THE CREATION AND APPLICATION OF TWO INNOVATIVE REAL-TIME DELPHI AND CROSS-IMPACT SIMULATION APPROACHES TO FORECAST THE FUTURE: FORECASTING HIGH-SPEED BROADBAND DEVELOPMENTS FOR THE STATE OF HAWAI‘I

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ABSTRACT

Technology development is moving rapidly and our dependence on information services is growing. Building a broadband infrastructure that can support future demand and change is therefore critical to social, political, economic and technological developments. It is often up to local policy makers to find the best solutions to support this demand and development.

Because policy making is inherently a long-range planning exercise optimal solutions are best identified using methodologies that deal with planning for alternative futures. Futures methodologies identify, study, and plan for alternative futures, and are therefore a good fit to increase the probabilities of success when developing telecommunication policies.

The goals of this study were to contribute to methodology in the futures field by evolving and extending existing methods, to create an expert based model for future broadband related developments in Hawaii, and to develop recommendations for future Hawaii broadband developments.

The study took advantage of recent technological developments to evolve and extend well known futures studies methodologies and develop novel Real-Time Delphi and Cross-Impact simulation software. Next, future broadband related trends and events were identified via interviews with high level telecommunications experts. These trends and events were then used as input in the Real-Time Delphi software for expert forecasting. The output from the forecasts were used as input to the Cross-Impact simulator, creating

and exploring models of possible, probable and desirable futures for broadband in Hawaii. The final results were recommendations of specific focal areas for broadband developments in Hawaii.

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1 INTRODUCTION

Technological development is moving rapidly, and society's information production and demands are growing exponentially. Building an information transportation infrastructure that can support future demand and change is therefore critical to the social, political, economic, and technical development of society. How to best develop and take advantage of this infrastructure can differ from place to place; it is often up to local policy makers to find the best solutions to support future demand and development in their respective areas. Because policy making is inherently a planning exercise, optimal solutions are best identified using methodologies that deal with planning for alternative futures. Methodologies for identifying, studying, and planning for alternative futures are therefore required in order to increase the probability of success when developing telecommunications policies.

This study identifies and forecasts future opportunities and threats regarding high-speed broadband developments in Hawaii. It collects expert data to create a model of the interrelationships between these opportunities and threats, which in turn is used to simulate alternative future scenarios for the development of high-speed broadband in the State of Hawaii. The study identifies the most important opportunities and threats, and uses the data to create a simulation model that charts interactions. These simulated interactions are then used to see which of the opportunities and threats are the most critical to track and guide. The scenario simulations are applied so that constantly changing drivers of change can be identified. As a result, opportunities can be enhanced, and threats can be reduced, whether in an individual organization or in society at large.

The study combines and significantly enhances generally accepted and widely-used futures studies methodologies, which is an important contribution on its own accord. The ultimate goal of this study is to provide concrete policy recommendations for guiding decisions of how to best deal with the threats and to best take advantage of the opportunities in the short, medium and long range future.

By simulating how the most important threats and opportunities of broadband implementation interact, specific recommendations for policy making and policy changes for broadband development in the State of Hawaii could be made. These recommendations can, in turn, be used to assist policy makers or company owners in areas that have a similar context. Finally, recommendations generated by this study can serve as a starting point for how businesses can better position themselves in the Hawaiian market (amongst others), in order to take advantage of future opportunities.

To accomplish these goals, the study combined and enhanced generally accepted futures methodologies. In this study, the primary methods used are Real-Time Delphi and Cross-Impact analysis. To assist in the study, a new software package was created that takes advantage of recent technological advancements. It significantly expands upon current implementations of methodologies, in order to better suit studies that identify how technology and developments are rapidly changing the potential opportunities and threats and how they are interacting with each other. The software is generic and can be applied to any study that employs to use Real-Time Delphi methodology and Cross-Impact Simulation.

1.1 Background

In 2008, the State of Hawaii published a report about the economic status in Hawaii. The report identifies the State as having one of the least diversified economies in the United States, with a current rank of 46 (Sharma, 2008). One of the main sectors of the economy in Hawaii is tourism. It creates one in three jobs, but shows very limited growth potential (*Hawaii Statewide Comprehensive Economic Development Strategy*, 2005). This leaves the economy in as a fragile a state as existed when the New York terror attacks occurred in 2001. This greatly affected tourism in Hawaii and thereby threatened the economy of the State (Bonham, Edmonds, & Mak, 2006; Bonham & Gangnes, 2001). The Statewide Comprehensive Economic Report emphasized that a more diversified economic foundation is needed. This recommendation comes from a number of different sources (Bonham & Gangnes, 2001; Dator & Dunagan, 2006; Glenn, 1994; Hawaii State, 2011; *Hawaii Statewide Comprehensive Economic Development Strategy*, 2005; Sharma, 2008).

The Organisation for Economic Co-operation and Development (OECD) (2011a) points out that:

> "Future economic growth in Members and non-Members will depend greatly on the ability to utilize high-speed Internet access to support

> breakthroughs in areas such as cloud computing and smart infrastructures. To fully reap the benefits of high-speed broadband, countries will have to develop and promote broadband Internet access and coverage at high speeds" (p. 2).

This is reinforced by new findings that suggest that increasing the speed attainable by current broadband infrastructure has a consistent and persistent positive effect on the growth of GDP (Greenstein & Mcdevitt, 2009; Katz, 2012)

Broadband is perceived as a technology that has a wide impact on a variety of industries. It also impacts social interaction and interaction between entities, which can lead to a range of new and innovative services both in private and public sectors, as well as private households. These innovations can diffuse rapidly across economies, and the economic impact of broadband is therefore frequently linked to competitiveness in the market. In addition, the speed at which broadband is adopted is often linked to lower prices and better quality. The OECD concludes that policy makers should therefore review regulatory frameworks to discover ways to increase bandwidth and adoption (OECD, 2009).

The United States is currently ranked 15th in the world in broadband adoption and expansion, and the trend is on a downward slope (OECD, 2011b). Ken Wirt, a vice president at CISCO systems warned in 2008 that Hawaii was quickly running out of bandwidth as demand increases (Miyake, 2008). A refocused development of increased bandwidth at affordable prices is therefore needed for Hawaii to be competitive both nationally and internationally.

As in so many other industries, an efficient telecommunications infrastructure is a prerequisite for the development of information and communication technology (ICT) services and industry (Castells, 1999). Telecommunications infrastructure is identified as an information and communication technology enabler that consists of services shared by individuals and institutions. It is an enabler of more efficient and effective creation, adaptation, and diffusion of useful information (Branscomb, 1994). Hawaii's remote location makes developing telecommunications infrastructure even more critical because of time and space constraints. In addition, Hawaii had in 2008 the 42nd slowest connection amongst the US 50 states (Newman, 2008). One report finds that 55% of Hawaii households have Internet speeds below the national minimum FCC recommended standard at 4mbps (The Communications Workers of America, 2010). As one of the major drivers in both emerging and current economies, telecommunication infrastructure has been identified by many different large international organizations as critical in developing and keeping a thriving future ICT industry. This leads to the conclusion that Hawaii needs to develop strategies for new broadband policies. These could be informed by forecasted futures scenarios using expert knowledge about relevant future events and trends.

As technological capacities increase, our choices have more impact on the shape of the future. Future planning efforts often start with a goal, which then leads to policy making. These efforts frequently trigger a series of processes that supports the policy making process.

The pace of technological advancement changed radically when President Kennedy proposed a long-range goal of landing a man on the Moon. It led to a sequence of events, in terms of technology advancements, to accomplish the goal set forth by the President. In more specific terms, it led to the invention of satellite communication, the creation of new and better materials, and advancements in medicine.

"Society cannot control the future, but it can influence the course of history. This influence makes the effort to consider the balance between what we want and what is possible, to be worthwhile" (Glenn, 1994, p. 3).

For a long time, policy makers in Hawaii have debated an initiative to create a state wide broadband policy. The Broadband Task Force was created in 2008 with the goal of recommending a broadband plan for the State of Hawaii (House of Representatives, 2007). The Task Force retired as the new broadband initiative was introduced. In August 2011, a broadband policy outline was published with the vision that: "All of Hawaii's citizens will have access to ultra-high-speed gigabit broadband services at affordable prices by 2018" (Hawaii State, 2011, p. 1). It continues to state that "World-class broadband services and their application will improve overall productivity, support innovation and creativity, lead to job creation, and improve the overall quality of life through advances in education, health care and civic engagement" (2011, p. 1). A more thorough discussion on what broadband is and how it should be defined is included in the literature review section. It is sufficient to say that even the definition of broadband changes over time (International Telecommunications Union, 2011; Kim, Kelly, & Raja, 2010; OECD, 2008).

The ever-changing landscape of technology is one of the issues that makes policy making for broadband a high-risk undertaking. Technological development within the area is rapid, and the target is not static. This changing landscape requires that broadband policies be able to accommodate that moving target, and be functional in any of several possible future scenarios. There are many examples of at least partially failed policies in this sector. For instance, the Telecommunications Act of 1996 had good intentions, but its goal of deregulation to some extent failed, and instead of increasing competition, massive consolidation was the result (Crawford, 2013; Kimmelman, Cooper, & Herrera, 2006; Nuechterlein & Weiser, 2005). The idea behind the act was to open up new competitive markets. Instead, the increase in the speed of technological innovation combined with technology industry convergences lead to an unforeseen massive consolidation of media (Crawford, 2013). In addition, the Telecommunications Act did not cover the consequences of massive media convergence that became the outcome of the policy. It could have been more successful if policy makers had attempted to plan with a longer time horizon.

1.1.1 The Study

The study identified potential opportunities and threats related to broadband development in Hawaii in the next 20 years. Additionally, it simulated how these opportunities and threats interacted, for the purposes of discovering which factors are most important to focus on when developing relevant policies.

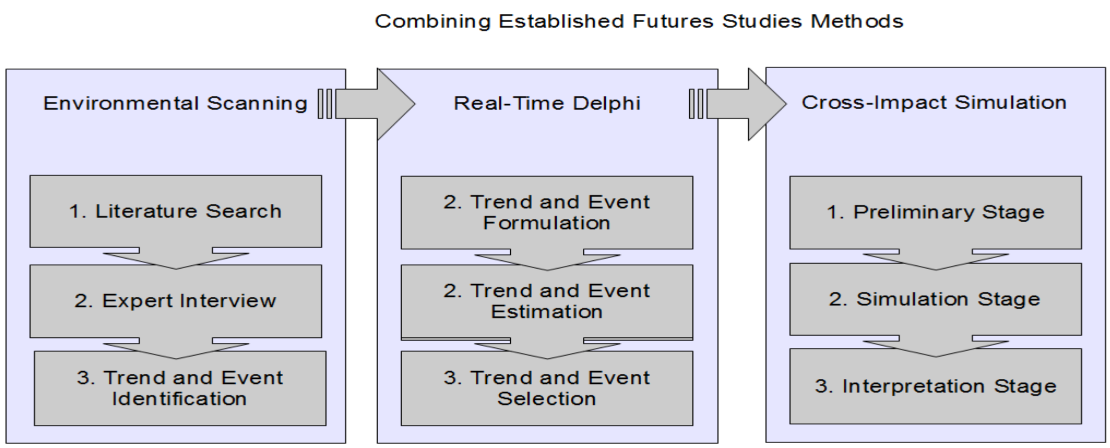

Figure 1: Study Methods

This was achieved by applying a combination of well-known and generally used futures studies methodologies: Real-Time Delphi and Cross-Impact Simulation. The study produced two methodological software tools called RTD2 and XImpact, that supports the combination of these methodologies for research beyond this particular study. The combined methodology included the sub-steps outlined in (Figure 1: Study Methods, p. 21). Before the Real-Time Delphi process began the study conducted an environmental scanning process to identify the most influential trends and events for each of the social, economic, technological, and political facets of influence. Those trends and events were then assigned various forecasts by experts. Once the experts had rated the trends and events, the software supported the process of identifying the most important trends and events to focus on in the following simulation. The Cross-Impact Simulation started with the preliminary stage where the most important trends and events from the Real-Time Delphi were reduced to a smaller set of representative trends and events, selected based on the judgments made by experts in the field of telecommunications, and more specifically, how those trends and events relate to Hawaii. The study then identified the most influential trends and events as input for the simulation. The study assumed that the experts' input in the Real-Time Delphi already accounted for the interactions between trends and events. The trends and events were then entered into the software.

A calibration of the model for simulation was completed to fit with the data created in the Real-Time Delphi. Once the model was calibrated, the software could perform simulations of different scenarios to see what effects the scenarios settings had on the outcome of those trends and events. The output of the simulations were interpreted and concrete recommendations for broadband development in Hawaii were made.

The outcomes of the study were threefold. First of all, the study identified specific opportunities and threats in regards to future broadband development in Hawaii, using both qualitative and quantitative data. Second, the study significantly enhanced a traditional Real-Time Delphi approach with a feature used in regular Delphi studies of adding to experts' self-evaluation of their confidence level, along with a self-evaluation of their expertise level for each question addressed. A software tool was created to implement this. Finally, the study combined and implemented the Real-Time Delphi method with Cross-Impact Simulation in a novel software, that used the outcome of the Real-Time Delphi as input to create a futures Cross-Impact Simulation. The outcome of the futures simulations comprised a ranked list of the most important focal areas for developing broadband in Hawaii. The simulation supported a normative process of focal areas that need attention in order to achieve a successful implementation of broadband in Hawaii.

This outcome can serve to support broadband policy making as well as decision-making for individual companies affected by the Broadband Initiative so that they can best position themselves in response to events and trends identified by the study. In addition, the outcomes may be seen as a model for other states that would like to develop their own broadband policy.

1.1.2 Rationale

policy making in general is a challenging planning effort, and industries where technological developments are changing as rapidly, as in the ICT field, policy making with long terms goals of implementation is even more difficult. The Hawaii Broadband Initiative has recently published a policy outline with four primary goals (Hawaii State, 2011):

- Ensure ubiquitous access to world-class gigabit-per-second broadband service at affordable prices throughout Hawaii, without leaving behind our underserved communities (p. 1).
- Increase the use of high-speed broadband services and applications for economic development, health care, education, public safety, governmental efficiency and civic engagement while reducing the digital divide that leaves some citizens behind (p. 1).
- Reduce Hawaii's barriers to global participation by promoting greater trans-Pacific fiber connectivity and ensure equitable access for all our islands (p. 1).
- Develop and implement a modern regulatory and permitting environment that supports and advances investment in broadband infrastructure and services for the public (p. 1).

This study looked at the more generic impact of high-speed broadband in Hawaii, rather than following this proposed policy outline because policies often change from initial draft stage to final implementation. The current broadband plan is an ambitious goal that, if implemented correctly and with the necessary supporting structures, may have significant impact on Hawaii. The successful implementation of a broadband policy that deals with telecommunication as a growth engine for economic development faces challenges in both the present and future. Identifying future threats and opportunities, and exploring how they might interact, is the main goal of this study. There are many considerations to make, especially in a state like Hawaii, which has unique geographic, cultural, and political considerations to deal with. A structured undertaking, using expert knowledge to identify inherent risks of trends and events and then using futures simulation to find the interaction of these trends and events, is therefore needed. This will effectively lead to a better understanding of what the main risks and opportunities are in the sector.

1.1.3 Need for the study

Internet access has been proposed by the United Nations as a new human right (LaRue, 2011). Finland has already identified it as critical for the country's economic prosperity, and have enacted policies and laws that ensure broadband for all its citizens (BBC, 2010). Access to broadband is a tenet to economic development because it is a pro-sumer technology; users are provided the opportunity to contribute to economic growth by offering services (Atkinson, 2007). Telecommunication technologies are critical to better information access, which in turn is crucial for the development of a more diversified economy in Hawaii. The OECD recommends ubiquitous, government-supported broadband development supported by the government (Reynolds & Wunsch-Vincent, 2008). The connection between economic prosperity and increased broadband development may not be a linear one, but the common assumption is that high quality broadband can increase economic growth if effective policies are implemented and the biggest threats are avoided (House of Representatives, 2007; Newman, 2008; The Communications Workers of America, 2010). Recent studies support this notion, and attribute sustained economic growth directly to an increase in bandwidth (Katz, 2012).

As the demand for bandwidth grows, many industries will be increasingly dependent upon a reliable fast broadband connection (*Hawaii Statewide Comprehensive Economic Development Strategy*, 2005; Kim et al., 2010). The reliability, resilience and recoverability of the network, along with an understanding of other potential opportunities and threats, are critical to effective policy making. In a multifaceted context, it is important to decision makers to know what the projected forecasts are. Olufs points directly to the importance of asking questions about the future of telecommunications before implementing policies (Olufs, 1999). Exploring views of projected futures images can have a reflexive effect on how the future develops (Giddens, 1984, 1990). By exploring the future, we can change today, in order to lead our society towards more desirable options.

At present, there are no futures-oriented studies that focus on opportunities and threats for broadband implementation in Hawaii, nor is there currently an encompassing broadband theory that provides a good framework for Hawaii to build upon. Though general studies over large areas are plentiful, ill-fitted information might be detrimental when making specific forecasts for Hawaii. One of the major reasons for doing an anticipatory study is to explore how the forces that influence the future images of broadband are interrelated, and subsequently, to identify which of those forces are the most critical to focus on in order to increase the probability of creating a more desirable future. As technology evolves and computational power increases, so does our demand for bandwidth. In turn, as new technologies and services are developed, the potential for cheaper, higher quality bandwidth increases. How to position oneself in the market, anticipate future developments, and avoid future pitfalls, is important, and knowing how to direct policy to maximize these developments is critical.

In terms of methodologies, futures studies is a fast-evolving field that needs to take better advantage of newer technologies (Gordon & Pease, 2006). Recent developments of Real-Time Delphi have started this process, but using more modern technologies to evolve the methodologies further has yet to be explored. Combinations of futures studies methodologies have so far been performed manually, and while combining Real-Time Delphi with Cross-Impact Simulations has been mentioned as an important process yet to be implemented (Gordon, 2009). This study seeks to both combine these methodologies, and to implement them using current technology, making it easier for users to participate.

The main objectives for the research can be summarized as follows: it aimed to utilize future foresight to support a needed policy planning effort for high-speed broadband development in the State of Hawaii; it combines two futures studies methodologies, Real-Time Delphi and Cross-Impact Simulations; and it created and used a new software tool implementing a Real-Time Delphi with a Cross-Impact Simulation engine, that can also be used in other futures related studies.

The study did not attempt to predict the future; it forecasted future images by mapping probabilities of events occurring, what impact they might have on other events, and to what degree they affect changes to trends. It then simulated how these events and trends interacts, in order to discover which are important to focus on for a more successful implementation of effective broadband policies.

1.2. Research Questions

RQ1. What threats related to broadband development are likely to impact Hawaii the next 20 years?

RQ2. What opportunities related to broadband development are likely to impact Hawaii the next 20 years?

RQ3. How can a workable model of the most critical drivers be built and tested?

RQ4. What concrete recommendations for policy makers can be given regarding broadband development in Hawaii on the basis of futures simulation?

The Social, Technological, Economic, and Political (STEP) analysis is used in strategy development for companies and governments as an aid to understand the external environment in which they will operate. It is primarily concerned with the opportunities and threats of a Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis. These are the external factors that influence broadband development. In a STEP analysis, there are three main steps: creating a list of external factors; developing a way of finding the implications of those external factors; and deciding the relative importance of those external factors.

In this context, a threat refers to an external element in the environment that could have a negative impact on the broadband development, and an opportunity refers to any external factor that has a positive impact on broadband development in Hawaii. For each factor of the STEP, this study identified and quantified the implications of the opportunities and threats.

Once the opportunities and threats were identified, data about how they influence each other were used in a model simulation created from data provided by experts. This interrelationship between drivers of change is critical to understanding which specific drivers are the most important to focus on to improve chances for success in policy making environments. Once the created data had been incorporated into the simulation, the results could be interpreted, and concrete recommendations could be provided to improve the chances of implementing successful policies.

1.2.1 Assumptions and Limitations

One of the assumptions of this study is this study does not do predictions, but rather use experts' estimation of the probabilities of occurrence of events or changes in trends. The mere suggestion of a forecast will influence the current situation, thereby effectively changing the outcome of the future. This reflexive relationship between the current state of affairs and a possible future has been explored by social theories

(Giddens, 1990). This leads to a situation where validity is not a goal in itself. The study also assumes that the future is not deterministic.

A limitation is that the base assumption for the simulation study is that an event can only occur once, and that trends do not influence occurrences of events.

2 LITERATURE REVIEW

This chapter has two main parts. First it will discuss the methodological background for future studies, and its epistemological foundation. Secondly, it will discuss broadband and telecommunications policy making.

2.1. Grounding the research

The general theoretical models used in this study come from Castell's network society, where networks are the new social morphology for society (Castells, 2000). This network society is organized around capital, management, information and knowledge whose technological access is at the roots of productivity and competitiveness. Government, private and public organizations and institutions are all organized in networks of differing topologies. These topologies change and merge and to a large extent, extinguish the distinction between large and small business, between private and public, and between time and place. It spreads along varying geographical clusters of economic units, leading to a work process that increasingly is aggregated by a multiplicity of interconnected tasks in different sites- all based on the skills of the worker (Castells, 1999, 2007). A basic premise for this to work is easy access to information and ability to connect to these topologies.

In addition to the perspective of observing how the interaction between technology and humans work, we will adopt a normative social informatics orientation. Kling notes social informatics usually focuses on the near term (5-to-20-year perspective) and does not attempt a disconnected discourse, but rather focuses on the future by identifying relevant experts to create a link to knowledge that can indicate our likely social futures (Kling, Rosenbaum, & Sawyer, 2005). As indicated in the previous frameworks, social informatics emphasizes the reflexivity between technology and humans in a socio-technical system. One of the most commonly agreed upon working definitions of social informatics is "the interdisciplinary study of the design, uses, and consequences of ICS's that takes into account their interaction with institutional and cultural contexts" (Kling et al., 2005, p. 6).

One of the major impacts of social informatics is its tenet recognizing that systems are complex and reflexive. While socio-technical systems are studied in a futures context, the system itself is irreducible, and therefore all the major facets have to be considered. The normative orientation of social informatics recognizes that ICT's are more successful when major stakeholders influence and support the development. In a broadband policy environment, this means engaging with experts in policy and telecommunication along with practitioners with a special interest or knowledge of broadband or influencing factors. The general public largely ignores big policy implementations, so they might therefore have very little information to contribute to the developments or factors that influence the successful implementation (Olufs, 1999). As we will see in the next section, it is critical that the experts invited to participate have a varied background within the field of telecommunications and more specifically broadband policy making.

2.1.1 Field of Futures Studies

Policy making is indivisibly linked to planning and decision making that deals with future events and trends. This planning effort then influences the current status and therefore changes what the futures event might have been. Giddens (1990) asserts, “Modernity is inherently future oriented, such that the “future” has the status of counterfactual modeling.[...] Anticipations of the future becomes part of the present, and thereby rebounding how the future actually develops” (p. 157). This statement emphasizes the importance of understanding how reflexive policy development and policy evolution is. It is in this context, I situate my choice of research methodology.

Future studies as a field has a long tradition, dating back to its first emergence in the fifties (Bell, 2009). Suffice to say the study's methodology has a long track record in academic, public, and private institutions such as Central Intelligence Agency, Millennium Project and large multinational institutions such as the United Nations.

In general any future studies undertaking assumes that the future is not deterministic, and that it therefore can be changed. Many methods in the field also have a flavor of normativeness. Following up on the theoretical framework that situates the research, a normative study seeks not to discover what will necessarily be, but to explore how things can come about and to what extent those scenarios are desirable. One of the main tenets for future studies is that “the likelihood of a future event can be changed by policy, policy consequences therefore can be forecasted” (Glenn, 1994, p. 6). These forecasts can also be graded in terms of the expert level of the participant and the participant's confidence level.

Planning for the future is by no means a trivial task. The current rate of technological development far outpaces the government's ability to implement policy. Policy makers can find themselves constantly outpaced by technology and technology's use, sometimes even before policies are enacted. For example, the Telecommunications Act of 1996 in many respect failed to serve its purpose because the policy makers did not accurately anticipate how the market evolved (Olufs, 1999).

2.2. Futures Studies

In 1996 John Gibbons, assistant to the President, introduced a plan to reduce the cost associated with natural disasters. It argues one of the most important shifts needed is from one of response to a forward looking planning effort where attention shifts from the current emphasis of reaction to one that does long-range risk assessment (Gibbons, 1996). This is not a new issue; those in the field of futures studies have advocated shifts like this since the sixties (Bell, 2009).

Futures studies generally serves the purpose of long-range planning. This ability to plan is seen as "a human attribute that allows us to weight up pros and cons, to evaluate different courses of action and invest possible futures on every level with enough reality and meaning to use them as decision-making aids" (Slaughter, 1995, p. 1). Future studies lends itself well to any framework that deals with complex problems and future planning. Policy making is also inherently a planning effort in complex social systems, making futures studies an ideal companion to explore and anticipate the trends and events that affect development. Even if futures studies only became a field of scientific inquiry after the second world war, it has always been part of the nature of human kind (Bell, 2004, 2009).

Some of the large scale events that impacted America over the past decade or so were forecasted. For example, before the September 11 attacks in 2001, many warnings and indicators predicted a terror attack, even the specific tools and targets were identified (Cornish, 2005). However the warnings were not heeded and nothing specific was done to prevent an attack. A futures group within the government warned President George W. Bush in January of 2001 that a large terror attack might be imminent on US soil, and that the best cause of action was to create a group that combined the efforts of international and national security agencies. Likewise before the financial crises of 2007 to 2008, several economists warned about the imminent crash in the housing market, but were not taken seriously. The information is out there, and futures studies uses structured methodologies to find and publish this information. Futures research takes advantage of the reflexivity between future and present, which Giddens theorizes about.

Futures studies generally takes a systematic approach to exploring the future (Bell, 2009). This undertaking involves a stringent set of planned activities designed to search and identify future events and trends. Bell describes the basic concern of future studies as “the study of images of the future” (Bell, 2009). The idea is not to predict what will happen, but to ask how one can reduce the unknowable in a specific domain (Gordon & Glenn, 1994). Using the knowledge of experts and providing methodologies to look at how potential future events will significantly influence trends in the future is not a new arena of study. However as new technologies emerge, the opportunity for using these methodologies in a new context emerges along with them. Futures research often supports policy planning. However many of the policy decisions made relating to communication technologies seemingly are often motivated by short-term goals, detrimentally affecting their future usefulness. A study that involves a new combination of methodologies using updated and tailored tools can help advise policy decisions on a long term futures horizon by predicting how different communication policy events will affect the use and potential abuse of telecommunication technologies.

Now it is important to discriminate between the speculative writings of science fiction authors and the structured, non-fictional futures work based on extrapolation, logic and academic scholarship. Even if there is evidence on how science fiction authors have influenced the development of certain images of the future, they often deal with a narrower knowledge base for scenario creation and also often deal with more dystopic futures images (Clarke, 1979). The academic tradition within futures studies is a more formalized, structured inquiry into the future.

Furthermore, it is also necessary to discriminate between predictions and forecasts. Predictions pertain to specific events happening at specific times. They provide the notion of exact certainty and exact predictions. That is not the task of futures studies (Masini, 1988). Instead futures studies are lifting the veil of the future by redefining the game of chance into a game of more calculated risk. If one can identify the risk or the probability of an event occurring, then and only then can one start planning for how to avoid any detrimental effects or take advantage of any known potential advantages. One must understand futures studies does not claim predictions or prophesies, but instead claims to know something more about a range of possible and desirable futures and how they interact (Glenn, 1994). The ultimate goal is therefore not to predict a future, but to understand alternatives, to map out different images of the future and then to develop an understanding for a decision context with better options and choices (Slaughter, 1995). How one maps these images of the future is a matter of great debate and discussion. However, Bell describes the purpose neatly: “The purposes of future studies are to discover or invent, examine and evaluate, and propose possible, probably and preferable futures” (2003, p. 73). Helmer noted, “Forecasts are an essential ingredient of the planning process. Although frequently inaccurate, they can nevertheless be of considerable utility; for they should not be judged by the degree of uncertainty they convey but by the degree to which they permit differentiation between genuine and avoidable uncertainty” (1977, p. 1).

It would be a mistake to try to predict the future of social systems because of the inherent complexity (Slaughter, 2004). It is not a physical system with clearly defined boundaries. In pure technical or physical systems, one can make good predictions because most of the interactions are understood. However as the complexities increase, these predictions become less accurate. For example, even after thorough planning efforts have been undertaken, catastrophes still happen or technical systems fail.

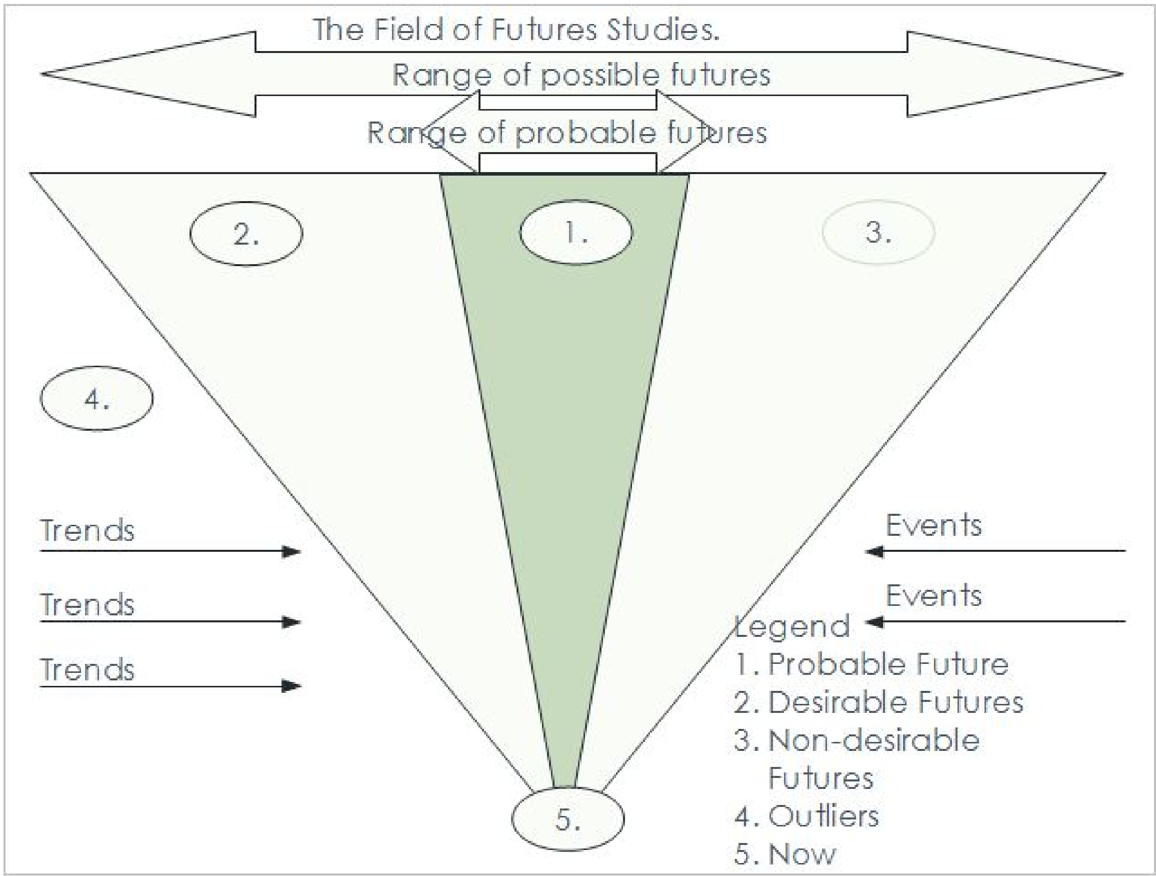

Figure 2: Possible and Probable Futures Images

Foresight, or futures forecasting, mainly identifies and decides what are the most critical risks and opportunities within a given domain. Although futures planning has been part of human kind for as long as it has existed, the formalized field dates back to 1950 (Bell, 2009; Cornish, 2005). Since then, through emerging technologies, established methodologies have adapted and become more efficient, and new methodologies have emerged. The UN Millennium Project identifies Real-Time Delphi with a Cross-Impact simulation as a promising way of expanding futures studies methodologies for policy making (Gordon, 2009). Real-Time Delphi efficiently communicates with experts to create data about risks. Cross-Impact Simulation is used to investigate how these risks are interrelated. The UN Millenium Project recognizes combining these methodologies as an attractive and promising way to simulate and create data about one or more future images.

Futures studies is not attempting to predict anything, but as mentioned, it attempts to uncover potential risks both in the forms of threats and opportunities. History is rewritten all the time by new discoveries by reassigning causes of developments. Why should the future not be rewritten by reassigning risk? The present and the future is a reflexive process in which uncovering the risks will influence the planning process. These risks are then taken into consideration and accommodated in the scenario. Policy making is very much a planning effort. Planning seeks to identify and minimize risk for a higher probability of a defined success of the project or policy, which this study seeks to support.

Futures studies is, in many ways, a structured way of identifying unknown chances, then quantifying and redeveloping them into risks to see how they will develop into scenarios. This process of identification is therefore what futurists seek to know: what it can or could be (the possible), what is likely to be (the probable) and what it ought to be (the preferable) (Bell, 2009).

2.3. Epistemology of Future Studies

The discrimination between exact and inexact science is a misnomer (Helmer, 1983). This study takes the stance that science is grounded in good post-modernist tradition in that finding the point where something is an exact science or not is impossible to identify. Even the discussion between validity and reliability is always one of bias.

In terms of the epistemology of future studies, there are two major issues at hand. First regarding the exactness of predictions or forecasts, predictive argumentation is not demonstrative, but only evidential. It follows that the formal logic of argumentative structures of the “covering law” which deals with the symmetry between the forecasts and the explanation, is not valid as a measurement for epistemology for futures studies. Even if the strict, logical positivist tradition that inspired it no longer is as dominant as it once was, it seems to be a constant in critical reviews of futures studies. As indicated earlier, several sociological theorists have pointed to the reflexivity of forecasts in social systems and how these forecasts are influencing the present to what could be a future image (Giddens, 1990). At the more advanced level, one of the distinguishing features of human awareness is this reflexivity (Slaughter, 2004). Since knowledge and futures are not evolving in a vacuum, the reflexivity will affect how the future will develop. The reflexivity supports the notion that humans can change their presuppositions when clear and contradicting evidence is present. This notion leads to an ability to change the approaching future by making other choices, as in, the future is not deterministic. Furthermore, futures research also aims to identify undesirable futures and use knowledge to avoid it.

The lack of positivist verification still does not yield to the scientific rigor involved in making futures studies a valid scientific study. In a more comparative study of evaluation of methods in futures studies, a variation of the methodology employed was found to improve forecasting accuracy (Armstrong, 2006; Wilson, 1999). These studies also noted the results in a Delphi using non-experts, as expected, yielded little value. The combination of Real-Time Delphi and simulation methodologies were deemed as very promising because it handled both the notion of collecting quantitative, and to a certain extent qualitative data from experts and then performing simulations on them to create scenarios (Gordon, 2009). If the nature of predictive arguments is evidential then the epistemology of prediction should be based not on mere formal logic but on a larger theory of argumentation. Second, the criticism illuminates the complex problem of the types of knowledge and information used in predictive arguments to build up evidence.

Explicit and formalized knowledge and statistical evidence are not enough for a successful forecast procedure. Background information, including personal, local and tacit knowledge, plays a surprisingly large role in forecast arguments. Their procedures have very important epistemological consequences (Aligica, 2003). In many other types of science, operations science for instance, to construct a complex model in which there are no theoretical models to work from, one must turn to experts (Helmer, 1983). The purpose of these models is to select features that have critical impact and relevance. Other variables might be omitted because they are judged as irrelevant or because too much uncertainty exists. One does a form of abstraction and even conceptual transference.

Theory is used as a planning tool. However, some issues are extremely complex and might not lend themselves to theories that are not very open (Middleton, 1980). Theories also tend to be limited in scope, so long term forecasting is not easily applied. Also, in general the irreducible nature of futures forecasting creates certain obstacles when attempting to apply them to theoretical frameworks.

The idea is not to redefine social science nor physical science, but to ensure that the quasi-laws in the social sciences and futures studies can be treated more in the same way that the natural laws of the physical sciences. The epistemology of exact versus non-exact science does not have the clear boundaries many assume they have (Helmer, 1983). Furthermore, forecasts do not need to adhere to strict logical derivation, because the ‘‘covering laws’’ of logical-empiricism are not able to fully include the reflexivity of complex social system (Aligica & Herritt, 2009). Therefore the forecasts and explanations are not logically symmetrical as positivists believe, thus the conditions needed for explanation are not those required for forecasts. They change in the reflexive process. Lastly local, tacit, personal and expert knowledge play a crucial role in developing a foresight methodology. In conjunction, the knowledge opens the way to a unique theory of social foresight and to varieties of ‘‘unorthodox items of methodological equipment for the purposes of prediction in the inexact sciences” (P. D. Aligica & Herritt, 2009, p. 1). Therefore “if our conception of inquiry is 'fruitful' (notice, not 'true' or 'false' but 'productive') then to be scientific would demand that we study something (model it, collect data on it, argue about it, etc.) from as many diverse points of view as possible.” (Linstone & Turoff, 1976a). This is exactly what futures studies accomplish (Helmer, 1983).

2.4. Methodology

"You cannot know the future, but a range of possible futures can be known" (Glenn, 1994, p. 6).

The value of futures research lies less in forecasting accuracy, than in its usefulness in planning and opening minds to consider new possibilities and changing the policy agenda (Glenn, 1994). The philosophical underpinnings of futures research is not one of determinism. Most futures researchers agree the strength and value of futures research lies in stringent use of methodology. The main goal is not an accurate prediction, rather it is a systematic way of looking at probabilities of events and how trends would be affected.

Through the years, a wealth of methods have been developed for futures studies. To properly situate this study, one must understand the difference between forecasting and planning. Any kind of planning requires the exploration of potential futures whether they are events or trends. The greater the quantity and the higher the quality of information one has, the easier and more successful the planning effort will likely be. Forecast methodologies provide a framework by creating data about the future.

Futures studies forecasting can be divided in two separate but important sections: exploratory and normative forecasting (Gordon & Glenn, 1994). Exploratory futures research looks at the possible future images with attention directed to the probable futures images. Normative futures studies focuses on desirable future images. This study lies mainly in the exploratory domain, though any interpretation of the simulation results will naturally implement a recommendation of what is a desirable future and what has to be done to get there. Once the data has been created and the simulations conducted, one can look at the scenarios created by the simulation . These are both needed for policy planning and recommendation, and they do interact with the data created for the studies. As mentioned, futures studies assumes a reflexive stance to knowledge, that is to say, learning about the future influences how the futures develop. Therefore, what the constructed futures images are and how the future actually unfolds are not necessarily the same, yet the goal is to move probable futures towards a desirable future.

As in much qualitative research, futures studies does not have any hypotheses testing. Instead the environmental scanning and expert interviews lead to the careful identification of trends and events as well as the construction of questions that will lead to answers.

Schmidt & Hunter (1997) concluded a reliance on significance testing in qualitative research is logically indefensible and in many cases retards the research enterprise by hindering the development of cumulative knowledge. This situation applies to futures research as well. Because the goal is to use the knowledge to change the future, the forecast and how the future actually unfolds are not necessarily correlated.

Where quantitative researchers seek causal determinations and theory-based predictions to arrive at generalizations, qualitative researchers seek illumination of knowledge and understanding to extrapolate across similar situations (Golafshani, 2003;

Hoepfl, 1997). For futures studies, this illumination is critical, but does not necessarily need to be generalized. Though the identification of generic traits in situations can be used, the general idea is to apply a stringent set of methods to one situation. For this reason, any kind of talk about the validity of research should be directed only at the use of the methodological framework. A lot of literature questions significance testing on a more fundamental level and more particularly, the point of having null hypothesis testing in relation to social research and futures studies (Armstrong, 2007; Gliner, Leech, & Morgan, 2002; Harlow, Mulaik, & Steiger, 1997; Levin, 1998).

2.4.1 Delphi

Delphi was developed in 1953 by for RAND corporation by two scientists, Olaf Helmer and Norman Dalkey to improve the process of getting expert judgments (Cornish, 2005). It was developed as a way of structuring experts opinions and eventually finding a consensus (Mitroff & Turoff, 2002). “Delphi may be characterized as a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem” (Linstone & Turoff, 2002, p. 5). A Delphi study usually receives answers to questions about the probabilities of future events and trends. These answers are kept anonymous and separate. A Delphi usually has several rounds. The method has been used in countless of studies in both academia and industry. For graduate and PhD studies, Delphi has been used in a variety of ways. Over 280 dissertations were identified as using variations of the methodology (Skulmoski & Hartman, 2007). As a study, Delphi can be used both qualitatively and quantitatively, with a wide array of variations. The traditional Delphi has a few drawbacks. One of which is that it hinges on a reasonably deep commitment from the participants over a long time. Because of the time it takes with its multiple rounds, traditional Delphi can have a high attrition rate (Gordon, 2009).

This study seeks to take advantage of the Internet to serve the Delphi study. It will implement a variation of Delphi called Real-Time Delphi, where there is only one explicit round, but where participants can come back and change their response at any time (Gordon, 2009).

A couple of notable pitfalls of the traditional Delphi have been identified, including the danger of imposing the monitors' views and preconceptions of a problem upon the respondent group. This is often done by over-specifying the structure of the Delphi and not allowing for the contribution of other perspectives related to the problem domain. This study deals with this pitfall by including a set of experts in the initial background analysis.

Another potential issue is assuming the Delphi survey represents all other human communication. Dissenting experts are encouraged to explain why they disagree with the median scores. To avoid a situation in which people feel locked in by the community, this study allows participants to explain why they are dissenting from the median score, enabling a qualitative aspect of the scoring. The researcher can then evaluate what specific information the person has. The extra notes are also anonymized and shown to the other participants.

One of the advantages of a Real-Time Delphi over a regular Delphi is the there is no summarizing of responses or explicit second round. Because the participants will see immediately the participants' median score, there is no need to summarize the answers. The software will, however, have a prompt that triggers at a certain threshold of discrepancy from the median score, asking for more information. The overall results will then be viewed and evaluated in collaboration with selected experts. Finally, those results can be used in the simulation phase.

As early as in the eighties there was a call for a social technology that could support and improve the Delphi process (Helmer, 1983). An emerging answer to this call is called Real-Time Delphi, where technological developments are used to simplify the process. Often a normal Delphi will need 3 to 6 months to complete. A Real-Time Delphi can be done in a shorter time, making it more appealing to use than a more traditional multi-round Delphi (Linstone & Turoff, 1976b).

2.4.2 Real-Time Delphi

The Delphi method was established as a form of structural surveys using experts' available knowledge, promoting the creation of quantitative as well as qualitative data (Contract, 2007). It has, in addition to its exploratory aspects, normative and communicative elements. There is not one Delphi methodology, but many variations of Delphi. This study in particular uses Real-Time Delphi.

In 2004 Defense Advanced Research Projects Agency (DARPA) helped develop a Delphi-based method for improving the speed and efficiency of collecting judgments in tactical situations requiring rapid decision making (Gordon & Pease, 2006). This version of Delphi does not have an explicit second round. However the feedback and anonymity requirements from Delphi are taken care of through feedback loops presenting the median score of previous participants answers to the question without displaying personally identifiable information. Recent studies show the merit of a Real-Time Delphi over a more traditional, explicit two-round Delphi (Gnatzy, Warth, Von der Gracht, & Darkow, 2011).

Another issue with traditional Delphi and even the Real-Time Delphi is that there is no handling of how the identified and created data interact. Not only is the data influencing how the future develops, but there is also reflexivity between events and trends. These can be simulated using a Cross-Impact software.

2.4.3 Cross-Impact Simulation

Cross-impact analysis simulation methodology has seen a resurgence in popularity in recent years (Turoff & Banuls, 2011). This methodology is especially useful when being applied to very complex situations. Commissioned by Kaiser Aluminum, Helmer and Gordon developed the Cross-Impact Analysis in 1966. The result was a promotional game in which participants construct a future world (Helmer, 1983). Much like the building of grounded theory, Cross-Impact simulations treat concepts as variables and explores the relationships between them (Charmaz, 2006). In many ways, it functions like a theory replacement (Middleton & Wedemeyer, 1985). According to Wedemeyer, Cross-impact Simulation is “a systematic method in long-range planning for dealing with individual trend and event interactions" (1985a, p. 202). This method is useful in analyzing and simulating how events influence other events and trends. Cross-Impact Analysis has been identified as a powerful tool for forecasting the occurrence of a set of interrelated events in complex situations (Turoff & Banuls, 2011). This tool is also used for analytical tasks in which the use of theory-based computational models is hard due to their disciplinary heterogeneity and the relevance of soft system knowledge, but on the other hand are too complex for a purely argumentative systems analysis (Weimer-Jehle, 2006). This holds especially true for long-range planning, in which complexity increases and the number of interacting variables is high. Thus Cross-Impact is often used instead of social theory (Helmer, 1983).

2.4.4 Futures Field's Impact on Policy

Foresight can impact policy making multi dimensionally. At least six general ideas of its influence have been identified (Da Costa, Warnke, Cagnin, & Scapolo, 2008). First, the futures field informs policy makers by generating insight regarding the dynamics of change and how different drivers for change interact. The futures field also facilitates policy implementation by building common awareness of the current situation, future challenges and future visions amongst the stakeholders. Furthermore, the futures field is facilitating embedding the participation of civil society in policy making, creating a closer relationship between the policy makers and the stakeholders. In the process, it also supports the joint translation of outcomes from the collective processes into more specific options for policy implementation. Finally it reconfigures the policy orientation from a response system to an explicit planning system (Da Costa et al., 2008).

2.5. Telecommunications

"The network is the message," writes Castells (Castells, 2001, p. 1). What he means is that in the new era of telecommunication and information, the flexibility and adaptability of the network is proliferating all aspects of society to a degree that it becomes a necessity for our core social, technical, economic and political activities, basically all aspects of life. The exclusion from this network has become one of the most damaging forms of exclusion for the economy. Furthermore the speed of the technological transformation is so high that scholarly activities and policy making are struggling to keep pace (Castells, 2001).

Telecommunications as a field focuses often on the factors of building telecommunication networks and has become the backbone of modern society. As information production and needs grow exponentially, nations and states struggle to develop policies that effectively moderate these developments (Olufs, 1999). Policy making has two major roles to play. First it should moderate a marketplace for private industry and at the same time ensure the Internet keeps its structure and architecture open. Furthermore, to secure a sustainable economic growth, policy making should make sure people are not left behind in the digital divide (OECD, 2011a).

With the 1934 Communications Act, when the U.S. Congress started regulating the telecommunications industry, Congress had two separate and distinct technologies to consider: telephone and radio (Nuechterlein & Weiser, 2005). Since then, the industry has experienced radical and increasingly rapid changes. The once distinct technologies are now competing not only with each other, but also in a market of convergence, where the technologies merge in large-scale technological conglomerates. There is no reason to believe these fundamental changes in the market place will stop. If anything, there is reason to believe the changes will not only continue, but also increase in speed and impact. These changes raise the importance of looking forward to and getting a better view of the future as it approaches.

The flow of information and knowledge is recognized as the fabric of society, and how this information is shared is called the web-of-society (Middleton, 1980). This web-of-society is important for the sector of telecommunications, Internet connections and ICT's in general. All of these make up the overall package when different international, multinational and transnational organizations are considering access to information and broadband Internet connections as human rights. It is an absolute necessity to not be left behind in development in the digital divide (Atkinson, 2007; Crandall, Jackson, & Singer, 2003; Kim et al., 2010; OECD, 2011c, 2008, 2011a; Reynolds & Wunsch-Vincent, 2008). The broadband connections are among the more important technologies because they are the so-called pro-sumer technologies (Atkinson, 2007; ICT Development ITU, 2010). These enabling technologies let previous consumers participate in the conversation by allowing them to contribute to economic growth and innovation.

2.5.1 Broadband

Different organizations define broadband and ultra-high speed broadband differently. However, the change of broadband's definition creates a notion of high-speed bandwidth connection relative to other connections. For example, recently the FCC has updated its definition of high-speed broadband to mean above 10Mbps and regular broadband to mean 4 Mbps (Akamai, 2012; FCC, 2010).

What effect does broadband development have? Federal Communications Commission (FCC) notes the importance of broadband for a variety of different sectors such as eduction, healthcare, energy, environment, government performance, civic engagement, public safety and economic opportunity (FCC, 2010). The International Telecommunication Union notes an obvious shift in ICT development: there is a need for broadband (International Telecommunications Union, 2011).

The OECD noted in 2008 that regulators should consider to what extent network architectures are relying on old copper networks rather than fibre. These networks should be regarded as different from the all-fibre networks that the new networks would rely on (Reynolds & Wunsch-Vincent, 2008). A second consideration would be to consider separating the lines from service providers to secure a fair and non-discriminatory access to broadband services. Though broadband services have improved, significant differences between urban and rural areas still exist. The OECD believes governments should help secure the development of the next-generation broadband (Reynolds & Wunsch-Vincent, 2008).

One concern is which approach do policy makers take to development? Should broadband be developed as a facilities-based competition or an open-access network?

Some ask for a mixed-development process in which a facilities-based competition warrants comprehensive deregulation of the telecommunications industry. This deregulation could produce serious market failures and potentially harm consumers (Nuechterlein & Weiser, 2005). In addition to questioning how policy makers develop broadband, it is necessary to explore how a futures oriented study can gain clout with policy makers.

Using experts and futures studies in the planning process can be useful for setting an agenda for discussion (Birkland, 2001). Often these experts will also be stakeholders and maybe to some extent, be involved in the process of the policy making. Birkland (2001) writes the likelihood of an issue rising by itself is small and that setting the agenda does not occur in a vacuum. Usually a function of the issue, the actors, institutional relationships and sets of random social and political variables interact. Often these factors are hard or impossible to replicate, but often can be explained in retrospect. Aligning this argument with Olufs' claim that large technological public policy issues often do not attract the general public and using individuals with expert knowledge in areas that affect that process is therefore needed (Olufs, 1999).

"Broadband is also increasingly important as an enabling technology for structural changes in the economy, most notably via its impact on productivity growth, but also by raising product market competition in many sectors, especially in services." (OECD, 2008). This factor fuels the desire to implement high-speed broadband, an investment that leads to a wider economical foundation for growth. For Hawaii, it would mean a more diverse economic structure.

More recent studies have also found not only does broadband technology spur growth initially, but also the growth is sustained when broadband speed increases (Stryszowski & OECD, 2012). This report measuring growth relative to Gross Domestic Product (GDP) found the direct growth influences an increase in broadband speed by 0.3% of the GDP.

New innovative industries could be spawned based on an ICT-enabled services industry with global reach (OECD, 2008). It fundamentally impacts economies. Not only in terms of information use and demand, but also by contributing to productivity and economical growth by expanding markets, increasing business efficiency and reinforcing competitiveness in a global market.

Dr. Toure, President of International Telecommunications Union (ITU), declares this decade as the decade of broadband (ICT Development ITU, 2010). The ITU emphasized the importance of broadband and increased Internet access and bandwidth for different cultures to develop self-sustainable economies. These organizations' focus on broadband as critical to sustainable and growing economies certainly does not lessen the impact and importance of building infrastructure that can handle high-speed network connections. This situation is even more apparent when considering that some regard bandwidth development not only as important, but also as a 5^{th} utility of the next era of computing ICT's (Buyya, Yeo, Venugopal, Broberg, & Brandic, 2009). Other countries, such as Finland, have made broadband access a legal right for every citizen (BBC, 2010).

The General Assembly of the United Nations declares “the Internet, as a medium by which the right to freedom of expression can be exercised, can only serve its purpose if States assume their commitment to develop effective policies to attain universal access to the Internet” (LaRue, 2011). The UN focuses on avoiding a digital divide. However, as noted, as computing and processing capabilities increase, to not be left behind, it is critical to develop high-speed connections (Miyake, 2008; Newman, 2008; The Communications Workers of America, 2010).

2.5.2 Telecommunications and Futures Studies

The current telecommunications marketplace does not look very much like the telecommunications market envisioned in the 1996 Telecommunications Act. Different critiques point to Congress’s not foreseeing the consequences of the Internet (Nuechterlein & Weiser, 2005). The Internet has fostered entry and innovation because it has traditionally operated as a “dumb network” that rewards the creativity of individuals and small firms at the edge of the network. “In spite of many attempts, the established service providers and their suppliers have an abysmal record in innovation in user services . . . . The real ‘killer apps,’ such as email, the Web, browsers, search engines, [instant messaging], and Napster, have all come from users.” (Nuechterlein & Weiser, 2005, p. 409). Significantly, many of the emerging Internet innovations, such as VoIP, depend on the widespread adoption of broadband Internet access—a platform that did not yet exist in the mass market when Congress enacted the 1996 Act.

3 RESEARCH DESIGN

This chapter provides an overview of the steps taken to complete the study, beginning with a short introduction to futures studies that builds on concepts introduced in the literature review chapter, followed by details regarding the experts selection process. It then goes into some detail about the methods used, and how they were applied. Descriptions of system developments are also discussed, but it will not go into much detail about what choices were made to accomplish this. That is detailed in the discussion chapter.

3.1. Futures Methodologies

This section will go through the general idea behind futures methodologies before it goes into more detail about the methods used for this study. “The purpose of futures methodology is to systematically explore, create, and test both possible and desirable futures to improve decisions” (Glenn, 1994, p. 3).

Inherent in research is the principle of informing the current, so that we may make better informed decisions for the future. Whether via a well informed theoretical foundation, or even if there is a great deal of uncertainty that has to be dealt with in a very complex and localized setting, the goal of future research is simply to try and make sense of the future.

As this study seeks to identify and simulate possible and probable future events and trends, it is important to acknowledge that the data does not yet exist. Trend extrapolations are hard to estimate in complex local environments, especially considering the relatively short history of high-speed broadband technology and the large technological leap that is suggested in the near future. In a highly complex situation where events and trends can and will influence the outcome, it is critical that we also acknowledge the importance of the use of expert testimony as a source upon which to build data (Helmer, 1983). Given a far from ideal epistemological situation relating to broadband in Hawaii, experts can use their resources and background knowledge, as well as a cultivated sense of relevance, to support reasoned forecasts (Helmer, 1983).

In general, futures research is supported by a variety of methods and tools used to create data. A combination of research tools that work together is recommended (Gordon, 1994a). The choice to use a variation of Delphi in combination with Cross-Impact Analysis for the purpose of this study was not a coincidence, as the two have been suggested as complementary methods for some time (Gordon, 1994b; Helmer, 1981; Middleton & Wedemeyer, 1985). Using a combination of methodologies secures a more solid platform from which to say something about the outcome. The idea is that many indicators provide a wider and more solid platform from which one can say something with a bit more certainty. Each of the methods that were used in this study are well known and widely used, however the combination and additional features in the implementation are novel.

The methodologies used in this study identified the main drivers of change in regards to the implementation of a statewide high-speed broadband in Hawaii. They identified and analyzed social, technological, economic and political forces. These forces are taken into consideration, along with opportunities and threats from a Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis, in order to identify and categorize events and trends in relation to impact on the broadband development, in the hope that such analysis might guide policy decision-making regarding high-speed broadband development in Hawaii.

This study used a combination of qualitative and quantitative inputs to provide data that can be input into models to help and guide effective decision making in Hawaii. It did so by combining two discrete methodologies into one generic software program, in order to better identify opportunities and threats, as well as investigating how these interacted by simulating alternative futures . This software also improved the speed in which participants could provide the estimations.

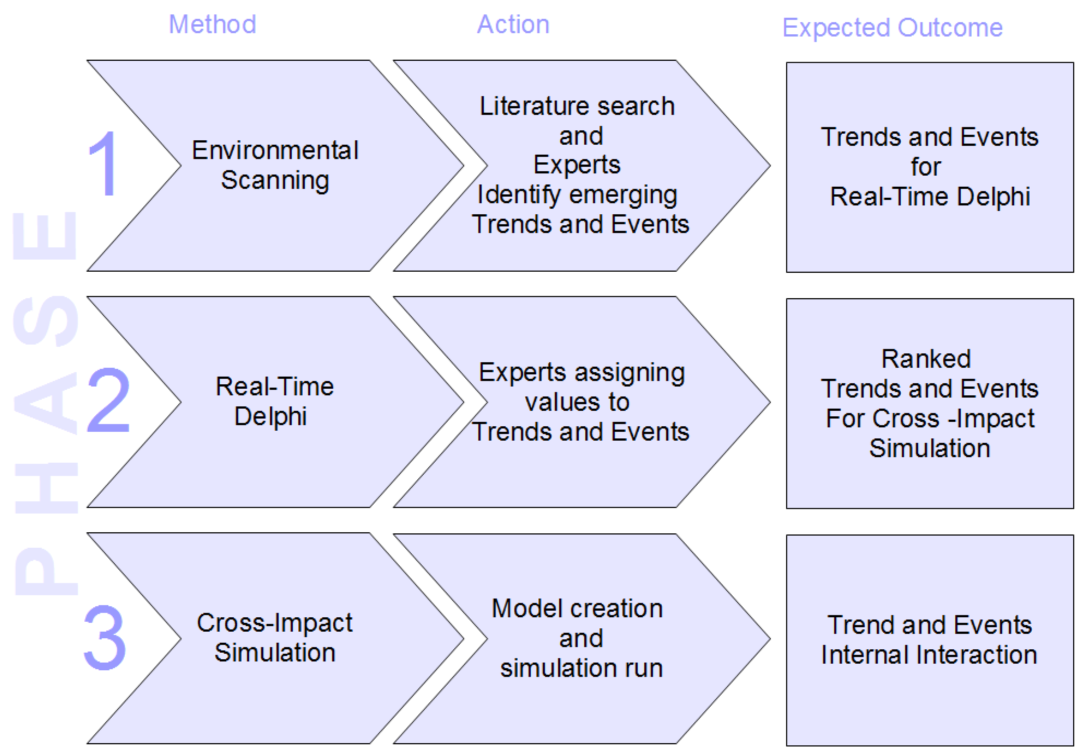

Figure 3: Study Steps

This study employed three methods. The first method was Environmental Scanning. Environmental Scanning is a method used by futurists to assist in a structured exploration of drivers that impact the future (Gordon & Glenn, 2010). In this study, it was used in the early exploration phase for identifying critical events and trends in broadband development. The study used a mix of different scanning techniques. One of the main techniques was to conduct interviews with high-level domain experts who identified the most important trends and events in each of the social, technical, economic, and political dimensions. The study required input from at least one professional in each of the STEP categories. These experts were at the highest level of expertise in the state each covering several of the categories. These experts also represented governmental, academic, and private enterprise.

In the second step, the outcome of the Environmental Scanning was fed into the Real-Time Delphi. Once Environmental Scanning was completed, trends and events questions were formulated for the Real-Time Delphi. The Real-Time Delphi involves input from a broad set of experts. Any Delphi or Real-Time Delphi study is dependent on the use of experts judgments. This study identified several sets of qualified experts that were invited to participate in the study. In the probabilistic phase of the Real-Time Delphi, the experts were asked to provide judgments regarding what future point in time an event will have happened with a given amount of probability, and at what level a trend is occurring at a given point in time.

The third method used was the Cross-impact simulation. The output from the Real-Time Delphi provided variables that were fed to the Cross-Impact simulation matrix. Estimations on how the variables influence each other were made based on the interviews and qualitative feedback in the Real-Time Delphi, and futures models were created. This provided the ability to create alternative images of the future based on the data created. Finally, simulations were run and the outcomes were interpreted.

3.2. Participants

This section provides more detailed overview over the criteria for selecting and inviting experts. It begins with a brief discussion of why futures studies use experts, before the section provides details on the process of selecting experts for this particular study.

Futures-related studies are commonly based on judgments made by experts that rely on estimates anchored in their knowledge of the problem domain. In this study these judgments were level estimates of identified trends and events. The methodology behind selection and use of experts has been scrutinized by several studies (Audenhove, 2007; Rowe & Wright, 2001; Scapolo & Miles, 2006). It is critical to understand that it is not the number of experts that necessarily matter, but rather that the overall coverage of expertise areas are sufficient, that the experts are from a variety of areas within the subject domain, and that the experts are committed to providing their expertise. The use of expert judgment is not incompatible with scientific objectivity as the selection process is objective and not based on personal preference, but rather an expert's performance in the field (Helmer, 1983). This study, therefore, took great care in inviting experts from government, academia and private industry.

To perform a successful Delphi study, participants must be experts. They are not supposed to be representative of the general population, but rather have specialized knowledge relevant to the subject matter. There are different ways of securing them; this study recruited expert participation using two processes. First, it identified potential expert participants who were contacted and invited to participate in the study. These experts were then asked to provide names of other experts who could be contacted. These recommended experts were also, in turn, vetted.

Next, several relevant committees and organizations were identified and contacted with requests for the use of their member databases in order to identify potential expert participants. These organizations are described in more detail in the participant overview.

3.2.1 Domain Knowledge

Whenever there are subjective judgments of probabilities or level estimates, specific domain knowledge is required. In expert knowledge-based studies, questions of which experts one should use, how many, and how the study should elicit their forecasts are all relevant (Rowe & Wright, 2001). This holds true especially in fields where the knowledge required to make any kind of forecast has to be advanced. In many telecommunications policy decisions, even if the general public is highly affected by the outcome, the topic areas may often be too complex and too removed for the general public to have enough knowledge to provide useful insight (Birkland, 2001). In policy making for technology fields, the general public is mostly oblivious to the implications of the policies implemented, and are typically not invited to participate (Olufs, 1999). This is why a probabilistic-type sampling technique was not used. General non-experts could certainly could be part of a normatively focused study where slowly-emerging problems are the focal points (Winter, 2003). Normative studies analyze what one wants the future to be, rather than looking at forecasts for what will happen.

Studies using the Delphi Technique have been criticized for using students as subjects in a too large a degree, proposing that their inexperience might affect the outcome of the study. It is therefore paramount that the participants have an appropriate domain knowledge. An expert will better resist yielding to group consensus and group-think. In addition, because experts have specialties within the field, it is important to select experts whose combined knowledge and expertise reflect some understanding of the full scope of the problem (Rowe & Wright, 2001).

To what extent one uses differing levels of expertise is a debate that has been going on for some time. Should one use only very top-level experts, or a broader set of regular-level experts? Using a mix of experts from differing levels of expertise, and each having different areas of expertise within the problem domain, is a good way to secure expertise, as long as they are using some form of self-reporting in the Delphi. Self-rating is an appropriate method for selecting experts used for individual questions (Tichy, 2004). Though the study notes that some discrepancies between experts from academia and business exists, it emphasizes the importance of obtaining a varied selection of experts. Studies in regular Delphi have used the self-reporting features of confidence level in addition to expertise level for some studies (Wedemeyer, 1985b). This has yet to be implemented in Real-Time Delphi. There will be more about this in the Delphi section of the methodology chapter.

One suggested feature of accounting for expertise levels is weighting schemes. In most studies, appropriate levels of expertise might not be readily available for an effective weighting scheme. This study implemented a more direct approach, where people assessed their own level on a per-questions basis. Other studies have found that overall, expert forecasts were more accurate than those of non-experts (Rowe & Wright, 2001). This study implemented a self-reporting boolean weighting scheme. Anyone registered who did not meet certain criteria were dropped. These criteria were dynamic, and could be changed down to the individual trend of event.

The most common way to select experts for future studies is by evaluating qualities such as peer recognition, academic standing, job title, experience, and activity level in the field of telecommunications and broadband (Helmer, 1983). This notion supports seeding via other participants- a form of snowball technique. This study, took great care in avoiding overly uniform groups, and used experts from three main groups, namely academia, business, and government. Seeding via other participants would normally be considered snow-ball sampling, but the study evaluated each individual participant's expertise level before allowing seeded applicants access to the study. A select few particularly high-level experts had expertise in several different areas, and were invited to participate in phase 1 as well as in phase 2.

The study also used professional fora and communities of practice for selecting candidates. The study started by identifying different fora where telecommunications professionals, academic experts and governmental experts would participate in broadband discussions, including events such as conferences and presentations. The study also identified participants in broadband initiatives and other political initiatives dealing with broadband in Hawaii, such as membership in the Hawaii Broadband Task Force.

For the invitations in phase one, most of the participants were initially contacted at events, and then followed up via email. For the participants in phase 2, the primary way of contact was via email.

3.2.2 Number of Experts

Selecting research participants is a critical component of Delphi research, since it is their expert opinions upon which the output of the Delphi is based (Ashton, 1986). In normal Delphi based research, usually a group of five to 20 participants is considered normal (Rowe & Wright, 2001). A study of of variations of the Delphi method have found that participation numbers between five and 171 for doctoral dissertations is normal (Skulmoski & Hartman, 2007). There is no recommended sample size; what matters is that the areas of expertise is covered, and that the expertise level is sufficiently high. What follows is that for smaller, more localized domains a small N is sufficient to cover the expertise areas (Adler & Ziglio, 1996; Skulmoski & Hartman, 2007).

There is no upper limit to how many may participate in the Real-Time Delphi study phase because the technology supports any number of participants, but geographical population limitations could provide a natural limit to how many individuals meet the participation criteria (Adler & Ziglio, 1996). Participation in the Real-Time Delphi phase of this study was monitored in order to make sure that participants from each of the categories were responding. The software helped support the process of monitoring representation in each of the STEP dimensions based on participants' self-evaluation of their level of expertise.

3.2.3 Recruiting Participants

The initial step of expert participant recruitment was to identify a number of domain experts and stakeholders. These were selected from different organizational databases, committees, and from reputation and employment history. Several organizations that had experts with the required skill sets were identified. Experts with exceptionally broad skill sets were also identified and recruited for participating in the phase 1 identification of trends and events. They were vetted based on reviews of credentials and their reputation in the field. They were contacted either face-to-face or by email.

A person's expertise in an area can be judged by facets such as status among peers, years of professional experience, and self-appraisal of competence in the areas of inquiry. It can also be judged by the amount of relevant and otherwise inaccessible information to which the person has access, or finally by some combination of objective indicators and a priori judgment factors (Brown, 1968). In addition to background information, the software used in this study further supported the expert selection process using self-evaluational features for each question.

In the Environmental Scanning phase of the study, semi-structured interviews with experts knowledgeable about various STEP dimensions were conducted, the goal of which was to identify their images of relevant opportunities and threats in the coming decades. The interviews were structured around how these experts perceived opportunities and threats for each of the different STEP dimensions affecting the broadband initiative success. After each interview was conducted, the outcome was synthesized and implemented into the next interview. Once all the interviews were completed, the most important opportunities and threats were formulated into events and trend questions that were fed into the Real-Time Delphi study software.

3.2.4 Phase 1 Experts

The primary experts for the Environmental Scanning phase were participants with a wide array of expertise, and knowledgeable about more than one of the social, technical, economical, and political dimensions. It was important that the study find experts in each of the dimensions to secure a well-rounded expert base and thereby cover the most important trends and events. Most had high expertise levels in all aspects, and this study classified them as such. This group of experts was invited to support the identification of important trends and events.

For the initial expert interviews the goal was to cover most of the areas in the Social, Technical, Economic and Political dimensions. Once opportunities and threats were identified, they were translated into event and trend questions used in the Real-Time Delphi software.

In phase 1, a very high-level expertise set of experts that have had great impact on the broadband debate in Hawaii was identified and invited to an interview. Some of these experts work in academia, some were part of the broadband task force, others were recently in high-level positions in organizations that either provide broadband services, or were part of future planning for broadband in Hawaii. These interviews provided background information needed to create the trend and events questions. The process for selecting these experts included attending conferences, and reading material about the broadband developments in Hawaii. The experts identified and invited were all asked in person, before an invitation email was sent out. Five experts accepted an invitation and met for an interview.

3.2.5 Phase 2 Experts

For phase 2, a more varied group of experts was invited. They were invited to provide level estimates on the trends and events that were developed as a result of Phase 1. These forecasts were forecasts in the Real-Time Delphi software.

A participant could receive an invitation one of three ways. Either they were invited directly with a personalized link that would grant them immediate access to the study because of their professional reputation. The second way was by being suggested by other participants. The final way was via a more generic invitation, based on participation in a group. The generic invitations were tracked and experts evaluated using the same criteria for expertise. The software had several ways of supporting the process of evaluating the expertise levels, and was subsequently able to immediately drop potential answers given by non-experts. Any unidentified or inexpert registrants were dropped from the study.

The primary participant sampling technique used for this study were purposive sampling: a non-probabilistic sampling technique where judgments of a participant fit were based on a set of criteria established by this study and supported by literature

(Babbie, 2005). The basic axiom for the expert in this study is that the candidates have to be experts in their fields, and they have to have some specific expert knowledge about broadband in Hawaii. Following Helmer's criteria, the study developed a matrix of criteria.

The secondary sampling technique could be described as a form of snowballing technique with post-registration expertise evaluation. It effectively ends as being a purposive sampling technique, but initial registration was allowed as the participant was vetted. The idea was to accept participants, but control to ensure they were balanced, and at a sufficient level of expertise. In principle there were three ways this snowballing sampling technique would work. The primary interviewees were asked if they knew people who could contribute to the study. The software supported suggestions of new experts, and it also enabled someone to be forwarded a generic invitation link.

The first seed of invited participants were selected on the same criteria as phase one: people in professional careers that deal with Telecommunications and broadband in particular, participating in public debates and on expert panels on broadband events.

The second seed of invitees included experts chosen from a list of affiliates of the Pacific Telecommunications Council (PTC). Selection criteria included job titles, job location, registered place of domicile, professional reputation, participation in public debate, and overall educational and professional background.

For the Real-Time Delphi study, 256 selected individuals from the Pacific Telecommunications Council's (PTC) database of over 11,500 telecommunications professionals were invited to participate. In the PTC database was information about members' interest areas, professional and academic backgrounds, job titles, and employers. This information was used to identify and recruit suitable study participants. For instance the criteria was that members had to live in Hawaii to be considered. The selection criteria looked at the person's attachment to Hawaii, and any expert knowledge related to broadband development in Hawaii. PTC sent an invitation email on behalf of the study to the invited participants, endorsing the study, and recommending participation to its members (Appendix A).

The third set was more generic invitations posted via TechHui.com and Innovations Alliance Hawaii Facebook group. TechHui (www.techhui.com) is an online community of practice for local scientists, techies, tech entrepreneurs, and new media enthusiasts, many of whom have been heavily involved in lobbying for Gigabit broadband development in the State of Hawaii. Each of these links contained codes that would help sort where a participant registered from. The invitation text clearly noted that it was for telecommunications experts only. In addition, a post registration evaluation of expertise level was applied. The system notified administrators immediately when a new registrant started the registration process. Great care was taken to make sure that unsuitable participants would not influence the study.

3.3. Phase 1 - Environmental Scanning

This section describes the process used for collecting information from the highest level experts in Hawaii, and the subsequent development of trends and events questions that were used in the Real-Time Delphi software.

This phase was started with a thorough scanning of the context in which broadband development in Hawaii is set. Forecasts are based on assumptions about the future, and scanning the horizon is important as it challenges current assumptions and find new developments about future threats and opportunities (Gordon & Glenn, 2010).

This section describes the process for collecting information from the highest level experts in Hawaii, and the subsequent development of trends and events questions that were used in the Real-Time Delphi software.

This phase was started with a thorough scanning of the context in which broadband development in Hawaii is set.

The purpose of an environmental scanning exercise could be viewed as the core input to any futures research initiative (Gordon & Glenn, 2010). A typical exercise follows these systematic phases:

- Scanning background (press releases, monitoring websites, articles, conferences, seminars and finding key people in the area)
- Synthesizing and refining
- Trends and Events output

The scanning and synthesizing phase is an iterative and repetitive process that mutually feeds and informs each of the constituent parts. Special care was taken in the study to avoid confirmation biases. This was particularly true in the interviews of high-level experts.

The trend and event outputs from the scanning technique are usually interdependent. In futures studies they are generally categorized into social, technical, economic, and political dimensions (Bell, 2004). This ensures that single aspects of the overall process do not become overly dominant. It also serves as a tool to make sure that no areas of importance are forgotten.

First, the study identified papers and reports that deal with broadband in Hawaii- both in terms of policy making and development. Several major reports such as the Hawaii Broadband Task Force and Broadband Initiative reports were identified (Hawaii State, 2011; Lassner, n.d.). Key people were identified, and their respective areas of expertise were tracked. Events relating to broadband and Telecommunication were attended. At events talks were noted and a lot of general informal conversations were conducted to get a feel for who were the most important contributors and experts in Hawaii. It also found several topics of interest regarding current developments in the industries.

Once the key people regarding broadband developments were identified, a priority list was made and evaluations of their perceived expertise levels were conducted, then a strategy for preferred order of interviews was made. Finally these experts were contacted for an interview. These people were either contacted in-person at the events, or later, via email.

3.3.1 Semi-structured Interviews

The interviews were conducted using a semi-structured interview method wherein the researcher uses an interview guide with fairly specific topics, but still allows the interviewee a great deal of leeway in how to follow up questions and reply. It also allows the interviewer to pursue topics of interest if more detail is needed (Lindlof & Taylor, 2010). One major difference in a semi-structured interview compared to a structured interview is that questions do not necessarily have a given order. Questions that are not included in the guide may be asked as deemed important as the research progresses. This means that the research can follow up on important topics stated by interviewers. The basic format for the interviews was to:

- Introduce the study;
- Review the institutional review board (IRB) approval and sign an agreement to participate;
- Ask permission to record the interview;
- Introduce the social, technical, economic and political (STEP) areas and ask the area in which the expert has the highest level of expertise;
- Follow the framework of themes within each (STEP) that laid the foundation for the interview;
- Follow each focal area in the framework that had subtopics to be explored;
- Ask questions in according to how the interviewee rated his/her STEP expertise;
- and refined in subsequent interviews

It was critical to the study that all areas were covered by the interviewees.

After the interview, all notes and audio recordings were reviewed for the creation of trends and events developments. The output from this process was a set of developments used for the Real-Time Delphi methodological software tool.

3.4. Phase 2 - Real-Time Delphi

This section explains the purpose, development, and implementation of the Real-Time Delphi software, the process of creating and testing questions, and the overall process for completing a Real-Time Delphi in this study. “Delphi may be characterized as a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem ” (Linstone & Turoff, 2002, p. 5). A Delphi is a group technique that uses expert opinion and communication to deal with complex problems that have less than an optimal amount of information. Traditionally a Delphi has two or even three rounds, but in this case a novel and an original methodological software tool was developed to elicit these expert opinions and forecasts with less time commitment from the experts, with potentially better results due to a more engaging experience.

The basic assumption is that a group forecast consisting of experts is superior to an individual expert forecast, as more nuances may be elicited. There is also an assumption that in the communication between the system and the expert, a process will occur in which they better question their forecasts. The assumptions prove out in the literature, that is to say, domain experts are better at providing forecasts- especially in the area of telecommunications.

In traditional Delphi-based studies there are four necessary characteristics of the data collection process (Rowe & Wright, 2001):

- anonymity;
- iteration;
- controlled feedback of forecasts; and
- statistical aggregation of members' responses.

For this study a generic methodological software tool that would take care of the basic requirements for Delphi was designed and created. It follows and extends a modernized version of Delphi called Real-Time Delphi. This software tool provided a generic and reusable extension to the methodology by implementing some novel features.

Anonymity was protected via self-administered forecasts designed for this study. The forecast could be done from anywhere. The IRB and notes in the interface clearly stated that any information they used to register would not be attributed to the participants, and no answers provided would be attributed to them. By allowing the group members to express their opinions and judgments privately, one may be able to diminish the effects of social pressures, as from dominant or dogmatic individuals, or from a majority, as some studies find that there is a form of group pressure still that needs to be alleviated. The software alleviated that using a feedback routine that would only show aggregate group results after the participant had provided forecasts. Selected anonymized qualitative data was shown, in addition to aggregated group data.

The iteration was implemented into the first round. Real-Time Delphi does not have an explicit second round. The iteration is taken care of by providing the participants with immediate feedback and group data so they can compare their answers immediately.

The controlled feedback and statistical aggregation is taken care of by presenting aggregated quantitative answers from the group in addition to selected qualitative answers.

A Real-Time Delphi study provides feedback to users on how other users judged the specific question as the goal is to create some agreement rather than simply measure some average. Real-Time Delphi is a one-round version of a more traditional Delphi study. To date, this method has been applied to studies of the future including, resource allocations, study designs, effective policies, and decision making procedures in a wide variety of application such as academic studies, UN environmental assessments, and CIA research (Gordon, 2009).

Other research has found variations of Real-Time Delphi to be faster and simpler ways to perform Delphi investigations (Gnatzy et al., 2011). Studies find that the participation rate in Real-Time Delphi is usually higher, and yet the results remain comparable to traditional Delphi studies (Geist, 2010).

As opposed to a traditional Delphi, only one explicit round is required in a Real-Time Delphi study, however, participants are encouraged to come back and review their answers as new information is provided them by the system. The second round is implicitly implemented into the methodological tool. Each respondent can view his or her previous responses when they return to review the questions. As part of the review procedure, they can also view the new medians for the answers, as well as reasons given by other panelists for their responses to the same question. This information is recalculated whenever new input is received from other participants.

The Real-Time Delphi central thesis is to bring the Delphi process forward into a technological current state. It eliminates the need for explicit secondary rounds by presenting the respondents' aggregated results of other experts responses, the median of the group response, as well as the ability to return at any time to the forecasts and modify responses without restriction (apart from the restrictions put in place by question itself).

When a new respondent joins the on-going study, an on-screen form is presented, which contains, questions for that individual . The methodological software tool created for this study provides the ability to:

- provide quantitative forecasts;
- provide expertise level;
- provide certainty level;
- see a quantitative forecast feedback panel containing;
    - the median of all of the responses of the group,
    - the Semi-Interquartile range,
    - the number of responses given so far,
    - live graphical representations of these numbers,

- see a qualitative forecast feedback panel containing;
  - a window that shows reasons that others have given for their responses
  - qualitative forecasts ordered by extreme answers and median answers

When the participant is entering data, the data are automatically submitted to the database, and the feedback panel is shown. Upon comparing one's own answer with the group answer, it prompts the participant to pause and review the given answer, which serves as an automated second round. Whenever answers are submitted, the group's quantitative data is recalculated and fed back to the participants. When the respondents come back to the study, the original input form including the given answers is presented,, in addition to updated statistics.

3.4.1 The Software – Real-Time Delphi 2: RTD2

The Real-Time Delphi software was designed and developed so that it can be used in any Real-Time Delphi study. It was evaluated using different interface elements on common platforms like laptop or desktop computers, phones or pad type tools. The design is available for different platforms to increase the ability for busy expert participants to complete the questions at their convenience.

Unless the participants were pre-registered, they were asked to provide a valid email address and create a password so a user account could be created. This allowed them to return to the study and update their answers whenever they wished. Other types of information were asked but not required. The IRB and privacy statements were available at any time.

The Real-Time Delphi software developed for this study satisfies the Delphi requirements and provides:

- Anonymity: via being able to do the forecasts from anywhere, and answers not attributed to participants
- Iteration: via timed feedback of aggregate results, and email reminders that there are aggregate data available for review
- Controlled feedback of forecasts: via feedback of other participants anonymized qualitative responses sorted by extreme forecasts that are different and their given expertise level and confidence levels
- Statistical aggregation: via aggregate statistics of median scores, semi interquartile scores and number of qualified responses
- An interface allowing the study participant to provide:
    - an estimate of the time of a given probability of an event occurring in the future or an estimate of the trend level at a given point of time in the future.
    - the thinking behind their answers and their expert level in the context.
    - an estimate of their expertise level for the given forecast
    - an estimate of their certainty for the given question
- Feedback about:
    - the median of all of the participants' responses to the current question the number of responses made so far.
    - Semi-interquartile range of participants responses

    - the rationale that other participants have given for their responses to the current question
- Expands the methodology in the following ways:
    - Provides instant feedback on other responses (dynamically updated)
    - Adds a metric of self-rated expertise for each question
    - Adds a metric of self-rated certainty for each question

Even if the participants have submitted their estimates, they are encouraged to reevaluate them, and adjust them if they so desire. However, to make sure they are not influenced unduly by other participants' information, group answers were not provided until forecasts had been input. Email reminders about new aggregate forecasts were sent out with a few weeks in between forecasts. The study also tracked participants who returned, and how they changed their answers.

3.4.2 Considerations of Real-Time Delphi Software

This will describe the considerations of the study used when designing the Real-Time Delphi software and extending the methodology in the software.

The following are some of the factors that were considered when designing and implementing the Real-Time Delphi software. Because Real-time Delphi is one round, even if the participants were encouraged to come back and update their responses, no explicit second round was necessary as would have been in a conventional Delphi. This meant less time and fewer resources were needed for study completion.

Whenever a participant came back to update an answer, no matter when, the participant's original input were pre-populated in the form, together with the new aggregate responses from the set of users.

The implicit second round could be important because other participants may have contributed additional answers, so the medians may have changed since the participant first responded. Answers that fell outside the interquartile range received special attention in the interface for their qualitative answers. Once an answer was flagged as differing significantly from the mean, the participant's rationale for the answer became more important.

Early respondents were not shown a mean for the previous answers until a certain number of participants with a certain expertise level provided a forecast. This level was set at a minimum of five participants.

- Participants were not shown the group median until they input the forecasts.
- The answers were submitted automatically once the forecast fields had been filled out.
- Group answers were loaded once the initial forecasts had been submitted. This meant the answers could show a group median without an explicit submission, and still potentially measure if people changed their answers.
- If a participant came back to review, an arrow noted where they could compare their forecasts to the group answer. This arrow faded out after 5 seconds.
- Randomization of questions was used to reduce the effect of bias caused by question placement and order in the questionnaire.

- A set of 5 core questions were asked of all respondents.
- A permanent record is maintained of responses including both quantitative and narrative responses.
- Extra effort was taken to keep the user interface clean and easy to use across devices.
- Error testing and reporting features were implemented to avoid data loss due to system outages, as well as to avoid design and implementation flaws.

3.4.3 System Development

This section will go into more detail about the development of the methodological tools used.

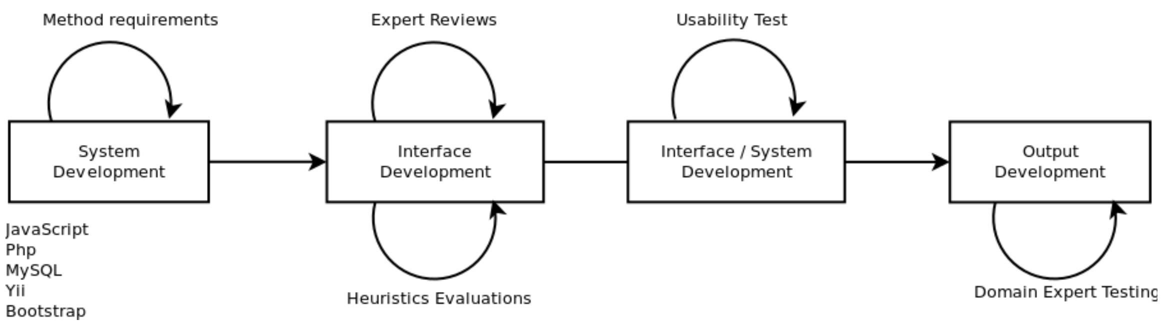

Figure 4: Software Development Process

The technology behind the Real-Time Delphi method tool was a relational MySQL database with a web-based interface implemented in HTML5, PHP, CSS3, and AJAX. Using AJAX allowed for taking advantage of recent technological developments to speed up the answering and feedback processes. It was also heavily used in providing explanations for different interface elements.

The software ran on a discrete server accessible via a dedicated world wide web domain (www.broadbandhi.com), and each participant had a unique login to the system.

The system was developed in a typical software development process. It started by collecting requirements from the methodology. The interface design was completed adhering as much as possible to heuristics for good interface design (Nielsen, 1989, 1993). As the design development moved forward, it next entered a phase where the overall system was functioning, as a set of usability experts reviewed the overall system to ensure maximum usability (Nielsen, 2000). Once the first set of issues had been addressed, the next round of testing had a set of 20 non-experts completing tasks simultaneously. This was to ensure that the system could deal with simultaneous use and that it entered and retrieved that information correctly to and from the database. Feedback from the users was elicited to discover issues relating to the task they completed. The time users spent to complete tasks was also measured. In addition, users who did not complete the task were interviewed to determine the reasons and solve potential problems related to the software use.

Finally, a small set of dual experts were used for a final review of the system as a whole, including a review of the questions developed from phase 1. For the purposes of this study, a dual expert is defined as having knowledge both about the method / software and about developing questions for futures forecasting. The system was not tested with telecommunications experts, as the study did not want to take away from an already small pool of qualified experts in broadband simply to test the overall functionality of the system. The testing procedures covered areas where errors are typically found in the development process of software (Tullis & Albert, 2008).

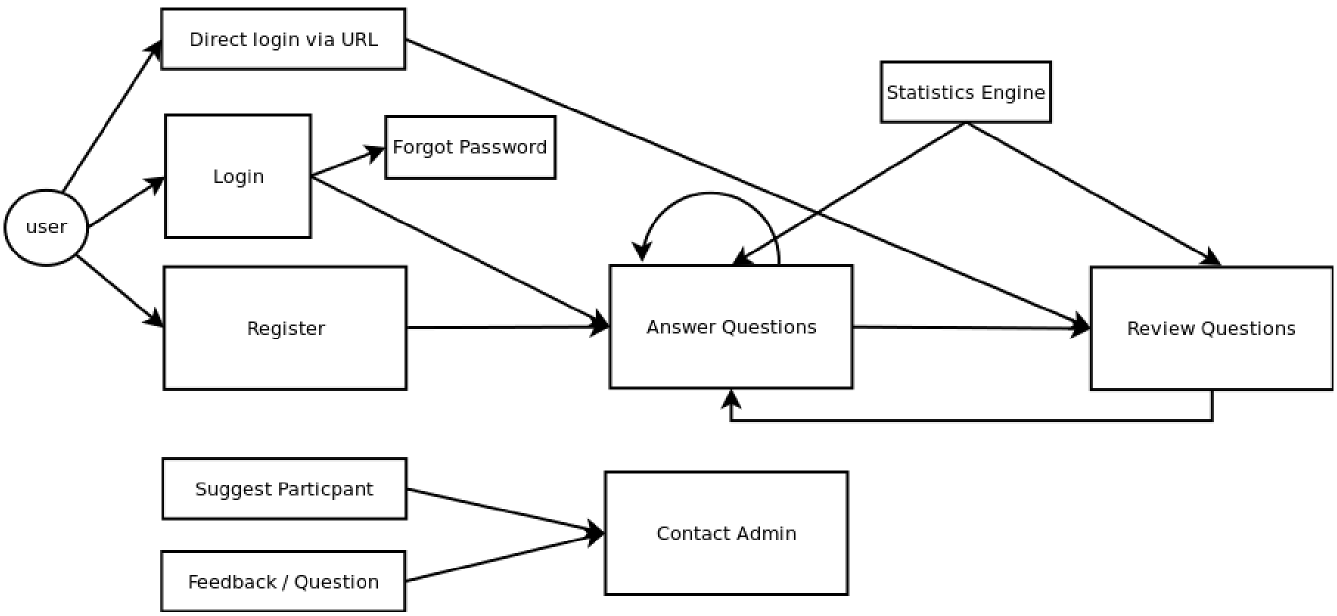

Figure 5: Use Case for the Real-Time Delphi

The use case illustration on page (p. 84) shows the primary uses of the system. There were three ways to get invited to the study:

- You could be part of a group that received a group specific email with a link to go and register for the study.
- You could be preregistered and receive a personalized email with a link that logs you directly in and gets going faster, or,
- You could be referred by another user, and then receive a link to register.

To manage expertise, and better be able to account for expertise levels, the system tracks which link you register from, where you are when you register, how many times you log in, and to what extent you change your answers when new information is presented to you.

To manage the expertise requirement and the overall study requirement about knowledge about Hawaii, the system stores information such as email, IP address, name, and job title. These are types of information used to identify a user. If a user could not be identified to verify the expertise level, the entry was dropped.

When responding to a given question, the participant could evaluate how other respondents answered and what reasons they provided for their answers. For event questions, the participant supplied the year in which they think an event had a 10%, 50%, or 90% probability of occurring. For a trend forecast, the participants estimated the level a trend would have in a given year (2013, 2023, and 2033). No results were shown to participants before they had answered the trend or event question.

As noted earlier, in this method (as opposed to a regular Delphi), there was no explicit second round. This made it more efficient for experts to participate, and the study could be completed in a shorter time. Participants were, however, encouraged to come back and re-evaluate their responses as the study progressed.

Many studies have implemented email reminders to encourage participants to return. The rationale for reminders was that participants who gave their response early in the process could later return and re-evaluate their input as averages and medians for responses to questions had changed. Each of the participants' answers were stored, so the study recorded if, how, and when a participant changed his or her opinion about a given answer.

3.4.4 Interface Design

This section will detail the overall design as it ended up after the refinement processes, in addition to exploring the ideas behind the methodological data gathering tool, and how it was implemented. Finally it will also show how the software extended the methodology and made sure the Delphi requirements were sufficiently addressed .

Keeping with usability heuristics as outlined by Nielsen, the design tried to maintain a simple and natural dialogue, with ample feedback (Nielsen, 1993). Figure 6: Broadbandhi.com - Frontpage shows how the color choices in blue and orange signified a serious but exciting tone (p. 87). The interface provided a simple menu, with static elements on the right-hand side, and dynamic elements on the left-hand side. The dynamic elements changed contextually as the user logged in to the system. Forms are shown in boxes and given visual emphasis (p. 88).

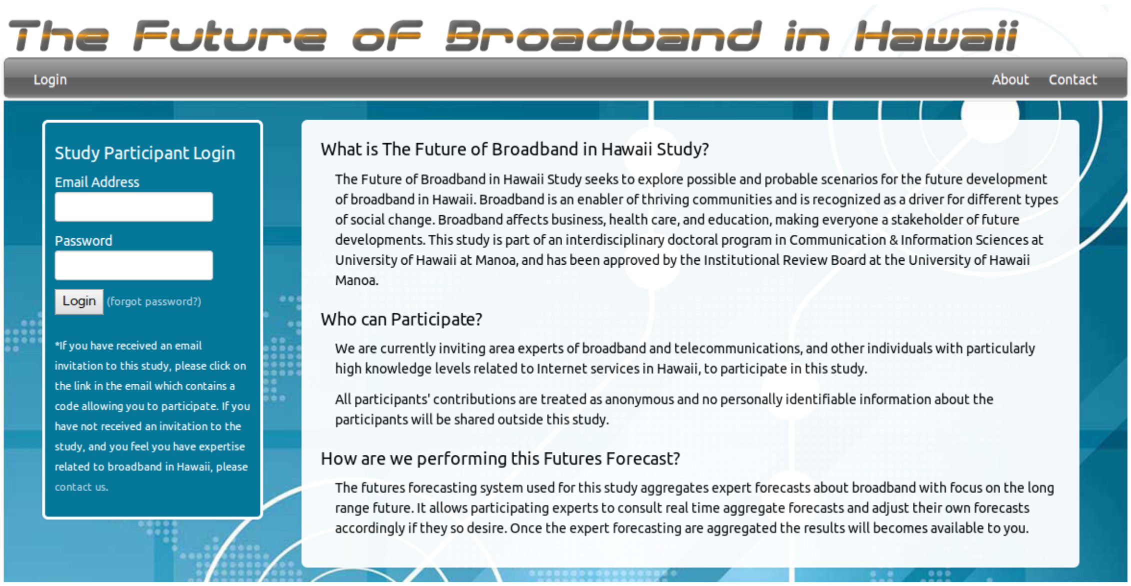

Figure 6: Broadbandhi.com - Frontpage

The study description and contact form were available on the main menu. IRB-required study information was also available for the participants via the web interface. If a participant was given a restricted registration, the URL containing a code that provided the software provided an indication of where the participant received the URL (via a code that also is used to identify the user in the database). The registration particulars are as seen in the Figure 7: Registration Form (p. 88).

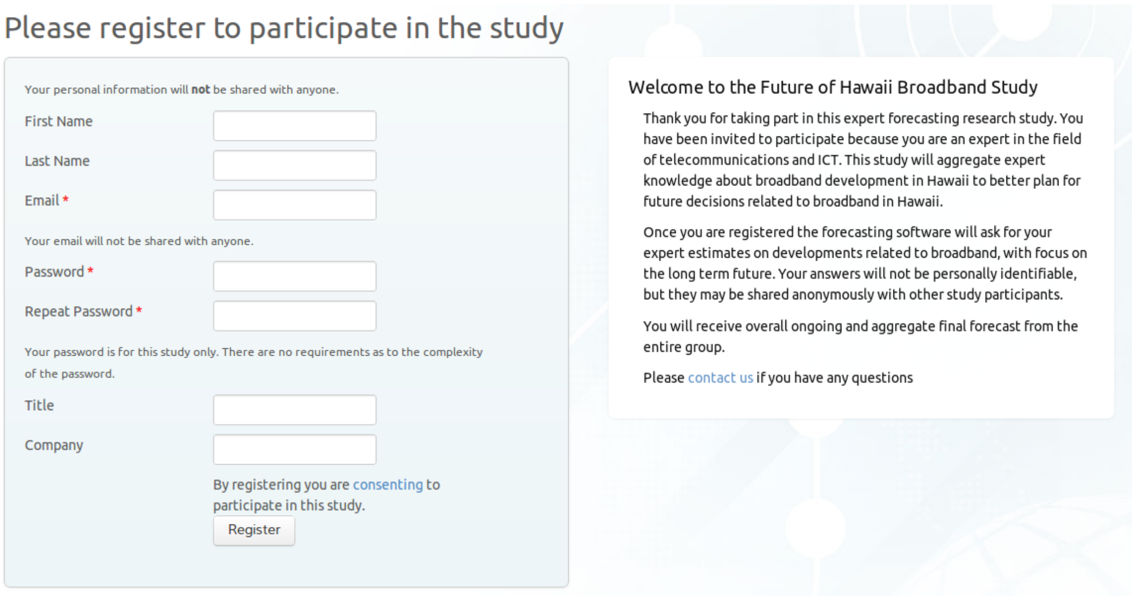

Figure 7: Registration Form

Some high-level participants were added directly to the database by the software, and sent an invitation to participate along with a unique URL that would bypass the registration and login process and move the user straight into the forecasting process. The email itself explained the process and gave them links to the IRB. It also contained a more detailed explanation of the study.

Once a participant started, they were provided an interface to start forecasting

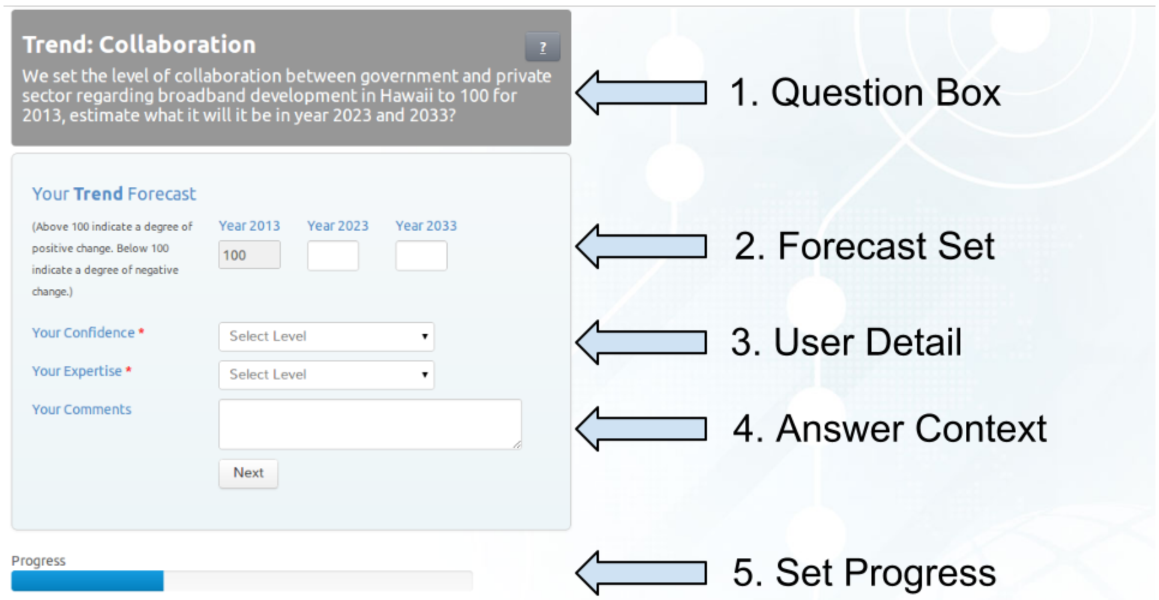

Figure 8: Forecast Interface

(Figure 8: Forecast Interface, p. 89). In keeping with Nielsen's heuristics, the forecast interface was split into three areas, two of which are shown here. These are the two areas that were not displayed until the forecast set fields were filled in.

In the user detail section, a participant would indicate an expertise level and confidence level for the given question. The users enumerated their expertise on a scale of 1 through 10, indicating that 1 is a low level of expertise / confidence and 10 means that the participants judges himself to be a high-level expert.

If the participant had more specific information about the question, the answer context provided an option for adding qualitative data. Finally, the interface provided an indication of the participant's progress through the question set. It was critical to give the study participants the feeling of being in control, and always give them an option to jump in and out of the study, while still providing an overview of their forecasts. The system also encouraged them to move forward and provide answers. The main incentives for participants include not only an intrinsic feeling of supporting a study that deals with their expertise field, but also the ability to review how other experts are judging the same trend and events.

The basic interface had a question panel (1) that was separated from the forecast input panel. The question panel used a headline to set the context for the question, clearly identifying the question as a trend or event. If the question used terminology that needed context, the most important word was emphasized (bold and underlined) and a hover-over definition of the term was also provided in order to minimize confusion. The question panel also had a button that showed the user how to fill in the form. The feedback given was contextualized by the type of question. A trend question would have a different explanation from an event question.

For each event question the system forced the user to provide feedback related to three aspects. The first asked at what time in the future he given probability was expected to occur. Trend questions were expert estimations of levels of given points in the future. This study identified 2013, 2023, and 2033 as points of time in the future. The second asked the expertise level for the given question, and third asked the participant's confidence level related to the question.

The primary forecast panel (2) required three inputs. Text to the left explained what inputs were expected. Hover-overs would provide the user more information about types of input. If the user mistakenly input unexpected data, the system would prompt the participant to correct it. For instance, in event questions, the user was prompted for an estimation of what year a given probability of occurrence would happen. The system encouraged the participants to provide a year. The field kept track of all responses and provided feedback to the user if an unusable estimate was provided. For example, if the participant estimated that there was a 10% probability of an event occurring by 2014, the user would be prompted to estimate the same for a later year in a 50% probability forecast. After all the three fields in the forecast panel were properly filled out, the system stored the response (before it was submitted manually by the user) and then checked to see if aggregate forecasts could be loaded. The system would then dynamically set the number of responses needed, as well as what level of expertise and confidence a participant had to have in order for the participant's answer to be used in the aggregate data.

One major difference between the this study software and other Real-Time Delphi software is that experts self-evaluate their expertise level in addition to expressing their confidence level. A person who has little knowledge about a given topic may still be very confident that the forecast is correct. Conversely, a person with a high level of expertise may still have little confidence in their forecast. These are two parameters that provided a little more detail about the nature of the forecast. For the answers to be used they had to score reasonably high levels of confidence and expertise. It should be noted that self-evaluated expertise levels are usually a better measurement than certainty level (Wedemeyer, 2004).

The software was designed to load group feedback dynamically. The timing of the load was important in order to avoid problems of peer influence, while still giving the participants the option to review their forecasts. The loaded aggregate group were scored as each participant supplied their forecast but before they provided their expertise and confidence levels.

The panel provided multiple ways of showing the participants the aggregate results. The trend line showed the median answers for each of the forecasts. For instance, if the questions asked about a trend, the graph displayed the development of median answers for each of the years 2013, 2023, and 2033. Then under the graph it provided the actual median scores. The third indicator was a box graph of the median score and range. Under the median score the 50% range was displayed. Finally, from the quantitative data the number of responses used for calculation were also provided. Each of these types of statistics showed different aspects of the data, and each of the sections provided explanations of those statistics.

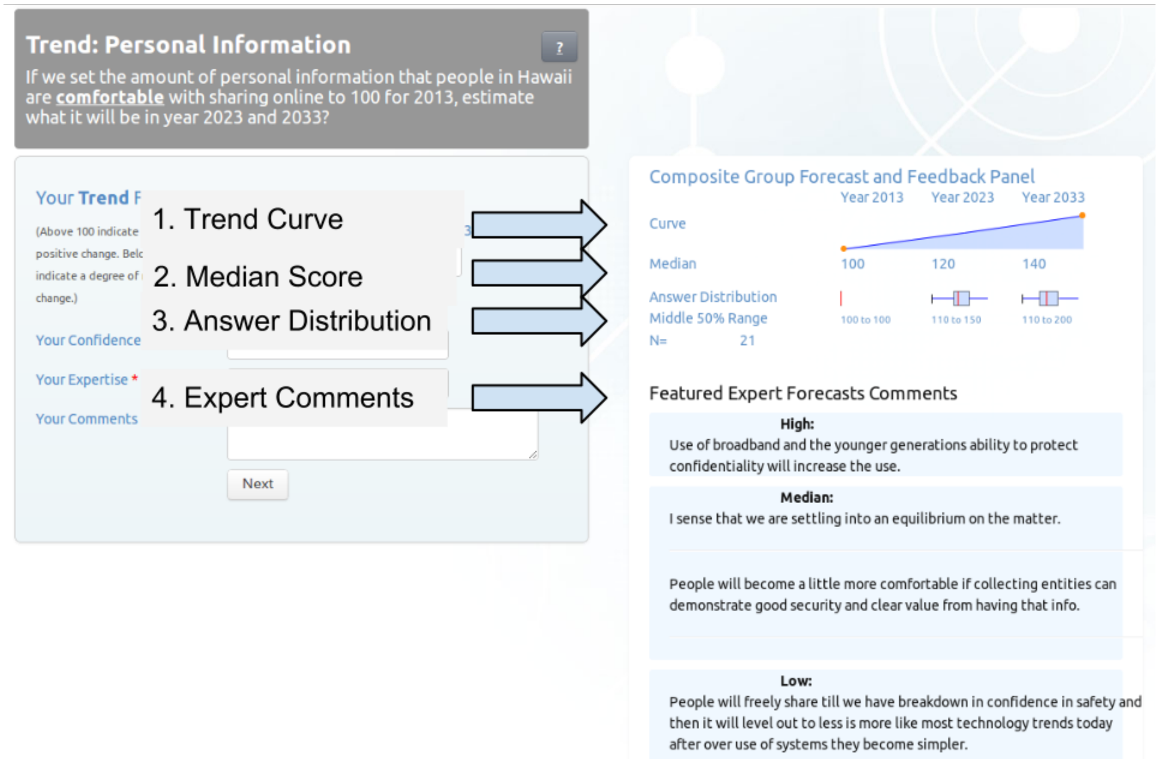

Figure 9: Composite Feedback Panel

The next section of the panel displayed the qualitative data. It provided the two answers given by the experts that scored the highest self rated expertise and confidence in their forecasts for each of three groups of answers: The highest 25% of the forecasts, the middle 50% of the forecasts, and the lowest 25% of the forecasts.

After the participants provided an answer, the software updated the results from the aggregated group feedback every 30 seconds using an AJAX connection. As more answers arrived, aggregated results were updated. If the participant self-evaluated as not being an expert on the given question domain (below a certain threshold), the answer provided would not be not included in the final set of aggregate results. Finally, an option for the study participant to enter a rationale for the answer was also provided. The rationale for this covers the Delphi study requirement of collecting qualitative data. Knowledge about specific information that can be critical to other participants' decision process is encouraged by the study (Gordon & Pease, 2006).

3.5. Phase 3 - Cross-Impact Simulation

This section will outline the steps needed to complete a simulation of the Cross-Impact analysis, in addition to a short outline of the simulator.

“Well-known for many years, the Cross-Impact analysis is a family of methods that has been developed into many variants to generate rough scenarios for complex, but weakly structured systems.”(Weimer-Jehle, 2006, p. 336). This type of analysis makes an ideal candidate for studying complex problems such as sensitivity studies, scenario building, and comparative policy analysis (Wedemeyer, 1985a). In forecasting, expert participants make judgments about items that are identified as important drivers for given trends. Cross-Impact analysis provides an opportunity to adjust given probabilities based on events' interaction with other events and trends. Simply put, it can answer the question of “what if a given event happens?”.

There are three main steps to the Cross-Impact Simulation process (Figure 3: Study Steps, p. 59). In the preliminary stage, problem boundaries were defined, and suitable and critical trends and events that were used in the simulation were selected.

Next, a matrix of Cross-Impact factors that described paired relationships was developed. These comprised the initial trend levels, event probabilities, and the calibration of the mathematical model.

The probabilities gained from the Real-Time Delphi were evaluated and the topmost events in terms of probability of occurrence and impact were selected for simulation. The most important trends were also used.

The selection of events and trends was based on the real-Time Delphi output, with emphasis placed on the phase 1 interviews and the researcher knowledge and understanding of the field. Trends Hawaii had little influence over were dropped. They were still important in an overall understanding of the problem situation, but would only make the model unnecessarily complex. The total number of developments recorded depended on the results from the Real-Time Delphi. If there had been a clear demarcation between the event estimations in the Real-Time Delphi it would naturally separate them, but in this situation, deeper judgments had to be made in order to select the events. This identification was supported by the software that suggested candidates based on the created data from the Real-Time Delphi.

The matrix for probability estimations also had to be set up. This is a matrix which allows events to include some Cross-Impact information, and accompanying influence on other events and trends. Events and trends are jointly called developments. These developments influence each other differently.

In a Cross-Impact simulation the events influence events and trends, but trends do not influence other developments. For example, if event E1 occurs, how it affects event E2, will influence a change in probability of occurrence. If event E1 occurs and E2's probability of occurrence goes up, it immediately impact other developments. If E1 has an effect on trend T1, that change is given as a fluctuation from its given course.

Note that the probability estimation still has to be within the initial probability boundaries set by the Real-Time Delphi.

These calculations had to be done for every possible event on event and event on trend (but not trend on event) and then allowable ranges were used to estimate the conditional interactions, leading to the construction of a Cross-Impact Matrix. Once the matrix was set up, the process of calibration could be completed.

The calibration was completed when the outcome of the Cross-Impact Matrix simulation closely followed the forecasts from the Real-Time Delphi. Once the development on development influence was found, the simulation could start. The main point was to create a model that fit closely with the expert estimations from the Real-Time Delphi process. The influence calibration error acceptance was set at (+/-) three degrees.

Once the influences were calculated, the method proceeded as follows:

1. Set the number of runs
2. Started the first run
3. Started from year one (2013)

4. Randomly selected an event from the event set

5. Randomly selected a number between 0 and 100 and used it to compare against the event being tested. If the random number was equal or smaller than the estimated probability of the event, then the event was assumed to occur.

6. If the event was said to occur, then the values of all the developments were adjusted according to the influence matrix. New probabilities of all other events are recorded, and used to compare with the randomly selected number. If the event did not occur, then no impacts were calculated.

7. Steps 4, 5, and 6 were repeated until all the events had been tested for occurrence against a unique random selected number.

8. Moved to the next year, repeated steps 3 through 7.

9. Once all the years had been completed, moved to the next run (steps 2 through 7)

Steps 3 through 7 represent a single run of the matrix. These were repeated a large number of times using a Monte Carlo simulation. The occurrence frequency of occurrence for each event, for all runs of the Cross-Impact matrix, determined the new probability of that event.

Finally, the study took the output from the Cross-Impact simulation and interpreted the results to provide different scenarios of risk for broadband development. The model provided the ability to set events to occurring or not, and then looked and evaluated the effects they had on the trends.

4 REAL-TIME DELPHI RESULTS

This section will detail the results from the Real-Time Delphi process. It will first present the participants with a brief summary of the general statistics. It will then review some of the strategies for how these experts were included. In addition their response rate will be presented. The chapter will then go through more detailed results from Real-Time Delphi. It will detail what results were selected and why they were selected. For each selected question the type of question (trend / event), the headline seen by the participants, the question text and which STEP dimension it belongs to will be presented. Finally it will graphically present the response median and interquartile range (q1, median, q3). Then it will show average confidence, average expertise, and uncertainty levels reported for each question. Finally the study introduces a new concept of measuring uncertainty that will be used to order the questions results. Each question was assigned a unique ID in the database and that is noted as Q (uppercase q) + the ID number will signify that particular question throughout the study.

4.1. General Real-Time Delphi Results

This section will go through the general results from the Real-Time Delphi starting with the participants.

4.1.1 Participants.

This section describes the participants and participant data. In general there were a few different ways people could be invited to the study. The idea was to capture more experts by allowing different ways of participating.

As described there were three ways to get invited to the study: direct contact; an email list; and references. The first group that was elicited for participation was selected from a list of more than 11500 members. The primary criteria for selection was that the person was a telecommunications expert with special knowledge about Hawaii. Though it might be possible that experts outside Hawaii have expertise about broadband in Hawaii, the assumption was that they had to live in Hawaii. That cut the list to a more manageable 973. From this list some people had specifically asked not to be solicited. Additional criteria included an expert's place of work, position in an organization and general interests. This left 256 people to be invited via email. The email was sent from Pacific Telecommunications Council with an endorsement from the CEO.

The email yielded 19 visitors to the page- all of whom were located in Hawaii. Of these 19 visitors, 13 registered in the system, and 8 answered 1 or more questions. A more detailed discussion about the actions this caused will be made in Chapter 6.

Overall there were 67 participants registered in the software. Forty-four of these were pre-registered and invited directly based on reputation, job description, role and overall participation in the field. Four participants were recruited from general solicitation of other expert groups. Six were participants referenced by other high level experts. Some experts were recommended by several other participants. All the experts that came in from a general link were vetted. This resulted in one deletion due to the study's inability to verify the person's expertise level.

Many of the participants were members in the Hawaii Broadband Task Force and served in prominent telecommunications jobs for the State, in academia and / or in private industry. Some play dual roles. The remainder was people that were selected and invited via databases of telecommunication professionals.

Of the total 67 participants, 41 logged in to the study. This means that 26 of the pre-registered experts never opened the link to the study. Of the 41 participants, 32 answered one or more questions, with an average of 27 questions answered and a total of 859 answered questions. Seven of the participants that provided answers were female.

The average confidence across all questions was 5.56 and the average self-reported certainty level was 5.57. The choice to make *five* the threshold for expertise and certainty was selected based on this average. Overall there were 16 participants that logged in to the system more than once (for follow up and review of answers) and the time spent on each question was between 30 and 60 seconds.

Over the course of the study 90 people had visited the site.

Login Distribution across the academic, government and industry is as follows:

	Academic	**Government**	**Industry**
Logged In	13	12	16
Not Logged In	0	15	11

Table 1: Participant Logins

The "Not Logged In" column refers only to the experts that were directly invited-either via reference, or via their roles on central committees. In addition there were about 250 individuals who received a general link they never clicked on. Military is sometimes categorized separately, but this study categorized military personnel with the government.

A brief review showed that all devices used to access the study had been pre-tested with the system. No errors were reported.

4.1.2 Real-Time Delphi results

This section will present the forecast results from the Real-Time Delphi. First it will present some general information about the questions before each of the selected questions will be presented. The questions will also have details such as type of question. If it was an event or trend. It will provide the headline for the question and the question text.

Initially the study presented 83 questions, however, only questions that have a large enough number of answers with high confidence ratings and expertise levels were selected to be presented in this section. The threshold was set at five or more numbers of experts that have five or higher for confidence, and five or higher for expertise. For a full overview of all the questions see Appendix B and C.

The questions are presented in the order of events, then trends, and then ordered by the number of participants who answered and who have expertise and confidence level at 5 or higher.

For each of the graphs, three lines will be reported. First of all, and most importantly the median answer for each of the forecasts is shown. Secondly, the semi-interquartile range represents the range of dispersions while also avoiding extreme outliers. It is computed as one half the difference between the 75th percentile (in our graphs called q3) and the 25th percentile (in our graphs called q1). (The formula for semi-interquartile range is therefore: (q3-q1)/2).

This study introduces a new measurement of uncertainty dubbed uncertainty index. The index has not been used before and should provide indications on how much uncertainty is related to the forecasts provided for a given question. The assumption is that the more the expert's forecasts vary, the higher the uncertainty relating to that question is. The formula for the uncertainty index (U) is a measure of IQR / Q3. Because the questions have different parameters set, it is not an entirely relative scale where all the questions can be perfectly compared, but if we take the U average from 2023 to 2033, and it shows one aspect of how much uncertainty relates to a question / forecast.

Overall there were 46 questions that met the criteria of more than five answers that had a confidence and expertise level at or above five. These questions were distributed over the STEP categories as follows:

Category	**Number of questions**
Social	7
Technological	11
Economic	13
Political	13
Environmental	2

Table 2: Question Distribution in STEP categories

There are more economic and technological and political questions. The question selection and presentation was made based on the interviews in the environmental scanning method.

Question Type	Number
Event	14
Trend	32

Table 3: Selected Event and Trend Questions

Top 5 Confidence for Events

These are the events that the experts had the most confidence in answering. While considering confidence the study mainly evaluates how sure the experts are in their forecasts. Though there could be some correlation between an expert's confidence and expertise, the questions lists are not the same.

In the following tables, the column labels means that only participants that had a five or higher in both confidence and expertise for the given forecast were counted and used. The column labeled confidence measures the average confidence on the participants that had five or higher in self rated confidence and five or high in self-rated expertise. The column labeled expertise means the average expertise level on the participants that had self rated expertise and confidence over five.

Q	Type	Category	Experts	Confidence	Expertise
76	Event	Environmental	5	8.2	7.8
36	Event	Political	10	7.6	6.8
66	Event	Technical	5	7.4	7.8
27	Event	Political	10	7.4	7.5
17	Event	Political	11	7.36	7.18

Table 4: Top 5 Confidence for Events

Top 5 Expertise for Events

These are the events where the experts considered themselves as having a lot of expertise. A more detailed discussion of this will follow in chapter 6, but it is worth noting now that the study notes that experts self-judge relatively high on the environmental question- about the probability of a natural catastrophe.

Q	Type	Category	Experts	Confidence	Expertise
66	Event	Technical	5	7.4	7.8
76	Event	Environmental	5	8.2	7.8
27	Event	Political	10	7.4	7.5
17	Event	Political	11	7.36	7.18
16	Event	Technical	8	7.25	7

Table 5: Top 5 Expertise for Events

Top 5 Confidence for Trends

These are the trend questions that the experts judged themselves as having the highest amount of confidence in. The top question relates to the percentage of businesses that subscribe to 1 GBit connections in the future. The second highest relates to the price of storage in the future.

Q	Type	Category	Experts	Confidence	Expertise
4	Trend	Economic	7	8.29	8.14
73	Trend	Technical	5	8.2	7.2
24	Trend	Economic	6	7.83	7.67
89	Trend	Political	6	7.83	7.5
86	Trend	Economic	9	7.67	7.67

Table 6: Top 5 Confidence for Trends

Top 5 Expertise for Trends

On top of the top five in expertise, the same Q4 comes back. The second highest rated question is the price of connection in the future. We can see that experts rate their expertise highest in trends that deal with economic questions. This could be because prices are trends that are used to projecting and so the processes of forecasting economic trends is more familiar.

Q	Type	Category	Experts	Confidence	Expertise
4	Trend	Economic	7	8.29	8.14
8	Trend	Economic	6	7.33	7.83
86	Trend	Economic	9	7.67	7.67
24	Trend	Economic	6	7.83	7.67
34	Trend	Economic	6	7.33	7.67

Table 7: Top 5 Expertise for Trends

Overall there are 14 event, and 32 trend results that are presented.

Given in the results is that an event can never have a higher probability of occurring than 99%. Conversely, it can never have less than 1% chance of occurring. If the answer provided by experts is that the event will never occur, it is displayed as a line of the previously reported probability of occurrence. This means that if the answer for 2013 is never, it will remain at 1% probability of occurring. Other events can still occur and influence it. If the last probability of occurring was 10%, the curve will level out and remain at 10%.

Trends are value estimations and can have any value provided by the experts as long as it is within the value parameters set for that question. For most of the questions this was -9999 to 9999.

For all events, the probability of occurrence follows the Y axis and the year that event will have happened in is the X axis.

All questions are labeled with upper case Q, and a unique ID. Appendix B and C contain a full overview over all the questions.

4.2. Detailed Real-time Delphi results

Detailed results for each of the 46 questions follow below.

4.2.1 Q17 Event: Internet Content Regulation

Question Text: The US federal government creates a law to monitor all content served via the Internet?

Question Details	
Q	17
Type	Event
Category	Political
Experts Details	
Number of experts	11
Average Confidence	7.36
Average Expertise	7.18
Uncertainty Index	0.49
Median Results	
2013	9.50
2023	9.75
2033	9.99

Table 8: Q17 - Event: Internet Content Regulation

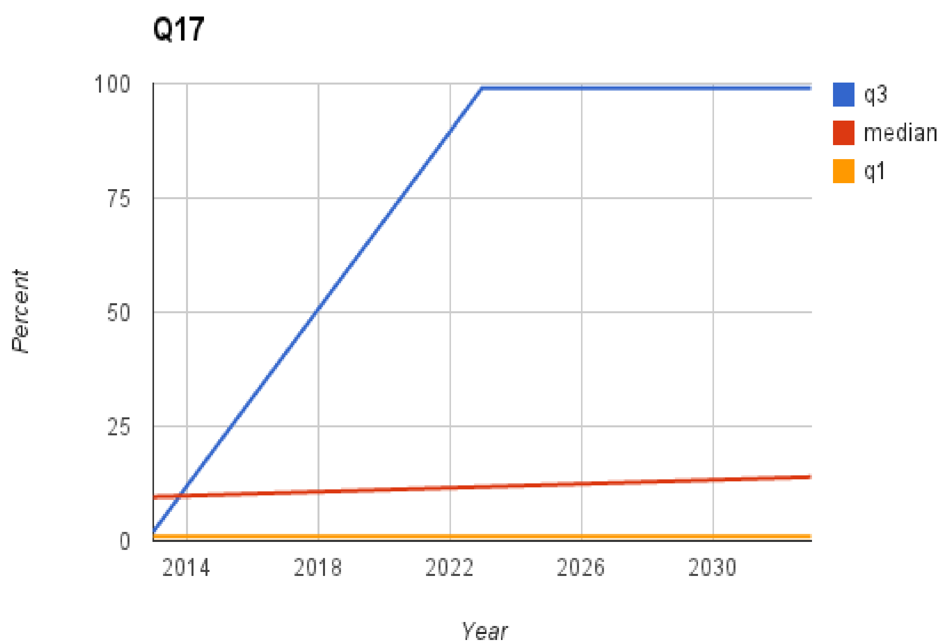

Figure 10: Q17 - Internet Content Regulation

The 3rd quartile shows that quite a few experts forecast that this event will never happen. Yet the median score shows that the probability of it occurring will stay at about 10% through 2033. q1 forecasts this will happen by 2023. A closer look at the qualitative data shows a person in q1 that claims that this is already happening. The large distance between q1 and q3 could indicate that there is a lot of uncertainty regarding the topic, and how people define the parameters for what all content consists of, and indeed the U shows almost a max score for U in a world of only positive values. The forecast states a steady 10% chance of the federal government implementing monitoring of all content served via the Internet.

This is identified as a threat to development and partially answers research question 1.

4.2.2 Q36 - Event: One-Stop Permitting

The State of Hawaii created a new one-stop regulatory and permitting authority for the advancement of broadband in the State.

Question Details	
Q	36
Type	Event
Category	Political
Experts Details	
Number of experts	10
Average Confidence	7.60
Average Expertise	6.80
Uncertainty Index	0.35
Median Results	
2013	1
2023	82
2033	99

Table 9: Q36 - Event: One-Stop Permitting

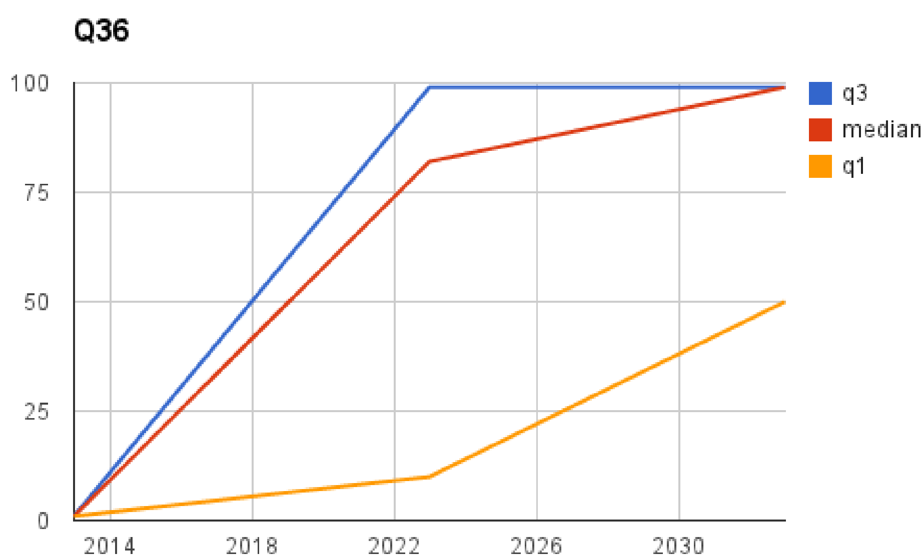

Figure 11: Q36 - Event: One-Stop Permitting

In interviews this was one of the topics the study found that experts agreed upon the most. The regulatory process is too complex and it needs refinement. To what extent the telecommunication regulatory process actually will change and how such a one-stop process would work is a matter of discussion, but the experts do forecast that a one-stop regulatory process will exist before 2033. Because it seems that there is a degree of agreement that not only is this important, but that it will happen, it is included in the simulation effort. Taking the uncertainty index into account, this question stands out in that compared to many others Moreover, this is a question that experts seem to agree on.

In the study this was identified as a broad opportunity that will benefit most.

4.2.3 Q46 - Event: Internet as a Utility

Broadband is declared a utility (like electricity and water) in Hawaii?

Question Details	
Q	46
Type	Event
Category	Social
Experts Details	
Number of experts	11
Average Confidence	6.36
Average Expertise	6.55
Uncertainty Index	0.457
Median Results	
2013	1
2023	99
2033	99

Table 10: Q46 - Event: Internet as a Utility

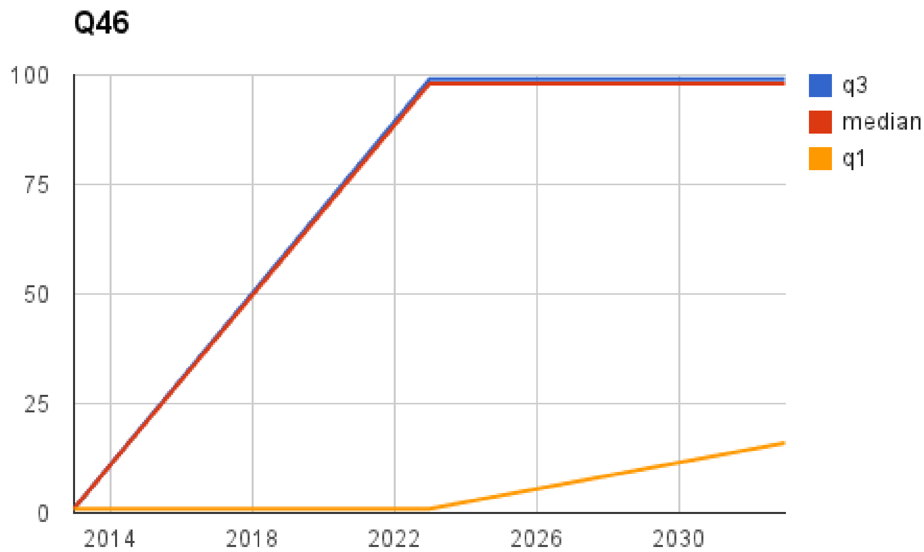

Figure 12: Q46 - Event: Internet as a Utility

The results from this question show that the median answer is overlayed by q3. In terms of broadband as a utility, a few experts think this will never happen. The median answer forecasts Internet will be treated as a utility by 2023. The large gap between q3 and median might suggest that there are two main camps: one believes it will not happen and one may believe it most definitely will. In conversations they also do suggest that the reason for this is Telecommunications history of deregulation in the 96 Act. Others point to how critical broadband services will be in the future.

In the study this is identified as an opportunity. Though some industry experts expressed concern the overall perception was that it is a utility. As one of the participants expressed it: “It is a utility already just not from a regulation standpoint”.

4.2.4 Q27 - Event: Human Right

The Hawaii congress makes broadband a human right (in Hawaii)

Question Details	
Q	27
Type	Event
Category	Political
Experts Details	
Number of experts	10
Average Confidence	7.40
Average Expertise	7.50
Uncertainty Index	0.4718
Median Results	
2013	1
2023	22
2033	56

Table 11: Q27 - Event: Human Right

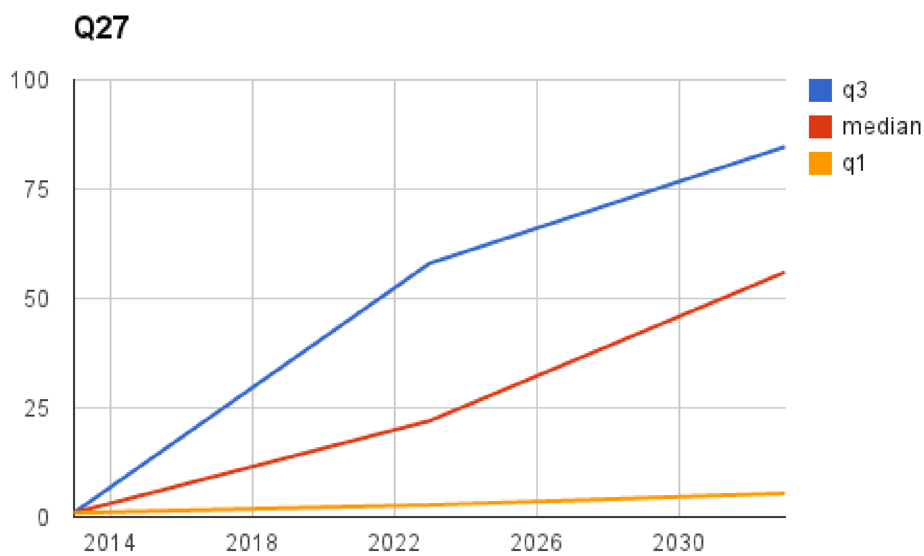

Figure 13: Q27 - Event: Human Right

This question came up in all the interviews. Finland making broadband access a human right spurred a lot of discussion around the world- so much so that other countries have made efforts to make information access a human right. Now there are others such as Vinton Cerf who feel Internet access is not a human right because it is the tool in which you get to information (Cerf, 2012).

Overall, experts thought there was only about a 50% probability that Internet would be made a human right in Hawaii by 2033. Making Internet a human right would increase the visibility and effort for Hawaii to focus on the digital divide. The results show there is almost 50% chance that it will happen by 2033.

This was identified as an opportunity.

4.2.5 Q15 - Event: Privacy Law

A modernized privacy law will protect personally identifiable information of individuals in Hawaii better than the currently passed policies?

Question Details	
Q	15
Type	Event
Category	Political
Experts Details	
Number of experts	9
Average Confidence	6.78
Average Expertise	6.78
Uncertainty Index	0.3164
Median Results	
2013	2
2023	42
2033	82

Table 12: Q15 - Event: Privacy Law

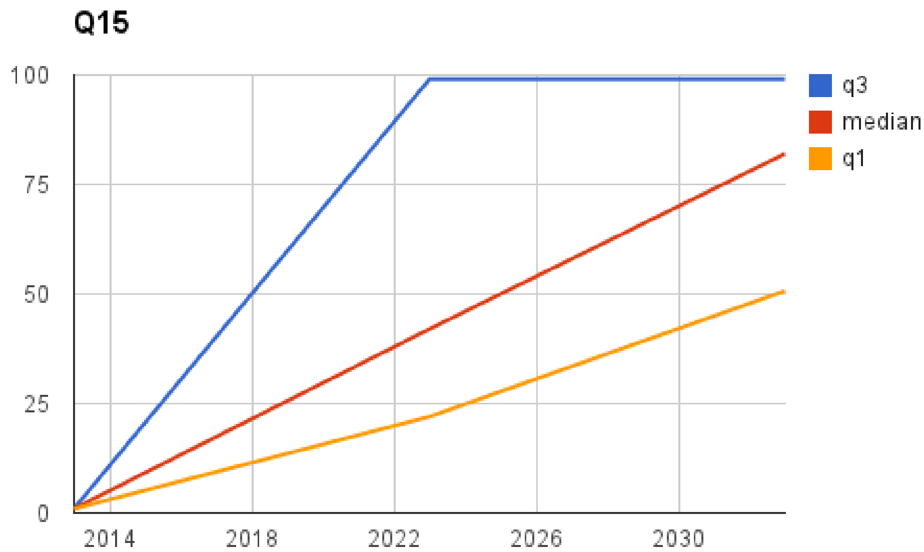

Figure 14: Q15 - Event: Privacy Law

Debates about trust in online services are becoming more prevalent. As privacy is discussed at all levels from blogs to multinational politics, more focus will be put on the protection of individual privacy. The experts forecast that the probability of Hawaii as a state creating laws for the protection of its citizens before 2033 to be over 75%. How effective a law like that would be is a matter of degree. Not only did the experts believe that this would happen, but they were also in reasonable agreement.

This was identified as an opportunity. A law protecting citizens will probably lead to more trust. However if the law is adverse to running a company efficient it could be seen as a threat.

4.2.6 Q56 - Event: Actionable Offense

Broadband network downtime as a result of negligence becomes a legally actionable offense in Hawaii?

Question Details	
Q	56
Type	Event
Category	Political
Experts Details	
Number of experts	9
Average Confidence	6.78
Average Expertise	6.56
Uncertainty Index	0.4928
Median Results	
2013	1
2023	27
2033	54

Table 13: Q56 - Event: Actionable Offense

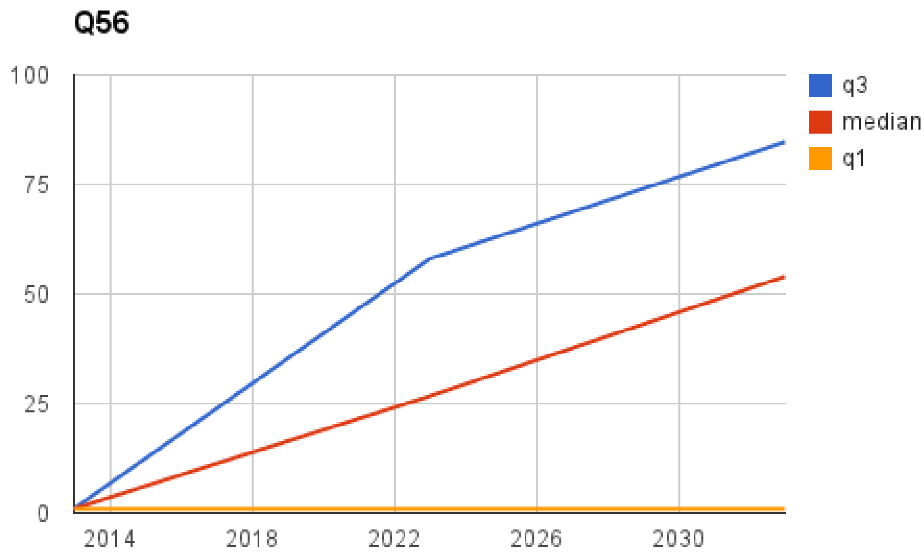

Figure 15: Q56 - Event: Actionable Offense

Very important resources for societies will often be protected by laws. In a society that becomes more and more dependent on network connection services to do any of its production, it is not unimaginable that companies that offer such services can be held legally liable if that infrastructure fails as a result of negligence- especially if that network connection is a relatively fragile but mission critical piece of infrastructure.

Recently a customer in Germany successfully sued an ISP for negligence. He was awarded not only a refund, but also reparations for the loss of Internet connection. The experts found that there is an about 50% chance that this will become law in Hawaii by 2033.

To what extent this is a threat or an opportunity depends on perspective. This is one of the issues that can be turned to an opportunity. It would probably affect prices, but the level of service would be higher. It would reflect a high level of dependence on the service.

4.2.7 Q64 - Event: Political Scandal

A major scandal occurs that negatively affects the development of 1 gigabit per second synchronous Internet connection in Hawaii?

Question Details	
Q	64
Type	Event
Category	Political
Experts Details	
Number of experts	9
Average Confidence	7.11
Average Expertise	5.38
Uncertainty Index	0.4921
Median Results	
2013	1
2023	50
2033	50

Table 14: Q64 - Event: Political Scandal

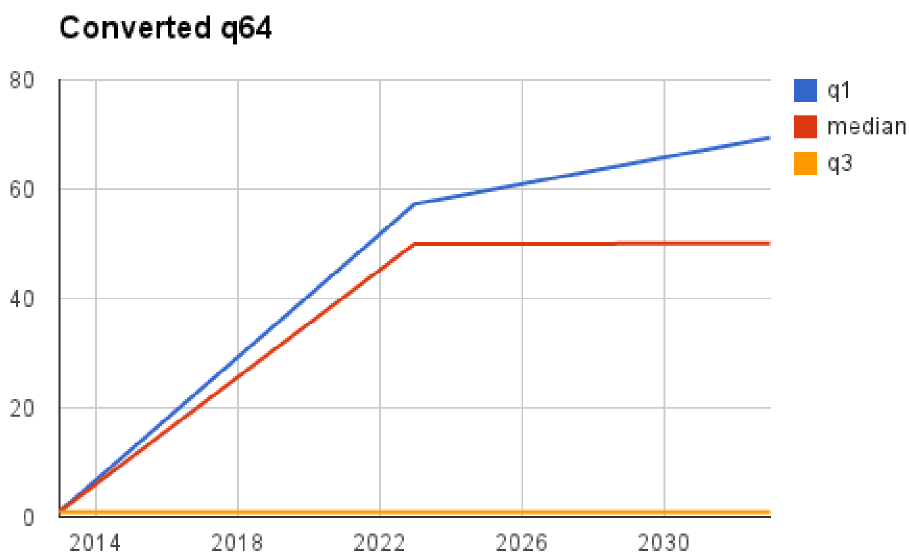

Figure 16: Q64 - Event: Political Scandal

A political scandal can often be very detrimental to development. It often leads to distrust in officials, and it makes it harder to make legislation. This question had a lot of uncertainty related to it, and people seemed split in two camps. Though many said it was unlikely to happen ever, it is considered an overall threat as an event like that can have consequences that are hard to estimate.

4.2.8 Q35 - Event: Roaming Outages

Hawaii is experiencing roaming outage on Internet connections due to high bandwidth demand?

Question Details	
Q	35
Type	Event
Category	Social
Experts Details	
Number of experts	8
Average Confidence	6.63
Average Expertise	6.75
Uncertainty Index	0.343
Median Results	
2013	1
2023	41
2033	71

Table 15: Q35 - Event: Roaming Outages

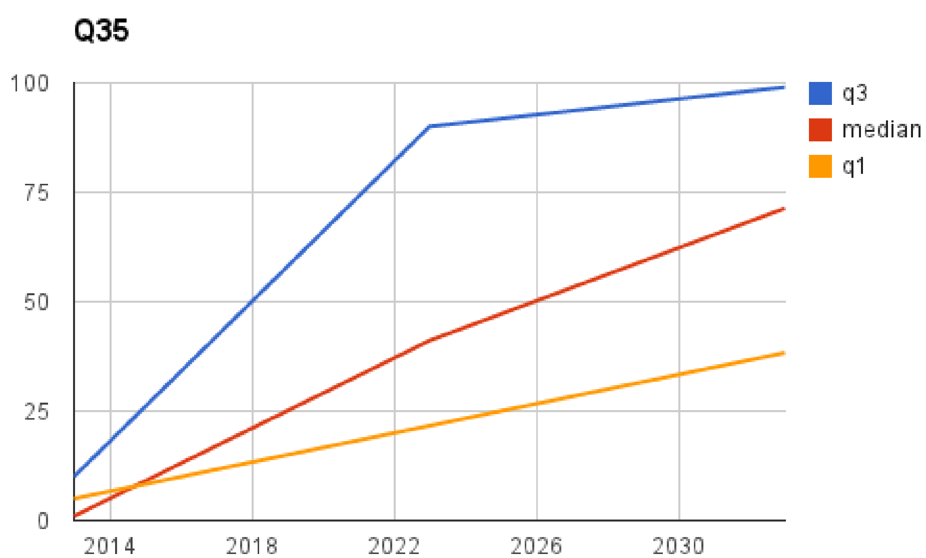

Figure 17: Q35 - Event: Roaming Outages

The interviews showed that Hawaii has to a certain degree already run out of bandwidth. It also became clear that the current submarine cables to and from Hawaii are not expected to sustain the anticipated growth in bandwidth use- despite a current bandwidth surplus and growing capacity. It does seem that there was some difference in opinion between different groups in terms of the probability of running out of bandwidth.

In an economy that is dependent on these submarine cables for all industries, avoiding adding to bandwidth can have a severe rippling effect. The experts, upon forecasting, were may be not as certain as some of the previous questions, but overall forecasted it to be an about 70% chance it will happen before 2033. This is seen as an overall threat. Several of the high level experts noted how important it is to expand service before an event like that happens. It further emphasizes the need for a forward looking study.

4.2.9 Q16 - Event: Security Breach

A serious security breach at one or more of the Internet service providers has left 50% or more of the population in Hawaii with no Internet access for more than a day?

Question Details	
Q	16
Type	Event
Category	Technological
Experts Details	
Number of experts	8
Average Confidence	7.25
Average Expertise	7.00
Uncertainty Index	0.2483
Median Results	
2013	1
2023	59
2033	90

Table 16: Q16 - Event: Security Breach

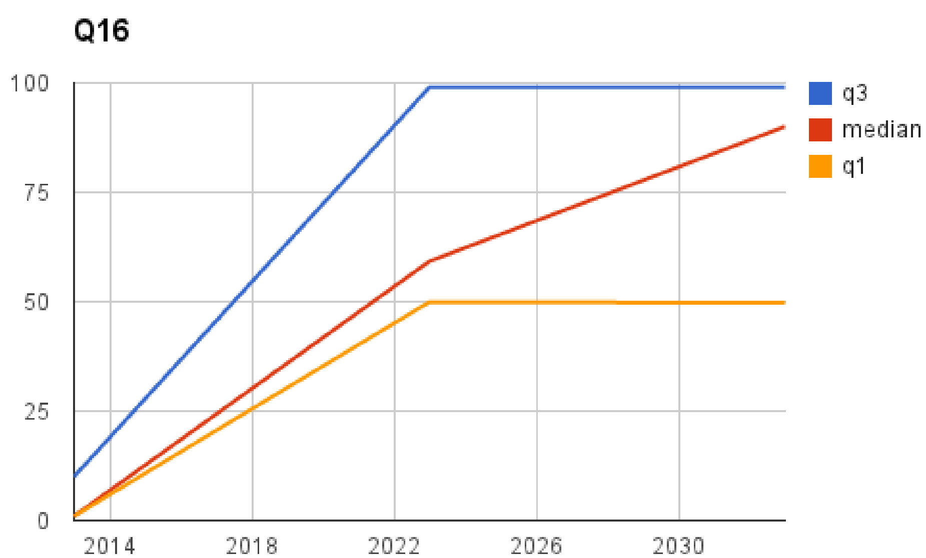

Figure 18: Q16 - Event: Security Breach

There seems to be a lot of agreement among the experts on this. The uncertainty index was a low 0.24. The overall forecast says there is a 90% probability that a security breach will leave over 50% of the population with no Internet for a day or more. In terms of productivity it is not hard to quantify the impact such an event would have. Not long ago most of the west side of Oahu was left with no Internet connection for several days due to someone cutting the main line. Events like that emphasize the need for plans with criteria for resilience and recoverability of the network. One comment was “We have to build redundancy into our networks...we cannot become dependent and die.”. This is evaluated as a threat.

4.2.10 Q33 - Event: Economic Crisis

By what year will Hawaii experience an economic crisis at the same level or worse than in 2008/2009?

Question Details	
Q	33
Type	Event
Category	Economic
Experts Details	
Number of experts	7
Average Confidence	6.57
Average Expertise	6.86
Uncertainty Index	0.2879
Median Results	
2013	1
2023	62
2033	85

Table 17: Q33 - Event: Economic Crisis

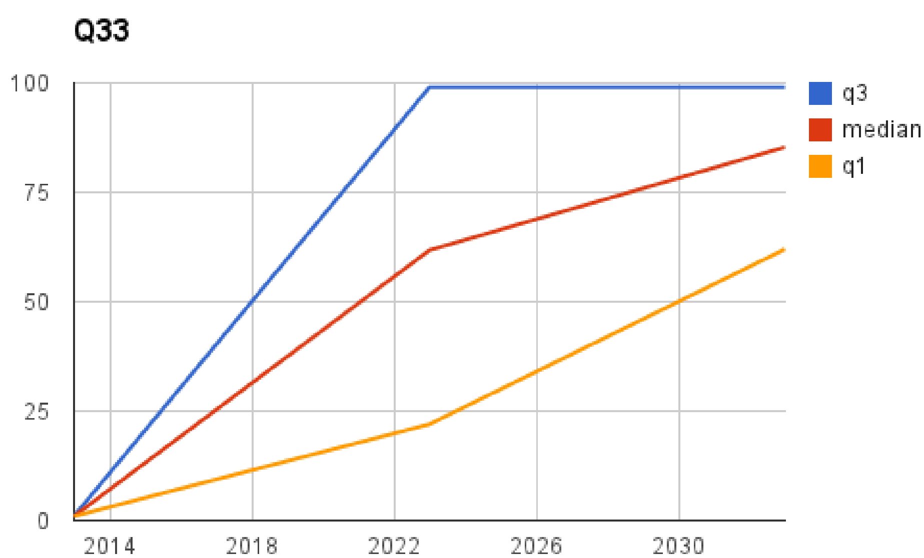

Figure 19: Q33 - Event: Economic Crisis

In 2023 there will be a 60% probability that Hawaii has seen a large economic recession. This is definitely a threat to the overall development. Given Hawaii's experience before it only serves to emphasize the importance of a diversified economy. It also emphasizes the need to make positive changes in the near future.

4.2.11 Q76 - Event: Natural Disaster

A major natural disaster interrupts the Internet connection for a majority of the State of Hawaii for 1 day or more.

Question Details	
Q	76
Type	Event
Category	Environmental
Experts Details	
Number of experts	5
Average Confidence	8.20
Average Expertise	7.80
Uncertainty Index	0.183
Median Results	
2013	1
2023	98
2033	99

Table 18: Q76 - Event: Natural Disaster

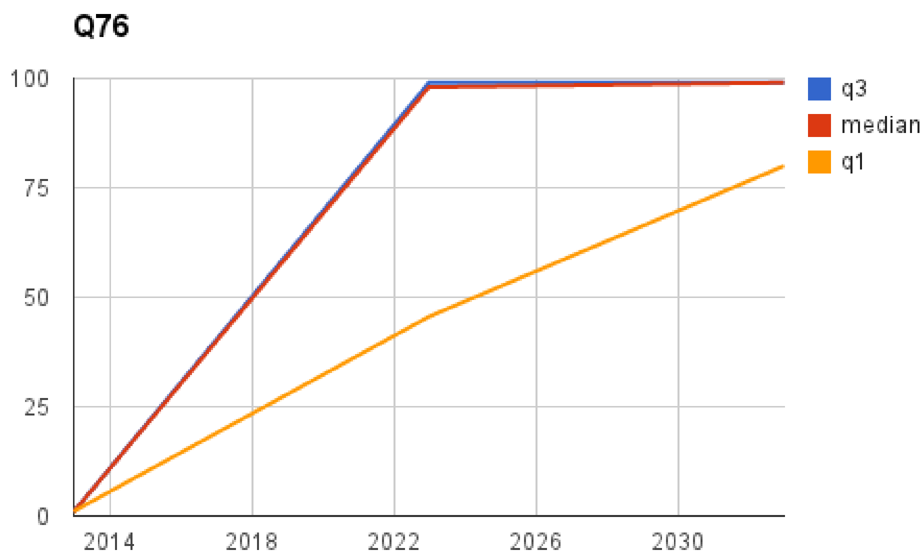

Figure 20: Q76 - Event: Natural Disaster

The experts were in agreement that this will happen with a high degree of confidence- and fairly soon. Now this particular question might be influenced by the recent tsunami warnings. High tension events such as that might have undue influence. Regardless, it does show that some effort should be put on increasing the resilience of the network itself. A quick note. This study was launched after a set of Tsunami warnings. These might have influenced as proximity in time does influence judgments. Still this is evaluated as a threat.

4.2.12 Q39 - Event: Minimum Quality of Service

Policy makers set legal restrictions and minimum standards for quality of Internet service in the State of Hawaii?

Question Details	
Q	39
Type	Event
Category	Political
Experts Details	
Number of experts	9
Average Confidence	6.33
Average Expertise	6.78
Uncertainty Index	0.49
Median Results	
2013	2
2023	42
2033	82

Table 19: Q39 - Event: Minimum Quality of Service

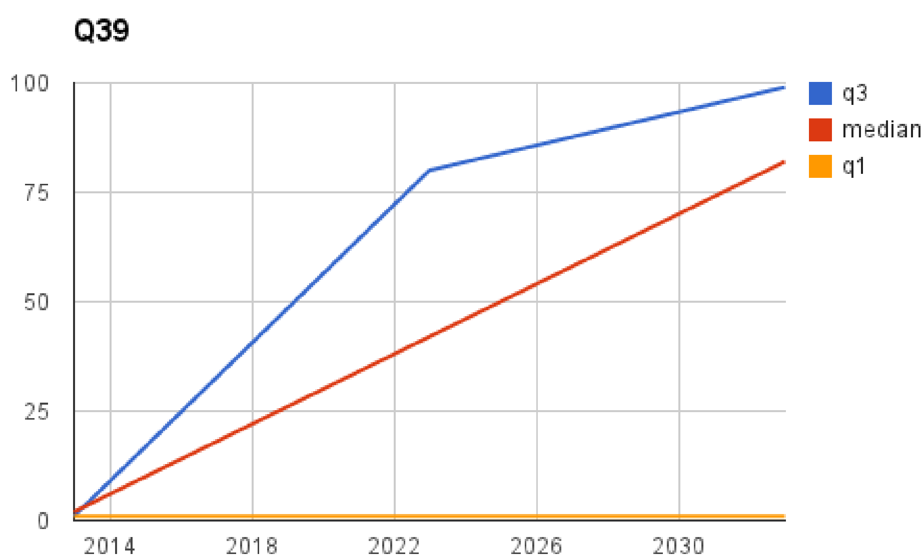

Figure 21: Q39 - Event: Minimum Quality of Service

Again, services that are critical to running any kind of business might become more regulated. Experts forecast that quality of service should be a defined parameter for the ISPs. That said, there was quite a bit of disagreement. The telecoms industry might see this as a threat, but overall it could be an opportunity for many to offer services with a higher reliability of service.

4.3. Trends.

4.3.1 Q53 - Trend: Personal Information

If we set the amount of personal information that people in Hawaii are comfortable with sharing online to 100 for 2013, estimate what it will be in year 2023 and 2033?

Question Details	
Q	53
Type	Trend
Category	Social
Experts Details	
Number of experts	21
Average Confidence	6.76
Average Expertise	6.67
Uncertainty Index	0.1792
Median Results	
2013	100
2023	120
2033	140

Table 20: Q53 - Trend: Personal Information

This question had the first forecast defined as 100, and otherwise an open field that had to be answered numerically.

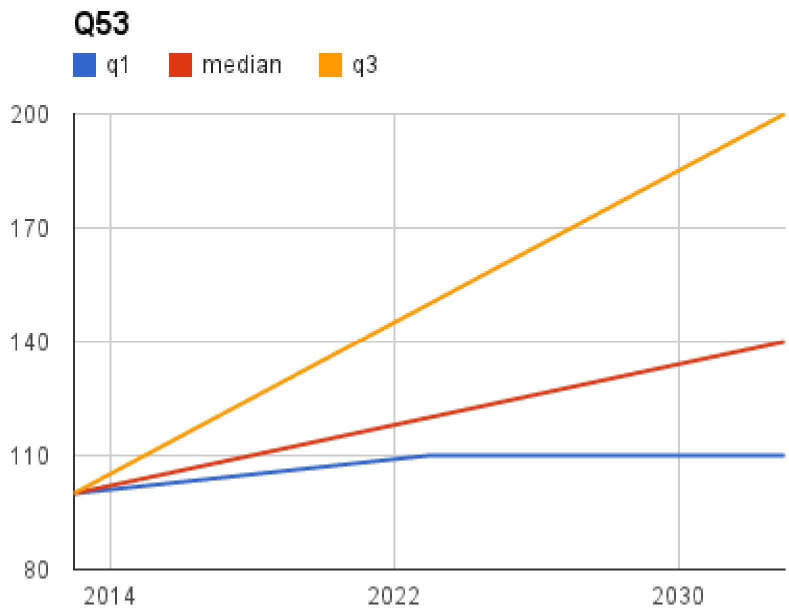

Figure 23: Q53 - Trend: Personal Information

Overall, there were 28 experts that responded to this question. The value for 2013 was predefined to 100, and the software let the participant forecast for 2023 and 2033. We can see the median score being linear with a value for 120 for 2023, and 140 for 2033. This means that the experts overall feel that people will be more inclined to share a bit more information about themselves over the coming years. In 2033 there is a disagreement on how much information people are comfortable with sharing, but all agree it will increase. In terms of the uncertainty, even if the numerical value of the disagreement is relatively high, the experts were consistent on an increase in amount of information people are willing to share. This leaves the uncertainty index low simply because it is a relative value. Now for someone looking to offer services that share information there is an opportunity in positioning for the increase in sharing. Otherwise this is neither an opportunity nor threat.

4.3.2 Q68 - Trend: ICT Dependence

If we peg the high-speed Internet connection dependency of Hawaii's users to 100 in 2013. What will it be in 2023 and 2033?

Question Details	
Q	68
Type	Trend
Category	technological
Experts Details	
Number of experts	18
Average Confidence	7.61
Average Expertise	7.33
Uncertainty Index	0.3318
Median Results	
2013	100
2023	195
2033	275

Table 21: Q68 - Trend: ICT Dependence

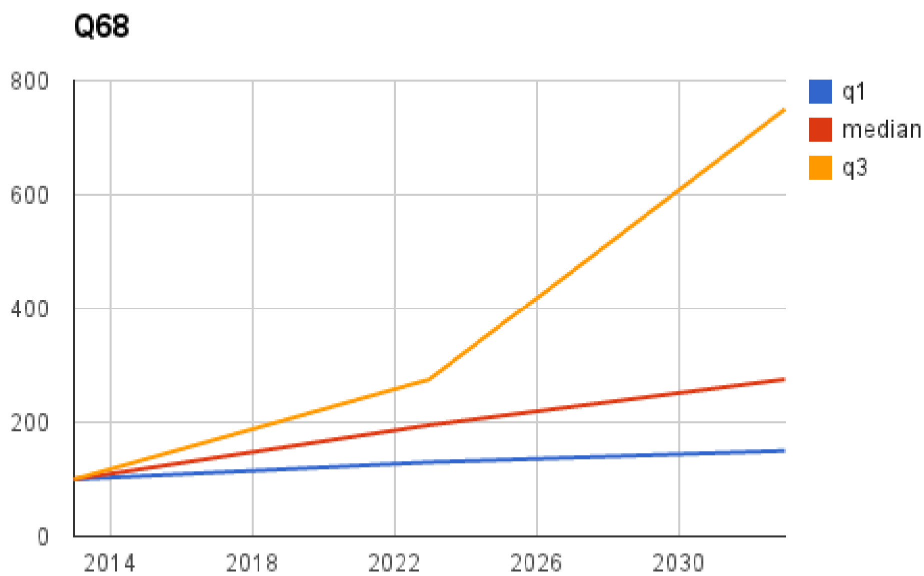

Figure 24: Q68 - Trend: ICT Dependence

Our dependence on ICT goes up by a factor of three the next 20 years. This is an opportunity for companies that offer services related to that broadband services. For the State it should be a strong signal to secure a more resilient network. There were some uncertainty relating to how much it will grow, but the overall results are fairly clear.

4.3.3 Q25 - Trend: Quality of Life

We set the quality of life index rating in Hawaii to 100 for 2013, estimate what it will be in year 2023 and 2033?

Question Details	
Q	25
Type	Trend
Category	Social
Experts Details	
Number of experts	17
Average Confidence	7.00
Average Expertise	6.41
Uncertainty Index	0.095
Median Results	
2013	100
2023	99
2033	100

Table 22: Q25 - Trend: Quality of Life

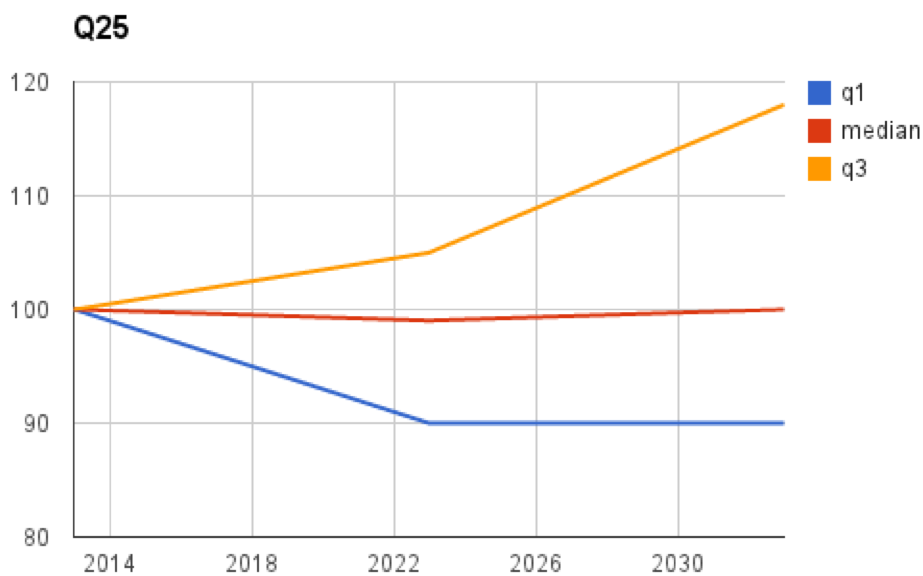

Figure 25: Q25 - Trend: Quality of Life

Quality of life in Hawaii is something that people value high. Though the experts seem to differ, neither of the median, q1 nor q3 forecast major changes. The median falls at 100 even, exactly the same as the starting point was. If the country at large see a general increase, does that mean Hawaii is lagging behind, or does it mean that Hawaii is already ahead? If ahead, perhaps there is not a huge potential for improvement. This study does not deal with those values in depth, but suffice to say that even if there is no difference in forecasted quality of life, it does not mean the broadband development does not influence it. What it can mean is that broadband development can counter other negative trends relating to quality of life. Obviously this is a bit of speculation, but if one compares this result to a development of the value of dollars, then maybe the broadband developments could have a potential to counteract negative effects of other variables.

This is not evaluated as a threat nor an opportunity.

4.3.4 Q52 - Trend: Privacy

If we set the level of privacy laws that protect the online privacy rights of individual citizens in Hawaii to 100 for 2013, what will it be in year 2023 and 2033?

Question Details	
Q	52
Type	Trend
Category	Political
Experts Details	
Number of experts	16
Average Confidence	7.31
Average Expertise	7.19
Uncertainty Index	0.1594
Median Results	
2013	100
2023	108
2033	118

Table 23: Q52 - Trend: Privacy

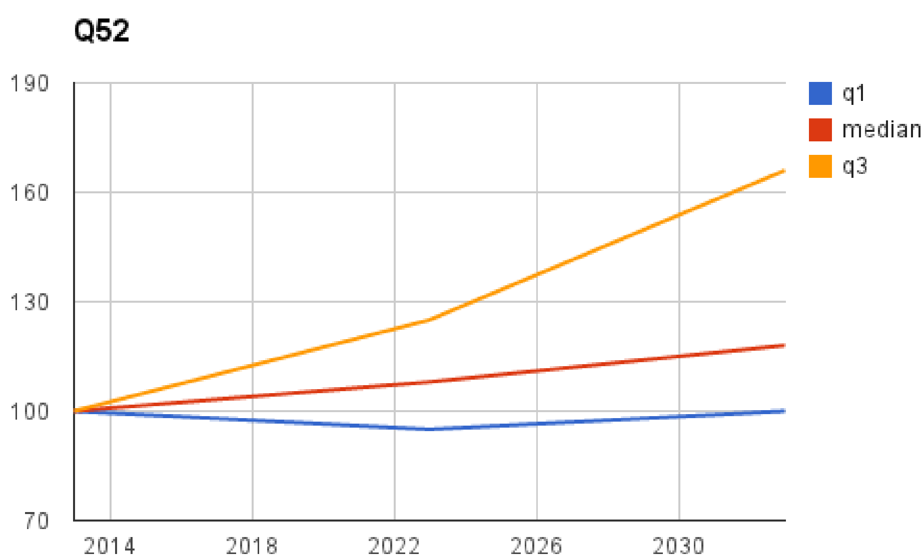

Figure 26: Q52 - Trend: Privacy

Experts forecast that the privacy laws that protect individuals in Hawaii will positively be influenced by 2023. The low estimates show that they will not be influenced by much, but have a steady increase. In February of 2013, the Hawaii House postponed a bill relating to Internet privacy. House Bill 39, which required operators of commercial websites that collect personal info "to conspicuously post their privacy policies online." (Oshiro, 2013). This may neither confirm or disconfirm the forecasts, but it does show that it is an important issue that will have to be dealt with probably more than once.

This is not identified as a threat nor an opportunity.

4.3.5 Q88 - Trend: Gross State Product

Percentage of Hawaii Gross State Product dependent on Internet connection in 2013, 2023, and 2033?

Question Details	
Q	88
Type	Trend
Category	Economic
Experts Details	
Number of experts	15
Average Confidence	7.33
Average Expertise	7.20
Uncertainty Index	0.1799
Median Results	
2013	40
2023	60
2033	89

Table 24: Q88 - Trend: Gross State Product

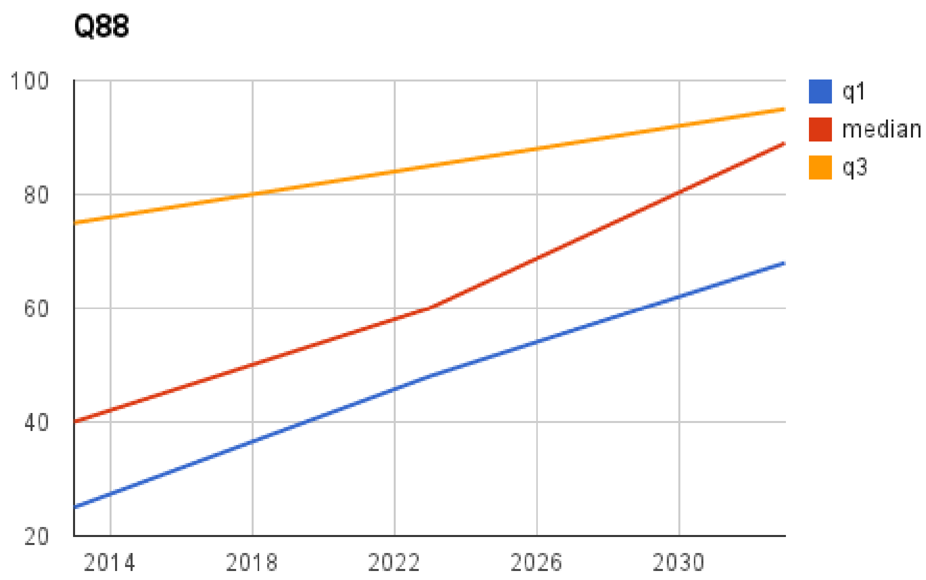

Figure 27: Q88 - Trend: Gross State Product

This forecast seems to have more disagreement at the outset than at the end. This might not be as important as the fact that all the forecasts point to a much higher degree of dependency on an Internet connection for Hawaii's overall GDP. Now this does not necessarily mean that the Internet itself is directly responsible for the GDP, but it does indicate the involvement of the Internet in transactions and importance for Hawaii GDP. The experts said this with a reasonably high degree of confidence and there was a low level of disagreement.

This can be an opportunity depending on how it is handled at the legislative levels. It relates back to how dependable the broadband connection is. What level of service is acceptable? For broadband industry it is a huge opportunity to position themselves for this.

4.3.6 Q6 - Trend: Connection Affordability

What percentage of homes in Hawaii will subscribe to a 1 gigabit per second or faster synchronous Internet connection in the following years?

Question Details	
Q	6
Type	Trend
Category	Economic
Experts Details	
Number of experts	12
Average Confidence	7.42
Average Expertise	7.42
Uncertainty Index	0.384
Median Results	
2013	0
2023	23
2033	68

Table 25: Q6 - Trend: Connection Affordability

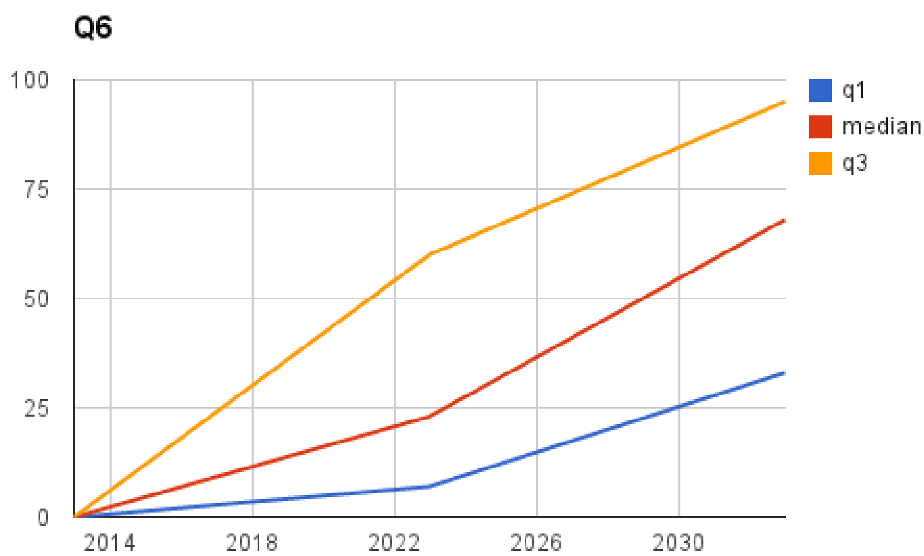

Figure 28: Q6 - Trend: Connection Affordability

For this question the initial value was 0%. This means that 0% of homes are today subscribing to a 1 Git connection. Note though that it does not necessarily mean there are 0 homes with 1 Gbit synchronous connection, but that it is low. It became clear in the interview phase that getting a 1GBit connection is a matter of where you live and how much money you are willing to spend. It would certainly take a lot of money, and you would have to live reasonably central. The experts forecast that over 75% of Hawaii's population will actually subscribe to a 1GBit connection by 2033. This is evaluated as an opportunity for broadband industry.

4.3.7 Q3 - Trend: Internet Connection Price

What will the monthly cost (in 2013 dollars) of 1 gigabit per second synchronous

Internet connection for a home in Hawaii be in 2013, 2023, and 2033?

Question Details	
Q	3
Type	Trend
Category	Economic
Experts Details	
Number of experts	12
Average Confidence	7.42
Average Expertise	7.42
Uncertainty Index	0.37
Median Results	
2013	425
2023	150
2033	90

Table 26: Q3 - Trend: Internet Connection Price

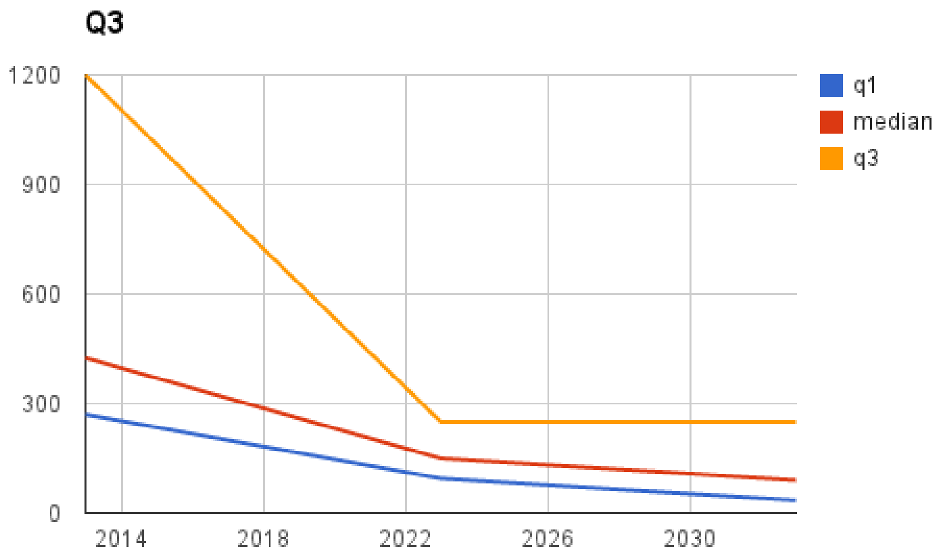

Figure 29: Q3 - Trend: Internet Connection Price

The way to interpret this forecast, would be that if a household wants a 1Gbit Internet connection today, they have to pay a lot for it. There are no publicly available pricing schemes for that pricing, and a special connection would have to be set up. There is quite a bit of agreement that the price will go down, but maybe not as much as the researcher expected. The median answer in 2033 was $90 which is not unreasonable. If having an Internet connection will increase in importance for GDP, it would mean that reliability of this service would increase. If the median cost of a 1GBit connection in Hawaii is $90 (in 2013 Dollars), and 75% of households will subscribe to it, it means the GBit market in Hawaii is a 0.5-0.3 Billion dollars a year market for companies to compete over.

This trend is identified as an opportunity.

4.3.8 Q78 - Trend: Natural Catastrophe

If we set the ability for the network to recover after a natural catastrophe to 100 in 2013, what will it be in 2023, and 2033?

Question Details	
Q	78
Type	Trend
Category	Environmental
Experts Details	
Number of experts	12
Average Confidence	6.58
Average Expertise	7.08
Uncertainty Index	0.1452
Median Results	
2013	100
2023	120
2033	153

Table 27: 78 - Trend: Natural Catastrophe

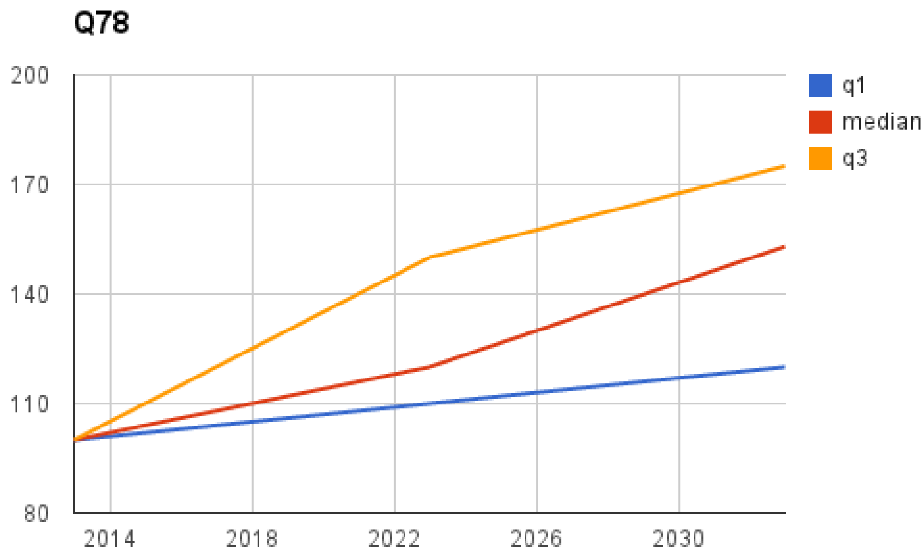

Figure 30: Q78 - Trend: Natural Catastrophe

Recoverability of a network is a facet that has gained too little attention. This is one of those issues that needs special attention in Hawaii simply because of how the Islands are connected. The islands of Hawaii have some cables that are stretched between the islands. If one or more of these cables are impacted it means that the rest of the cables have to bear extra data transfers until the cable can be repaired. In Hawaii there are no boats on call that can take care of the repair. This means there would be minimum of 4 days before a boat could arrive and begin repairs.

This could be either a threat or an opportunity depending on how it is handled.

4.3.9 Q2 - Trend: Internet Connection

What percentage of homes in Hawaii have technical and physical access to 1

Gigabit per second or faster synchronous Internet connection in the following years?

Question Details	
Q	2
Type	Trend
Category	Social
Experts Details	
Number of experts	11
Average Confidence	6.91
Average Expertise	6.13
Uncertainty Index	0.3148
Median Results	
2013	0
2023	50
2033	80

Table 28: Q2 - Trend: Internet Connection

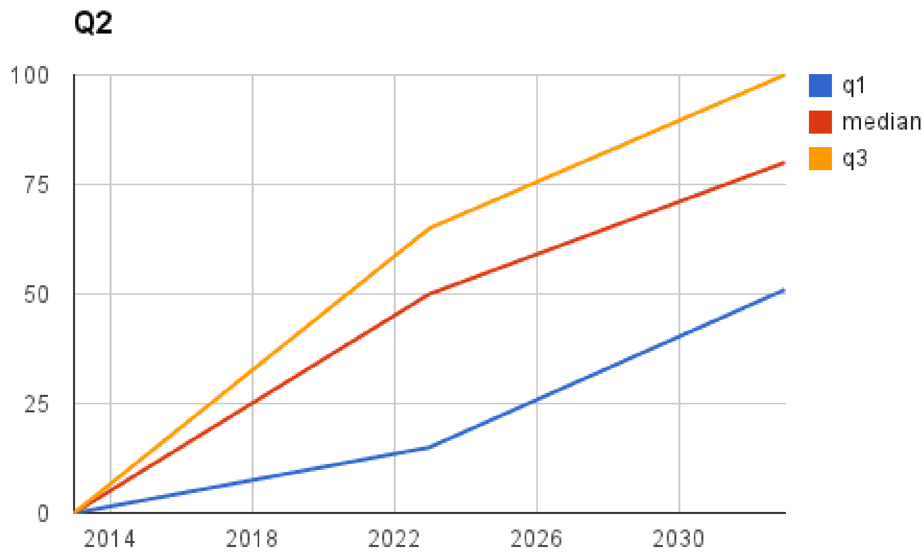

Figure 31: Q2 - Trend: Internet Connection

The forecasts state that in 2023 50% of households in Hawaii will have access to 1GBit synchronous broadband connection. This is well below the broadband goal for the State for 2018. Not only is it well below, it also does not state to what extent that connection is affordable, as is also a stated goal for the State. This was one of the questions where the study built in a check. Q6 asks what percentage of homes subscribe to 1GBit connection. If this had been higher than 50%, the study would have to re-evaluate at least some of the participants. As it were, the median answer results from Q6 was 23% for the same year. Now 100% affordable coverage 2018 has been cited as an optimistic goal for broadband, but it is interesting to see how experts forecast the actual deployment. If the deployment is lagging other states this could be a threat.

4.3.10 Q23 - Trend: IT Dependence

We set the level of the IT dependent workforce productivity in Hawaii to 100 for 2013, estimate what it will be in year 2023 and 2033?

Question Details	
Q	23
Type	Trend
Category	Economic
Experts Details	
Number of experts	11
Average Confidence	7.36
Average Expertise	7.55
Uncertainty Index	0.1807
Median Results	
2013	100
2023	120
2033	250

Table 29: Q23 - Trend: IT Dependence

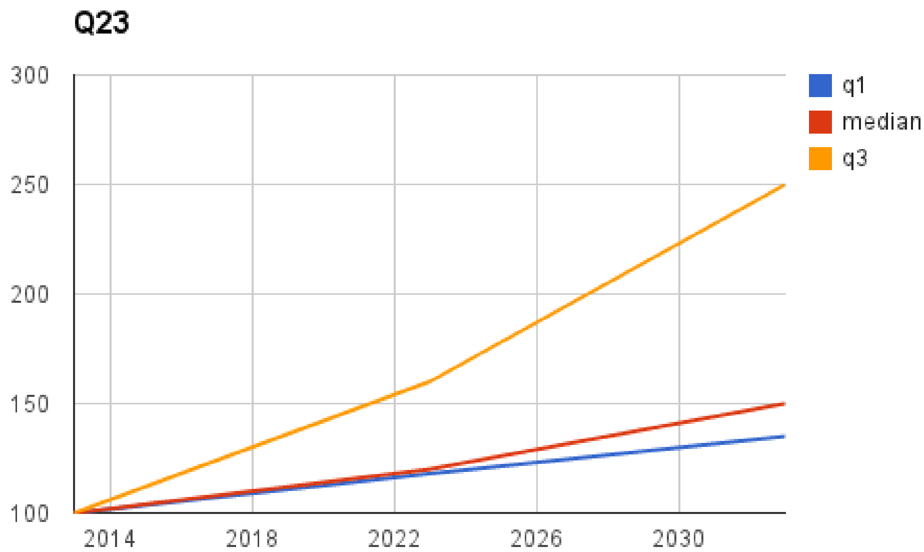

Figure 32: Q23 - Trend: IT Dependence

The IT dependent workforce in Hawaii is estimated to increase by 50% by 2033. To what extent this is new workforce, a change in current workforce, or current job becoming more IT dependent is not dealt with. The answer is perhaps a mix of all or the above, however, the point is that the workforce in Hawaii will become more IT dependent, and therefore considerations should be made. This is a general indicator, and is not assumed a threat nor an opportunity.

4.3.11 Q5 - Trend: Connection Affordability

What percentage of homes in the USA will subscribe to 1 gigabit per second or faster synchronous Internet connection in the following years?

Question Details	
Q	5
Type	Trend
Category	Economic
Experts Details	
Number of experts	11
Average Confidence	7.00
Average Expertise	7.18
Uncertainty Index	0.3466
Median Results	
2013	1
2023	35
2033	75

Table 30: Q5 - Trend: Connection Affordability

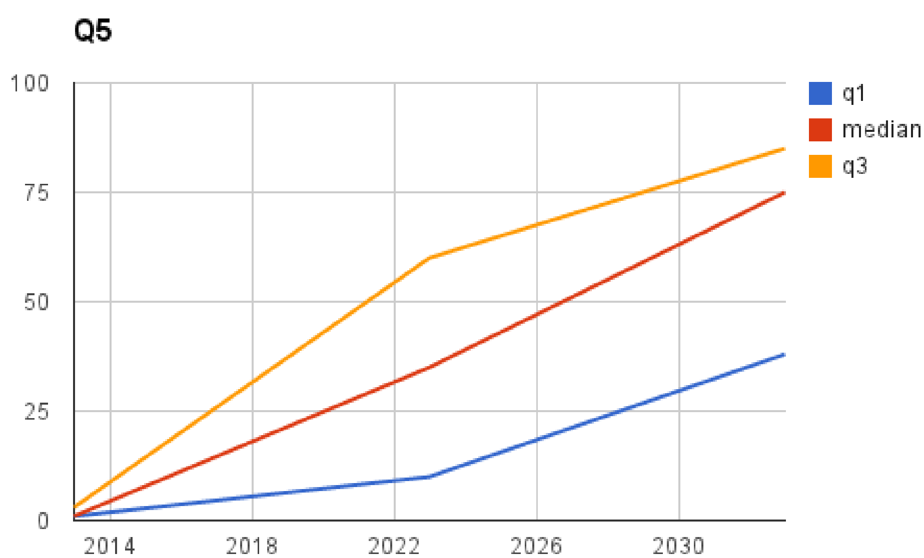

Figure 33: Q5 - Trend: Connection Affordability

The median answer for 2023 states that 35% of households in the US will subscribe to a 1GBit connection. Compare this to the median answer for Hawaii (Q6) in the same year at 25%. If this holds up, Hawaii will continue to trail the mainland and face a downward trend for average connection speeds relative to other states- it might go even further down. However, the trend for Hawaii is that more homes will connect and the growth for connected homes will increase after that. Also, Hawaii as a state will catch up to the rest of the US and a median of 50% of homes or more will have a 1GBit or higher broadband connection.

A little note: most of the comparisons are made by average speeds, and these questions do not deal with that issue. They are solely focused on the 1GBit as a minimum connection speed. Obviously as more people gain bandwidth the averages will go up, but the outliers are not accounted for here. This is not related to threats or opportunities for Hawaii. It is a stake to compare the relative speed in Hawaii.

4.3.12 Q77 - Trend: Network Resilience

If we set network / Internet resilience to natural catastrophes (hurricanes, tsunamis) to 100 in 2013, what will it be 2023 and 2033?

Question Details	
Q	77
Type	Trend
Category	Technological
Experts Details	
Number of experts	11
Average Confidence	7.27
Average Expertise	7.18
Uncertainty Index	0.2021
Median Results	
2013	100
2023	120
2033	150

Table 31: Q77 - Trend: Network Resilience

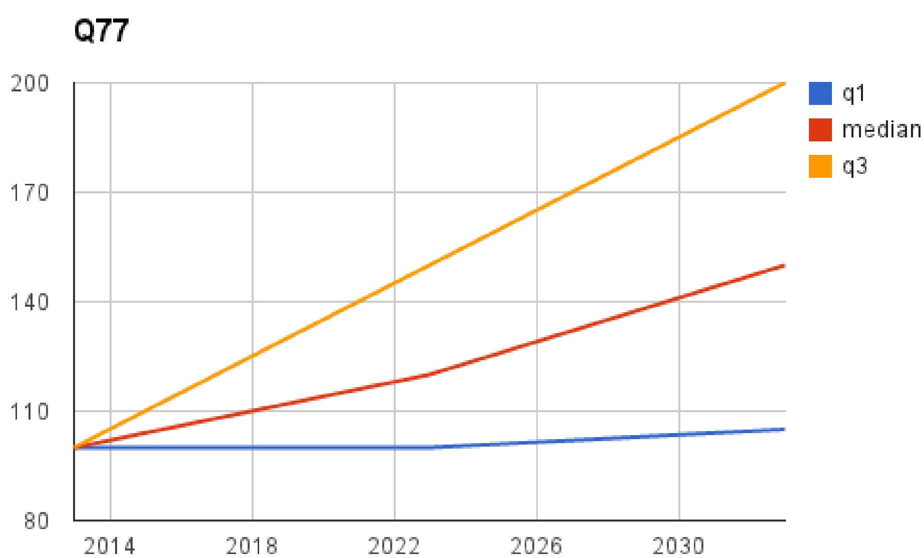

Figure 34: Q77 - Trend: Network Resilience

As mentioned above recoverability of the network is a critical factor. Recoverability is a reactive solution. It is something done after a shutdown has happened. Another facet of network reliability is its resilience towards external factors that might affect it. The experts estimated a 40% increase in the network's ability to resist natural catastrophes. The uncertainty is pretty low on this, even if the interquartile range is 100. Proper resilience has to be designed into the system. A great example of a more resilient network is the Southern-Cross Submarine cable landing in Hawaii. This is not using the more traditional landing, instead, it has redundancy built into the system by its topology figure eight configuration. Even if the cable physically breaks, as it has done on several occasions, the network can still transmit, albeit at half the speed. A resilient network that is also easier to recover is of course the ideal solution, though, this demands detailed, centrally-organized planning and scenario building efforts. Low resilience is a threat.

4.3.13 Q61 - Trend: Hawaii Dependence

We set Hawaii's overall dependence on high speed broadband connection to 100 for 2013, estimate what it will be in year 2023 and 2033?

Question Details	
Q	61
Type	Trend
Category	Social
Experts Details	
Number of experts	11
Average Confidence	6.55
Average Expertise	6.64
Uncertainty Index	0.1875
Median Results	
2013	100
2023	150
2033	200

Table 32: Q61 - Trend: Hawaii Dependence

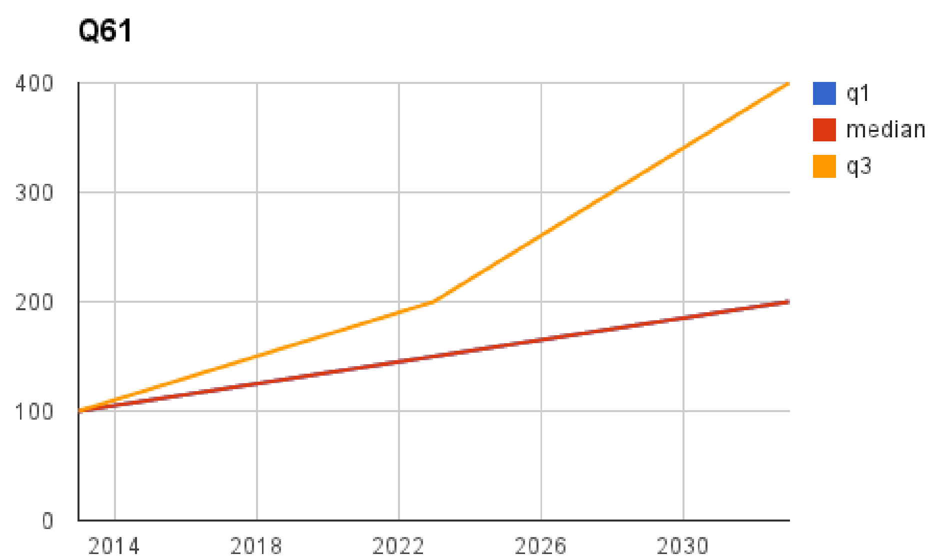

Figure 35: Q61 - Trend: Hawaii Dependence

To what extent Hawaii will have an increase in Internet dependence in the future seemed to elicit very little disagreement. The overall forecast states that Hawaii will double its dependency on the Internet. The study would have had to have negotiated what types of biases were present if all the experts had been too uniform, however, since there is a balance among industry, government and academic experts (and the lowest q1 estimate saw a doubling) it is highly probable that this will be the effect. Q3 forecasts a quadrupling of the Internet dependency. This is not seen as a threat nor an opportunity. However for industry it would be an indicator they could use to position themselves to take advantage of the growth.

4.3.14 Q40 - Trend: Competitiveness

The level of competitiveness in the Hawaii broadband industry is set to 100 for 2013, estimate what it will be in year 2023 and 2033?

Question Details	
Q	40
Type	Trend
Category	Economic
Experts Details	
Number of experts	11
Average Confidence	7.36
Average Expertise	7.45
Uncertainty Index	0.1664
Median Results	
2013	100
2023	100
2033	110

Table 33: Q40 - Trend: Competitiveness

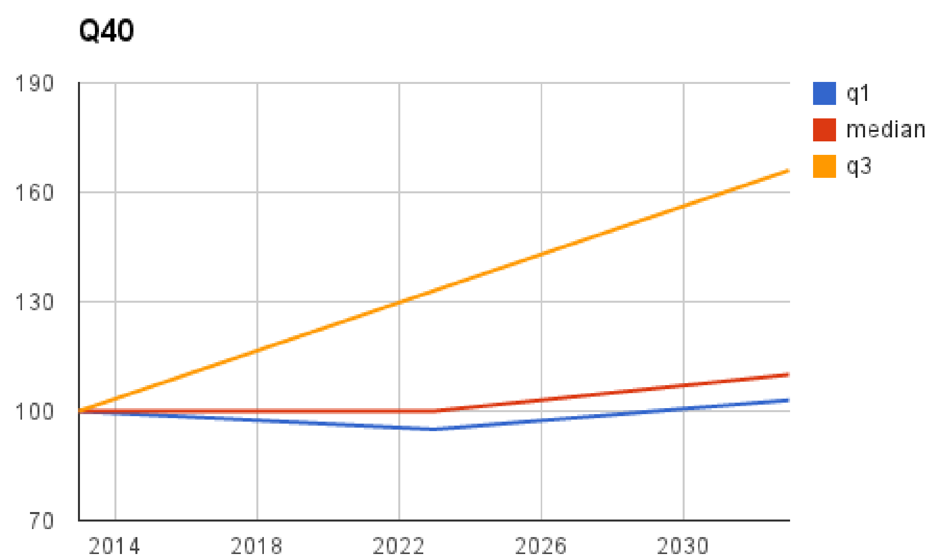

Figure 36: Q40 - Trend: Competitiveness

The forecast estimates that the level of competitiveness remains at the same level. This would seem to be in accordance with the overall broadband development estimation of Hawaii relative to the rest of the US. There is also little disagreement on this, though q3 estimates a 60% increase it is over 20 years. The level of competition in Hawaii is generally low. The level of competition in Hawaii could be seen as a threat to consumers.

4.3.15 Q60 - Trend: Political Participation

If we set the level of participation in public decision making for private companies in Hawaii to 100 for 2013, estimate what it will be in year 2023 and 2033?

Question Details	
Q	60
Type	Trend
Category	Political
Experts Details	
Number of experts	10
Average Confidence	6.90
Average Expertise	6.60
Uncertainty Index	0.2018
Median Results	
2013	100
2023	115
2033	138

Table 34: Q60 - Trend: Political Participation

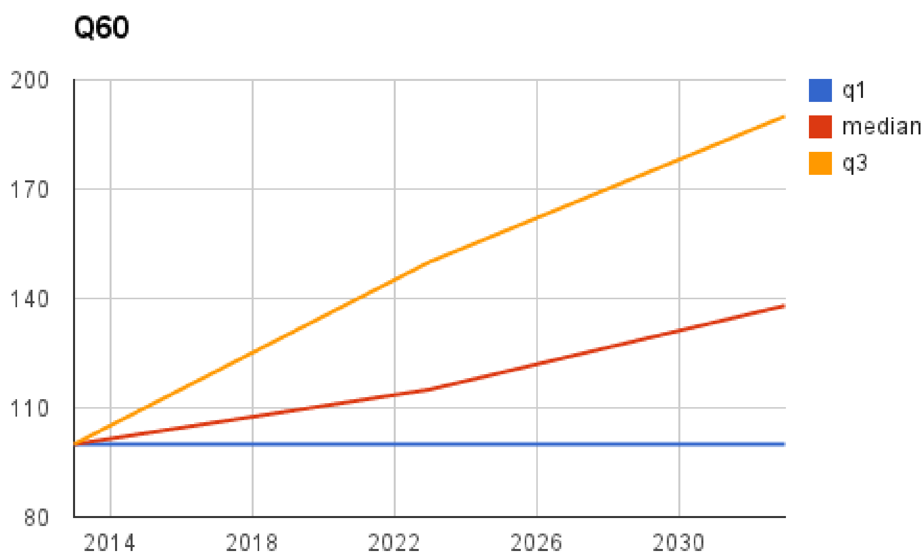

Figure 37: Q60 - Trend: Political Participation

The median answer forecasts a 40% increase in private companies participation in public decision making. There is also little uncertainty around this, as the experts are reasonably on the same line. This could mean that the open government initiatives are working to some extent, even if they are primarily directed at the general public.

A low level of participation can be seen as a threat. However, if the industry participates and the general public does not there might be an imbalance that needs to be corrected.

4.3.16 Q11 - Trend: Policy Knowledge

If we set Hawaii's policy maker's telecommunication knowledge to 100 in 2013, estimate what it will be in year 2023 and 2033?

Question Details	
Q	11
Type	Trend
Category	Political
Experts Details	
Number of experts	9
Average Confidence	7.22
Average Expertise	7.22
Uncertainty Index	0.1445
Median Results	
2013	100
2023	110
2033	150

Table 35: Q11 - Trend: Policy Knowledge

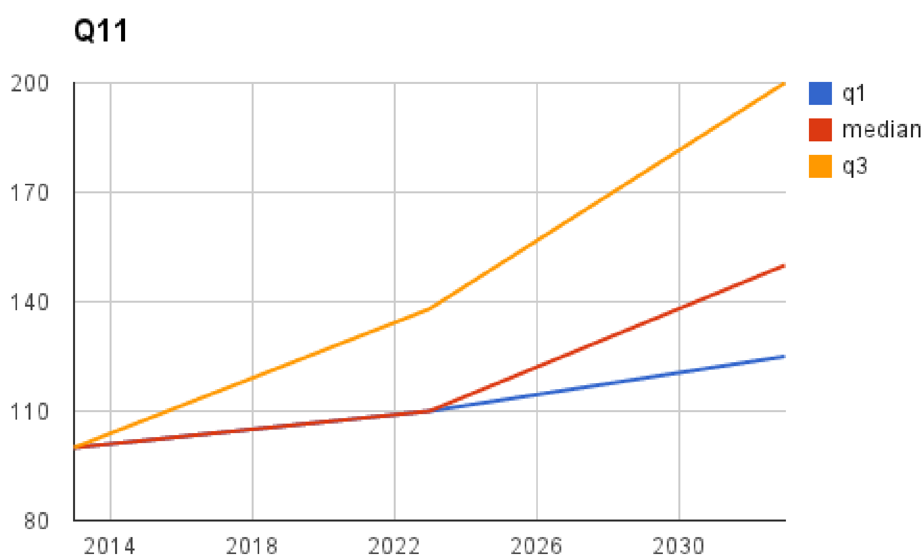

Figure 38: Q11 - Trend: Policy Knowledge

The experts are in reasonable agreement on the development of the policy makers telecommunications knowledge. Several of the interview subjects mentioned that the lack telecommunications knowledge among policy makers, in some cases, could be a hindrance to good policy making. It seems that the forecast of the telecommunication knowledge will maintain a steady but slow increase until 2023 where it will increase a lot more. There is a low degree of uncertainty surrounding this. Maybe it is because people are getting dependent on their broadband connection at a faster rate than the policy-makers are gaining knowledge about it. This could lead to pressures from the general public. Politicians, in a second order, have to become more knowledgeable to avoid more failed policies. It is fairly certain that as initiatives such as Cyber Intelligence Sharing and Protection Act (CISPA) get attention, it increases the focus on telecommunications overall. In this case, many politicians were surprised at the outrage the proposed act spurred. A low level of understanding how the industry is developing into something that that citizens are dependent on is a threat.

4.3.17 Q1 - Trend: Broadband

Today (2012) broadband is defined by FCC as a minimum of 4 megabit per second download speed. What will it be for the following years (in Megabit per second)?

Question Details	
Q	1
Type	Trend
Category	Technological
Experts Details	
Number of experts	9
Average Confidence	7.11
Average Expertise	7.44
Uncertainty Index	0.418
Median Results	
2013	4
2023	10
2033	22

Table 36: Q1 - Trend: Broadband

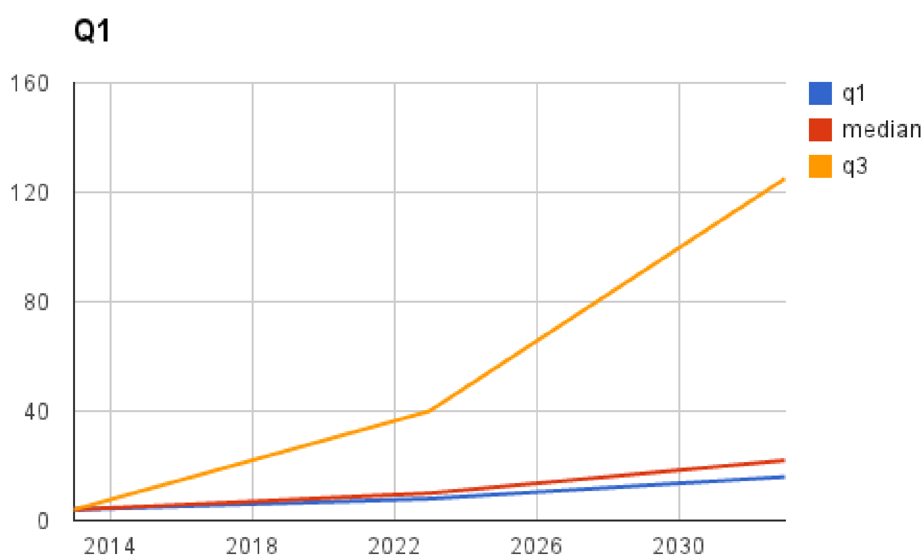

Figure 39: Q1 - Trend: Broadband

The median answer forecasts that the FCC will define broadband as 22 MBps. Q3 estimates 125 MBit. There seems to be a fairly high degree of uncertainty around this- even among experts who estimate with confidence. The reason for this could be that the FCC tends to change their definition of what broadband is fairly often. It could be that new concepts will define high speed Internet and that because FCC now grades their broadband definitions in several different categories, it adds uncertainty to how they will define it in 2033. This is an indicator that is neither a threat nor an opportunity for Hawaii.

4.3.18 Q49 - Trend: Internet Economic Dependency

What percentage of Hawaii's economy is directly dependent on an Internet connection in 2013, 2023, and 2033?

Question Details	
Q	49
Type	Trend
Category	Social
Experts Details	
Number of experts	9
Average Confidence	6.78
Average Expertise	7
Uncertainty Index0.0865	0.0865
Median Results	
2013	40
2023	75
2033	96

Table 37: Q49 - Trend: Internet Economic Dependency

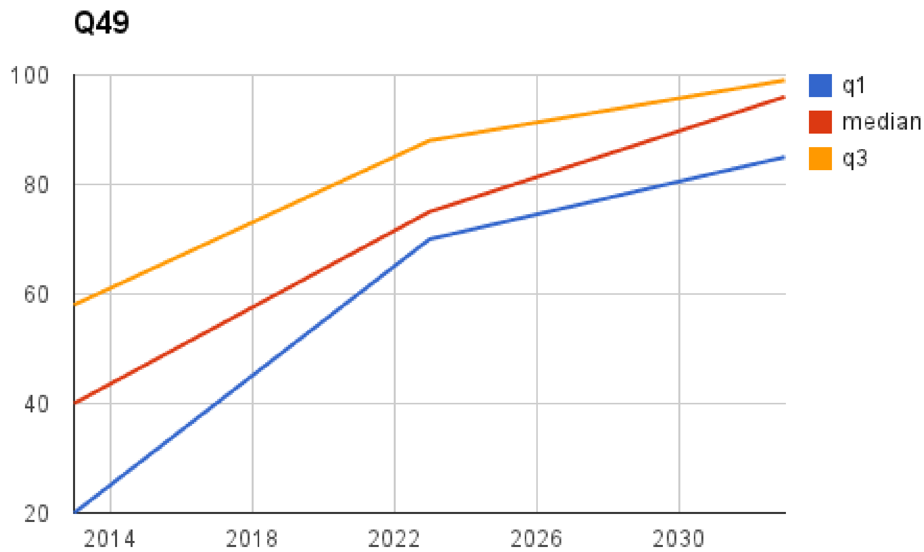

Figure 40: Q49 - Trend: Internet Economic Dependency

The experts forecast that 96% of Hawaii's economy will be dependent on an Internet connection in 2033. If the network is well developed, has good resiliency and recoverability with built in redundancy the dependency is not an issue. If the dependency turns the economy form being highly dependent on one industry to another it is a threat. However because broadband technologies are industry agnostic a high level of economic dependency does not imply that Hawaii moves from one dependency to another. Hawaii can have a diversified economy and be dependent on broadband.

4.3.19 Q86 - Trend: Economic Transaction

What percentage of business transactions in and out of Hawaii are conducted entirely online?

Question Details	
Q	86
Type	Trend
Category	Economic
Experts Details	
Number of experts	9
Average Confidence	7.67
Average Expertise	7.67
Uncertainty Index	0.1922
Median Results	
2013	30
2023	55
2033	75

Table 38: Q86 - Trend: Economic Transaction

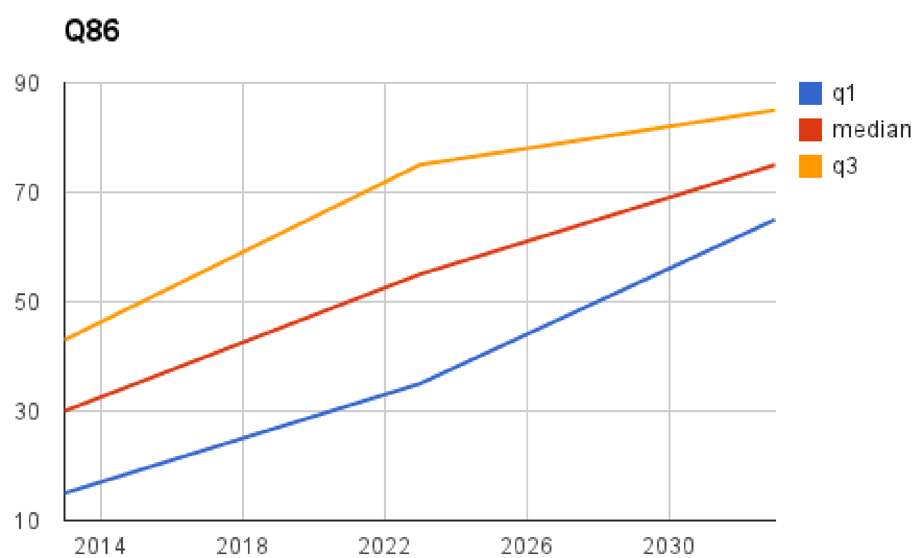

Figure 41: Q86 - Trend: Economic Transaction

Well over 70% of business transactions in and out of Hawaii will be conducted entirely online in 2023. This is a growth and change that has not been seen yet. Hawaii again can be ready for it by evolving its network. This can be an opportunity as markets will increase.

4.3.20 Q82 - Trend: Data Drivers

Big-Data, the rise of e-science, healthcare, education etc. are some drivers for bandwidth use. If we set these top five data drivers' use of bandwidth in Hawaii to 100 in 2013, what will it be in 2023, and 2033?

Question Details	
Q	82
Type	Trend
Category	Technological
Experts Details	
Number of experts	8
Average Confidence	7.25
Average Expertise	7.50
Uncertainty Index	0.4227
Median Results	
2013	100
2023	210
2033	210

Table 39: Q82 - Trend: Data Drivers

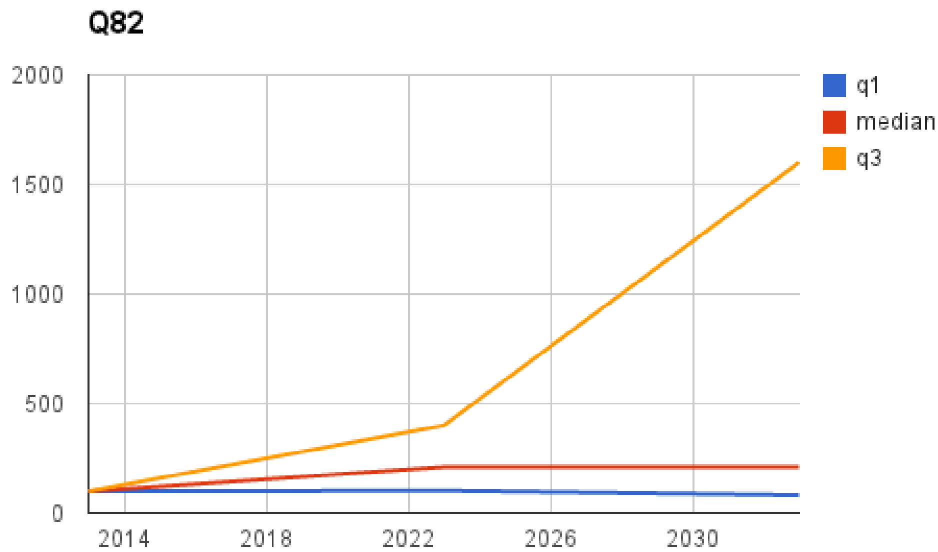

Figure 42: Q82 - Trend: Data Drivers

The growth in data driver is not a threat. It can be an opportunity for certain industries as it means a higher need for computing and storage services. Most of these services will be offered in the cloud and therefore require a dependable network connection.

4.3.21 Q72 - Trend: Business Attraction

We set the level of new businesses attracted to Hawaii by the State's ICT capabilities to 100 in 2013. What will it be in 2023, 2033?

Question Details	
Q	72
Type	Trend
Category	Economic
Experts Details	
Number of experts	7
Average Confidence	7.57
Average Expertise	7.57
Uncertainty Index	0.0943
Median Results	
2013	100
2023	90
2033	90

Table 40: Q72 - Trend: Business Attraction

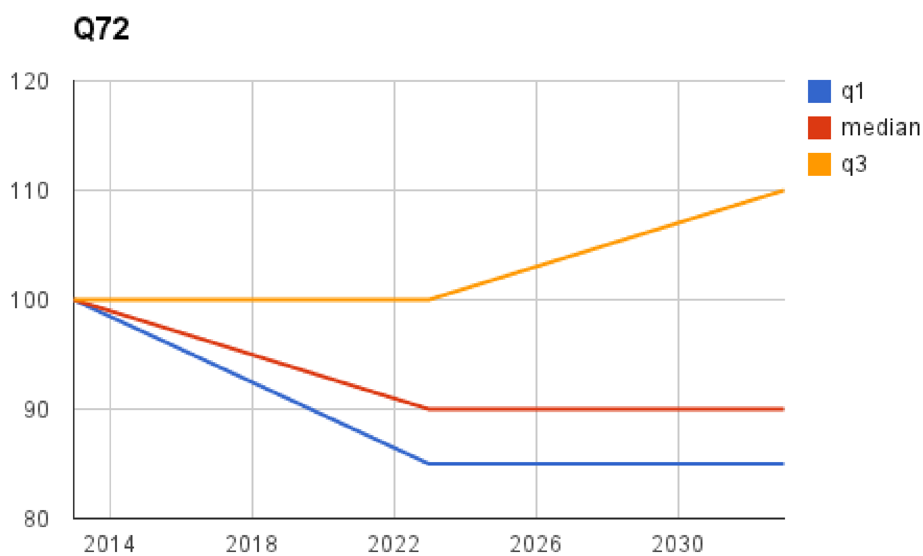

Figure 43: Q72 - Trend: Business Attraction

This is a forecast that should worry policymakers. It is not a threat in itself, but it illustrates how Hawaii is not attracting new business even when time and space constraints are broken down by network connection. This indicator is something should be taken seriously and more attention should be paid to how it can change in the long term.

4.3.22 Q87 - Trend: Hawaii Workforce

What is the percentage of workforce in Hawaii that is dependent on network connections as a secondary work tool in 2013, 2023 and 2033?

Question Details	
Q	87
Type	Trend
Category	Technological
Experts Details	
Number of experts	7
Average Confidence	7.00
Average Expertise	7.29
Uncertainty Index	0.0722
Median Results	
2013	50
2023	90
2033	95

Table 41: Q87 - Trend: Hawaii Workforce

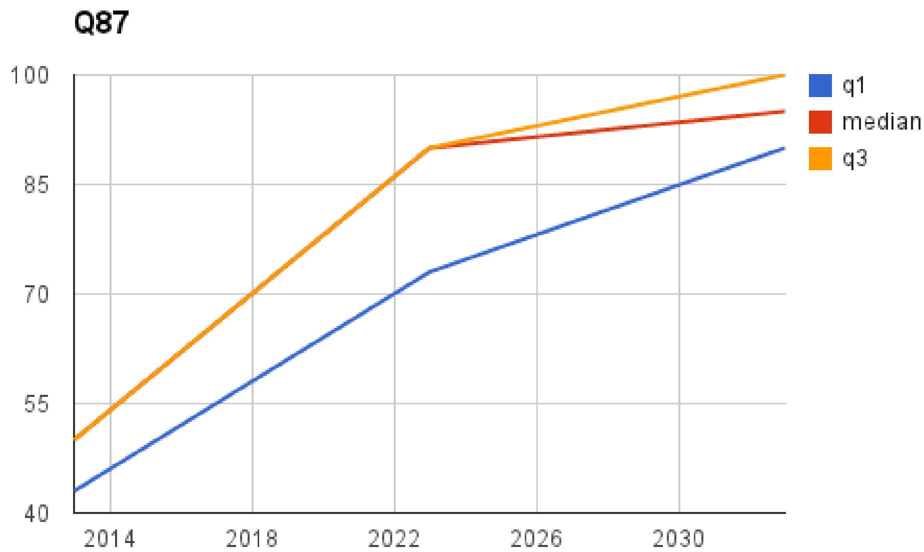

Figure 44: Q87 - Trend: Hawaii Workforce

The dependence on the network grows. It is a radical growth that again needs attention because it needs reliability for people to continue to be efficient in their jobs. Calculations of how much productivity goes down related to dependence on the network connection could be made.

4.3.23 Q4 - Trend: Connection Affordability

What percentage of businesses in USA will subscribe to 1 Gigabit per second or faster synchronous Internet connection?

Question Details	
Q	4
Type	Trend
Category	Economic
Experts Details	
Number of experts	7
Average Confidence	8.29
Average Expertise	8.14
Uncertainty Index	0.2714
Median Results	
2013	5
2023	50
2033	95

Table 42: Q4 - Trend: Connection Affordability

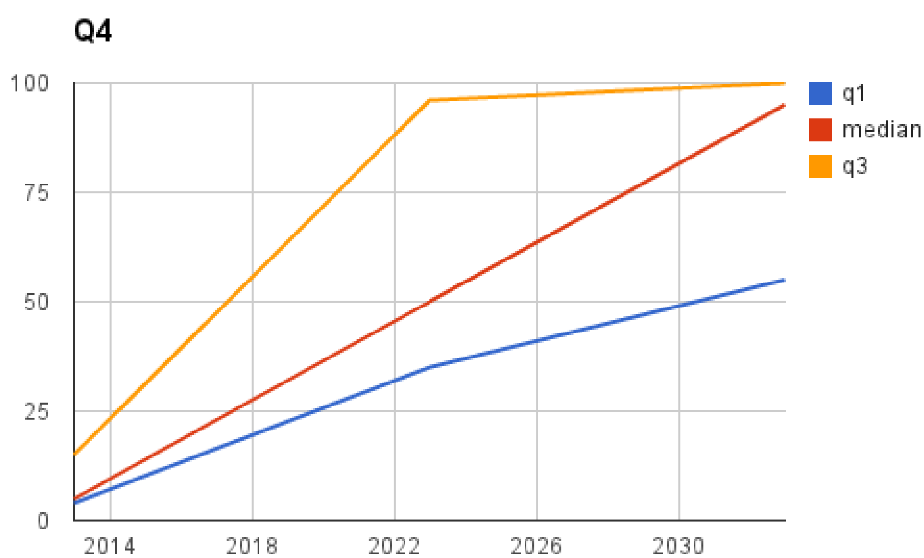

Figure 45: Q4 - Trend: Connection Affordability

This would be a good comparison to similar trend lines to see how Hawaii is doing at a national level. This is not a threat nor an opportunity.

4.3.24 Q34 - Trend: Purchase Power

We set the purchasing power of the American dollar relative to foreign currencies to 100 for 2013, estimate what it will be in year 2023 and 2033?

Question Details	
Q	34
Type	Trend
Category	Economic
Experts Details	
Number of experts	6
Average Confidence	7.33
Average Expertise	7.00
Uncertainty Index	0.1534
Median Results	
2013	100
2023	90
2033	73

Table 43: Q34 - Trend: Purchase Power

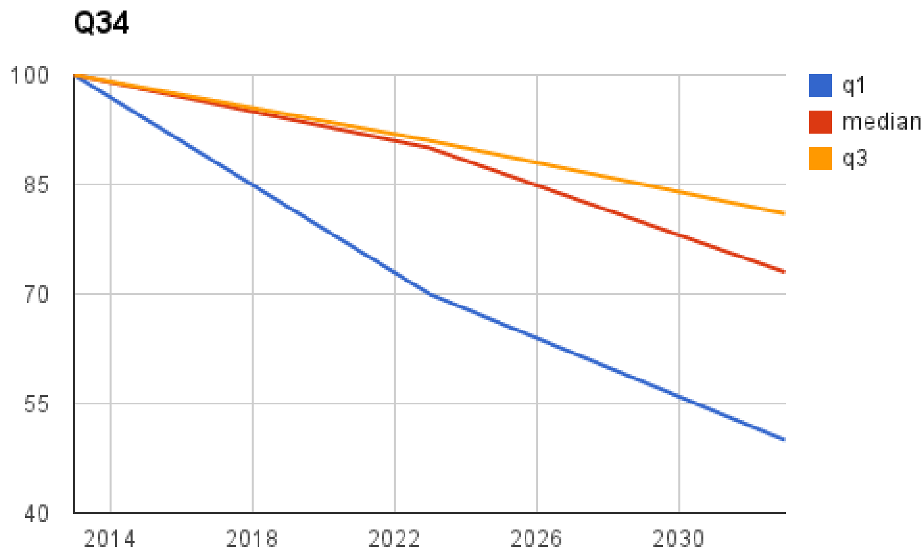

Figure 46: Q34 - Trend: Purchase Power

The overall purchase power of dollar goes down. This does not have to be a threat as Hawaii's tourism industry could see influx of more Japanese and Chinese tourists. It might mean less growth in other key industries that depend on imports, and it might be detrimental to a more diversified industry.

4.3.25 Q89 - Trend: Regulation of Broadband Networks

The regulation of broadband networks is set to 100 for 2013. What will it be in 2023 and 2033?

Question Details	
Q	89
Type	Trend
Category	Political
Experts Details	
Number of experts	6
Average Confidence	7.83
Average Expertise	7.50
Uncertainty Index	0.1874
Median Results	
2013	100
2023	124
2033	146

Table 44: Q89 - Trend: Regulation of Broadband Networks

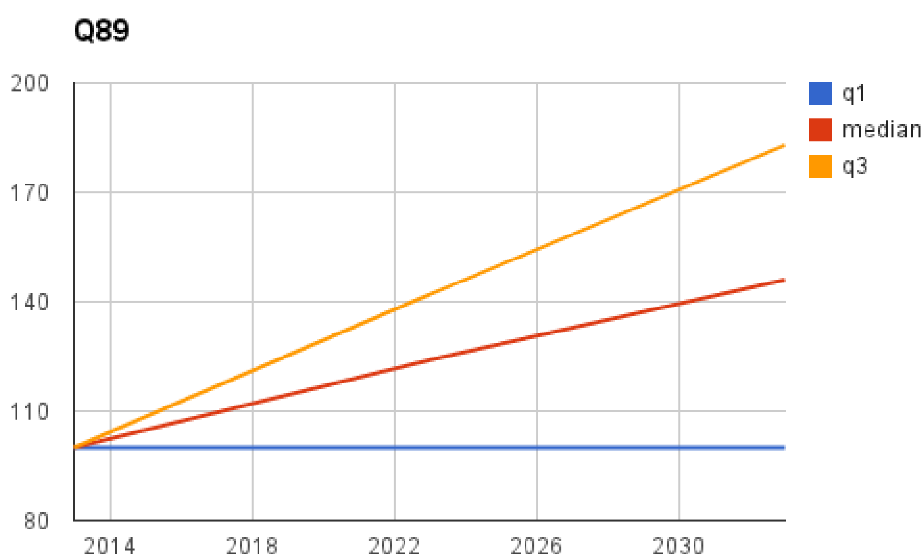

Figure 47: Q89 - Trend: Regulation of Broadband Networks

Hawaii will see a growth of broadband regulation of 40% the next 20 years. This is not entirely unreasonable as the dependence on broadband services go up. This is not in it self a threat though some industries do not welcome regulation.

4.3.26 Q8 - Trend: Price of Connection

What will the price (in 2013 dollars) of an average household network connection be in Hawaii in 2023 and 2033?

Question Details	
Q	8
Type	Trend
Category	Economic
Experts Details	
Number of experts	6
Average Confidence	7.33
Average Expertise	7.83
Uncertainty Index	0.1159
Median Results	
2013	35
2023	40
2033	50

Table 45: Q8 - Trend: Price of Connection

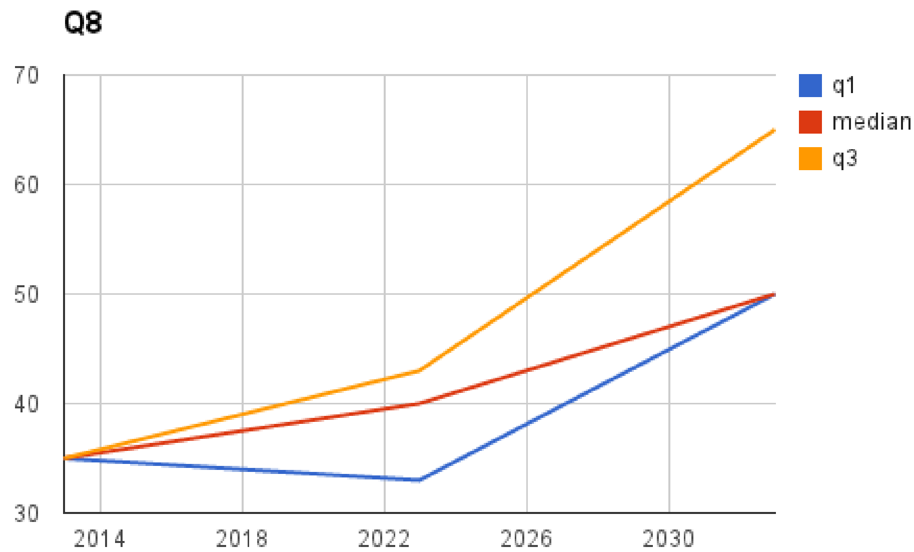

Figure 48: Q8 - Trend: Price of Connection

The price of an average connection will go up slightly. This might not be a huge threat to most people. It might increase the digital divide as any increase in price for lower income families might lead to not subscribing. Hawaii could set up program to support lower income families with network connection. Programs like that has to be followed up with digital literacy eduction.

4.3.27 Q24 - Trend: Job Creation

Hawaii job creation rate that is ICT dependent is set at 100 for 2013, estimate what it will be in year 2023 and 2033?

Question Details	
Q	24
Type	Trend
Category	Economic
Experts Details	
Number of experts	6
Average Confidence	7.83
Average Expertise	7.67
Uncertainty Index	0.086
Median Results	
2013	100
2023	130
2033	150

Table 46: Q24 - Trend: Job Creation

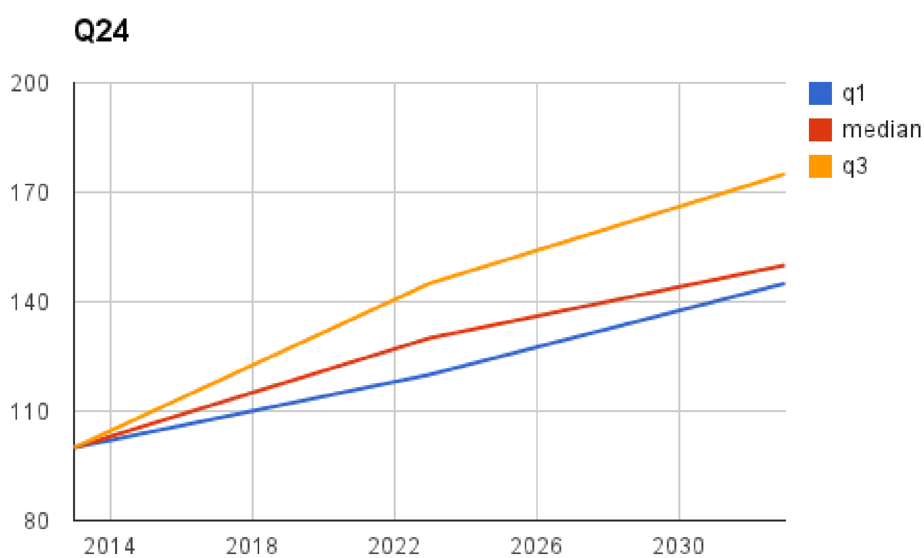

Figure 49: Q24 - Trend: Job Creation

Hawaii will see growth in ICT job creation. This is a good sign. It might mean that Hawaii's overall industry will be more diversified.

Considering the lack of outside businesses attracted to Hawaii this indicator means it is mostly created in Hawaii. This is seen as an opportunity.

4.3.28 Q43 - Trend: Public Roads

What percentage of public roads in Hawaii will have phone and Internet access coverage by year 2013, 2023, and 2033?

Question Details	
Q	43
Type	Trend
Category	Technological
Experts Details	
Number of experts	6
Average Confidence	6.50
Average Expertise	6.67
Uncertainty Index	0.0353
Median Results	
2013	84
2023	96
2033	98

Table 47: Q43 - Trend: Public Roads

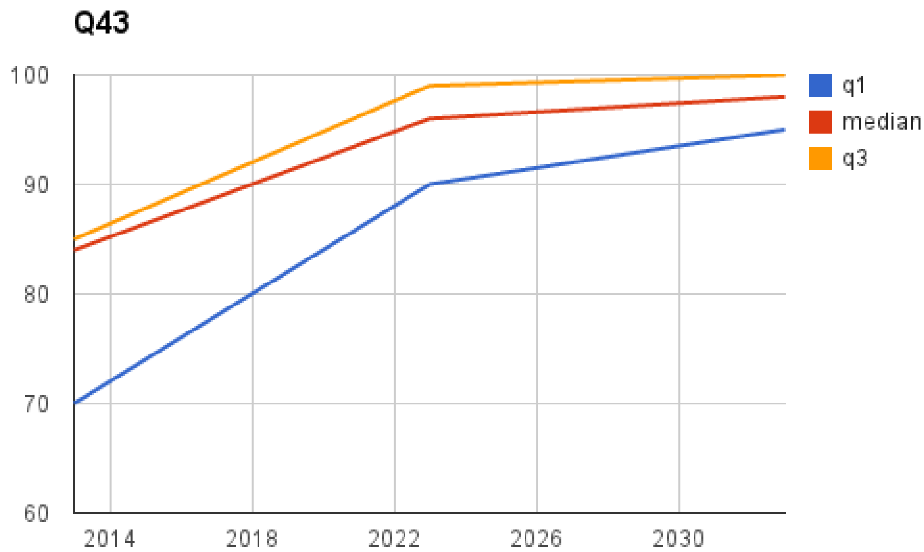

Figure 50: Q43 - Trend: Public Roads

This is not an opportunity nor a threat. It is an indicator how how well the network is built out.

4.3.29 Q50 - Trend: Policy Decision

If we set the telecommunication / ICT policy decision making process efficiency in Hawaii to 100 for 2013, estimate what it will be in year 2023 and 2033?

Question Details	
Q	50
Type	Trend
Category	Political
Experts Details	
Number of experts	5
Average Confidence	7.40
Average Expertise	7.20
Uncertainty Index	0.2383
Median Results	
2013	100
2023	130
2033	160

Table 48: Q50 - Trend: Policy Decision

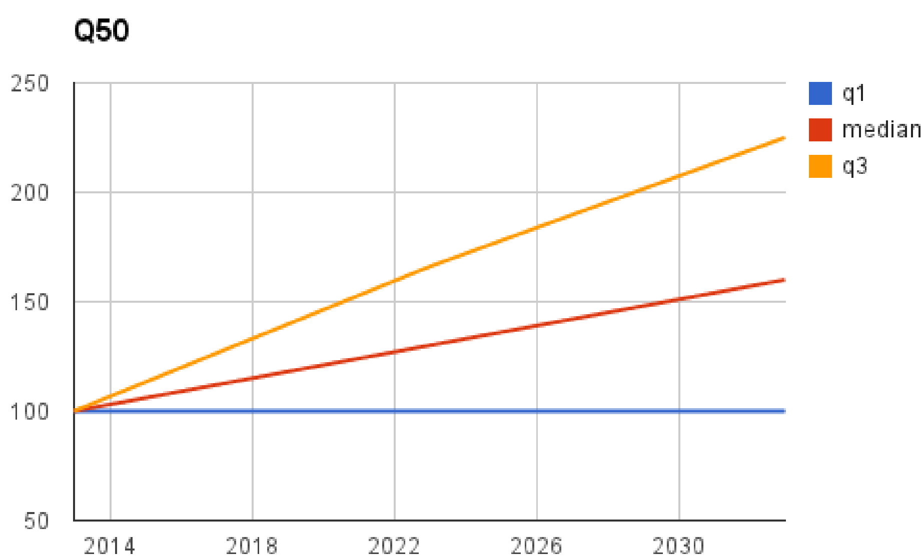

Figure 51: Q50 - Trend: Policy Decision

There was a lot of agreement between industry, academic and government experts that the policy process is too slow. It makes it more expensive and it drags out time. This forecast shows there will be a slight increase. It might not be enough. Overall the policy decision making process in Hawaii is currently evaluated as a threat.

4.4. Conclusion

This has detailed the results from the Real-Time Delphi. Overall there were a lot of interesting and critical factors dealt with. The next chapter will move the suitable developments into a Cross-Impact simulation.

5 RESULTS CROSS-IMPACT SIMULATION

This chapter will go through the results from the Cross-Impact simulation. It will detail which questions were deemed fit to be used in the simulation and why. The chapter will then shortly go through some of the choices made before it moves through the calibration runs. Then the chapter will go through some of the scenario runs and show selected results. More detailed results can be found in Appendix D.

A scenario is when we ask the question “what if this happens”? In risk calculations of investments, an asset's worth is calculated as estimated worth multiplied with the probability of occurrence. Thus if the investment has an estimated worth of 1 million if successful, but has only a 50% chance for success, then the actual worth for that investment is 500k. What happens if the investor can increase that probability? The investment increases in value by increasing the probability of occurrence.

When the study changes the initial probability values, it modulates the other developments according to the relationships established in the calibration. A scenario is evaluating how developments respond to efforts to change the probabilities of drivers occurring. The policy advice becomes what to do to increase the probability of occurrence for opportunities and what to do to decrease the probability of occurrence for threats.

5.1. Introduction to the Cross-Impact Simulation Results.

There are many ways of doing a Cross-Impact simulation. The median answers were uploaded to a Google server by the Real-Time Delphi software. The Google spreadsheet acted as a front-end organizer of the data, and was programmed to pre-process the data.

For instance, for each event question in the Real-Time Delphi method, the experts had to provide years in which the event had a given probability of occurring. The pre-processing meant the data processing could be completed effectively. The spreadsheet was programmed to convert the event estimation to probabilities in given years, and this step was part of getting the data ready for the simulation. The actual simulation ran on a private server that interfaced with the spreadsheet.

The study selected 42 of the questions with more than five experts that also had five or more in confidence and five or more in expertise. The questions not picked had less to do with the overall simulation model, but could serve well as comparable trends for other metrics in the overall study. An example of a discarded question is Q4. Events happening in Hawaii have very little impact on the percentage of businesses in the United States overall that subscribe to 1Gbit or higher connection. The question itself is interesting from a comparison standpoint in the Real-Time Delphi study, but is not relevant for a Cross-Impact analysis. From the selection, there were 14 events and 26 trends.

The setup for the Cross-Impact simulation had a time horizon of 20 years, which aligned with the forecasts made in the Real-Time Delphi software (From 2013 to 2033). The setup used scene values of one year making it 20 segments for simulation. The runs were set at 5000 iterations, which smoothed out the results and made them consistent within about 5%, which is acceptable.

The Cross-Impact got the expert forecasts from the Real-Time Delphi, and they had results for 2013, 2023, and 2033. The Cross-Impact simulation software took those results and created a best-fit regression line as a baseline to calibrate the impacts. The impacts used were events on events, and events on trends. Obviously many configurations of a model could possibly be calibrated to create a simulation regression line similar to the Real-Time Delphi, but the general impact was elicited from the expert interviews.

The results of the Real-Time Delphi was used as a baseline to calibrate the model. The environmental scanning interviews and data gathering were used in estimating the general positive or negative impact in the calibration, and the interviewees emphasis helped support that impact's strength. Other drivers were estimated, supported by literature and general focus in talks. The fine tuning was done by doing test runs. The matrix used a measure of angle between the Real-Time Delphi regression line and the simulated regression line. Once the angle between the lines were three degrees or less, the model was calibrated. For more details on the actual calibration values, see appendix D.

The initial probability estimations for the events were as follows: (p.253).

Question ID	2013	2023	2033
Q76	1	98	99
Q66	1	1	99
Q27	1	22	56
Q17	10	10	10
Q36	1	82	99
Q16	1	59	90
Q64	1	50	50
Q15	2	42	82
Q33	1	62	62
Q65	1	53	53
Q35	1	41	41
Q56	1	27	54
Q39	2	42	82
Q46	1	99	99

Table 49: Initial Probability Estimation from Real-Time Delphi

The overall point of simulating is not to predict a future, but rather to look at how different images of the future can evolve. Simulating further emphasizes the reflexivity and non-determinism of the future by looking at how events can impact the future developments. They therefore serve as good examples for policymakers to use while creating new policies (Bell, 2004; Giddens, 1990). Simulating also further helps to support answering the research questions. What it does not do is to prove definitely. Even if the Cross-Impact provides accurate numerical estimations, they should be taken as general trend changes (Middleton & Wedemeyer, 1985).

The estimations take care of the question of what if. For instance, in the scenario of Q36, this question asked in what year there was a given probability that Hawaii would create one-stop permitting for its telecommunications needs. This has been needed for a while, and many experts and industry people alike have been asking for it, stating it would make the process of running cables easier and much more efficient. Given this model's calibration, what will then happen with the other developments if Hawaii creates a one-stop telecommunication permitting authority. By setting the initial probability of occurring to 100% instead of the probability assigned by the experts, the results can show how dependent developments change accordingly. All other event probabilities were left untouched. Here is a couple of notable changes. If the State of Hawaii simplifies its policy process and create a one-stop permitting office, the overall cost of Internet will decrease by about 10%. The resilience of the network itself will go up, and more people will have access to a 1Gbit bandwidth earlier, which was exactly what the experts in the interviews were forecasting. Currently the overall price will decrease. All the drivers were checked in the same manner to secure consistency of the model.

5.2. Policy Runs

This section will detail three different scenarios as illustrated in 2: the probable, desirable, and undesirable future scenarios. A probable future deals with “the question of what is the most likely future of some specified phenomenon” (Bell, 2009, p. 80). A possible future widens the range significantly and looks at what many would state as impossible as it attempts lateral thinking and explores new possibilities. Both the desirable and non-desirable scenario runs fall within the possible futures. Given the responses from the experts in the Real-Time Delphi, they are at the threshold between probable and possible futures. There are ways of exploring impossible futures, which would challenge some of our notions of reality. Exploring the impossible futures, however, requires a different study with higher order interactions using a much longer time frame, going beyond the scope of this study.

5.2.1 Probable Futures

Given the answers from the Real-Time Delphi study, one probable future could be just taking the forecasts from the Real-Time Delphi and run with them. However, exploring probable futures might expand and improve the understanding of the relationships between the drivers and the other developments. Viewing it as deterministic and letting it run its course do not necessarily indicate what the solutions to looming threats can be. For instance, if the experts forecast a 11% probability that a natural catastrophe will interrupt network connections this year, the Real-Time Delphi model does not answer what can be done from a policy standpoint to minimize this risk. Obviously it is hard to minimize for instance an earthquake, but policies can be implemented to minimize the impact of the earthquake. Such a policy would focus on increasing the resiliency of the network itself.

As mentioned before, the reflexivity of a futures study lies within exploring the scope of the present to see how it could affect the future. Given some of the developments, the uncertainty index, and other qualitative data; a few significant changes can be made within the range of probable- futures that creates a more desirable future.

During the interviews with experts and review of the salient local literature, such as the broadband task force report, clearly the barriers to broadband deployment included complex fee structures, duplicate regulatory authorities and time-consuming processes (Broadband Taskforce, 2008). All the high-level experts agreed on this assessment.

Cross-Impact Calibration Settings in percent probability of occurrence.

QID	Calibration	Probable
Q76 – Natural Catastrophe	1	1
Q66 – Terabit Connection	1	1
Q27 – Human Right	1	Never
Q17 – Internet Content Regulation	9.99	9.99
Q36 – One-Stop Permitting	1	100
Q16 – Security Breach	1	100
Q64 – Political Scandal	1	1
Q15 – Privacy Law	2	2
Q33 – Economic Crisis	1	Never
Q65 – Network Crisis	1	1
Q35 – Roaming Outages	1	Never
Q56 – Actionable Offense	1	1
Q39 – Minimum Quality of Service	2	100
Q46- Internet as a Utility	1	100

Table 50: Probable Scenario Simulation Settings

The table can be read as the initial probability of occurrence.

For the scenario described in Q36, the Real-Time Delphi experts forecast a 10% probability of occurring in 2015. However, given other data, there is a significant chance that it may happen before. The interquartile range is low at only 10 years between q1 and q3 for 90% probability of occurring, and the uncertainty index level is also very low. Therefore for the probable run, the value of Q36 is set to 100%.

Q27 is set to never occur. The question of making broadband a human right in Hawaii seems to have elicited a lot of disagreement, and the median forecast states it will reach a 90% probability in 2050.

Q16 is set to occur. The median answer states a 50% probability of occurring by 2020. It is not entirely unreasonable to assume a network that society heavily depends on becomes a target of terrorism, protesters, or even just random accidents. In 2013 a small fire by the Honolulu International Airport impacted network connection (including cable, Internet and phone) for all major carriers for west Oahu and Kauai (Star-Advertiser, 2013).

Q33 is set to not occur. Though there are risks in the market, economic indicators are looking at a small growth the coming years. Q35 of roaming outages are also set to not occur. However, as our society becomes more dependent on an Internet connection, regulatory policies regarding what constitutes acceptable bandwidth can happen; therefore, Q39 is set to happen. The same holds for Q46. Broadband has replaced phone connections for a large part of the population and could therefore be treated as a utility (Crawford, 2013). Making it a utility is a way of increasing the focus on the necessity for broadband and would increase the State's responsibilities to its citizens.

During the simulation run, a few notable results occurred. First, the networks' recoverability increased by 50% (Q78), indicating the network could be easier to maintain and manage. One of the drawbacks of the current system is that several regulatory offices are sharing the responsibilities for the overall network. Restructuring eases the process of maintaining and deploying cables, possibly leading to a more maintainable and better developed overall system. The average price of an ultra-highspeed Internet connection was lowered by 50%, yet the overall price increases slightly in the beginning. If the One-Stop permitting and broadband advancement authority succeeds, a high-level of initial investment might lead to an initial higher price. If the State creates laws about minimum acceptable Internet speeds, doing so might lead to a higher price and perhaps better reflects our dependence on the system.

Hawaii's dependence on the connection increases as does the Gross State Product. An interesting development in Hawaii's policy efficiency increases by 50%, which makes sense when the overall system is simplified.

For the core developments Q53, Q68, Q25, Q52 and Q88; people are more willing to share personal information, possibly leading to an easier integration of health and educational services. Our dependence on the Internet connection increases slightly yet overtime actually decreases, possibly due to a better diversification across economies. That industries more dependent on the Internet create a secondary growth in industries that does not depend on the Internet as much. Interestingly, though the development does not seem to particularly affect the quality of life, this research approaches the quality of life as a counterweight for other negative developments, such as the purchasing power of the dollar.

5.2.2 Non-Desirable Future

The second run is an undesirable future scenario. In this scenario, 3 undesirable events are set to occur, and three desirable events are set to never occur. The events set to occur are Q16, Q64, and Q33. In this scenario, a major political scandal inhibits the Gigabit initiative, while a security breach affects the Internet service providers and a major economic crisis occurs. Independently these events may happen. This scenario is further amplified by Hawaii never actually making Internet a human right or a utility and failing to create a one-stop permitting authority.

QID	Calibration	Non-desirable
Q76 – Natural Catastrophe	1	1
Q66 – Terabit Connection	1	1
Q27 – Human Right	1	Never
Q17 – Internet Content Regulation	9.99	9.99
Q36 – One-Stop Permitting	1	Never
Q16 – Security Breach	1	100
Q64 – Political Scandal	1	100
Q15 – Privacy Law	2	2
Q33 – Economic Crisis	1	100
Q65 – Network Crisis	1	1
Q35 – Roaming Outages	1	1
Q56 – Actionable Offense	1	1
Q39 – Minimum Quality of Service	2	2
Q46- Internet as a Utility	1	Never

Table 51: Non-Desirable Scenario Settings

In this scenario, the results show a catastrophic development for most of the indicators. In terms of the core developments, they include Q53, Q68, Q25, Q52 and Q88. The events seemed to affect people, who are less willing to share personal information, possibly affecting the development of online health services as an example. They are still depending more on the Internet services, but the increase in dependence is overall lower, slightly affecting the overall quality of life in Hawaii. The events also negatively affect laws to protect people's privacy. In situations with a lot of uncertainty, such as ongoing economic recessions events, they are harder to forecast. People and companies in general tend to take a little less risk as the overall event situation is more volatile. The events also affect how much of Hawaii's Gross State Product depends on Internet connection, maybe because the overall economy lacks the diversification called for by several studies, which may lower the competitiveness in the overall broadband industry as well as considerably lower the attractiveness of Hawaii for outside businesses.

5.2.3 Desirable Future

The third scenario run does not extremely differ from the probable run, is slightly more towards the ideal, and makes a few assumptions the experts in the Real-Time Delphi disagreed with. The primary difference is that the third makes Internet a human right in Hawaii. This could take many forms and does not necessarily mean free or ultra-high-speed Internet for all. There are even arguments that points to the Internet as only a medium of information (Cerf, 2012). However, the way the information is shared today is radically different than how it was when the right to information became a human right (UNESCO, 2010). One could discuss the utility of such an act, but availability and access are two different things. In this scenario, broadband is a human right.

QID	Calibration	Desirable
Q76 – Natural Catastrophe	1	1
Q66 – Terabit Connection	1	1
Q27 – Human Right	1	100
Q17 – Internet Content Regulation	9.99	9.99
Q36 – One-Stop Permitting	1	100
Q16 – Security Breach	1	Never
Q64 – Political Scandal	1	1
Q15 – Privacy Law	2	2
Q33 – Economic Crisis	1	Never
Q65 – Network Crisis	1	1
Q35 – Roaming Outages	1	Never
Q56 – Actionable Offense	1	1
Q39 – Minimum Quality of Service	2	100
Q46- Internet as a Utility	1	100

Table 52: Desirable Scenario Settings

Compared to the probable scenario, the preferable scenario set Q16 to not happen. There will be no security breach leading to downtime anytime in this scenario. In a scenario where the systems have more redundancy, it becomes harder to identify single points of failure that could be attacked, resulting in an overall strategy for land- and submarine cables, a strategy for land cables as well as other potential points of failure.

In this run, the core indicators Q53, Q68, Q25, Q52 and Q88 show interesting movements. People are more willing to share information just like in the probable run. In a society where people feel safer, they have less constraints on sharing. Like in the probable run, the overall Internet dependence spikes, but then tapers off. In 20 years, the dependence is actually lower, possibly due to the level of privacy rights increased by 50%. Quality of life also spikes before it slowly goes down. Hawaii's Gross State Product becomes very dependent on the Internet. The policy decision making becomes much more efficient, and the overall competitiveness in Hawaii's broadband industry increases. Now obviously to what extent the competition level actually does increase will depend on how broadband as a utility is actually implemented. If one looks at public utilities in a traditional sense, then usually it would mean a monopoly situation. Today Hawaii has an effective duopoly, with a smaller third player.

In most cases, public utilities have very little competition. This situation does not have to be that way. One can set public utilities as a minimum standard and compete within given frameworks. The utility competition would then act as a framework for minimum standards. It could be modeled after some of the electric utilities. The next chapter contains a fuller discussion of this.

5.2.4 Scenario Comparisons

This section will compare a few selected results from the scenario runs, which illustrate how the different scenarios can be used to evaluate the outcomes of policy choices. All the graphs are grounded in the forecasts made by the experts in the Real-Time Delphi study tool. The calibrated scenario line is the simulation overlay of the forecasts by the experts in phase 2. When the initial probability setting was changed from the experts forecasts in the Cross-Impact tool, it affected the other individual developments as shown in figure 52. That figure shows how all the scenarios influenced one development, namely Hawaii's economic dependence on the Internet. The changes can be seen relative to the calibrated line, a line that aligned with the experts' forecasts.

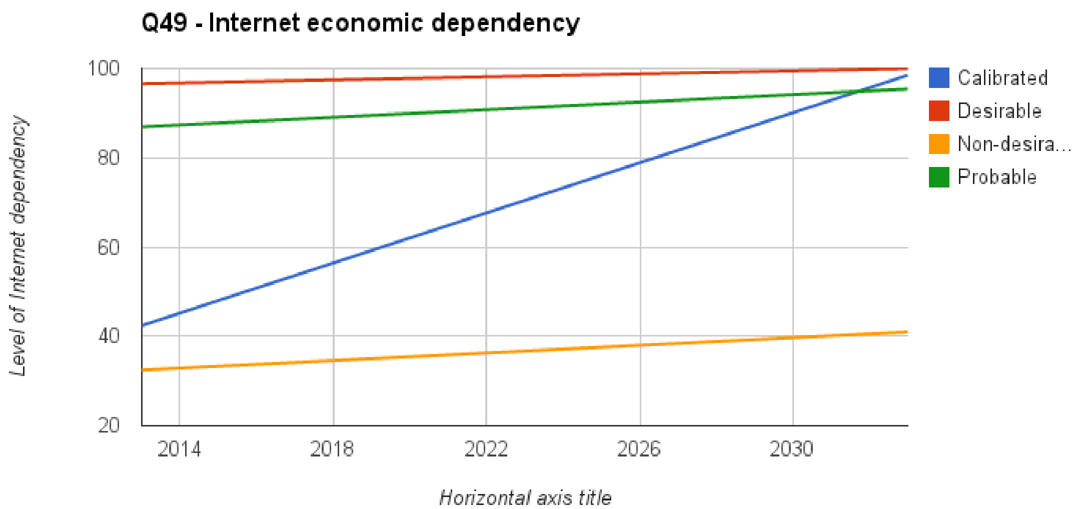

Figure 52: - Scenario: Q49 - Internet economic dependency

For Q49 – Internet economic dependency, the forecast states Hawaii's economy is moving towards becoming almost completely dependent on the Internet. This dependence will come in all of the scenarios except the non-desirable. In the desirable and probable scenario, the dependence emphasizes how important it is for the State to make consideration regarding the quality of the service. If the economic dependence in the State will increase and almost become completely dependent on the Internet, the network must also be resilient and have a high level of recoverability. Therefore, policymakers must make decisions based on this knowledge.

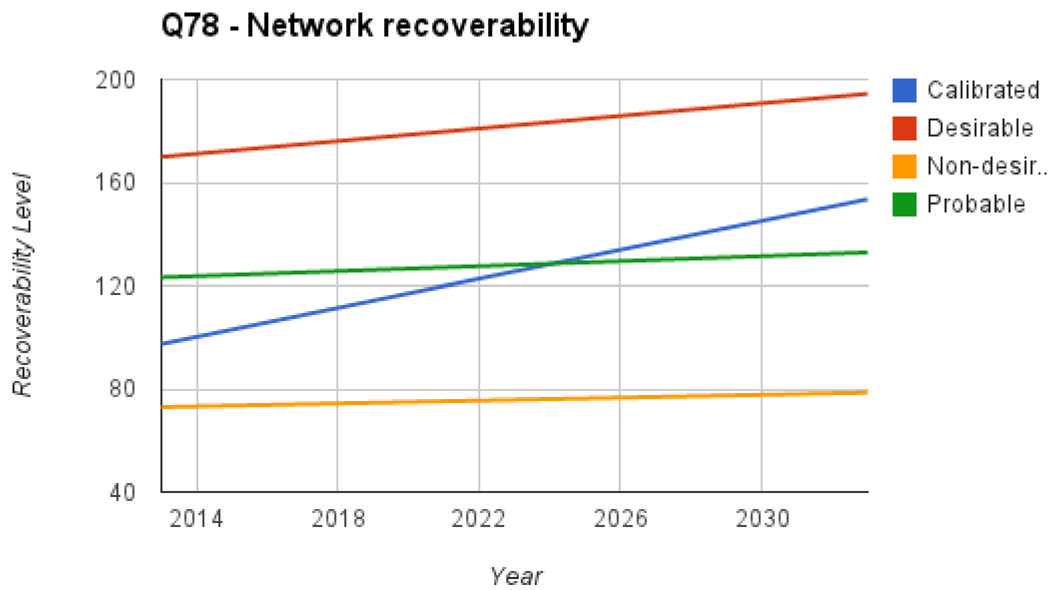

Figure 53: - Scenario: Q78 - Network Recoverability

Internet economic dependence could potentially be interpreted as a threat; however, it does depend on the general state of the network. As seen in figure Error: Reference source not found, the same scenarios also increase the general recoverability of the network. The desirable scenario sees a higher increase in the overall recoverability.

5.3. Conclusion

Simulations of this model identified a few major drivers for change. The two most critical positive opportunities were the Q36, the one-stop permitting authority, and Q46, Internet as a utility. Its positive effects on development and society at large in this model were obvious. By increasing the probability of this occurring, Hawaii could see some radical developmental changes relatively quickly. The simulation answers research question 3. A simulation model that is internally consistent and consistent with the interviews and the foretasted date can be created successfully.

6 DISCUSSION

This chapter will summarize in more detail the results from chapters four and five. Chapter 6 also will go into more detail on the analysis and considerations made during the research.

6.1. Environmental Scanning

The background scanning considers many inputs: newspapers, journal articles, legal and policy documents, and identification of and interviews with experts in the field. Because current research material takes years to get published, environmental scanning has to consider many other sources of information.

In many cases, random conversations might not be of much interest, but while scanning an environment, it is good to have an awareness of which topics people in the field are preoccupied with. One can also converse with people who otherwise would not be able to meet for interviews. These conversations were used only as inputs for the formal interviews and for clarifying the current situation. Obviously these conversations were not used to direct the study, but to support the overall gathering of information.

6.1.1 Selection

Diversity of the group - Demographics

This study had access to the highest level of expertise on the island of Oahu. Three of the interviewees had served on the Broadband Task Force and presently serve in high-level positions in leading institutions. One served as a Chief Information Officer for a governmental organization. Another served as the president of a Telecommunications organization, in addition to serving at a high-level capacity in a private Telecommunications firm. The diverse group included representatives from academia, government, and private industry. Though more than five interviewees would have been ideal, the quality and diversity of the interviewees were sufficient for informing the question-creation phase in the RTD. The interviews lasted between 45 and 150 minutes.

Throughout the interviews, a lot of topics seemed to resurface, emphasizing concerns. The interviews provided context for the evaluation and discussion that follows. These are also some of the main trends and events that lead to opportunities and threats for broadband development in Hawaii.

6.2. Real-Time Delphi

This section will discuss in more detail developments and choices made during the RTD2 process. It starts with a general discussion on the participants before it moves to thoughts on Real-Time Delphi as a study method and tool. Finally, there is discussion on interesting results best approached within the context of qualitative data.

6.2.1 Participants

This section discusses relevant information about how to access experts ways to elicit more responses from them, and overall strategies and statistics about results coming from different initiatives to get experts to participate.

For the Delphi, the groups were seeded into three groups. The study sent out invitations to the groups in this order: secondary seeded experts, the primary seeded group, and the third-seeded group. The idea was to invite the primary seeded group after the system started giving feedback on group forecasts.

- Primary Seed - Direct decision makers and policy influencers
- Secondary Seed - Members receiving direct invitation
- Third Seed - Experts who are members of overall broadband groups

To make sure the high-level experts were represented in the initial groups, the second-seeded group was invited first. The second-seeded group included experts from the PTC lists, experts who have high levels of expertise, but might not have the power to decide or high levels of influence in broadband development. The study could also, to some extent, pre-seed and verify expertise. Each expert was emailed directly with an invitation. For the third set, a sweeping invitation was sent to groups of experts, but control was designed to evaluate expertise level post-registration. Though the study diligently collected names from the broadband industry, a more sweeping invite might have captured experts not picked up by the two other processes.

For the third seed, the invitations were posted in two professional groups, noting the study was looking for high-level experts on broadband and Telecommunications in Hawaii. To ensure the high levels of expertise, alerts were set up for the system administrator, so credentials could be verified immediately as the participants were entering their answers. Emergency strategies were implemented for monitoring and evaluating participants in case someone attempted to unduly influence the study.

As mentioned before, only one person had to be dropped from the study due to unverifiable credentials. In addition to an administrator intervention, the system itself filtered answers from people with low self-estimated expertise. A more detailed discussion on the threshold for participation follows below.

Once members of the second-seeded group had received their emails, the study was expecting most of the 83 questions would have enough expertise forecasts to show feedback for the primary group. Because the response rate was only three percent, the study set in motion a pre-planned alternate way of presenting questions. A more detailed discussion will follow in the next section.

6.2.2 Technical Aspects of Study Design

This section briefly discusses the study design and how some ongoing monitoring strategies had to be initiated. An extension of the RTD2 software was an ability to cover more questions using experts serving questions in random order.

6.2.3 Question Selection and Study Redesign

Experts could of course choose to answer all the questions. However because experts are often busy people, the software was designed to present the questions in a seeded random order. First, a core set of five questions was presented in random order. Then questions from the two STEP categories for which experts self-evaluated themselves to have the highest levels of expertise would be presented randomly. If these two categories had less than 25 questions, the system would add questions to make it a set of 30 questions. The reason behind this was while doing the usability testing, the domain experts gave some feedback about the number of questions. Another reason was most experts were busy and might not have time for a set of 83 questions. Thus checking the internal consistency of the initial set of five questions would ensure using experts for the parts of the field they consider themselves stronger in.

Once the study saw the number of experts who answered from the second seed was lower than expected, a second set of seeded questions was initiated.

Instead of having all 83 questions (except the five core) used with an even probability based on the STEP selection, the secondary set of questions was used after the primary group of questions. The self-reported STEP categories were set aside to ease the access to the questions. The second set of questions consisted of a set of 25 questions, which were selected on the basis of belonging to the second most important category determined in the interviews. These questions were also presented in random order to secure an even coverage of answers in case participants dropped out. Online links that automatically logged participants into the pages with the questions were sent to all registered participants, leading to a flow for the new participants that cut out several steps.

Although the dropout rate did not seem to be too high, once the experts actually started answering questions, avoiding the sign-up phase might have lessened this rate. The experts who answered questions averaged 26 answered questions. Most participants who received their initial invitation after the addition of the second set of questions ended up answering all 30 questions.

The estimations of time per question were based in part on the final usability testing in which the study was looking at how much time the domain experts spent answering the questions. The second set of questions also showed up in random order to avoid any possible internal influences from having one question influence how experts answer the next.

6.2.4 Feedback and Privacy

Some concerns were expressed about the privacy in the system. More specifically, one interviewee expressed concerns about how his company's privacy policy would apply to the study. The study considered privacy a priority, while implementing the methodology.

With the accessible Institutional Review Board (IRB), invited participants could see small notices about privacy. Every invitation email expressed that the email would not be shared, that participants could review only aggregate group responses, and that no personally identifiable information would be shared. Even with the IRB being clearly stated, one participant cited his own company policy.

Privacy was also a clearly stated criteria for doing a Delphi. To verify expertise credentials and to be able to take out results from participants that are not experts, answers had to be tied to the experts in the database. It was unacceptable for the study to end up in a situation in which it could not identify and correct errors that might have happened while gathering data.

When quoted an estimation of 15 to 20 minutes, an invited expert said he would not participate if the survey took more than one minute. Now obviously this expert might not be the ideal candidate, as soliciting meaningful forecasts within a minute would be hard. Nonetheless this scenario does provide some insight to the time crunch experts are in and that other motivations might also be influential when they participate in studies. Most of the general feedback and email conversations stated how important the study was.

6.2.5 Server Issues

Though the study took great care in selecting a host with a good track record and good reputation, a few misfortunes happened during the study. Most notably, the server was down twice for over a day during the most critical period of invitation, possibly affecting the participation levels. However after one of the downtime periods, the study sent a reminder email to the invited experts, which apologized if anyone had attempted to access and announced the problems were fixed.

The second issue was a change of emailing policies from the hosting company. All alerts from the system, such as participant proposal feature and contact, use an email function to alert system administrators. Because of this policy change, some of the alerts did not come in a timely manner. Instead, the change was discovered during a check of the secondary alert system. Contacts were both stored in the database, and sent out through email as well.

6.2.6 Methodological Extension

This section will elaborate on considerations that had to be taken while implementing the methodology in a generic software.

The primary requirements in a Real-Time Delphi listed included: anonymity, feedback and the ability to include both quantitative and qualitative data.

A trivial systems design element enabled anonymity in the study while enabling the identification of the participants as experts in a remote system. Yet, implementing this design element and enabling users to understand are two different matters. Great care was taken in the interface to explain how the personal data would not be attributed to participants, which the invitation also explicitly explained.

In terms of feedback, the system would provide the participants' aggregated statistics only after the forecasting fields have been filled out. The information was dynamically loaded and did not need the participants to click any buttons. The system also showed qualitative information about the questions and the choice to display only a few selected answers. Because the qualitative answers should come from a high-level expert, qualitative answers from the highest-level experts in the q1, median and q3 were shown. The novel way of displaying this information should save even more time for the participants and should prompt an unbiased answer by requiring an answer prior to displaying the estimates of others. The aggregated quantitative feedback was also presented in a graphical form to give it more depth and to make the interface more visually appealing.

Once the requirements were taken care of, multiple designs were tested in a low-level prototype. Using Nielsen's design heuristics, the final implementation looked very different from the prototype presented in the proposal phase of this study. The design chosen was a more panel-focused layout where different elements were put in context. More recent advances in technology let the study stay constantly connected to the server and store answers as they were given. The study was also enabled to display the feedback more dynamically.

Care was also taken to make the implementation of the method generic, so it could be used for other studies. Thus the design was implemented using a relational database for storing information. All parameters relating to the questions were from the database, enabling a more dynamic way of displaying information. Systems were coded under a Model-View-Design philosophy, which ran on a LAMP stack, using MySQL, PHP, CSS, and JavaScript.

6.2.7 Questions in General

This section will detail how the questions evolved and will discuss the results from the RTD that the study found interesting.

First, the questions selected to move to the Cross-Impact were based on criteria that minimum of five experts having an expertise and confidence in their answers at the level of five or higher.

So why did the study set the level at five? The initial values were set at seven for all. The implementation even allowed setting these values at the level of the individual questions, but that feature was not used in this study. As the study moved forward, even very high-level experts seemed to rate themselves low. The study therefore picked the average expertise level and confidence level as minimum measurements for the selection.

Even if studies have found self-rating expertise to be correlated with actual expertise, cultural elements could potentially influence the self-judgments.

The study also required a minimum of five responses before presenting the aggregate results. If the results from the first answer were presented, an outlier could potentially influence and skew the whole result set. Secondly, a certain number of responses was needed for the statistical functions to work properly without receiving too much influence from outliers.

Results selected had therefore a minimum of five in confidence and minimum of five expertise. The results also had to have a minimum of five people with a level equal to or greater than five in expertise and confidence.

Some results ended up looking very similar to the pre-test questions. In the feedback, some noted they thought they had answered the questions already. A decision was therefore made to create questions that were more dissimilar, also forcing more cognitive load and having people think about the question.

6.2.8 Selected Question Results by STEP Category

Overall, 46 questions had enough answers with enough confidence and expertise. Some of these questions were picked for a closer discussion.

The software has a novel way of presenting questions to experts. Where other implementations of Real-Time Delphi will present questions in order, RTD2 presents the questions randomly to avoid a bias of question order. In addition, by using a random order and an order based on the top-expertise category, the methodology was extended, so that it could accommodate more questions and thereby create a more complex model. The only drawback of such a solution is that it would require more experts. Even if Hawaii is geographically limited, enough experts were anticipated to sustain the number of questions initially created. The fallback was to limit the number of questions if too few experts participated. This strategy seemed successful, although it obviously would have been better if all the questions and answers could be used.

6.2.9 Expectations on Growth

Before looking at the results, the study made some assumptions. First uncertainty would increase as one moves forward in time. Because a greater number of variables will influence the developments over time (e.g. trend or events), more unknown changes could happen. Indeed this was the case. The uncertainty can be seen as q1 and q3 open up more and more. The difference between q1 and q3 is usually larger at the end of period.

This scenario however is not the case when an event is reaching its limits. An event cannot have more than 100% probability of occurring, and as a result the q3 stops at 100%. The lower forecasts still can grow, and in some cases they do.

Now some experts will predict some events will have a 0% chance of occurring, yet others will increase the probability of occurrence. This difference in prediction can be attributed to a few different possibilities.

First, the difference could be a temporal problem. Experts saying an event will never happen might be a matter of perspective as to how the developments influence each other.

Secondly, the experts' different backgrounds and areas of expertise may result in the experts' different focal points, another possible cause of the difference in prediction. Thus the software enables providing a qualitative answer.

The third possible cause of the difference in forecasts is a semblance of exponential growth. Hawaii’s growth has stagnated a bit, but the new Broadband Initiative might improve it. Conversations seem to indicate a lot of disagreement about what the future should be. Telecom providers state users are not using the already available bandwidth, yet policymakers state the need for more available bandwidth.

In interviews, a lot of effort was put into the idea of being a first mover. In Kansas, the Google Gigabit project is already happening, and the State has already seen an influx of technology startups coming to the city to take advantage of the bandwidth (Talbot, 2012a). New companies result in an influx of people, skills, and capital. Some startups even rent houses to get access to the zip codes where the Gigabit connections are deployed.

6.2.10 Questions

Events:

Q17-Internet Content Regulation (Event - Political), Q46-Internet as a Utility (Event - Social), Q27-Human Right (Event - Political) , Q36-One-Stop Permitting (Event - Political), Q15-Privacy Law (Event - Political), Q56-Actionable Offense (Event - Political), Q64-Political Scandal (Event - Political), Q39-Minimum Quality of Service (Event - Political), Q35-Roaming Outages (Event - Social) , Q16-Security Breach (Event

- Technical) , Q33-Economic Crisis (Event - Economic), Q66-Terabit Connection (Event - Technical) , Q76-Natural Catastrophe (Event - Environmental), Q65-Network Crisis (Event - Technical)

Trends:

Q53-Personal Information (Trend - Social), Q68-ICT Dependency (Trend - Technical), Q25-Quality of Life (Trend - Social), Q52-Privacy (Trend - Political), Q88-Gross State Product (Trend - Economic), Q6, Q3-Internet Connection Price (Trend - Economic), Q78-Natural Catastrophy (Trend - Environmental), Q2, Q40-Competitiveness (Trend - Economic), Q61-Hawaii Dependence (Trend - Social), Q23-ICT Dependency (Trend - Technical), Q5, Q77-Network Resilience (Trend - Technical), Q60-Political Participation (Trend - Political), Q1, Q86-Economic Transaction (Trend - Economic), Q49-Internet Economic Dependency (IED) (Trend - Social), Q11-Policy Knowledge (Trend - Political), Q82-Data drivers (Trend - Technical), Q87-Hawaii Workforce (Trend - Technical), Q4, Q72-Business attraction (Trend - Economic), Q8-Price of Connection (Trend - Economic), Q24-Job Creation (Trend - Economic), Q34, Q89-Regulation of Broadband Networks (Trend - Political), Q43-Public Roads (Trend - Technical), Q73, Q31-Home Appliances (Trend - Technical), Q37-Collaboration (Trend - Political), Q50-Policy Decision (Trend – Political).

Five Core Questions.

Originally, this software would support a large number of experts answering a small set of questions based on their highest self-rated STEP expertise categories. To ensure internal consistency between the experts, a core set of indicators was selected to be answered on the basis of the interviews and importance for the State of Hawaii. The questions were Q53-Personal Information (Trend - Social), Q68-ICT Dependency (Trend - Technical), Q25-Quality of Life (Trend - Social), Q52-Privacy (Trend - Political) and Q88-Gross State Product (Trend - Economic). The common theme for these questions was that they were general and identified as important indicators.

The generality of the core questions did seem to frustrate a few of the participants; they felt their expertise was not targeted well enough. How to introduce the study to the participants was of concern, and several options were considered and explored with regard to usability and domain experts. To avoid the problem of questions influencing one another, a random order was used for certain categories. The core questions were necessary in the beginning to evaluate internal consistencies.

In Q68-ICT Dependency (Trend - Technical), the median forecast shows ICT dependency will almost triple over the next 20 years. Q88-Gross State Product (Trend - Economic) forecasts Hawaii's GDP dependence on a network connection will increase by 120% over the next 20 years. These two indicators alone clearly demonstrate as our dependence on the network connection increases, so should the resilience and recoverability of the network. Q6-Connection Affordability (Trend - Economic) forecasts a 50% growth in recoverability of the network.

What does the recoverability mean for Hawaii? Recoverability deals with how long it takes to correct downtime. For example, years ago a submarine cable snapped in Hawaii. Coincidentally a repair ship was close by to repair it quickly. No such ship is permanently harbored in Hawaii. If enough damage to the cables is done, it might lead to a significant amount of downtime for the other islands. The damage may also indicate perhaps it is time to change from a point-to-point connection and focus on more resilient network topologies such as the Southern Cross configuration. Growing more dependent on a network connection should lead to better emergency preparedness or better yet, create networks that can sustain more wear before going down.

Q52-Privacy (Trend - Political) forecasts a slight increase in the privacy laws for Hawaii. Indeed there are several initiatives both locally and internationally focusing on privacy. Hawaii recently failed to enact a law forcing companies to disclose their privacy policies on their websites. This question also seems to spark qualitative feedback that presents salient points. One in the middle 50% notes, “I think it will become an issue and will be addressed. Some privacy will be compromised in the meantime, but slowly corrected”. One of the forecasters in the low 25% notes, “Privacy will continue to be redefined and decrease significantly compared to our current definition”. Indeed, indicators hint privacy could go either way. Recent debates about how large companies are using information to sell advertising are becoming more prevalent. As another median forecaster notes, “Protection of privacy rights will continue to gain popularity/speed at national/state levels. While hiccups are likely to occur along the way, public scrutinization will aid in drowning misguided policies. National level debates will remain critical.” Recently a federal effort to “stop online piracy” act led to an outcry, and several large websites shut down their site for the day to express their outrage (Pepitone, 2012; Timm, 2013). This incident did show the general public can and will organize for a cause. On that note, one question that did not have enough responses (with regard to high level of expertise and confidence) asked for a forecast about the policy involvement in the general public in Hawaii.

Q25-Quality of Life (Trend - Social) showed an even trendline for quality of life. This might indicate broadband does not greatly impact the overall quality of life in the State or the increase in bandwidth is counteracting other trends that seem more detrimental to the State –such as the value of the American Dollar . A recent study shows Hawaii at the top of the well-being index made by Gallup for the fifth year in a row (Gallup, 2013). Maybe the experts consider the quality of life as peaking. Some of the comments show the median answers feel it will slightly dip before stabilizing: “Hawaii’s fiscal and social nets will initially face impacts caused by the passing of Senator Daniel K. Inouye in concert with the retirement of Senator Daniel K. Akaka. However stabilization will occur once the predecessors’ replacements are selected”. Another median estimate f the overall quality of life will deteriorate as the population increases. An expert with a low forecast proposes a solution: “We have to get corruption out of decision making or it is going to deteriorate.”

6.2.11 STEP - Social

The questions in this category include Q2-Internet Connection (Trend - Social), Q49-Internet Economic Dependency (IED) (Trend - Social), Q53-Personal Information (Trend - Social), Q25-Quality of Life (Trend - Social), Q35-Roaming Outages (Event - Social), Q61-Hawaii Dependence (Trend - Social) and Q46-Internet as a Utility (Event - Social). The results from this category were interesting on many levels. First, Q2-Internet Connection (Trend - Social) forecasts 50% of homes will have access to 1GBit networks by 2023. The significance lies in comparing it to the stated goals of the Broadband Initiative. This goal states all citizens in Hawaii should have access to affordable synchronous one Gbit network by 2018 (Hawaii State, 2011). The large difference between the forecast and the goals of Governor's office could be due to a distrust in political ability to achieve goals or may simply reflect a more moderate estimation of what usually happens when political goals are set.

Within 20 years, 96% of Hawaii's economy will directly depend on Internet connection. “Directly dependent” is defined as the percentage of the economy that directly depends on an Internet connection. Now this dependency does not mean all storefronts will close, but does mean the Internet will take part in most of a company's processes and transactions. For instance most devices will use much of the same protocols and connect to the same network, and this dependence has to be accounted for when planning the networks.

Now contrast the dependence the economy will have on the Internet with the forecast for roaming Internet outages. The median answer forecasts a 50% probability that Hawaii will have experienced this by 2025. The interquartile range for 90% probability is 2023 to never. The median answer forecasts a 90% probability that Hawaii will experience roaming outages by 2040. Considering Hawaii already has run out of bandwidth once, it could happen again, especially as the wireless demand for bandwidth increases. Now some of the interviewees stated the market would take care of such an event and more submarine cables would be built. Surely this situation would be temporary, but how much loss of productivity could the State tolerate? Planning, funding and building a submarine cable is not a trivial matter as the lead time for planning is significant. Although companies project bandwidth use, the exponential growth is still hard to account for. Cisco report the new generation 4G handset generates 19 times more traffic than a non-4G set. The average mobile data usage grew 81% in 2012, and the overall mobile data traffic will surpass 10 Exabytes by 2017 (Cisco, 2013, 2012). The statistics show the enormous growth will exhaust current capacity.

The submarine cables that land in Hawaii today still have capacity left. They will also receive an upgrade, and capacity will be increased. However, the upgrades will be filled by the increased demand as more devices are using high bandwidth services.

The discussion regarding capacity and demand is not new. The suppliers say the bandwidth will be there when the demand is there. The cost of having outages in an economy highly dependent on the connection, however, is significant.

Q61-Hawaii Dependence (Trend - Social) forecasts Hawaii's dependence on high-speed broadband will double over the next 20 years. This question was also designed to partially check for internal consistency between questions. Indeed when compared to Hawaii's economic dependence on the Internet, (Q49) implies they are comparable. The questions do provide slightly different aspects of broadband dependence.

When declaring Internet as a utility, the government would need to assure a certain level of access with an affordable price. In many respects, broadband is treated as a utility; however, it seems many of the required actions that go with it are not properly addressed. Hawaii has good Internet coverage, but the level of service varies. The forecast stated Internet would be declared a utility by 2020.

6.2.12 STEP - Technological

The selected questions belonging to this category were Q73, Q66-Terabit Connection (Event - Technical) , Q68-ICT Dependency (Trend - Technical), Q82-Data drivers (Trend - Technical), Q1, Q77-Network Resilience (Trend - Technical), Q31-Home Appliances (Trend - Technical), Q87-Hawaii Workforce (Trend - Technical), Q16-Security Breach (Event - Technical), and Q65-Network Crisis (Event - Technical).

Q66 looks at connection speeds and forecasts a 90% probability that the first home will have a Terabit connection by 2030. If by 2023 50% of homes in Hawaii have access to 1 Gbit, and only 7 years down the road the first home in Hawaii will have a connection speed that is 1,000 times faster, then one can get an idea of the scaling necessary for the connections leading in and out of Hawaii.

Secondly, one of the main arguments of the industry professionals is if the demand is there, the industry will provide the service and that customers in Hawaii are not using the bandwidth they already have. On the other hand, proponents of high-speed bandwidth argue if the service is provided, the users will use it, and new services will be created. This dichotomy is far from new, yet it is still fairly persistent across markets. These arguments are both valid, but based on slightly different motives.

According to the recent reports by the ITU, growth in bandwidth directly correlates to growth in GDP (Katz, 2012). In the initial interviews, two of the participants pointed out the effectiveness will increase if Hawaii is a first or early mover. Taking into consideration some of the early reports from Kansas, where Google Inc. started a 1 Gbit project, this argument might have some merit (Talbot, 2012a). Kansas is already seeing an influx of startup companies and innovators. In other places, the high bandwidth is combined with other initiatives to spur innovation (Talbot, 2012b).

Hawaii's predicament is that such leaps in bandwidth need longer lead time as planning transpacific cables is not a trivial undertaking.

Q1 was of interest because of a few things. First, it forecasts FCC will define broadband as 22 Mbit in 20 years, which could have several implications. First, the forecast could mean experts see FCC as trailing when it comes to defining broadband. It could also mean a future emergence of a new digital divide. This digital divide would not necessarily be between those with access and those without, but that levels of access create boundaries of what could be achieved with a network connection.

This study forecasts in 20 years (Q31-Home Appliances (Trend - Technical)) 80%

of home appliances will be connected to the Internet. Most new TV's and amplifiers sold today already have a network connection. Samsung Electronics developed a refrigerator that can connect to the Internet and keep tally of contents. Once all these different devices start interacting more, a large shift in how the home interacts with its residents and with world around them will happen. So far the technology is rudimentary, but eventually the technologies will mature and become much more useful. Eventually the devices will connect to the Internet and use broadband services to communicate with the world around them. Though this result is not revolutionary, it does support the notion that bandwidth needs are growing.

All these services need to be secure. Q16-Security Breach (Event - Technical) forecasts a 90% probability of a serious security breach leading to downtime for 50% or more of the population in Hawaii by 2033. Now if most of our appliances are connected and we heavily depend on our network connection, what will happen? Q77-Network Resilience (Trend - Technical) deals with the resilience of the network. The forecasts state the network will become 50% more resilient. Given our heavily increased dependence on the network, both as a primary and secondary tool, should perhaps more effort be made to increase the resilience of the network?

Through the past decade, several destructive computer viruses have shut down companies. In 2004, a very simple little virus shut down networks around the world and caused damages worth over $18 billion. Most commonly, these viruses are made by children who wanted to see what they could do. What would happen if a set of skilled individuals set into motion a targeted attack on the networks? The World Economic Forum identifies cyber attacks as the biggest global risk for critical systems failure in both 2012 and 2013 (Schwab & Howell, *2012*; Howell, 2013). Building a more resilient network might mitigate some of these risks.

6.2.13 STEP – Economic

The questions belonging to this category were Q4, Q24-Job Creation (Trend - Economic), Q86-Economic Transaction (Trend - Economic), Q8-Price of Connection (Trend - Economic), Q72-Business attraction (Trend - Economic), Q34, Q23-ICT Dependency (Trend - Technical), Q6-Connection Affordability (Trend - Economic), Q40-Competitiveness (Trend - Economic), Q88-Gross State Product (Trend - Economic), Q5, Q3-Internet Connection Price (Trend - Economic), Q33-Economic Crisis (Event - Economic).

The ICT-dependentjobcreation rate will increase by 50% by 2033. Considering the higher increase in ICT-dependent firms and the forecast that slightly lowers the overall job creation rate, ICT-related jobs seemingly will become more prevalent in Hawaii’s economy. This scenario means either Hawaii's economy does indeed diversify as recommended or that current industries are depending more on ICT (DBEDT, 2007; HTDC, 2009; Sharma, 2008). A mix of both is probable. The economic forecast of 89% of Hawaii Gross State Product depending on an Internet connection is staggering.

The Real-Time Delphi study forecasts a slight increase in the monthly price of a broadband connection. If considering possible initiatives that make broadband more resilient, this forecast is reasonable in this the case as it would reflect the future higher dependence on the connection. However, with the stated goal of affordable broadband for all, some segments in the market are more price sensitive than others. If this price is too high, it could lead to an increase in the digital divide, devastating society–essentially creating two completely separate communities. One of the stated goals of the broadband initiative was to drive broadband demand by supplying lower-income families with computers in an initiative called “no child left off line” (Broadband Taskforce, 2008).

The review of the results combined the Q3, the average price of a 1Gbit connection forecast of $90, together with Q6Connection Affordability (Trend – Economic), which forecasts 68% of homes in Hawaii will subscribe to a 1Gbit connection in 2023. The current census estimates Hawaii has 445,513 households, which provides a total market of $272 million in 2013 dollars. The forecast (Q8-Price of Connection (Trend - Economic)) also states the average price for broadband is about $50, and that the broadband definition is about 22Mbits in 2033, showing internally consistent results.

The forecast shows a slight decrease in new businesses attracted to Hawaii because of its ICT capabilities. This forecast is consistent with the lack of faith in the State’s 1Gbit coverage goal. Obviously, the increase in bandwidth does not only have to be increased, it has to increase more than other states. This situation makes Hawaii more competitive in attracting businesses. Obviously, the bandwidth issue is only one facet of the overall package a company is looking for; other initiatives are also needed. However, as more communication is moving online, the time and space constraints that could hinder a company from establishing in Hawaii are breaking down. The level of competitiveness in the broadband industry could also discourage companies moving to Hawaii as it has an effective duopoly. The experts forecast a meager 10% increase in broadband supplier competition level in the next 20 years.

6.2.14 STEP - Political

The questions belonging to this category were Q89-Regulation of Broadband Networks (Trend - Political), Q27- Human Right (Event - Political) , Q50-Policy Decision (Trend - Political), Q17-Internet Content Regulation (Event - Political), Q52-Privacy (Trend - Political), Q11-Policy Knowledge (Trend - Political), Q36-One-Stop Permitting (Event - Political), Q64-Political Scandal (Event - Political), Q37-Collaboration (Trend - Political), Q15-Privacy Law (Event - Political), Q60-Political Participation (Trend - Political), Q56-Actionable Offense (Event - Political), Q39-Minimum Quality of Service (Event - Political).

The regulation of broadband networks will increase by 50%. Thus companies might want to start preparing for more regulations in Hawaii and have many ways of negotiating this scenario into something constructive. By participating in the regulatory processes more, companies can better influence how the policies are formed. The forecast does forecast the private enterprises and government will increase collaboration by 50% within 20 years. The overall participation of companies in the public decision-making process will increase by 40%. The general public's involvement should also increase as the open government initiative provides for better options to do so.

The trend with regard to people in Hawaii being willing to share more information is not entirely positive. Though it seems sharing information will not increase by a lot, very little oversight exists for the protection of personally identifiable information, which may result in an increase in identity theft. Perhaps programs for educating people about how much information they should share online could be created and could potentially be countered with a new privacy law that better protects individuals in Hawaii.

Implementation of such a privacy law is not trivial. First of all, Hawaii does not have jurisdiction outside the State. Thus adding laws for all sites is neither desirable nor practically implementable. Adding strict laws in Hawaii might hinder local companies too much compared to outside companies- so a balance has to be struck. One option would be to work with the federal government to increase privacy protection. In the United States, privacy protection is mostly between federal government and private citizens. Often problems arise when people use the web. The users do not know all of the information collected about them as they browse through the Internet. There seemed to be some disagreement to what extent there will ever be a law that better protects personally identifiable information.

In terms of Internet content regulation, the median answer for this question says the probability of having federal laws that monitor all content served via the Internet will stay at an even 10%. As a stable low probability, this answer might seem valid. The most interesting part was really how much the experts were differing in opinion. A lot of answers stated that the federal regulation of the Internet will never happen. A few answers claimed, “[It is] essentially already happening within the existing laws. COTS technology is available for packet inspections, content filtering, pattern analysis, etc.” The spread of answers seems wide, and there was a lot of uncertainty around the question.

Privacy in the United States has well-defined parameters, but has seen some significant changes with the introduction of the Patriot Act. Recent news also show the European Union showing concern about the United States taking steps to enabling itself to monitor foreign citizens' data, even if the person does not live in the United States.

Current debates on privacy and laws are ongoing. Internet users as well as sites such as Wikipedia strongly protested against several proposed acts in 2012. Wikipedia shut down its whole site for a full day to protest. Other companies, such as GoDaddy, who supported the measure faced backlash from its users who conducted a mass exodus. Recent news showed the government failed to enact the act last year, An act providing private companies with the ability to inspect packets, the Cyber Intelligence Sharing and Protection Act (CISPA) is now back in the House of Representatives. Given the forecasts, it might be reasonable to predict a stable 10% chance of this scenario happening-especially considering the outrage some of the already proposed acts have faced.

6.3. Cross-Impact

This section will further discuss running a Cross-Impact simulation.

6.3.1 Simplify - The Model

The fallacy of modeling a complex world is that not all variables are covered. People tend to choose to simplify their options and settle for what is good enough. If the study had unlimited resources, it could have developed a much more complex model and analyzed the relationships in much greater detail. However overall the shortcomings in the modeling has to be both acknowledged and tolerated. Now when considering the model, these shortcomings do not mean the simulations do not add value to the data. On the contrary, by creating and building models, studies can find relationships that are not obvious, including complex ones.

For example, the models of the simulation of climate change have been developed through decades of cumulative research, generating an accurate prediction. Even still, the model keeps on being improved and added to.

This research obviously did not aim to be able to in absolute terms state what will happen in the development of broadband in Hawaii, but tried to shed some light on and evolve the understanding of broadband development.

While doing a Cross-Impact Simulation, one must accept this model is out of potentially many ways to configure the relationships between the variables. For instance, this study took advantage of the results from the face-to-face interviews, the overall literature in the field and the researchers' knowledge to implement the interactions.

Like any future-related study, the accurate numbers from a Cross-Impact analysis should not be taken as a truth or a prediction. However it should be taken as an indicator of how different elements might relate to each other and that the interactions exemplify relative strengths of relationships, but not numerically accurate estimations.

One of this model's issue is that it is relatively shallow. Increasing the number of drivers might have improved the model. Yet, the developments from the interviews were presented as questions in the Real-Time Delphi.

6.3.2 Variability of Random

How random is random? Many times events seen as random happenings are not really random at all. When analyzing factual developments leading up to the random events, there are ways to explain what happened. In many random shooting events, people will in retrospect ask why someone did not stop it before as there were so many indicators that the event would happen. Cross-Impact is a way to solidify the different developments and relationships between the events and trends that lead to changes.

Randomness is often not so random when looking at causes in retrospect. The seemingly randomness comes from a multitude of intersecting variables. Cross-Impact looks at individual relationships and moves a model closer to how these developments actually influence each other.

How do you calculate the risk of occurrence? In fields with a lot of organized data and solid theory, calculating probabilities of occurrence can be almost trivial; however, in very complex local settings, doing so is not as easy. Thus the future forecasting methodology Real-Time Delphi was used.

Often experts in a field can provide much more detailed information about the event before it happens. Cross-Impact analysis takes advantage of this dynamic to create a model and estimate impacts. By using that model in simulations, Cross-Impact analysis also emphasizes what will happen if initiatives were made to change the probabilities of occurrence or lower the impact of the inevitable. That way, Cross-Impact can support a planning process that eventually will lead to a better and more desirable future.

6.3.3 Improvements

The Cross-Impact could potentially be improved somewhat. First, a model with more complex relationships can be made. Trends can be made to influence other trends and events. The issue is that the way a trend would influence is marginal and slow, and other functions have to be implemented into the model.

Creating a model that could accomplish this is possible, but one still needs to get feedback about the direction and strength of the influence among the developments.

If this model had trend as an influencer, the number of relationships would be over 1,700, making it hard to get experts to do this without pay.

6.4. Research Question 4: Policy Recommendations

The study has dealt with the three first research questions in the previous two chapters. This section will detail the policy recommendations based on all the facets of the research process and uses information form the interviews, Real-Time Delphi and the simulation runs to come up with a set of policy recommendations.

6.4.1 Create a One-Stop Policy Authority

Creating a one-stop permitting authority simplifies the process.

Doing so makes the process cheaper and easier for the State in addition to enabling the building of new networks. This proposition is not novel, but is a critical one (Broadband Taskforce, 2008). This issue had a unified agreement across the board and was one of the biggest positive drivers of rapid-positive change and a major opportunity for the State in terms of cost versus benefit. One of the most critical factors of this process would be to develop a complete oversight over where the cables are and how they are being used. If combined with a policy for reporting the use of cables, the authority could provide a much faster turnover than it does currently.

6.4.2 Develop Strategies for Making the Network more Resilient

Natural disaster can significantly threaten development of broadband. The State has to realize the importance of the network in the future economy and increase its resiliency. The State could do so by making it easier to lay cables through simplifying the licensing process. The identified opportunity would be a one-stop permitting authority. Other recommendations include collaborating with industry to implement plans of networks with better redundancy, creating more landing spots for submarine cables and protecting them more effectively. Initiatives exist, but move slowly.

In addition to increasing resiliency, the recoverability of the network has to increase. One way is to ensure submarine cabling boats are at hand.

6.4.3 Create Innovation Hubs

The debate about what is driving bandwidth demand has been going on for some time. Industry says it is ready once the demand is there, but policy makers are interested in driving bandwidth to create new services and innovation. One ongoing project is a drive to have 1 Gbit connections in state schools and libraries (Lassner, 2009). These were designed to be hubs of bandwidth where people could experience what 1Gbit connections speed can and will do and thereby spur demand for higher bandwidth. This idea can be expanded and it can take many forms. It could be creating such hubs in certain metropolitan areas, designated to be technology hubs in forms of open access wireless speeds.

The expansion of the idea could be as simple as redesigning and add purpose to libraries, so they become multi-purpose public places of information gathering and knowledge creation. If the public libraries were to be modernized and their role redefined, they can become hubs of innovation that drive Hawaii into a positive future.

As physical books become digitized, re-purposing the libraries could keep them relevant, further their information-and-knowledge-sharing cause and increase their role to limit the digital divide and provide access for all people. This initiative could also help drive the innovation and in the extension, make Hawaii more attractive to small businesses and innovators. Libraries can serve as places for local technologists to meet with their laptops and spur innovation via programs for information building and knowledge sharing. The required cost to do so would be almost negligible.

6.4.4 Avoiding Networks Crisis

The State should plan and develop incentives for networks to make it more resilient. By also developing plans for recoverability, Hawaii will be better equipped against catastrophes, acts of vandalism or even just random accidents. Any network exposed to sustained and multi-faceted attacks can be vulnerable, but networks with a built-in redundancy can sustain more before going into downtime. Because more of Hawaii's economy will depend on the network, the State of Hawaii has to take a higher stake and a stronger stance in the development. This argument is not for state ownership, but for creating stronger policies that better reflect the impending dependence.

Plans to avoid issues relating to congestion should also be initiated. Some plans have already been investigated, and some plans will be in the future, but there seems to be little structure and overall control of how the developments are moving forward.

6.4.5 Public Utility

Finally the State should recognize that high-speed broadband is a utility. Doing so does not imply state ownership or a monopoly situation. Rather doing so implies the emphasis and importance of a broadband connection to the citizens of the State, that the State understands and acknowledges this, and that the State is responsible for providing access to that connection one way or another.

The implementation of a utility could be done in many ways. A minimum service level would have to be established, and providers would have to follow that standard. The price could be tiered, but the emphasis should be on minimum speeds and not maximum speeds as it is today. Geographical areas could have different designations. One version could be a bid to be able to offer services in larger metropolitan areas where telecoms can own lines. In more rural areas, a coop with telecoms and the government could both own the lines in a non-profit agreement, then everyone could compete on services on the same lines.

Another version would be to establish ownership of cables and provide broadband services at spot price. Then companies can offer bandwidth as they become available. The line fee would be charged as a separate universal fee. The point of this is that to establish exactly what is the best solution would need in-depth studies of markets and feasibility. There is no one solution for this, but because our future heavily depends on broadband connection for education, health services, and business, so these solutions should be explored.

6.5. Conclusion

This chapter has gone into a bit more detail on some of the issues in the research process. This chapter has discussed the forecasts based from the perspective of STEP categories and noted a little more on the Cross-Impact simulation before it used the forecast in combination with simulation and experts interviews to recommend concrete policies for Hawaii.

The next chapter will conclude this study.

7 OVERALL DISCUSSION AND CONCLUSION

This study has addressed the development of high-speed broadband in Hawaii over the next 20 years. Regardless of what actually will unfold, this much discussed topic will greatly impact the State as a whole. Acknowledging the rapid change in technologies and the radical increase in demand for bandwidth in Hawaii is at a crossroads for how to deal with the future of broadband. The choice seems to be between resignation as a laggard or aspiring to become a leader in bandwidth speed. This is not a trivial choice; the decision will have significant social, technical, economic and political implications for Hawaii.

The study identified trends and events and asked high-level telecommunications experts in Hawaii for their forecasts regarding those trends and events. The trends and events were characterized as opportunities for development or threats that could hinder the development of broadband in Hawaii. Current methods were extended, and two new and generic methodological tools were developed. A new way of combining these methods answered researchers' calls. Finally, policy recommendations were made with regard to the benefit of the community.

This final chapter presents the conclusions and recommendations.

7.1. Major Content Contributions: Future Broadband Developments

The major content contribution was the identification of major developments in broadband in Hawaii the next 20 years. The developments were used to create a model. In the model, the relationships between the developments were used to simulate future scenarios. The study finally used the developments and scenarios to provide policy advice to the State of Hawaii.

The research identified and forecasted future developments of high-speed broadband in Hawaii, specifically major trends and events useful for policy making.

The study did an initial environmental scanning that included five semi-structured interviews with high-level experts to identify developments relating to broadband in Hawaii over the next 20 years. Through literature reviews and interviews, it identified 83 broadband related developments. These developments were used in a method (Real-Time Delphi) to elicit forecasts from experts in Telecommunications. The developments were further refined, and 43 of them moved into a Cross-Impact simulation of future scenarios.

7.1.1 Some Real-Time Delphi Forecasts:

- 90% probability that Hawaii will experience an economic crisis before 2035 and 50% chance it will happen before 2018.
- A steady 10% probability that Internet content will see regulation from the federal government.
- Hawaii will experience downtime as a result of a security breach by 2033 (90%).
- Policymakers will set standards for minimum quality of service by 2035 (90%).
- In 2033, 75% of business transactions in Hawaii will be conducted

entirely online.

- The regulatory level for Broadband Networks goes up by 50% within 20 years.
- Price of a broadband connection stays at $50 per month.
- The network becomes 50% more resilient to natural catastrophes.
- The monthly price of a 1Gbit connection will be $90 in 2033.
- Only 60% of Hawaii's households will have access to 1 Gbit connection by 2023.
- 80% of households in Hawaii will have access to a 1Gbit or faster connection, and 68% of households will subscribe.

Finally, one major development that had agreement across the board was the complexity of the policy process. The forecast for (Q36) one-stop permitting authority had a 90% chance of occurring within 11 years. The overall uncertainty related to this event forecast was low. It was also the event that had one of the higher overall impacts on other developments in the simulation runs. It affected price of connections, deployment speed and overall efficiency of the policy process.

7.1.2 Cross-Impact Simulation Results

This study also contributed by the creation of a model for simulation of scenarios. Once the model was created, it was used to simulate different scenarios for the developments.

Out of the 83 total developments, 46 questions were picked for further analysis.

The choice of which questions to analyze was made by several factors such as overall expertise level, confidence level, and the number of experts above the threshold. From these 46 developments, there were:

14 events (drivers of change)

32 trends (indicators of change)

From these 46 developments, 43 were suitable for a Cross-Impact simulation study of the relationships between the developments.

First, the simulation consisted of calibrating relationships between the developments that adhered to the expert interviews in terms of strength. Second, it adjusted the relationships to align the model with the forecasts from the experts in the Real-Time Delphi method. Finally, it ran the new scenarios, which answer questions as to what happens to critical indicators if a given event happens.

Scenario run: Probable future

In this run, settings for events that has pressure on society to happen are set to happen. According to the experts' forecasts, they could probably happen, and there is not an adverse amount of uncertainty. The overall results showed that, by increasing the probability of some key events happening, the overall effect on critical indicators would dramatically improve. This had a 50% increase in resiliency of the network, and the price of ultra-high-speed Internet decreased dramatically.

Scenario run: Non-desirable future

In this scenario, the settings highlighted included a major political scandal, a security breach and a new economic crisis. The outcome saw a severely lowered quality of life, a lower willingness to share information and lower overall level of competitiveness in the Broadband sector. Policy makers should prevent these events from happening.

Scenario run: Desirable future

This future lies right outside the border of a probable future, but well within the boundaries of a possible future. This future resembles the probable future, yet it adds making access to Internet connection a human right. In this run, people are more willing to share personal information, the quality of life increases, and policy making becomes more efficient. The potential downside is that Hawaii's Gross State Product will become more dependent on the broadband connection.

7.2. Secondary Content Contribution

This study found a set of developments (trends and event) that could potentially be used in other future of broadband studies. The developments would have to be adapted geographically to the locale where it is to be used.

7.3. Major Contribution to Methodology

This study extends the current Real-Time Delphi methodology by taking advantage of more recent technologies to better care for the methodological requirement of feedback. With a more dynamic process in providing feedback to the experts, the study could better satisfy the requirements of a traditional multi-round Delphi study. Moreover, the feedback given was richer than other implementations of the Real-Time Delphi methods as it provided more incentives for re-evaluating the forecast. The new technology also decreased the time lag inherent to older technologies, increasing the efficiency of the process.

The study also introduced a per-question self evaluation combination that has not been used in a Real-Time Delphi methodology before. Using a per-question self-evaluation makes it easier to select answers of higher level experts. It is also acknowledges experts have varying levels of expertise within the same general area.

The study created a new way of measuring uncertainty in analyzing the forecasts. During the review of the answers, the uncertainty can be expressed as the semi-interquartile value divided by the value from quartile three, which demonstrates an intuitively easy way to understand the level of disagreement and uncertainty of a question.

The study created and combined the Real-Time Delphi methodology with a Cross-Impact simulation called for by other theorists (Gordon, 2009).

7.4. Secondary Methodological Contributions

A secondary methodological contribution was the creation and implementation of a generic methodological software tool dubbed “RTD2” to use in other futures studies. The implementation of the Real-Time Delphi method in a generic software that can be repurposed and reused in other studies can benefit other futures researchers and the community at large.

The generic design of this software can be used in both regular Delphi and Real-Time Delphi studies. In Real-Time Delphi, discriminating between the method and software is hard because the implementation of the method will invariably be in a software tool.

Considering how many Delphi-related studies are completed in graduate research every year, the new Real-Time Delphi (RTD2) methodological tool can significantly impact the overall time it will take researchers to complete their studies.

The RTD2 software was also combined with a new Cross-Impact software designed to support the analysis of the results from the RTD2 software. The Cross-Impact simulation takes a Google Spreadsheet as input to run its simulations, but the actual simulation is run on a private server. The connection between the spreadsheet is dynamic to make updates, and Delphi runs fast and is manageable. The output is shown graphically for easy interpretation.

7.5. Discussion of Overall Results

The following section addresses the research questions.

7.5.1 RQ1. What threats related to broadband development are likely to impact Hawaii the next 20 years?

In the interviews, a few major points of concern were brought up. The interviewees focused on unrealized opportunities and the inefficiency of the policy process. If this trend continues, it will hinder development. Thus this heavy policy process, if mishandled, can threaten future development as it has been in the past. The forecasts and the following simulations support that notion.

There were several threats identified in this study. The greatest threats in terms of probability of occurring were natural catastrophes that interrupt Internet connections in Hawaii. The forecasts estimate a 90% probability of this happening by 2022. The second highest probability of occurrence was a major security breach affecting Internet access for 50% of the population. The overall forecast showed a 90% probability of this happening by 2033. Developing policies for creating a more resilient network could mitigate the effects of such disruptions. Other identified and quantified threats included a new economic crisis and a global network crisis that impacted the use of the Internet.

The adoption, use and overall dependence on broadband are affected by state policies. For instance, does the overall trust in the system matter? Privacy, though not greatly affected, indicates increasing privacy protection of citizens will lead to a slight increase in the adoption. By contrast, creating laws for regulating content could lead to lower dependence on the network.

The question as to whether dependence on high-speed broadband could be a threat or an opportunity depends on how lawmakers handle it. For instance, a network with a high level of resilience or recoverability will be vulnerable to a high level of dependence. The dependence will be there regardless; the strength of it will probably correlate to which type of economy Hawaii will have in the future. The policymakers should anticipate this scenario and create a resilient network.

Indicators can be evaluated as threats or opportunities, depending on what the goal is. For instance, the level of competition in the broadband industry in the future can be good for citizens, but at the same time a threat to parts of the industry. The question is often how do one turn a threat into an opportunity? This study provided many indicators that could help decide how to do so.

7.5.2 RQ2. What opportunities related to broadband development are likely to impact Hawaii the next 20 years?

The most important policy decision the government can make is to simplify the policy-making process. This is not to say there should be no oversight, far from it, but time, complexity, and price hinder the implementation of new networks. The State can also assert broadband as a utility, increasing its obligations to its citizens. The effects shown in the simulations were positive, and the results had many forecasts that could indicate future developments. By using these indicators, government and industry can position themselves positively for the future market. For instance, if by combining future price of Internet connection with the percentage households that subscribe, one can find the total market for that type of connection. In all, 46 developments were identified and forecasted.

7.5.3 RQ3. How can a workable model of the most critical drivers be built and tested?

This study showed a workable model could be successfully created and used for modeling future scenarios of broadband development. Consistent with both quantitative and qualitative data, the model was used in a simulation of future scenarios that forecasted developments.

7.5.4 RQ4. What concrete recommendations for policy makers can be given regarding broadband development in Hawaii on the basis of futures simulation?

Two major recommendations can be given to the policymakers. First they should create a one-stop permitting authority. The simulations showed its potential to uniquely and positively impact the broadband development in Hawaii. Secondly policymakers should define broadband as a utility, which does not mean it has to be a government-owned, or even a monopoly-driven situation. Instead, it focus more on the responsibilities of the State to its citizens, which are detailed in the discussions chapter (Chapter 6). Other recommendations to the State are:

Redefining public libraries as innovation hubs, and providing access to the ultra-high-speed Internet to create demand for high-speed Internet.

Anticipate future dependence, and set up plans for creating more redundancy in the network and thereby increase resiliency.

Anticipate downtime due to natural catastrophes, and have a submarine cable boat at hand.

7.6. Limitations of the Study

Futures studies methodologies have certain assumptions that obviously are different from more traditional research methods. First, the study's data highly depend on the experts participating in the study. It is critical to have a wide array of experts from different groups and with different professional and experiential backgrounds.

One must understand the study is not attempting to predict, but rather to estimate probabilities of occurrence. Forecasts are then used for data useful for planning procedures. Forecasts are also reflexive in that, by being studied, they inherently influence the need to change the outcome of the future.

Human judgment is biased and to some extent, constrained by the present. By definition, the future cannot be known, but can be studied in the same way the past and the present are studied. Therefore, the study aims to lower uncertainty, to provide guidance about possibilities, and to create a more desirable future.

Though a wide array of developments were used in the Real-Time Delphi method, the number used in the simulation to simulate was not exhaustive. Refining the model for future use remains a goal for future study.

7.7. Directions for Future Research

This study has enabled many new types of research. In terms of broadband, the developments could be further refined and adopted to other geographical locations. More in-depth analysis for the individual development could serve as another opportunity for research. Further studies could look at them individually to see if more information could be extracted via other means.

The methodology could be further refined, and a comparative study could be performed to determine the effectiveness of methodological adjustments. Further enhancements could be created to bind the Real-Time Delphi and Cross Impact even closer. By implementing an automated matrix for positive or negative impact, increased information could be implemented into the Cross-Impact and thereby reduce the overall time it takes to calibrate the model. A further enhancement of the methodology could include full integration, having the experts judge the actual relationships between the developments–in addition to forecasting data.

7.8. Closing Comment

7.8.1 Broadband in Hawaii

There is little doubt that broadband will play a major part in the future of Hawaii. The current situation leaves Hawaii's economy too dependent on one industry, and many have called for diversification away from tourism. Broadband as a driver of positive change can help diversify Hawaii's economy and will make Hawaii's economy more resilient against events that affect tourism.

A very complex process, the development of high-speed broadband does not guarantee any implementation of broadband services will succeed. By using different sets of planning tools, Hawaii will have a better chance for success in its development process.

This study has identified opportunities and threats related to broadband development that can support Hawaii as it navigates into the future. These developments were also used in simulations of future scenarios that could further support the decision-making process. Finally some recommendations were made based on the overall data sets.

Overall there is a positive drive to make sustainable, improve and further drive the broadband development to the next level. Hawaii has many very knowledgeable people willing to work hard to make positive changes for Hawaii.

7.8.2 Futures Methodology

Far from a new field, future studies is still an exciting, dynamic and developing field. Futures science and research aims not to predict, but to shed light on different versions of the future and what might happen given drivers and indicators that interact. Future studies is dealing with the paradox that the future as it is now cannot be predicted, yet we still have to decide what is coming as the future will happen regardless.

In many cases, the overarching point of futures research is to intervene for a more desirable outcome. The further forward you look, the more complex the model is because an ever greater number of variables interact. This leads to choices of different types of methodologies. If virtually unlimited amount of funds and time were available, a highly complex model can be created. However given the means most researchers are awarded, the methodology will change radically depending on the time frame. For very near future considerations, more orthodox research tools are best suited. Once the time horizon and complexity increases, other tools are better suited. In the 10-to-20-year time frame, methodological tools such as Delphi are well suited. Once the time frame increases again, other futures related methodologies are more appropriate. Most of the time in futures research, a suite of methods used together will create the best data. The whole idea is to pick the right tool for the job as was done in this study.

APPENDIX A – INVITATION LETTER

The Future of Broadband in Hawaii

As one of the premier local experts in the telecommunication industry you are invited to participate in this study of the future of broadband in Hawaii. The study is part of a doctoral dissertation at University of Hawaii at Manoa. Your knowledge is critical to the study, and by participating you will gain access to how other experts view the future of broadband in Hawaii.

To participate click on the link:

http://www.broadbandhi.com/?r=user/indiv_user&code=ptc

What is The Future of Broadband in Hawaii Study?

The Future of Broadband in Hawaii Study seeks to explore possible and probable scenarios for future developments of broadband in Hawaii. Broadband is an enabler of thriving communities and is recognized as a driver for different types of social change. Broadband affects business, healthcare, education, etc., making it central to Hawaii's development and making everyone a stakeholder in its future development. This study is part of an interdisciplinary doctoral study in Communication & Information Sciences at University of Hawaii at Manoa, and is approved by the Institutional Review Board at the University of Hawaii Manoa.

Who can Participate?

We are currently inviting domain experts of broadband and telecommunications, and other individuals with particularly high knowledge levels related to Internet services in Hawaii, to participate in this study. Your participation is critical to this study.

All participants' contributions are treated anonymously and no personally identifiable information about the participants will be shared outside this study.

How are Futures Forecasting done?

The futures forecasting system used for this study aggregates expert forecasts about broadband with focus on long range futures. It allows participating experts to consult real time and aggregate forecasts and adjust their own forecasts accordingly if they so desire. Once the expert forecasts are aggregated, the system will create simulations for possible and probable future scenarios related to broadband development in Hawaii. This data can be used for planning purposes by government, businesses, and other organizations. As a participant you will get access to outcomes of the study.

http://www.broadbandhi.com/?r=user/indiv_user&code=ptc

Thank you for your participation.
Best regards
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APPENDIX B – QUESTIONS

Q	Dimension	Type	Headline	Text
1	Technical	Trend	Broadband	Today (2012) broadband is defined by FCC as a minimum of 4 Megabit per second download speed. What will it be for the following years (in megabit per second)
2	Social	Trend	Internet Connection	What percentage of homes in Hawaii have technical and physical access to 1 Gigabit per second or faster synchronous Internet connection in the following years?
3	Economic	Trend	Internet Connection Price	What will the monthly cost (in 2013 dollars) of 1 Gigabit per second synchronous Internet connection for a home in Hawaii be in 2013, 2023, and 2033?
4	Economic	Trend	Connection Affordability	What percentage of businesses in USA will subscribe to 1 gigabit per second or faster synchronous Internet connection?
5	Economic	Trend	Connection Affordability	What percentage of homes in USA will subscribe to 1 Gigabit per second or faster synchronous Internet connection in the following years?
6	Economic	Trend	Connection Affordability	What percentage of homes in Hawaii will subscribe to 1 Gigabit per second or faster synchronous Internet connection in the following years?
8	Economic	Trend	Price of Connection	What will the price (in 2013 dollars) of an average household network connection be in Hawaii in 2023 and 2033?
10	Technical	Trend	Ubiquitous Internet Devices	What will the average ubiquitous wireless device network connection speed be for individual citizens in Hawaii for the

Q	Dimension	Type	Headline	Text
				following years (in Mbps)?
11	Political	Trend	Policy Knowledge	If we set Hawaii's policy maker's telecommunication knowledge to 100 in 2013, estimate what it will be in year 2023 and 2033?
12	Political	Trend	Policy Involvement	If we set Hawaii's general public's telecommunication policy participation to 100 in 2013, estimate what it will be in 2023 and 2033?
13	Social	Trend	Broadband Coverage	What percentage of Hawaii households will have access to two-way broadband in 2013, 2023, and 2033?
14	Social	Trend	Privacy	We set the general public's privacy concerns in Hawaii to 100 in 2013, estimate what it will be in year 2023 and 2033?
15	Political	Event	Privacy Law	A modernized privacy law will protect personally identifiable information of individuals in Hawaii better than the currently passed policies?
16	Technical	Event	Security Breach	A serious security breach at one or more of the Internet service providers has left 50% or more of the population in Hawaii with no Internet access for more than a day?
17	Political	Event	Internet Content Regulation	The US federal government creates a law to monitor all content served via the Internet?
18	Social	Trend	Healthcare	We set the level of e-healthcare in the State of Hawaii to 100 for 2013, estimate what it will be in year 2023 and 2033?
19	Technical	Trend	Broadband price	What is the price (in 2013 dollars) of a 1 gigabit per second duplex broadband

Q	Dimension	Type	Headline	Text
				connection for homes in Hawaii in year 2023 and 2033?
20	Social	Trend	University Students	What percentage of undergraduate courses will be taken online by full time university students residing in Hawaii and enrolled at a Hawaii university?
22	Social	Trend	Video Phonecalls	What percentage of phone calls will have two way video feeds in Hawaii in year 2013, 2023, and 2033?
23	Economic	Trend	IT dependence	We set the level of the IT dependent workforce productivity in Hawaii to 100 for 2013, estimate what it will be in year 2023 and 2033?
24	Economic	Trend	Job Creation	Hawaii job creation rate that is ICT dependent is set at 100 for 2013, estimate what it will be in year 2023 and 2033?
25	Social	Trend	Quality of Life	We set the quality of life index rating in Hawaii to 100 for 2013, estimate what it will be in year 2023 and 2033?
26	Social	Trend	University graduates	Today (2013) the percentage of the Hawaii population who are university graduates with bachelor or higher equivalencies is about 30%. Estimate what the percentage will be in year 2023 and 2033?
27	Political	Event	Human Right	The Hawaii congress makes broadband a human right (in Hawaii)
28	Technical	Trend	Wearable Technologies	What percentage of Hawaii's population are using wearable technologies that are always connected to the Internet?
29	Technical	Trend	Submarine Cables	There are currently 4 submarine cables landing in Hawaii (2013), how many will there be in 2023, 2033?

Q	Dimension	Type	Headline	Text
30	Technical	Trend	Submarine Cables	Currently about 30% of the cross Pacific submarine cables land in Hawaii. What percenatage will land in Hawaii in 2023, 2033?
31	Technical	Trend	Home Appliances	What percentage of home appliances in Hawaii are networked and connected to the Internet in the following years?
32	Technical	Trend	Cars	What percentage of cars drive themselves in Hawaii in the following years?
33	Economic	Event	Economic Crisis	By what year will Hawaii experience an economic crisis at the same level or worse than in 2008/2009?
34	Economic	Trend	Purchase Power	We set the purchase power of the American dollar relative to foreign currencies to 100 for 2013, estimate what it will be in year 2023 and 2033?
35	Social	Event	Roaming Outages	Hawaii is experiencing roaming outage on Internet connections due to high bandwidth demand?
36	Political	Event	One-Stop Permitting	The State of Hawaii created a new one-stop regulatory and permitting authority for the advancement of broadband in the State.
37	Political	Trend	Collaboration	We set the level of collaboration between government and private sector regarding broadband development in Hawaii to 100 for 2013, estimate what it will it be in year 2023 and 2033?
38	Technical	Trend	Internet Traffic	What is the the world wide yearly Internet IP traffic growth rate in percent? Current total IP Internet traffic is growing with 29% per year.
39	Political	Event	Minimum	Policy makers set legal restrictions and

Q	Dimension	Type	Headline	Text
			Quality of Service	minimum standards for quality of Internet service in the State of Hawaii?
40	Economic	Trend	Competitiveness	The level of competitiveness in the Hawaii broadband industry is set to 100 for 2013, estimate what it will be in year 2023 and 2033?
41	Technical	Trend	Households	What percent of Hawaii households have 1 gigabit per second or more synchronous internet connection for the following years?
42	Technical	Trend	Personal Internet Connection	What percentage of Hawaii's population have ubiquitous personal Internet connections at speeds of 1 gigabit per second or higher for the following years?
43	Technical	Trend	Public Roads	What percentage of public roads in Hawaii will have phone and Internet access coverage by year 2013, 2023, and 2033?
44	Technical	Trend	Maximum Generally Available Speed	What is the maximum generally available Internet connection speed (in megabit per second) for individual households in Hawaii for the following years?
45	Technical	Trend	International Speed	What is the average Internet bandwidth speed (in megabit per second) for the leading country in the world for the following years?
46	Social	Event	Internet as a Utility	Broadband is declared a utility (like electricity and water) in Hawaii?
48	Social	Trend	Collaborative Work	If we set the level of Hawaii networked workers working electronically in collaborative teams with someone outside the State to 100 for 2013, estimate what it will be in year 2023 and 2033?

Q	Dimension	Type	Headline	Text
49	Social	Trend	Internet Economic Dependency (IED)	What percentage of Hawaii's economy is directly dependent on an Internet connection in 2013, 2023, and 2033?
50	Political	Trend	Policy Decision	If we set the telecommunication / ICT policy decision making process efficiency in Hawaii to 100 for 2013, estimate what it will be in year 2023 and 2033?
52	Political	Trend	Privacy	If we set the level of privacy laws that protect the online privacy rights of individual citizens in Hawaii to 100 for 2013, what will it be in year 2023 and 2033?
53	Social	Trend	Personal Information	If we set the amount of personal information that people in Hawaii are comfortable with sharing online to 100 for 2013, estimate what it will be in year 2023 and 2033?
54	Social	Trend	Personal Safety	If we set perception of IT dependent personal safety to 100 for Hawaii in 2013, estimate what it will be in year 2023 and 2033?
55	Social	Trend	Civil Liberties	If we set the level of IT dependent civil liberties in Hawaii to 100 for 2013, estimate what it will be in year 2023 and 2033?
56	Political	Event	Actionable Offense	Broadband network downtime as a result of negligence becomes a legally actionable offense in Hawaii?
57	Social	Trend	Empowermen t	If we set the level of IT dependent individual empowerment in Hawaii to 100 for 2013, estimate what it will be in year 2023 and 2033?

Q	Dimension	Type	Headline	Text
58	Political	Trend	State Power	If we set the level of Hawaii and federal state ability to oversee citizens online behavior to 100 for 2013, estimate what will it will be in year 2023 and 2033?
59	Social	Trend	Second Class Citizen	What percentage of Hawaii's population is regarded as a 'second class of citizens' due to a lack of high speed broadband connection?
60	Political	Trend	Political Participation	If we set the level of participation in public decision making for private companies in Hawaii to 100 for 2013, estimate what it will be in year 2023 and 2033?
61	Social	Trend	Hawaii Dependence	We set Hawaii's overall dependence on high speed broadband connection to 100 for 2013, estimate what it will be in year 2023 and 2033?
62	Social	Trend	Public Trust	If we set the Hawaii public's level of trust in government to regulate ICT to 100 for 2013, estimate what it will be in year 2023 and 2033?
63	Social	Trend	Information overload	If we set the level of citizen's information overload in Hawaii to 100 for 2013, estimate what it will be in year 2023 and 2033?
64	Political	Event	Political Scandal	A major scandal occurs that negatively affects the development of 1 gigabit per second synchronous Internet connection in Hawaii?
65	Technical	Event	Network Crisis	A crisis in the global network shuts down internet traffic in Hawaii for 1 day or more.
66	Technical	Event	Terabit	The first home in the State of Hawaii gets

Q	Dimension	Type	Headline	Text
			Connection	a synchronous Terabit per second connection?
67	Technical	Trend	Hawaii Workforce	What percentage of the workforce in Hawaii is dependent on a network connection as a primary tool in 2013, 2023 and 2033?
68	Technical	Trend	ICT Dependency	If we peg the highspeed internet connection dependency of Hawaii's users to 100 in 2013. What will it be 2023 and 2033
69	Social	Trend	Social Development	What percentage of Hawaii's social development is dependent on an Internet connection in 2013, 2023, and 2033?
70	Social	Trend	Hawaii Households	What percentage of Households in Hawaii generates a terabyte of total data up and down stream per month?
71	Social	Trend	Hawaii Households	What percentage of households have highly interactive multi user video display technologies including HD video conferencing in the following years?
72	Economic	Trend	Business attraction	We set the level of new businesses attracted to Hawaii by the State's ICT capabilities to 100 in 2013. What will it be in 2023, 2033?
73	Technical	Trend	Price of storage	The price of storing 1 TB in the cloud today is about $900 per year for personal users at the large cloud service suppliers. What will it be in 2023, 2033 (in 2013 dollars)?
74	Technical	Trend	Price of Bandwidth	The price of broadband in Hawaii today is $35 per month for households. What will it be in 2023, 2033 (in 2013 dollars / broadband)?

Q	Dimension	Type	Headline	Text
75	Technical	Trend	Internet of Things	Today approximately 20% of all non-video traffic on the internet is from the Internet of things. What will that percentage be in 2023, and 2033?
76	Environmental	Event	Natural Catastrophe	A major natural catastrophe interrupts the Internet connection for a majority of the State of Hawaii for 1 day or more.
77	Technical	Trend	Network Resilience	If we set network / Internet resilience to natural catastrophes (hurricanes, tsunamies) to 100 in 2013, what will it be 2023 and 2033?
78	Environmental	Trend	Natural Catastrophe	If we set the ability for the network to recover after a natural catastrophe to 100 in 2013, what will it be in 2023, and 2033?
80	Environmental	Event	Honolulu Flooded	Downtown Honolulu is flooded leading to a downtime of 1 day or more for the data storage and computing centers?
81	Environmental	Event	Earthquake	A large earthquake interrupts data communication for a majority or more of households in Hawaii for 1 day or more?
82	Technical	Trend	Data drivers	Big-Data, rise of e-science, healthcare, education etc. are some drivers for bandwidth use. If we set these top five data driver's use of bandwidth in Hawaii to 100 in 2013, what will it be in 2023, and 2033
83	Political	Event	Wireless spectrums	The US government re-allocates 400MHz or more of underused spectrum for mobile broadband
84	Political	Event	Internet	The Internets single and open global network is closed by local regulatory schemes

Q	Dimension	Type	Headline	Text
85	NULL	Trend	ICT Dependency	What percentage of Hawaii economy is dependent upon information and communication technology
86	Economic	Trend	Economic Transaction	What percentage of business transactions in and out of Hawaii are conducted entirely online?
87	Technical	Trend	Hawaii Workforce	What is the percentage of workforce in Hawaii that is dependent on network connections as a secondary work tool in 2013, 2023 and 2033?
88	Economic	Trend	Gross State Product	Percentage of Hawaii Gross State Product dependent on Internet connection in 2013, 2023, and 2033?
89	Political	Trend	Regulation of Broadband Networks	The regulation of broadband networks is set to 100 for 2013. What will it be in 2023 and 2033

Table 53: Real-Time Delphi - Questions

APPENDIX C – REAL-TIME DELPHI RESULTS

Real-Time Delphi Forecasts						
ID	Type		10%	50%	90%	IQR
76	Event	q1	2014	2016	2019	17
76	Event	median	2014	2017	2022	UI
76	Event	q3	2015	2024	2036	0.00835
ID	Type		10%	50%	90%	IQR
66	Event	q1	2017	2018	2020	15
66	Event	median	2025	2028	2030	UI
66	Event	q3	2025	2030	2035	0.00737
ID	Type		10%	50%	90%	IQR
27	Event	q1	2015	2020	2035	7964
27	Event	median	2020	2030	2050	UI
27	Event	q3	2050	9999	9999	0.79648
ID	Type		10%	50%	90%	IQR
17	Event	q1	2014	2019	2019	7980
17	Event	median	2015	9999	9999	UI
17	Event	q3	9999	9999	9999	0.79808
ID	Type		10%	50%	90%	IQR
36	Event	q1	2014	2016	2020	10
36	Event	median	2015	2019	2024	UI
36	Event	q3	2023	2033	2030	0.00493
ID	Type		10%	50%	90%	IQR
16	Event	q1	2013	2014	2015	7984
16	Event	median	2015	2020	2033	UI
16	Event	q3	2016	2020	9999	0.79848
ID	Type		10%	50%	90%	IQR
64	Event	q1	2015	2017	2050	7949
64	Event	median	2015	2020	9999	UI

Real-Time Delphi Forecasts						
64	Event	q3	9999	9999	9999	0.79498
ID	Type		10%	50%	90%	IQR
15	Event	q1	2014	2017	2020	7979
15	Event	median	2015	2025	2035	UI
15	Event	q3	2020	2030	9999	0.79798
ID	Type		10%	50%	90%	IQR
33	Event	q1	2014	2017	2020	20
33	Event	median	2014	2018	2035	UI
33	Event	q3	2020	2030	2040	0.0098
ID	Type		10%	50%	90%	IQR
65	Event	q1	2014	2017	2020	7979
65	Event	median	2014	2018	2080	UI
65	Event	q3	2020	2034	9999	0.79798
ID	Type		10%	50%	90%	IQR
35	Event	q1	2013	2018	2023	7976
35	Event	median	2016	2025	2040	UI
35	Event	q3	2016	2040	9999	0.79768
ID	Type		10%	50%	90%	IQR
56	Event	q1	2015	2020	2035	7964
56	Event	median	2018	2030	2060	UI
56	Event	q3	9999	9999	9999	0.79648
ID	Type		10%	50%	90%	IQR
39	Event	q1	2015	2020	2024	7975
39	Event	median	2015	2025	2035	UI
39	Event	q3	9999	9999	9999	0.79758
ID	Type		10%	50%	90%	IQR
46	Event	q1	2015	2017	2020	60
46	Event	median	2018	2019	2020	UI
46	Event	q3	2030	2050	2080	0.02885

Real-Time Delphi Forecasts						
ID	Type		2013	2023	2033	IQR
4	Trend	q1	4	35	55	45
4	Trend	median	5	50	95	UI
4	Trend	q3	15	96	10	0.45
ID	Type		2013	2023	033	IQR
24	Trend	q1	100	120	145	30
24	Trend	median	100	130	150	UI
24	Trend	q3	100	145	175	0.17143
ID	Type		2013	2023	2033	IQR
73	Trend	q1	900	50	1	249
73	Trend	median	900	100	25	UI
73	Trend	q3	900	625	250	0.996
ID	Type		2013	2023	2033	IQR
86	Trend	q1	15	35	65	20
86	Trend	median	30	55	75	UI
86	Trend	q3	43	75	85	0.2353
ID	Type		2013	2023	2033	IQR
89	Trend	q1	100	100	100	83
89	Trend	median	100	124	146	UI
89	Trend	q3	100	142	183	0.45355
ID	Type		2013	2023	2033	IQR
8	Trend	q1	35	33	50	15
8	Trend	median	35	40	50	UI
8	Trend	q3	35	43	65	0.23077
ID	Type		2013	2023	2033	IQR
72	Trend	q1	100	85	85	25
72	Trend	median	100	90	90	UI
72	Trend	q3	100	100	110	0.22727
ID	Type		2013	2023	2033	IQR

Real-Time Delphi Forecasts						
34	Trend	q1	100	70	50	31
34	Trend	median	100	90	73	UI
34	Trend	q3	100	91	81	0.38271
ID	Type		2013	2023	2033	IQR
68	Trend	q1	100	130	150	600
68	Trend	median	100	195	275	UI
68	Trend	q3	100	275	750	0.8
ID	Type		2013	2023	2033	IQR
23	Trend	q1	100	118	135	115
23	Trend	median	100	120	150	UI
23	Trend	q3	100	160	250	0.46
ID	Type		2013	2023	2033	IQR
6	Trend	q1	0	7	33	62
6	Trend	median	0	23	68	UI
6	Trend	q3	0	60	95	0.65263
ID	Type		2013	2023	2033	IQR
40	Trend	q1	100	95	103	63
40	Trend	median	100	100	110	UI
40	Trend	q3	100	133	166	0.37952
ID	Type		2013	2023	2033	IQR
82	Trend	q1	100	103	83	1517
82	Trend	median	100	210	210	UI
82	Trend	q3	100	400	1600	0.948125
ID	Type		2013	2023	2033	IQR
50	Trend	q1	100	100	100	125
50	Trend	median	100	130	160	UI
50	Trend	q3	100	166	225	0.55556
ID	Type		2013	2023	2033	IQR
1	Trend	q1	4	8	16	109

Real-Time Delphi Forecasts						
1	Trend	median	4	10	22	UI
1	Trend	q3	4	40	125	0.872
ID	Type		2013	2023	2033	IQR
88	Trend	q1	25	48	68	27
88	Trend	median	40	60	89	UI
88	Trend	q3	75	85	95	0.28421
ID	Type		2013	2023	2033	IQR
52	Trend	q1	100	95	100	66
52	Trend	median	100	108	118	UI
52	Trend	q3	100	125	166	0.39759
ID	Type		2013	2023	2033	IQR
77	Trend	q1	100	100	105	95
77	Trend	median	100	120	150	UI
77	Trend	q3	100	150	200	0.475
ID	Type		2013	2023	2033	IQR
11	Trend	q1	100	110	125	75
11	Trend	median	100	110	150	UI
11	Trend	q3	100	138	200	0.375
ID	Type		2013	2023	2033	IQR
31	Trend	q1	2	33	75	25
31	Trend	median	2	40	80	UI
31	Trend	q3	5	73	100	0.25
ID	Type		2013	2023	2033	IQR
87	Trend	q1	43	73	90	10
87	Trend	median	50	90	95	UI
87	Trend	q3	50	90	100	0.1
ID	Type		2013	2023	2033	IQR
2	Trend	q1	0	15	51	49
2	Trend	median	0	50	80	UI

Real-Time Delphi Forecasts						
2	Trend	q3	0	65	100	0.49
ID	Type		2013	2023	2033	IQR
5	Trend	q1	1	10	38	47
5	Trend	median	1	35	75	UI
5	Trend	q3	3	60	85	0.55294
ID	Type		2013	2023	2033	IQR
37	Trend	q1	100	120	150	30
37	Trend	median	100	125	150	UI
37	Trend	q3	100	145	180	0.16667
ID	Type		2013	2023	2033	IQR
49	Trend	q1	20	70	85	14
49	Trend	median	40	75	96	UI
49	Trend	q3	58	88	99	0.14141
ID	Type		2013	2023	2033	IQR
3	Trend	q1	270	95	35	215
3	Trend	median	425	150	90	UI
3	Trend	q3	1200	250	250	0.86
ID	Type		2013	2023	2033	IQR
78	Trend	q1	100	110	120	55
78	Trend	median	100	120	153	UI
78	Trend	q3	100	150	175	0.31429
ID	Type		2013	2023	2033	IQR
60	Trend	q1	100	100	100	90
60	Trend	median	100	115	138	UI
60	Trend	q3	100	150	190	0.47368
ID	Type		2013	2023	2033	IQR
53	Trend	q1	100	110	110	90
53	Trend	median	100	120	140	UI
53	Trend	q3	100	150	200	0.45

Real-Time Delphi Forecasts						
ID	Type		2013	2023	2033	IQR
25	Trend	q1	100	90	90	28
25	Trend	median	100	99	100	UI
25	Trend	q3	100	105	118	0.23729
ID	Type		2013	2023	2033	IQR
61	Trend	q1	100	150	200	200
61	Trend	median	100	150	200	UI
61	Trend	q3	100	200	400	0.5
ID	Type		2013	2023	2033	IQR
43	Trend	q1	70	90	95	5
43	Trend	median	84	96	98	UI
43	Trend	q3	85	99	100	0.05

Table 54: Selected Forecast Results

APPENDIX D - CROSS IMPACT-SIMULATION SETTINGS

Cross Impact Calibration Settings

QID	Calibration	Desirable	Probable	Non-desirable	One-Stop Permitting
Q76	1	1	1	1	1
Q66	1	1	1	1	1
Q27	1	100	-1	-1	1
Q17	9.99	9.99	9.99	9.99	9.99
Q36	1	100	100	-1	100
Q16	1	-1	100	100	1
Q64	1	1	1	100	1
Q15	2	2	2	2	2
Q33	1	-1	-1	100	1
Q65	1	1	1	1	1
Q35	1	-1	-1	1	1
Q56	1	1	1	1	1
Q39	2	100	100	2	2
Q46	1	100	100	-1	1

Table 55: Cross Impact Calibration Settings

Question	Year	Calibrated	Desirable	Non-desirable	Probable	One-Stop Permitting
id76	2013	16.7	30.32	55.67	31.25	31.36
id76	2033	107.18	58.93	88.25	101.71	115.28
id66	2013	-15.3	44.56	-8.45	35.36	16.27
id66	2033	71.06	68.92	10.62	64.49	77.2
id27	2013	-1.25	92.7	-7.82	-7.82	10.35
id27	2033	52.79	86.62	-7.82	-7.82	60.13
id17	2013	10.09	10.09	10.09	10.09	10.09
id17	2033	10.09	10.09	10.09	10.09	10.09
id36	2013	11.7	102.25	1.47	98.82	100.04
id36	2033	97.81	99.22	1.47	88.68	90.8
id16	2013	5.85	-9.67	89.7	81.53	27.08
id16	2033	80.32	-9.67	73.38	88.97	89.92
id64	2013	9.41	-5.7	100.11	3.66	1.74
id64	2033	64.34	-0.42	98.12	45.33	69.77
id15	2013	2	67.43	2.36	57.88	15.77
id15	2033	74.28	73.2	8.2	48.31	79.75
id33	2013	7.2	-5.63	94.57	19.44	11.25
id33	2033	80.8	-5.63	92.34	93.34	83.95
id65	2013	8.88	15.51	23.58	20	18.22
id65	2033	74.95	42.87	66.83	68.65	78.9
id35	2013	3.05	-6.98	26.71	19.84	19.69
id35	2033	81.58	-6.98	58.72	76.86	89.01

Question	Year	Calibrated	Desirable	Non-desirable	Probable	One-Stop Permitting
id56	2013	0.45	44.6	-16.47	24.27	2.96
id56	2033	48.41	48.48	4.65	30.69	58.17
id39	2013	2	68.63	-8.67	89.66	23.21
id39	2033	72.64	58.08	7.04	59.58	74.38
id46	2013	17.7	108.31	8.42	62.1	38.43
id46	2033	100.1	96.05	8.42	87.72	102.31
id24	2013	101.5	178.29	88.28	145	125.3
id24	2033	148.14	189.56	63.36	129.71	156.81
id86	2013	31.25	105.05	2.04	73.36	57.62
id86	2033	72.76	112.75	-2.49	55.17	81.18
id89	2013	99.9	142.43	57.94	139.44	116.55
id89	2033	148.13	178.92	111.13	149.28	152.89
id8	2013	33.75	1.65	62.85	41.87	18.64
id8	2033	47.44	16.44	76.83	82.78	51.81
id72	2013	98.5	153.74	48.06	97.01	112.04
id72	2033	88.56	153.15	39.48	76.64	90.97
id68	2013	102.75	169.15	125.37	148.44	131.74
id68	2033	254.07	227	187.9	243.13	270.34
id23	2013	98.5	146.65	84.78	133.38	119.51
id23	2033	149.45	163.71	98.83	155.08	157.05
id6	2013	-3.8	64.55	-27	30.49	19.36
id6	2033	60.91	89.8	-8.37	45.56	70.71
id40	2013	98.5	114.55	75.66	103.55	117.18

Question	Year	Calibrated	Desirable	Non-desirable	Probable	One-Stop Permitting
id40	2033	109.88	119.63	98.94	112.04	109.02
id82	2013	118.5	224.46	76.26	163.69	149.68
id82	2033	202.36	261.65	100.6	179.94	217.45
id50	2013	100	181.9	55.63	140.57	132.71
id50	2033	156.93	210.91	73.46	138.95	163.52
id88	2013	38.85	85.35	43.99	66.91	57.92
id88	2033	84.35	81.8	29.64	75	90.97
id52	2013	99.7	123.63	91.11	108.89	103.61
id52	2033	119.5	132.23	98.46	117.34	124.07
id77	2013	98.5	145.82	73.53	122.03	107.69
id77	2033	141	158.35	92.25	124.28	150.13
id11	2013	95.5	120.63	88.7	127.4	113.04
id11	2033	154.28	149.8	133.73	150.88	159.27
id31	2013	1.7	57.23	-10.16	25.74	12.56
id31	2033	66.56	88.18	12.14	52.48	78.5
id87	2013	56.25	101.77	41.08	80.56	64.62
id87	2033	98.74	123.77	56.19	93.12	107.61
id2	2013	3	121.94	-34.94	40.61	33.5
id2	2033	74.81	114.25	-50.5	26.81	86.68
id37	2013	100.5	144.57	94.27	122	130.36
id37	2033	145.21	133.73	94.2	136.22	145.8
id49	2013	42.4	96.59	32.43	86.94	68.07
id49	2033	98.49	110.53	40.97	95.41	104.6

Question	Year	Calibrated	Desirable	Non-desirable	Probable	One-Stop Permitting
id3	2013	389.25	141.24	421.03	265.75	261.14
id3	2033	68.35	8.14	295.29	81.59	47.78
id78	2013	97.45	169.94	73.01	123.16	111.55
id78	2033	153.48	194.42	78.62	132.84	164.33
id60	2013	98.7	130.36	95.04	118.97	108.36
id60	2033	133.6	126.17	99.19	123.64	137.36
id53	2013	100	143.49	85.05	119.17	107.79
id53	2033	142.19	167.52	101.52	138.31	151.67
id25	2013	100	121.51	87.42	102.14	102.07
id25	2033	100.72	111.29	77.4	92.23	103.78
id61	2013	100	164.04	102.88	142.81	124.91
id61	2033	185.08	182.94	114.69	175.19	196.13
id43	2013	86.1	117.35	72	104.55	100.7
id43	2033	99.34	115.29	64.83	93.81	100.42

Table 56: Cross-Impact Simulation Results

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