The Principles of Enterprise Engineering

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Abstract. A century ago, Taylor published a landmark in the organizational sciences, his Principles of Scientific Management. Many researchers have elaborated on Taylor's principles, or have been influenced otherwise. The authors of the current paper evaluate a century of enterprise development, and conclude that a paradigm shift is needed for dealing adequately with the challenges modern enterprises are facing. Three generic objectives are identified. First, employee empowerment; modern employees are highly educated knowledge workers; yet, the mindset of managers has not evolved accordingly. Second, mastering complexity; current approaches fall short in mastering the complexity of enterprises and enterprise changes. Third, unity and integration; this can only be achieved by deliberate enterprise design. The emerging discipline of Enterprise Engineering is able to achieve these objectives satisfyingly. It does so by providing new, powerful ideas and intellectual techniques, collected in the Principles of Enterprise Engineering.

Key words: Scientific Management, Enterprise Engineering, Enterprise Governance, Enterprise Ontology, Enterprise Architecture.

Introduction

A century ago, Frederic Winslow Taylor published his famous paper, titled "The Principles of Scientific Management" [1]. In the present paper we take the anniversary of Taylor's seminal paper as an opportunity to look back at a century of theory and practice in enterprise[1] development, to assess the current state, and to propose a radical new way of addressing current problems, under the name of 'Enterprise Engineering'.

Typical characteristics of the scientific management approach are the minute division of labor in simple, repetitive tasks, and the clear separation between thinking and doing. Workers are instrumentally viewed as parts of the enterprise 'machine'. According to Taylor, a man fit to do the manual work is however unfit to understand the science of doing his work. Hence, managerial control is essential. Taylor's perspective is supported by contemporary writers, such as Henri Fayol [2] and Max Weber [3].

[1] With "enterprise" we refer to all kinds of organized activity (like companies, governmental agencies, health care institutions, and building projects).

Over the years, scientific management has contributed to significant increases in the productivity of enterprises. Nonetheless, the approach has been heavily criticized. Basically, two kinds of criticisms can be identified. The first one regards ethical considerations concerning the deployment of human capacities in enterprises. Various researchers have argued that the principles of scientific management lead to worker deprivation and alienation, and to destroying the meaning of work itself [4, 5, 6]. These phenomena were already visible a few years after Taylor published his paper, when his principles were practiced in Ford car manufacturing: workers' jobs were depleted of skill, autonomy and control, leading to extreme worker turnover rates [7]. Contenders of Taylor thus argue the importance of employee development, self-initiated behavior, and self-control.

Considerations concerning the effectiveness and efficiency of enterprises constitute the second kind of criticism. Essentially, the critique boils down to two aspects. First, the notion that proper attention to employees as a social group can significantly enhance enterprise effectiveness and efficiency, as for example, evidenced by the classical Hawthorne studies [8]. Noteworthy within this perspective is the 'socio-technical approach' – introduced by the seminal work of [9] – that argues the mutual relationship between the social and technological 'system' of an enterprise. Hence, these systems must be jointly designed since they can mutually support each other to enhance enterprise effectiveness and efficiency. Second, it is argued that the mere instrumental view on employees – workers as resources for labor – undervalues human cognitive and intellectual capacities. This shift in focus is evidenced by landmark publications like [10], [11], and [12]. The shift in focus considers employees, and their involvement and participation, as the critical core for enterprise success. Rightly so, Drucker considers aspects of human behavior as the primary concerns of management science [13]. Hence, "the test of a healthy business is not the beauty, clarity or perfection of its organizational structure, it is the performance of people" [13, p. 602].

Next to the involvement of employees for productivity improvement, said involvement is further essential for a focus on quality, as well as on service and customer orientation [14]. Moreover, one might observe that the character of work for a considerable part has shifted from physical labor to intellectual labor: creating, processing, integrating and applying knowledge [15, 16]. It is virtually all about making knowledge productive [17]. Within this perspective, enterprise learning[2] is, and will increasingly become, an indispensable competence. Learning is a prerequisite for innovation, adaptation and change. Again, the focus on employees is crucial. Evidently, a learning enterprise is inconceivable without individual learning of employees, on whose skills and commitment enterprise learning depends [18, 19]. This type of learning acknowledges the non-planned, emerging character of many enterprise developments [20].

Progress in the area of information and communication technology (ICT) has enabled the creation of massive amounts of data associated with enterprise processes. Work is no longer merely automated (to enhance productivity), but 'informated' [22]. As indicated earlier, work has almost become synonymous with 'knowledge work': the proc-

[2] In the traditional organizational sciences this notion is commonly referred to as 'organizational learning'.

essing of physical assets is increasingly replaced or complemented by the processing of intellectual assets [15, 17]. Making knowledge productive thus amounts to integrating knowledge (information) into a common task [op. cit.]. Creating and sharing knowledge is considered crucial for gaining competitive advantage [23]. Evidently, this holds likewise for the competence of enterprise learning. It seems superfluous to stress the importance of ICT for enterprise learning, hence for the ability to improve, adapt, and change. Without enterprise learning, these changes cannot be established.
From the perspective of the 'relationship economy' the new capabilities and possibilities created by information and communication technology are essential for successfully pursuing long-standing relationships with customers, and for employees supporting them. The vast amount of actions and data pertinent to customers, and their relationships, desires and needs, can only be meaningfully and effectively addressed with the help of ICT. Deep support cannot take place outside the digital medium [21]. Additionally, ICT makes customer self-support possible and valuable. Moreover, since establishing relationships cannot take place within the principles of the transaction economy, the nature of ICT utilization must change; not only for effectuating customer support and proactively exploiting the relationship in a value-adding manner, but also for making the economic value of customer relationships explicit.
Finally, one can observe the increasing 'commoditization' of basic products and services. Customers can easily switch between suppliers of commodities. However, highly valued individual supportive relationships with customers are anything but a commodity. Hence, they can create a considerable competitive advantage.

Over the years, various other approaches have been proposed in addition to, or as a replacement for, Taylor's principles of scientific management in order to enhance enterprise performance. The list is impressive: Activity-Based Costing, Balanced Score Card, Business Process Management, Business Process Reengineering, Customer Relationship Management, E-business, End-to-End (Supply) Chain Management, Enterprise Resource Planning, Lean Production, Learning Organization, Mergers and Acquisitions, Quality Function Deployment, Six Sigma, Total Quality management, and so on. Many, if not all, of these initiatives heavily depend on the successful utilization of ICT services.
Based on reviews of these approaches, their successful application in enterprises is limited: the majority of initiatives fail [20]. Also from the general perspective on enterprise strategic initiatives, the picture is not overly favorable. Mintzberg speaks of less than 10% success rate [24]. Other sources show comparable figures. According to Kaplan and Norton, many studies show that between 70% and 90% of strategic initiatives fail, meaning that the expected results are not achieved [25]. Whereas all too often, for convenience sake, unforeseen or uncontrollable events are presented as the causes of failure, research has shown that strategic failure is mostly the avoidable result of inadequate strategy implementation. Rarely is it the inevitable consequence of a poor strategy [25]. A plethora of literature indicates that the key reason for strategic failures is the lack of coherence and consistency, collectively also called congruence, among the various components of an enterprise [28, 29, 27, 31, 32, 14, 26, 33, 34]. At the same time, the need to operate as an integrated whole is becoming increasingly important. Globalization, the removal of trade barriers, deregulation, and so on, have led to networks of cooperating enterprises on a large scale, enabled by the enor-

mous possibilities of modern ICT. Future enterprises will therefore have to operate in an even more dynamic and global environment than the current ones. They need to be more agile, more adaptive, and more transparent. Moreover, they will be held more publicly accountable for every effect they produce.

Creating a unified and integrated enterprise is by no means simple. An enterprise is an intentionally created entity of human endeavor [35, 36]. Enterprises are organized complexities [37]: highly complex, as well as highly organized. Unlike problems of 'organized simplicity' that can be dealt with analytically, or problems of 'unorganized complexity' that can be addressed statistically, the large problem area of 'organized complexity' is in need of a formal approach [37]. The apparent lack of a theory for addressing the problem of organized complexity was mentioned decades ago as a core problem confronting modern science [39, 40].

Motivation for Enterprise Engineering

As stated, an enterprise is an intentionally created entity of human endeavor with a certain purpose. The intentional character of enterprise creation requires design activities. For some, the term 'design' in the context of enterprises has uncomfortable connotations, as it is associated with mechanistic approaches to enterprises: arranging them as if they are machines. The 'social engineering' label is sometimes used to identify the mechanistic view on organization and management [38]. This approach essentially equates management with control, with the associated conviction that by using certain 'controls' management is able to steer the enterprise 'machine' (top-down) within the desired range of operation. The enterprise is thereby assumed to be an objective entity, external to management, which, like a machine, merely needs to be controlled. This appears to be the perspective espoused by Taylor; it has been criticized above. Our notion of design, however, must be interpreted broadly and seen as devising "courses of action aimed at changing existing (enterprise) situations into preferred ones" [41, p.111]. Ultimately, on the one hand design concerns understanding the strategic intentions that are to be operationalized, and on the other hand, arranging this to happen. As Winograd and Flores put it: design concerns "the interaction between understanding and creation" [42, p.3]. The discipline of enterprise engineering should thus be viewed broadly from this perspective.

The focus on design has enormous practical implications, and is associated directly with strategic and operational enterprise success [43]. Unfortunately, the importance of design is not generally recognized by management. A fairly recent McKinsey report argued that "Most corporate leaders overlook a golden opportunity to create a durable competitive advantage and generate high returns for less money and less risks: making organizational design the heart of strategy" [44, p.21]. Managers traditionally focus on structural arrangements for enterprise change; however, "They would be better off by focusing on organizational design" [44, p.22]. Hence, "Organizational design, we believe, should be about developing and implementing corporate strategy" [44, p.25].

Over the years (academic) insights have been developed about how to (1) enhance the effectiveness and efficiency of enterprises, (2) effectively ensure quality, service

and customer orientation, and (3) avoid core reasons for strategic failure. One would expect that a century after Taylor published his principles of scientific management their influence would have vanished. However, it appears not to be the case. As Doz and Thanheiser observed at the end of the former century: "Despite the 'modernization' of corporate structures and systems, the mindset of managers appears to be remarkably similar to the Taylorist model developed at the beginning of the century" [45, p. 296]. Thus, principles that follow from "a machine-like concept of the organization still dominate managerial practice" [45]. Others argue that "Corporations continue to operate according to a logic invented at the time of their origin, a century ago" [21]. Specifically concerning the use of ICT, the picture seems not radically different. Despite the alternative perspectives to Taylor presented before – including the value-adding, competitive use if ICT – the Taylorist influence appears still remarkable. For example, the Butler group "has consistently found that management in 9 out of 10 companies have never considered the use of IT other than achieving labor replacement" [46, pp 7-9].

The continuation of the Taylorist model can additionally be demonstrated by observing the increase in the number of management functions. For example, in the country where Taylor expressed his views, managers accounted for less than 1% of the labor force in 1900. Thirty years later this figure was already 7.5%, increasing to 10.5% by 1970. By 1990, the figure was approaching 14% [47]. These increases must be understood against the background of increasing population and workforce. Others have given comparable data concerning the magnitude of management positions and the associated administrative burden [48].

The increased population of managers largely consists of people who believe that management is a profession like other professions. As Edward Deming, the renowned quality and productivity leader, observed: "Students in schools of business in America are taught that there is a profession of management; that they are ready to step into top jobs. That is a cruel hoax" [49, p. 130]. This 'hoax' resulted in the widely observable management crises. An article in the Standardization News (1983) stated that "Practical all our major corporations were started by technical men – inventors, mechanics, engineers, and chemists, who had a sincere interest in the quality of products. Now, these companies are largely run by men interested in profit, not product. Their pride is the P&L statement or stock report" [49, p. 131]. Detrimental effects of these developments have been documented pertinent to the American automobile industry [50]. Not surprisingly, a recent Time article correlated the rise of business schools with the fall of American industry [51].

Such a paradigm shift is provided by the emerging discipline of Enterprise Engineering. It amounts to a theory-based methodology for addressing enterprise (re-) development in an all-encompassing way. A sound and rigid theoretical foundation is crucial. As Deming states: "Experience alone, without theory, teaches management nothing about what to do to improve quality and competitive position, nor how to do it" [49, p. 19]. In view of our previous discussion, and the tenacity of Taylor's principles, little learning seems to have taken place. We posit that an Enterprise Engineering theory is required to give experience meaning, and to provide the basis for appropriately understanding enterprises.

It is the aim of Enterprise Engineering to be theoretically, conceptually, and methodologically complete, in pursuing the next three generic objectives:

Unity and integration
In order to perform optimally and to implement changes successfully, enterprises must operate as a unified and integrated whole, taking into account all aspects that are deemed relevant. Many approaches to enterprise engineering are ill suited and suffer from theoretical and methodological weakness and incompleteness. It is evidently not sufficient to consider enterprise design domains like processes, the information relevant for the processes, the applications providing the information, and their underlying infrastructure. A viable theory and methodology for enterprise engineering must be able to address all relevant aspects, even those that cannot be foreseen presently, such that the operating enterprise is always a coherent and consistent whole.

Mastering complexity
Proper theories about the construction and operation of enterprises are needed, next to powerful means for mastering complexity, in order to intellectually manage enterprise changes. Enterprise phenomena that are not fully understood cannot be effectively addressed. Hence, the nature of necessary changes cannot be determined; consequently they cannot be brought about effectively. In addition, current development approaches, both for enterprises as a whole and ICT applications in particular, are cursed with combinatorial impacts of changes, which make their implementation slow and practically unmanageable. New and proper ideas of enterprise evolvability are needed for making changes expeditious and manageable.

Employee involvement
Contrary to Taylor's mechanistic view on organizations, Enterprise Engineering takes a human-centered view. Enterprise Engineering considers human beings to be the 'pearls' of every enterprise. Therefore, all employees should be fully empowered for the tasks they have to perform. They must be endorsed with transparent authority and have access to all information they need in order to perform their tasks in a responsible way.

The theories and concepts on which Enterprise Engineering is based can address these three generic objectives successfully. A detailed outline of the methodology of Enterprise Engineering exceeds the scope of this article, and is discussed elsewhere [52, 53, 20, 54]. For now, we limit ourselves to presenting the principles on which Enterprise Engineering is founded.

The Enterprise Engineering Principles

In order to address the generic objectives of enterprise engineering, we have formulated seven principles for dealing effectively with enterprise changes, which may range from small ones (like installing a new e-mail system) to major transformations (like mergers and acquisitions).

Principles 1 and 7 are visionary principles. They convey our conviction that the employees of an enterprise primarily constitute the enterprise, and that consequently

they must get the proper empowerment to perform optimally. Put differently, in our view, enterprises are participatory networks of competent people. The employees of an enterprise (including both workers and managers) also collectively constitute the enterprise's identity. In economic terms, they are the most precious assets. Everything else only serves to support them in doing their work. Principles 1 and 7 are the primary means to achieve employee empowerment. Principles 2 and 3 serve to make enterprise changes intellectually manageable. They constitute the theoretical basis for understanding enterprises in a proper way, i.e. by doing justice to their inherent nature of being social systems. Principles 5 and 6 serve to make enterprise changes practically manageable. They guide the implementation of changes in such a way that unity and integration are achieved, paired to avoiding combinatorial explosions of change impacts. Principle 4 is the pivot principle, connecting intrinsically the more analytic principles 2 and 3, and the more synthetic principles 5 and 6. All of them contribute to the objectives of mastering complexity and achieving unity and integration.

Principle 1: distributed operational responsibility

Employee empowerment implies that as much responsibility as possible is given to the individual employees. It does not go along with strong hierarchical control mechanisms. As it turns out, and as will elaborated in principles 2 and 3, many management or control measures are counterproductive and redundant. This is a common observation in numerous enterprise studies that have been undertaken with DEMO[3]. A typical example is the organizing of one's work. It is our conviction that the ideal person to organize work is the worker him- or herself, provided that he/she has access to the information needed. Responsibility is the natural response of a human being to whom full authority is assigned for performing a task or fulfilling a role. Moreover, responsible employees are dedicated to achieve the optimal performance of an enterprise in all aspects. There is ample practical evidence for our conviction, as exemplified by enterprises like Alcoa Inc, W.L. Gore & Associates, Nordstrom, and Semco.

Therefore, we consider it to be an ethical necessity to bestow authorities on the employees of an enterprise, and having them bear the corresponding responsibility. The prerequisite is that they fully understand their role(s) in the enterprise. This entails that the employees are enabled to internalize the (relevant parts of the) ontological model of the enterprise, as elaborated in principle 4. Bearing responsibility includes that these employees constantly validate the correspondence of the ontological model with the operational reality and take appropriate measures in case of deviations.

A typical demonstration of the validity of principle 1 can be found in the current application of DEMO within the Royal Netherlands Marechaussee, which is a gendarmerie force performing military police and civil police duties[4].

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[3] DEMO is an acronym for Design and Engineering Methodology for Organizations. It is a pioneering methodology in Enterprise Engineering, based on the theoretical basis as laid down in [Dietz 2006] and [Dietz 2008]. See also www.ee-institute.com.

[4] A short description of the study can be found on www.ee-institute.com.

Principle 2: transaction based organization

The operating principle of enterprises is that the employees, together with representatives of the customers and the suppliers, enter into and comply with commitments regarding the products (services) that they cooperatively produce. This very basic observation makes enterprises primarily social systems, of which the elements are human beings in their role of social individuals, bestowed with appropriate authority and bearing the corresponding responsibility.

Commitments are raised and complied with in universal coordination patterns, called transactions, between two actor roles: the initiator (consumer) and the executor (producer). The two actors are fully authorized and responsible for performing all steps in the universal transaction process [52]. The notion of transaction holds for all activities in an enterprise, including e.g. managerial tasks.

The deep structure of every enterprise process is that it is a tree of transactions. Every observable process (instance) is some path through a transaction tree. The executor of a transaction is fully and only responsible for the delivered result. In order to live up with this responsibility, he/she may feel the need to initiate a number of other transactions, of which the results become components of the end result. In particular, he/she is responsible for negotiating delivery times of the components and subsequently provide the delivery time of the end result. Hence, the arrangement of work – which Taylor completely reserved for managers – is back again with the employees.

Note that current business process modeling approaches, even the most popular ones (like BPMN, ARIS/EPC and Petri Net) completely ignore this underlying structure, whereas the recognition and application of the universal transaction process provides for an enormous contribution to mastering the complexity in understanding the construction and operation of enterprises.

There is no typical application of DEMO for demonstrating the validity of principle 2. In all of the hundreds of studies performed in the past decades, the notion of the universal transaction process has been crucial for the appropriate understanding of an enterprise, and for mastering its complexity. Moreover, principle 2 is not limited to the operational processes in an enterprise. It is applicable to all activities, as demonstrated in [55]

Principle 3: actor based modularity

The complexity of enterprises necessitates a division of tasks to be performed. It is neither effective nor efficient to let every employee do all tasks. Put differently, there is a need for task differentiation. Because the enterprise must operate as a unified whole, task differentiation must be properly paired to the integration of the distinct tasks. The organizational sciences have for long recognized the non-trivial issue of differentiation on the one hand, and integration on the other [56, 36]. Despite this recognition, however, an effective approach to address the issue is still lacking. In our experience, hierarchical schemes, or pseudo (value oriented) process schemes are of little use.

The notion of transaction (principle 2) implies the notion of elementary actor. An (elementary) actor role is defined as the amount of authority and responsibility to be

executor of a transaction kind, which has exactly one kind of result (e.g. concluding an insurance policy or buying a house). Actor roles are the atomic building blocks of the ontological model of an enterprise [52]. In addition to being the executor of one transaction kind, an actor role may be initiator of a number of transaction kinds. An actor role may be fulfilled simultaneously by several persons (in parallel or collectively), and a person may simultaneously fulfill several actor roles.

Constructing enterprises by applying actor roles as the elementary building blocks provides another major contribution to mastering the complexity of enterprises and enterprise changes. In addition, it is the best guarantee that even the most encompassing enterprise changes will not lead to severe combinatorial explosions of effects. An interesting extension of this idea towards software engineering is presented in [57], where the notions of service and of business component are based on this organizational building block. The same idea of elementary building blocks can be applied to software engineering, as is demonstrated by the Normalized Systems approach [56].

Like it was the case for principle 2, there is no typical application of DEMO for demonstrating the validity of principle 3. In all studies performed in the past decades, the notion of actor role has been as crucial as the universal transaction process for appropriately understanding the construction and operation of an enterprise, and for mastering its complexity.

Principle 4: technology independent essence

Taking advantage of the notion of transaction that we have adopted (principle 2), we now abstract from the technology with which transaction steps are performed. For example, we focus on the essence of a request being made by actor A towards actor B, and disregard the particular way in which the request is made knowable to B (e.g. by face-to-face communication, by postal mail, or by e-mail). Secondly, we also abstract from all transaction kinds of which the result is informational or documental, because they do not necessarily need human competence and authority. Informational transactions include the remembering and recalling of information as well as the computing of information. Documental transactions include storing, retrieving, copying, and transmitting data. Modern ICT can effectively take over the production of informational and documental tasks. Only original transactions, in which truly new facts, like decisions and judgments, are produced, need human actor role fulfillers.

Focusing on the original transactions – thus, where the product or service consists of decisions, judgments, manufacturing, etc. – while at the same time abstracting from the technology with which transaction process steps are performed, provides us with the third major contribution to mastering complexity. Combined with the ones from principle 2 and principle 3, a reduction of the size of models is achieved that amounts to well over 90%. The typical size of the diagram in which the so-called essential model of DEMO is represented, is an A4 or A3 sheet of paper for a small or medium sized enterprise.

At the same time, the represented ontological essence of the enterprise contains all relevant elements. Moreover, it has been arrived at in a structured and controlled manner, and the way back to the implementation level is again structured and controlled. Current modeling techniques, like BPMN and ARIS/EPC, are totally unable

to achieve such an abstraction, because they lack a theoretical basis of proper and powerful ideas, like the ones presented in principles 2 and 3.

A typical demonstration of the validity of principle 4 can be found in the current application of DEMO in the post merger integration of the cargo divisions of Air France and KLM[5]. Without the insight and overview that is offered by the essential model (on an A2 sheet of paper!), such integrations are unmanageable. The complexity of modern organizations can only be managed intellectually if all change initiatives are based on the essential model of the organization. In addition, the correctness of an implemented change can only be validated from the essential model.

Principle 5: function construction alternation

Unity and integration in implementing strategic change initiatives can only be established through deliberate re-development of the enterprise, where development includes (ontological) design, engineering (in the narrow sense, i.e. implementation design), and implementation. In this process, the conscious distinction between a system's function and construction, and the insight in their alternating roles in system development, is of paramount importance. To start with, only the construction of a system is objective. A constructional model (or white-box model), like the essential (ontological) model of an enterprise, can always be validated from the actual construction. Contrarily, a functional model (or black-box model) is by its very nature subjective, because function is not a system property but a relationship between a system and a stakeholder. Consequently, every system has (at any moment) one construction, but as many functions as there are stakeholders. All these functions are brought about by the (same and only) construction. Next, the construction of a system as a composition of sub systems can only be understood through the alternating roles of function and construction. As an example, the functional specifications for the engines of an aircraft are derived from the constructional model of the aircraft, not from the aircraft's functions. In addition, the actual construction of the engines is immaterial for understanding the construction of the aircraft.

Let us call the system to be designed the object system, and every stakeholder point of view a using system [53]. We conjecture that the integrity of a development process can only be ensured if it starts from the ontological (construction) models of the using systems. Based on these models, the functional model of the object system is designed. Next, the ontological construction model of the object system is designed. Starting from this model, the engineering of the object system can take place, as a model driven process of including more and more technology dependent details, until the implementation model is arrived at.

A logical consequence of principle 5 is, that it makes no sense to develop enterprise information systems, starting from the goals of the enterprise (although many approaches makes one believe so). Another consequence is, that business IT alignment can never be achieved through IT governance (although many approaches makes one believe so), because one lacks the knowledge of the business, i.e. the construction of the enterprise. A third important consequence is the insight that every

[5] A short description of the project can be found on www.ee-institute.com.

operational enterprise information system is some implementation of (some part of) the essential model of the enterprise. Since in current information system development practice, essential models of the supported enterprise are not produced, one should not be amazed that these systems (including parameterizable ERP systems) do not meet customer expectations. A very interesting new way of developing information systems, founded on the basic insight of principle 4, is presented in [59].

A typical demonstration of the validity of principle 4 and 5 can be found in the application of DEMO in the modeling of granting subsidies on different governmental levels[6].

Principle 6: strategy-operation alignment

It is one thing for an enterprise to have clear strategic goals and areas of concern, derived from a broadly sustained mission statement. It is quite another thing to have all operational details in the enterprise's organization fully compliant with them. The challenge is to align strategy and operation in a satisfying way.

To ensure that an enterprise operates in a unified and integrated manner, and in compliance with its strategic intentions and areas of concern, the development process of enterprises and of their supporting systems must be controlled by functional and constructional normative principles, which guide the (re-) development of the enterprise, in addition to the applicable specific functional and constructional requirements. A coherent, consistent, and hierarchically ordered set of such principles for a particular class of systems is called an architecture. The collective architectures of an enterprise are called its enterprise architecture.

The notion of architecture can best be conceived as the deliberate restriction of design freedom, which comes in addition to the specific functional and constructional requirements in (re-) designing an organization. It is expressed in (functional and constructional) design principles regarding a number of areas of concern and applied in one or more enterprise design domains [53, 20]. As emphasized before, this approach methodologically addresses the enterprise in all its facets. So, for example, the concern for motivated employees must be addressed through appropriate design principles that are applied in relevant enterprise design domains. An extensive study of architecture principles is contained in [60].

A typical demonstration of the validity of principle 6 can be found in a study on developing architectures at KLM Cargo[7].

Principle 7: distributed governance responsibility

For continuously maintaining unity and integration in the (re-) development and operation of an enterprise, organizational measures are needed that exceed operational responsibilities and tasks (including management). These measures are collectively called governance. Hence, unlike operational management ('running the mill') gov-

[6] A short description of the project can be found on www.ee-institute.com.
[7] A short description of the project can be found on www.ee-institute.com.

ernance concerns enterprise adaptation and renewal ('changing the mill').Very often, the responsibility for taking and applying such measures on a continuous basis, usually called enterprise governance, is assigned to higher levels of management. Factually, this amounts to the continuation of the Taylorist separation of thinking (management) and doing (workers): the locus of knowledge and control rests with executive management. Such an approach is inherently problematic and dysfunctional [20].

Indeed, how could executive management possibly know and comprehend all internal (operational) issues and external developments that necessitate enterprise change and adaptation, and translate them in top-down directives that would innovatively yield a new, adapted, unified and integrated enterprise? We posit, however, that it is essential to extend the notion of employee involvement also to the realm of enterprise governance. All employees are considered creative sources for (bottom-up) enterprise improvements and adaptation. Of course, they must be enabled and competent to do so. In order to ensure coherence and consistency in the development and implementation of new ideas and ways of working, a central governance capability must be exercised at the holistic enterprise level. This central guiding governance capacity utilizes the enterprise engineering theory and methodology for achieving the generic objectives mentioned before.

Note that IT governance is an integral part of enterprise governance, despite the many views that do not acknowledge or adequately operationalize this notion due to the absence of a focus on enterprise-wide design [61, 62].

Discussion

Enterprises are purposeful entities of human endeavor, and they come in a wide range of forms and dimensions. Arguably, society is largely constituted and dominated by enterprises. For healthcare, education, transportation, or the production and acquisition of commercial and governmental goods and services, individuals depend on, and are influenced by, the characteristics and performance of enterprises, as ~~a~~ citizen, consumer or employee. Hence, the characteristics and performance of enterprises has a bearing on the quality of individual life and society at large: societal and environmental conditions, the quality of work and private life, individual physical and mental health, and economical circumstances: they all are impacted by enterprises.

As we have seen, almost all (94%) manifestations of inadequate enterprise performance are the inevitable results of how enterprises are arranged [49]; the underlying causes are 'common causes'. Only a limited percentage (6%) of inadequate enterprise performance manifestation are attributable to employees ('special causes'). Put differently, poor quality or service, alienated customers and employees, inefficiency, low productivity, waste of human, natural or financial resources, burn-outs, financial crises, or failing disaster recovery (to name but a few), are all the inevitable consequences of the very nature of enterprises producing these effects. Yet, within the planning and control (Taylorist) mindset of managers, virtually only attention is paid to 'special causes', leading to even more employee control with no, or detrimental effects. All too often, this mindset is combined with relentless focus on short-term financial gain.

In view of the enormous impact that enterprises have on individual and societal well-being, we contend that enterprises have a moral obligation to avoid undesired enterprise outcomes and secure desired ones. Since, in line with Deming's observation, these outcomes are the inevitable consequences of how enterprises are arranged, achieving enterprise outcomes is thus first and foremost a matter of adequate and intentional enterprise design. Consequently, proper attention to enterprise design also has moral connotations. To our knowledge, enterprise engineering is the only effective means to formally operationalize the moral responsibilities that enterprises face. As outlined in this article, it is precisely here that serious rethinking is desperately needed. In a century after Taylor, scientific thinking about enterprises has progressed significantly. Nonetheless, enterprises continue to operate according to a century-old mindset. Hence, there is a large chasm between what science knows and what enterprises do. It is the aim of enterprise engineering to further increase that knowledge and to make it practically useable. This could initially aggravate the chasm. Therefore, top-management's comprehension about the importance of enterprise engineering is essential.

Our paper is not the first plea for enterprise engineering. For example, more than a decade ago, James Martin stated that "Enterprise Engineering is an integrated set of disciplines for building or changing an enterprise, its processes, and systems" [63, p.58]. With deep insight he foresaw that "A new type of professional is emerging – the enterprise engineer" [63, p.xii]. It coincided with the founding paper by Liles et al. [64] and the set up of the International Society for Enterprise Engineering[8]. However, this society seems not be active anymore since about 2004. In addition – and presumably the cause of their failure – the aforementioned proposals lack a sound and rigorous scientific foundation.

Great leaders may have great ideas, but only engineers can change the world, a deep truth that many managers still have to get used to. And as it goes for all engineering disciplines (mechanical engineering, aeronautical engineering, electrical engineering, etc.), enterprise engineering will only become a serious and successful discipline if it is based on sound theoretical foundations.

References

1. Taylor, F. W.: The Principles of Scientific Management. Harper Brothers NY 1911
2. Fayol, H.: General Principles of Management. In: Pugh, D.S. (ed.) Organization Theory. London, Penguin Books 1990
3. Weber, M., Legitimate Authority and Bureaucracy, 1924, In: Pugh, D.S. (Ed.), Organization Theory, London, Penguin Books 1990
4. Fromm, E., The Fear of Freedom, London, Routledge and Kegan Paul 1942
5. Fromm, E., The Sane Society, New York, Rinehart and Company 1955
6. Mintzberg, H.: Mintzberg on Management. New York Free Press 1989
7. Hounshell, D.: From the American System to Mass production, 1800 – 1932, Baltimore, John Hopkins University Press 1984

[8] Cf. www.iseenet.org

8. Mayo, E., The Social Problems of an Industrial Civilization, London, Routledge and Kegan Paul 1949
9. Trist, E.A., Bamforth, K.W., Some Social and Psychological Consequences of the Longwall Method of Coal-getting, Human Relations, Vol. 4, No. 1, 1951
10. McGregor, D.M., The Human Side of Enterprise, New York, McGraw-Hill 1960
11. Likert, R.: New Patterns of Management. New York, McGraw-Hill 1965
12. Katz, D., Kahn, R.L.: The Social Psychology of Organizations, New York, Wiley 1978
13. Drucker, P., Management, New York, Harper 1985
14. Hoogervorst, J.A.P., Quality and Customer Oriented Behavior: Towards a Coherent Approach for Improvement, Delft, Eburon 1998
15. Drucker, P., The New Productivity Challenge, Harvard Business Review, November/December 1991, pp. 69-79
16. Drucker, P., The New Society of Organizations, Harvard Business Review, Vol. 70, No. 5, 1992a, pp. 95-104
17. Drucker, P., The Post-Capitalist Society, New York, Harper Business 1993
18. Argyris, C., Schön, D., Organizational Learning, Reading MA, Addison-Wesley 1978
19. Kim, D. H, The Link between Individual and Organizational Learning, Sloan Management Review, Vol. 35, No. 1, 1993, pp. 37-50
20. Hoogervorst, J.A.P., Enterprise Governance and Enterprise Engineering, Berlin, Springer 2009
21. Zuboff, S., Maxmin, J., The Support Economy, London, Penguin Press 2002
22. Zuboff, S., In the Age of the Smart Machine, New York, Basic Books 1989
23. Nonaka, I., Takeuchi, H., The Knowledge Creating Company, New York, Oxford University Press 1995
24. Mintzberg, H., The Rise and Fall of Strategic Planning, New York, The Free Press, 1994
25. Kaplan, R.S. en D.P. Norton, Strategy Maps. Harvard Business School Press, Boston 2004
26. Galliers, R.D., Baets, W.R., Information Technology and Organizational Transformation, Chichester, Wiley 1998
27. Strassmann, P.A., The Business Value of Computers, New Canaan, The Information Economics Press 1990
28. Miles, R.E., Coleman, H.J., Douglas Creed, W.E., Keys to Success in Corporate Redesign, California Management Review, Vol. 37, No. 3, 1995, pp. 128-145
29. Miles, R.E., Snow, C.C., Fit, Failure and the Hall of Fame, California Management Review, Vol. 26, No. 3, 1984, pp. 128-145
30. Beer, M., Eisenbach, R.A., Spector, B., Why Change Programs Don't Produce Change, Harvard Business Review, November/December 1990, pp. 158-166
31. Kaufman, R.S., Why Operations Improvement Programs fail: Four managerial Contradictions, Sloan Management Review, Vol. 34, No. 1, 1992, pp. 83-93
32. Kotter, J.P., Leading Change: Why Transformation Efforts Fail, Harvard Business Review, Vol. 71, No. 2, 1995, pp. 59-67
33. Pettigrew, A., Success and Failure in Corporate Transformation Initiatives, In: Galliers, R.D., Baets, W.R.J., Information Technology and Organizational Transformation, Chichester, Wiley 1998
34. Leinwand, P., Mainardi, C., The Coherence Premium, Harvard Business Review, June 2010
35. Robbins, S.P., Organization Theory, Englewood Cliffs, Prentice-Hall 1990
36. Daft, R.L., Organization Theory and Design, Mason, South-Western Publishing, 2001.
37. Weinberg, G.M., An Introduction to General Systems Thinking, New York, Dorset House Publishing 2001
38. Tsoukas, H., Refining Common Sense: Types of Knowledge in Management Studies, Journal of Management Studies, Vol. 31, No. 6, 1994, pp. 761-780

39. Weaver, W., Science and Imagination. Selected Papers of Warren Weaver, New York, Basic Books 1967
40. Bertalanffy, L. von, General Systems Theory, New York, George Braziller 1969
41. Simon, H.A., The Sciences of the Artificial, Cambridge, MIT Press 1969
42. Winograd, T., Flores, F., Understanding Computers and Cognition: A New Foundation for Design, Boston, Addison-Wesley 1987
43. Nadler, D.A., Tushman, M.L., Competing by Design: The Power of Organizational Architecture, New York, Oxford University Press 1997
44. Bryan, L.L., Joyce, C.I., Better strategy through organizational design, McKinsey Quarterly, No. 2, 2007
45. Doz, Y., Thanheiser, H., Regaining Competitiveness: A Process of Organizational Renewal, In: Hendry, J., Johnson, G., Newton, J., Strategic Thinking: Leadership and the Management of Change, Chichester, Wiley 1993
46. Butler, M., Measuring the Value of IT, Information Economics Journal, March 2005, pp. 7-9
47. Osterman P., Broken Ladders: Managerial Careers in the New Economy, New York, Oxford University Press 1996
48. Witteloostuijn, A., De Anorexiastrategie, Amsterdam, De Arbeiderspers 1999
49. Deming, W.E., Out of the Crisis, Cambridge, Cambridge University Press 1986
50. Lutz, B., Car Guys vs. Bean Counters: The Battle for the Soul of American Business, New York, Penguin 2011
51. Foroohar, R., Driven of the Road by MBA's, Time, July 18, 2011
52. Dietz, J.L.G., Enterprise Ontology, Berlin, Springer, 2006.
53. Dietz, J.L.G., Architecture: Building Strategy into Design, SDU Publishing, The Hague 2008
54. Hoogervorst, J.A.P., A Framework for Enterprise Engineering, International Journal of Internet and Enterprise Management, Vol. 7, No. 1, 2011, pp. 5-40
55. Aveiro, D., Rito Silva, A., Tribolet, J.: Control Organization: A DEMO Based Specification and Extension. In: Albani, A., Dietz, J.L.G., Verelst, J. (eds.) Advances in Enterprise Engineering V. LNBIP, vol. 79, pp 16-30. Springer, Heidelberg (2011)
56. Lawrence, P.,Lorsch, J., Organization and Environment, Boston, Harvard Business School Press 1967
57. Albani, A., Terlouw, L., An Enterprise Ontology-Based Approach to Service Specification, in: IEEE Transactions on Services Computing, Oct-Dec 2010
58. Mannaert, H. and Verelst, J. Normalized Systems, Re-creating Information Technology Based on Laws for Software Evolvability. Koppa, Kermt, 2009.
59. Kervel, S.J.H. van: Enterprise Ontology driven Information Systems Engineering. Dissertation Delft University of Technology (forthcoming, 2012)
60. Greefhorst, D., Proper, E.: Architecture Principles – The Cornerstones of Enterprise Atchitecture. Springer-Verlag Berlin Heidelberg 2011
61. IT Governance Institute, *Board Briefing on IT Governance*, Rolling Meadows 2003
62. Maizlish, B., Handler, R., *IT Portfolio Management Step-By Step*, Hoboken, Wiley 2005
63. Martin, J., The Great Transition. Using the Seven Principles of Enterprise Engineering to Align People, Technology and, Strategy. American Management Association 1995
64. Liles, D.H., Johnson, M.E., Meade, L.: The Enterprise Engineering Discipline, In: Proceedings of the Society for Enterprise Engineering, Orlando, 1995