

Waissi, Gary R.; Demir, Mustafa; Humble, Jane E.; Lev, Benjamin

Article

Automation of strategy using IDEF0 – A proof of concept

Operations Research Perspectives

Provided in Cooperation with:

Elsevier

Suggested Citation: Waissi, Gary R.; Demir, Mustafa; Humble, Jane E.; Lev, Benjamin (2015) :
Automation of strategy using IDEF0 – A proof of concept, Operations Research Perspectives, ISSN
2214-7160, Elsevier, Amsterdam, Vol. 2, pp. 106-113,
<https://doi.org/10.1016/j.orp.2015.05.001>

This Version is available at:

<https://hdl.handle.net/10419/178254>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



<http://creativecommons.org/licenses/by/4.0/>



Automation of strategy using IDEF0 – A proof of concept



Gary R. Waissi^{a,*}, Mustafa Demir^a, Jane E. Humble^a, Benjamin Lev^b

^a The Polytechnic School, Ira A. Fulton Schools of Engineering, Arizona State University, 6049 South Backus Mall, Sutton Hall #340J, Mesa, AZ 85212, USA

^b LeBow College of Business, Drexel University, Philadelphia, PA 19104, USA

ARTICLE INFO

Article history:

Available online 1 June 2015

Keywords:

Strategy modeling
Intelligent strategy
Strategy automation
Operations management
Strategic management

ABSTRACT

The goal of this interdisciplinary paper is to show that an existing modeling language, Integration Definition for Function Modeling (IDEF0), is applicable for use in strategy modeling and for automation of strategic plan development and implementation. We will show how utilization of the systems modeling language IDEF0 simplifies strategic plan development, and moves strategic planning and management from a static, document-based approach to a model- and software-based approach. A sequence of examples, as a proof-of-concept, is shown to demonstrate the use of IDEF0 to translate document-based strategic plans to model-based plans. The advantages of IDEF0 include: a well-tested language, and comprehensive systems modeling technique. The resulting IDEF0 models are well-defined, well-structured, easy to understand, easy to modify and use, and can be extended to any depth of detail. It is noted, that while the paper focuses on small- and medium manufacturing enterprises (SME), the approach can be used for strategy development and strategy automation of any size company or organization.

© 2015 The Authors. Published by Elsevier Ltd.

This is an open access article under the CC BY license

(<http://creativecommons.org/licenses/by/4.0/>).

1. Introduction

The motivation for this research originated from a study and survey of Arizona aerospace- and defense manufacturing companies conducted in 2011 [1,2]. Among others, it was found that “strategic planning and plan implementation” were weaknesses for a significant percentage of the 132 survey respondents. The surveyed companies were all aerospace- and defense manufacturers, and, overwhelmingly, 92% were manufacturing small and medium-sized enterprises (SMEs). To summarize the results, it was found that: 21% had no vision or mission, 30% had no leadership succession plans, only 24% considered innovation a strategic priority, nearly half engaged in “reactive” innovation on an “as-needed” or “after system breakdown or failure”-basis, 21% reported having no process improvement programs, 33% did not measure “effectiveness of their inventory management”, 33% did not implement just-in-time (JIT) in purchasing in their supply chain management, 33% had no written purchasing plan, 35% had no hiring or retention strategy, 46% had no global strategy, 62% had no green strategy. In addition, there appeared to be a lack of knowledge, or lack of

interest toward strategy and strategic planning, especially by smaller companies.

Why would so many high tech companies not take full advantage of what strategic planning and management have to offer? While there may be no definitive answer to the question, two clear issues emerge: methodology and strategy. First, there is either no comprehensive, flexible, simple to use, programmable modeling tool or methodology available, or a methodology has not been identified that would be able to encompass and support a complete strategic plan for the leadership of the SME to use. Ideally, to be value-adding, such a plan should be updated in real-time, and should have built-in “intelligence” for autonomous updating of plan data, information and knowledge. Secondly, a lack of understanding of strategy, strategic management and strategic planning leave even well-intentioned and best-designed plans on the shelf. It appears that strategic plans, if they exist, are not implemented because they are most commonly in the form of reports, and are not well-communicated. In summary, these two shortcomings identified are likely to negatively affect the competitiveness of an enterprise.

The objective of this paper is to present a proof-of-concept for strategic plan development and strategic plan automation using an existing modeling language *Integration Definition for Function Modeling* or IDEF0. IDEF0 modeling is designed and used primarily to model systems. This paper is highly interdisciplinary, as it proposes to use IDEF0 for strategy modeling, strategic plan development and implementation. We will show, with examples

* Corresponding author.

E-mail addresses: gary.waissi@asu.edu (G.R. Waissi), mustafa.demir@asu.edu (M. Demir), jane.humble@asu.edu (J.E. Humble), OmegaJournal@drexel.edu (B. Lev).

step-by-step, utilizing the SME framework and the IDEF0 language, how such a plan is developed. The example will also demonstrate that existing IDEF0 language has sufficient features and capabilities to support strategic plan development. The example starts with high level strategy view, and then details the high-level view at lower, more specific, levels of strategy.

It is noted, that the proof-of-concept, and the examples, focus on small- and medium manufacturing enterprises (SME) to provide context and specificity. Manufacturing SMEs, based on our above cited survey [1,2], generally, do not appear to have the resources, and possibly, do not have the knowledge, to engage in dedicated strategic plan development at a competitive level when compared to larger organizations. This was found to be a competitive disadvantage of the surveyed SMEs. However, it has to be pointed out, that the modeling approach appears applicable for any type- and size of an organization or company.

2. Findings from the literature

In a 1981 study [3] Porter integrated both enterprise-level and industry-level concepts to a Market Oriented Theory (MOT). According to his approach, a framework can be established, which simultaneously deals with both an individual company and its broader operating environment. The study states that “a company’s performance depends critically on the characteristics of the industry environment within which it competes”. Porter concludes, in the referenced study and also in (1985) [4], that the MOT takes into consideration two factors: the “attractiveness of industries that companies seek to enter” and the “improvement of their relative competitive position”.

In order to further explain the above two factors, Porter developed the well-known “Five Competitive Forces” model, (see Porter, M.E. [5] 1979, [6] 1980, [4] 1985, [7] 1991, [8] 2008). According to the model, the “competitive rivalry” or attractiveness of a market depends on the existence of competitive forces: “bargaining power of buyers, bargaining power of suppliers, threat of new entrants, and threat from substitute products” with the “interaction of these forces creating industry competition”. Even though Porter advocates company-level use of the “competitive forces” strategy, the framework appears to relate better to industry-level applications. This approach may describe the current industry-level “big picture”, and, is therefore, better suited to policy makers than it is to SMEs.

Broadly stated, as concluded by Lee and Wilhelm (2010) [9], a strategic management model aims to assist the company leadership with a better understanding of decision making relating to, “fundamental determinants of competitiveness of a company, or an industry, and their interaction as a system”. According to Tallman (1991) [10], a strategic management model should provide a dynamic and efficient model of competitiveness for a company. Drucker in (1985) [11] and (1974) [12] also emphasized that the purpose of a strategic management model is to serve as a tool for a company to help the “company achieve a sustainable competitive advantage”. Drucker further states that strategic management modeling should consider all aspects of a company, including “innovation” and “innovation management” [11], because, especially, “technology-based products have shorter life cycles due to rapid innovation, as well as because of customer expectations for latest innovations” [13] (see: Gan, Pujawan, and Widodo, [13]). According to Herrmann (2005) [14], strategic management is inherently complex because it considers an entire organization and it is largely uncontrollable. In the study, the author emphasizes that “the dominant design” in strategic management in the future will depend on “individual and organizational capabilities to learn and to innovate”.

Other studies, including [15–18], have attempted an integration of the internal and external factors under the banner of a Resource-Based Model (RBM). Within the concept of the RBM, a company is a collection of resources and capabilities, which facilitate product/market competition [19–21]. The basic idea of the RBM, as presented in the 1959 classic “The Theory of the Growth of the Firm” [22] by Penrose, is that a company will achieve a sustainable competitive advantage by developing and applying distinctive company resources. When company-specific resources are costly, rare and non-replicable, these resources can become the basis of sustainable competitive advantage. According to Penrose the RBM can be framed in the “Schumpeterian” [23] (Schumpeter 1934) competition approach of “creative destruction”, because competition is dynamic and involves uncertainty.

The Schumpeterian [22,23] approach takes into consideration both technological (product) and non-technological (organizational) innovation. Also, Rumelt [16, 1984, p. 569] relates the RBM to the Schumpeterian concept by stating that both approaches share “the constant search for ways in which the firm’s unique resources can be redeployed in changing circumstances”. See also Rivard et al. [24], Mahoney and Pandian [25], and Bogner et al. [26].

According to Del Canto et al. (1999, [27, p. 896]), there are three types of resources in a company’s environment: (1) tangible resources—defined as “the resources which are easy to identify and available”, for example, in stored records and financial statements; (2) intangible resources—defined as “a company’s image or its scientific and technological knowledge”; and (3) human resources—classified as resources which “offer the company the skills, knowledge, and reasoning as well as decision-making ability” (see e.g. [28, p. 125]). Barney [29] and Hall [30] observe, that intangible resources are difficult for competitors to detect and evaluate because they are “invisible”. In support of Del Canto, [27], Greening et al. in [31] conclude that the quality of employees is key to a company’s competitive advantage, because success is associated with the ability of the company to create, manage and transfer knowledge.

For an interesting comparison, Spanos and Lioukas in their study in 2001 [32], contrast Porter’s Competitive Strategy Framework (Market Oriented Theory (MOT)) and the Resource-Based Model (RBM) perspective. For additional discussion of strategic management models see, for example, Moore (2011) [33], Kor and Mahoney (2000), [34], Mahoney and Pandian (1992), [35].

On this background from the literature, we repeatedly see mentions of “sustainable competitive advantage”, “learn and innovate”, “creative destruction”, “dynamic competition”, “dynamic and efficient model”, “constant search for ways”, “changing circumstance”, “ability to create and transfer knowledge”, etc. It appears obvious that there is a strong desire to move toward intelligent, self-learning, strategy models, but attempts thus far have not been successful. This is a major dilemma, especially, for the SMEs with limited resources for such efforts. What can an SME do and what specific steps can be taken to automate and update strategic plans in real time, provide for “intelligence” to strategic plans for the purpose of achieving and to maintain competitive advantage?

3. Proof-of-concept background and foundations

3.1. From a document-based to a model and software-based “intelligent” strategic plan

The goal of the proof-of-concept model is to identify and demonstrate the feasibility of a modeling approach for strategic plan development with the detail and specificity to allow for programmability and development of a software tool. A key objective under this goal is to take advantage of existing enterprise

Table 1
Key requirements for the modeling methodology (compare with [36]).

Modeling methodology Key requirements
Easy to learn and to use
Powerful
Easy to modify
Standardized
Have precise rules
Flexible
Scalable
Support modularity
Support adaptability

Table 2
Desired model features.

Desired model features
Complete (include all important functions)
Comprehensive (include meaningful, understandable functions)
Minimal (include only important functions)
Orthogonal (include functions that are independent of each other)
Measurable (include child functions that are actionable)
Non-redundant (include only relevant functions, and omit redundant functions)
Support desired level of specificity within a developed model
Support model linking and integration
Programmable
Support capability for self-learning, auto-updating, and, thereby, model intelligence
Provide specific actionable guidance, a “roadmap”, for all levels of the enterprise

systems (including data and information sources), and design and develop the strategy model and software implementation on the top of those existing systems. Therefore, this objective includes that the software implementation is integrated for data and information input into the organization’s enterprise resource planning (ERP) system (including, and as applicable, accounting and financial management-, customer relationship (CRM)-, supplier relationship (SRM)-, supply chain- (SCM), and product lifecycle management (PLM), as well as, e.g. material requirements planning (MRP)). While enterprise systems and data support operational implementation of strategy, they are transactional and internally focused, not sufficiently forward looking or “vision driven”, and do not include important components of strategic planning. Those components include strategic vision-, and goal-driven real-time assessment of the “environment” with respect to opportunities and threats (“trends”), and appraisal of “capabilities” with respect to strengths and weaknesses.

Within the proof-of-concept we will first identify basic requirements for the modeling methodology, and then list desired model features. Then, we will discuss a modeling methodology that satisfies most of the stated requirements, and show a step-by-step sequence of examples of strategic plan building to support the proof-of-concept.

3.1.1. Requirements for modeling methodology and desired features for models

The model should provide the enterprise leadership with actionable guidance, which can actually be used to improve strategic management, and thereby improve the competitive and strategic positioning of the enterprise. When we were evaluating available modeling approaches for strategy modeling, a list of *key requirements* and *desired features* was identified. As the list of *key requirements* was most closely met by the IDEF0 modeling language [36] that language was chosen. The *key requirements* for the modeling methodology are identified in Table 1, and *desired features* for a model are summarized in Table 2.

3.2. IDEF0

To address the key requirements and desired features, the proof-of-concept proposes the use of the Integration Definition for Function Modeling (IDEF0) methodology for strategic plan development and management. While the modeling technique has been around since 1993 (as a (proposed) Draft Standard [36]), it has not made its way to strategic planning and management applications. The Draft Standard is based on the Integrated Computer-Aided Manufacturing (ICAM) Function Modeling Manual (IDEF0) [37].

Within the IDEF family of models, there are models for *function modeling* (IDEF0), *information modeling* (IDEF1), *data modeling* (IDEF1X), *process modeling* (IDEF3), *object oriented design* (IDEF4), and *ontology description capture* (IDEF5). For a review of IDEF model types, see [36,37]. Among these versions, it was considered that IDEF0 most closely satisfies the above stated modeling requirements (Table 1) and desired model features (Table 2) for strategic planning and management.

The language of IDEF0 is standardized with respect to syntax and semantics; therefore, models are well-defined, well-structured, easy to understand, easy to modify and use, and can be extended to any depth of detail. The IDEF0 models are also flexible, scalable, and adaptable to varying situations and conditions. The IDEF0 models can be considered to be three dimensional, because any two-dimensional IDEF0 function model diagram can be extended to child functions presented at different layers, or levels, of the model. There is also no limitation on the number of child function layers.

IDEF0 models are most commonly developed and used by systems engineers to model and analyze complex systems, study function and interrelation of system components, model system life cycles, as well as model enterprise operations. An example of such operational IDEF0 use is given, for example, in [38].

This paper uses the notation, definitions and terminology specified in the “Draft Standard” [36]. The relevant notation, definitions, and terminology are repeated here for completeness and to aid with reading, and understanding, the model structure and graphs.

3.2.1. IDEF0 definitions

Table 3, summarizes the definitions used by the presented proof-of-concept model as given in [36].

4. Proof-of-concept example—developing an IDEF0 model for SME strategy

4.1. Top level function

In IDEF0 modeling the function always refers to an activity, process or transformation. The role of the function is to transform some inputs into some outputs using some resources under some specified constraints or rules. All functions are modeled and represented in the same way. This simplicity and structure are the elegance of an IDEF0 model.

In strategic management, similarly, we want to transform inputs into outputs. We have limited resources and are subject to rules, policies, and other external as well as internal influences and factors that must be considered. Further, we want this “input to output transformation” to result in some desired outcome. We also want the transformation process (the execution of the function) will be efficient and lean. The IDEF0 modeling methodology will provide the tools to accomplish those objectives for strategic plan development and for strategic management.

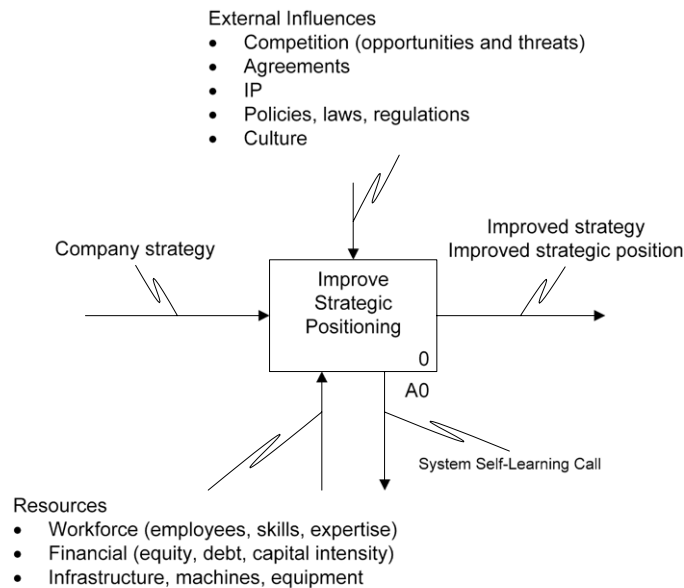
Fig. 1 shows the modeling of the top-level function, identified as A-0 (“A minus zero”). In comparison to a strategic plan, this top-level function corresponds to an overall vision or a high-level goal.

Table 3

IDEFO Definitions used by proposed model.

Source: Selected definitions adapted from [36].

Model term	Definition
IDEFO model	A graphic description of a system or subject that is developed for a specific purpose and from a selected viewpoint.
Model title	A verb or verb phrase that describes the overall function presented on an IDEFO diagram; the title of a child diagram corresponds to its parent box name.
Function	An activity, process, or transformation (modeled by an IDEFO box) identified by a verb or verb phrase that describes what must be accomplished.
A-0 diagram	The special case of a one-box IDEFO context diagram, containing the top level function being modeled and its inputs, controls, outputs and mechanisms, along with statements of model purpose and viewpoint.
Arrow	A directed line, composed of one or more arrow segments, that models an open channel or conduit conveying data or objects from source (no arrowhead) to use (with arrowhead). There are four arrow classes: Input Arrow, Output Arrow, Control Arrow, and Mechanism Arrow (includes Call Arrow).
Arrow label	A noun or noun phrase associated with an IDEFO arrow or arrow segment, specifying its meaning.
Box	A rectangle, containing a name and number, used to represent a function.
Box name	The verb or verb phrase placed inside an IDEFO box to describe the modeled function.
Box number	The number placed inside the lower right corner of an IDEFO box to uniquely identify the box on a diagram.
Input arrow	The class of arrows that express IDEFO Input, i.e., the data or objects that are transformed by the function into output. Input arrows are associated with the left side of an IDEFO box.
Output arrow	The class of arrows that express IDEFO Output, i.e., the data or objects produced by a function. Output arrows are associated with the right side of an IDEFO box.
Control arrow	The class of arrows that express IDEFO Control, i.e., conditions required to produce correct output. Data or objects modeled as controls may be transformed by the function, creating output. Control arrows are associated with the top side of an IDEFO box.
Mechanism arrow	The class of arrows that express IDEFO Mechanism, i.e., the means used to perform a function; includes the special case of Call Arrow. Mechanism arrows are associated with the bottom side of an IDEFO box.
Call arrow	A type of mechanism arrow that enables the sharing of detail between models (linking them together) or within a model.
Tunneled arrow	An arrow (with special notation) that does not follow the normal requirement that each arrow on a diagram must correspond to arrows on related parent and child diagrams.
Parent diagram	A diagram that contains a parent box.
Child diagram	The diagram that details a parent box.
Decomposition	The partitioning of a modeled function into its component functions.
Diagram node number	That part of a diagram's node reference that corresponds to its parent box node number.

**Fig. 1.** IDEFO context diagram: Node A-0/0, representation of strategic management of a company.

The viewpoint chosen is “Strategic management by the CEO”, as ultimately the CEO in any organization is responsible for strategic plan development and implementation.

In Fig. 1, the IDEFO Context Diagram, the top-level function entitled “Improve strategic positioning” is represented by a Box “0”, as “Node A-0”. The “Purpose” of the model is identified as “The assessment, planning and strategic focusing of the company activities”. Each activity within the model is represented as a function, and each function is represented by a box. The “Viewpoint” of the model is stated as “Strategic management by the CEO” of the company or enterprise.

The IDEFO box has arrows connected to it as follows:

- INPUT arrow, representing data or objects as input to the function, connected to the left side of the box, and pointing into it. The INPUT in this case consists of “company strategy”. Initially, if the company has no strategy, the INPUT (strategy) is empty.
- OUTPUT arrow, representing data or objects resulting from execution of the function, connected to the right side of the box, and pointing outward. The OUTPUT in this case includes “improved strategy, improved strategic positioning”.

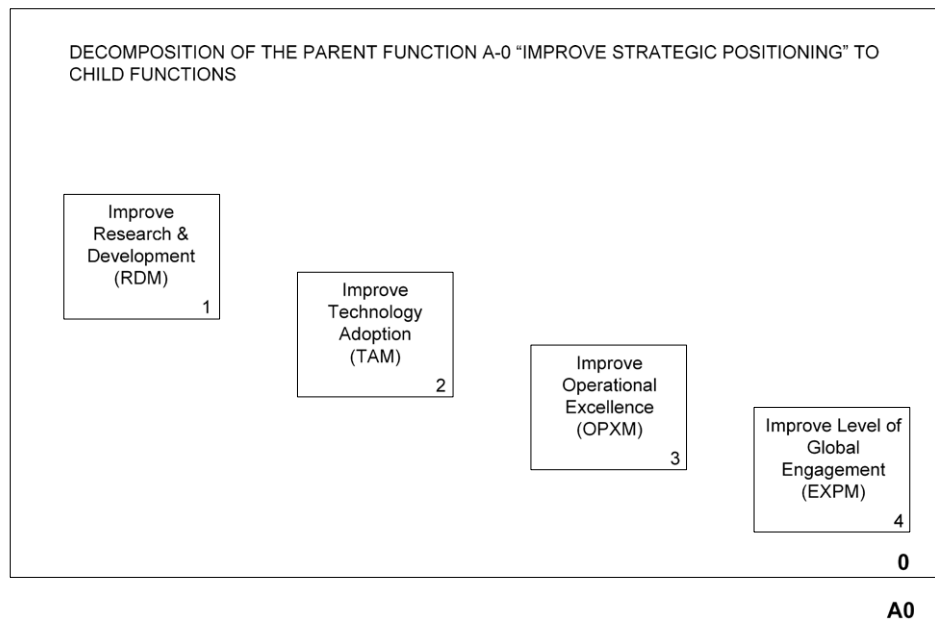


Fig. 2. Decomposition of the parent function A-0 “improve strategic positioning” to child functions.

- CONTROL arrow, representing conditions, rules or constraints, imposed on the function, connected to the topside of the box, and pointing into it. The CONTROL in this case includes “external influences”, consisting of “competition, agreements, intellectual property, policies, laws, regulations, and culture”. The “external influences” include opportunities and threats of the traditional SWOT analysis.
- MECHANISM arrow, representing means and resources to perform the function, connected to bottom side of the box, and pointing into it. The MECHANISM in this case includes “resources” consisting of “workforce (employees, skills, expertise), financial (equity, debt, capital intensity)”, as well as “infrastructure, machines, and equipment”. The “resources” include strengths and weaknesses of the traditional SWOT analysis.
- CALL arrow, representing information and data sharing (or model linking) based on an internal or external call, connected to the bottom side of the box, and pointing outward. The CALL in this case is information and data sharing with other functions or internally within the function. Information and data sharing also serve the purpose of “system self-learning” and the creation of an intelligent system for strategic management. The information and data sharing for continuous improvement, and model linking, correspond to the “repetitive process” (Mintzberg) of the traditional strategic planning process.

It is noted that some of the CONTROL and MECHANISM input data and information will be obtained from, for example, the enterprise resource planning (ERP) system, including from the customer relationship (CRM)-, supplier relationship (SRM)-, supply chain- (SCM), product lifecycle (PLM)-, human resource (HR)-, and accounting and financial management systems, as well as material requirements planning (MRP) systems. These integrated systems aid and support day-to-day managerial decisions focusing on operational efficiencies, and, at the same time provide data and information for automated strategic planning. Other data sources relating to, in particular, “environmental assessment” include, among others, automated mining of “big data”, and social media trends (real-time feed) (e.g. on product “likes” and competitors’ products).

Finally, within IDEF0 syntax and rules, a function (box) may contain more than one (sometimes none) INPUT, OUTPUT,

CONTROL, and MECHANISM arrows, but at most one CALL arrow. It is noted, that within this paper these words (INPUT, OUTPUT, CONTROL, MECHANISM, CALL) are capitalized to signify that the words are reserved, and shall not be used alone to describe a function or an arrow.

4.2. Child functions

Next, the top-level function (also called the root, or parent function) is decomposed into meaningful child functions conforming to the desired model characteristics identified earlier. In strategic planning this corresponds to formulating goals to support a vision, or formulating objectives to support a goal.

In this case the overall strategic goal, the top-level function, “Improve strategic positioning”, is decomposed into four child functions: “improve research and development”; “improve technology adoption”; “improve operational excellence” and “improve level of global engagement”. See Fig. 2.

In Fig. 2, the frame of the figure represents the box “0” of Fig. 1 with the child functions listed inside the parent box. While the figure shows the functions sequentially, IDEF0 does not require sequential processing of functions. Function relationships (arrows) can be specified to provide for function execution in any order or simultaneously. The “A0” below the right hand corner signifies that the box “0” has been detailed in “Node A0”. Node A0 is given in Fig. 3.

It should be noted that the child functions, for this proof-of-concept, of Fig. 2 were chosen from the Next Generation Manufacturing (NGM) categories ([39] 2011 Next Generation Manufacturing Study, The Manufacturing Performance Institute, 2011; and the Next Generation Manufacturing, National Science Foundation website, [40]).

Fig. 3 shows the Node A0 detailing. This includes the child functions and their relationships inside the parent function. It can be seen, that “company strategy” is the INPUT, “improved strategy/improved strategic positioning” is the OUTPUT, “external factors” are the CONTROL, “resources” are the MECHANISM, “system learning” is the CALL. All function boxes and arrows are labeled to identify their purpose.

In Fig. 3, “company strategy” is divided (represented by a forked arrow) into strategies for research and development

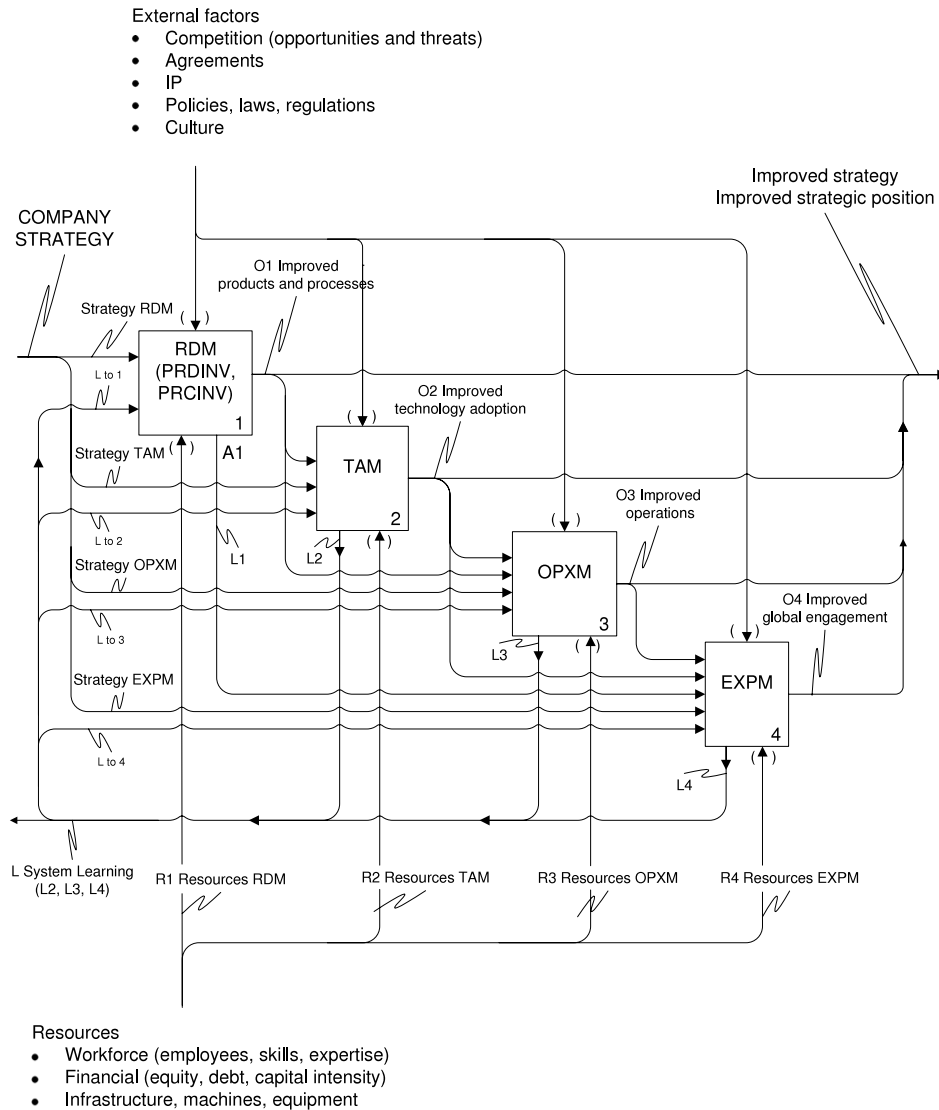


Fig. 3. Node A0: IDEF0–A0 representation of the child functions and relationships.

(RDM—Research and Development Model), technology adoption (TAM—Technology Adoption Model), operational excellence (OPXM—Operational Excellence Model), and global engagement (EXPM—Export Performance Model). Here RDM stands for the function “improve research and development by product innovation and development (PRDINV) and by process innovation and development (PRCINV)”. TAM stands for the function “improve technology adoption”. OPXM stands for the function “improve operational excellence”. EXPM stands for the function “improve export performance”.

In Fig. 3, function RDM has as INPUT the RDM strategy, and a system learning CALL to TAM, OPXM and EXPM for information and data. The OUTPUT, identified as O1, includes research and development results for “improved products and processes”, and O1 (data and objects) serves also as input to functions TAM and OPXM. The function EXPM has a CALL, identified as L1, to RDM for sharing research and development data and information. To perform the function RDM uses the “resources” and follows the constraints imposed by the “external factors”.

In Fig. 3 function TAM has as INPUT the TAM strategy, and a system learning CALL to OPXM and EXPM for information and data. This CALL also includes a self-loop for continuous improvement. The OUTPUT, identified as O2, includes technology adoption results

for “improved technology adoption”, and O2 (data and objects) serves also as input to functions OPXM and EXPM. Function RDM has a CALL to TAM for data and information on technology adoption. To perform the function, TAM uses the “resources” and follows the constraints imposed by the “external factors”.

In Fig. 3 function OPXM has as INPUT the OPXM strategy, and a system learning CALL to EXPM and TAM for information and data. This CALL also includes a self-loop for continuous improvement. The OUTPUT, identified as O3, includes data, information, processes, and implementation for “improved operational excellence”, and O3 serves also as input to function EXPM. Function RDM has a CALL to OPXM for operational excellence data and information. To perform the function EXPM uses the “resources” and follows the constraints imposed by the “external factors”.

In Fig. 3 function EXPM has as INPUT the EXPM strategy, and a system learning CALL to RDM, TAM and OPXM for information and data. This CALL also includes a self-loop for continuous improvement. The OUTPUT, identified as O4, includes data, information, processes, and implementation for “improved export performance”. Function RDM has a CALL to EXPM for export performance data and information. To perform the function EXPM uses the “resources”, and follows the constraints imposed by the “external factors”. Cumulatively, the function outputs, O1, O2, O3,

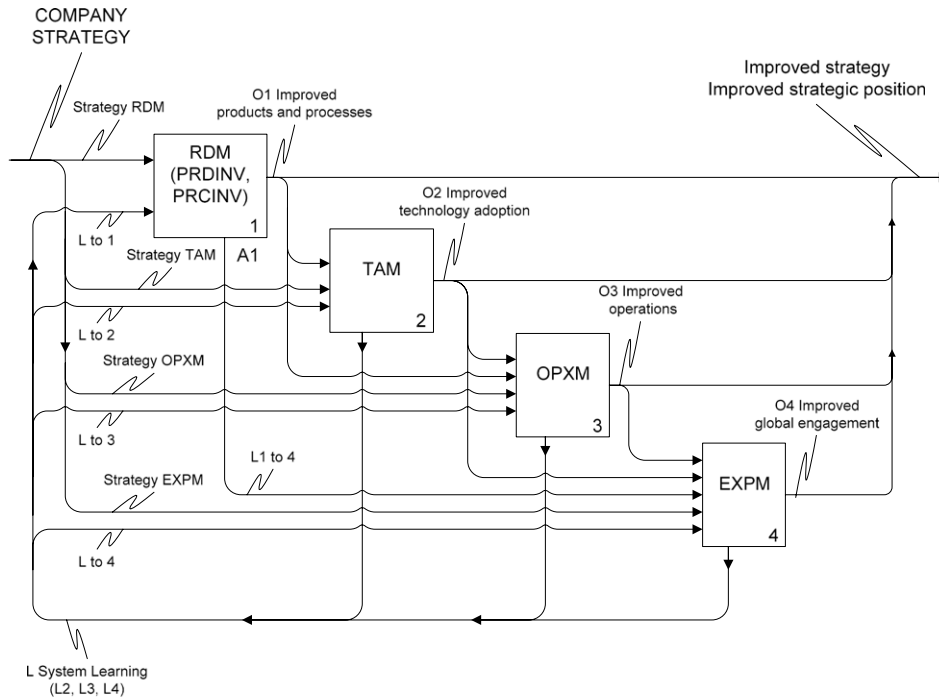


Fig. 4. Node A0: tunneled arrows removed to focus on function input and output relations.

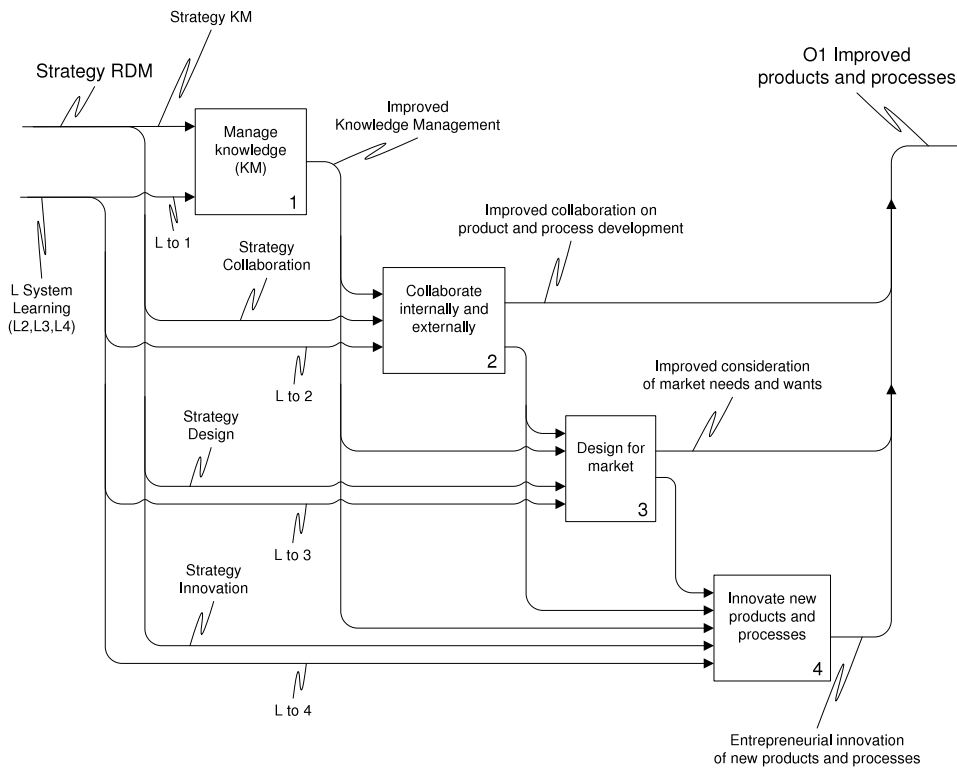


Fig. 5. Node A1: IDEF0–RDM product- and process research and development functions.

and O4, serve the strategic goal of improved strategy and improved strategic positioning.

In Fig. 3, the arrow heads of “external factors” connected to the top of the function boxes have parentheses around them. Similarly, the arrow heads of “resources” connected to the bottom of the function boxes have parentheses around them. The parentheses signify “tunneled” arrows in the model. A “tunneled” arrow, while it continues to exist, may not be shown in all child or parent

model diagrams to simplify model reading and interpretation. Fig. 4 shows the Node A0 with tunneled arrows removed.

In Figs. 3 and 4 under the right-hand corner of box 1, function RDM, there is a label “A1”. This label A1 suggests that Box 1, RDM, has been detailed in an IDEF0 diagram titled “Node A1”. In comparison to strategic planning, this corresponds to providing more specific objectives under a goal. Here the goal, presented by function RDM in Box 1, is to improve research and development

by improved product innovation and development (PRDINV), and by improved process innovation and development (PRCINV), and thereby to improve the company's strategy and strategic positioning.

Fig. 5 shows that improved products and processes (O1) through research and development (RDM) can be accomplished by better knowledge management, enhanced collaboration on product and process research and development both internally and externally, better designs of products for market “needs and wants”, and by engaging in entrepreneurial new product and process innovation.

Similarly, as is shown in Fig. 5, all the other functions (TAM, OPXM, EXPM) can be detailed to objective-level functions, and those again at the next child (child of the grandchild) level to functions representing lower-level objectives and tasks. This process can be continued to any depth and any level of specificity.

5. Summary and conclusions

IDEFO modeling has been primarily used to model and analyze complex systems, study function and interrelation of system components, model system life cycles, and model enterprise operations. Because a company, or an enterprise, and its strategic plan can each be considered to be systems respectively, the IDEFO modeling methodology appears to be well suited for the purpose of strategic plan development as well as operational and strategic management.

This proof-of-concept paper demonstrates how to develop an IDEFO model for strategic planning and strategic management specifically for SMEs. A basic structure, in form of a sequence of examples, for an IDEFO strategic plan and strategic management model is developed, and the development is shown and explained step-by-step. This proof-of-concept demonstrates the power and simplicity of using IDEFO for the complex task of strategic plan and management model development. Because the syntax and semantics of IDEFO are well defined, the resulting model or parts of the model (for a strategic plan and strategic management) become programmable to allow for dynamic model changes and model improvements. The “external factors” and “resources” interfaces can also be programmed to obtain (download) real-time data into the model to add “intelligence” into the model.

References

- [1] Arizona State University, College of Technology and Innovation, Next generation manufacturing study, Arizona aerospace and defense supply chain. Final report. Mesa: Arizona State University; 2011.
- [2] Waissi G, Humble J, Demir M. Competitiveness of small- and medium enterprises of the Arizona aerospace and defense supply chain. *J Logist Manag* 2013;2(1):15–25.
- [3] Porter M. The contributions industrial organization to strategic management. *Acad Manag Rev* 1981;6(1):609–20.
- [4] Porter M. *Competitive advantage: creating and sustaining superior performance*. New York: The Free Press; 1985.
- [5] Porter M. How competitive forces shape strategy. *Harv Bus Rev* 1979.
- [6] Porter M. *Competitive strategy*. New York: Free Press; 1980.
- [7] Porter M. Towards a dynamic theory of strategy. *Strateg Manag J* 1991;95–117.
- [8] Porter M. The five competitive forces that shape strategy. *Harv Bus Rev* 2008; 23–40.
- [9] Lee C, Wilhelm W. On integrating theories of international economics in the strategic planning of global supply chains and facility location. *Int J Prod Econ* 2010;124(1):225–40.
- [10] Tallman S. Strategic management models and resource-based strategies among MNEs in a host market. *Strateg Manag J* 1991;12(Special Issue):69–82.
- [11] Drucker P. *Innovation and entrepreneurship*. New York: Harper & Row; 1985.
- [12] Drucker P. *Management: tasks, responsibilities, practices*. New York: Harper & Row; 1974.
- [13] Gan SS, Pujawan IN, Suparno, Widodo B. Pricing decision model for new and remanufactured short-life cycle products with time-dependent demand. *Oper Res Perspect* 2015;2:1–12.
- [14] Herrmann P. Evolution of strategic management: the need for new dominant designs. *Int J Manag Rev* 2005;7(2):111–30.
- [15] Nelson R, Winter S. *An evolutionary theory of economic change*. Cambridge (MA): Belknap Press of Harvard University Press; 1982.
- [16] Rumelt R. Towards a strategic theory of the firm. In: Lamb R, editor. *Competitive strategic management*. Englewood Cliffs: Prentice-Hall; 1984. p. 556–70.
- [17] Wernerfelt B. A resource-based view of the firm. *Strateg Manag J* 1984;5: 171–80.
- [18] Barney J. Strategic factor markets: expectations, luck, and business strategy. *Manage Sci* 1986;32(10):1231–41.
- [19] Amit R, Schoemaker P. Strategic assets and organizational rent. *Strateg Manag J* 1993;14(1):33–46.
- [20] Kay J. *Foundations of corporate success: how business strategies add value*. Oxford: Oxford University Press; 1993.
- [21] Teece D, Pisano G. The dynamic capabilities of firms: an introduction. *Ind Corp Change* 1994;3(3):537–55.
- [22] Penrose E. *The theory of the growth of the firm*. 4th ed. New York: Oxford Press; 1959.
- [23] Schumpeter J. *The theory of economic development: an inquiry into profits, capital, credit, interest, and the business cycle*. Cambridge (MA): Harvard University Press; 1934.
- [24] Rivard S, Raymond L, Verreault D. Resource-based view and competitive strategy: an integrated model of the contribution of information technology to firm performance. *J Strateg Inf Syst* 2006;15:29–50.
- [25] Mahoney J, Pandian J. The resource-based view within the conversation of strategic management. *Strateg Manag J* 1992;13(5):363–80.
- [26] Bogner W, Mahoney J, Thomas H. Paradigm shift: the parallel origin, evaluation, and function of strategic group analysis with the resource-based theory of the firm. *Adv Strateg Manag* 1998;15:63–102.
- [27] Del Canto J, Gonzales I. A resource-based analysis of the factors determining a firm's R&D activities. *Res Policy* 1999;28:891–905.
- [28] Grant RM. *Contemporary strategy analysis: concepts, techniques, applications*. 2nd ed. Cambridge (Massachusetts): Basil Blackwell Ltd.; 1995.
- [29] Barney J. Firm resources and sustained competitive advantage. *J Manag* 1991; 17(1):99–120.
- [30] Hall R. A framework linking intangible resources and capabilities to sustainable competitive advantage. *Strateg Manag J* 1993;14(8):607–18.
- [31] Greening D, Turban D. Corporate social performance as a competitive advantage in attracting a quality workforce. *Bus Soc* 2000;39(3):254–80.
- [32] Spanos Y, Lioukas S. An examination into the causal logic of rent generation: contrasting Porter's competitive strategy framework and the resource-based perspective. *Strateg Manag J* 2001;22(10):907–34.
- [33] Moore K. “Porter or Mintzberg: whose view of strategy is the most relevant today?” 03 March 2011. [Online]. Available: <http://www.forbes.com/sites/karlmoore/2011/03/28/porter-or-mintzberg-whose-view-of-strategy-is-the-most-relevant-today/>.
- [34] Kor Y, Mahoney J. Penrose's resource-based approach: the process and product of research creativity. *J Manag Stud* 2000;37(1):109–39.
- [35] Hart S. A natural-resource-based view of the firm. *Acad Manag Rev* 1995; 20(4):986–1014.
- [36] National Institute of Standards and Technology, “Announcing the Standard for Integration Definition for Function Modeling (IDEFO),” National Institute of Standards and Technology, NIST, 1993.
- [37] Air Force Wright Aeronautical Laboratories, ICAM architecture part II-volume IV—function modeling manual (IDEFO), AFWAL-TR-81-4023. Ohio 45433: Air Force Systems Command, Wright-Patterson Air Force Base; 1981.
- [38] Cochran L, Wheaton K. *A conceptual operational model for command and control of international missions in the Canadian forces*. Ottawa: FirstMark Technologies Ltd.; 2002.
- [39] The Manufacturing Performance Institute, “2011 next generation manufacturing study, national executive summary,” The Manufacturing Performance Institute, 2011.
- [40] National Science Foundation (NSF), “Next generation manufacturing,” National Science Foundation.