

ENTERPRISE TRANSFORMATION: CONCEPTUAL FRAMEWORKS FOR UNDERSTANDING NONLINEAR GROWTH DYNAMICS

Mark G. Mykityshyn

*Tennenbaum Institute
School of Industrial and Systems Engineering
Georgia Institute of Technology
Atlanta, Georgia 30332 USA*

Abstract: The high technology enterprise is considered as a complex Socio-Technical System (STS). Given the current environment of rapidly changing markets and technologies, many factors affect the operation of such complex systems. The enterprise system operating in this environment is characterized by a high degree of dynamic complexity, variability, and uncertainty, thereby making prediction of its emerging future extremely difficult. Two frameworks are presented that collectively attempt to outline and characterize the nonlinear behavior of emerging growth enterprises. They also attempt to provide context for the study of multi-phase dynamics, add clarity to the variability associated with these dynamics, and serve as the basis for the development of an algorithm-based analysis/predictive tool that will benefit both investors in, and managers of complex enterprise systems. Some existing models, modeling techniques, and theories are suggested that might be employed to help explain the mechanisms underlying these complex phenomena. A range of related future research issues are suggested based on this analysis. *Copyright © 2004 IFAC.*

1. INTRODUCTION AND BACKGROUND

In this paper, the enterprise is treated as a system that is comprised of various resources including technical, human, and financial, among others (Rouse, 2004). The high rates of change characteristic of today's business environment mandate that organizations possess the ability to respond to environmental dynamics in order to capitalize on both opportunities and challenges. Those enterprises that are flexible, adaptable, and understand the underlying dynamics of not only how they can change but are apt to change, are more likely to continue to grow into high performance organizations. Conversely, those enterprises that are less agile and knowledgeable about phase of growth-related dynamics and change tend to be less sustainable over the longer term and ultimately fail. Consequently, a principal function for management is to design and lead the enterprise through a myriad of strategic and operational challenges. These range from transition issues related to phase of growth dynamics to enterprise transformation, defined as a fundamental change in the manner in which the enterprise conducts its business.

Axelrod (2000) notes that such systems challenge understanding as well as prediction due to the large number and heterogeneity of its participants who interact in intricate ways that continually shape their

future. The high technology enterprise is comprised of people (the social system) who are using tools, techniques, technology, and knowledge (the technical system) in order to produce, in this case, a technology-based product and provide it to a market (a broader social system).

Compared to the management of mature enterprises, transformation of the enterprise in the early phases of growth presents a unique challenge to the founding entrepreneurs. In addition to building the enterprise day-to-day, they must, in parallel, focus on building a long-term sustainable enterprise. However, in the process, many do not survive. As evidence from business mortality statistics shows, discontinuance rates can be as high as 70 % in the first five years depending on the industry under study (Timmons 1999, Gruber 2002).

Against this backdrop, the purpose of this paper is to arrive at an integrated understanding of how emerging enterprises either transform into high performance organizations, or fail. The approach is integrated because the paper explores both some of the elemental functions that need to be completed to evolve the enterprise, as well as the characterization of those functions in terms of their uncertainty, dynamics, and nonlinearities. In order to generate a fresh perspective, two novel frameworks are presented. The first, a conceptual phase of growth

framework, provides the context for the study of multi-phase dynamics. The second, a state / phase transition framework, attempts to capture the essence of what's actually happening in each phase. This analysis may help to determine whether or not the enterprise is ready to transition to the next phase of growth, and perhaps predict the outcome of such a transition/transformation.

2. GROWTH DYNAMICS: FUNCTIONS & UNCERTAINTIES

Complex socio-technical problems, by definition, are ill-structured. This means that one or more elements that "define" the problem to be solved may either be omitted from the definition of the problem, or incorrectly represented. Even when problem elements are correctly specified, the relationship among and between these elements may be unknown or obscure, making it difficult or impossible to determine the strength and significance of causal relations.

2.1 *Discontinuance Rates*

As stated earlier, discontinuance rates can be as high as 70 % in the first five years. This might suggest that:

1. Many investment decisions are made in the absence of any quantifiable methodology to understand dynamic complexities, characterize uncertainties, and predict the emergent growth of an enterprise growth and survival;
2. Managers of the enterprise may not fully understand what functions/uncertainties they face. Consequently, they lack clarity on the tasks they need to focus on in order to have the greatest impact, thereby reducing the likelihood for future growth of the enterprise;
3. Sufficient alignment does not exist between investors and management in terms of the criteria that need to be satisfied for the enterprise to secure the appropriate growth capital;
4. The stochastic nature of the processes, where well-informed decisions quite often lead to poor returns because of the inherent probability distribution of returns.

2.2 *Toward Emergent Growth Predictability*

Currently, no tools or methods exist to predict the emergent behavior of an enterprise. Standard tools of decision theory such as risk-benefit analysis, applied economics/cost-benefit analysis, and others

do not provide the robustness for such a tool, nor are helpful in adequately "framing" the problem of predicting the emergent behavior of an enterprise.

The development of such a framework is, in and of itself, quite challenging, partially because the dynamics for each enterprise are different. Consequently, actions taken by both the entrepreneur and investor to put the enterprise on a positive growth trajectory and maintain that trajectory need to be customized to that particular enterprise. That said, it is hypothesized here that if general frameworks were constructed that captured the essence of enterprise growth dynamics, added clarity to the variability associated with these dynamics, and aligned the objectives of both investors and management, enterprise failure rates could be reduced.

One might argue that the mode of operation for a growing, thriving enterprise is one of sustained transition. One might also argue that the "health" of an enterprise is the exact inverse of the health of a person in that, from the time an enterprise is created, it is dying. Action must be taken to keep it alive and growing. The natural law of a company is to fail. Consequently, it is incumbent upon both investors and management of the enterprise to discover the underlying mechanisms for success and facilitate the further growth of that success. Some 'tools' exist to monitor, track and account for "vital signs" of the business. Unfortunately, because there is no such thing as a business steady-state, very few managers of the enterprise will even know if a symptom occurs, much less what to do about it. Even if they did, how could one predict the ultimate success of the enterprise?

Development of such a tool, an algorithm-based analysis/predictive, tool could provide the following benefits:

For Investors:

- As an analysis methodology to understand growth dynamics;
- As an "investment filter" to aide in making better informed decisions;
- Enable them to be approximately right, and not precisely wrong, in assessing the probability of continued enterprise growth.

For Management:

- Endow managers with the ability to quantify current performance, identify obstacles, and predict future success;

- Enable managers to strip away ‘noise and clutter’ to focus on those tasks that have the greatest impact on organizational growth.

3. FRAMEWORKS

In a rapidly changing marketplace where the emerging future of an enterprise is extremely difficult to predict, what actions should management and investors take to ensure growth and hence sustainability over the longer term?

3.1 Phase of Growth Framework

Because of its complexity, this problem must be appropriately structured before it can be solved. The conceptual phase of growth framework outlines the functions/uncertainties faced by entrepreneurs as they attempt to grow the enterprise and distinguishes them in four phases of growth and two dimensions, strategy and operations.

3.1.1 Purpose and Motivation

The purpose of the phase of growth framework is to:

1. Provide an appropriate context for the study of multi-phase dynamics;
2. Determine the extent to which existing models, modeling techniques, and theories might help provide a solutions to this problem;
3. Provide the basis for the development of an algorithm-based analysis/predictive tool.

The phase of growth framework was, in part, based on previous work conducted in the aeronautical systems laboratory at the Massachusetts Institute of Technology (Mykityshyn & Hansman, 1991). In that effort, systems and human engineering design issues associated with an advanced avionics system were explored. Pilot usage patterns concerning the information presented to them on paper Instrument Approach Plates (IAPs), the relative importance of that information, and the point in time they needed it to successfully complete the tasks at hand were investigated.

To facilitate the analysis, it seemed logical to separate the conduct of a flight into various phases in order to fully understand the dynamics of information management and to test for the effects on pilot performance when using this information. Based on empirical pilot performance data, a feature was designed to allow pilots to selectively de-clutter

the electronic display. This enabled the pilot to see only that information that they felt was necessary to successfully complete the tasks required of that phase of flight.

Mykityshyn (2003) hypothesized that a similar approach could be applied to the emergent growth trajectory of a high technology venture. The conceptual framework depicted in Figure 1 is focused on phase of growth-specific functions/uncertainties. If management understood these functions/uncertainties and could “selective de-clutter” day-to-day activities to focus only on those tasks that had the greatest impact on growth, the likelihood that the enterprise would progress to the next phase would be increased.

3.1.2 Structure

The only phenomena of interest here are those functions/uncertainties faced by entrepreneurs, an understanding of which may help to predict the evolution of the firm. The cognition of both investors and managers might relate to their abilities to perceive enterprise states, infer underlying mechanisms, reach understanding of emerging phenomena, and make appropriate decisions. While these cognitive phenomena might influence the firm, this is quite different from predicting the evolution of the firm. This constitutes a different class of phenomena that are not investigated here.

It should also be noted that functions faced by management are also referred to as uncertainties simply because there exists a level of uncertainty in the ability of management to successfully surmount each challenge (Uncertainty is defined in Section 3.2). Consequently, one might also regard the phase of growth framework as a generic uncertainty profile for an emerging growth enterprise.

The growth trajectory of an enterprise has been separated into four phases; functions/uncertainties have been grouped into two dimensions, strategy and operations. Generally, the core foci at the strategic level are developing and/ or acquiring requisite resources and the development of suitable strategies to position the firm relative to its competition (if known). Firm operations are all about the timely execution of tasks and strategies. Building on this general description of management tasking, Figure 1 provides an overview of some of the core strategic and operational functions/uncertainties.

	Phase I	Phase II	Phase III	Phase IV
	<i>Conceptual Design & Innovation</i>	<i>Development</i>	<i>Expansion & Commercialization</i>	<i>Business Maturity</i>
Strategic Dimension				
Corporate/ Executive Management	<ul style="list-style-type: none"> ▪ Create vision, mission, and value structure ▪ Define early organization 	<ul style="list-style-type: none"> ▪ Develop corporate strategy ▪ Formulate strong management team 	<ul style="list-style-type: none"> ▪ Expand board with outside / unbiased directors ▪ Review management skills and experience 	<ul style="list-style-type: none"> ▪ Review long term strategy ▪ Obtain / develop mgt. tools and systems
Operational Dimension				
Operations	<ul style="list-style-type: none"> ▪ Define facilities requirements ▪ Define capital expenditure requirements 	<ul style="list-style-type: none"> ▪ Beta test / customer acceptance ▪ Develop hiring plan, basic R&D 	<ul style="list-style-type: none"> ▪ Review / meet staff needs ▪ Expanded customer base ▪ Review / revise facilities & infrastructure needs 	<ul style="list-style-type: none"> ▪ Obtain / develop operational tools / systems ▪ Review cost structure
Accounting & Finance	<ul style="list-style-type: none"> ▪ Identify start-up costs ▪ Identify capitalization requirements 	<ul style="list-style-type: none"> ▪ Obtain required funding / capitalization ▪ Implement / monitor budget 	<ul style="list-style-type: none"> ▪ Develop or expand accounting systems / infrastructure for expansion ▪ Analyze BE requirements 	<ul style="list-style-type: none"> ▪ Review / implement expense management
Sales & Marketing	<ul style="list-style-type: none"> ▪ Initial market sizing ▪ Competitive analysis 	<ul style="list-style-type: none"> ▪ Establish market for the product and begin sales process ▪ Develop sales & marketing strategies 	<ul style="list-style-type: none"> ▪ Refine pricing strategy ▪ Expand infrastructure ▪ Refine product & company image 	<ul style="list-style-type: none"> ▪ Analyze / expand into new markets ▪ Review / analyze product ROI
Technology / Products & Services	<ul style="list-style-type: none"> ▪ Technical feasibility assessed ▪ Initiate IP protection 	<ul style="list-style-type: none"> ▪ Develop architecture. ▪ Develop prototype 	<ul style="list-style-type: none"> ▪ Refine / standardize development process ▪ Expand product(s) life cycle 	<ul style="list-style-type: none"> ▪ Implement new functionality as required by market

Figure 1. Phase of Growth Framework with Management Functions/Uncertainties

The following assumptions have been made:

- Various business functions are defined early on;
- Failure modes should be (and are) interspersed in a time variant manner throughout the company’s life cycle. Identification and avoidance of these modes should increase the likelihood to progress from one phase to the next.

Phase I: Conceptual Design and Innovation

One core functions/uncertainties is the creation of the firm’s vision, underlying value structure, and market-facing value proposition. Another may be a lack of a defined “roadmap” as to how to build the company, and realizing what and when (phase of growth) different functions are needed.

Phase II: Development

The core challenge here is to plan the company’s construct to a much more rigorous level of detail. The core functions in the development phase are to, (1), ensure that the product concept is under control so that product development can be scheduled and accurately budgeted for, and, (2), establish the market for the product. This is the period of time during which needed improvements are made and

the product is tested and proven to be commercially producible. Also, the team confirms that the product will perform as specified by constructing and testing engineering prototypes or pilot processes, resulting in a tested and proven product.

Phase III: Expansion and Commercialization

During this phase of growth, the focus of the enterprise is developing the product for the purpose of commercialization. A core function for management is to determine how best to strategically position the product within the market to develop a competitive advantage. If the product proves to be technically feasible and has achieved market acceptance, this is usually the demarcation point for further growth and expansion.

Phase IV: Business Maturity

Business maturity is the period of time during which the enterprise secures its market position, reaches cash flow break even or profitability from business operations and, from a product perspective, explores diversification to pursue various markets.

Phase V: Business Transformation

The enterprise has successfully evolved into a healthy and enduring organization. The core objective of this phase is to maintain its competitive advantage and maximize profit potential of the

enterprise. This may require various forms of transformation as opportunities, threats, competitors, and crises emerge. (This phase is not shown in Figure 1.)

3.2 State / Phase Transition Framework

The state / phase transition framework attempts to capture the essence of what's actually happening in each phase. To illustrate the concept, the underlying dynamics and nonlinearity associated with the functions/uncertainties that were presented in the strategic dimension of the phase of growth framework for each phase are evaluated in Figure 2.

Take for example the Phase I function/uncertainty, "Create vision, mission, and value structure". Dynamically, the completion of this function is slow; through discussions and debate, the founders typically cultivate a common understanding of all three. The nonlinearity is elastic since, as more people join and the business evolves, the firm needs to adapt and change so as to maintain its culture, orientation, and business focus.

This type of an analysis may aide investors and entrepreneurs in determining whether or not the enterprise is ready to transition to the next phase of growth. It may also help to predict the outcome of such a transition or transformation.

	Phase I <i>Conceptual Design & Innovation</i>	Phase II <i>Development</i>	Phase III <i>Expansion & Commercialization</i>	Phase IV <i>Business Maturity</i>
Function / Uncertainty	<ul style="list-style-type: none"> ▪ Create vision, mission, and value structure ▪ Define early organization 	<ul style="list-style-type: none"> ▪ Develop corporate strategy ▪ Formulate strong executive management team 	<ul style="list-style-type: none"> ▪ Expand board with outside / unbiased directors ▪ Review management skills & experience 	<ul style="list-style-type: none"> ▪ Review long term strategy ▪ Obtain / develop management systems
Dynamics of Each Function (<i>Slow, fast, time-variant</i>)	<ul style="list-style-type: none"> ▪ Slow ▪ Fast 	<ul style="list-style-type: none"> ▪ Slow ▪ Time-variant 	<ul style="list-style-type: none"> ▪ Slow/time-variant ▪ Slow/time-variant 	<ul style="list-style-type: none"> ▪ Slow/time-variant ▪ Slow/time-variant
Nonlinearity Characterization (<i>Elastic, inelastic</i>)	<ul style="list-style-type: none"> ▪ Elastic ▪ Elastic 	<ul style="list-style-type: none"> ▪ Elastic ▪ Elastic 	<ul style="list-style-type: none"> ▪ Elastic ▪ Elastic 	<ul style="list-style-type: none"> ▪ Elastic ▪ Elastic

Figure 2. State / Phase Transition Framework

The following definitions apply to Figure 2:

- **Uncertainties:** Uncertainty is an unavoidable aspect of entrepreneurship and yet is essential to the existence of future opportunities (McGrath, 1996). The root cause of entrepreneurship-based uncertainty stems both from a lack of knowledge, and a lack of clarity/definition about goals and objectives, vagueness in the definition of functions, etc. This is especially acute in the earlier phases since no "roadmap" exists to build the enterprise.
- **Phase Dynamics:** The enterprise is considered as a dynamically complex system and must react to change. Many factors affect the operation of such complex systems and may vary as a function of time or be time-invariant. Here, certain core functions/uncertainties from the contextual phase of growth framework are characterized as either fast, slow, or time-invariant;
- **Nonlinearities:** Organizational behavior is inherently nonlinear (i.e., not simply a linear

extrapolation of past behaviors) and results may not be in proportion to corresponding actions. Here, the core functions/uncertainties from the contextual phase of growth framework are characterized as either elastic or inelastic.

4. STATE / PHASE TRANSITION MECHANISMS AND MODELING

Change and transformation are inherent qualities of enterprise systems. Enterprise systems tend to operate away from equilibrium; the mode of operation is one of constant and sustained transition.

It appears that phase transitions happen for one or more of the following reasons:

1. The dynamics of the enterprise move it forward, or back;

2. The dynamics of the industry carry the enterprise forward or back;
3. Decisions by either management of the enterprise or its investors carry it forward or back.

Enterprise Dynamics: The core functions needed to secure future growth are an appropriate capital structure and those resources that enable the enterprise to gain and maintain competitive advantage. The dynamics associated with these functions could be modeled either dynamically from first principles, statistically using historical data, or by a hybrid approach using both techniques.

Industry Dynamics: Variability may exist depending on whether or not an industry is established or emerging. Regardless, the competitive “landscape”, is constantly evolving. Gaining and sustaining competitive advantage in the midst of industry turbulence is the prime determinant of new product success. Market dynamics could also be modeled either dynamically from first principles, statistically using historical data, or by a hybrid approach using both techniques.

Management/Investor Decision Dynamics: The ability of both investors and managers to perceive enterprise states, infer underlying mechanisms, reach understanding of emerging phenomena, and make appropriate decisions can have a substantial impact the enterprise. First principles of decision theory, and/or various rule-based formulations could be used as the basis for an agent-based model of these dynamics. Such a model could be used to represent the collective emergent behavior of these decision makers.

5. SUMMARY & CONCLUSIONS

The analysis and discussion in this paper is the first step toward the development of an algorithm-based analysis/predictive tool that can be applied to enterprise transformation. Such a tool currently does not exist. The phase of growth framework outlined some hierarchical functions/uncertainties faced by entrepreneurs. An initial treatment of the finer points and subtleties such as dynamics, nonlinearities, and/or discontinuities associated with functions/uncertainties was presented in the state/phase transition framework. A treatment of the dynamics and interdependencies of decisions, relationships, and skills is left to future research. This analysis may help us determine whether or not the enterprise is ready transition to the next phase of

growth, and perhaps predict the outcome of such a transition/transformation.

REFERENCES

- Cohen, M.: “*Harnessing Complexity*”, 2000
- Gruber, M.: “*Transformation as a Challenge: New Ventures on their* Hastings, D., & McManus, H. (2004) “*A Framework for Understanding Uncertainty and its Mitigation and Exploitation in Complex Systems*”, 2004 Engineering Systems Symposium, Massachusetts Institute of Technology, Cambridge, MA
- McGrath, R. G.: “*Options and the entrepreneur: Toward a strategic theory of entrepreneurial Behaviour*”. Working Paper Columbia University, New York 1996.
- Mykityshyn, M., and Hansman, R.J.: “*Design and Evaluation of Advanced Electronic Cockpit Displays for Instrument Approach Information*”, Masters Degree Thesis, Massachusetts Institute of Technology, Cambridge, MA, 1991
- Mykityshyn, M.: “*Toward an Understanding of Dynamic Complexity in Emerging Growth Technology Ventures*”. Working Paper Georgia Institute of Technology, 2003
- Pritchett, A, et.al.: “*Examining Air Transportation Safety Issues Through Agent-Based Simulation Incorporating Human Performance Models*”, 2004
- Rouse, W.: “*Engineering Complex Systems: Implications for Research in Systems Engineering*”, IEEE Transactions on Systems, Man, and Cybernetics, Part C: Applications and reviews, VOL.33, NO 2, May, 2003
- Rouse, W.: “*Enterprises (As) Systems*”, Presented at the 2004 IFAC Conference, Atlanta, GA, September, 2004
- Sproles, N. 2000 a, *Coming to Grips with Measures of Effectiveness*, Systems Engineering, the Journal of the International Council on Systems Engineering, Vol.3, No.1, 2000, John Wiley & Sons, New York, NY, USA
- Timmons, J. A.: *New Venture Creation – entrepreneurship for the 21st Century*. New York 1999.

