# GENERATIVE SENSING AND SEIZING (GSS) MODEL: AN ADAPTIVE DYNAMIC DEVELOPMENT MODEL AS A TOOL FOR STRATEGIC ORIENTATION IN AEROSPACE ORGANIZATIONS

DINAH ELUZE SALES LEITE
National Institute for Space Research (INPE) / Embraer, Technological Strategy, Brazil
salesleite@gmail.com

MILTON DE FREITAS CHAGAS JUNIOR
National Institute for Space Research (INPE) / Space Engineering and Technology, Brazil
milton.chagas@inpe.br

## ABSTRACT

In times of discontinuous change, complex organizations, in terms of uncertainty, need to ensure flexibility and agility to renew their technological strategy. The article discusses the development of a strategic, dynamic, and adaptive model to improve the success of long-term technological definitions through the detection and use of opportunities, hence the name generative sensing and seizing model. The study proposes the link between scenario planning and dynamic capabilities and assesses the contribution of this connection to decision making, in the sense of directing decision making towards alternative futures and its unfolding in strategic actions. The research is based on multiple, retrospective, and prospective case studies explored in Embraer's research and development sector. The cross-analysis of the cases allowed to identify relevant elements for the structuring of the model. It is expected to contribute to the improvement of the technology strategy and the ability to detect changes in the environment that affect the selection of a more innovative technological portfolio. The analysis of the relationship of the GSS model with dynamic resources can help to take advantage of uncertainty as a potential source of change in strategic development, based on future possibilities.

**Key words:** Generative sensing and seizing. Dynamic capabilities. Scenario planning. Technological strategy. Uncertainty.

## INTRODUCTION

Strategic dynamics in aerospace organizations involve complexity and different types of uncertainty. These organizations make many investments in research and development (R&D) but have difficulty in predicting economic and scientific returns. In this environment of discontinuous change (Levinthal, 1992; Teece, Pisano & Shuen, 1997; Eisenhardt & Martin 2000; Helfat and Peteraf, 2003; Rohrbeck, 2010), strategic developments can impact the growth and sustainability of organizations seeking to adapt to changing the environment and capture opportunities (Ramírez, Österman & Grönquist, 2013).

Research on strategic factors involves the resource-based view (Penrose 1959; Wernerfelt 1984; Grant 1991; Barney 1991) and a better understanding of investment growth and perpetuity. The resource-based view has evolved into the concept of dynamic capabilities (Teece & Pisano, 1994; Teece; Pisano & Shuen, 1997), due to the importance of adaptability of organizations in transformative environments (Teece, 2007; Augier & Teece, 2008; Teece , Peteraf & Leih, 2016;

Pisano, 2016; Teece, 2018). Dynamic capabilities, defined as organizational and strategic routines (Eisenhardt & Martin, 2000), have emerged as a framework for explaining how organizations act to adapt to changes in turbulent environments (Helfat & Peteraf, 2009; Teece, 2007). These capabilities are very present in R&D environments, where the search for information requires organizations to develop more dynamic mechanisms to ensure competitive advantage and economic growth (Leite & Chagas Jr., 2019).

The article explores the characteristics of decision making in complex systems and under uncertainties, expanding the concept of generative sensing to generative sensing and seizing (GSS Model). This expansion includes inside-out and outside-in strategies. The first one is associated with dynamic capabilities and the second one with scenario planning associated with Technological Readiness Level (TRL). The association of dynamic capabilities with scenario planning contributes to the strengthening of decision-making processes in organizational strategies (Ramírez, Österman & Grönquist, 2013).

## LITERATURE REVIEW

### Dynamic Capabilities (Inside-Out)

The resource-based view does not explain the competitive advantage of organizations in dynamic markets over time (Teece, Pisano & Shuen, 1997; Barney, 1996). The evolution of the concept has led to the definition of dynamic capabilities as the company's ability to integrate, create and reconfigure internal and external competencies to cope with rapidly changing environments (Teece, Pisano & Shuen, 1997; Eisenhadt & Martin, 2000).

Dynamic capabilities underlie the strategic development of organizations (Teece & Pisano, 1994; Teece, Pisano & Shuen, 1997; Teece, 2007), allowing agility to deal with uncertainty (Teece, Peteraf & Leih, 2016). These resources explain how organizations adapt and reconfigure their dynamic and operational resources to respond and anticipate change (Teece, Peteraf & Leih, 2016), seizing opportunities and maintaining a competitive advantage (Eisenhardt & Martin, 2000). The key to the competitive advantage of some successful organizations is capturing opportunities (Eisenhardt & Sull, 2001; Dong, Garbuio & Lovallo, 2016).

### Ontological Uncertainty and Reflexivity in Strategic Development

Many analyzes and data modeling is performed in strategic development, generating subjective evidence (Sanderson, 2002). The subjective probability of this evidence requires the creation of antecedents based on current knowledge of future possibilities, whose relative probabilities are updated as new information is revealed over time (Derbyshire & Giovannetti, 2017; Derbyshire, 2019).

Ontological uncertainty results from the individual's ignorance of the future (Shacke, 1980), and refers to changes that may have been caused by a specific strategy (Derbyshire, 2019). The surprises resulting from what is currently unknown are sources of uncertainty, as well as the reflexivity provoked by decisions in response to emerging developments (Derbyshire, 2019; Derbyshire & Giovannetti, 2017). Reflexivity affects certainty about knowledge and the notion that more experience means greater control (Giddens, 1990; Sanderson, 2002).

**Technology Readiness Level (TRL)**

Managing technology investments is critical to the success of projects and programs and is based on arguments that they can reduce performance, time, and cost uncertainties (Mankins, 2009a, 2009b). If research and technological development are implemented early, systems composed of these technologies can result in high costs, delays, and erosion of initial performance objectives (Mankins, 2009a). The Technology Readiness and Risk Assessment (TRRA) model includes technology development and risk analysis elements at each TRL level (Mankins, 2009b, Azizian, Sarkani, & Mazzuchi, 2009). The model consolidates TRL, R&D Difficulty Degree (R&D3), and Technological Need Value (TNV), which assesses the importance of developing a technology for program success.

Investments in R&D may improve performance parameters, system applications, and risk mitigation for subsequent activities, treated in this study as uncertainties. The most critical of decision-making is assessing whether the technologies required for the system have collectively reached the point of maturity, risk, uncertainty, and performance needed to continue system development, which can impact program success or failure (Mankins, 2009b).

**Scenario Planning (Outside-In)**

In the 1970s, the Royal Dutch Shell popularized scenario planning, created by the RAND CORPORATION after World War II (Bradfield et al., 2005). It is an essential methodology for prospective analysis, which allows the study of alternative futures and the construction of the trajectory between present and future situations (Godet, 1983; Van der Heijden et al., 2002; Van der Heijden, 2005; Bradfield et al., 2005; Schwartz, 2008).

The relevance of scenario planning lies in building plausible futures and in generating strategies that can contribute to capturing opportunities, protect against threats, and minimize uncertainties (Ramírez & Selin, 2014). Thus, scenario development can facilitate the exploration of future situations (Schoemaker, 1995), as a tool to support decision making (Schwartz, 1991).

Van der Heijden (2005) includes uncertainty as a central element of effective strategic planning based on changes in the organizational environment. Scenario planning is beyond strategic development and includes anticipation, sensemaking, and organizational learning. Organizations should develop future scenarios (Courtney, Kirkland & Viguerie, 1997) and relate them to exploratory modelling to support decision making under uncertainty (Kwakkel & Pruit, 2013).

**METHODOLOGY**

The method defined for this study is multiple case studies. Through the development and application of the GSS model, we seek to generate scientific knowledge about technology selection in aerospace industry organizations. Case studies fragment cases into multiple dimensions, allowing for recognition of patterns and relationships between them, a better understanding of events, testing of existing theory, and developing a new approach (Eisenhardt, 1989; Eisenhardt and Graebner, 2007).

The study considers the combination of inductive and abductive reasoning to deal with ontological uncertainty in the R&D environment. Induction is the reasoning that results from inference and leads to long-term truth. Abduction represents the inference process used to explain the evidence, explore data, identify patterns, suggest hypotheses, and allow discoveries (Peirce, 1974, 1998; Hevner, March, Park, & Ram, 2004).

## RESEARCH RESULTS ANALYSIS

The article includes data from two Embraer cases. The technological development strategy was detailed through document analysis, research, and interviews, and sought to improve the understanding of the relevant aspects in the definition of technological portfolios. The projects analyzed were: Fly-by-wire (FBW) and Sky (Flying-car).

Firstly, the analysis of internal (Embraer) and public (articles) documentation was made for general awareness of these developments. Next, some key professionals who work or work on developing technologies involved in these programs were interviewed. The interviews were conducted through a guiding script and recorded. When necessary, respondents provided additional clarification. Other professionals who are also working on these developments were asked to respond to a survey, designed on Google Forms, to mitigate bias and incompleteness. This study, which is part of a doctoral thesis, continues with the exploration of other technological developments. Topics explored are: (1) uncertainties and emerging properties and (2) map of critical choices of dynamic capabilities.

### Uncertainties and Emerging Properties

This topic explores the influence of uncertainties on decision-making, the evolution of technology domains (integration domain to proprietary domain), and their impacts, as well as the influence of emerging properties of technologies on organizational learning.

*Fly by Wire (FBW)*

Leaders and teams performed FBW system development without scenario planning as part of the technology strategy. Early warnings were lost until market demand imposed a critical need that could compromise the sustainability of the organization.

FBW is a system that controls flight control surfaces through embedded software (Spitzer, 2011), and has become essential for aircraft manufacturers (Niedermeier & Lambregts, 2012). This technology has become a key factor for the first-generation EMBRAER 170/190 (E1) family, even under conditions of uncertainty. Embraer dominated the aircraft's dynamic behavior (TRL 5/6) but was not ready to develop the FBW. To ensure competitiveness, it decided to transform the technology integration domain into a proprietary domain (Chagas Jr., Leite & Jesus, 2016).

The uncertainties had a significant impact on decision-making processes due to the influence of the FBW system on aircraft safety. This experience in technology and product development, where the integration domain compromised program completion, influenced the evolution to the proprietary domain. The organization identified the opportunity to verticalize development from the technical difficulties that the supplier encountered in the complexity of the system, compromising the program goals. This decision has improved return on investment, increased product value-added, shortened the development cycle, reduced dependence on suppliers, improved control over the development cycle, and the definition of technological improvements, favoring the retention of intellectual property.

The emergent properties of the system were predictable and enabled organizational learning, increasing internal decision-making power, and product competitiveness. The results impacted the maturity of the second generation Embraer 170/190 (E2) and C390, encouraging the organization to expand the initiative to more systems. Integration of embedded software was strategic, and this development allowed for greater autonomy and speed in the development cycle, improving aircraft safety, performance and efficiency. The R&D activity started on demand and, after reaching more maturity, generated solutions for the program area.

*Sky Project (Flying Car)*

The experience of the previous case has brought learning to the organization about the importance of scenario-based strategic development. A perceived value in the scenario planning exercises undertaken was a broader understanding of complex issues such as political, economic, and social changes and early warning of technological trends in the aerospace sector.

The commitment of urban mobility infrastructure in recent years is making flying cars a reality, and aircraft manufacturers have realized this opportunity (Bülthoff, 2017, Ben-Haim, Ben-Haim and Shiftan, 2018). Flying cars require accelerated developments in an environment of commercial and technological uncertainty, where technology development and integration time is critical to program success and requires strategic partnerships. Embraer has no control over this dynamic and needs to rely on partners' knowledge to make critical decisions about technology portfolio definitions. Key benefits include model flexibility and knowledge building from the information generated in this development consortium.

**Map of capability strategy choices**

The research also considered the capacity choices map (Pisano, 2016), which is related to the strategy from the inside out. Strategies for systems consisting of technologies with varying degrees of uncertainty may require investments in specific combinations of capabilities. The two cases analyzed showed that the evolution of capabilities was natural due to the historical process of development.

*Application Fortifying (Case FBW)*

During the development of E1, Embraer was able to integrate FBW systems, but not their vertical growth. In this case, capacity building is related to product improvement and capacity expansion to the demands of innovation. For flight controls and certification technologies, features must be specific, but for embedded software, general-purpose.

Embraer realized the need to revise its strategy regarding its risk-based capabilities that an aircraft manufacturer assumes with critical and complex systems, highlighting the importance of a proprietary domain.

*Domain Expanding (Case Sky)*

In the Sky project, the uncertainties are substantial, both on the client-side and on the organization side, which has invested in general-purpose capacity building and established the necessary partnerships for specific capabilities. This strategic combination is strongly associated with the time required for the technology and program to mature.

The flying car, unlike a conventional aircraft, defines the search by the expansion of general-purpose capacity. Embraer has the proprietary domain of aeronautical technologies but must participate in the development of still immature technologies. This strategic model, which considers the combination of different capabilities, aims to accelerate the development of low-maturity technologies for integration into an equally immature mobility system, but with an estimated launch time already defined. The project represents a highly complex, innovative, and critical, immature technology-intensive, a regulated system set in a competitive and uncertain environment (Leite & Chagas Jr., 2019).

## GENERATIVE SENSING AND SEIZING (GSS) MODEL

Recently, new scenario tools have emerged to address uncertainties (Derbyshire, 2019), such as Dynamic Adaptive Policy Pathways (Haasnoot, Kwakkel, Walker & Ter Maat, 2013; Kwakkel, Haasnoot & Walker, 2016). This market of discontinuous changes and uncertainties requires more agility in the responses of organizations, aiming to improve the performance of strategic definitions (Leite & Chagas Jr., 2019). These definitions depend on decision-makers, who must create a vision of the future (Haasnoot, Kwakkel, Walker & Ter Maat, 2013) and adapt their strategic plans to the new reality (Albrechts, 2004; McInerney, Lempert, & Keller, 2012) from uncertainty situations (Hallegatte, Shah, Lempert, Brown & Gill, 2012).

In the Dynamic Adaptive Policy Pathway (DAPP), politics itself, which is an essential component of total uncertainty (Haasnoot, Kwakkel, Walker & Ter Maat, 2013), constitutes a recognition of reflexivity (Derbyshire, 2019). DAPP is developed in a 10-stage cycle (Haasnoot, Kwakkel, Walker & Ter Maat, 2013), which was redesigned in this study to 7 stages.

Stages 1 and 2 address strategic gaps (Kwakkel, Haasnoot & Walker, 2015). Stage 1 addresses the analysis of the current situation, both internal and external to the organization, which includes critical expectations, trends, and uncertainties, and stage 2 considers the analysis of problems, opportunities, and vulnerabilities of technologies, products, businesses, and regulations. At this stage, TRL levels should be considered, especially in terms of the time required for aerospace technology development and investments. The cost of developing aerospace technology is continually increasing, but investment motivation behaves differently. Early development highlights interest in research and, in the end, interest in products. Many projects are interrupted during this transition period due to the lack of resources for technology development to product exploitation. Reducing this period depends on better integrating the inside-out and outside-in strategies, which can improve the success rate of technologies that meet market needs.

The steps 3 and 4 seek to identify possible actions that can assist in the solution of strategic gaps identified above. The purpose of stage 3, with hypothesis generation, is to define the system concept even without sufficient information. In stage 4, scenario building allows a systemic exploration of future alternatives. Stage 5 defines the monitored information. Stage 6 defines the technology strategy, with the challenge of keeping options open most of the time. In stage 7, strategic actions are implemented and prioritized in the short, medium, and long term horizons. Strategic actions are initiated, altered, stopped, or expanded in response to data, increasing system flexibility.

A dynamic and adaptive model identifies strategic actions that can lead an intervention on a very different path from that initiated, in order to take advantage of the ontological uncertainty in the form of continuity, both those induced by the strategy itself in the form of reflexivity and those related to unknowns that occur over time (Derbyshire, 2019). A dynamic and adaptive model can deal with ontological uncertainty, like strategy or strategic actions may change over time as new knowledge about future states becomes available (Maier et al., 2016; Derbyshire, 2019). Thus, the decision-maker must continually revaluate future possibilities, eliminating and adding possibilities, as implicit in the stock of evidence accumulated by the assessment of each state considered. Evidence of the possibilities of each future considered ensures that radically different futures of the present are considered, counteracting the tendency of decision-makers to discard extreme futures based on current data (Derbyshire, 2019).

## CONCLUSION

This paper aims to improve the confidence level of decision-making processes under conditions of ontological uncertainty by expanding the concept from generative sensing to generative sensing and seizing (GSS).

Ontological uncertainty stems from the changing nature of reality, resulting from surprises about what is currently unknown and from cases of reflexive responses stimulated by new developments (Derbyshire, 2019).

The GSS model, which aligns the inside-out and outside-in strategies of an aerospace organization, shows that dynamic capabilities associated with scenario planning improve strategic decision-making in discontinuous change environments. The environment of change and uncertainty favours the detection and capture of opportunities but requires quick and flexible action by organizations.

## REFERENCES

Albrechts, L. (2004). Strategic (spatial) planning reexamined. Environment and Planning B, 31 (5), 743 – 758.

Anderson, B. (2010) Preemption, precaution, preparedness: anticipatory action and future geographies. Progress in Human Geography, 34(6), 777–798.

Augier, M., & Teece, D. J. (2008). Strategy as Evolution with Design: The Foundations of Dynamic Capabilities and the Role of Managers in the Economic System. Organization Studies, 29 (8–9), 1187–1208.

Azizian, N., Sarkani, S., & Mazzuchi, T. (2009)A comprehensive review and analysis of maturity assessment approaches for improved decision support to achieve efficient defense acquisition. In Proceedings of the World Congress on Engineering and Computer Science, 2, San Francisco, CA.

Barney, J. (1996). Gaining and sustaining competitive advantage. Massachusetts, Addison-Wesley Publishing Company.

Barney, J. (1991). Firm resources and sustained competitive advantage. Journal of Management, 17(1), 99-120.

Ben–Haim R., Ben–Haim G. & Shiftan Y. (2018). Penetration and impact of advanced car technologies. MOJ Civil Eng., 4 (4), 175−184.

Bradfield, R.; Wright, G.; Burt, G.; Cairns, G. & Van Der Heijden, K. (2005). The origins and evolution of scenario techniques in long range business planning. Futures, 37(8), 795–812.

Bülthoff, H. (2017). Flying Air Taxis: the next big game changer? Talk presented at Universität Ulm: Colloquium Cognitive Systems. Ulm, Germany.

Chagas Junior, M. F., Leite, D. E. S., & Jesus, G. T. (2017). 'Coupled processes' as dynamic capabilities in systems integration. Revista de Administração de Empresas, 57 (3), 245-257.

Courtney, H., Kirkland, J. & Viguerie, P. (1997). Strategy Under Uncertainty. Harvad Business Review, 67-79.

Derbyshire, J. (2019) Answers to questions on uncertainty in geography: Old lessons and new scenario tools. Environment & Planning A (in press).

Derbyshire, J. & Giovannetti, E. (2017). Understanding the failure to understand New Product Development failures: mitigating the uncertainty associated with innovating new products by combining scenario planning and forecasting. Technological Forecasting and Social Change, 125, 334–344.

De Sordi, J. O., Azevedo, M. C., Meireles, M. A., Campanario, M. A. (2013). A Abordagem Design Science no Brasil segundo as publicações em administração da informação. In: Encontro da Associação Nacional de Pós-Graduação e Pesquisa em Administração (EnANPAD), 2013, Rio de Janeiro. XXXVII Encontro da ANPAD, 1, 1-16.

Dong, A., Garbuio, M., & Lovallo, D. (2016). Generative sensing: a design perspectivemicro-foundationsndations of sensing capabilities. California Management Review, 58 (4), 97-117.

Eisenhardt, K. M., & Sull, D. (2001). Strategy as simple rules. Harvard Business Review, 79 (1), 106-119.

Eisenhardt, K. M., Graebner, M. E. (2007). Theory building from cases: opportunities and challenges. Academy of Management Journal, 50 (1), 25-32.

Eisenhardt, K. M., & Martin, J. A. (2000) Dynamic capabilities: what are they? Strategic Management Journal, 21, 1105–1121.

Eisenhardt, K. M. (1989). Building theories from case study research. Academy of Management Review, 14 (4), 532-550.

Giddens, A. (1990). The Consequences of Modernity. Cambridge, UK: Polity Press.

Grant, R. M. (1991). The Resource-Based Theory of Competitive Advantage: Implications for Strategy Formulation. Californian Management Review, 33 (3), 114–135

Godet, M. (1983). Méthode des Scénarios . Revista Futuribles.

Haasnoot M., Kwakkel J. H., Walker, W., & ter Maat, J. (2013). Dynamic adaptive policy pathways: a new method for crafting Robust decisions for a deeply uncertain world. Global Environmental Change, 23 (2), 485-498.

Hallegatte, S., Shah, A., Lempert, R., Brown, C., & Gill, S. (2012). Investment decision making under deep uncertainty application to climate change. The World Bank.

Helfat, C. E., & Peteraf, M. A. (2009). Understanding dynamic capabilities: progress along a developmental path. Strategic Organization, 7(1), 91-102.

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design science in information systems research. MIS Quarterly, 28 (1), 75-105.

Kwakkel, J. H., Haasnoot, M. & Walker, W. E. (2016) Comparing robust decision-making and dynamics adaptive policy pathways for model-based decision support under deep uncertainty. Environmental Modelling and Software, 86, 168–183.

Kwakkel, J. H., Haasnoot, M. & Walker, W. E. (2015) Developing dynamic adaptive policy pathways: a computer-assisted approach for developing adaptive strategies for a deeply uncertain world. Climatic Change, 132(3), 373–386.

Kwakkel, J. H., Pruyt, E. (2013). Exploratory Modeling and Analysis, an approach for model-based foresight under deep uncertainty. Technological Forecasting and Social Change, 80 (3), 419-431.

Leite, D. E. S.; Chagas Junior, M. F. (2019). Uso de um modelo de desenvolvimento dinâmico adaptativo (DDA) como ferramenta para a orientação estratégica em organização do setor aeroespacial. In: SemeAd 2019 - XXII Seminários em Administração, São Paulo, FEAUSP.

Levinthal, D. (1992) Surviving Schumpeterian environments: an evolutionary perspective. Industrial Corporate Change, 1(3), 427-443.

Maier HR, Guillaume JHA, van Delden H, Riddell, G. A., Haasnoot, M. & Kwakkel, J. H. (2016) An uncertain future, deep uncertainty, scenarios, robustness and adaptation: how do they fit together? Environmental Modelling and Software, 81, 154–164.

Mankins, J. C. (2009a). Technology readiness assessment: a retrospective. Acta Astronautica , 65, 1216-1223.

Mankins, J. C. (2009b). Technology readiness and risk assessments: a new approach. Acta Astronautica, 65, 1208-1215.

McInerney, D., Lempert, R., & Keller, K. (2012). What are robust strategies in the face of uncertain climate threshold responses. Climate Change, 112, 547–568.

Niedermeier, D., Lambregts, A. A. (2012). Fly-by-Wire augmented manual control - basic design considerations, ICAS 2012, 28th International Congress the Aeronautical Sciences, Brisbane, Austrália.

Peirce, C. S. (1998). The Essential Peirce. Selected Philosophical Writings, 2, 1893–1913. The Peirce Edition Project, (Eds.) Bloomington: Indiana University Press.

Peirce, C. S. (1974) Collected papers de Charles Sanders Peirce. In: Hartshorne, C., Weiss, P., Burks, A. (Eds.) Cambridge, Massachusetts, Harvard University Press, 1-8.

Peirce, C. S. (1958) The fixation of belief. In: Hartshorne, C., Weiss, P., Burks, A. (Eds.), Collected Papers of Charles Sanders Peirce, Cambridge, Massachusetts, Harvard University Press, 5, 223-247, 1931-1935 (First published 1877).

Penrose, E. T. (1959). The theory of the growth of the firm. New York: John Wiley.

Pisano, G. P. (2016). Toward a prescriptive theory of dynamic capabilities: connecting strategic choice, learning, and competition. Industrial and Corporate Change, 26 (5), 747-762.

Ramírez, R., Selin, C. (2014). Plausibility and probability in scenario planning. Foresight, 16 (1), 54–74.

Ramírez, R., Österman, R. and Grönquist, D. (2013). Scenarios and early warnings as dynamic capabilities to frame managerial attention. Technological Forecasting and Social Change, 80 (4), 825-838.

Rohrbeck, R. (2010). Corporate foresight: towards a maturity model for the future orientation of a firm. Physica-Verlag, Springer, Heidelberg and New York.

Sanderson, I. (2002). Evaluation, policy learning, and evidence-based policy making. Public Administration, 80(1), 1–22.

Schoemaker, P. J. H. (1995). Scenario planning: a tool for strategic thinking. Sloan Management Review, 36 (25).

Schwartz, P. (1991). The Art of the Long View: Planning for the Future in an Uncertain World. Doubleday Currency, New York.

Schwartz, O. J. (2008). Assessing the future of future studies in management. Futures, 40 (3), 237-246.

Shackle, G. L. S. (1980) Imagination, unknowledge and choice. Greek Economic Review, 2(2), 95-110.

Simandan, D. (2010) Beware of contingency. Environment and Planning D. Society and Space, 28(3): 388–396.

Simon, H. A. (1996). The sciences of the artificial. 3rd. ed. Cambridge, MA: Massachusetts Institute of Technology Press.

Spitzer, C. R. (2011). The Avionics Handbook. CRC Press.

Teece, D. J., & Pisano, G. (1994). The dynamic capabilities of firms: an Introduction. Industrial and Corporate Change, 3 (3), 537–556.

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. Strategic Management Journal, 18 (7), 509-533.

Teece, D. J. (2007). Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. Strategic Management Journal, 28 (13), 1319–1350.

Teece, D. J., Peteraf, M., & Leih, S. (2016). Dynamic capabilities and organizational agility: risk, uncertainty, and strategy in the innovation economy. California Management Review, 58 (4), 13-35.

Teece, D. J. (2018). Business models and dynamic capabilities, Long Range Planning, 51, 40-49.

Van der Heijden, K., Bradfield, R., Burt, G., Cairns, G. & Wright, G. (2002). Sixth Sense: Accelerating Organisational Learning with Scenarios. John Wiley & Sons.

Van der Heijden, K. (2005). Scenarios: The Art of Strategic Conversation. John Wiley & Sons.

Wernerfelt, B. (1984). A Resource-based View of the Firm. Strategic Management Journal, 5(2), 171–180.