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# Technology foresight in communications regulation

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## Abstract

Technologies are changing rapidly in the communications industry, posing challenges for communications regulators. Regulators need to anticipate and prepare for future technological changes to make informed decisions on regulatory actions that foster innovation and protect consumers. This paper examines the application of technology foresight in communications regulation, based on a literature review. It discusses the importance of technology foresight in addressing the pacing problem, managing environmental uncertainty, and supporting the roles of communications regulators. The paper discusses a framework for conducting technology foresight in communications regulation, primarily based on "Framework Foresight." Additionally, it explores foresight methods and the institutionalization of foresight within organizations. By utilizing technology foresight, regulators can identify emerging technologies, assess their potential impacts, and develop appropriate regulatory responses.

**Keywords:** Foresight, Regulation, Technological Change

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## 1. Introduction

Technologies are changing rapidly in the communications industry, posing challenges for communications regulators. Regulators need to anticipate and prepare for future technological changes to make informed decisions on regulatory actions that foster innovation from business and protect consumers from any potential harms. Failing to respond to technological changes in a timely manner can have severe consequences. For technology that requires regulatory approval or license before use, delay in the approval process would result in economic opportunity cost. Even for technology that can be used without regulatory approval, negative side effects from its use may occur unless regulators come up with proper regulations. Preparing for dynamic and uncertain future technological changes requires regulators to explore the futures systematically.

Foresight is “the discipline of exploring, anticipating and shaping the future ... in a structured and systemic way to anticipate developments and better prepare for change” (European Commission, 2020). Technology foresight is a process that can be used to identify and explore potential future developments of technologies, as well as assess their possible impacts on the communications industry. Communications regulators such as Ofcom in the UK are using foresight to understand how changing technologies could affect the communications industry in the future and direct their work on possible high impact technologies. In the academic literature, there has been discussion on using foresight for policymaking, especially in general science and technology policies. However, technology foresight in communications regulation received limited attention in the academic literature. This paper aims to fill this gap by exploring the application of technology foresight in communications regulation. The main research question of this paper is: How can technology foresight be conducted to help communications regulators anticipate and prepare for future technological changes?

The methodology of this paper is based on a comprehensive literature review of existing research on technology foresight and its use by science and technology policy agencies and communications regulators and companies. Findings on technology foresight from the literature are then synthesized and discussed in the context of communications regulation.

The outline of this paper is as follows. Section 2 presents a literature review on foresight and its practices in various countries and organizations. Section 3 highlights the importance of technology foresight in communications regulation. Section 4 discusses a framework for conducting technology foresight in communications regulation based on the widely accepted and referenced "Framework Foresight" (Hines & Bishop, 2013; Hines et al., 2015). It also addresses foresight methods and the issue of institutionalizing foresight in organizations. The paper concludes in Section 5.

## 2. Literature review

### 2.1 Foresight

Foresight is “the discipline of exploring, anticipating and shaping the future ... in a structured and systemic way to anticipate developments and better prepare for change” (European Commission, 2020). "Foresight" is one of several terms used to describe forward-looking activities

from a long-term perspective (Miles, 2010). Others include “futures studies, futures research, futurology, futuristics, futurics, ... forecasting, prognostics” (Marien, 1984, p. 35).

The term "foresight" was popularized by John Irvine and Ben Martin (Miles, 2010). They conducted studies on the application of futures methods to science and technology policymaking in the early 1980s. Their books, "Foresight in Science" and "Research Foresight," explored how governments determine research funding priorities. The term "foresight" was coined humorously as a contrast to "hindsight." Their influential studies popularized the concept of "Foresight" as a program that studies research and innovation plans in relation to long-term future developments. Although the term "Technology Foresight" was not explicitly used in their books, it became widely adopted to describe such programs.

Foresight can contribute to shaping policies that are "more appropriate, more flexible, and more robust in their implementation" to evolving times and circumstances (Coates, 1985, as cited in Cuhls, 2003, p. 96). Objectives of foresight in policy-making include: expanding opportunities, setting priorities, evaluating impacts, assessing the impacts of current policy, identifying new demands and possibilities, defining preferred and unpreferred futures, and encouraging dialogues (Cuhls, 2003).

There are several foresight frameworks available in the literature (Streit et al., 2021; Yuksel et al., 2017). Those include Framework Foresight (Hines & Bishop, 2013; Hines et al., 2015), Six Pillars (Inayatullah, 2013), Generic Foresight Process (Voros, 2003) and Integrated Foresight (Schultz, 2006). These are shown in Table 1.

**Table 1** Some foresight frameworks in the literature

Framework	Author	Steps
Framework Foresight	Hines and Bishop (2013), Hines et al. (2015), Hines (2020)	<ul style="list-style-type: none"> <li>● <i>Framing</i>: Determine the scope and areas of focus for the study.</li> <li>● <i>Scanning</i>: Scan the environment for information within the identified scope.</li> <li>● <i>Forecasting</i>: Create multiple future scenarios.</li> <li>● <i>Visioning</i>: Construct a strategic vision and assess implications.</li> <li>● <i>Planning</i>: Generate strategic alternatives.</li> <li>● <i>Acting</i>: Communicate findings, monitor relevant indicators, and integrate strategic thinking into organizational practices.</li> </ul>

Framework	Author	Steps
Six Pillars	Inayatullah (2013)	<ul style="list-style-type: none"> <li>• <i>Mapping</i>: Understand the history and the forces that are shaping the future: images of the future, drivers and trends, and barriers to the change.</li> <li>• <i>Anticipation</i>: Think about the possible futures that could emerge.</li> <li>• <i>Timing the future</i>: Understand the timing of change, involving the patterns, the stages, and the mechanisms of changes.</li> <li>• <i>Deepening the future</i>: Understand the deeper forces that are shaping the future, including the systemic causes, worldview, and myths.</li> <li>• <i>Creating alternatives</i>: Develop alternative futures.</li> <li>• <i>Transforming the future</i>: Develop a preferred future and take action towards it.</li> </ul>
Generic Foresight Process	Voros (2003)	<ul style="list-style-type: none"> <li>• <i>Inputs</i>: Scan the environment to find changes that are influencing the future.</li> <li>• <i>Analysis</i>: Evaluate the Inputs to investigate potential changes that are happening.</li> <li>• <i>Interpretation</i>: Recognize the deeper forces that shape the interpretation of the future.</li> <li>• <i>Prospection</i>: Generate alternative futures.</li> <li>• <i>Outputs</i>: Determine strategic options.</li> <li>• <i>Strategy</i>: Make decisions and direct actions.</li> </ul>
Integrated Foresight	Schultz (2006)	<ul style="list-style-type: none"> <li>• Identify and monitor change</li> <li>• Assess and critique impacts</li> <li>• Imagine alternative futures</li> <li>• Envision preferred futures</li> <li>• Plan and implement change</li> </ul>

Despite the slight variations in the steps and terminology used, these frameworks share common elements, including scanning the environment for information, generating alternative futures, and planning for change.

## 2.2 Review of technology foresight in some countries and organizations

### 1) Korea Institute of Science and Technology Evaluation and Planning (KISTEP)

Republic of Korea has been actively conducting technology foresight since the late 1960s (Heo & Seo, 2018). The Korea Institute of Science and Technology Evaluation and Planning (KISTEP), under the Ministry of Science and ICT, conducted the 6th Science and Technology Foresight (2021-2045) using the Delphi survey method, which encompassed 241 technologies (KISTEP, 2022). The study focused on analyzing various issues related to these technologies, such as their innovativeness, level of uncertainty, potential negative impacts, significance, anticipated year of realization, and desired government policies.

## **2) National Institute of Science and Technology Policy (NISTEP), Japan**

Japan has a long history of conducting technology foresight. Since 1971, the National Institute of Science and Technology Policy (NISTEP) has been carrying out "Science and Technology Foresight" every five years (NISTEP, 2020). The 11th Science and Technology Foresight aims to provide valuable information for shaping science and technology innovation policies and strategies, including the 6th S&T Basic Plan from 2021 to 2025. The study focuses on a time horizon of about 30 years until 2050. It comprises four parts: horizon scanning, visioning, Delphi survey, and scenario planning (Urashima, 2021). In the Delphi survey, 702 technologies were evaluated based on their importance score, international competitiveness score, and the projected time for realization (NISTEP, 2020).

## **3) The Office of Communications (Ofcom), the United Kingdom**

Ofcom is the independent regulator for the UK communications industry. Ofcom has been conducting technology foresight with the aim of identifying emerging technologies and their potential impacts on the communications industry. They published a report titled 'Technology Futures: Spotlight on the technologies shaping communications for the future' (Ofcom, 2021). The report focuses on technological advancements and trends in communications. It is divided into five sections that cover different technology groups: Immersive communications and applications, Mobile and wireless technologies, Fixed and optical technologies, Broadcasting and media technologies, and Satellite technologies. The report explores the current state of these technologies, their future prospects, as well as the barriers and opportunities for their adoption. The study was conducted through interviews with experts from academia and industry, as well as a call for input. The findings are presented in the report, providing a brief description for each technology.

Furthermore, Ofcom has introduced a horizon scanning function to broaden their scope beyond immediate, short-term concerns and explore the potential evolutions of factors like technology and consumer behaviors that will affect their sectors and consumers over the next 5-10 years (Ofcom, 2023). This program aims to generate strategic insights and guide policy-making, ensuring a forward-looking perspective in an ever-changing and complex environment.

## **4) Deutsche Telekom**

Deutsche Telekom is a German telecommunications company that has conducted technology foresight studies to support product development, competitiveness assessment, and strategic decision-making (Thom & Rohrbeck, 2009). Their technology foresight process involves several key steps. The Identification and Observation stage focuses on using scouts to gather information from various sources, including universities, research institutions, conferences, and personal networks. In the Selection stage, technologies are evaluated based on novelty and relevance to Deutsche Telekom. The Assessment stage involves ranking technologies based on market potential and technological complexity. Finally, in the Dissemination stage, selected technologies are presented with descriptions and their potential business implications. These technologies are visualized in a tool called Technology Radar.

## **5) Deloitte**

Deloitte is a global consulting firm that has conducted studies related to technology foresight in various sectors, including the communications industry. Deloitte's Center for Technology, Media & Telecommunications published a report on technology, media, and telecommunications predictions for various technologies (Deloitte, 2021). The study answered key questions related to those technologies, including: What is the nature of the technology? Why is it important? Who would benefit from its implementation? What factors are driving the demand for this technology? Who are the key players in the technology ecosystem? And what potential challenges or obstacles could hinder its adoption? The research methodology involved the analysis and insights provided by their experts who specialize in the specific technology domains. The findings and conclusions were presented in the form of articles.

From the literature review, it is noted that there is a greater emphasis on technology foresight in general science and technology policies compared to communications regulation. Ofcom (2021) is a notable publication that presents the results of technology foresight in the context of communications regulation, but it lacks detailed guidance on conducting foresight. To address this gap, this paper aims to explore the application of technology foresight in communications regulation.

### **3. Importance of technology foresight to communications regulation**

#### **3.1 Addressing the pacing problem**

Regulators face significant challenges due to the rapid pace of technological changes, referred to as the "pacing problem" (Marchant, 2011). Technology often advances at a pace that surpasses regulators' capacity to keep pace with it, and achieving desired regulatory outcomes typically requires significant timeframes (Könnölä et al., 2012). As a result, regulators often find it challenging to keep up with emerging technologies. One example of the pacing problem in communications regulation is the emergence of over-the-top (OTT) services which have disrupted traditional communications markets. Video streaming services have disrupted broadcasting markets, and messaging applications have challenged voice and short messaging service (SMS) markets. However, in several countries, OTT are not subject to the existing communications regulations, which were adopted for traditional communications markets (ITU & The World Bank, 2020).

Technology foresight can help address the pacing problem by enabling early identification of emerging technologies and trends (Rejeski, 2011). By systematically scanning the horizon for emerging developments, regulators can identify emerging issues early on, assess their implications, and prepare for appropriate regulatory responses in a timely manner; (Rohrbeck & Kum, 2018; UNDP, 2018). This early identification enables regulators to take a proactive approach, rather than being reactive to emerging issues.

### 3.2 Managing environmental uncertainty

Regulators need to navigate the inherent uncertainty in the rapidly changing environment driven by technological changes. Technology foresight can help alleviate environmental uncertainty in the following three aspects (Milliken, 1987; Kreiser & Marino, 2002):

1) *State uncertainty*: This refers to the unpredictability of the environmental state of the organization, e.g. technological developments within the communications industry. Technology foresight enables regulators to better anticipate potential technological advancements that may impact the industry (Hines, 2007).

2) *Effect uncertainty*: This relates to the difficulty organizations face in anticipating how future environmental changes, such as technological advancements, will impact them. Technology foresight provides regulators with deeper insights into the potential impacts of technological advancements (Hines, 2007).

3) *Response uncertainty*: This arises from the challenge faced by organizations in selecting response options and predicting their outcomes. Foresight enables regulators to evaluate the possible outcomes of current decisions across a variety of future scenarios, enabling them to identify robust policy responses to technological changes (Cook et al., 2014; Hines, 2020; Hines, 2007).

### 3.3 Supporting the roles of communications regulators

Communications regulators have a crucial role in promoting the public interest by ensuring widespread access to communication services, fostering effective competition in the industry, and protecting the interests of consumers (The World Bank et al., 2011). Specific roles of regulators may vary depending on the legal framework of each country. Nevertheless, communications regulators generally perform various roles as follows (InfoDev & ITU, 2014):

- Establishing and implementing an authorization framework that enables new companies to establish communications businesses.
- Regulating competition, including tariffs, to enforce market principles that are fair and equitable, limit the power of dominant players, and create a level playing field for new entrants.
- Facilitating the interconnection of networks and facilities.
- Establishing mechanisms that enable universal service to make communication services widely available and affordable.
- Effectively managing the radio spectrum to foster the adoption of new technologies and the introduction of new players.
- Establishing measures to prevent unfair business practices and protect consumers.



Technology foresight provides valuable support to these roles by enabling regulators to anticipate and respond effectively to technological changes and their impacts. Table 2 provides an overview of how technology foresight supports various roles of communications regulators.

**Table 2 Communications regulator roles and benefits of technology foresight**

<b>Communications Regulator Role</b>	<b>Benefits of Technology Foresight</b>
Establishing and implementing an authorization framework	Technology foresight helps in identifying emerging technologies and trends in the communications industry. This knowledge can enable regulators to create an authorization framework that accommodates new companies and business models associated with emerging technologies.
Regulating competition and enforcing market principles	Technology foresight can empower regulators to anticipate technological advancements and their potential disruptive impact. For example, incumbent players in the market may face a potential loss of market power in the future when challenged by new entrants who leverage emerging technologies. This foresight can equip regulators with the knowledge to effectively assess future competition in the communications industry and regulate competition accordingly.
Facilitating network interconnection	Technology foresight can help regulators anticipate evolving communication technologies, allowing them to develop policies and regulations that facilitate the seamless interconnection of networks and facilities.
Ensuring universal service	Technology foresight can assist regulators in identifying technologies that can support universal service goals, making communication services widely available and affordable for all.
Managing the radio spectrum	Technology foresight can enable regulators to effectively manage spectrum resources to foster the adoption of new technologies.
Preventing unfair business practices and protecting consumers	Technology foresight can help regulators anticipate potential negative impacts of new technologies. This knowledge empowers them to establish regulations that safeguard consumers and prevent abusive practices.

#### **4. Framework of technology foresight in communications regulation**

This section discusses the framework of technology foresight primarily based on the widely accepted and referenced "Framework Foresight" (Hines & Bishop, 2013; Hines et al., 2015), which serves as a reference framework endorsed by the Association of Professional Futurists (APF) (Hines et al., 2017). Each step of the framework is described in relation to communications regulators. Furthermore, this section explores foresight methods and addresses the issue of institutionalizing foresight within organizations.

## 4.1 Framing

Framing in technology foresight involves establishing the scope of the foresight exercise, considering various dimensions of the typology presented in Table 3 (Porter, 2010).

**Table 3 Technology foresight typology**

<b>Dimension</b>	<b>Values</b>			
Drivers	Scientific Research & Technological Development	Broader contextual factors (e.g. social, economic, political)		
Scope	Single technology	Multiple technologies	Wide-ranging planning	
Geography	Institution	Sector	Nation/Region	Global
Time horizon	Short	Medium	Long	
Purpose	Informational	Action-oriented		
Participation	Narrow mix, closed process	Intermediate	Diverse mix, representative process	
Study duration	Day(s)	Month(s)	Year(s)	Continuous

These dimensions are described in the context of communications regulators as follows.

*Drivers:* The drivers dimension encompasses the factors affecting changes in the future considered in the foresight exercise. They include scientific research and technological developments and the broader contextual factors (e.g. social, economic, political) that shape the communications industry. Defining the type of drivers helps regulators clarify the key forces that will affect the future of communications regulation.

*Scope:* The scope dimension refers to the breadth of the foresight exercise. It can focus on a single topic or technology, multiple technologies, or have a wide-ranging planning approach that considers various aspects of communications regulation. Defining the scope helps regulators determine the specific areas they want to explore within the foresight exercise.

*Geography:* The geography dimension considers the level at which the foresight exercise takes place. It can be institution-focused, sector-specific, nation/region-centric, or global. For a communications regulator, geography dimension typically are communications sector-specific within their country, but they may consider relevant international activities.

*Time Horizon:* The time horizon dimension reflects the timeframe considered in the foresight exercise. It can be short-term, medium-term, or long-term. The time horizon considered and its specific duration (e.g. 10 years for medium-term) should be aligned with the regulator's strategic planning and decision-making processes.

The Three Horizons framework provides a structured approach for thinking about the future (Curry & Hodgson, 2008; Hines et al., 2018). Within this framework, the first horizon represents existing systems that emphasize business as usual in the current context. As time progresses and the environment changes, these systems become less fit with the environment. The third horizon involves long-term possibilities that currently have little relevance in the present context. However, as time elapses, they could fundamentally transform the future. Acting as a transition phase, the second horizon is where alternative futures start to emerge as the collision between the first and third horizons takes place. By simultaneously considering all three horizons, regulators can strike a balance between addressing short-term operational needs and considering long-term issues to ensure future relevance and effectiveness in their regulatory roles.

*Purpose:* The purpose dimension outlines the intended outcomes and use of the technology foresight exercise. It can be informational, aiming to provide general insights, or action-oriented, aiming to address specific strategic issues. Clarifying the purpose helps regulators define the expected deliverables and the practical application of the foresight findings.

*Participation:* The participation dimension focuses on the stakeholders involved in the foresight exercise. It can range from a narrow mix with a closed process to a diverse mix with a representative process. As discussed in a later section, regulators typically need to ensure adequate participation to incorporate diverse perspectives and establish the legitimacy of the foresight exercise.

*Study Duration:* The timeframe required to conduct the foresight exercise can vary from days for focused workshops, months for more in-depth analysis, to year(s) for comprehensive studies. Additionally, technology foresight can be conducted continuously, e.g. continuous horizon scanning (Palomino et al., 2012). Understanding the study duration helps regulators plan the schedule and allocate resources accordingly.

By considering these dimensions within the framing process, regulators can design technology foresight exercises to their specific needs and context in communications regulation.

## 4.2 Scanning

Horizon scanning, also referred to as environmental scanning (Schultz, 2006), offers "a systematic approach to support the early identification and collective exploration of emerging issues" and enables "the timely implementation of appropriate policy actions" (Könnölä et al., 2012, p. 223). Horizon scanning aims to identify, compile, and analyze various signals of change that have the potential to impact the future of a specific domain (Hines et al., 2019). Horizon scanning contributes to a more evidence-based approach to policy-making (Georghiou, 2007, as cited in Amanatidou et al., 2012).

The information gathered during scanning can be categorized as follows:

- *Weak signals* encompass events and developments that are not yet fully understood in terms of their impact and required responses (Hiltunen, 2008).
- *Emerging issues* arise when multiple weak signals combine, leading to interlinked possible impacts (Amanatidou et al., 2012).

- *Trends* refers to changes that occur gradually over a long period of time and move in a particular direction (Hines & Bishop, 2013).
- *Plans* refers to a stakeholder's announced intention to bring about future change (Hines & Bishop, 2013).
- *Projections* refers to forecasts made by third parties, which can shape the public's expectations regarding futures (Hines & Bishop, 2013).

Scanning topics can be categorized as social, technological, economic, environmental, and political, often referred to as the "STEEP" acronym (Hines & Bishop, 2013). Note that these categories extend beyond the technological area, as factors in other areas can also influence the future.

Callaway et al. (2019) explained that the progression of issue emergence can be understood by combining the public policy lifecycle curve (Molitor, 1977) with the "Three Horizons" framework (Curry & Hodgson, 2008). Issues gradually develop over time. Weak signals, primarily associated with Horizon 3, indicate potential long-term transformations and initial signs of emerging issues. As these signals grow stronger, they transition into emerging issues within Horizon 2, although decision-makers may not yet recognize them as requiring policy attention (Hines et al., 2019). Subsequently, these emerging issues progress into current issues within organizations or fields, entering the Horizon 1 timeframe, when significant events propel them into public attention (Molitor, 1977; Hines et al., 2019).

Horizon scanning can be categorized into two approaches: exploratory scanning and issue-centered scanning (Amanatidou et al., 2012). Exploratory scanning involves identifying and describing emerging issues by processing information from diverse sources. On the other hand, issue-centered scanning utilizes preliminary descriptions of issues as a core to identify additional signals to confirm or challenge their actual emergence.

Deciding when to take actions related to weak signals involves a trade-off between thoroughness and the risk of missing early opportunities, as well as the balance between neglecting significant threats and allocating resources to potential issues that may not materialize (Cook et al., 2014; Sutherland et al., 2012).

The scanning process can be broadly categorized into three steps as follows (Hines et al., 2019; Hines et al., 2017):

1) Finding: This initial phase involves actively seeking potential weak signals, also known as scanning hits (Bengston, 2013). These scanning hits represent novel and possibly disruptive issues that have the potential to significantly impact or drive change in the future. There is a wide range of tools available for discovering and keeping track of real-time information, including search engines, Internet feeds, alerts, social media, and specialized software or databases. Furthermore, expert panels can be used to offer additional or in-depth examinations of issues that are considered significant.

2) Collecting: The second step of horizon scanning involves storing and organizing the identified scanning hits (Bengston, 2013). The purpose is to maintain a record of these hits, which

can serve as the foundation for identifying emerging issues. Scanning hits can be tagged with relevant descriptions for efficient organization of the scanning library.

3) **Analyzing and Synthesizing:** The analysis phase involves prioritizing the collected scanning hits based on criteria such as credibility, novelty, likelihood, impact, relevance, time to awareness, and time to prepare (Bengston, 2013). Multiple weak signals are then synthesized to identify emerging issues and their implications. Effective interpretation of weak signals, as a sense-making activity, should be converted into policy recommendations (Könnölä et al., 2012; Amanatidou et al., 2012).

The outputs of horizon scanning can include a library of raw scanning hits, blog posts showcasing scanning hits, a digest summarizing notable emerging issues with relevant scanning hits, comprehensive articles or reports exploring emerging issues, presentations to internal and external stakeholders, input contributions to other strategic foresight initiatives (Hines, 2019), and visualization as radars (Rohrbeck et al., 2006; Institute of Risk Management, 2018). Two types of outputs are highlighted: *Technology foresight digest* and *Technology Radar*.

### **Technology foresight digest**

To summarize emerging issues and monitor their development, a technology foresight digest can be created. This digest template captures issues of interest for communications regulators based on literature review (Gordon & Glenn, 2009; Ofcom, 2021; KISTEP, 2022; NISTEP, 2020; Thom & Rohrbeck, 2009; Deloitte, 2021) and includes the following elements:

- 1) **Description:** A brief explanation of the technology and potential applications.
- 2) **Drivers:** The factors or forces that are pushing the technology forward, such as market demand, technological advances, etc.
- 3) **Challenges:** The barriers or obstacles that the technology must overcome, such as technical limitations, regulatory hurdles, etc.
- 4) **Stakeholders:** The individuals, organizations, or groups that are affected by or have a stake in the technology, including users, operators, developers, and regulators.
- 5) **Signals, Trends, Plans, Projections:** The collected information from scanning, which serves as evidence for potential technology trajectory, such as research and development efforts, market trends, industry forecasts, or international policy initiatives, etc.
- 6) **Likelihood/Certainty:** The probability or level of confidence in the technology's development and adoption.
- 7) **Timing:** The expected timeline for the technology's development and widespread adoption.
- 8) **Impacts:** The potential economic and social impacts of the technology on the communications industry, including both positive and negative effects on various stakeholders and the public.
- 9) **Policy Consideration:** The policy implications and considerations for regulators or policymakers, e.g. the need for regulations or standards, etc.

## Technology radar

Technology radars are visual tools that represent emerging issues based on three key aspects: timing, impact, and likelihood (Institute of Risk Management, 2018). The position of a technology on the radar indicates its timing (short-term, medium-term, or long-term), the size of the circle represents its impact (low, medium, or high), and the darkness or color of the circle indicates its likelihood of occurrence or adoption (low, medium, or high). By presenting information in a visual format, technology radars facilitate easier prioritization of technologies. Figure 1 shows an example of technology radars.

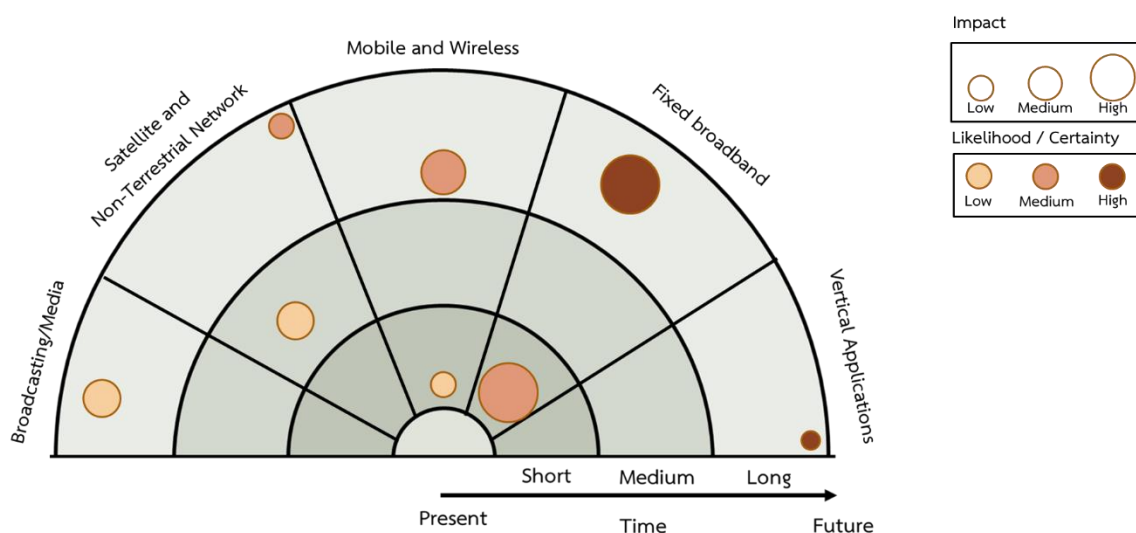


Figure 1 Example of technology radars  
(Note: Each circle represents a particular technology.)

Overall, horizon scanning can enable communications regulators to identify emerging issues that have the potential to impact the communications sector.

### 4.3 Forecasting

Scenarios offer a useful approach to interpreting emerging issues identified through horizon scanning (Bengston, 2013). They facilitate deep and creative thinking about the future by providing depictions of various plausible futures, thereby helping to avoid surprises and unpreparedness. Considering the uncertainty of the future, it is important to prepare for a range of plausible futures rather than relying solely on the expected one (Bishop et al., 2007). Drivers, which are "thematic clusters" of related information obtained from scanning, play a key role in driving change and serve as inputs for scenario development (Hines, 2020).

Scenarios can be created using various approaches, and one such approach is scenario archetypes (Hines, 2020). This approach suggests that a domain or system typically conforms to one of four archetypes, representing generic patterns of change. The four scenario archetypes, namely Continuation/Baseline, Collapse, New Equilibrium, and Transformation, are outlined in

Table 4. These archetypes serve as a foundation for constructing both the baseline and alternative future narratives. In this approach, the outcomes of the drivers identified earlier are projected within each archetype, forming the building blocks or plot elements for developing the scenarios. This methodology ensures the creation of a comprehensive and diverse set of scenarios to work with.

**Table 4 Scenario archetypes**

<b>Archetype</b>	<b>Description</b>
Continuation/Baseline	The existing trends within the domain persist without significant disruptions or unexpected events. The domain maintains its current course without notable deviations.
Collapse	The system/topic experiences dysfunction or breakdown, as conventional practices become ineffective, resulting in a decline in the system's or topic's condition.
New Equilibrium	The system/topic faces a significant challenge to its existing operation and must undergo adaptation. As a result, the system achieves a new equilibrium among competing forces that significantly differs from the existing balance.
Transformation	Involves a fundamental transformation of the system/topic where the existing rules are discarded and new practices emerge.

The outcome of scenario development is a collection of stories, which should not be seen as predictions but rather as representations of a range of plausible futures (Bengston, 2013). By engaging with scenarios, regulators can enhance the resilience of their decisions by proactively preparing for various alternative futures.

#### **4.4 Visioning**

In visioning step, two distinct approaches can be identified: normative foresight and exploratory foresight (Dreyer & Stang, 2013). Normative foresight focuses on determining the preferred future, what we want to achieve. On the other hand, exploratory foresight considers possible futures, including those that may seem undesirable, to comprehensively understand the possibilities. Regardless of the chosen approach, most projects involve analyzing the implications of the identified futures for an organization's specific context (Hines et al., 2015). The visioning step is crucial in interpreting these futures, leading to the formulation of plans, and ultimately driving action.

The Implications Wheel<sup>®</sup> is a structured process designed to examine the potential impacts of changes (Barker, 2011). This approach utilizes "cascade thinking," which involves exploring how a single event or implication can lead to multiple possible impacts, each of which subsequently leads to further possible impacts (Barker & Kenny, 2011). The process begins by

generating the first-order implications of the change under consideration. Subsequently, the second-order implications of each first-order one are analyzed. Lastly, the third-order implications of each second-order one are assessed. These implications encompass both positive and negative aspects and are directly derived from the preceding implication. By considering higher-order impacts, cascade thinking enables regulators to anticipate the long-term, indirect consequences of change (Bengston et al., 2019).

In the context of communications regulation, regulators can assess the potential impacts of emerging technologies and trends on the communications industry. Various potential economic and social impacts on the communications industry, encompassing both positive and negative effects on stakeholders and the general public, should be taken into account. Examples of such impacts to be considered are outlined below (Ofcom, 2021).

- Enables the provision of highly valued new services for individuals and businesses.
- Expands and enhances access to services, reaching a wider audience.
- Enhances network performance, leading to improved user experiences.
- Reduces barriers to entry for service providers, promoting competition and greater choices for consumers.
- Decreases the cost of service delivery.
- Disrupts the regulatory and authorization framework for networks and services.
- Reduces the overall environmental impact of communication service delivery and related activities.
- Ensure secure and reliable service delivery.

#### **4.5 Planning**

In this step, the individual or clusters of implications that have been identified are reframed as strategic issues, which then become inputs for strategic planning or policy analysis (Hines et al., 2015). To prioritize which implications or issues should be further addressed, each one can be assessed and rated based on factors such as likelihood, impact, and the organization's level of preparedness.

Some types of implications may require special attention from regulators. First, implications that are highly likely and have significant negative impacts should be addressed through policies aimed at reducing their likelihood or mitigating their effects. Second, implications that have a low probability of occurrence but offer highly positive outcomes may justify the adoption of policies to increase the likelihood of their realization (Bengston et al., 2019). Additionally, in terms of the organization's level of preparedness, the regulator should give greater attention to implications for which they are less prepared (Hines et al., 2015).

With strategic issues determined, regulators can develop appropriate regulatory responses to address the implications associated with emerging technologies and trends. This may involve developing new regulations or revising existing ones to ensure their continued relevance and effectiveness. In certain cases, regulators may also need to repeal regulations that have become obsolete.



An integrated strategic approach enables regulators to explore all scenarios and consider various possible approaches (Hines, 2020; Asian Productivity Organization, 2019). There are four approaches available, ranging from the safest to the riskiest, as follows.

1) Robust strategy: A robust strategy identifies elements that are common to all scenarios and focus on these shared aspects.

2) Hedge-your-bets strategy: A hedge-your-bets strategy involves assigning equal weight to all scenarios, assuming their equal probability, and distributing actions evenly across them.

3) Core-satellite strategy: In a core-satellite strategy, one scenario is emphasized as the most likely, receiving the highest level of attention, while the other scenarios are given comparatively less attention as a precautionary measure.

4) Bet-the-farm strategy: A bet-the-farm strategy involves selecting one scenario as the best and investing all resources and efforts into pursuing that scenario.

Hines (2020) highlights that organizations often opt for a core-satellite strategy. Nevertheless, it is crucial for regulators to consider their organization's context when choosing these approaches.

#### 4.6 Acting

Monitoring uncertainties and their resolution is important for navigating the future. While exploring uncertainties of the distant future, it is important to recognize that these uncertainties will gradually be resolved as the future approaches, ultimately converging into a single present (Hines & Bishop, 2013; Hines et al., 2015; Hines, 2020). Therefore, understanding how these uncertainties are resolving themselves at the earliest possible stage is crucial for navigating through future challenges. Indicators serve as focused pieces of information that reveal the direction in which uncertainties are being resolved. They consist of precursor events or statistics that point towards specific alternative futures. Observing indicators provides a clear indication of the increasing likelihood of one alternative future over another. It is assumed that the baseline, representing the continuation of present trends, is actively unfolding. Therefore, the emphasis should be on monitoring the alternative futures.

#### 4.7 Foresight methods

Several foresight methods can be considered for implementation. Table 5 shows some methods that can be applied in each step of framework foresight (Hines et al., 2017).

**Table 5** Examples of foresight methods

<b>Foresight Step</b>	<b>Examples of Methods</b>
Framing	domain mapping, integral futures
Scanning	environmental scanning, causal layered analysis, content analysis, cross-impact analysis, data mining, patent analysis

<b>Foresight Step</b>	<b>Examples of Methods</b>
Forecasting/ Futuring	Delphi, personas, scenarios, simulation
Visioning	appreciative inquiry, futures wheel, implications analysis
Planning/ Designing	decision modeling, personas, prototyping, risk analysis, strategic planning
Acting/ Adapting	action research, change management, coaching, consulting

Methods can be categorized based on their nature and capability (Popper, 2008). Regarding their nature, methods can be categorized as qualitative, quantitative, or semi-quantitative.

- Qualitative methods focus on interpreting events and perceptions subjectively. Examples include interviews and scenarios.
- Quantitative methods involve the measurement of variables and the application of statistical analyses. Examples include bibliometrics and simulation.
- Semi-quantitative methods combine mathematical principles with subjective judgments. Examples include cross-impact analysis and Delphi.

According to Popper (2008), qualitative methods are more widely used than quantitative and semi-quantitative methods in foresight projects. This preference may arise from the fact that foresight necessarily relies on subjective and imaginative interpretations of the changes that shape the future.

Regarding their capability, methods can be categorized based on their tendency to collect and process information using creativity, expertise, interaction, or evidence (Popper, 2008).

- Creativity involves innovative and imaginative thinking. Examples include scenarios and science fictioning.
- Expertise relies on the knowledge and skills of individuals in a specific subject. Examples include interviews and expert panels.
- Interaction acknowledges the substantial benefits obtained when expertise is brought together and engaged with other stakeholders. Examples include workshops and brainstorming.
- Evidence involves using reliable references. Examples include literature review and horizon scanning.

According to Popper (2008), on average, a typical foresight project incorporates around five or six methods. Projects that utilize five or more methods often select them in a way that all four fundamental capabilities are covered. However, it is impractical to suppose that all foresight studies will evenly prioritize all four fundamental capabilities.

Regulators typically need to include methods that have interaction capabilities because a key characteristic of foresight is the enabling of collective decision-making for the future through participation (Saritas, 2007). Benefits of participation by stakeholders in foresight can be observed in three aspects (Currie-Alder, 2003; Saritas, 2007):

1) Understanding: By involving a diverse range of stakeholders in the foresight process, participation enhances the understanding of complex issues. Different perspectives and expertise can be shared, contributing to a more comprehensive understanding of the future.

2) Legitimacy: When stakeholders have the opportunity to contribute their perspectives, the outcomes are more likely to be accepted by those affected. This increases the legitimacy and credibility of the foresight exercise and its outcomes.

3) Capacity: By engaging in the foresight process, stakeholders develop skills and knowledge to anticipate and navigate future changes effectively.

#### **4.9 Institutionalizing foresight within organizations**

Hines and Gold (2014) states that incorporating the use of foresight into organizations is challenging. They suggest a framework for integrating foresight into organizations as follows.

1) Publicizing: Spreading knowledge about foresight capabilities.

2) Introducing: Generating interest and participation from internal clients (policy-makers), often with the support of an internal champion.

3) Doing the work: The foresight project is conducted by the foresight team with the support of the client.

4) Evaluating outcomes: The project's results are assessed. If the client considers the project successful, they may promote it internally, thereby expanding opportunities for additional foresight works.

5) Positioning: The foresight team develops a strategy to promote its foresight capability.

After developing the positioning strategy, the process continues with "doing the work," involving both the foresight project work and the positioning efforts, and "evaluating outcomes" for both types of work accordingly.

6) Institutionalizing: The organization formally recognizes the role of foresight, integrating it into formal processes.

As foresight may be a relatively new concept for some communications regulators, they can consider adopting this framework to institutionalize foresight within their organization, integrating it into their decision-making processes.

## 5. Conclusion

This paper has explored the application of technology foresight in communications regulation. The rapid pace of technological change in the communications industry poses significant challenges for regulators, who must anticipate and prepare for future technological changes to make informed decisions on regulatory actions that foster innovation and protect consumers. The importance of technology foresight in communications regulation has been discussed: addressing the pacing problem, managing environmental uncertainty, and supporting the roles of communications regulators. A framework for conducting technology foresight in communications regulation, primarily based on "Framework Foresight," has been presented. The paper also explores foresight methods and the institutionalization of foresight within organizations. By employing technology foresight, regulators can identify emerging technologies, evaluate their potential impacts, and develop appropriate regulatory responses. This paper contributes to the literature on effective regulation of emerging technologies in the communications industry and provides guidelines to communications regulators considering the implementation of technology foresight practices.

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