organisation regarding acceptable risk, costs or disruption.

4.4 Interpretation in relation to the research aim

The research has successfully met its aim by identifying the important elements required in building a successful business case for IPv6 and in developing recommendations to increase the likelihood of successful project approval. These completed deliverables are displayed in Appendix 6 - tables A6-11, A6-14, A6-16 and A6-18, showing key elements identified from the research; that when modelled (figure 4-12 & 4-13) and compared with *White's (2003)* PSFFSM (appendix 10 - figure A10-1) provided recommendations for those attempting to build a case for IPv6 adoption in their organisation.

4.4.1. Most Important Elements Needed for Success

Based on the literature review, interview and Delphi method results from from IT practitioners and IT/Business managers from within the UKE FE sector, an IT practitioner attempting to build a case for adoption should be aware of the elements listed below and the associated recommendations (section 4.4.2).

- The support of senior management is key to building a successful case for IPv6.
- A case must show a synergy between IPv6's and the organisation's business goals, either directly (new services/applications, facilitate connectivity to business partners) or indirectly (future proofing the IT network).
- Technical advantages alone are not sufficient to *sell* IPv6 to an organisation.
- The UK government, vendors/suppliers of hardware/software and other organisations will be a useful source of both influence and assistance in building a case and in subsequent implementation.
- The benefits and drawbacks of the IPv6 protocol and its adoption are widely known by IT practitioners.
- A lack of IT staff trained and skilled in IPv6 is seen as an important barrier to building a successful case and adoption.
- IPv6 is seen as inevitable and yet at the same time not relevant to current business needs.
- The technical issues are less important in promoting or inhibiting a successful case for IPv6, not to say they are solved, just less important in affecting the current situation.

- Coexistence of IPv4 and IPv6 protocols (dual-stack) on an organisation's IT network for a sustained period of time will be required.

4.4.2 Recommendations for Success

The recommendations below have been formulated from this research's primary and secondary research results, revealing a divergence from the success elements *(Fortune and Peters, 2005)* and *White (2003)* described in their FSM and PSFFSM. The critical elements to building a successful case (and therefore their omission contributing to failure) are identified within figure 4-14; these are the key stakeholders, their communications or influences that combined are the key elements needed for success. From which these recommendations when used with the ideal IPv6 model project system (figure 4-14) can contribute toward success.

- A successful case will need to show synergy between the organisation's goals and how the benefits of IPv6 can help support these goals either now or in the future.

- The senior management need to define the scope of IPv6 implementation and provide sufficient resources: financial, staff and political, (in the form of an IPv6 champion, ideally at the senior management or board level.)

- The organisation's IT procurement policy should be changed to ensure new hardware/software purchases support IPv6 and ideally configure IPv6 at the point of installation, avoiding future expense of retrofitting.

- The dual-stack approach is recommended to allow a staged migration; reducing risk, disruption and increasing likelihood of case acceptance. IPv6 should be enabled on new systems or networks as they are added or changed. The inevitable change across an organisation's IS over time means the majority of systems will become IPv6 enabled eventually.

- Make use vendors of hardware/software (identified as a key stakeholder) in terms of practical technical assistance or lending support to building the case for approval.

- Ensure the organisation's IT staff are trained in installation, configuration and support of IPv6 as soon as possible to allow the effects of normative isomorphism *Singh & Tan (2013)* to influence the organisation's toward acceptance and support of an IPv6 project.

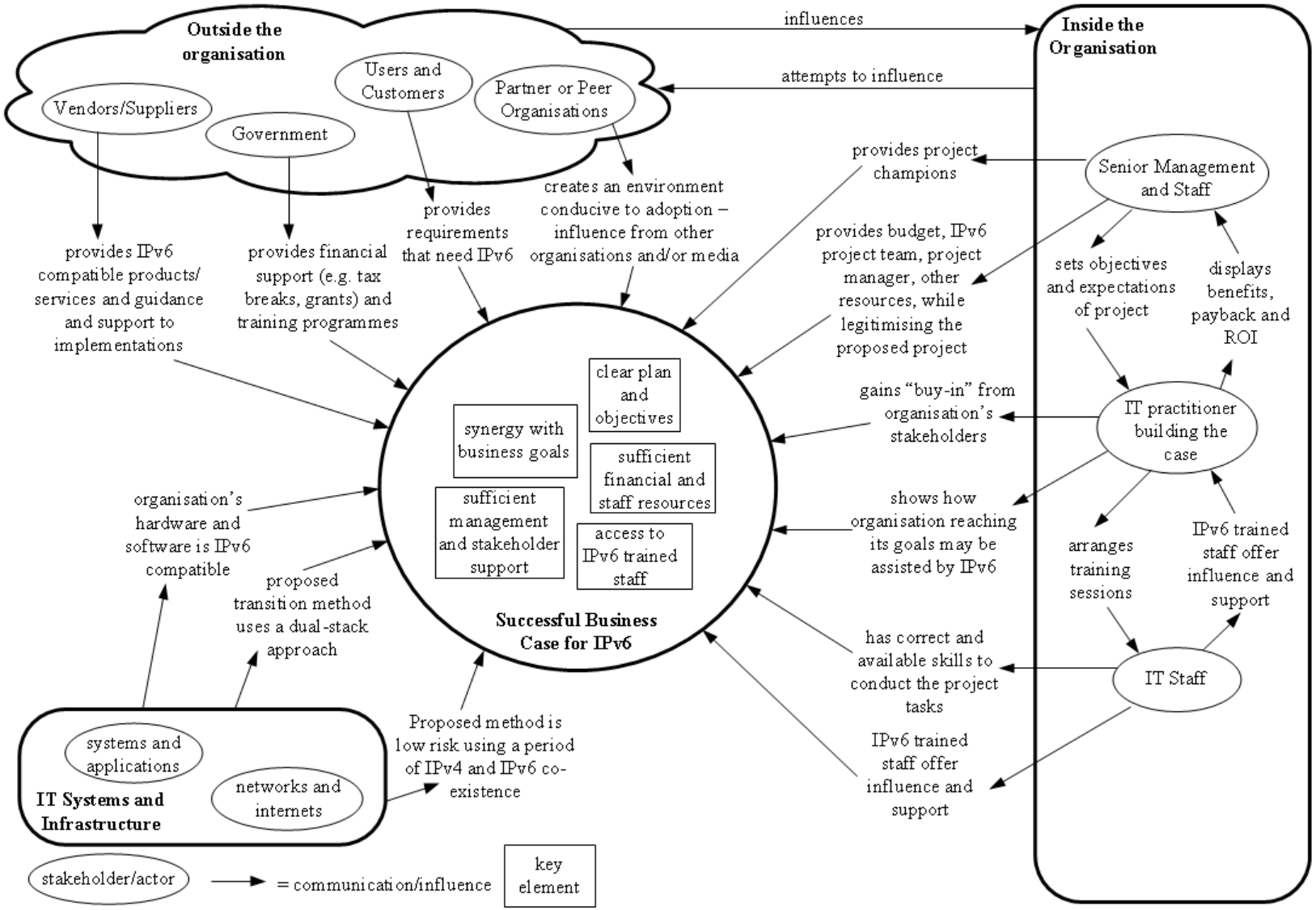


Figure 4-14 – Diagram of the ideal IPv6 business case model system

Adapted from: Formal System Model (Fortune and Peters, 2005) and Project Specific Form of the Formal Systems Model White (2003).

Chapter 5 (Conclusions)

5.1 Conclusions about the objectives (and research questions)

The research methods supplied the data needed to successfully complete the research aim, answer the research questions and meet the objectives as described below.

1. What are the key factors that will assist or inhibit an organisation in making a successful case for IPv6?

IPv6 appears to be encouraged by 'IPv4 address depletion' and IPv6's 'inevitability', agreeing with the future encouraging factors *Waterworth (2006)* identified, but juxtaposed against feelings IPv6 is not yet relevant enough for a successful case to be built. This research's conclusions also agreed with the reviewed literature's inhibiting factors: 'lack of short term benefits (business case)' or 'lack of clear ROI' (cost) *Bons (2011)* and 'IPv6 skill shortages' as *Waterworth's (2006)* also identified.

Concluding from this, IT practitioners, to create a successful case for IPv6 must focus on promoting the new functionality, services and costs savings while showing synergy/relevance with the organisation's goals, agreeing with *Chiniah's (2011)* work.

2. Which transition approach would be most favourable to building a successful case for IPv6?

The transition approach proposed by *(Reddy et al., 2012; Huston 2008)* needs to be low risk and require a long period of IPv4 and IPv6 coexistence. The 'dual-stack' method identified as most favourable by the panel fits these requirements. Allowing an incremental implementation of IPv6 throughout an organisation's IT networks; a conclusion supporting BT Plc's (2012) survey results. In practical terms, the research was successful in answering the research question, with implications that IPv6 friendly purchasing decisions of hardware/software coupled with dual-stack co-existence would mitigate a potentially costly "big-bang" approach, creating a more appealing case.

3. What role does government have in assisting an organisation to formulate a successful case for IPv6?

The research question and objective 4 were successfully answered by the research panel who identified the UK government does indeed have a role supporting an organisation in building a case for IPv6. By providing 'financial support' (e.g. grants or tax breaks) and improving access to 'training for IT staff', findings that reinforce the practical actions that *(Yadav et al., 2012)* purport the

governments of Japan and China have used financial support to reduce financial uncertainty and training programmes to increase knowledge, to successfully increase IPv6 adoption.

4. Do organisations take an interest in the implementation of IT infrastructure technologies like IPv6?

The research question (and objective 5) was successfully achieved, but showed a perception that organisations are typically un-interested in IT infrastructure technologies like IPv6. This should be concerning to IT professionals who need their organisation's support and resources to invest in IT infrastructure that allows them to develop the very infrastructure the organisation relies on to function. These findings appear to support the assertion of (Singh & Tan's, 2013) Process Model, that the perception of the technology is a more prevalent factor in adoption IT infrastructure technologies (like IPv6) than other IT systems; where the organisation isn't so much resistant to the change IPv6 would bring, moreover its unaware of the benefits such a change would bring.

5. Do the benefits of IPv6 support the goals of an organisation enough to allow a successful business case to be made today?

This research was unable to provide a definitive answer either way to this research question (objective 5). However, this lack of consensus supported the paradoxical situation identified within the literature, where *Dell's (2012)* survey showed 75% of CIOs think IPv6 is necessary in future, but 52% also believing it is not urgent. From which, it would appear building a successful case for IPv6 today will be difficult but not impossible, although this difficulty is seen as only a temporary state, where IPv6 will be inevitable eventually as *Waterworth (2006)* asserts and this research supports (table 4-1).

6. Which stakeholders will be most important in building a successful case for IPv6?

The research question (objective 6) was successfully answered, allowing conclusions that *senior management* support is essential, with *hardware/software vendors* and *government* likely to play a key role assisting IT practitioners building a case. As *(Kaur et al.'s, 2013) network externalities* and *peer influences* show, these external stakeholders offer guidance and resources to assist adoption. This agrees with *Clark's (2011)* conclusions of senior management and project champion (the human and relationship assets) importance and additionally *(Ross et al.'s, 1996)* findings, that successful technology adoption needs the engagement of the business in sharing risk and responsibility with the IT department

7. Where are and in what context are the interactions (communications) that may determine the success or failure of IPv6 technology adoption?

This research question and objective 7 was successfully answered by the primary research (table 4-5), indicating certain parts of PSFFSM *White (2003)* would be more important than others in determining a successful IPv6 business case. Where the proposed ideal model (figure 4-14) identifies where and in what context the interactions that determine success reside. Thus leading to conclusions that support *(Kaur et al.'s, 2013)* assertions of the importance of Network Externalities (i.e. the influences of peers/competitors) to IPv6 adoption, whilst disputing *(DiMaggio & Powell's, 1991; 1983)* Institutional Theory. Conclusions, that appear to show successful IPv6 adoption does rely upon effective communication between the organisation's actors both, internal and external. Where an organisation competitors or peers starting to use IPv6, can influence the organisation by highlighting IPv6's benefits or the negative implications of inaction.

5.2 Conclusions about the research aim

The aim of this research was to identify the most important elements needed to build a business case for IPv6 adoption and to develop recommendations that will increase the likelihood of success, both in project approval and subsequent implementation. This has been achieved: the important elements have been identified (table 4-6) and recommendations pertaining to elements of the environment, influences, communications, actions and stakeholders needed have been identified and are visible in the ideal model IPv6 project system (figure 4-14).

The research is qualitative in nature, relying almost wholly on the opinions of IT engineers and IT/business managers in UK FE Colleges. The Delphi method, conducted with best practice, is limited in that an inherent risk of bias exists in qualitative (subjective) research; although measures were taken to reduce its impact. Time constraints limited the scope of data collection to only the UK FE sector and a single research period. Further investigation would be valuable, repeating the Delphi method with a different panel to allow comparison of the results. To test the recommendations and model with organisations that have already been successful in building a business case for IPv6. Another notable limitation upon the research conclusions was the lack of UK FE Colleges who had started an IPv6 transition who could be included within this research.

The research successfully met its aim, shown by these discovered elements and recommendations:

- Closer collaboration between IT staff and the organisation is needed. IT infrastructure technologies (like IPv6) are so fundamental to an organisation's operation they are seen merely as "plumbing" and perceived not to be relevant to achieving an organisations goals when compared to a more tangible IT business application or CRM (customer relationship management).
- The need of senior management support, to provide resources (staff, budget) and legitimise the project.
- The need of IPv6 trained staff, looking beyond just the practical skills, to the influence that the normative isomorphic forces *(Singh & Tan, 2013)* of IPv6 aware employees encouraging adoption from within the organisation.
- That dual-stack will be the most suitable transition approach, supporting *Bons (2011)* findings. Additionally ensuring purchasing decisions for IT systems or components are made in an "IPv6 friendly" way ensuring new systems are IPv6 enabled, or its activation is trivial in future.
- External stakeholders, like internal stakeholders will be important in supporting a successful case. Government and vendors should be aware that their support (in terms of financial

incentives, training or advice) is likely to be crucial in creating an environment conducive of IPv6 adoption.

Finally, the research revealed IPv6 technology adoption is no longer just the technical problem it was in the past, supporting the literature's assertions that softer (non-technical) factors would be more important in future. Disparate technical, human, relationship *(Singh & Tan, 2013)* assets making up a modern IT dependent organisation are more interconnected than ever before; so changes to technology has implications beyond hardware/software; to the perceptions, needs and goals of the organisations themselves.

5.3. Further work

There are three areas where this research could be further developed for results of enhanced size, scope, relevance or application.

5.3.1 Sample Size and Scope

Although the sample size followed best practice for the Delphi method, time constraints limited it to 20 participants over 3 rounds, interviews of only 3 participants, and the scope to just the UK FE sector. Expanding this in future works, to include University (Higher Education) establishments or private businesses within the UK or beyond, could provide data to further refine this research's findings or give results that are more generalisable to other sectors; especially when the dynamic of international partners, customers or users is involved and their effects on the identified success factors.

5.3.2 Changes over Time

The research conducted used methods that were cross-sectional in nature (examining a point in time). IPv6 has been available for a number of years, studies like *BT Plc's (2012)* surveys have revealed changes in thinking over time, repeating this research periodically (longitudinal survey), could shed additional light on key success factors and their changes over time as the environment and situation around IPv6 adoption develops in the coming years.

5.3.3 Causality and Application

The research provided an ideal model system developed from consensus of thinking around certain elements of building a success case for IPv6, it does not however show causality. Applying the conceptual model using a practical process like that of *White et al. (2009)* to determine both the model's validity and practical application could determine if the elements discovered constitute a causal link to success or failure and so provide IT practitioners a method to analyse their own situation, to determine their best course of action.

5.4 Implications of the research

The research demonstrated that IPv6 technology adoption, must be considered within the paradigm that *(Fortune & Peters, 2005)* assert. The success or failure of an information system (in this case IPv6 adoption) exists within the concept of system, boundary and environment; that an information system (IS) is indeed embedded within the organisation itself. The implication being that the elements of successful technology adoption are not centred on correct implementation of a particular technology (although this is also crucial) but more enacting change both to technology and the organisation in such a way that it is palatable, supported and adequately resourced by the organisation.

Time constraints limited the Delphi method; a more definitive consensus could have been gained by using more rounds or participants; or alternatively repeating (with a different panel) to verify the results of the first. The research and conclusions were limited by the vector of study, i.e. to UK FE sector. Potentially if private business was also consulted, the views may have differed, especially those who are conducting overseas commerce with countries with higher IPv6 adoption rates than the UK, and taking into account effects of the customer, profit or shareholders a different set of conclusions may have emerged. The conclusions however may be generalised to HE organisations (Higher Education) sector (i.e. Universities) or other public sector organisations, that have similar goals, services and constraints.

A further limitation was that none of the participants' organisations had started or completed an IPv6 transition. Therefore the experts' opinions would not have the benefit of hindsight of what makes a successful IPv6 case for adoption; however the results did agree with success elements within existing knowledge of technology adoption more generally.

The use of the semi-structured interviews followed by the Delphi method, was successful in identifying key factors, stakeholders and perceptions that the panel felt would contribute to a successful IPv6 project. Framing the research as a systems failure, allowed a different range of analytical tools to be brought to bear; the Systems Failures Approach *(Fortune & Peters, 2005)* coupled with the (Project Specific Form of) Formal System Model allowed the development of recommendations and a model (figure 4-14) allowing the problem to be investigated more broadly as an IS failure. Investigating beyond the technological aspects alone, to a symbiotic relationship displaying traits of (*Checkland and Holwell's, 1998)* conceptualisation of an IS, that is made of interacting human and technology components. Where the human elements: support of management, vendor and government stakeholders, IPv6 trained staff, coupled with technological elements: compatible hardware/software, are crucial in building a successful IPv6 case.

Possibly the most important implication of this research is that the body of knowledge on IPv6 adoption has been expanded by this research to include a method to measure an organisation's current situation, coupled with what elements are key to building a successful business case for IPv6; creating something akin to an IPv6 adoption health check, this is the model in shown in figure 4-14.

5.5 Reflection on the experience of the research process

This section differs in making use of a first-person writing style.

The T802 research process has allowed me to develop my skills in creating interview questions, questionnaires and conducting interviews; especially keeping on-topic when using semi-structured methods. Additionally conducting the Delphi method developed my skills in orchestrating a group of disparate individuals using web based tools to acquire the necessary data.

I have achieved a greater understanding of discovering and reviewing research literature, learning how to extract the pertinent points and compare authors' views in order to formulate my own position. I found this a very challenging part of the overall process and I had underestimated the amount of time it would take, but I feel that this helped me develop personally through persistence and determination to ultimately improve my research skills.

My knowledge of IPv6 has been improved, but more specifically, my understanding of technology adoption as more than merely technical challenges, where the human aspect is as important if not more so; findings I hope have been conveyed within the conclusions of this research.

To begin again, I would ensure I planned for additional time to conduct the Delphi method process. I had underestimated how long it would take to analyse each iteration and how long some participants would take to respond, even when using a convenient web survey format.

To conclude, I feel happy with the end result, showing new perspectives on examining IPv6 protocol adoption, a many tentacle problem that spans organisations, people and technology. Finally, I hope that I have prepared a piece of research that can stand up to academic scrutiny and add to the existing body of knowledge about IPv6 adoption.

References

Agarwal, R. and Prasad, J. (1998) - "The antecedents and consequents of user perceptions in information technology adoption." Decision support systems 22.1 (1998): 15-29.

Alafouzos, P.N. (2006). Deploying IPv6 in Greece: A Network Economics Approach. London: University of London.

Anglin, G. L. (1991) – "Instructional technology past, present and future" Englewood, CO: Libraries Unlimited Inc.

Archibald, R. (1992) – "Managing High-Technology Programs and Projects" John Wiley & Sons, Chichester.

BT Plc. (2012) – "IPv6 Industry Survey Results" – BT Plc. BT Connect URL: http://www.ipv6.bt.com/downloads/2012_ipv6_survey.pdf
Accessed: 28th January 2015.

BT Plc. (2014) – "IPv6 Industry Survey Results" BT Plc. BT Connect URL: http://www.globalservices.bt.com/static/assets/pdf/products/diamond_ip/BT_Diamond_IP_2014_IPv6_Survey.pdf
Accessed: 1st July 2015

Biggam, J. (2011) – "Succeeding with your master's dissertation: a step-by-step handbook." 2nd ed. Maidenhead: Open University Press. ISBN-10: 033524225-1

Birley, G. & Moreland, N. (1998) – "A practical guide to Academic Research." London: Kogan Page.

Bogdan, R. and Biklen, S. (1982) – "Qualitative research for education: An introduction to theory and methods", Boston, Allyn and Bacon.

Bons, E. (2011) – "IPv6: Drivers and Barriers for Adopting." Tilburg University: Department of Information Management.

Bohlin, E. and Lindmark, S. (2002) - ''Incentives to innovate with next generation networks'', Communications and Strategies, Vol. 48 No. 4, pp. 97-117.

Boyatzis, R. (1998) – "Transforming qualitative information: Thematic analysis and code development." Thousand Oaks, London, & New Delhi: SAGE Publications.

Bryman, A., & Bell, E. (2011) – "Business research methods 3e." Oxford university press.

Burnett, N. & Youker, R. (1980) – "Analysing the project environment" EDI Course Notes CN-848, World Bank, Washington, DC

Chandra, D., Kathing, M. and Kumar, D. (2013) - "A Comparative Study on IPv4 and IPv6." Communication Systems and Network Technologies (CSNT), 2013 International Conference on. IEEE, 2013.

Che, X & Lewis, D (2010) – "IPv6: Current Deployment and Migration Status" – Faculty of Applied Design and Engineering, Swansea Metropolitan University, International Journal of Research and Reviews in Computer Science (IJRRCS), Vol. 1, No. 2, June 2010.

Checkland, P. (1972) – "Towards a systems-based methodology for real world problem solving." Journal of Systems Engineering, 3: 87-116.

Checkland, P. B. (1981) – "Systems Thinking, Systems Practice" John Wiley & Sons, Chichester.

Checkland, P. & Holwell, J. (1998) – "Information, Systems and Information Systems", Chichester, John Wiley & Sons.

Chittimaneni, K. K. (2011). Enterprise IPv6 Deployment: Experiences from the Field (Google): URL: http://www.rmv6tf.org/2011-IPv6-Summit-Presentations/4-%20presoipv6-rmv6tf-2011.pdf Accessed: 1st July 2015

Chiniah, A. (2014) - "Assessment of IPv6 Readiness and Adoption Strategy for Mauritius, International Conference on Advances in Engineering and Technology (ICAET'2014) March 29-30, 2014 Singapore URL: http://iieng.org/siteadmin/upload/5598E0314230.pdf (Accessed 29th December 2014)

Chown, T (2011) – "IPv6 – Technical Guide" School of Electronics and Computer Science, University of Southampton. The JNT Association, JANET(UK)
URL: https://community.ja.net/system/files/487/ipv6-tech-guide-for-web.pdf
Accessed: 5th October 2014

Churchman, C. (1971) – "The design of inquiring systems", Basic Books, New York.

Cisco Systems Inc. (2010) – "Role of Government in IPv6 Adoption"
URL:
http://www.cisco.com/en/US/services/ps6887/ps10716/docs/ipv6_govt_services_whitepaper.pdf
Accessed: 16th March 2015

Clark, D. (2011) – "IPv6 state sector adoption phase 1 report on status and barriers", IPv6 state-sector adoption, New Zealand IPv6 Task Force Trust.
URL: http://www.ipv6.org.nz/wp-content/uploads/2011/12/IPv6inGovt-Report.pdf
Accessed: 25th March 2015

Crang, M. (1997) – "Analysing qualitative materials" in Flowerdew, R. and Martin, D. (eds.) (2005) "Methods in Human Geography: a guide for students doing a research project", Second Edition, Harlow, UK, Pearson.

Data Protection Act 1998 (1998) - London: Stationery Office. Also available on-line:
URL: http://www.ico.gov.uk/for_organisations/data_protection/the_guide/principle_7.aspx
Accessed: 15th December 2014.

Dalkey, N. C. & Helmer, O. (1963) - "An experimental application of the Delphi method to the use of experts." Management Science, 9 (3), 458-467.

Dalkey, N. C., & Rourke, D. L. (1972) – "Experimental assessment of Delphi procedures with group value judgments" In N. C. Dalkey, D. L. Rourke, R. Lewis, & D. Snyder (Eds.). Studies in the quality of life: Delphi and decision-making (pp. 55-83). Lexington, MA: Lexington Books.

Davies, M. B. (2007) - "Doing a Successful Research Project: Using Qualitative or Quantitative Methods", Palgrave Macmillan.

Dell, P., Kwong, C., & Liu, Y. (2008) – "Some reflections on IPv6 adoption in Australia." Emerald Group Publishing Limited VOL. 10 NO. 3 , 3-9.

Dell, P. (2010) – “Two Economic Perspectives on the IPv6 Transition”, Volume 12, Issue 4, pp. 3 – 14. Emerald Group Publishing Limited.
URL: http://dx.doi.org/10.1108/14636691011057046
Accessed: 1st December 2014

Dell, P. (2012) – “Australian IPv6 readiness: Results of a national survey.”, Journal of Research and Practice in Information Technology 44.1 (2012): 3.

Denscombe, M. (1998) – “The Good Research Guide.” Buckingham. Open University Press

DiMaggio, P. & Powell, W. (1991) – “Introduction”. In P. J. DiMaggio and W. Powell (eds.) “The New Institutionalism and Organizational Analysis”, pp. 1–38. Chicago: University of Chicago Press.

DiMaggio, P. & Powell, W. (1983) - “The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields,” American Sociological Review 48:147-60.

Drevin, L. (2008) – “Making sense of information systems failures by using narrative analysis methods.” In Combined Proceeding of the 13th and 14th CPTS Working Conference.

Ely, M., Anzul, M., Freidman, T., Garner, D., McCormack-Steinmetz, A. (1991) - "Doing qualitative research: Circles within circles (Vol. 3)". Psychology Press. Routledge. ISBN: 1850008140

Flowerdew, R. and Martin, D. (1997) - “Methods in human geography” 1st ed. Harlow, England, Pearson Education.

Fortune, J. & Peters, G. (2005) - “Information Systems – Achieving Success by Avoiding Failure”, Wiley, ISDN: 0-470-86255-6

Gall, M. D., Gall, J. P., & Borg, W. R. (2003) – “Educational research: An introduction (7th ed.)” Boston, MA: A & B Publications.

Gallaher, M.P., & Rowe, B.R. (2005) – “IPv6 Economic Impact Assessment.” Research Triangle Park: RTI International Health, Social, and Economics Research.

Gallaher, M. & Rowe, B. (2006) “The costs and benefits of transferring technology infrastructures underlying complex standards: the case of IPv6.” Journal of Technology Transfer 31 (5), 519–544.

Gallagher, M. & Jeffrey, W. et al. (2006) – “Technical and Economic Assessment of IPv6” – IPv6 Task Force, U.S. Department of Commerce, National Institute of Standard and Technology. National Telecommunications and Information Administration. 2006.
URL: http://www.ntia.doc.gov/files/ntia/publications/ipv6final.pdf
Accessed 29th December 2014

Geer, D. (2008) – “To Boost Adoption, IPv6 Proponents Back Once-Shunned Technology” – Computer October 2008, Volume 41, Issue 10, pp16-19. ISSN: 0018-0162

Geertz, C. (1973) - "Thick Description: Toward an Interpretive Theory of Culture". In The Interpretation of Cultures: Selected Essays. New York: Basic Books, 1973. 3-30.

Ghobakhloo, M. Hong, T. Sabouri, M. and Zulkifli, N. (2012) - "Strategies for successful information technology adoption in small and medium-sized enterprises." Information 3.1 (2012): 36-67.

Gill, F. Leslie, G. Grech, C. & Latour, J. (2013) – “Using a web-based survey tool to undertake a Delphi study: Application for nurse education research”, Nurse Education Today, 33, 11, pp. 1322-1328, Science Citation Index, EBSCOhost, viewed 18 February 2015.

Glaser, B. and Strauss, A. (1967) – "The Discovery of Grounded Theory." Chicago: Aldine.

Google Inc. (2015) – IPv6 Usage Statistics
URL: http://www.google.com/intl/en/ipv6/statistics.html
Accessed: 28th January 2015

Gordon T. J. (1994) – "The Delphi Method", The Millennium Project
URL: http://fpf.ueh.edu.vn/imgnews/04-Delphi.pdf
Accessed: 12th December 2014

Green B., Jones M., Hughes D. & Willimas A. (1999) – "Applying the Delphi technique in a study of GP's information requirements." Health and Social Care in the Community 7(3), 198-205.

Guerin, R. & Hosanagar, K (2010) – "Fostering IPv6 Migration Through Network Quality Differentials", ACM SIGCOMM Computer Communication Review, Volume 40, Number 3, July 2010 URL: http://www.cs.nott.ac.uk/~rmm/teaching/g54acc/2010/material/p18-2v40n3e-guerinA.pdf (Accessed 29th December 2014)

Hilson, G. (2012) - "World IPv6 Launch Day Is Here: Time for an IPv6 Deployment Strategy", Networkcomputing.com.
URL: http://www.networkcomputing.com/next-gen-network-techcenter/240001570?printer_friendly=this-page
Accessed: 2nd July 2015

Hovav, A., Patnayakuni, R. and Schuff, D. (2004) – "A model of Internet standards adoption: the case of IPv6." Information Systems Journal, 14: 265–294. doi: 10.1111/j.1365-2575.2004.00170.x

HSE (2014) – "Risk Assessment. A brief Guide to Controlling Risks in the Workplace" - Health and Safety Executive
URL:http://www.hse.gov.uk/pubns/indg163.pdf
Accessed 29th December 2014

Hsu, C & Sandford, B. (2007) – "The Delphi Technique: Making Sense of Consensus", The Ohio State University and Oklahoma State University, "Practical Assessment, Research & Evaluation" Volume 12, Number 10, August 2007 ISSN: 1531-7714

Huston, G. (2008) - "The changing foundation of the internet: confronting IPv4 address exhaustion." The Internet Protocol Journal 11.3 (2008): p19-36.

Huston, G. & Michaelson, G. (2008) – "IPv6 Deployment: Just where are we?" The ISP Column, April 2008.

Jacobs, J. (1996) – "Essential assessment criteria for physical education teacher education programs: A Delphi study" Unpublished doctoral dissertation, West Virginia University, Morgantown.

Jairath N. & Weinstein J. (1994) - "The Delphi methodology: a useful administrative approach." Canadian Journal of Nursing Administration 7, 29–42.

Jara, A. J. Ladid, L. & Skarmeta, A. (2013) – "The Internet of Everything through IPv6: An Analysis of Challenges, Solutions and Opportunities" - Journal of Wireless Mobile Networks, Ubiquitous Computing, and Dependable Applications, volume: 4, number: 3, pp. 97-118 2013.

Katz, M., & Shapiro, C. (1986) – "Technology Adoption in the Presence of Network Externalities", Journal of Political Economics (94:4) , 822-841.

Kaur, A. Singh H. & Tan F. (2013) – "Why isn't digital infrastructure being updated? – the case of IPv6" – 24th Australasian Conference on Information Systems 4-6 December 2013. Business Information Systems Department, Auckland University of Technology, Auckland, New Zealand.

Kaur, A. Singh, H. (2014) – "Impact of network externalities on digital infrastructure adoption and assimilation", Auckland University of Technology (AUT), New Zealand.

Leavitt, N. (2011) – "IPv6 – Any closer to adoption" – IEEE COMPUTER SOC, ISSN: 00189162

Lett, J. (1990) – "Emics and etics: Notes on the epistemology of anthropology." In T.N. Headland, K.L. Pike, & M. Harris (Eds.). "Emics and etics: The insider/outsider debate." Frontiers of anthropology, v. 7. Newbury Park, Calif: Sage Publications.

Limoncelli, T. A., & Cerf, V. G. (2011) – "Successful strategies for IPv6 rollouts.: Really.", Communications of the ACM, 54(4), 44-48.

Loughlin K. & Moore L. (1979) – "Using Delphi to achieve congruent objectives and activities in a pediatrics department", Journal of Medical Education 54, 101-106.

Ludwig, B. (1994) – "Internationalizing Extension: An exploration of the characteristics evident in a state university Extension system that achieves internationalization." Unpublished doctoral dissertation, The Ohio State University, Columbus.

Ludwig, B. (1997) – "Predicting the future: Have you considered using the Delphi methodology?", Journal of Extension, 35 (5), 1-4.
URL: http://www.joe.org/joe/1997october/tt2.html
Accessed: 10th May 2015.

Mason, A., & Mahindra, T. (2011) –"Report for IDA: IPv6 Adoption Guide for Singapore." Singapore.

McKenna H.P. (1994) – "The Delphi technique: a worthwhile approach for nursing?", Journal of Advanced Nursing 19, 1221—1225.

Murphy, M. Black, N. Lamping, D. McKee, C. Sanderson, C. Askham, J. (1998) – "Consensus development methods and their use in clinical guideline development." Health Technology Assessment 2(3).

Newcombe, R. (2003) "From client to project stakeholders: a stakeholder mapping approach", Construction Management & Economics, 21, 8, pp. 841-848, Business Source Complete, EBSCOhost, viewed 10 February 2015.

NRO (2013) – "NRO's 2013 Global IPv6 Deployment Monitoring Survey 2013", based on the results of GNKS 2013 survey.
URL: https://www.nro.net/wp-content/uploads/Global-IPv6-Deployment-Survey-2013-final.pdf
Accessed: 10th June 2015

Quynh Anh, N., & Minh Nguyen, N. P. (2012) – "Transition from IPv4 to IPv6: best transition method for large enterprise networks.", Lahti University of Applied Sciences, Finland

Ofcom (2012) – "MC/111 Internet Protocol Version 6 Deployment Study" Interconnection Communications Ltd.
URL: http://stakeholders.ofcom.org.uk/binaries/research/technology-research/2013/internet-protocol.pdf
Accessed: May 12th 2015

Okoli, C. Pawlowski, S.D. (2004) – "The Delphi method as a research tool: an example, design considerations and applications", INFORMATION & MANAGEMENT, Vol. 42, No. 1, pp. 15-29

Onuora, C. E. (2010) – "Paradigm Shift of the Internet from IPv4 to IPv6.", Edited by: Prof. RE Sheriff School of Engineering, Design and Technology University of Bradford, 7, 24bit.

Oxley, A. (2014) – "Issues affecting the adoption of IPv6" - Computer and Information Sciences (ICCOINS), 2014 International Conference on, vol., no., pp.1,6, 3-5 June 2014, ISBN: 978-1-4799-4391-3

Padgett, D. K. (2008) – "Qualitative methods in social work research (2nd Edition)", Thousand Oaks, CA: Sage.

Palet, J. (2007) – "The Choice: IPv4 Exhaustion or Transition to IPv6", Recuperado en Agosto de. URL: https://www.afrinic.net/images/stories/Library/corp/platelet.pdf Accessed: 10th December 2014

Pare, G. C., Poba-Nzaou, G. & Templier, M. (2013) – "A Systematic Assessment of Rigor in Information Systems Ranking-Type Delphi Studies", Information & Management [Online].
URL: http://dx.doi.org/10.1016/j.im.2013.03.003
Accessed 1st April 2015

Pike, K. L. (1967) - "Language in Relation to a Unified Theory of Structure of Human Behaviour "(2nd ed.), The Hague, Netherlands: Mouton. Published by Den Haag, Mouton and Co. 1967.

Reddy, P. V. P., Ali, K. M. I & Ravi, S. T. (2012) – "Importance and Benefits of IPv6 over IPv4: A Study" - Electronics & Communication Engineering, K L University, Vaddeswaram, India, International Journal of Scientific and Research Publications, Volume 2, Issue 12, December 2012, ISSN 2250-3153
URL: http://www.ijsrp.org/research-paper-1212/ijsrp-p1288.pdf
Accessed 29th December 2014

Reddy, P. R. , Reddy, D. M. , Reddy, B. R. , Madhavi, P. , Krishna, V. V. (2014) – "The Future Configuration Version Protocols of Global and Private IP – IPv6 Security Features. International Journal of Research Science & Management. 1(7): December 2014
URL: http://www.ijrsm.com/issues%20pdf%20file/Archive-2014/Decmber-2014/1-IJRSM_DEC_Formatted_PulmiraviReddy_THE%20FUTURE%20CONFIGURATION%20VERSION%20PROTOCALS%20OF%20GLOBAL%20AND%20PRIVATE%20IP%20-%20IPv6%20SECURIT%20FEATURS.pdf
Accessed: 29th December 2014

Rodgers, B. L. & Cowles, K. V. (1993) – "The qualitative research audit trail: A complex collection of documentation." Research in Nursing and Health, 16, 219 - 226.

Robert, G., Greenhalgh, T., MacFarlane, F. & Peacock, R. (2009) – "Organisational factors influencing technology adoption and assimilation in the NHS: a systematic literature review", Queen's Printer and Controller of HMSO 2009.

Ross, J. Beath, C. and Goodhue, D. (1996) - "Develop long-term competitiveness through IT assets." Sloan management review 38.1 (1996): 31-42.

Rowe, B. & Gallaher, M. (2006) – "Could IPv6 Improve Network Security? And, If So, at What Cost?", I/S: A Journal of Law and Policy for the Information Society, 2(2), 231-268.
URL: http://www.hpc.mil/images/hpcdocs/ipv6/2isjlp231rowe_and_gallaher.pdf
Accessed: 10th April 2015

Rowe, G., & Wright, G. (1999) – "The Delphi technique as a forecasting tool: Issues and analysis. International Journal of Forecasting", 15(4), 353-375.

RIPE NCC (2012) – "RIPE NCC Begins to Allocate IPv4 Address Space from the Last 8",
URL: http://www.ripe.net/internet-coordination/news/announcements/ripe-ncc-begins-to-allocate-ipv4-address-space-from-the-last-8
Accessed: 29th December 2014

Sauer, C. (1993) – "Why Information Systems Fail: A Case Study Approach" Alfred Waller, Henley on Thames.

Scheibe, M., Skutsch, M., & Schofer, J. (1975) – "Experiments in Delphi methodology." In H. A. Linstone, & M. Turoff (Eds.). The Delphi method: Techniques and applications (pp. 262-287). Reading, MA: Addison-Wesley Publishing Company.

Schmidt, R. (1997) – "Managing Delphi surveys using nonparametric statistical techniques." Decision Sciences,28(3), 763-774.

Shields, T. , Silcock, G. , Donegan, H., & Bell Y. (1987) – "Methodological problems associated with the use of the Delphi technique." Fire Technology, 23(3), 175-185.

Skulmoski, G. & Hartman, F. (2007) – "The Delphi Method for Graduate Research", Journal of Information Technology Education, Volume 6, 2007.

Singh, H. & Tan, F. (2013) - "A process theory of IT infrastructure adoption: the IPv6 story," 2013 New Zealand Information Systems Doctoral Consortium (NZISDC), Auckland, New Zealand, 26-27 July.
URL: http://docs.business.auckland.ac.nz/Doc/NZISDC2013-Awinder-Kaur.pdf
Accessed: 30th November 2014

Silverman, D. (2002) – "Qualitative Research: Meanings or Practices?", Information Systems Journal, Vol. 8 No.1, p3-20.

Sridevi (2013) – "Barriers for Adopting Internet Protocol Version6" International Journal of Scientific Research, Vol : 2, Issue : 6 June 2013

Stone, D. Jarrett, C. Woodroffe, M. & Minocha, S. (2005) – "User interface design and evaluation." Morgan Kaufmann.

Strauss, A. (1987) – "Qualitative analysis for social scientists", Cambridge: Cambridge University Press.

Strauss, A. L. and Corbin, J. (1990) – "Basics of Qualitative Research: Grounded Theory Procedures and Techniques." London: Sage.

Sumsion T. (1998) – "The Delphi technique: an adaptive research tool", British Journal of Occupational Therapy" 61(4), p. 153-156

Tabachnick, B. G. and Fidell L. S. (1989) – "Using multivariate statistics", 2nd Edition, published by Harpercollins College Division, ISBN 10: 0060465719 ISDN 13: 9780060465711

Taylor, P. (2010) – "A study into the usability of the Formal Systems Model to investigate Critical Success Factors that have been accepted for the management of an IT project" Department of Computing, Faculty of Mathematics, Computing and Technology, The Open University. 2010

Timbrell, G. and Chan, T. (2003) – “Investigating Enterprise Systems Issues using a Modified Delphi Method and Exploratory Factor Analysis”, 14th Australasian Conference on Information Systems, Centre for Information Technology Innovation, Queensland University of Technology, Brisbane, Queensland. 2003

The Open University (2014) – T802 Course Team, Milton Keynes, The Open University.

Turner, D. (2010) - “Qualitative Interview Design: A Practical Guide for Novice Investigators.” The Qualitative Report, Volume 15 Number 3, 2010. May: 754-760.

Waterworth, A (2006) – “An assessment of the factors influencing the implementation of Internet Protocol Version 6 (IPv6) to date and in the future”, MSc Thesis, Open University. Milton Keynes. UK, 2006.

Weaver, W. T. (1971) - “The Delphi forecasting method” Phi Delta Kappan, 52 (5), 267-273.

Weiss, R. (1995) – “Learning from strangers: The art and method of qualitative interview studies.” Simon and Schuster.

White, D (2003) - “A systems view of project management risk” PhD Thesis, The Open University.

White et al. (2009) – "The project-specific Formal System Model", International Journal of Managing Projects in Business, Vol. 2 Iss 1 pp. 36 - 52
URL: http://dx.doi.org/10.1108/17538370910930509
Accessed: 18th April 2015

Willis G. B. (1999) – “Cognitive Interviewing: A “How To” Guide; Reducing Survey Error through Research on the Cognitive and Decisions Processes in Surveys” Short Course Presented at the 1999 Meeting of the American Statistical Association.

Yadav, A. Abad, P. & Kaul, A. (2012) – “IPv6 Protocol Adoption in the US - Why is it so Slow?” interdisciplinary Telecommunications at the University of Colorado, Boulder, 4 May 2012 URL: http://morse.colorado.edu/~tlen5710/12s/IPv6Protocol.pdf

Yin, R.K. (2009) – “Case Study Research: Design and Methods: 5 (Applied Social Research Methods)”, 4th ed., Sage Publications.

Zhai, Y., Bao, C., & Li, X. (2011, July) – “Transition from ipv4 to ipv6: A translation approach.” In Networking, Architecture and Storage (NAS), 2011 6th IEEE International Conference on (pp. 30-39). IEEE.

Zhu, K. (2004) – “Information Transparency of Business-to-Business Electronic Markets: A Game-theoretic Analysis.” Management Science (50:5) , 670-685.

Extended Abstract

IPv6 (Internet Protocol version 6) is widely regarded as the future protocol of the Internet and IT network connectivity. The Internet Task Force developed IPv6 to replace the ubiquitously used IPv4 (Internet Protocol version 4) protocol in answer to the accelerating growth of the Internet's size, services, devices and uses.

1. Summary of the motivation (research problem) and research aim

The research literature shows that the rate of IPv6 adoption is still very low despite increasing hardware/software support, better understanding of the protocol and that the pool of unallocated IPv4 addresses was exhausted in 2012.

This research was instigated to address the limited guidance within the literature of how IT practitioners can *connect* the benefits of IPv6 to progress their organisation's adoption of IPv6. The key themes identified (listed below) from the literature review, were used with the aim of identifying the most important elements needed and to provide practical recommendations that can assist IT practitioners in building a successful case for IPv6.

• IPv6 technology adoption within the context of organisational influences and failures (i.e. how technology adoption is affected by the organisation into which it is to be implemented).
• What factors, drivers or perceptions are affecting business decisions to adopt IPv6?
• Is there a contemporary business case for IPv6 adoption?
• Who in the organisation can support a case for IPv6 (i.e. which stakeholders?)

2. Summary of the methodology

The research proposed the notion that an organisation being unable (or unwilling) to adopt IPv6 on its IT networks and internets is an information systems failure and to conduct the primary research was conducted using the Systems Failures Approach (Fortune & Peters, 2005) as a framework. The methodology made use of seven distinct objectives, preceded by a literature review to identify themes and areas for development within existing knowledge. Broadly, the objectives started with the data collection and pre-analysis followed by modelling of the situation, analysis and finally the synthesis from which conclusions and recommendations were drawn.

Using the objectives, the research consulted IT professionals from Colleges within the UK FE (Further Education) Sector to explore the key themes identified from the literature review. The semi-

structured interviews consulted three individuals from separate FE Colleges to determine in-depth opinion and context in preparation for the Delphi method. The Delphi method, an iterative questionnaire process that consulted a panel of 20 experts from different FE Colleges in three rounds of questionnaires to attempt to reach consensus on the key elements required in building a successful case for IPv6. This was achieved by producing interview and Delphi method survey questions to seek answers on what are the most important factors encouraging or discouraging IPv6 adoption, the most appropriate transition method with which to implement IPv6 and the stakeholders (and their actions) inside or outside the organisation that could be of assistance to an IT practitioner building a case for adoption.

3. Key Results

The key results identified from the iterative Delphi method questionnaires showed the most important factors encouraging IPv6 were:

- IPv4 address depletion;
- inevitability of IPv6;
- access to new functionality or applications.

Conversely the most discouraging:

- IPv6 not relevant to current business goals or needs;
- a lack of IPv6 skills;
- lack of clear ROI (return on investment).

Dual-stack was seen as most favourable approach by 88% of panellists, to conduct the transition to IPv6. Government support through the actions of: financial support (grants), training for IT staff and sponsorship were seen as most pertinent; where along with the senior management of the organisation and hardware/software vendors were identified as the most important stakeholders in supporting an IPv6 business case.

Fifty nine percent of the panel felt an organisation's staff and management are typically uninterested in IT infrastructure technologies like IPv6 and only 12% of panellists agreed IPv6's benefits would support a contemporary business case.

The results showed that an organisation's influences to support a successful case for IPv6 would require from the environment: identifiable motives for change, project context in relation to business goals and the influence of customer and/or user requirements. Additionally the organisation would need to provide: clear objectives, goals and success criteria, senior management support (of the

project) and sufficient budgetary resources. Additionally the proposed IPv6 project team would need: clear planning of project tasks, a suitable budget and clear definition of success criteria that showed synergy with business goals.

4. Summary Analysis

The results of the semi-structured interview were analysed by drawing out key words or phrases ('emic' codes) used in the subsequent Delphi method survey, but also to identify the language used to prepare effective questions for the process. The Delphi method results were analysed by frequency analysis and presented within bar and pie charts.

These results were shown in a Rich Picture *(Fortune & Peters, 2005)*, a method that visualises a situation within a cartoon like diagram to ease assimilation and understanding of the factors at work. Then followed by the modelling of the discovered situation and results within *White's (2003)* Project Specific Form of the Formal System Model, derived from *(Fortune & Peters', 2005)* Formal System Model (FSM), allowing a comparison with the ideal, from which these noteworthy elements emerged:

1. The environment (outside the organisation) should be encouraging adoption, although IPv4 address depletion appears to be a factor, encouragement from UK government is limited.
2. The business cannot formulate a design of how they want to use IPv6 because they do not understand its benefits sufficiently to do so.
3. The lack of management support seems to stem from a lack of understanding, a perception that IT infrastructure is not relevant, with a lack of synergy with business goals and that an IPv6 project has an unclear ROI.

5. Summary Discussion

The research process has allowed a clearer understanding of what would be required to build a successful case for IPv6, merely resolving the technical obstacles within the transition is not enough to gain support for a technology that is viewed by some as a "leap of faith." An IT practitioner must look beyond their just their discipline and seek to fully understand the business implications of IPv6 adoption. And more importantly must assist those within the organisation who provide influence, support, resources and sponsorship to understand it too.

By using the Systems Failures Approach to view the problem not so much as a technical problem but instead something more systemic i.e. as information systems failure, the research has made use of analytical tools to view the problem from a different aspect. This provided results that may help IT

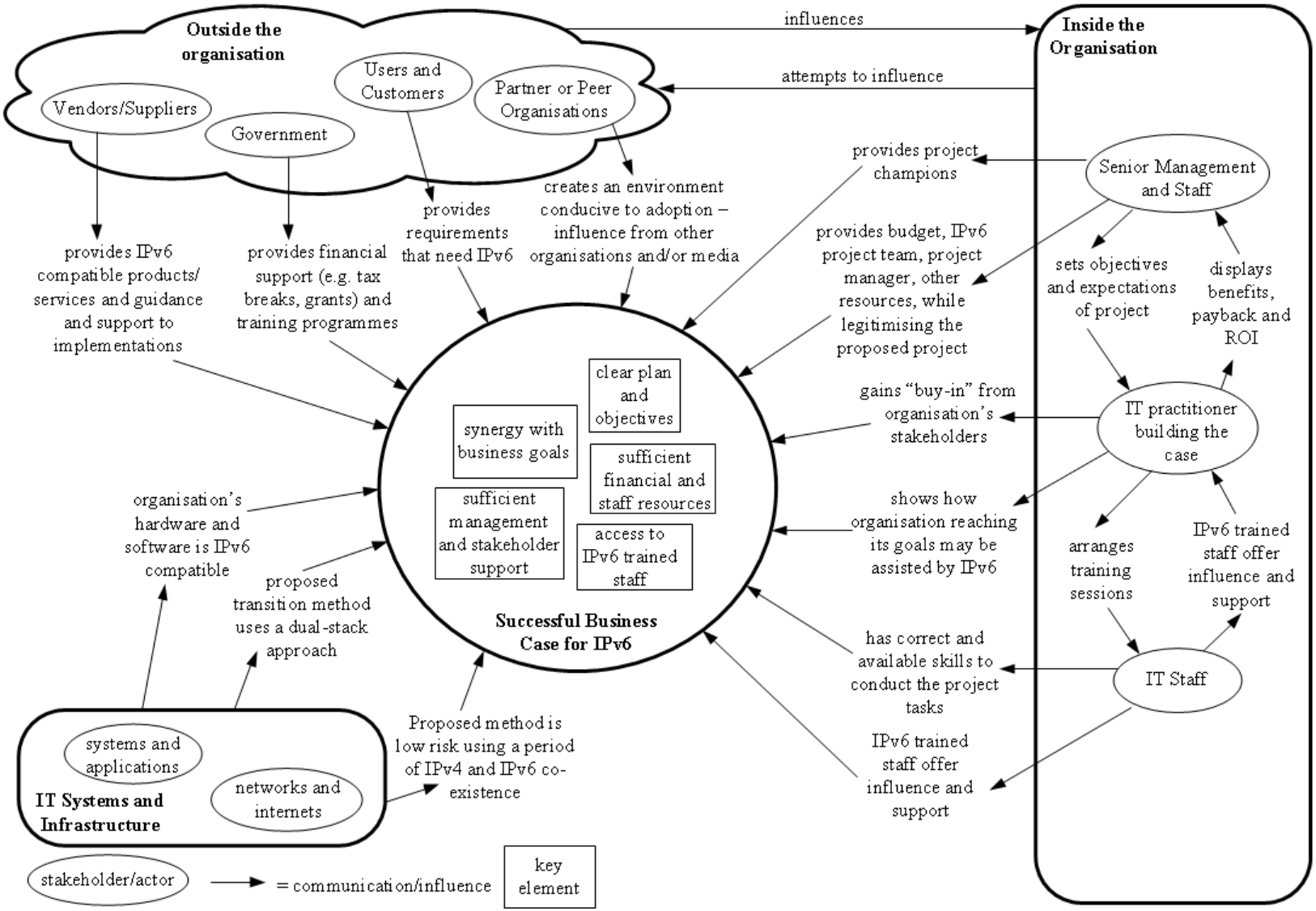
practitioners to develop successful business cases for IPv6 adoption; while showcasing the use of the Systems Failures Approach as a method with which to examine technology adoption problems.

6. Key Outcomes

The research fulfilled its key objectives and aim, by identifying for IT practitioners the key success factors to building a successful business case for IPv6 adoption whilst highlighting the failure factors to be avoided:

1. Support of senior management.
2. Synergy with business goals.
3. Identifying and reducing either the technical, human or relationship barriers to adoption.
4. Successfully using the influences of external stakeholders (such as government or vendors).
5. Proposing a staged approach to adoption (dual-stack) that although conducted over long period reduces risk, upfront costs and disruption.

The research also provided practical recommendations and ideal model IPv6 project system adapted from *(Fortune & Peters, 2005)* and *White's (2003)* FSM shown below that IT practitioners may use to analyse their actions so as to identify areas for action.


Outside the organisation
Vendors/Suppliers
Government
Users and Customers
Partner or Peer Organisations
influences
attempts to influence
Inside the Organisation
provides IPv6 compatible products/ services and guidance and support to implementations
provides financial support (e.g. tax breaks, grants) and training programmes
provides requirements that need IPv6
creates an environment conducive to adoption – influence from other organisations and/or media
provides project champions
provides budget, IPv6 project team, project manager, other resources, while legitimising the proposed project
Senior Management and Staff
sets objectives and expectations of project
displays benefits, payback and ROI
gains "buy-in" from organisation's stakeholders
IT practitioner building the case
shows how organisation reaching its goals may be assisted by IPv6
arranges training sessions
IPv6 trained staff offer influence and support
has correct and available skills to conduct the project tasks
IT Staff
IPv6 trained staff offer influence and support
clear plan and objectives
synergy with business goals
sufficient financial and staff resources
sufficient management and stakeholder support
access to IPv6 trained staff
Successful Business Case for IPv6
organisation's hardware and software is IPv6 compatible
proposed transition method uses a dual-stack approach
Proposed method is low risk using a period of IPv4 and IPv6 co-existence
systems and applications
networks and internets
IT Systems and Infrastructure
stakeholder/actor
= communication/influence
key element

Appendices

Appendix 1 – Semi-Structured Interview Questions

Interviewer:
Interviewee Reference:
Date:
Time:
Place:

Thank you for agreeing to this interview session. This interview makes up part the research component of my dissertation into the use of IPv6 within UK FE Colleges and more widely. The purpose of the interview is to obtain your views and opinions on IPv6 generally and more specifically how it relates to your organisation. Your responses will be anonymised so that you cannot be identified from your responses.

Section A: General

Question A1
What is your role within the organisation? Does your role require you to manage information, information systems or IT?

Question A2
Does your organisation's strategy contain an IT component? And if so, in what key ways do you see IT adding value to your organisation, or assisting you reach your organisational goals?

Question A3
Could you identify the key stakeholders of your organisation (internal and external) who take an interest in the implementation of new technology within the organisation?

Question A4
Please briefly describe the structure of your organisation.

Section B: Drivers for IPv6 Protocol Uptake

Question B1
What do you understand as the benefits and drawbacks are of implementing the IPv6 protocol on your organisation's IT network or internets?

Question B2
How could you see the IPv6 protocol being of benefit to your organisation, now or in the future? How could you see IPv6 protocol being of benefit to your College's staff and/or students?

Question B3
How do you go about making a case for the implementation of a technology (such as IPv6) and how does its Return on Investment (ROI) get considered?

Question B4
What human factors would help drive or facilitate IPv6 protocol uptake within your organisation? How do you think they would do this?

Question B5
What technical factors would help drive or facilitate IPv6 protocol uptake within your organisation?

How do you think they would do this?

Question B6
What relationship/business/organisational factors would help drive or facilitate IPv6 protocol uptake within your organisation? How do you think they would do this?

Section C: Barriers to IPv6 Protocol Uptake

Question C1

Please state your opinion of this statement: *IPv6 is a, or is going to be a useful technology for use within your organisation's IT networks or internets to help support your organisation's business goals.*

Strongly agree
Slightly agree
Neither agree or disagree
Slightly disagree
Strongly disagree

Could you elaborate on your view please?

Question C2
Do you see the lack of the IPv6 protocol implementation being a problem to your organisation, its staff and/or students?

Question C3
Do projects without a clear ROI get funded and supported by senior management within your organisation? Can you elaborate on if/how this occurs?

Question C4
What human factors would impede the IPv6 protocol uptake within your organisation? How do you think they would do this?

Question C5
What technical factors would impede the IPv6 protocol uptake within your organisation? How do you think they would do this?

Question C6
What relationship/business/organisational factors would impede IPv6 protocol uptake within your organisation? How do you think they would do this?

Section D: Government Involvement

Question D1
Have you already received any assistance from the UK government or another external organisation (e.g. a Quango) with any IPv6 planning or implementation, if so what form did it take, and was it useful?

Question D2
What help from government (or associated organisations) would help you to make the case for IPv6 within your organisation more easily?

Question D3
What practical assistance could be provided by government (or associated organisations) in respect to

resolving the technical implementation issues?

Section E: Organisational Attitudes toward IT

Question E1
Is your organisation (generally) and its leadership interested in IT? And how IT may be used to drive business growth, or provide the methods with which to reach the organisation's goals?

Question E2
How do you see IPv6 aiding your organisation in reaching its goals, if at all?

Section F: Technical Issues

Question F1
Does a lack of IPv4 addresses cause you issues at the moment, and please elaborate? If it's not causing you issues, do you think it will in future and what form do you think this will take?

Question F2
Do you use NAT (Network Address Translation) to work around IPv4 address shortages and provide internet connectivity? What issues does this cause you and your users?

Section G: The Place of Information Technology within Your Organisation

Question G1
When you implement or change the organisation's information systems (e.g. a student record system) what methods/activities take place?

Question G2
Does your organisation take an interest in the implementation or change of the organisation's information systems?

Question G3
Does the organisation take an interest in the implementation or change of the organisation's IT infrastructure? Please elaborate.

Appendix 2 – Semi-Structured Interview Results

Interviewee 1, College 1, 13/02/15 @ 9:15
Interviewee 2, College 2, 13/02/15 @ 11:30
Interviewee 3, College 3, 20/02/15 @ 15:00

These notes were collected during the interview sessions based on the questions posed from appendix 1, notes were taken and voice recordings made of the sessions that have been transcribed (and paraphrased or edited) for clarity and brevity.

Table A2-1 –Section A (General)

Question	Answers	
A1	*Interviewee 1: IT Systems Engineer. I manage IT systems, infrastructure and information Systems. This involves the design, configuration and support of these systems including network components, operating systems and hardware.* *Interviewee 2: Business Manager. I manage all of not in a hands on technical way but in a more strategic and tactical sense. So the information, information systems and IT.* *Interviewee 3: Network Manager and technical architect. Managing the network, servers and telephone system.*	
A2	*Interviewee 1: Yes it does. The business model relies on technology to assist education and support the business functions of the organisation. The organisation as a whole is dependent on IT and it is essential to it reaching its organisational goals, even if sometimes this is not fully acknowledged by the management or users.* *Interviewee 2: Yes it does. It adds to the organisation as it is part of the core strategy of the organisation needed to allow us to reach our goals within financial constraints. However it's worth noting that IT as a whole is difficult to explain the value it adds. So a new system like email or an HR system is easier to explain and sell the value of compared to something that is "behind the curtain" so to speak. This would be things like the networking or servers or something like the IPv6 protocol that you are investigating, its intangible and more importantly the business can't see it or use it, it's just seen as magic.* *Interviewee 3: Yes it does. IT is key to the college's strategy and providing and delivering the services and tools to support the teaching and learning of the organisation. However the IT strategy tends to be driven by what we can do, rather than what the business would like us to do.*	
A3	Internally *Interviewee 1: Students, employees (teaching staff and business support staff), managers and then the corporation.*	Externally *Interviewee 1: JISC perhaps (for sharing of best practice), the corporation, customers like local businesses who use our apprenticeships also interest from*

	Interviewee 2: The staff (teaching or support), the students, senior leadership team (SLT), senior management team (SMT), the IT staff, perhaps the student union too. *Interviewee 3: The students, staff (teaching and support), SLT, management, the IT staff. We do get a lot of drivers from students for what they'd like to see.*	*government in the form of Ofsted or LEA (Local Education Authority) and Council perhaps. Also the parents or guardians of students or potential students might also be interested in what we are doing.* *Interviewee 2: The corporation (governors), potential students, perhaps customers of the college such as those companies that use our services for training of their staff or for apprenticeships might be interested in us providing up to date technology.* *Interviewee 3: The potential students, the organisations that we have partnerships with, the corporation governing the college. Some local businesses perhaps.*
A4	*Interviewee 1: The corporation is a body made up of internal and external stakeholders that assist in the strategic direction of the organisation. Followed by the SLT (Senior Leadership Team) who deal with strategy and the tactical aspects of the organisation, and finally the SMT (Senior Management Team) who deal with the operational aspects of the business. Under which this there are the various departments and faculties of the College within which you find teaching staff, administration and business support services like HR, Finance, IT, Estates, Facilities and so on. Basically a hierarchical structure of Corporation, SLT, SMT and Heads of Department.* *Interviewee 2: We have three main levels to the organisation. At the top is the corporation (governors) with the SLT, this is where the principal sits as do the other directors. Then at the next level down the SMT who are the Heads of Department of each of the various support services (like HR, Finance, IT etc.) and the teaching areas of Business, ICT, Sports, Sciences, Arts etc. Then within each of the departments the staff that make up these areas, I guess you'd need to include the students in there too.* *Interviewee 3: There's the principal and some vice principals. They then have various heads of departments and directors they manage, who in turn have the staff below them. Essentially its split into the curriculum and business support sides of the business, the curriculum side is much larger than the business support sides of the business.*	

Table A2-2 – Section B (Drivers for IPv6 Protocol Uptake)

Question	Answers	
B1	**Benefits** *Interviewee 1: The benefits of IPv6 would be "future proofing" the network and systems as I'd say it's inevitable that IPv6 will be needed eventually. Perhaps simpler network and system configuration i.e. we'd be able to get rid of DHCP (Dynamic Host Configuration Protocol) and NAT. But beyond that I'd struggle for any further benefits for this organisation.*	**Drawbacks** *Interviewee 1: The drawbacks would be the effort, resources and money to get it installed, we are lacking in money and staff time to get a big project like IPv6 installed on top of our current work. I'd say that we'd need to bring all the IT staff up to speed on IPv6 with training which could be time consuming and expensive so they can actually support it all. Also because we wouldn't be able to switch over to IPv6 altogether, we'd need to run it dual-stack this would just increase the support overheads of maintaining two networks (IPv4 and IPv6) rather than just one (IPv4 or IPv6) for the foreseeable future.*

	Interviewee 2: More addresses, so that all devices could have their own globally routable address, however I'm not sure how this would be of benefit at the moment. Internet of Things so new services based upon that, but again we've not had any demand for this at the moment. *Interviewee 3: For our organisation now, I can't think of any real reasons. IPv4 isn't stopping us from doing anything at the moment.*	*Interviewee 2: A fundamental change such as IPv6 to the networking could have unseen consequences this is concerning as the SLT is worried about loss of IT services if something was to go wrong.* *Interviewee 3: Older hardware we still have isn't compatible and would need a load of upgrading to make this work. I guess the other drawbacks are complexity of it, we'd need training and we'd need to spend more time supporting things. IPv6 isn't backward compatible, so we'd need to run it side by side with our IPv4 network.*
B2	*Interviewee 1: No real benefits I can see straight away for the staff and students, but in the future potentially yes. It really depends on the uptake in the world at large, I doubt we would be trailblazing, and wouldn't use IPv6 unless we had to. I think the killer application is missing, if the only real benefits are more addresses and no speed or reliability performance increase then there are little benefits now. Perhaps if we had demand from teaching staff of IT courses to implement it we may be able to build a case, or if an (web) application required it then we would be compelled.* *Interviewee 2: I can't see any real benefits to the organisation at the moment it's all in the future. But in the future I suppose that IPv6 could give direct access to systems if we needed it because everything could have a unique address, and this might mean we can use new systems and applications but beyond that I'm struggling to see a benefit.* *Interviewee 3: No benefits at the moment. The only place I see it being useful for our organisation is on our edge facing services like DNS (Domain Name System) or web servers at the edge of the network. Using IPv6 within the network seems a bit of a waste of time for us. Plus most home ISPs don't support IPv6 so anyone connecting in would be unlikely to be able to use it from home to access our services.*	
B3	*Interviewee 1: We need to build a business case that we put through a bidding process for available CapEx (Capital Expenditure), normally the ROI is considered as part of this, will the expenditure ensure funding or provide resources for students/staff to use? These types of thing are fairly easy "sells" from our point of view. So something like IPv6 would need a clear ROI or a benefit to be successful, they do sometimes put through projects which have some prestige value without a ROI but these are rare and therefore need more compelling reasons! I see it as pure future proofing which would be a difficult sell to management. We might be able to get it installed as part of a separate project, so for example replacing our network equipment we turn it on, on the new switches or routers we are installing.* *Interviewee 2: The process for putting forward a case for a new system or technology requires a business case to be put together detailing what you want to do, why you want to do it and what benefits the organisation would get (e.g. cost saving, better performance, new more efficient ways of working.) This is then reviewed by the SLT and if they can see that it is of benefit and the financials and the ROI stack up then it can go ahead, that being said things can sometimes be approved even if there is no payback as long as it's imperative can be explained clearly.* *Interviewee 3: The business case needs to be strong reasons to get funding and support from management. ROI would be considered by the factor, if the proposed project is worthwhile then it would get support from management.*	

B4	*Interviewee 1: Within IT, training and presentations to drive enthusiasm. Outside of IT an explanation of the benefits of IPv6 and show how this might practically benefit the organisation, so building of interest and understanding would be helpful; the winning of hearts and minds. Helping with training of IT staff would assist building of interest and the skills needed to start an IPv6 implementation project. This includes management support of the project both in terms of providing the resources to allow it to happen and also supporting its implementation within the organisation.* *Interviewee 2: I think that training for IT staff would overcome some of the barriers, coupled this with reassurance to stakeholders that this is the right way forward would also too. Basically opinion and winning "hearts and minds" will be key to getting the support so being able to sell IPv6 to staff and management would allow it to go ahead, although I'm not fully sure of how the benefits of IPv6 would help the organisation at the moment.* *Interviewee 3: The users don't really want to know, they just want it to work, so I can't see anyone wanting IPv6, and we've not had anyone ask for it at the moment.*
B5	*Interviewee 1: A killer application, something that only worked on IPv6 meaning that we'd need to implement IPv6 would be a key factor to get it installed within the organisation. A new building built on campus that needed equipping with new networking equipment, so this could be a catalyst to installing IPv6 within the organisation. Having equipment and operating systems that support IPv6 would be another key factor, also if enabling IPv6 is a simple process then this would be more encouraging. Being able to do the implementation in stages would be good too, e.g. just on the switches or routers first, then work our way through from there. Another argument might come from an external audit, if we were compelled by government policy, or if we had an audit conducted by an external party, this might add weight to any argument we could make for IPv6 adoption.* *Interviewee 2: The technical factors to drive adoption might be overcoming the problems with some types of connectivity i.e. things connecting through NAT, but at the moment we don't really get any issues with this at the moment. Things like Skype work fine on IPv4 through the NAT firewall. I suppose the auto-configuration of IPv6 would mean we wouldn't need to manage DHCP that would help, but if we need to have dual-stack IPv4 and IPv6 for some time we couldn't get rid of it straight away.* *Interviewee 3: If we had a big new deployment of network equipment across the network then we could wrap the IPv6 implementation into that. Also if there are new features that people were demanding then this would drive uptake needs. The withdrawal of IPv4 support in software or applications would be a big driver but I can't see this happening for decades. Perhaps if there were loads of security concerns on IPv4, this might be a driver. Or if we needed to get rid of NAT or proxying on our network, but at the moment, we can still use applications with this without IPv6.*
B6	*Interviewee 1: Having management awareness at SMT or SLT level, typically if there is enthusiasm at this level this would translate to support to help it get done. A key business driver would be the cost, if the costs were very high and therefore required that we had to make a business case and bid for CapEx money then this would be difficult. However if it could be started (at least) within "spare" existing budgets then this might translate to making it easier. Support from external parties like JISC (or other government entities) with support, training or pre-prepared designs that would all help. Also more coercive means that mean we are compelled to such as government policy dictating we must use it, or an IT apprenticeship course where they want to teach the cutting edge tools/systems that the IT students would find in their future careers.* *Interviewee 2: For something like IPv6 that doesn't directly affect the staff and students using the systems then really I'd expect any drive from relationship or organisational factors to come from the outside. So if government or the sector was promoting it and/or offering support this would be a good drive to being able to get people on-board. Another key point might be that senior managers going to seminars etc. if they see IPv6 being promoted there, that might spark an interest in getting*

	support at that high level. *Interviewee 3: Can't really think of much at the moment exactly. However it's likely that external factors would be what drives it like, withdrawal of support and/or more people in the outside world using it or adding content to it.*

Table A2-3 – Section C (Barriers to IPv6 Protocol Uptake)

Question	Answers
C1	*Interviewee 1: Slightly Agree – Without a driving factor(s) internally it would be difficult to drive uptake. If however the benefits could be made more clearly in the outside world, then the selling process internally might be made more easily. The thing is with IPv6 the selling of it is weak because it's not a product per se. So for example when we implemented virtualisation or new storage area network storage there we clear benefits that were easy to sell to the management to gain support. With IPv6 there isn't anybody championing it in the same way as it's not a product.* *Interviewee 2: On a personal level I'd say I slightly agree, at an organisational level I'd say they'd neither agree or disagree about using it. So as I work in IT and have an interest in it for me it's appealing. But from an organisational point of view I can't see that it is that very interesting, if a vendor from the outside would sell it to management then that might increase awareness and interest.* *Interviewee 3: As an organisation I'd say it's neither agree or disagree. I think personally it would be the same, it has a place in the perimeter but internally I can't see a real business reason, working in IT, if I can't see it how could a business person or manager or user have any interest!?*
C2	*Interviewee 1: At the moment I can't see it as a problem that is immediately pressing. So us not implementing IPv6 in the next few years won't cause major business problems like not getting new storage or new servers would. This is one of the problems it's almost a "leap of faith" into something that is solving a problem we don't currently have with no payback in the short term.* *Interviewee 2: I suppose the biggest concerns would be around the stability of the network before, during and after the implementation of IPv6, would stuff not work properly, or take longer to fix because of it. That would be problematic for users. The other thing I can see is that management of the network might become more difficult because we'd be supporting an IPv4 and IPv6 network so any network changes would need twice the work I doubt this would go down well; because I can't see us switching straight to native IPv6 or lots of applications or web sites we use won't work, because they don't offer an IPv6 version of it.* *Interviewee 3: No, if it was going to be a problem you probably wouldn't implement it. That being said there's bound to be some problems with the installation and support you would just need to minimise these.*
C3	*Interviewee 1: Sometimes yes if a strong technical case is made, with enough push from technical people, then yes it is possible. We haven't ever been able to do it though where clear benefits didn't exist which the IT people making it didn't fully get why we should be doing it. Also a key point is the cost, if the cost is small to set it up, then the lack of a clear benefit or ROI would be less of an issue, however if we were talking replacements of loads of equipment or large amount of staff time, then the lack of clear benefits or ROI would make it impossible.* *Interviewee 2: Yes they do surprisingly, if it fits into the vision that the principal or SLT have for the college, then sometimes projects without a clear ROI can be put*

	through. Although my personal opinion is that I'd be surprised to find an organisation that didn't invest in technology without a clear ROI at some point. *Interviewee 3: Yes sometimes they do. If there is a need for something that the management has identified, but the ROI is not as clear as it might be then, if they have a plan or vision for something it can get funding. Something like IPv6 would be very hard to justify, or justify a ROI. But something that would save the College money for example would be much easier to sell to management. To come back to your point, yes they do, but typically they are not IT infrastructure projects, more commonly IT system projects like a new HR system or Finance system, which might be attached with business change as well as a catalyst; so a clear ROI may not be defined.*
C4	*Interviewee 1: Lack of knowledge or training in IPv6 would be a key factor impeding adoption. Misunderstanding of what it is and its impact, leading to fear of the unknown or fear of change, this more specific to the IT staff than the users, who likely wouldn't notice anything. This is an interesting point if users won't see a difference in what they can/can't do, then getting support and funding would be difficult to achieve. Also there is significant concern about system unavailability, there is a worry that this new technology might be more unreliable and cause compatibility problems, this is especially true when we start discussing with a system owner, they may not be happy for IPv6 to be enabled on their information system (or servers) as they might consider it too risky.* *Interviewee 2: Paranoia or privacy concerns would be a big one, if people think that they'd become less anonymous. I suppose the other one is to being unable to sell the benefits to management with clear ROI and reasons why we need IPv6, at the moment I can't think of any good reasons beyond getting more addresses and assigning them to each device. The lack of IPv6 skill would be another big factor, without training some staff might go out and find out for themselves but others wouldn't and would need some training, so in all a lack of skills and experience in design and support of an IPv6 network would be a key one.* *Interviewee 3: I think just the lack of knowledge and interest from the IT staff for a start. Without training implementation would be more difficult and then the long term support more difficult, so these together would work against the uptake of IPv6 in our case.*
C5	*Interviewee 1: Key problems here would be bugs, incompatibilities or support problems on legacy equipment. If the equipment is working but doesn't support IPv6 then getting it replaced would be difficult. Our ISP has supported IPv6 for years, but at home I can't use it my ISP doesn't support it nor has plans to implement it. The increased complexity might make diagnosis of issues longer which would make it more difficult to meet our SLAs (Service Level Agreements.)* *Interviewee 2: Software/hardware compatibility, for the most part I think this is trivial but we might come across something legacy that is very expensive to change or remove that could hold stuff up. I think the other thing is unforeseen consequences so unseen dependences, we had lots of these for the student information system implementation we did recently, there's were things people were doing with the system and data that we didn't know about I guess that could be even worse with the network and we could inadvertently cause problems to users because of this.* *Interviewee 3: The main technical factors would be hardware/software compatibility, old equipment just not supporting it. Then in some cases what benefits would arise from installing it on a printer say, very little point really, it may cause more issues trying to upgrade firmware and software than the benefits we get. So risks outweigh the benefits.*
C6	*Interviewee 1: Paranoia or misinformation, so if there are scare stories in the press, this can be very pervasive, we've had it in the past with viruses, if something similar about IPv6 came out about its privacy, then this would make management support trickier. There's the inertia of the organisation I suppose to change, people can normally be brought along if benefits can be shown, but if these are hazy or things might get worse while we deploy it then people can become apprehensive especially in the past when we've lost data or services for some time after botched setups or upgrades.*

	Interviewee 2: I think a lack of a clear ROI and lack of clear business benefits would be some of the biggest factors that would make it difficult. *Interviewee 3: A difficult one to answer as really the main barriers within the organisation are the lack of clear benefits and reasons for us to solve a problem that IPv4 is creating and IPv6 will fix at the moment there isn't one.*

Table A2-4 – Section D (Government Involvement)

Question	Answers
D1	*Interviewee 1: Yes our ISP JISC/JANET have provided us with technical information in the form of training documents and some basic assistance when we've had a look at IPv6 from an investigative point of view. If we did go for an installation, as much external help for as cheap as possible would be really handy to us.* *We've not had any help or funding from UK government or any incentives that we are aware of to encourage us to set it up.* *Interviewee 2: We've had a bit of information about IPv6 from JISC, but beyond that nothing else.* *Interviewee 3: No. I haven't asked for any direct assistance, nor have I asked for any. However we know that JANET/JISC are likely to be able to provide us with some help if required or at least point us in the right direction.*
D2	*Interviewee 1: Financial incentives such as a grant from a pot of money in government would be useful to get it going; perhaps then momentum could build from there? Any advice, so like a canned implementation approach would be useful, I know that might be difficult because everyone's networks and systems are different and differently configured even if you use the same manufacturer for your networking equipment. There's so many different things that are affected by it, its difficult to know where to start. All of these would help us make the case, by reducing the problems or lack of knowledge about an installation.* *Interviewee 2: I think if we got technical help, i.e. some free consultancy that would be helpful in reducing the costs and therefore getting the management support; so if the government could provide that somehow, perhaps through existing avenues like JISC then that would be good. Perhaps a fund for Schools, Colleges or Universities to claim a grant for partial funding again would be handy, we implemented our first Wi-Fi system using money from a development fund offered to the college by the government.* *Interviewee 3: If we got assistance with the setup of a pilot I think that would help us understand the technical issues better and begin to work out a implementation strategy, however it doesn't help with us with actually determining and promoting why we need to implement IPv6 on our College IT network.*
D3	*Interviewee 1: The practical help would need to be as I said before the same as what would make the case more easily, so for example getting a pot of money or so many days of free service or consultancy to help us on a design and help to build knowledge within the team.* *Interviewee 2: Free training for IT staff would be one, subsidised or free consultancy to assist in planning an implementation, I think once the hurdles of the design our out the way, the IT staff themselves with training would be confident to do the rest knowing it's a "painting by numbers" type deployment and all the hard risky work has been done up front. So a canned route to adoption would be helpful, not really sure if that would be possible though as everyone's network is different.*

	Interviewee 3: Free training courses to help our IT staff to get up to speed would be the most useful, even if not free subsidised would help us get people on to it. If there was government policy or educational policy to do this, then the organisation would be compelled, and then if coupled with assistance/training etc. we would be able to do move forward with it. That being said the on-going support would be my primary concern with if we got the implementation taken care of, if we are having to support a dual-stack arrangement for a long period of time.

Table A2-5 – Section E (Organisational Attitudes toward IT)

Question	Answers
E1	*Interviewee 1: Typically the organisation is interested in the opinions of staff and students more than the quality of the IT itself. This is a difficult one to explain, essentially it doesn't matter how good we actually make something it's what people think of it that counts. This is especially true if you have something that is working fine e.g. the IPv4 network and Internet connection, and you want to change it people might be concerned it would get worse. It's the "if it ain't broke don't fix it" type situation.* *Interviewee 2: Yes it is interested and as are managers even if they don't fully understand the implications. This I think is where IPv6 struggles a bit, if you're an IT person (like I am) and you're struggling to see a reason at the moment for the organisation to use it, then this won't translate well to enthusiasm at a management level to support it which is really key to its success.* *Interviewee 3: The leadership of the organisation and the organisation as a whole are generally interested in IT and would it can be done to provide new information, support teaching and learning and improve efficiency. However that's normally were the interest ends, the technical aspects and implications are not of their concern, as long as it work! There is a drive and interest for technology if it can help us do new things, for example allowing home working.*
E2	*Interviewee 1: It's a difficult one to gauge, at the moment IPv6 I could not map IPv6 directly to assisting any of the organisations goals. However in future I could see that it could well be important in future, if only because it becomes used elsewhere around the world and we need to use it just because of necessity. I could see that having IPv6 would open up the possibilities for individualised learning that the organisation wants to pursue coupled with more online learning perhaps this gives some promise.* *Interviewee 2: I don't have a clear vision for its use in the organisation at the moment. I'm more interested than most would be as its within my discipline but I can't put my finger on anything at the moment. Saying that however; it will happen at some point anyway so we'd just need to sit and wait for the benefits to show up so we can put forward a decent case for it, or of course we might get some member of IT staff who takes it upon themselves to have a go and learn and implement for themselves in a staff development type way or a personal interest thing. But overall no I can't see it helping the organisation reach its goals now, but maybe in the future.* *Interviewee 3: I can't see it helping the organisation in doing much at the moment, but that could change in future but I doubt it will be driven from the inside, it will likely be external factors and force us into taking action.*

Table A2-6 – Section F (Technical Issues)

Question	Answers
F1	*Interviewee 1: The lack of IPv4 addresses at the moment isn't really causing us an issue at the moment, we have some left. In future I see it could well provide some technical issues, either because we run out of IPv4 addresses on the firewall and get assigned anymore but need to provide new services. Or otherwise the problems that IPv4 services might be withdrawn, or services starting up that the organisation wants to use that are on IPv6 only.* *Interviewee 2: Not at the moment no, we have enough external IPv4 addresses at the moment. I suppose in the future this might become a problem if we use our (IPv4) range up and can't get any more assigned to us, at that point we would have a problem that would add pressure to adopt IPv6, but if everyone else hasn't it could cause more problems for example if we made a new system available on IPv6, but staff and students didn't have IPv6 at home because their ISP didn't support it we've not solved the problem!* *Interviewee 3: At the moment, it's not really causing us any issues. In future I guess I could see it causing problems if new services need to use IPv6, some sort of new application that must have IPv6 to work, but this seems a bit unlikely at the moment.*
F2	*Interviewee 1: Yes we use NAT for all our internal clients to access the Internet, we find this creates very little problem with the bulk of what we use, sometimes when a machine has a virus and our ISP is reporting this problem traffic the fact all our traffic is hidden behind one address can make it really tricky to find and fix the source. I could see in future though that if we run out ofIPv4 addresses, we wouldn't be able to setup a web server on port 80 and then the workarounds would affect users, I guess at this point because there is a pressing issue then this would make the case for IPv6 easier.* *Interviewee 2: We do use NAT at the moment so as to provide Internet access to about 2,500 PCs and then all the various tablets, or mobile devices people are using on our wired and wireless networks, this isn't causing us any issues at the moment that we are aware of.* *Interviewee 3: Yes we make use of NAT to allow all our devices to connect out to the Internet. It used to cause us issues with some applications in the past, but now all the applications we use are developed to work around NAT and so operate fine. I guess that there are overheads, performance implications and scalability issues but this has not been a problem at the moment for us.*

Table A2-7 – Section G (The Place of Information Technology Within Your Organisation)

Question	Answers
G1	*Interviewee 1: The organisation takes a keen interest if there is a new business system that will directly affect users; sometimes this comes out of a change to the business that a new system is needed to support new working processes. So for these types of information system as you call them there is wide staff involvement at many levels of the organisation, in some cases people's jobs were affected or changed so they took a keen interest because of that. The process typically involves a scan of the market for suitable products, then making a business case and budget raising, with consultation typically cross college. For example we had a new student record system a few years ago, nearly every department in the college was affected or needed to be involved in some way it was very broad.* *Interviewee 2: There's the realisation typically from the management or users of a system that there is a need for something better. Sometimes an information system just isn't working for the organisation or its users or the new system might be part of a change to the organisation like a restructure to try to do things better. Normally once the realisation has been made then there is a scanning of the available products to find something that might do the job, once we think we have something we might try it as a demo or see it in action at another College and ask them what they think of it. From that a business case is made, the costs and benefits are put forward and then some goals are set of what we want to achieve with the new system. Assuming its successful it all flows from there, when we changed student record system although we could have purchased a cheaper system from other suppliers we went for a more expensive option because the supplier was able to sell the benefits better than the other suppliers and actually help us build the case for their product to help us sell it to management.* *Interviewee 3: The process for an information system like say the student record system is normally driven by the system owner, in this case the MIS (management information systems) team who identify a need, normally then they will look out at potential systems in the market place to fulfil that need. Once that is done, they would write a business case to put that forward to the SLT to gain funding, if it is approved, then the specification is written and a tender is made to a framework, this is then shortlisted with the supplier showing they can meet our requirements. There's normally a bit of checking of the requirements against reference sites. At the end of that process we purchase and then install the system.*
G2	*Interviewee 1: Yes very much so. An information system, i.e. something that staff and/or students actively use is of great interest and changes can be seen to be moving the organisation forward, money, resources and support therefore is given more easily in this case. I guess this is because the organisation itself wants change a new system can be a catalyst for other changes like staffing changes, more than just a purely technical one.* *Interviewee 2: Yes the organisation takes great interest in new information systems. There's project boards and steering groups setup to collect requirements from the various stakeholders, it is seen as very important to the organisation. Often this is because the new system is an extension or seen as a practical method with which to realise the vision or direction of the organisation in reaching its goals and as I've said before is often accompanied by change and so the two are tied together. This isn't the case for IT infrastructure changes, the link with the business imperative is non-existent.* *Interviewee 3: The organisation does take interest in new information systems. Normally it's the department that uses it that is the most interested and the trigger for adoption of a new system or an upgrade. However they don't understand that sometimes things need to change for technical reasons, they are very "on the ball" for any functionality or fixes that affect their work as a business imperative, but aren't interested when it is a technical imperative say something to do with the infrastructure that requires a change to their systems to be made.*

G3	*Interviewee 1: No we find the organisation isn't really interested in IT infrastructure at all. Typically as long as it works there is no interest in investment in something new unless it is absolutely necessary, especially if the end user won't see any benefit like a speed increase or more storage space. We have been successful in getting support for a few IT infrastructure projects when we've been able to show clear cost savings, provide greater reliability or provide something that allows people to do something completely new. At the moment IPv6 doesn't provide this for us so we struggle to find a reason for it, this means we don't get the "buzz" that we get when a new information system is proposed that affects the end user experience more. It's like when the new student record system was installed it supported the vision for the organisation, this seemingly isn't the case with IT infrastructure, it's like people can't relate to something that they can't see or don't directly interact with its just too intangible for them to understand.* *Interviewee 2: No the organisation isn't typically interested, it's just the plumbing as far as they're concerned, as long as it works people aren't interested. This is a bit of a contradiction, even though people aren't interested the networks (or hidden bits) of the IT infrastructure is probably the most important thing and it interacts more with the organisation than they are aware of! To an end user or management there typically isn't any distinction between an information system and the infrastructure on which supports it, it's all seen as IT and magic to a certain extent! I'd say that normally a new system would be easier for us to sell, people can see it or imagine it and therefore better understand how it might serve them or improve their work, with something that's infrastructure like a server or network this is more difficult but people can begin to understand it if we can use analogies like buying a new car. For a network protocol like IPv6 for example, something that is quite abstract and removed from reality, just selling it as "something" is near impossible, it would need real benefits that people could relate to or see, like a speed increase or new functionality, if that isn't able to be provided then just doing something because "we probably need to at some point" isn't likely going to be enough.* *Interviewee 3: No not really, they are typically only interested if something isn't working. Essentially all the rest outside of whichever information system they are using for their work is essentially seen as magic to the users. So they really aren't interested in the infrastructure as long as it works. So something like IPv6 is pretty much impossible to explain as it doesn't really have any application that we can see it on, because of that management aren't going to want to fund something just because we could do it, really the payback needs to be far more obvious and beneficial for an IT infrastructure project than say for a new system because it's so intangible, they can't picture it or how it will help them.*

Appendix 3 – Table of Emic Codes

The analysis of the interview transcripts provided the "emic" codes (table A3-1), there were words, or phrases that the interviewees had introduced themselves during the interviews. These were tagged by the research by reading each interviewees' transcript using the "open coding" method to iteratively to build up the terms identified *Strauss (1987, p. 32)*. This "emic" thematic coding contrasted with that of the literature review (tables 2-1 to 2-6), where the "etic" codes were that of outsider's views like scientific observers or within descriptions, accounts expressed as concepts *Lett (1990)*.

Once the etic codes were identified, they were reviewed to find common terms and themes *Crang's (1997)* in *(Flowerdew and Martin (eds.), 2005)*. It is worth noting that these findings were not absolute, but the perception of what the researcher developed through a comparison and interpretation of the etic codes.

Padgett (2008) suggests the triangulation of this data to corroborate the findings, appendix 4 table A4-1 shows the results of when etic codes (identified from the literature review) were applied to the emic codes identified from the interviews to produce key themes, words and phrases common to both the etic and emic datasets. These were not necessarily exact matches, but are synonyms or terms the researcher has decided are similar and that would assist in in the development of the Delphi method questions and provide additional context to the later analysis.

A general thematic analysis of the interviewees appeared to indicate "senior management" support, and support from the organisation would be key to building a successful case for IPv6.

Both IT practitioners and IT/business managers are finding it difficult to align the benefits of IPv6 with business goals to show how it can be tangibly used and of benefit to the organisation. IPv6 being widely used is inevitable, but the interviewees said they (i.e. UK FE Colleges) are unlikely to be trailblazing, instead waiting to be compelled by forces; either internal, external or both to support a case or begin adoption of IPv6.

The interviewees also seemed to identify that their organisation is typically uninterested in IT infrastructure (which would include IPv6) this coupled with the intangibility and abstract nature makes it more difficult to "sell" to the organisation when compared to a new student record system or finance system that users can imagine themselves using and would interact directly with the features of.

Table A3-1 – Semi-Structured Interview Response "Emic" Codes

Section	Interviewee	Emic Codes
A (General)	1	business functions; dependent; organisation goals; strategic direction; hierarchical; best practice; business model; systems; infrastructure; information systems; network components; best practice; sharing; customers; strategic direction; tactical; operational
	2	behind the curtain; intangible, magic; difficult to explain value; information systems; customers; technology
	3	drivers; architect; network; servers; partnerships; governing
B (Drivers for IPv6 Protocol Uptake)	1	future proofing; inevitable; simpler; DHCP (Dynamic Host Configuration Protocol); NAT; struggle; effort; resources; money; lacking; dual-stack; support overheads; future; trailblazing; killer application (is missing); compelled; bidding process; CapEx (Capital Expenditure); funding; fairly easy "sells"; projects; prestige value; compelling reasons; presentations; drive enthusiasm; practically benefit (the organisation); interest; understanding; winning of hearts and minds; catalyst; external audit; compelled; government policy; external party; add weight to any argument; awareness; spare existing budgets; cutting edge;
	2	more addresses; Internet of Things; not had any demand; fundamental change; unseen consequences; unique address; struggling; cost saving; better performance; efficient; no payback; imperative; reassurance; stakeholders; winning hearts and minds; support; NAT; Skype; auto-configuration; dual-stack; from the outside; on-board; senior managers; promoting; spark an interest
	3	IPv4 isn't stopping us; older hardware; compatible; upgrading; complexity; training; supporting; backward compatible; edge facing; waste of time; funding; support from management; withdrawal of IPv4 support; decades; security concerns; proxying; applications
C (Barriers to IPv6 Protocol Uptake)	1	selling process; weak; championing; virtualization; storage area network; business problems; leap of faith; no payback in short term; strong technical case; clear benefits; impossible; lack of knowledge; misunderstanding; fear of the unknown; fear of change; unreliable; compatibility problems; system owner; bugs; incompatibilities; legacy equipment; ISP support; SLAs (Service Level Agreements); increased complexity; paranoia; misinformation; inertia (of the organisation); hazy; apprehensive
	2	appealing; vendor; sell; awareness; interest; stability; native IPv6; vision; invest; paranoia or privacy concerns; anonymous; sell the benefits; lack of skills; software/hardware compatibility; legacy; unforeseen consequences; unseen dependences; inadvertently cause problems;
	3	perimeter; real business reason; problems; minimize; plan; vision; justify; catalyst; lack of knowledge and interest; hardware/software compatibility; old equipment; lack of clear benefits; reasons; solve a problem
D	1	ISP; JISC/JANET; technical; training; external help; funding; UK government; incentives; financial incentives; grant; pot of money;

(Government Involvement)		momentum; canned implementation approach; manufacturer; practical help
	2	JISC; technical help; consultancy; management support; development fund; grant; partial funding; subsidised; free consultancy; hurdles; painting by numbers; canned route;
	3	JANET/JISC; direct assistance; pilot; understand; technical issues; implementation strategy; determining; promoting; compelled; dual-stack; primary concern; on-going support
E (Organisational Attitudes toward IT)	1	if it ain't broke don't fix it; opinions; quality of the IT; necessity; open up the possibilities; necessity
	2	don't fully understand; implications; struggles; translate; enthusiasm; management level support; key; success; don't have a clear vision; my discipline; staff development;
	3	leadership; generally interested in IT; technical aspects; not of their concern; drive;. interest; new things;
F (Technical Issues)	1	IPv4 addresses; technical issues; IPv4 services might be withdrawn; IPv6 only; NAT; internal clients; workarounds
	2	IPv4 range; NAT; internet access; tablets; mobile devices;
	3	Issues; new services; new application; work around NAT; overheads, performance implications; scalability issues
G (The place of Information Technology within your Organisation)	1	keen interest; business system that will directly affect users; new working processes; staff involvement; suitable products; consultation; actively use; great interest; moving the organisation forward; money; resources; support; catalyst; organisation isn't really interested; clear cost savings; provide greater reliability; allow people to do something new; struggle; buzz; vision; intangible
	2	realisation; something better; scanning of the available products; project boards; steering groups; collect requirements; stakeholders; extension; practical method; vision; direction; link with the business imperative is non-existent; contradiction; hidden bits; magic; abstract; removed from reality; we probably need to at some point;
	3	system owner; identify a need; potential systems; gain funding; specification; tender; shortlisted; meet our requirements; trigger; adoption of a new system; technical reasons; on the ball; functionality; fixes; business imperative; technical imperative; only interested if something isn't working; magic; impossible to explain; payback; obvious; beneficial; intangible; can't picture it

Appendix 4 – Key Themes, Words and Phrases from Interviews

Table A4-1 – Table of common emic and etic codes within key themes, words and phrases

Key Themes	Words and Phrases	
• senior management support is necessary. • not seen as relevant to the current business goals. • IPv6 hidden from the end-user, lack of interest. • stakeholder involvement seems to be key. • someone needs to be championing IPv6 within the organisation. • government support is useful in encouraging IPv6 usage. • new functionality and services IPv6 allows may assist the case for IPv6 within an organisation.	• inevitable (inevitability) • (management) support • vendors • suppliers • inertia • vendors • NAT • stakeholder(s) • championing • government support • magic • compatibility • hidden • incentives	• killer application • dual-stack • behind the curtain • prevalence of NAT • steering groups • financial support

Appendix 5 – Delphi Method Questions

Table A5-1 - Delphi Method Questions - Round 1

Question	Response Options	Research Theme
1. In your opinion, what are the 3 most important factors encouraging adoption of IPv6?	e.g. inevitability, IPv4 address depletion, lack of scalability (of IPv4), government policy or assistance, vendor support (i.e. hardware/software support), access to IPv6 trained staff, offers competitive advantage, IPv6 standard and product maturity, mobile IPv6, negating the need for NAT (Network Address Translation), auto-configuration (i.e. simpler network management), external pressures from suppliers, customers or partners, new functionality e.g. VoIP (Voice over IP) or IoT (Internet of Things)…… *[Please add other factors not listed if needed, where 3 have not been selected from the list above]*	2
2. In your opinion, what are the 3 most important factors discouraging adoption of IPv6?	e.g. lack of interoperability with IPv4, an organisation's inertia, lack of clear ROI (return on investment), high transition cost, IPv6 skill shortages, prevalence of NAT, no business need (i.e. not relevant to business goals), lack of ISP (Internet Service Provider) support, sufficient IPv4 addresses available, institutional factors, immature standard, lack of vendor support, software development time/costs to adapt to IPv6, potential disruption to IPv4 services, lack of short term benefits (i.e. no urgent need or advantage to early adoption), no commercial incentive, no body acting as a champion, no killer application…….. *[Please add other factors not listed if needed, where 3 have not been selected from the list above]*	2
3. What would be your most favourable approach to the transition to IPv6 for your organisation that would allow a successful case for IPv6 adoption to be built? To assist, a short explanation of each approach is given below: • **Dual-Stack** – IPv6 is implemented alongside IPv4 on all network equipment, servers, clients and network devices, and a period of co-existence continues until there is no longer a need for IPv4. • **Translation (i.e. NAT)** – IPv6 addresses are translated (at some form of gateway) to corresponding IPv4 addresses allow an IPv6 host to communicate with an IPv4 host and vice versa. • **Tunnelling** - IPv4 nodes can communicate to IPv6 nodes and networks across an IPv4 only network by the use of a tunnels and a tunnel broker. • **IPv6 over WAN Links** – Dedicated IPv6 WAN links are deployed alongside IPv4 WAN links between the organisation's networks to facilitate communication between networks, which also need to run IPv6 and IPv4 simultaneously.	e.g. Dual-Stack, Translation (i.e. NAT), Tunnelling, IPv6 over WAN Links or Don't Know *[Please add any comments you feel are relevant, if you answered "Don't Know" please elaborate:]*	2

4. What are the 3 most important actions that the UK government could take to encourage/support IPv6 adoption within your organisation, and therefore you building a successful case for adoption?	e.g. template adoption plan, financial support (grants), government acting as a consumer (to build a market for IPv6 products), training for IT staff, sponsorship…….. *[Please add other factors not listed if needed, where 3 have not been selected from the list above]*	2
5. Give your opinion of this statement: *"My organisation's staff and management take an active interest in the development and implementation of Information Technology infrastructure technologies such as IPv6."*	• Strongly Agree • Agree • Neither Agree or Disagree • Disagree • Strongly Disagree *[Please add any comments you feel are relevant]*	2
6. In your opinion, which 3 stakeholders will be most important in supporting a successful business case to implement IPv6 within your organisation?	e.g. government, users (within the organisation), users (outside the organisation), suppliers, vendors (i.e. manufacturers of hardware/software), customers, senior management, project champions, project manager, IPv6 project monitoring/steering group, IPv6 project team…….. *[Please add other factors not listed if needed, where 3 have not been selected from the list above]*	4
7. Give your opinion of this statement: *"The benefits of IPv6 have synergy with my organisation's goals and therefore support the building of a contemporary business case for IPv6."*	• Strongly agree • Agree • Neither Agree or Disagree • Disagree • Strongly Disagree *[Please add any comments you feel are relevant]*	3
8. In your opinion, what are the 3 most important actions, communications or influences that the stakeholders **within your organisation's environment** (e.g. government, users, suppliers or customers) would have in supporting the building of a successful case and subsequent implementation of IPv6? *(If your organisation does not have an IPv6 implementation plan, please still give you opinion of what you think would be important if it was to).*	e.g. organisational culture, values or beliefs, project context (in relation to business goals), identifiable motives for change, organisational policy amenable to adoption, past experiences (of technology implementation), political pressures or policies from government, customer and/or user requirements, user/customer lobbying (for new features/functionality), suitable and accessible products/services in supply chain…….. *[Please add other factors not listed if needed, where 3 have not been selected from the list above]*	1

9. In your opinion, what are the 3 most important actions, communications or influences that stakeholders **within your organisation** (e.g. senior management, project champions or users) would have in supporting the building of a successful case and subsequent implementation of IPv6? *(If your organisation does not have an IPv6 implementation plan, please still give you opinion of what you think would be important if it was to).*	e.g. creation of achievable IPv6 adoption plans, creation of clear objectives goals and success criteria, selection of the correct methods/approaches/tools of implementation, selection of the available tools and techniques, setting criteria for measurements of performance, creation of communication plan, providing sufficient budget, selection of suitable project manager, selection of suitable project team, definition of success criteria, encouraging user involvement, communication of project (progress) to users/business, feedback from users/business, setting the project completion goals, senior management support …… *[Please add other factors not listed if needed, where 3 have not been selected from the list above]*	1
10. In your opinion, what are the 3 most important actions, communications or influences that stakeholders **within your organisation's IPv6 project team** (e.g. project manager, project champion(s), implementation team or monitoring team) would have in supporting the building of a successful case and subsequent implementation of IPv6? *(If your organisation does not have an IPv6 implementation plan, please still give you opinion of what you think would be important if it was to).*	e.g. adequate and clear planning of project tasks, sufficient and thorough project risk management, providing suitable budget, setting of project schedule, conducting training of users and the project team, capable and motivated IPv6 project team, ensuring user/business/management involvement, championing of project within the organisation, feedback of progress to user/business/management, clear definition of project success criteria (including synergy with business goals), senior management support……. *[Please add other factors not listed if needed, where 3 have not been selected from this list]*	1

Actions, communications or influences in questions 8, 9 and 10 of table A5-1 developed from *White's (2003)* Project Specific Form of the Formal System Model.

Table A5-2 - Delphi Method Questions - Round 2

Question	Response Options	Research Theme
1. Please consider the results of all participants' responses from round 1 (shown below). You may choose to refine your choices, change them completely or not change your opinion at all. In your opinion, what are the 3 most important factors encouraging adoption of IPv6? *(Graph of results of round 1 question 1 shown)*	e.g. inevitability, IPv4 address depletion, lack of scalability (of IPv4), government policy or assistance, vendor support (i.e. hardware/software support), access to IPv6 trained staff, offers competitive advantage, IPv6 standard and product maturity, mobile IPv6, negating the need for NAT (Network Address Translation), auto-configuration (i.e. simpler network management), external pressures from suppliers, customers or partners, new functionality e.g. VoIP (Voice over IP) or IoT (Internet of Things)…… *[Please add other factors not listed if needed, where 3 have not been selected from the list above]* Additional response options from round 1: security concerns, more efficient packet processing…….	2
2. Please consider the results of all participants' responses from round 1 (shown below). You may choose to refine your choices, change them completely or not change your opinion at all. In your opinion, what are the 3 most important factors discouraging adoption of IPv6? *(Graph of results of round 1 question 2 shown)*	e.g. lack of interoperability with IPv4, an organisation's inertia, lack of clear ROI (return on investment), high transition cost, IPv6 skill shortages, prevalence of NAT, no business need (i.e. not relevant to business goals), lack of ISP (Internet Service Provider) support, sufficient IPv4 addresses available, institutional factors, immature standard, lack of vendor support, software development time/costs to adapt to IPv6, potential disruption to IPv4 services, lack of short term benefits (i.e. no urgent need or advantage to early adoption), no commercial incentive, no body acting as a champion, no killer application…….. *[Please add other factors not listed if needed, where 3 have not been selected from the list above]* Additional response options from round 1: little or no public awareness (of the issues)……	2
3. Please consider the results of all participants' responses from round 1 (shown below). You may choose to refine your choices, change them completely or not change your opinion at all. What would be your most favourable approach to the transition to IPv6 for your organisation that would allow a successful case for IPv6 adoption to be built? To assist, a short explanation of each approach is given below: • **Dual-Stack** – IPv6 is implemented alongside IPv4 on all network equipment, servers, clients and network devices, and a period of co-existence continues until there is no longer a need for IPv4. • **Translation (i.e. NAT)** – IPv6 addresses are translated (at some form of gateway) to corresponding IPv4 addresses allow an IPv6 host to communicate with an IPv4 host and vice versa.	e.g. Dual-Stack, Translation (i.e. NAT), Tunnelling, IPv6 over WAN Links or Don't Know *[Please add any comments you feel are relevant, if you answered "Don't Know" please elaborate:]*	2

• **Tunnelling** - IPv4 nodes can communicate to IPv6 nodes and networks across an IPv4 only network by the use of a tunnels and a tunnel broker. • **IPv6 over WAN Links** – Dedicated IPv6 WAN links are deployed alongside IPv4 WAN links between the organisation's networks to facilitate communication between networks, which also need to run IPv6 and IPv4 simultaneously. *(Graph of results of round 1 question 3 shown)*		
4. Please consider the results of all participants' responses from round 1 (shown below). You may choose to refine your choices, change them completely or not change your opinion at all. In your opinion, what are the 3 most important actions that the UK government could take to encourage/support IPv6 adoption within your organisation, and therefore you building a successful case for adoption? *(Graph of results of round 1 question 4 shown)*	e.g. template adoption plan, financial support (grants), government acting as a consumer (to build a market for IPv6 products), training for IT staff, sponsorship…….. *[Please add other factors not listed if needed, where 3 have not been selected from the list above]* Additional response options from round 1: publicise IPv6 to ISPs and companies……	2
5. Please consider the results of all participants' responses from round 1 (shown below). You may choose to refine your choice, change them completely or not change your opinion at all. Please give your opinion of this statement: *"My organisation's staff and management take an active interest in the development and implementation of Information Technology infrastructure technologies such as IPv6."* *(Graph of results of round 1 question 5 shown)*	• Strongly Agree • Agree • Neither Agree or Disagree • Disagree • Strongly Disagree *[Please add any comments you feel are relevant]*	2
6. Please consider the results of all participants' responses from round 1 (shown below). You may choose to refine your choices, change them completely or not change your opinion at all. In your opinion, which 3 stakeholders will be most important in supporting a successful business case to implement IPv6 within your organisation? *(Graph of results of round 1 question 6 shown)*	e.g. government, users (within the organisation), users (outside the organisation), suppliers, vendors (i.e. manufacturers of hardware/software), customers, senior management, project champions, project manager, IPv6 project monitoring/steering group, IPv6 project team…….. *[Please add other factors not listed if needed, where 3 have not been selected from the list above]*	4
7. Please consider the results of all participants' responses from round 1 (shown below). You may choose to refine your choice, change them completely or not change your opinion at all. Please give your opinion of this statement: *"The benefits of IPv6 have synergy with my*	• Strongly agree • Agree • Neither Agree or Disagree • Disagree • Strongly Disagree *[Please add any comments you feel are relevant]*	3

organisation's goals and therefore support the building of a contemporary business case for IPv6." *(Graph of results of round 1 question 7 shown)*		
8. Please consider the results of all participants' responses from round 1 (shown below). You may choose to refine your choices, change them completely or not change your opinion at all. In your opinion, what are the 3 most important actions, communications or influences that the stakeholders **within your organisation's environment** (e.g. government, users, suppliers or customers) would have in supporting the building of a successful case and subsequent implementation of IPv6? *(If your organisation does not have an IPv6 implementation plan, please still give you opinion of what you think would be important if it was to).* *(Graph of results of round 1 question 8 shown)*	e.g. organisational culture, values or beliefs, project context (in relation to business goals), identifiable motives for change, organisational policy amenable to adoption, past experiences (of technology implementation), political pressures or policies from government, customer and/or user requirements, user/customer lobbying (for new features/functionality), suitable and accessible products/services in supply chain…….. *[Please add other factors not listed if needed, where 3 have not been selected from the list above]*	1
9. Please consider the results of all participants' responses from round 1 (shown below). You may choose to refine your choices, change them completely or not change your opinion at all. In your opinion, what are the 3 most important actions, communications or influences that stakeholders **within your organisation** (e.g. senior management, project champions or users) would have in supporting the building of a successful case and subsequent implementation of IPv6? *(If your organisation does not have an IPv6 implementation plan, please still give you opinion of what you think would be important if it was to).* *(Graph of results of round 1 question 9 shown)*	e.g. creation of achievable IPv6 adoption plans, creation of clear objectives goals and success criteria, selection of the correct methods/approaches/tools of implementation, selection of the available tools and techniques, setting criteria for measurements of performance, creation of communication plan, providing sufficient budget, selection of suitable project manager, selection of suitable project team, definition of success criteria, encouraging user involvement, communication of project (progress) to users/business, feedback from users/business, setting the project completion goals, senior management support …… *[Please add other factors not listed if needed, where 3 have not been selected from the list above]*	1
10. Please consider the results of all participants' responses from round 1 (shown below). You may choose to refine your choices, change them completely or not change your opinion at all. In your opinion, what are the 3 most important actions, communications or influences that stakeholders **within your organisation's IPv6 project team** (e.g. project manager, project champion(s), implementation team or monitoring team) would have in supporting the building of a successful case and subsequent implementation of IPv6? *(If your organisation does not have an IPv6*	e.g. adequate and clear planning of project tasks, sufficient and thorough project risk management, providing suitable budget, setting of project schedule, conducting training of users and the project team, capable and motivated IPv6 project team, ensuring user/business/management involvement, championing of project within the organisation, feedback of progress to user/business/management, clear definition of project success criteria (including synergy with business goals), senior management support……. *[Please add other factors not listed if needed, where 3 have not been selected from this list]*	1

implementation plan, please still give you opinion of what you think would be important if it was to). *(Graph of results of round 1 question 10 shown)*		

Actions, communications or influences in questions 8, 9 and 10 of table A5-1 developed from *White's (2003)* Project Specific Form of the Formal System Model.

Table A5-3 - Delphi Method Questions - Round 3

Question	Response Options	Research Theme
1. 1. Please consider the results of all participants' responses from round 2 (shown below). You may choose to refine your choices, change them completely or not alter your opinion at all. In this final round you'll be selecting the 3 most important factors as before, but now also ranking them by order of importance. In your opinion, what are the 3 most important factors encouraging adoption of IPv6, ranked by their relative importance to each other? *(Graph of results of round 2 question 1 shown)*	e.g. inevitability, IPv4 address depletion, lack of scalability (of IPv4), government policy or assistance, vendor support (i.e. hardware/software support), access to IPv6 trained staff, offers competitive advantage, IPv6 standard and product maturity, mobile IPv6, negating the need for NAT (Network Address Translation), auto-configuration (i.e. simpler network management), external pressures from suppliers, customers or partners, new functionality e.g. VoIP (Voice over IP) or IoT (Internet of Things), more efficient packing processing……. *[Please add other factors not listed if needed, where 3 have not been selected from the list above]* Additional response options from round 2: None	2
2. Please consider the results of all participants' responses from round 2 (shown below). You may choose to refine your choices, change them completely or not change your opinion at all. In this final round you'll be selecting the 3 most important factors as before, but now also ranking them by order of importance. In your opinion, what are the 3 most important factors discouraging adoption of IPv6, ranked by their relative importance to each other? *(Graph of results of round 2 question 2 shown)*	e.g. lack of interoperability with IPv4, an organisation's inertia, lack of clear ROI (return on investment), high transition cost, IPv6 skill shortages, prevalence of NAT, no business need (i.e. not relevant to business goals), lack of ISP (Internet Service Provider) support, sufficient IPv4 addresses available, institutional factors, immature standard, lack of vendor support, software development time/costs to adapt to IPv6, potential disruption to IPv4 services, lack of short term benefits (i.e. no urgent need or advantage to early adoption), no commercial incentive, no body acting as a champion, no killer application, little or no public awareness (of the issues) *[Please add other factors not listed if needed, where 3 have not been selected from the list above]* Additional response options from round 2:	2
3. Please consider the results of all participants' responses from round 2 (shown below). You may choose to refine your choices, change them completely or not change your opinion at all. What would be your most favourable approach to the transition to IPv6 for your organisation that would allow a successful case for IPv6 adoption to be built? To assist, a short explanation of each approach is given below: • **Dual-Stack** – IPv6 is implemented alongside	e.g. Dual-Stack, Translation (i.e. NAT), Tunnelling, IPv6 over WAN Links or Don't Know *[Please add any comments you feel are relevant, if you answered "Don't Know" please elaborate:]*	2

IPv4 on all network equipment, servers, clients and network devices, and a period of co-existence continues until there is no longer a need for IPv4. • **Translation (i.e. NAT)** – IPv6 addresses are translated (at some form of gateway) to corresponding IPv4 addresses allow an IPv6 host to communicate with an IPv4 host and vice versa. • **Tunnelling** - IPv4 nodes can communicate to IPv6 nodes and networks across an IPv4 only network by the use of a tunnels and a tunnel broker. • **IPv6 over WAN Links** – Dedicated IPv6 WAN links are deployed alongside IPv4 WAN links between the organisation's networks to facilitate communication between networks, which also need to run IPv6 and IPv4 simultaneously. *(Graph of results of round 2 question 3 shown)*		
4. Please consider the results of all participants' responses from round 2 (shown below). You may choose to refine your choices, change them completely or not change your opinion at all. In your opinion, what are the 3 most important actions that the UK government could take to encourage/support IPv6 adoption within your organisation, and therefore you building a successful case for adoption? *(Graph of results of round 1 question 4 shown)*	e.g. template adoption plan, financial support (grants), government acting as a consumer (to build a market for IPv6 products), training for IT staff, sponsorship, publicise IPv6 to ISPs and companies…….. *[Please add other factors not listed if needed, where 3 have not been selected from the list above]* Additional response options from round 2:	2
5. Please consider the results of all participants' responses from round 2 (shown below). You may choose to refine your choice, change them completely or not change your opinion at all. Please give your opinion of this statement: *"My organisation's staff and management take an active interest in the development and implementation of Information Technology infrastructure technologies such as IPv6."* *(Graph of results of round 2 question 5 shown)*	• Strongly Agree • Agree • Neither Agree or Disagree • Disagree • Strongly Disagree *[Please add any comments you feel are relevant]*	2
6. Please consider the results of all participants' responses from round 2 (shown below). You may choose to refine your choices, change them completely or not change your opinion at all. In this final round you'll be selecting the 3 most important stakeholders as before, but now also ranking them by order of importance. In your opinion, which 3 stakeholders will be most important in supporting a successful business case to	e.g. government, users (within the organisation), users (outside the organisation), suppliers, vendors (i.e. manufacturers of hardware/software), customers, senior management, project champions, project manager, IPv6 project monitoring/steering group, IPv6 project team…….. *[Please add other factors not listed if needed, where 3 have not been selected from the list above]*	4

implement IPv6 within your organisation, ranked by their relative importance to each other? *(Graph of results of round 2 question 6 shown)*		
7. Please consider the results of all participants' responses from round 2 (shown below). You may choose to refine your choice, change them completely or not change your opinion at all. Please give your opinion of this statement: *"The benefits of IPv6 have synergy with my organisation's goals and therefore support the building of a contemporary business case for IPv6."* *(Graph of results of round 2 question 7 shown)*	• Strongly agree • Agree • Neither Agree or Disagree • Disagree • Strongly Disagree *[Please add any comments you feel are relevant]*	3
8. Please consider the results of all participants' responses from round 2 (shown below). You may choose to refine your choices, change them completely or not change your opinion at all. In this final round you'll be selecting the 3 most important actions, communications or influences as before, but now also ranking them by order of importance. In your opinion, what are the 3 most important actions, communications or influences that the stakeholders **within your organisation's environment** (e.g. government, users, suppliers or customers) would have in supporting the building of a successful case and subsequent implementation of IPv6? *(If your organisation does not have an IPv6 implementation plan, please still give you opinion of what you think would be important if it was to).* *(Graph of results of round 2 question 8 shown)*	e.g. organisational culture, values or beliefs, project context (in relation to business goals), identifiable motives for change, organisational policy amenable to adoption, past experiences (of technology implementation), political pressures or policies from government, customer and/or user requirements, user/customer lobbying (for new features/functionality), suitable and accessible products/services in supply chain…….. *[Please add other factors not listed if needed, where 3 have not been selected from the list above]*	1
9. Please consider the results of all participants' responses from round 2 (shown below). You may choose to refine your choices, change them completely or not change your opinion at all. In this final round you'll be selecting the 3 most important actions, communications or influences as before, but now also ranking them by order of importance. In your opinion, what are the 3 most important actions, communications or influences that stakeholders **within your organisation** (e.g. senior management, project champions or users) would have in supporting the building of a successful case and subsequent implementation of IPv6? (If your organisation does not have an IPv6 implementation plan, please still give you opinion of	e.g. creation of achievable IPv6 adoption plans, creation of clear objectives goals and success criteria, selection of the correct methods/approaches/tools of implementation, selection of the available tools and techniques, setting criteria for measurements of performance, creation of communication plan, providing sufficient budget, selection of suitable project manager, selection of suitable project team, definition of success criteria, encouraging user involvement, communication of project (progress) to users/business, feedback from users/business, setting the project completion goals, senior management support …… *[Please add other factors not listed if needed, where 3 have not been selected from the list above]*	1

what you think would be important if it was to). *(Graph of results of round 2 question 9 shown)*		
10. Please consider the results of all participants' responses from round 2 (shown below). You may choose to refine your choices, change them completely or not change your opinion at all. In this final round you'll be selecting the 3 most important actions, communications or influences as before, but now also ranking them by order of importance. In your opinion, what are the 3 most important actions, communications or influences that stakeholders **within your organisation's IPv6 project team** (e.g. project manager, project champion(s), implementation team or monitoring team) would have in supporting the building of a successful case and subsequent implementation of IPv6? (If your organisation does not have an IPv6 implementation plan, please still give you opinion of what you think would be important if it was to). *(Graph of results of round 2 question 10 shown)*	e.g. adequate and clear planning of project tasks, sufficient and thorough project risk management, providing suitable budget, setting of project schedule, conducting training of users and the project team, capable and motivated IPv6 project team, ensuring user/business/management involvement, championing of project within the organisation, feedback of progress to user/business/management, clear definition of project success criteria (including synergy with business goals), senior management support……. *[Please add other factors not listed if needed, where 3 have not been selected from this list]*	1

Actions, communications or influences in questions 8, 9 and 10 of table A5-1 developed from *White's (2003)* Project Specific Form of the Formal System Model.

Appendix 6 – Delphi Method Questions Results

Appendix 6.1 – Result Summary

Table A6-1 – Response rates and sample size of the 3 round Delphi Method survey

Round	Survey Round 1	Survey Round 2	Survey Round 3
IT Engineer	**10**	**8**	**8**
IT/Business Manager	**10**	**9**	**9**
Total Invited	20	20	17
Total Respondents	20	17	17
Final Response Rate	85%		

Appendix 6.2 – Question 1 Delphi Method Results

Table A6-2 – Table of Delphi Method Responses for Question 1 over Rounds 1, 2 and 3

Question 1 - In your opinion, what are the 3 most important factors encouraging adoption of IPv6?

	Round 1			Round 2			Round 3		
Answer Choices	Total	ITE	ITBM	Total	ITE	ITBM	Total	ITE	ITBM
government policy or assistance	0	0	0	0	0	0	0	0	0
access to IPv6 trained staff	1	0	1	0	0	0	0	0	0
offers competitive advantage	1	1	0	0	0	0	0	0	0
IPv6 standard and product maturity	1	0	1	0	0	0	0	0	0
lack of scalability (of IPv4)	3	1	2	1	0	1	0	0	0
mobile IPv6	4	2	2	1	0	1	0	0	0
more efficient packet processing	0	0	0	1	0	1	0	0	0
auto-configuration (i.e. simpler network management)	5	4	1	3	2	1	4	3	1
vendor support (i.e. hardware/software support)	5	2	3	4	2	2	5	3	2
negating the need for NAT (Network Address Translation)	7	4	3	6	3	3	5	2	3
external pressures from suppliers, customers or partners (to remain compatible)	3	2	1	3	2	1	6	2	4
inevitability	7	4	3	8	3	5	10	5	5
access to new functionality and applications e.g. VoIP (Voice over IP) or IoT (Internet of Things)	9	2	7	10	5	5	10	4	6
IPv4 address depletion	14	8	6	14	7	7	11	5	6

Round 1 Comments: *Support For New Services and More Efficient Packet Processing*

Round 2 Comments: *None*

Round 3 Comments: *None*

ITE = IT Engineer, ITBM = IT/Business Manager

Table A6-3 – Ranked List Table of Delphi Method Responses for Question 1 - Round 3 (Final)

Question 1 - In your opinion, what are the 3 most important factors encouraging adoption of IPv6?

	IT Engineer					IT/Business Manager						
Answer Choices	1st Most Important	2nd Most Important	3rd Most Important	Total	Weighted Average	1st Most Important	2nd Most Important	3rd Most Important	Total	Weighted Average	**Grand Total**	**Overall Weighted Average**
government policy or assistance	0	0	0	0	0	0	0	0	0	0	**0**	**0**
access to IPv6 trained staff	0	0	0	0	0	0	0	0	0	0	**0**	**0**
offers competitive advantage	0	0	0	0	0	0	0	0	0	0	**0**	**0**
IPv6 standard and product maturity	0	0	0	0	0	0	0	0	0	0	**0**	**0**
lack of scalability (of IPv4)	0	0	0	0	0	0	0	0	0	0	**0**	**0**
mobile IPv6	0	0	0	0	0	0	0	0	0	0	**0**	**0**
more efficient packet processing	0	0	0	0	0	0	0	0	0	0	**0**	**0**
auto-configuration (i.e. simpler network management)	0	2	1	3	5	0	0	1	1	1	**4**	**6**
external pressures from suppliers, customers or partners (to remain compatible)	0	0	2	2	2	0	2	2	4	6	**6**	**8**
negating the need for NAT (Network Address Translation)	1	0	1	2	4	0	1	2	3	4	**5**	**8**
vendor support (i.e. hardware/software support)	0	3	0	3	6	0	2	0	2	4	**5**	**10**
access to new functionality and applications e.g. VoIP (Voice over IP) or IoT (Internet of Things)	1	1	2	4	7	1	0	5	6	8	**10**	**15**
inevitability	2	1	2	5	10	4	1	0	5	14	**10**	**24**
IPv4 address depletion	4	1	0	5	14	3	3	0	6	15	**11**	**29**

Weighted Average: *1st Most Important = x * 3*
*2nd Most Important = x * 2*
*3rd Most Important = x * 3*

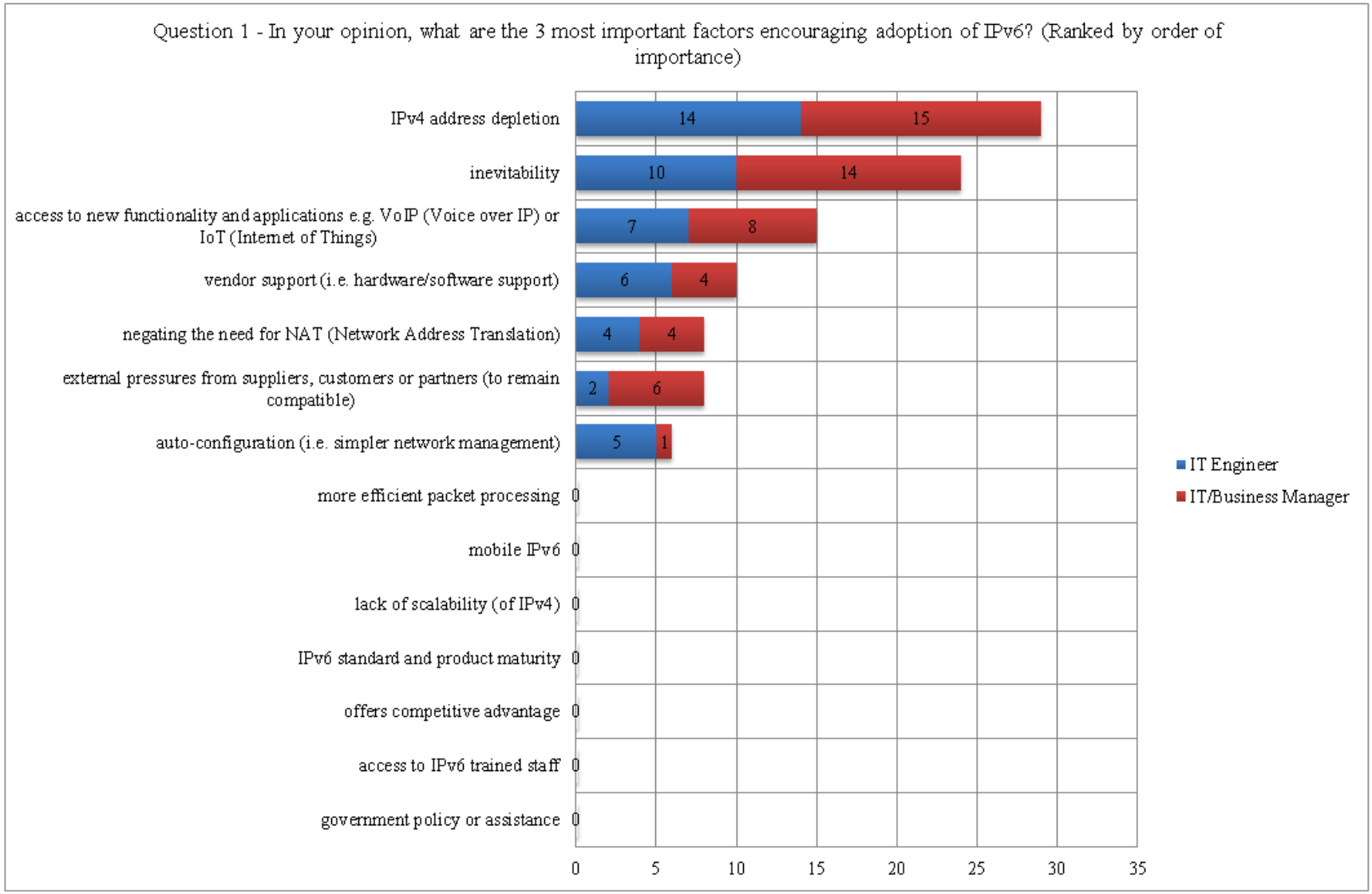


Figure A6-1 – Bar Graph of Delphi Method Responses (Ranked by Order of Importance) Question 1 – Round 3 (Final)
Raw data: Appendix 6 – Table A6-3

Appendix 6.3 – Question 2 Delphi Method Results

Table A6-4 – Table of Delphi Method Responses for Question 2 over Rounds 1, 2 and 3

Question 2 - In your opinion, what are the 3 most important factors discouraging adoption of IPv6?

	Round 1			Round 2			Round 3		
Answer Choices	Total	ITE	ITBM	Total	ITE	ITBM	Total	ITE	ITBM
immature standard	0	0	0	0	0	0	0	0	0
institutional factors	0	0	0	1	1	0	0	0	0
lack of vendor support	0	0	0	0	0	0	0	0	0
little or no public awareness (of the issues)	1	1	0	0	0	0	0	0	0
no body acting as a champion	1	0	1	0	0	0	0	0	0
no commercial incentive	3	2	1	1	0	1	0	0	0
potential disruption to IPv4 services	0	0	0	0	0	0	0	0	0
software development time/costs to adapt to IPv6	1	0	1	0	0	0	0	0	0
sufficient IPv4 addresses currently available	3	1	2	1	0	1	0	0	0
high transition cost	0	0	0	1	0	1	1	0	1
lack of interoperability with IPv4	2	1	1	2	1	1	1	1	0
lack of ISP (Internet Service Provider) support	3	3	0	1	1	0	1	1	0
an organisation's inertia	5	1	4	4	2	2	2	1	1
no advantage of early adoption	4	2	2	1	1	0	2	2	0
prevalence of NAT (Network Address Translation)	1	1	0	2	1	1	2	1	1
no killer application	4	1	3	2	2	0	3	2	1
lack of clear ROI (Return on Investment)	6	2	4	9	3	6	8	3	5
lack of short term benefits (i.e. no urgent need or advantage to early adoption)	9	4	5	7	5	2	9	4	5
IPv6 skill shortages	10	3	7	10	4	6	10	4	6
no business need (i.e. not relevant to business goals)	7	2	5	9	3	6	12	5	7

Round 1 Comments: *Little or no public awareness (of the issues)*
At the moment there is no clear driving force behind the need to move to IPv6

Round 2 Comments: *None*

Round 3 Comments: *None*

ITE = IT Engineer, ITBM = IT/Business Manager

Table A6-5 – Ranked List Table of Delphi Method Responses for Question 2 - Round 3 (Final)

Question 2 - In your opinion, what are the 3 most important factors discouraging adoption of IPv6?

	IT Engineer					IT/Business Manager						
Answer Choices	1st Most Important	2nd Most Important	3rd Most Important	Total	Weighted Average	1st Most Important	2nd Most Important	3rd Most Important	Total	Weighted Average	**Grand Total**	**Overall Weighted Average**
institutional factors	0	0	0	0	0	0	0	0	0	0	**0**	**0**
immature standard	0	0	0	0	0	0	0	0	0	0	**0**	**0**
lack of vendor support	0	0	0	0	0	0	0	0	0	0	**0**	**0**
potential disruption to IPv4 services	0	0	0	0	0	0	0	0	0	0	**0**	**0**
software development time/costs to adapt to IPv6	0	0	0	0	0	0	0	0	0	0	**0**	**0**
no body acting as a champion	0	0	0	0	0	0	0	0	0	0	**0**	**0**
little or no public awareness (of the issues)	0	0	0	0	0	0	0	0	0	0	**0**	**0**
sufficient IPv4 addresses currently available	0	0	0	0	0	0	0	0	0	0	**0**	**0**
no commercial incentive	0	0	0	0	0	0	0	0	0	0	**0**	**0**
high transition cost	0	0	0	0	0	0	0	1	1	1	**1**	**1**
lack of interoperability with IPv4	0	0	1	1	1	0	0	0	0	0	**1**	**1**
lack of ISP (Internet Service Provider) support	1	0	0	1	3	0	0	0	0	0	**1**	**3**
no advantage of early adoption	0	1	1	2	3	0	0	0	0	0	**2**	**3**
prevalence of NAT (Network Address Translation)	0	1	0	1	2	0	1	0	1	2	**2**	**4**
no killer application	0	1	1	2	3	0	0	1	1	1	**3**	**4**
an organisation's inertia	0	0	1	1	1	1	0	0	1	3	**2**	**4**
lack of short term benefits (i.e. no urgent need or advantage to early adoption)	1	1	2	4	7	1	2	2	5	9	**9**	**16**
lack of clear ROI (Return on Investment)	1	1	1	3	6	3	2	0	5	13	**8**	**19**
IPv6 skill shortages	3	1	0	4	11	1	1	4	6	9	**10**	**20**
no business need (i.e. not relevant to business goals)	2	2	1	5	11	3	3	1	7	16	**12**	**27**

Weighted Average: *1st Most Important = x * 3*
*2nd Most Important = x * 2*
*3rd Most Important = x * 3*

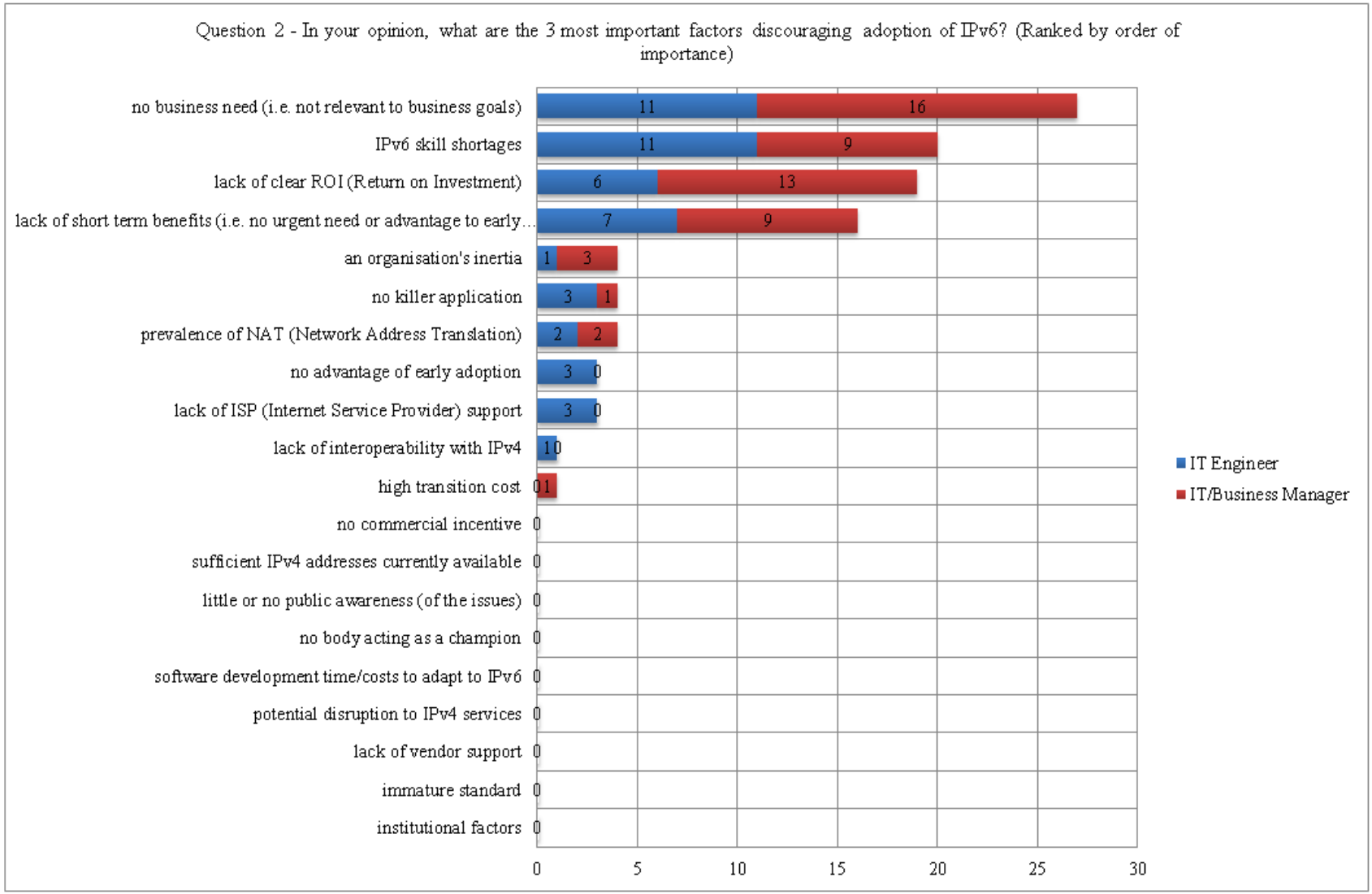


Figure A6-2 – Bar Graph of Delphi Method Responses (Ranked by Order of Importance) Question 2 – Round 3 (Final)
Raw data: Appendix 6 – Table A6-5

Appendix 6.4 – Question 3 Delphi Method Results

Table A6-6 – Table of Delphi Method Responses for Question 3 over Rounds 1, 2 and 3

Question 3 - What would be your most favourable approach to the transition to IPv6 for your organisation that would allow a successful case for IPv6 adoption to be built?

	Round 1			Round 2			Round 3		
Answer Choices	Total	ITE	ITBM	Total	ITE	ITBM	Total	ITE	ITBM
Dual-Stack	14	9	5	14	7	7	15	7	8
Translation (i.e. NAT)	1	0	1	1	0	1	0	0	0
Tunnelling	0	0	0	0	0	0	0	0	0
IPv6 over WAN Links	0	0	0	0	0	0	0	0	0
Don't Know	5	1	4	2	1	1	2	1	1

Round 1 Comments:
"Still not certain of the true benefits of various scenarios. I suspect it depends on different current network topographies."
"Lack of personal knowledge for best approach. Dual stack can have the effect of maintaining status quo - ie just stick to IPv4 it will still work!"

Round 2 Comments:
"Still not certain of the true benefits of various scenarios. I suspect it depends on different current network topographies."
"Dual Stack is ok - But I have a strong concern that in such an environment people stick with what they know and hope the "new stuff" will go away. Leaving a system that is neither completely one thing or the other but ends up not being both and as such rather fragile."

Round 3 Comments:
"While dual stack seems the favourite I would have to say it really depends on what if anything our existing network hardware can manage. in the end it needs to be seamless to our clients so if one option has less impact because of our current set-up then less impact is better than technical superiority."

ITE = IT Engineer, ITBM = IT/Business Manager

Appendix 6.5 – Question 4 Delphi Method Results

Table A6-7 – Table of Delphi Method Responses for Question 4 over Rounds 1, 2 and 3

Question 4 - What are the 3 most important actions that the UK government could take to encourage/support IPv6 adoption within your organisation, and therefore you building a successful case for adoption?

	Round 1			Round 2			Round 3		
Answer Choices	Total	ITE	ITBM	Total	ITE	ITBM	Total	ITE	ITBM
template adoption plan	8	4	4	4	3	1	3	3	0
publicise IPv6 to ISPs and companies	1	1	0	3	0	3	4	1	3
government acting as a consumer (to build a market for IPv6 products)	6	4	2	3	3	0	5	3	2
sponsorship	8	3	5	9	3	6	9	2	7
training for IT staff	17	8	9	16	7	9	14	7	7
financial support (grants)	17	9	8	16	8	8	16	8	8

Round 1 Comments: *"Publicise IPv6 to ISPs and companies."*

Round 2 Comments: *None*

Round 3 Comments: *None*

ITE = IT Engineer, ITBM = IT/Business Manager

Table A6-8 – Ranked List Table of Delphi Method Responses for Question 4 - Round 3 (Final)

Question 4 - What are the 3 most important actions that the UK government could take to encourage/support IPv6 adoption within your organisation, and therefore you building a successful case for adoption?

	IT Engineer					IT/Business Manager						
Answer Choices	1st Most Important	2nd Most Important	3rd Most Important	Total	Weighted Average	1st Most Important	2nd Most Important	3rd Most Important	Total	Weighted Average	**Grand Total**	**Overall Weighted Average**
template adoption plan	0	1	2	3	4	0	0	0	0	0	**3**	**4**
Publicise IPv6 to ISPs and companies	1	0	0	1	3	0	1	2	3	4	**4**	**7**
government acting as a consumer (to build a market for IPv6 products)	2	0	1	3	7	0	0	2	2	2	**5**	**9**
sponsorship	0	1	1	2	3	1	2	4	7	11	**9**	**14**
training for IT staff	4	2	1	7	17	0	6	1	7	13	**14**	**30**
financial support (grants)	1	4	3	8	14	8	0	0	8	24	**16**	**38**

Weighted Average: *1st Most Important = x * 3*
*2nd Most Important = x * 2*
*3rd Most Important = x * 3*

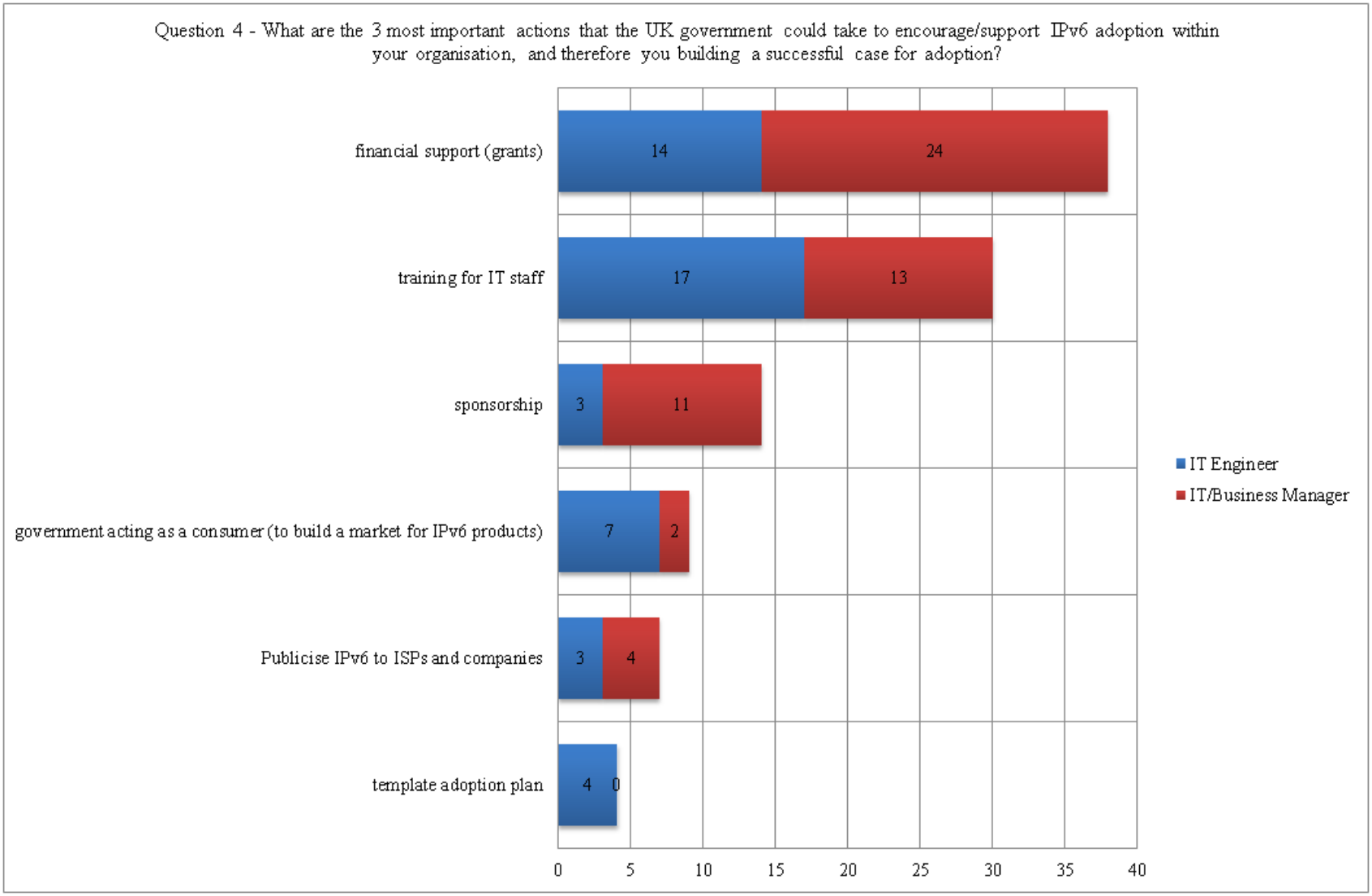


Figure A6-3 – Bar Graph of Delphi Method Responses (Ranked by Order of Importance) Question 4 – Round 3 (Final)
Raw data: Appendix 6 – Table A6-8

Appendix 6.6– Question 5 Delphi Method Results

Table A6-9 – Table of Delphi Method Responses for Question 5 over Rounds 1, 2 and 3
Question 5 - Give your opinion of this statement: “My organisation’s staff and management take an active interest in the development and implementation of Information Technology infrastructure technologies such as IPv6.”

	Round 1			Round 2			Round 3		
Answer Choices	Total	ITE	ITBM	Total	ITE	ITBM	Total	ITE	ITBM
Strongly Agree	2	0	2	1	0	1	1	0	1
Agree	6	3	3	3	1	2	3	1	2
Neither Agree or Disagree	5	4	1	5	3	2	3	1	2
Disagree	5	2	3	8	4	4	10	6	4
Strongly Disagree	2	1	1	0	0	0	0	0	0

Round 1 Comments: *"Not all staff who work here would know what Ipv6, I think the necessary people do."*

"I do what I must to keep things going and while I am interested in changes I try not to worry about them till I have to. If it ain't broke leave alone but prepare for the inevitable."

"My organisation is not really interested in IT (infrastructure), as long as it works! They do take more of an interest in actual systems though, like a new finance system that staff interact with directly on a day to day basis."

Round 2 Comments: *"Taking the organisation as a whole, only the relevant department would know what this is and take an interest, but most people who use the IT wouldn't know or care."*

"Staff and management are very different groups while there is technical interest there is no management interest in an expensive change that does nothing."

Round 3 Comments: *"Taking the organisation as a whole, only the relevant department would know what this is and take an interest, but most people who use the IT wouldn't know or care."*

"Most of the people here wouldn't know what an IP address is, let alone different versions."

"My organisation takes an interest. But We do not ACTIVELY seek out change and its implementation until we need to. IPv4 its beginning to break or could do if nothing is done."

ITE = IT Engineer, ITBM = IT/Business Manager

Appendix 6.7 – Question 6 Delphi Method Results

Table A6-10 – Table of Delphi Method Responses for Question 6 over Rounds 1, 2 and 3

Question 6 - In your opinion, which 3 stakeholders will be most important in supporting a successful business case to implement IPv6 within your organisation?

	Round 1			Round 2			Round 3		
Answer Choices	Total	ITE	ITBM	Total	ITE	ITBM	Total	ITE	ITBM
IPv6 project monitoring/steering group	0	0	0	0	0	0	0	0	0
project manager	1	1	0	0	0	0	0	0	0
suppliers	1	1	0	0	0	0	1	1	0
customers	3	2	1	1	0	1	1	0	1
project champions	2	1	1	1	1	0	2	2	0
users (outside the organisation)	7	3	4	4	3	1	2	1	1
IPv6 project team	7	3	4	6	3	3	2	1	1
users (within the organisation)	6	5	1	3	1	2	7	3	4
vendors (i.e. manufacturers of hardware/software)	8	4	4	9	5	4	10	5	5
government	9	3	6	9	4	5	10	4	6
senior management	12	5	7	16	7	9	16	7	9

Round 1 Comments: *"The only way this place will change will be due to external pressures, either because we have to (say JANET decided to go all IPv6,) or that funding was made available that we could tap into to make the transition."*

"The support needs to come from within, really from the senior management to support it."

Round 2 Comments: *"The only way this place will change will be due to external pressures, either because we have to (say JANET decided to go all IPv6,) or that funding was made available that we could tap into to make the transition."*

"The support needs to come from within, really from the senior management to support it."

Round 3 Comments: *"The pressure needs to come from external sources, eg government, to force the change. Once it impacts on Senior management then it will be easier to proceed with implementation. Trying to start the project internally first does not work - it won't be seen as important or have little business advantage and therefore no backing from the Bosses."*

ITE = IT Engineer, ITBM = IT/Business Manager

Table A6-11- Ranked List Table of Delphi Method Responses for Question 6 - Round 3

Question 6 - In your opinion, which 3 stakeholders will be most important in supporting a successful business case to implement IPv6 within your organisation?

	IT Engineer					IT/Business Manager						
Answer Choices	1st Most Important	2nd Most Important	3rd Most Important	Total	Weighted Average	1st Most Important	2nd Most Important	3rd Most Important	Total	Weighted Average	**Grand Total**	**Overall Weighted Average**
IPv6 project monitoring/steering group	0	0	0	0	0	0	0	0	0	0	**0**	**0**
project manager	0	0	0	0	0	0	0	0	0	0	**0**	**0**
suppliers	0	0	1	1	1	0	0	0	0	0	**1**	**1**
project champions	0	0	2	2	2	0	0	0	0	0	**2**	**2**
customers	0	0	0	0	0	1	0	0	1	3	**1**	**3**
users (outside the organisation)	0	0	1	1	1	0	1	0	1	2	**2**	**3**
IPv6 project team	0	1	0	1	2	0	0	1	1	1	**2**	**3**
users (within the organisation)	1	2	0	3	7	0	0	4	4	4	**7**	**11**
vendors (i.e. manufacturers of hardware/software)	1	3	1	5	10	1	1	3	5	8	**10**	**18**
government	0	1	3	4	5	1	5	0	6	13	**10**	**18**
senior management	6	1	0	7	20	6	2	1	9	23	**16**	**43**

Weighted Average: *1st Most Important = x * 3*
*2nd Most Important = x * 2*
*3rd Most Important = x * 3*

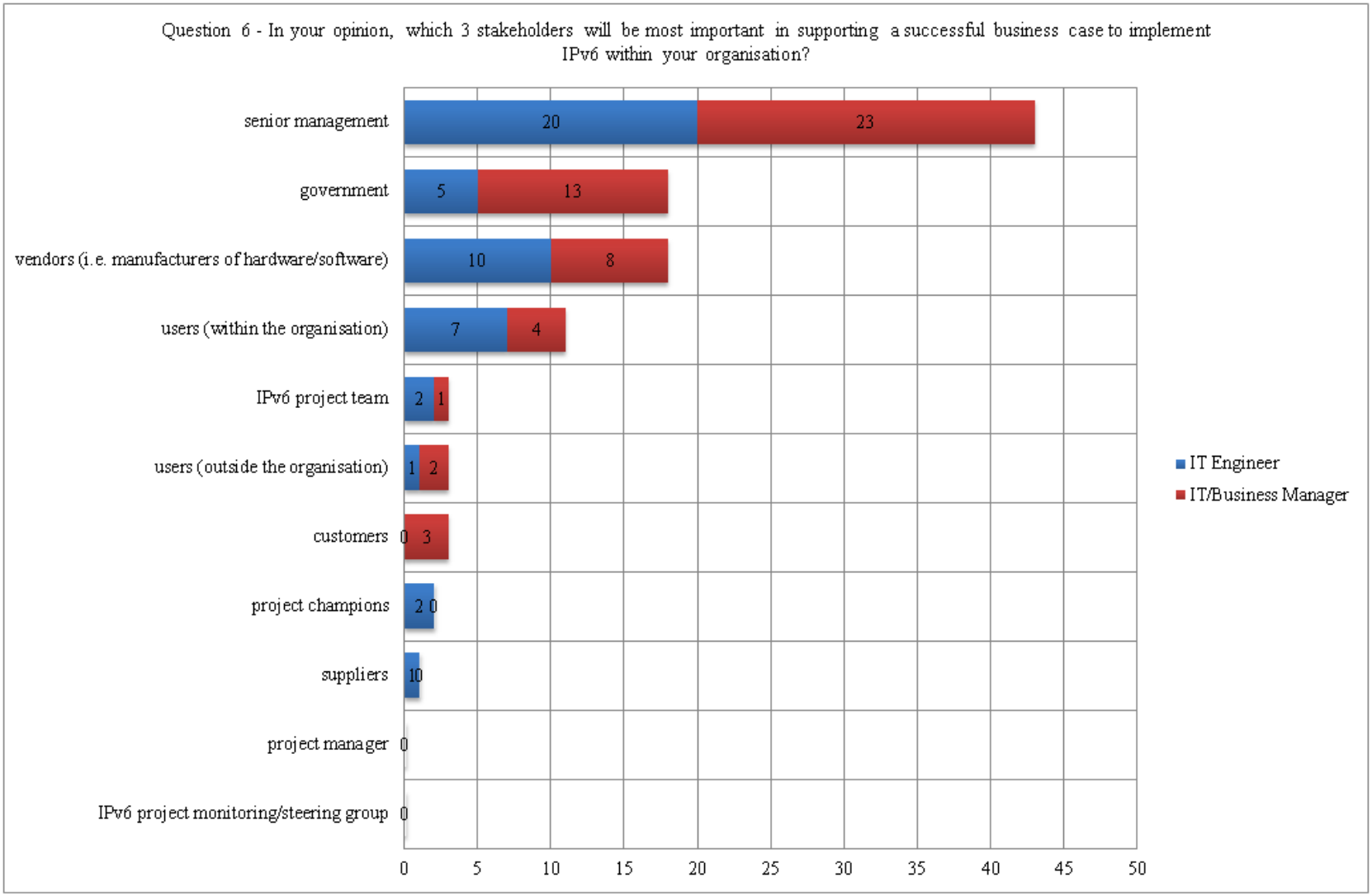


Figure A6-4 – Bar Graph of Delphi Method Responses (Ranked by Order of Importance) Question 6 – Round 3 (Final)
Raw data: Appendix 6 – Table A6-11

Appendix 6.8 – Question 7 Delphi Method Results

Table A6-12 – Table of Delphi Method Responses for Question 7 over Rounds 1, 2 and 3

Question 7 - Give your opinion of this statement: "The benefits of IPv6 have synergy with my organisation's goals and therefore support the building of a contemporary business case for IPv6."

	Round 1			Round 2			Round 3		
Answer Choices	Total	ITE	ITBM	Total	ITE	ITBM	Total	ITE	ITBM
Strongly Agree	1	1	0	0	0	0	0	0	0
Agree	3	3	0	2	2	0	2	2	0
Neither Agree or Disagree	10	4	6	10	5	5	11	6	5
Disagree	5	2	3	5	1	4	4	0	4
Strongly Disagree	1	0	1	0	0	0	0	0	0

Round 1 Comments:	*"The benefits of IPv6 for a small organisation are questionable. as hardware / ISPs etc. go towards IPv6 only adoption then the business case grows."*
	"There is little understanding of what networking is in this place, let alone IPv6! My organisation's goals bear little resemblance to anything IT!"
	"At the moment, the benefits of IPv6 don't match up directly the organisations goals (yet). However they might in future, if there is something that IPv6 gives us that we can't do using our existing IPv4 addresses."
Round 2 Comments:	*"The benefits of IPv6 for a small organisation are questionable. as hardware / ISPs etc. go towards IPv6 only adoption then the business case grows."*
	"There is little understanding of what networking is in this place, let alone IPv6! My organisation's goals bear little resemblance to anything IT!"
	"At the moment, the benefits of IPv6 don't match up directly the organisations goals (yet). However they might in future, if there is something that IPv6 gives us that we can't do using our existing IPv4 addresses."
Round 3 Comments:	*"IP4 supports my current needs - to connect to local equipment and internet. However IP4 will not support every ones needs and IP6 will increasingly become inevitable as the number of organisations choose (some by necessity) to change over."*

ITE = IT Engineer, ITBM = IT/Business Manager

Appendix 6.9 – Question 8 Delphi Method Results

Table A6-13 – Table of Delphi Method Responses for Question 8 over Rounds 1, 2 and 3

Question 8 - In your opinion, what are the 3 most important actions, communications or influences that the stakeholders within your organisation's environment (e.g. government, users, suppliers or customers) would have in supporting the building of a successful case and subsequent implementation of IPv6? (If your organisation does not have an IPv6 implementation plan, please still give you opinion of what you think would be important if it was to).

	Round 1			Round 2			Round 3		
Answer Choices	Total	ITE	ITBM	Total	ITE	ITBM	Total	ITE	ITBM
past experiences (of technology implementation)	0	0	0	0	0	0	0	0	0
organisational culture, values or beliefs	1	1	0	0	0	0	1	1	0
organisational policy amenable to adoption	2	2	0	0	0	0	0	0	0
suitable and accessible products/services in supply chain	3	1	2	1	1	0	0	0	0
user/customer lobbying (for new features/functionality)	5	2	3	4	2	2	3	1	2
political pressures or policies from government	8	4	4	5	3	2	9	4	5
project context (in relation to business goals)	11	5	6	11	6	5	12	5	7
customer and/or user requirements	12	7	5	12	7	5	10	5	5
identifiable motives for change	17	8	9	16	8	8	16	8	8

Round 1 Comments: *"I really can't think of three. with no clear advantage (yes more addresses but that always affects 'other' people) and no easy compatibility then we'll do it when we have to (have good reason) and not before."*

Round 2 Comments: *"Mandating the change."*

Round 3 Comments: *"really half of the above points are the same. reason for change. external from government or internal (customers' requirements, customer lobbying, motives for change, business goals). if there's a good reason then we will change. most of the other points haven't been picked the ones picked really come down to preferred wording but could otherwise be interchangeable."*

ITE = IT Engineer, ITBM = IT/Business Manager

Table A6-14- Ranked List Table of Delphi Method Responses for Question 8 - Round 3

Question 8 - In your opinion, what are the 3 most important actions, communications or influences that the stakeholders within your organisation's environment (e.g. government, users, suppliers or customers) would have in supporting the building of a successful case and subsequent implementation of IPv6? (If your organisation does not have an IPv6 implementation plan, please still give you opinion of what you think would be important if it was to).

	IT Engineer					**IT/Business Manager**						
Answer Choices	1st Most Important	2nd Most Important	3rd Most Important	Total	Weighted Average	1st Most Important	2nd Most Important	3rd Most Important	Total	Weighted Average	**Grand Total**	**Overall Weighted Average**
past experiences (of technology implementation)	0	0	0	0	0	0	0	0	0	0	**0**	**0**
organisational policy amenable to adoption	0	0	0	0	0	0	0	0	0	0	**0**	**0**
suitable and accessible products/services in supply chain	0	0	0	0	0	0	0	0	0	0	**0**	**0**
organisational culture, values or beliefs	0	0	1	1	1	0	0	0	0	0	**1**	**1**
user/customer lobbying (for new features/functionality)	0	0	1	1	1	0	1	1	2	3	**3**	**4**
political pressures or policies from government	0	1	3	4	5	1	1	3	5	8	**9**	**13**
customer and/or user requirements	2	2	1	5	11	1	2	2	5	9	**10**	**20**
project context (in relation to business goals)	2	1	2	5	10	4	0	3	7	15	**12**	**25**
identifiable motives for change	4	4	0	8	20	3	5	0	8	19	**16**	**39**

Weighted Average: *1st Most Important = x * 3*
*2nd Most Important = x * 2*
*3rd Most Important = x * 3*

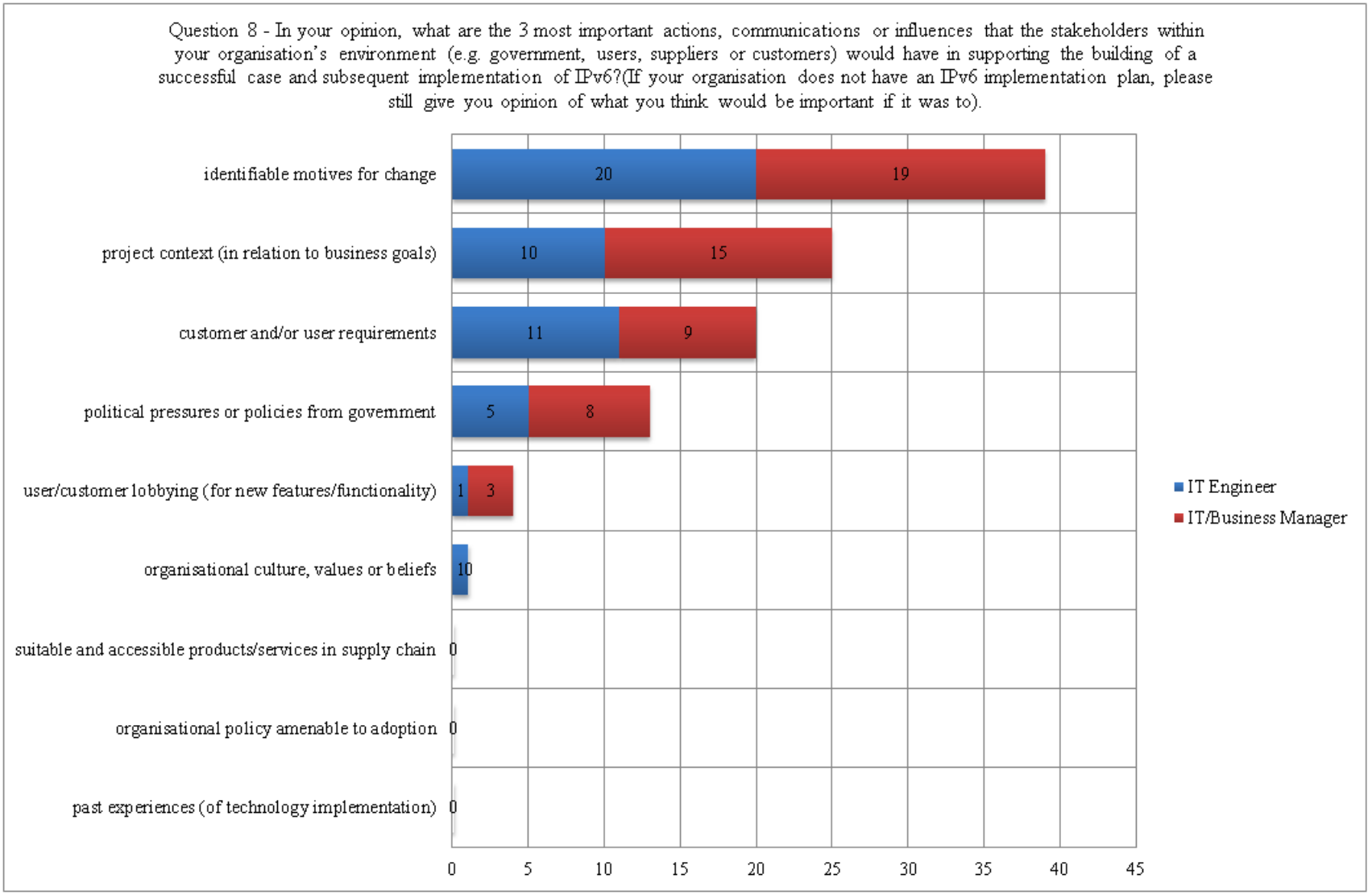


Figure A6-5– Bar Graph of Delphi Method Responses (Ranked by Order of Importance) Question 6 – Round 3 (Final)
Raw data: Appendix 6 – Table A6-14

Appendix 6.10 – Question 9 Delphi Method Results

Table A6-15 – Table of Delphi Method Responses for Question 9 over Rounds 1, 2 and 3

Question 9 - In your opinion, what are the 3 most important actions, communications or influences that stakeholders within your organisation (e.g. senior management, project champions or users) would have in supporting the building of a successful case and subsequent implementation of IPv6? (If your organisation does not have an IPv6 implementation plan, please still give you opinion of what you think would be important if it was to).

	Round 1			Round 2			Round 3		
Answer Choices	Total	ITE	ITBM	Total	ITE	ITBM	Total	ITE	ITBM
encouraging user involvement	0	0	0	0	0	0	0	0	0
selection of suitable project team	1	1	0	1	1	0	0	0	0
feedback from users/business	1	1	0	1	0	1	0	0	0
selection of the correct methods/approaches/tools of implementation	3	2	1	0	0	0	0	0	0
setting criteria for measurements of performance	1	0	1	1	0	1	1	0	1
selection of suitable project manager	1	0	1	0	0	0	1	1	0
creation of communication plan	2	1	1	1	0	1	1	1	0
communication of project (progress) to users/business	2	2	0	2	1	1	3	2	1
creation of achievable IPv6 adoption plans	5	4	1	3	2	1	3	1	2
providing sufficient budget	9	2	7	11	6	5	10	4	6
senior management support	15	9	6	16	8	8	15	7	8
creation of clear objectives, goals and success criteria	18	8	10	15	6	9	17	8	9

Round 1 Comments: *"The project needs a clear goal and benefits for it to be successfully approved."*

Round 2 Comments: *None*

Round 3 Comments: *"no plan but senior management support should probably read senior management orders it's not as if we're pushing for it."*

ITE = IT Engineer, ITBM = IT/Business Manager

Table A6-16- Ranked List Table of Delphi Method Responses for Question 9 - Round 3

Question 9 - In your opinion, what are the 3 most important actions, communications or influences that stakeholders within your organisation (e.g. senior management, project champions or users) would have in supporting the building of a successful case and subsequent implementation of IPv6?(If your organisation does not have an IPv6 implementation plan, please still give you opinion of what you think would be important if it was to).

	IT Engineer					**IT/Business Manager**						
Answer Choices	1st Most Important	2nd Most Important	3rd Most Important	Total	Weighted Average	1st Most Important	2nd Most Important	3rd Most Important	Total	Weighted Average	**Grand Total**	**Overall Weighted Average**
encouraging user involvement	0	0	0	0	0	0	0	0	0	0	**0**	**0**
selection of suitable project team	0	0	0	0	0	0	0	0	0	0	**0**	**0**
feedback from users/business	0	0	0	0	0	0	0	0	0	0	**0**	**0**
selection of the correct methods/approaches/tools of implementation	0	0	0	0	0	0	0	0	0	0	**0**	**0**
setting criteria for measurements of performance	0	0	0	0	0	0	0	1	1	1	**1**	**1**
creation of communication plan	0	1	0	1	2	0	0	0	0	0	**1**	**2**
selection of suitable project manager	1	0	0	1	3	0	0	0	0	0	**1**	**3**
communication of project (progress) to users/business	0	0	2	2	2	0	0	1	1	1	**3**	**3**
creation of achievable IPv6 adoption plans	0	0	1	1	1	1	0	1	2	4	**3**	**5**
providing sufficient budget	0	1	3	4	5	0	4	2	6	10	**10**	**15**
senior management support	5	1	1	7	18	5	2	1	8	20	**15**	**38**
creation of clear objectives, goals and success criteria	4	4	0	8	20	3	3	3	9	18	**17**	**38**

Weighted Average: *1st Most Important = x * 3*
*2nd Most Important = x * 2*
*3rd Most Important = x * 3*

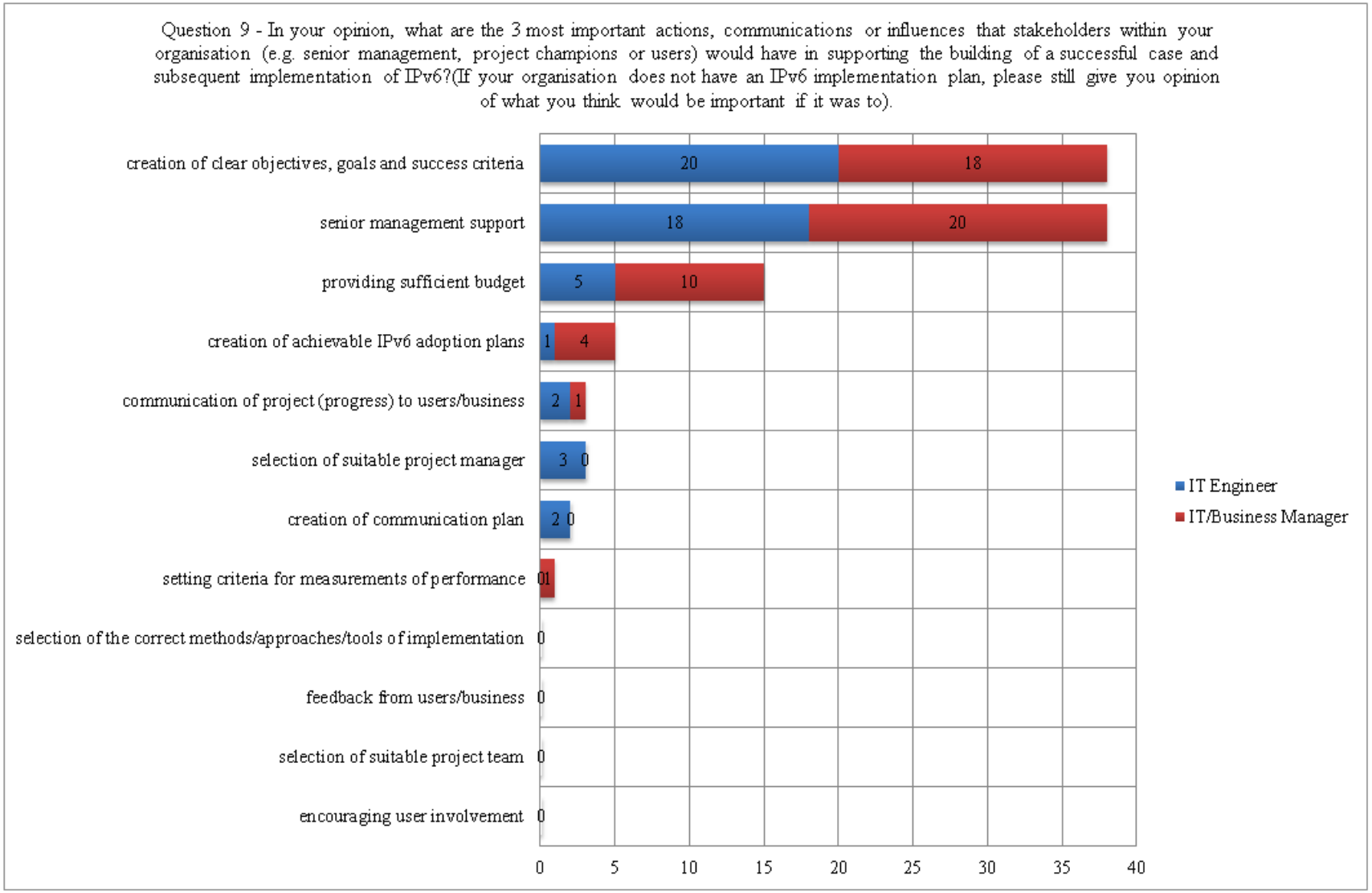


Figure A6-6 – Bar Graph of Delphi Method Responses (Ranked by Order of Importance) Question 9 – Round 3 (Final)
Raw data: Appendix 6 – Table A6-16

Appendix 6.11 – Question 10 Delphi Method Results

Table A6-17 – Table of Delphi Method Responses for Question 10 over Rounds 1, 2 and 3

Question 10 - In your opinion, what are the 3 most important actions, communications or influences that stakeholders within your organisation's IPv6 project team (e.g. project manager, project champion(s), implementation team or monitoring team) would have in supporting the building of a successful case and subsequent implementation of IPv6? (If your organisation does not have an IPv6 implementation plan, please still give you opinion of what you think would be important if it was to).

	Round 1			Round 2			Round 3		
Answer Choices	Total	ITE	ITBM	Total	ITE	ITBM	Total	ITE	ITBM
setting of project schedule	1	0	1	1	1	0	0	0	0
feedback of progress to user/business/management	2	1	1	0	0	0	0	0	0
ensuring user/business/management involvement	4	2	2	3	1	2	1	1	0
capable and motivated IPv6 project team	6	4	2	3	3	0	1	1	0
championing of project within the organisation	2	1	1	2	0	2	2	0	2
sufficient and thorough project risk management	5	3	2	1	1	0	2	2	0
conducting training of users and the project team	5	4	1	4	3	1	4	3	1
senior management support	8	4	4	10	4	6	7	3	4
clear definition of project success criteria (including synergy with business goals)	7	3	4	7	3	4	9	4	5
providing suitable budget	9	4	5	9	3	6	12	4	8
adequate and clear planning of project tasks	9	4	5	9	5	4	13	6	7

Round 1 Comments: *"Show me advantages and cost savings then the rest would follow easily. The problem with things like budget is that with no practical advantages then there are better things to do with the money."*

"They project needs a clear goal and benefits for it to be successfully approved."

Round 2 Comments: *"No team - no immediate plan."*

"The IPv6 implementation project must have management support and sufficient budget to allow it to get off the ground."

"We have no team because we have no advantages worth spending the money on. having a suitable budget just means saying there was nothing better to do with the money!"

Round 3 Comments: *"again no team, plan etc."*

ITE = IT Engineer, ITBM = IT/Business Manager

Table A6-18- Ranked List Table of Delphi Method Responses for Question 10 - Round 3

Question 10 - In your opinion, what are the 3 most important actions, communications or influences that stakeholders within your organisation's IPv6 project team (e.g. project manager, project champion(s), implementation team or monitoring team) would have in supporting the building of a successful case and subsequent implementation of IPv6? (If your organisation does not have an IPv6 implementation plan, please still give you opinion of what you think would be important if it was to).

	IT Engineer					**IT/Business Manager**						
Answer Choices	1st Most Important	2nd Most Important	3rd Most Important	Total	Weighted Average	1st Most Important	2nd Most Important	3rd Most Important	Total	Weighted Average	**Grand Total**	**Overall Weighted Average**
setting of project schedule	0	0	0	0	0	0	0	0	0	0	**0**	**0**
feedback of progress to user/business/management	0	0	0	0	0	0	0	0	0	0	**0**	**0**
ensuring user/business/management involvement	0	0	1	1	1	0	0	0	0	0	**1**	**1**
championing of project within the organisation	0	0	0	0	0	0	0	2	2	2	**2**	**2**
capable and motivated IPv6 project team	0	1	0	1	2	0	0	0	0	0	**1**	**2**
sufficient and thorough project risk management	0	1	1	2	3	0	0	0	0	0	**2**	**3**
conducting training of users and the project team	0	3	0	3	6	0	1	0	1	2	**4**	**8**
senior management support	1	0	2	3	5	4	0	0	4	12	**7**	**17**
clear definition of project success criteria (including synergy with business goals)	3	0	1	4	10	3	1	1	5	12	**9**	**22**
adequate and clear planning of project tasks	3	1	2	6	13	1	1	5	7	10	**13**	**23**
providing suitable budget	1	2	1	4	8	2	5	1	8	17	**12**	**25**

Weighted Average: *1st Most Important = x * 3*
*2nd Most Important = x * 2*
*3rd Most Important = x * 3*

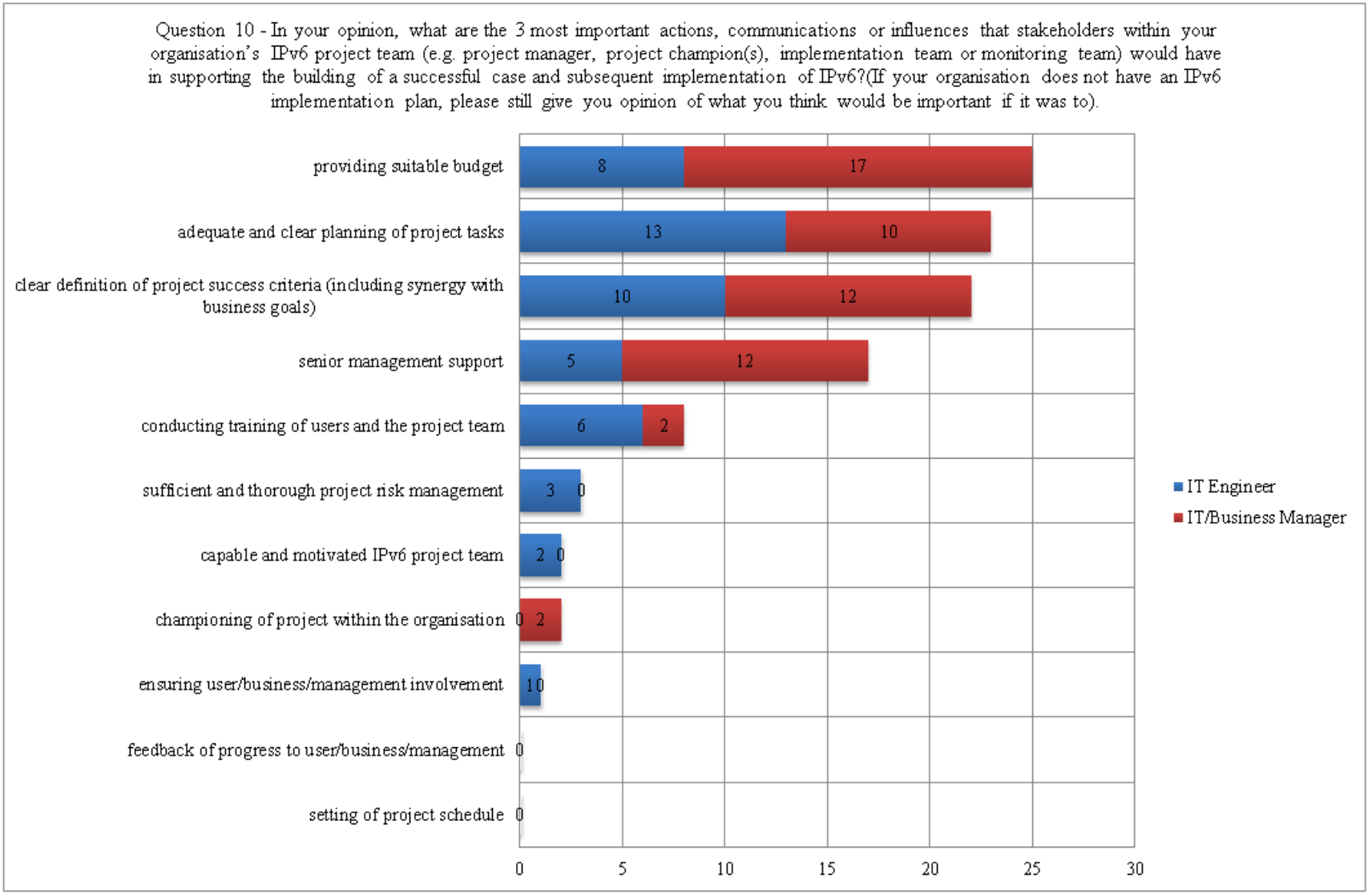


Figure A6-7 – Bar Graph of Delphi Method Responses (Ranked by Order of Importance) Question 10 – Round 3 (Final)
Raw data: Appendix 6 – Table A6-18

Appendix 7 – FMEA (Failure Modes and Effects Analysis) Analysis

Table A7-1 – FMEA Analysis

Table A7-1 - FMEA Analysis Title: IPv6: Identifying the critical factors to assist in building a successful business case for adoption

Research stage/process	Risk ID	Potential failure	Potential effect(s)	SR	Potential failure cause	LR	PRN	Prevention / Mitigation plan	PEN	RRF	Contingency Plan
Design of Delphi Method	R1	Poor design	Poor response data within questionnaire results.	5	Inexperience in questionnaire design.	5	25	1. Seek the advice of supervisor 2. Test prototype questionnaires on technical and non-technical colleagues	0.1	2.5	N/A
	R2	Insufficient selection size	Insufficient number of results to be able to draw sound conclusions.	6	Tight timeframe of T802 module having knock on effect of how many questionnaire can be reasonably distributed, completed and analysed in the time available.	4	24	1. Using the Delphi Method a view based survey such as this, may be conducted within the short time frame of the T802. 2. Ensure a large period of time is set aside to be able to complete at least 3 rounds of the Delphi Method. 3. Based on literature a 3 round Delphi process is seen as sufficient for a research project such as this. Skulmoski, G & Hartman, F (2007)	0.2	4.8	N/A
Design of Interview Questions	R3	Poor design	Poor responses to interview questions within arranged sessions.	5	Inexperience in interview (question) design.	5	25	1. Seek the advice of supervisor. 2. Test prototype interviews on technical and non-technical colleagues. 3. Read literature on interview (question) design to follow best practice.	0.1	2.5	N/A
	R4	Size of selection fails to give suitable results	Insufficient number of results to be able to draw sound conclusions.	6	Tight timeframe of T802 module limits the number of interviews may be successfully completed and analysed within the time available.	5	30	1. Another research method is needed to supplement the interviewing process. 2. Because scope is small interview questions designed to be best as possible and prototyped before being used. 3. Ensure interview sessions are made long enough to answer all the questions plus allowing time for elaboration (which could increase collected materials). 4. Interview used to "context build" in preperation of the Delphi Method technique, rather than a the core primary reearch method.	0.1	3	N/A

Interview Responses	R5	Interview conduct not good	Unable to engage with interviewee enough to get suitable interview answers.	**5**	Inexperience in conducting an interview.	**7**	**35**	Practice with colleagues (technical and non-technical) to get comfortable with the questions, format and conduct of an interview.	**0.1**	**3.5**	N/A
	R6	Interviews not fitting into available time	Unable to get all the interviews conducted in time.	**6**	1. Tight timeframe of T802 module limits the number of interviews may be successfully completed and analysed within the time available. 2. Interviewees are not available during my project interview window. 3. Interviewee has to cancel the booked date for some reason.	**4**	**24**	1. Ensure window for interviews is long enough to allow for difficulties in scheduling. 2. Contact interviewees sufficiently early enough to be able to arrange a time. 3. Prepare a follow-up interview period within schedule if there is a problem with the first date arranged, or the interviewee needs to drop out for some reason.	**0.2**	**4.8**	1. Conduct only a few interviews providing the function of "context" building in preparation of the Delphi Method (i.e. use them with a specific purpose, rather than as a full method.)
	R7	Interviewee(s) can't answer questions or introduce bias	Truthful or fully accurate responses to the Interview questions are not obtained.	**5**	1. Interviewee feels that their position may be compromised by answering the question. 2. Questions are not conducive to be answered easily.	**4**	**20**	1. Ensure they are on-board with the purposes of the interview. 2. Explain the results will be anonymised as much as possible to avoid identification. 3. Better interview question design, from prototyping, asking supervisor and following questionnaire best practice from literature.	**0.1**	**2**	N/A
	R8	Unable to recruit willing interviewee(s)	Unable to reach target number of interviewees to get a sufficiently broad result set to draw conclusions from.	**8**	Unable to get enough interviewees	**3**	**24**	1. Make use of participants within the local colleges of Hertfordshire, which will provide a sufficient number. 2. Contact college Principals to ask for assistance directly where required.	**0.2**	**4.8**	1. Use JISCMail via the JISC Technical Manager forums and mailing lists to find willing participants from across the UK.
	R9	Travelling costs prohibitive to conduct interviews	Unable to afford to get to all interview locations.	**6**	Unable to travel to complete all interviews.	**5**	**30**	1. All interviews are taking place within Hertfordshire, these are within a short travelling time by car from my house.	**0**	**0**	N/A
	R10	Interviewee wants to drop out	Unable to complete a sufficient number of interviews.	**4**	Unknown, an interviewee may drop out of personal, work or other reasons.	**7**	**28**	1. Ensure those taking part know what is going on to alleviate fears. 2. Be flexible with participants schedules as much as possible when arranging interviews.	**0.2**	**5.6**	1. Time available in the follow-up interview period to find a stand in and interview them if required.
	R11	Interviews create unclarified responses	Quality of answers gained not as good as expected.	**5**	Quality of interview questions low, so obtaining a suitable answer is difficult.	**5**	**25**	1. Consult supervisor and best practice literature about creating interview questions, identifying what I need to find out. 2. Follow up interview slot planned - arrange time within project plan for this to happen if needed.	**0.2**	**5**	N/A
	R12	Interview results not properly recorded	Not all that was said and discussed is properly recorded, quality of conclusions lower than desired.	**7**	Unable to keep up with note taking within interview so as to collect and document all the answers and ideas as they are being given over.	**3**	**21**	1. Tape record interview, so along with the contemporaneous notes, I'll have a record I can refer to at a later time.	**0**	**0**	N/A

Delphi Method Responses	R13	Insufficient number of completed questionnaires returned	Insufficient number of results to be able to draw sound conclusions.	**8**	Insufficient distribution to gain a sufficient number of responses, assuming that not all recipients will respond.	**7**	**56**	1. use easily creatable and distributable online methods rather than post. 2. Design questionnaire to be fairly short and asking easily answerable questions with minimal use of free text fields. 3. Obtain permission to distribute the questionnaire via UK FE and HE wide email groups hosted by JISC (e.g. JISCMAIL) 4. Use of the Delphi Method.	**0.1**	**5.6**	1. Ensure Delphi Method uses more than the minimum 12 participants required to start with, so that if there are drop outs, a minimum number of participants to ensure survey validity is maintained.
	R14	Unable to recruit willing participants for Delphi Method	Unable to reach target number of participans for the Delphi Method to get a sufficiently broad result set to draw conclusions from.	**8**	Unable to get enough interviewees	**3**	**24**	1. Make use of participants within the local colleges of Hertfordshire, which will provide a sufficient number. 2. Contact College Principals to ask for assistance directly where required. 3.	**0.2**	**4.8**	1. As a contingency plan, use JISCMail via the JISC Technical Manager forums and mailing lists to find willing participants from across the UK.
	R15	Participant would like to withdraw their questionnaire responses	Insufficient number of results to be able to draw sound conclusions.	**6**	The participants are not fully sure how their results are to be used or are concerned they may be mis-represented.	**4**	**24**	1. Ensure buy in from participants by explaining the purpose and how their results will be used. 2. Leave sufficient time within the project plan to be able to gain additional results if required.	**0.1**	**2.4**	N/A
	R16	During the survey using the Delphi method, a participant drops out.	Insufficient number of results to be able to draw sound conclusions.	**6**	Initial sample size too small to cope with one or two participants dropping out.	**4**	**24**	1. Assume that at least one participant is likely to drop out so look to distribute questionnaires to more than the minimum size you'd like to survey.	**0.2**	**4.8**	1. Ensure Delphi Method uses more than the minimum 12 participants required to start with, so that if there are drop outs, a minimum number of participants to ensure survey validity is maintained.
	R17	Size of survey insufficient to draw conclusions.	Insufficient number of results to be able to draw sound conclusions.	**9**	Method relies on obtaining a large number of results > 100, which is not possible within the time available.	**3**	**27**	1. Use the Delphi Method to improve the results using a smaller set of respondents in an iterative cycle.	**0.1**	**2.7**	N/A
	R18	Insufficient time for enough iterations of Delphi Method.	Quality of answers gained not as good as expected.	**8**	Not able to get enough iterations conducted within the short timescale of T802	**3**	**24**	1. Ensure a large period of time is set aside to be able to complete at least 3 cycles of the Delphi Method. 2. Based on literature a 3 round Delphi process is seen as sufficient for a research project such as this. Skulmoski, G & Hartman, F (2007)	**0.2**	**4.8**	1. Design methodology to allow 3 cycles of the Delphi Method as described by Skulmoski & Hartman (2007) as sufficient for a project such as this. 2. Ensure a "stopping rule" Pare et al. (2013) is in place to ensure the process can be brought to a logical conclusion.
	R19	Questionnaire distribution costs unaffordable	Unable to distribute all questionnaires.	**8**	Costs prohibitive to get the three rounds of questionnaires released, completed and returned.	**4**	**32**	1. Use online distribution which is either free or requires only a small fee for this scale of survey.	**0**	**0**	N/A

Analysis of Findings	R20	Analysis techniques (diagrams) not amenable to displaying the results of the research.	Unable to analyse situation adequately to be able to draw conclusions.	**7**	Rich Picture and Cause and Effect diagram can not be adapted to use for analysis of these research results.	**3**	**21**	2. Selected method is from literature and previous module in which failures have been successfully identified using these tools.	**0.2**	**4.2**	N/A
	R21	Format of interview and survey results not amenable to use in modelling techniques.	Quality of models and analysis with Rich Picture and Cause and Effect Diagram poor.	**7**	Research collected doesn't allow me to easily identify the core issues to be displayed within the selected analysis method diagrams.	**3**	**21**	1. Ensure that the structure of the questionnaire and interview (questions) are designed to meet the basic requirements of analysis with the select modelling and analysis diagram. 2. Use of categories to compartmentalise questions and therefore the results. 3. Ensure that there are sufficient quantitative questions to give more deterministic answers that are amenable to being represented in the diagrams. 4. Fit methods within an approach or framework that is designed to examine these kinds of problem, for example the Systems Failures Apporach.	**0.2**	**4.2**	N/A
Overall Research Methodology	R22	Bias introduced within the research methodology when it is conducted.	Quality of primary research findings deminished.	**9**	Research methods and techniques are carried out in such a way that bias is introduced.	**3**	**27**	1. Consult literature for best practice approaches to reducing bias and improving validity within the selected research techniques. 2. Consult supervisor for advice on reducing or eliminating bias from research methods. 3. Verify after conducting interviews that you have stuck to the best practice recommendations of literature and supervisior, if not repeat part or that entire research component.	**0.2**	**5.4**	1. Verify after conducting interviews that you have stuck to the best practice recommendations of literature and supervisor. 2. Confirm this by sharing the collected notes with the interviewees to enable them to comment upon any errors or omissions. 3. Further elaborate responses, within the follow-up interviews if needed to further clarify (or correct) the interviewee's responses if bias is found. Alternatively select a new participants to provide responses.

Appendix 8 – Systems Failures Approach

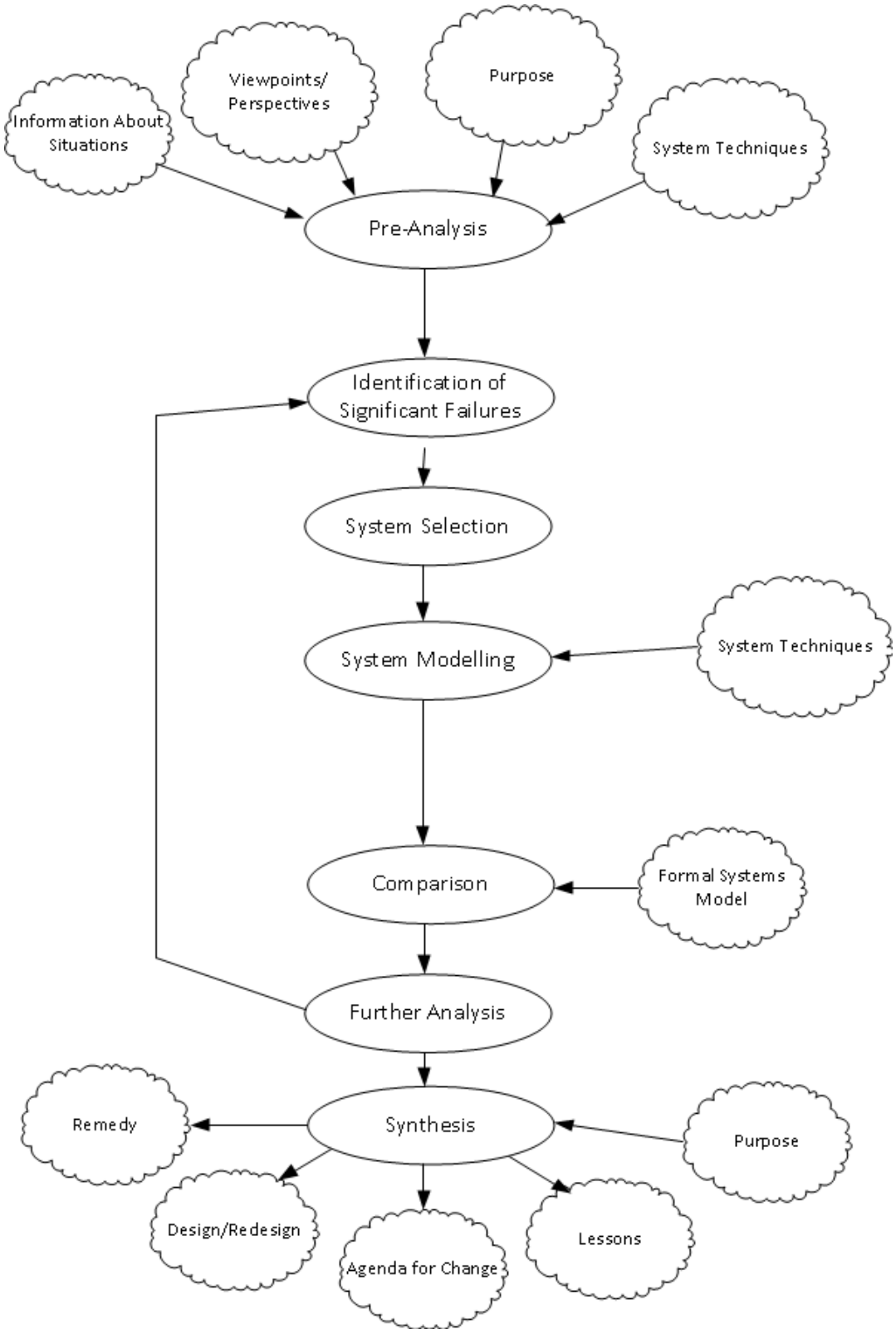


Figure A8-1 The Systems Failures Approach
(Fortune & Peters, 2005, p. 116)

Appendix 9 – Formal Systems Model

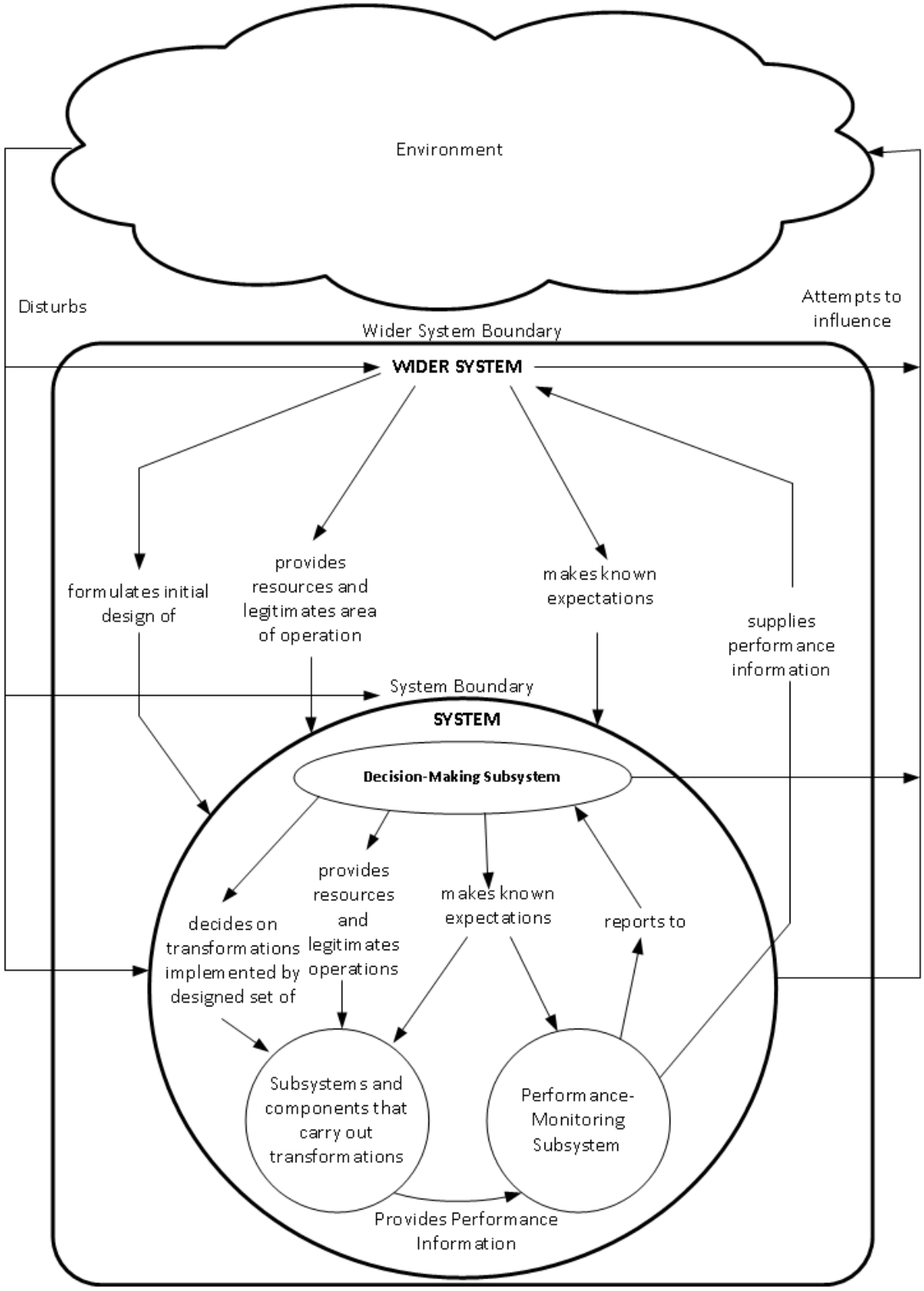


Figure A9-1 - Formal System Model
Taken From: (Fortune & Peters, 2005, p. 121)

Appendix 10 – Project Specific Form of the Formal Systems Model

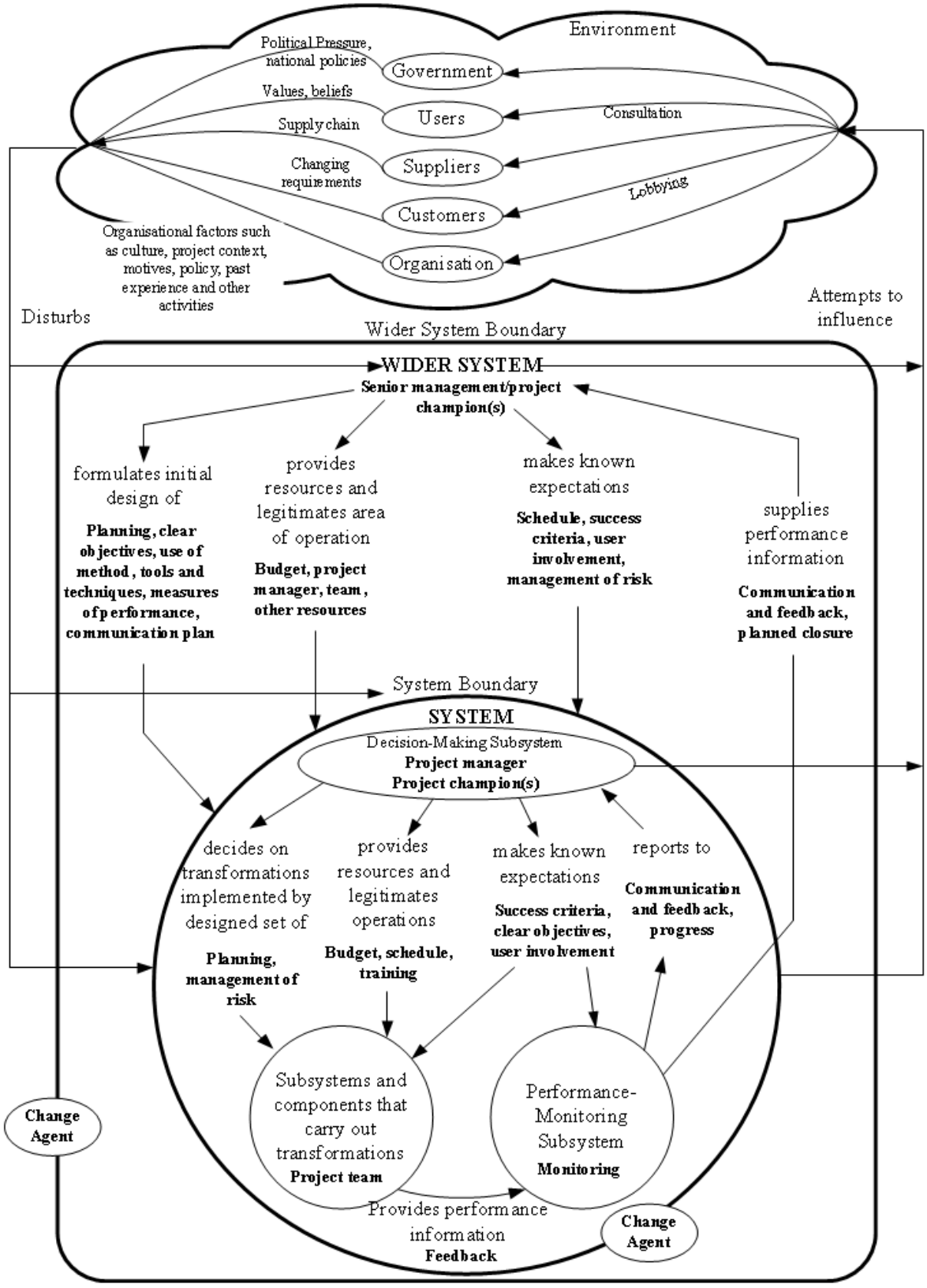


Figure A10-1 Project Specific Form of the Formal System Model (PSFFSM)
Taken from: White (2003)

Table A10-1 – Comparison between IPv6 project situation and the PSFFSM

Area	Aspect of the Formal Systems Model	Identified Discrepancies
Environment	Environment	The environment doesn't appear to be disturbing the wider system or system. I.e. although IPv4 address depletion is an encouraging factor, the UK government is not providing any real assistance and vendors are not providing any real incentives or support. There is also limited synergy of IPv6 with the organisation's goals yet; access to new functionality and services is important but not yet persuasive enough to build a successful case. Organisations are not using IPv6 so there is insufficient critical mass for others to be encouraged to do the same yet.
Wider System	Formulates initial design of	Business (organisation) cannot formulate an initial design of what they want from IPv6 because it has no clear objectives of how IPv6 could benefit them in reaching their business goals.
Wider System	Provides resources and legitimates area of operation	The ROI (return on investment) for a case is weak, so the area of operations cannot be legitimised. The management although having some interest in IT, does not provide the budget or support to allow a successful case to be made.
Wider System	Makes known expectations	The senior management does has little or no awareness of the benefits of IPv6, project champion(s) are missing, so expectations for what is wanted from an IPv6 project are missing.
Wider System	Supplies performance information	The IPv6 project team (system) is providing performance information, however it is not identified as important, and there is a lack of management "buy-in" to the project.
System	Decision making sub-system	Management support, project champions and project manager missing from the IPv6 project team (system).
System	Decides on transformations implemented by designed set of	Having adequate and clear planning of project tasks is important but is missing because of no management support. There is a lack of understanding of IT by the business and so a lack of understanding of technologies that might assist building a successful case.
System	Provides resources and legitimates area of operation	The project champion(s) if the existed would struggle to show a ROI of the project, or clear business advantage, in the short term. These missing resources means the area of operation cannot be legitimised.
System	Makes known expectations	There is a lack of expectations being set, a "leap of faith" is seemingly needed by an organisation to move an IPv6 project forward.
System	Reports to	The business is uninterested by "what is behind the curtain", essentially an IT infrastructure technology (like IPv6) is not what the organisation is interested in, as long as it works!
System	Subsystems and components that carry out transformations	There is no project team available, a shortage of IPv6 trained staff coupled with a lack of a mandate from the organisation.
System	Performance monitoring subsystem	Monitoring of an IPv6 project is seen as important but the business is uninterested unless implementing IPv6 leads to tangible benefits that show synergy with the organisation's goals or business strategy.

System	Provides performance information	No feedback to be given for monitoring the project.

Table A10-1 is based on the comparison of figure 4-12 the model of the current situation surrounding the building of a case for IPv6 within a modern organisation with appendix 10, figure A10-1 the ideal model developed from *White's (2003)* and *(Fortune and Peters', 2005)* Project Specific Form of the Formal Systems Model and Formal Systems Model.

Appendix 11 – Rich Picture

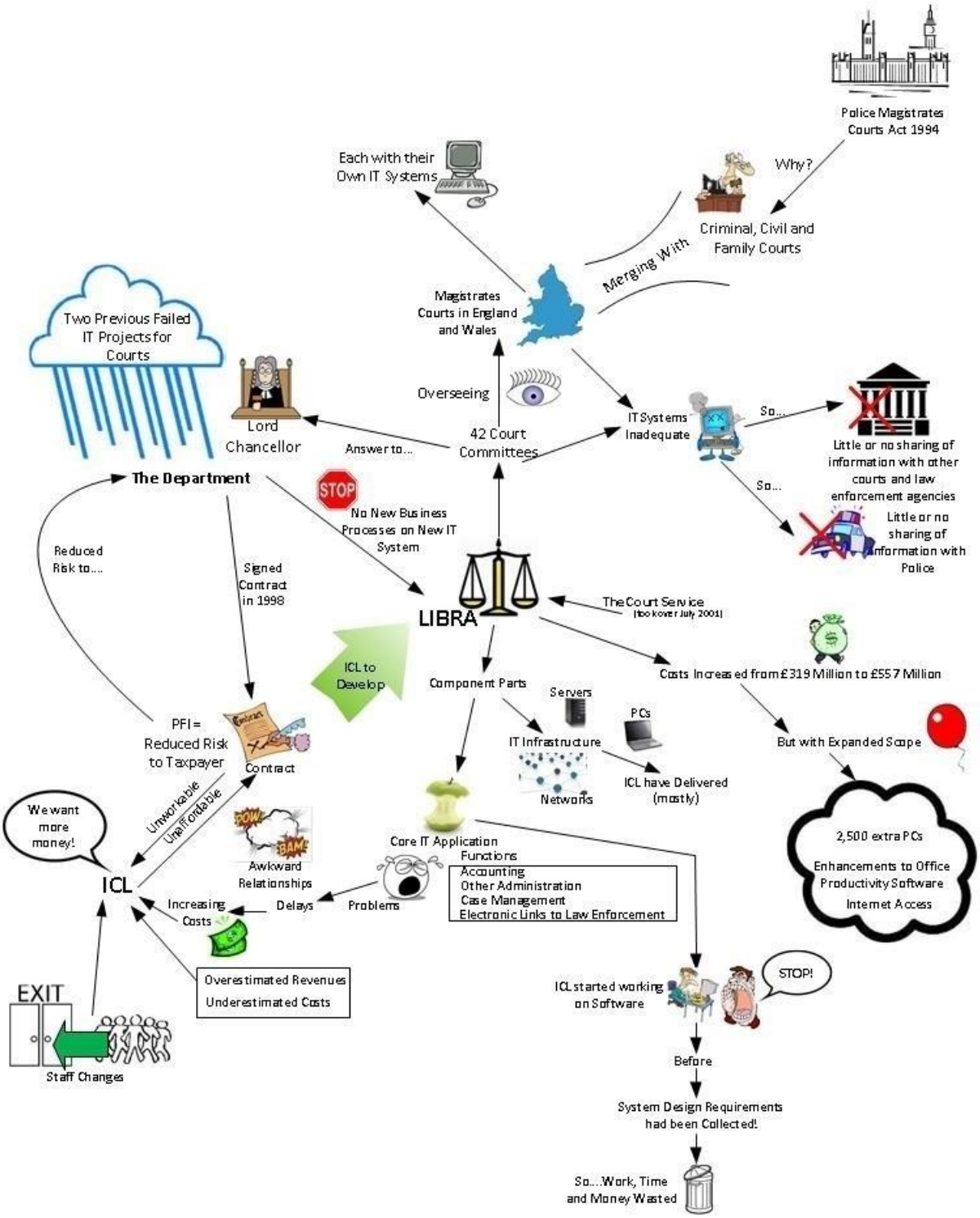


Figure A11-1 Rich Picture of Libra System and its Environment
Adapted from: (Fortune & Peters, 2005)

Appendix 12 – Delphi Method Survey Invitation Emails

The first email was sent to the JISCMail JISC-RSC-E-TECH@JISCMAIL.AC.UK mailing list to invite participants to volunteer to be part of the Delphi Method survey. Permission to use this mailing list was sought from the mailing list owner (JISC) and was permitted before sending the email to those on the mailing list. The second email was the mail sent from the SurveyMonkey web survey tool to all those who had volunteered with the URL (Uniform Resource Locator) web link to the first round of the survey, the third and fourth following for the second and third round.

Subject:

Request for your participation in an MSc research project survey (FE Colleges only please)

Body:

Dear Sir/Madam,

I am emailing to ask if you would be interested in participating in an MSc research project. The research focus is on the identification of how and what is needed for IT practitioners and/or business leaders to build a successful case for the IPv6 (Internet Protocol version 6) protocol adoption on their organisation's IT networks and internets; using UK FE colleges as a vector for this analysis.

For this survey I am using the Delphi Method, an iterative survey technique, comprising of 3 rounds, each of around 10 questions. It is expected each round of questions should take about 10 minutes to complete, each within a window of around 7 days to collect the completed responses of each round.

The proposed timetable for this is as follows:

Round 1 Questionnaire: Saturday 25th April 2015 until Sunday 3nd May 2015.
Round 2 Questionnaire: Monday 4th May 2015 until Sunday 10th May 2015.
Round 3 Questionnaire: Wednesday 13th May 2015 until Wednesday 20th May 2015.

If you are interested in taking part, please email me directly (at *emailaddress*) to register, please do not reply on this forum/mailing list as it is necessary that the participants do not know specifically who else is taking part, to ensure the validity of this process.

On receipt of your email I'll then forward the URL to first round of the web survey for you to complete, this email will be sent from the SurveyMonkey web survey website; I'll also include some more information about the process within this email and the survey first round will open for responses from Saturday 25th April 2015.

I would be very interested in your input and many thanks in advance for your time, thoughts and any help you can provide. If you would like to have a copy of the finished dissertation, please let know.

Yours sincerely,

Tristan Self
T802 MSc Student, The Open University

Round 1 – Survey Round 1 Invite Email

Subject / Message Header:

MSc research project survey on IPv6 (Internet Protocol version 6) adoption (Round 1 of 3)
IPv6: Building a successful case for adoption by understanding failure - Delphi Method Survey Round 1

Body:

Dear Sir/Madam,

I am emailing to ask if you would be interested in participating in an MSc research project, for those who have already agreed to take part, thank you for your assistance. The research is focussing on identifying how and what is needed for IT practitioners and/or business leaders to build a successful case for IPv6 (Internet Protocol version 6) protocol adoption within their organisation's IT networks and internets.

This survey makes use of the Delphi Method, an iterative survey technique (of 10 questions), comprising of 3 rounds, each of around 10 questions. It is expected each round of questions should take about 10 minutes to complete, each within a window of around 7 days to collect the completed responses of each round, the format being:

1. Send the first questionnaire to the participants.
2. Collect and collate the first questionnaire.
3. Send out this collected information back to the participants to ask you to revise/update your opinion(s) in view of the other expert's responses.
4. Then to collect and collate this second questionnaire.
5. Send this collected and collated information out once more to ask you for again to revise/update your opinion(s) in view of the other expert's responses.

This process is designed to hone in on a consensus within the participants surveyed on the questions posed, but it does not mean that you or the other participants will reach consensus in answering the questions of the questionnaire. The value to the research process, you and the other experts consulted, will be the reasons for the points of view held, and any disagreement between them becoming clearer throughout the iterations of the method.

The information collection will be done anonymously, so neither you nor your organisation will be identifiable to the other participants during the research process or in the completed research write-up; being identifiable only by a number to facilitate the research process. The completion of each iteration of the questionnaire should take no more than 10 minutes, of which there are expected to be 3 iterations over the next few weeks. If you would like to be sent a copy of the completed dissertation (at the end of the course) I'd be happy to make this available to you, if so please contact me to request this.

Thank you again for your assistance, you will find the link to the survey below. This first round of the survey closes on Sunday 3rd May 2015, after which the results will be collated and the second round sent out.

Yours sincerely,

Tristan Self
T802 Student, The Open University

Round 2 – Survey Round 2 Invite Email

Subject:

MSc research project survey on IPv6 (Internet Protocol version 6) adoption (Round 2 of 3)

Message Header:

IPv6: Building a successful case for adoption by understanding failure - Delphi Method Survey Round 2

Body:

Dear Sir/Madam, Thank you for your participation in the first round of this questionnaire. As I explained in the email for the first round, this research uses the Delphi Method to attempt to obtain a consensus from a group of experts, through multiple iterations of questionnaires; 3 in the case of this research. When answering this round of questions, please consider the results of participants' responses from the previous round before answering the questions. These will be shown under each question in the form of a graph. Based on the other respondent's responses shown in this graph: you may choose to refine your choices, change them completely or not alter your opinion at all. As a reminder to assist you in reaching your conclusions, I've attached your responses to the first round of the questionnaire to the bottom of this email. Once again thank you for your assistance in this research project. You should find an email (from SurveyMonkey) with the link to the survey send along with this email; please check your spam folder if you don't see it, if you haven't received it please let me know and I can resend it to you. The return date for this iteration is Wednesday May 27th 2015, please let me know in advance if you are unable to meet this deadline. Yours sincerely, Tristan Self T802 Student, The Open University

Round 3 – Survey Round 3 Invite Email

Subject:

MSc research project survey on IPv6 (Internet Protocol version 6) adoption (Round 3 of 3)

Message Header:

IPv6: Building a successful case for adoption by understanding failure - Delphi Method Survey Round 3

Body:

Dear Sir/Madam,

Thank you for your participation in the first and seconds rounds of this questionnaire. As I explained in the email for the first round, this research uses the Delphi Method to attempt to obtain a consensus from a group of experts, through multiple iterations of questionnaires; 3 in the case of this research.

This is the final round of questions for this survey; please consider the results of participants' responses from the previous round before answering the questions. These will be shown under each question in the form of a graph. Based on the other respondent's responses shown in this graph: you may choose to refine your choices, change them completely or not alter your opinion at all.

In this final round you'll not only be selecting your final choices, but then ranking your choices in order of importance.

As a reminder to assist you in reaching your conclusions, I've attached your responses to the first round of the questionnaire to the bottom of this email.

Once again thank you for your assistance in this research project. You should find an email (from SurveyMonkey) with the link to the survey send along with this email; please check your spam folder if you don't see it, if you haven't received it please let me know and I can resend it to you.

The return date for this final iteration is Tuesday June 9th 2015, please let me know in advance if you are unable to meet this deadline.

Yours sincerely,

Tristan Self
T802 Student, The Open University