PPROI

THE ROI
IN ACTION

NEW ENTERPRISE INFORMATION SYSTEM
TO MAXIMIZE EFFECTIVENESS AND GROWTH

ALIGNING
PRODUCTS, PROCESSES AND RESOURCES
TO MAXIMIZE ROI

SCIENTIFIC BREAKTHROUGHS IN MANAGEMENT SINCE 3RD MILLENNIUM

Prof. Milan Matějka et al.

I. WHY PPROI

01 FOREWORD OF THE CHIEF ARCHITECT OF PPROI

DEAR READER,

This document is a **PPROI presentation material conceived from a scientific point of view**. Its cover page highlights the breakthroughs in scientific management, which PPROI brings coincidentally since the beginning of the third millennium, and which we consider to be timeless. We must fully justify this strong claim and we try to do so in following pages of this text.

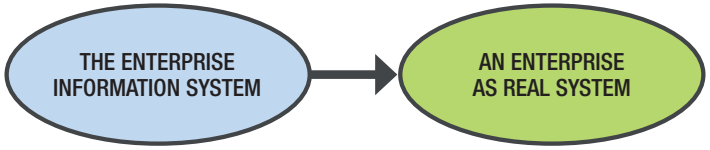
Development of this enterprise information system started in the early days of 2000 and PPROI became operational in the management of a particular company in 2007. In 2010 we prepared a PPROI presentation material, and distributed it in English to the Editors-in-Chief of 25 professional journals with a plea to response on its content and the possibility of its publication. The responses from different countries of the world were largely positive, with no criticism of the solutions described. In particular, conceptual aspects of the formulation and solving problems were appreciated, including the words *"innovative, relevant, wonderful, intriguing, suitable to undergraduate classes of management accounting, updated scientific management."* A more number of publication bids required a deeper description of the theoretical aspects of the issues. We were very pleased by such responses. Unfortunately, the intention to prepare the articles for journals was repeatedly postponed, due to the full drawdown of our available time by the continued development of the system, reflecting the different types of production processes and specific requirements of PPROI users.

In this updated version of PPROI presentation material we respond to the recommendations of experts by substantially reinforcing the theoretical aspects of the issue. On the contrary, in comparison with the document from 2010, we abandon the reader-friendly pages discussing PPROI's features with an IT and business intelligence expert Peter Zavoral and presenting assessment of PPROI benefits by its first user Radek Páleník. Both persons evaluate PPROI as a revolutionary information system. If you are interested in getting to know about it, this first presentation material is available on the PPROI Web site. Last page of the document quotes opinions of the 12 journals chief editors concerning PPROI.

THE ROLE OF INFORMATION SYSTEM FOR THE BEHAVIOR AND RESULTS OF AN ENTERPRISE

The enterprise we perceive as a living and changing system, an organism, whose properties create people by deciding on the structure and parameters of products and resources as well as on the types and parameters of processes. All these attributes in mutual relations should be oriented to ROI MAX. This requires support by so conceived information system. Its information should be also comprehensive, interrelated, accurate and timely.

Existence or non-existence of such information in the system is reflected in physical properties, financial results and competitiveness of an enterprise. Standard information systems known as **ERP**s are **closely linked** to the theory of **scientific management** which was born in the **early decades of the 20th century**. At that time the newly introduced information and computing practices meant great progress in enterprise management. As a whole, however, they **do not respect the natural laws** and **other attributes of science**. Therefore some of key management information in ERPs is either misleading or non-functional. In practice managers respond to this situation subjectively and in different ways, by ad hoc additional information and this all results in permanently chaotic management, generating huge albeit not perceived financial losses. We have solved this situation by building a **conceptually** and technically **new information system** from its very foundations by systematic **application** of **general principles** and **tools** of **true science**.



ONE ECONOMIC AIM WITHIN ENVIRONMENTAL AND SOCIAL LIMITS

The attributes of an enterprise information system that we consider necessary from a scientific point of view are formulated on page 03. We have divided them into six groups, each accentuating another aspect. PPROI meets all kinds of these requirements, while ERP none of them. Already in this foreword I emphasize that **anything within the enterprise must pursue the same aim, the natural aim of the whole enterprise** which is **ROI maximization**. As with other economic targets, maximizing ROI through **physical procedures** have to **respect the environmental and social limits set by legislation**.

ROI is c**omprehensive criterion** reflecting the **Basic Financial Principle** given by the economic nature from the origin of money ie **proportionality of the money income to the amount and time of available money**. However, the author of the term "**scientific management**" **Louis Brandeis** linked it with a focus to **minimizing the costs of processes for products**. This is being **accepted** by the **management theory and practice** as a matter of course **even today**. Consequently, the criterion of financial assessment of different products is the cost-effectiveness, ie the profit-to-cost ratio, or profitability, ie the profit-to-price ratio.

If the investor and the manager is one person, there is a **schizophrenia** of his **financial thinking**. The manager's thinking, i.e. the focus on minimizing costs, mostly outweighs as the person concerned does not realize that the enterprise products, their processes and resources should be managed in order to maximize ROI. And if he does, he does not know how. Therefore the investor manages the enterprise against his own interest on ROI MAX. The same applies when the investor role is fulfilled by CEO or CFO, but the products and their processes are financially assessed and controlled by the department of Chief Controller according to costs. Information about the ROI in financial accounting are of little use, since they are only **symptomatic; they report about the results, not about the main causes of ROI**.

In addition, specialized **operational managers** in the management of products, processes and resources, are using **different physical criteria** without realizing their possible mutual contradictions. Different focuses have very negative practical effects to all types of strategic and operating management and to the enterprise ROI.

Solution of this basic problem requires the application of a **definite integral**, measuring the **states of capital in processes in two-dimensional, money-time units**, and **projection of elementary parameters of products, resources, and processes in their links into the ROI enterprise value**. For the **first time in history**, PPROI allows both.

NEED OF MANAGEMENT EDUCATION THROUGH THE INFORMATION SYSTEM

The situation in practice reflects the state of the art in management theory and education at business schools which is fragmented into partial disciplines with different focuses.

The necessary **comprehensive view of enterprise** as an **organism** whose **parts and elemental components are interrelated and together focused to maximize ROI** is possible only using only using **thus conceived information system**. The above quoted evaluation of PPROI by renowned academics as „updated scientific management, suitable to undergraduate classes of management" inspired us to prepare the **"Demo version of PPROI"** for basic education of managers (see p. 14).

We live in the IT era, and therefore we think that **educating managers through the information system** – now a breakthrough – will sooner or later become an **educational routine**.

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I hope that the content of the following pages will interest you and I look forward to your responses.

Prague, March 2019 **Milan Matějka**

02 CONTENT OF THE DOCUMENT

MAIN TRENDS OF THE CONTEMPORARY SCIENCE IN PPROI

In most fields of human activity it is generally accepted that the "**best aid to practice is the science**." In current **enterprise management**, however, the **opposite opinion prevails**. The word "science" rarely occurs there, and if it does, it is rather intimidating. **Science is replaced by** the so-called "**best practices**". And more and more often, managers of individual enterprises consider their own practices the best ones. Easy calculations using Excel lead, among other things, to the fact that companies calculate the cost of products or create production plans in different ways, all of them incorrectly; management is increasingly **moving away from science**. It may be a reaction to the weaknesses of traditional scientific management. **PPROI** responds to these weaknesses in the **opposite way** – by substantially **strengthening** the **general procedures and tools of science within** the **scientific management**. This requires to **disprove** the **false theories of predecessors** and we do it **in this document**.

Our solutions strongly reflect the main trends in **development of science as a whole** on the threshold of the 3rd millennium identified by experts:

- **Disappearance of barriers between** branches **of science**,
- **Spreading the tools of mathematics previously considered as unnecessary in some branches**.

By perceiving an **enterprise as an organism** and **ROI** as a **measure of its reproduction** (see p. 05) the boundaries **between economics** and **biology** to a large extent **disappear**. The same trends are also evident within individual branches of science. The **control of organisms** is generally **changing from symptomatic to causal**. This trend indirectly but appropriately expressed professor of **medicine** Karl Lewit by words ***"Who heals pain where the patient feels it, forever is lost***." Similarly are **forever lost** the top **managers** trying to **control the enterprise ROI** through **financial accounting from enterprise-wide data**. Necessary is information about **ROI** and **employed capital in processes according products** which results in the ROI value of the enterprise. And this information must be **detailed** and **accurate** in terms of **resources generating costs** and **employed capital**. Thus, among others, it is necessary to abandon traditional product costing through the misty and misleading overhead surcharges and PPROI the concept of the overhead is not using at all.

The most striking example of mathematical tools the management previously has not worked with because of their **seeming uselessness**, is a **definite integral**. The **truth** is the **opposite**: **without application** of **integra**l, **proper management of the enterprise** is **impossible**. In **PPROI** the **definite integral** is widely applied as a **standard type** of both **physical and financial variables**.

The first journal information on PPROI we published in 2016-17 in the Czech version of practically oriented magazine "MM Industrial Spectrum" in series of 8 articles. The extremely positive responses of many readers led to the **conference devoted PPROI** in Technology Center of the Academy of Science of Czech Republic. It revealed that **managers** have the **biggest problem** just **with understanding the integral.** Picture on the left documents explanation of an integral as an area by Professor Matějka in a prompt response to the conference participants' request during the closing discussion.

In PPROI, **mathematical tools** and **procedures** are used on a **much larger scale than in ERP** and they are **always logically substantiated,** everything is **verified by logical tests**. In contrast, most current calculations of managers in Excel is shortsighted, logically mutually contradictory and represents misuse of mathematics.

STRUCTURE OF THIS PPROI'S PRESENTATION MATERIAL

The document is divided into **three parts** and on a deeper level into **pages, each** of which has **a coherent content**.

Part I outlines the **reasons** for **PPROI development**, its **benefits to users** and features the **PPROI architecture** – types and links of groups of physical and financial variables. It characterizes **attributes of enterprise as** an **organism**, the **necessity of** its management by a **comprehensive information system** and related **requirements** for **new knowledge** and **skills of managers** through a **new way of education.**

Part II is devoted to a fundamental **reassessment** of **false axioms** of **traditional management theory** most of which are reflected in the **weaknesses** of **ERP**. Described are **PPROI's conceptual solutions** that create the basis of **new thinking** and **measurement** in **management**.

Part III presents the **unique PPROI structures and procedures** which through methods of science **effectively evolved the new conceptual solutions** into the **mass** of **new, detailed and interrelated information** for the **management** of industrial enterprises **aimed at maximizing ROI.**

I. WHY PPROI

03 SIX "MUST HAVE" PPROI's FEATURES FOR TRULY SCIENTIFIC MANAGEMENT

1. PHILOSOPHY

The spectrum of PPROI's scientific innovation from multiple perspectives **unwinds from** its **philosophy**, briefly expressed in motto "**Aligning products, processes and resources to maximize ROI**."

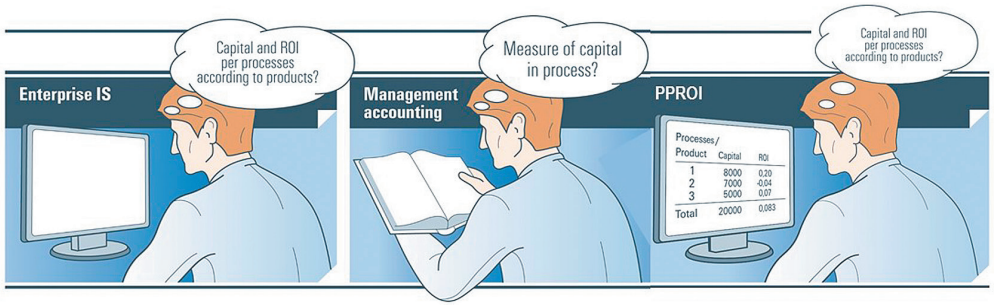
- The objective **goal of the enterprise** is **the permanent maximizing of its ROI value**
- The **means** by which **the goal can be achieved** are **products, processes and resources**
- The **role of information system** is **aligning products, processes and resources to jointly move towards the enterprise goal**

Only in this situation can the **enterprise fulfill its mission, respect the basic law of business** and **management of the enterprise** may have **truly scientific character**. Only in this situation, the **enterprise can optimally ensure its own development**, in **maximum** contribute to the **whole society**, and **fully satisfy investors interest**. Above all **this philosophy starts a new era of management**.

Even **before PPROI**, management theory and practice sometimes highlighted the maximization of the enterprise ROI value, but never in relation to the means that generate that value. The **management of products, their processes and resources was focused on various partial and** implicitly **contradictory objectives**, the **link between the enterprise ROI value and the monitored parameters of products, processes and resources did not exist**.

2. METRICS

As has already been highlighted on the previous two pages, the primary step towards the practical fulfillment of the declared philosophy is the **implementation of a definite integral** as a **standard way of measuring the states of phenomena in time**. The previous information in one-dimensional units – amount, time and money – are expanded by PPPROI with information in **two-dimensional units**, i.e. **amount-time** and **money-time**. E.g. the information on employed capital and ROI in the processes according to products require the use of money-time units. PPROI such fills a huge tabula rasa that existed both in information systems, and in the management and economic theory.



3. PRECISENESS

A well-known chronic problem of **existing information** is their **inaccuracy** in terms of **absolute values** and/or **location over time**. An example is information on costs of products and production plan in physical units. **PPROI** contains **uniquely accurate information in both directions** and **achieves it in two ways**

- The completeness of the **records of relevant product and resource parameters** and the details of the production process descriptions; of key importance is the **division of operations into microphases.**
- Unique **methods of processing the input data**, differing from traditional methods from the ground up

The **combination of both approaches** ensures the **accuracy of synthetic variables, finally ROI.**

4. SCOPE

PPROI significantly **exceeds boundaries of the production described in ERP**, whose **principles originated in the Industrial Revolution of the 18th century**, and whose time and quantity **standards** were introduced by **scientific management** in the first decades of the **20th century**.

In reality, however, alternatives to all the principles of this production have gradually emerged. The common cause of these **alternatives** was their **higher efficiency**, and PPROI cannot overlook these when focusing on maximizing ROI. **PPROI's information covers an innovative practice solution** defined from a **variety of perspectives**: inter alia, variants of lean production, processes on combinations of BOM parts, flexible production lots that PPROI generates systematically.

Classic production covered by **ERP information** is illustrated on the left by the **inner grey circle**. Even for this production, the ERP information is **incomplete** and **distorted**. Alternatives beyond the classical production boundaries (in the white ring) are tabula rasa for ERP.

PPROI's much more **complete** and **accurate information** (in the green circle) **covers** both the **classic production** and its **alternatives without boundaries.**

5. LINKS

ROI of an enterprise is a variable endowed by the economic nature with **comprehensiveness**, i.e. the implicit adequate **response to all elements of the enterprise** in their mutual relations, but **without determining the elements and their links in any way**. These are mainly determined by the company's management. In order to manage enterprise elements for maximum ROI value, the **authors of PPROI** logically **defined** the **information structures and their links**, through which the **properties of** the **elements** are gradually **projected into the enterprise ROI**. General idea about the outcome of this development is provided by the commented diagram of the **"PPROI Architecture"** on the following page of this document.

The **follow-up steps** of the PPROI creation are the **concretization** of enterprise **products, resources**, **territories** and **phases of production processes**, their **classification** and **parameterization**, and the formulation of **links of parameters by means of mathematics**. Through mathematical functions, the **value of each partial parameter** is **projected into the ROI enterprise value** while **respecting** the values of **other partial parameters**. This creates an irreplaceable **tool** for the **practical application of PPROI philosophy**.

6. EFFECTIVENESS

New types of variables, much **greater depth** and **scope of information**, and a much **larger number of PPROI links compared with ERP** raise the **question** of work and financial **requirements for obtaining information**. But as well as in science in general, even in scientifically conceived management, **atomization and sorting of phenomena** create basic **prerequisites** for the **application of mathematical functions** in generalized and correct **description of existing phenomena**, as well as for the **creation of new phenomena**. High **computational complexity** of this approach has **no effect** considering **current IT** hardware and software performance. Much **better information** can be **now** obtained **for** much **less money than previously** – in contrary to the traditional management theory axiom, that increasing the quantity and accuracy of information requires an increase in the cost of obtaining information.

The properties of the **information systems** also represent an **excellent environment** for the **synoptic creation of systems of mathematical** (including statistical) **functions**, and **PPROI extensively uses this environment**. Thus, **PPROI** is **unique even in the efficiency of obtaining information**, as the former methods of recording isolated data remain unchanged in the ERP and with the increase in the number of information there are also growing work requirements for ensuring them.

04 THE CORE OF PPROI ARCHITECTURE

THE GENERAL STRUCTURES

The realization of a completely **new concept of management** of products, processes and resources required building of a **new architecture of the whole enterprise information system**. The **structures** of the **PPROI architecture** (see the diagram on the right) are defined **in terms of content** and in terms of **units of measure** of parameters (variables), numerically characterizing the properties of products, processes and resources. Data in the **bottom part of the scheme** (in green rectangles) express product, process and resource parameters in **physical units of measure**. This part is therefore called **PPROI Physical**. Data in the **upper part** of PPROI scheme (in red rectangles), called **PPROI Financia**l, informs about parameters in **money** or in **moneytime units of measure**.

The building blocks of the system are physical **information** about enterprise **products, resources and territories**. The PPROI specialty is a **multi-stage classification** of these objects. The description of processes is specific by **process BOMs**, the possibility of recording the **integrated processes** of various **parts of BOM**, as well as **convergences** and subsequent **divergences** of different parts of BOM in the process stages. The basic **process phases** are defined in three-stage levels – **microphases** of operations, **operations**, **linked operations**. The **operations** and their **microphases** are **classified**. **Elementary standard** times and other **parameters** are **defined for microphases**, in which **resources** are **recorded**. From this data, the PPROI automatically calculates the **variants of piece times** for **linked operations** to the permissible numbers of workers. The atomization of processes into microphases and their sorting allow the **application of mathematical functions,** eliminating the influence of random factors on **process standards** and making their creation much **more efficient**. The uniquely designed **execution production plan** is determined for the production territories and **aligned with** the **plan of workers** within capacity limits of workplaces **in respective territories**. Plans of the **downstream territories** are **synchronized in time**. Such plans are termed "**territorially leveled and synchronized**".

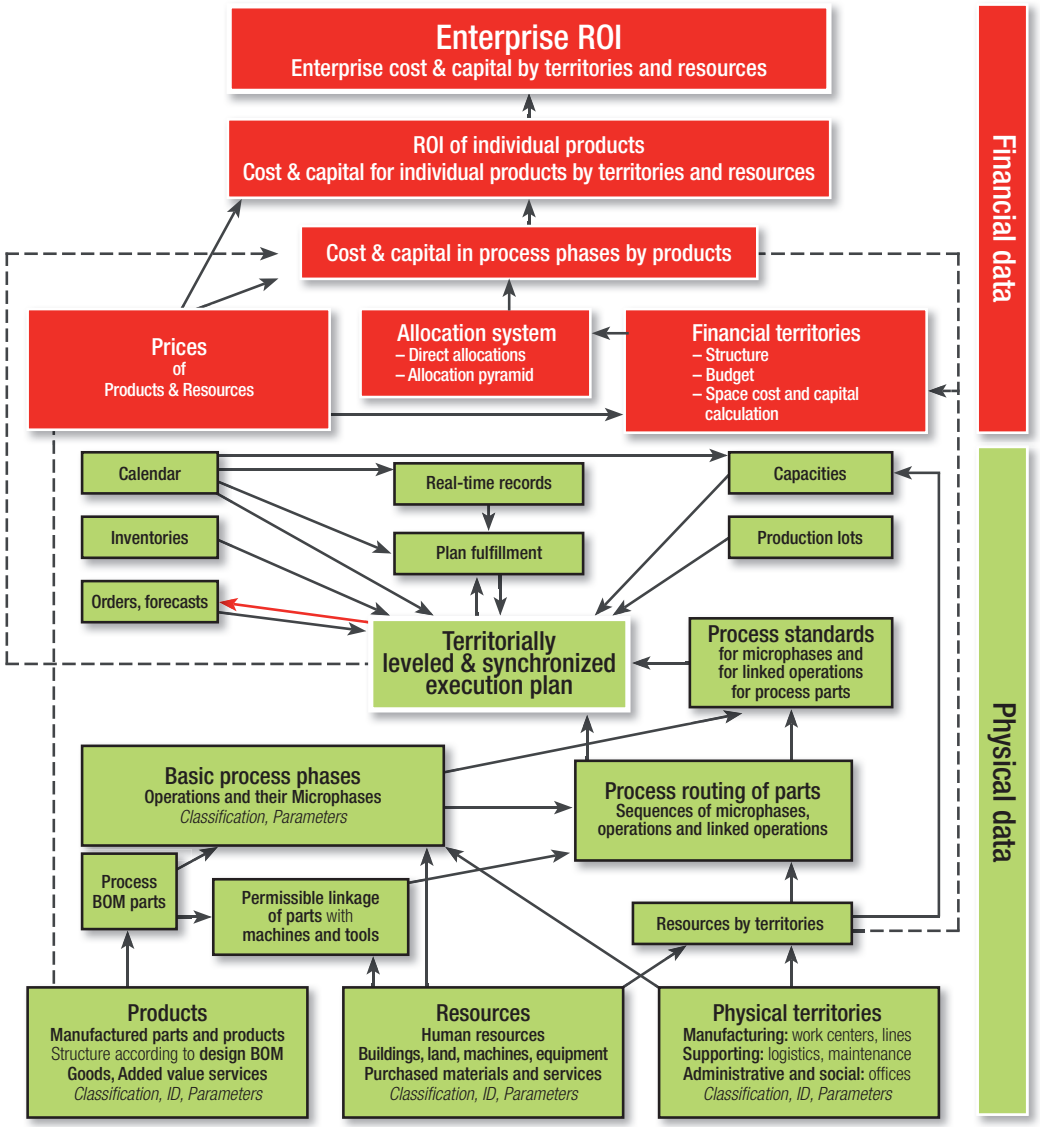
Data of **PPROI Financial** provide **completely new information** about the financial parameters of the products, their processes and resources according to the territories, both in terms of **conten**t and in terms of **detail** and **accuracy** of the information. Products, processes and resources are parameterized in terms of **costs and capital employed,** the products additionally by **ROI**. The **costs** and are identified **according resources** which generate the costs; traditional **overhead** surcharges **do not exist.** Also, **objects** containing **employed capital** are specifically **identified.**

Arrows in diagram show **intergroup data links**. Most groups contain a large number of entities with **internally linked information**. The **links of parameters are all mathematical.** Therefore**,** each **elementary information**, i.e. entry into the system, **can be automatically projected** by PPROI **into** the **ROI's enterprise value**, while **respecting the values of other input variables**. The **information system behaves** principally in the same way as the **real system,** i.e. a **living organism.** As such **PPROI can guide the real system,** i.e. the **enterprise, to its goal** – **maximization of ROI**.

RESPECTING THE SPECIFIC ATTRIBUTES OF ENTERPRISES

The structures in the schema are relevant for each industrial enterprise. In their framework PPROI allows to respect the specifics of individual enterprises. **Users can separately record** those **parameters of their products or resources** that are **relevant for further processing**, e.g. for the calculation of microphases times of the respective processes. Within PPROI, **users can** also **formulate functions** that determine these times. PPROI also respects the different **types of processes** in the **creation of production plans**. In this case, however, **users** only **choose variants relevant to their processes**. Production **plans are always created by internal PPROI functions.** This **also applies** to the calculation of the **financial parameters of the processes and products**.

PPROI Architecture



05 THE ENTERPRISE AS AN ORGANISM FOCUSING ON ROI MAX

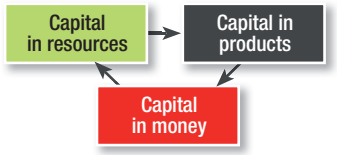
GENERAL ATTRIBUTES OF AN ORGANISM

An organism is currently perceived in a broader sense than just a biological entity. From several definitions of this term in literature we consider as substantial the following organism attributes: "**A living, self-sustaining system with properties and functions determined not only by the properties and relations of its individual parts, but also by the character of the whole, that they compose, and by the relations of the parts to the whole.**" An enterprise should have all these attributes.

AN ENTERPRISE AS LIVING SELF-SUSTAINING SYSTEM

The **continuous life** of an enterprise takes place through a **circulation of capital** during which capital **changes its forms** and **reproduces** its **value**.

Capital circulation and reproduction



The capital in the form of resources is through processes transformed into capital in the form of products (including finished and unfinished product parts) and after the sale of products the capital is transformed into a monetary form of which substantial part returns in the form of resources. For the **enterprise to be self-sufficient**, the **capital arising in the form of products** must be in the long term **higher than the capital extincting due to the consumption or function of resources**, i.e. enterprise has to generate **profit.**

For the existence of an enterprise, however, this is not a sufficient condition. **The investor wants** not only a positive value of the profit and thus the ROI, but also a **satisfactory value of the ROI,** measured by the **ratio of profit**, i.e. increase of capital, **to the integral of capital states in the relevant period.** This ratio is useful to interpret as the **rate of capital reproduction**. Calculation of ROI is in fact an application of universal rate of reproduction (used e.g. in measurement of population reproduction).

DEPENDENCE OF THE ENTERPRISE BEHAVIOUR ON THE INFORMATION SYSTEM

The **self-sufficiency** of the organism includes the **ability to manage oneself**. Also, this property of the organism suits the **enterprise** because it is **controlled by** the **people in the enterprise** that form **part** of its **resources**. People should **choose and implement** such a **portfolio of products** and **resources** and **types of processes** that in relations permanently **lead** to a **maximum** value of the enterprise **ROI**.

Fulfilling this extremely complex management task using only brain is impossible, **people need support** in the **information system**. **PPROI** is the **first** information system that **provides this support**. This must be clear from the diagram of PPROI architecture on the previous page to anyone who is familiar with the properties of ERPs or other enterprise information systems. **ERP** systems, among others

- **do not inform about employed capital and ROI of processes by products**
- **do not record** (except for operators) **resources in the processing of products** and therefore **cannot correctly calculate** the **direct costs** of processes and products
- **are not responsive**, because of the **lack of links between physical and financial parameters** of products and resources
- **ignore the sharing** of the **same resources by processes on different products**, and therefore their **MRP plans** are **unrealizable** and **overall costs calculations** are **distorted**
- **do not support lean processes** – they are designed for processes split into isolated operations

For these and other reasons the **management of an enterprise to ROI MAX through ERP** is **impossible**. The **enterprise behavior in terms of ROI** is therefore entirely **random**. But ERPs do not declare and in fact do not focus even on any other goal of "enterprise resource planning".

STANDARD VALUES OF THE ORGANISM PARAMETERS

The **normal functionality of biological organisms** requires certain **standard parameters of their parts**. The contemporary medicine works with a large number of standards. Standards are characterized by **mean values** and ranges of **acceptable deviations** from the means. **Excessive deviations found in individuals** are removed by **therapy** trying to respect the links between the parts of an organism and the consequences for the whole organism. But exceeding acceptable deviations can also be **fatal**.

There are **analogies with enterprise organisms**. The **standard technical parameters are** contained e.g. in **drawings of products, documentation of machines** and **technological prescriptions** for the **processing operations**. The **reality** is also **recorded**, and **corrections** are made when the **permissible deviations** (tolerances) are **exceeded**. Some of the excessive deviations have **fatal** consequences for individual products – result in **wasters**. However, these **technical standards** are **in ERPs** recorded in freestyle combinations of words and numbers **in text fields** that are **further unprocessable**.

Management of enterprise through an information system requires **recording** the **standard values** of **physical parameters** of products, processes and resources **individually in separate columns**. **ERPs** register **only a few standards of this kind** for traditional production processes on BOM parts split into independent operations. These standards are insufficient even for physical management of traditional processes. **PPROI** improves this situation in several aspects: by **much wider range** of **standardized parameters**, their **better detail** and **precision**, **usability for progressive production processes**, and by an **effective way to determine them**. Unlike biological organisms the enterprise parameters and their standards are **specific for individual enterprises** and **subject to improvement**.

RELATIONS OF PARTS MUTUALLY AND TO THE WHOLE

The enterprise managed by PPROI also fulfils the **organism** property as an **entity** that **contains** "**the relations of its individual parts and the relations of the parts to the whole**". This property is expressed in the graph on the previous page by the **arrows** that characterize the **relations of parts** and also by the **way the parameters of each part** are subsequently **reflected in** the synthetic property of the whole – the **ROI enterprise value**. Since the individual arrows and their links contain **mathematical functions**, the **enterprise is controlled** by the numerically expressed properties – the parameters of its elementary elements, in other words, "**on the root causes**". The **effect of each elementary parameter** (root cause) **value** for the ROI **depends on the values of all other elementary parameters**.

Clarification of the logic of mathematical functions hidden under the arrows and the arrow links requires a separate explanation. A detailed explanation of the specific functions is not necessary to the PPROI users. The understanding of function would be very demanding even for mathematically well-educated specialists familiar with the content aspects of the matter. The criterion for the functions correctness is compliance of calculated values with the values in practice. This has been always verified during PPROI system creation.

The PPROI logic, the content, mathematical properties, and relations of variables in the system, are outlined on the following pages of this text. Now we will just briefly mention one of the important advantages of PPROI related to elementary process parameters and their creation through functions:

Setting the standard process times of operators by traditional methods (MOST, MTM, ...) **in tables outside the information system** and transcription of data into the information system, which is a frequent **cause of its incorrect inputs**, is excessive and **undesirable** when PPROI is applied. **Records of elementary data directly in PPROI** permit the **application of regression functions** that ensure **consistency of standards, efficiency in obtaining them** and **spreading changes**. All **PPROI data is under full control right from the outset.**

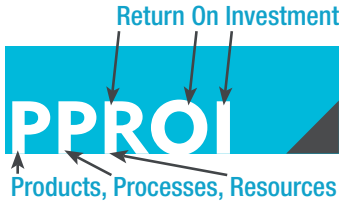
06 BENEFITS OF ONE RIGHT AIM IN ACTION

PPROI AS AN EYE OPENER

Proper application of PPROI in any enterprise substantially and **permanently increases the ROI enterprise value**, i.e. the **rate of capital reproduction**. This **removes** large financial losses, **waste of capita**l, which the **owners**, **managers** of companies **and anyone else are unaware of** before becoming acquainted with the PPROI's properties. **PPROI** is therefore primarily the "**eye opener**".

ONE CORRECT AIM, ROI IN ACTION

Philosophy of PPROI, expressed by motto ***Aligning Products, Processes, and Resources to Maximize ROI***, is reflected **also** by **PPROI logo**:



The key importance for management of products, processes and resources in all contexts lies in tracking only one aim, the ROI MAX and thus consistently respecting the mission of any business. **Only PPROI users** have this opportunity**,** due completely new system of information.

The ROI of an enterprise thus becomes the **governing criterion of anything**. It ceases to be a mere measure of the aggregate results of an enterprise over the past period, which it cannot influence during the period; **PPROI awakens ROI** to be **in action.**

Essential for the financial benefits of PPROI are also other unique PPROI properties listed on page 03, i.e. **accuracy** of calculations of ROI values in processes by products, **usability** of the system in situations **beyond** the boundaries of **classic production**, and the **efficiency** of **obtaining and processing information**.

TRADE-OFFS OF PARTIAL VARIABLES, ROI AS THE JUDGE

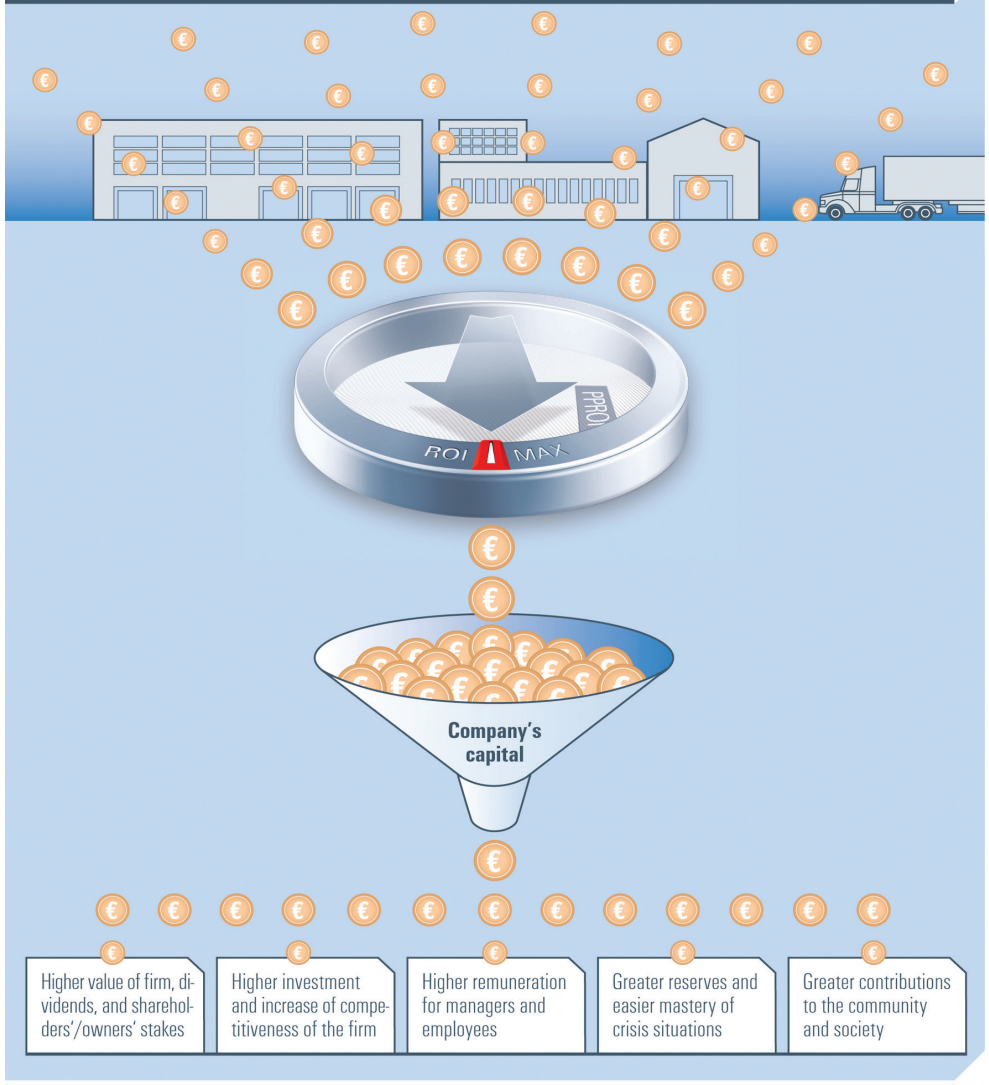
Because the ROI of an enterprise as a comprehensive variable integrates all the relevant partial variables, it may seem as a matter of course that the improvement in the value of any partial variable will lead to increase of the ROI value. This thinking is usual in applications of the pyramid of financial ratios. Often, though not always, an **improvement in the value of a particular partial variable is inseparably linked with deterioration** of the **value of another partial variable**, or several other partial variables. **Right judge**, **deciding which of variants is better, is the ROI.**

Trade-offs namely exist also **between cost and employed capital defined for processes according to products** in all kinds of **strategic decision-making** and also in **continuous improvement**. The generally proclaimed and accepted **focus on reducing product costs may** therefore **be incorrect**. But **ERPs contain no information about employed capital for products**, and **ERP information on product cost** relate **only** to a **portion of direct costs**. Using ROI as the judge is impossible. Management **theory does not deal with the issue of trade-offs of partial variables** (another tabula rasa of the theory) and **practicing managers are just groping among** the **various partial, often contradictory aims**. The **resulting enterprise ROI is well below the reachable maximum**. The issue of trade-offs is dealt with in more detail in following text.

GAINSHARING

The picture on the right should invoke the idea of wasting capital, throwing money into the air in enterprise management based on information in existing information systems except PPROI and drawing this capital into enterprise cash register by PPROI acting as a compass and a magnet. The bottom of the figure outlines the **possibilities** of **sharing unique PPROI revenues**. The **ordinary employees** should not be forgotten, because **thinking and behaving according PPROI is demanding and requires motivation.**

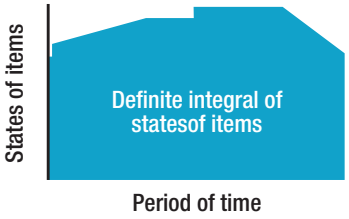
Management by PPROI → An end to capital waste as a result of IS' shortcomings



07 INTEGRAL: DECISIVE BREAKTHROUGH IN ECONOMIC MEASUREMENT

DEFINITE INTEGRAL IN MEASURING THE STATES OF ITEMS IN THE TIME PERIOD

According to **theory of measurement of economic phenomena** the **states of objects** can be **detected** only **at certain moments of time** and the state of objects in a certain **time period** is expressed by the **chronological average** of the detected instantaneous states. In practice, the states are usually detected at the start and end moments of the observed period, and a simple arithmetic mean is calculated from these values. When calculating the chronological average from more detected states in the period, first simple averages are calculated from two downstream states and then weighted average is calculated for the whole period, in which partial simple averages are weighted by the lengths of time between the adjacent states. Both the **detected and calculated values** are expressed in natural **units of** the **quantity** of the object concerned (numbers of pieces, units of weight, volume etc.), or in **money units**.



However these methods have an **alternative** expressing **continuous state of the objects during the time period by a function** and **calculating the area under the function** above the time axis – from a mathematical point of view it is the **definite integral**. While the values of the function remain expressed in one-dimensional units, either in natural units of amount or in money units, the **values of the integral** are expressed in **two-dimensional units** of measure, either **amount-time** or **money-time**.

This innovative method may seem unnecessarily complicated and useless for practice. The truth is just the opposite. **Application** of the **integral** is **necessary** for correct **measurement** of **key economic phenomena.** Only with the help of the integral **chronic problems of traditional financial and physical management of the enterprise** are **solvable**. Only with the help of the integral it is possible to **generally manage the enterprise to its objective aim. Understanding the integral and its use** is therefore one of the indispensable foundations of **managers' economic literacy**

APPLICATION OF DEFINITE INTEGRAL IN THE MAIN FINANCIAL RATIO

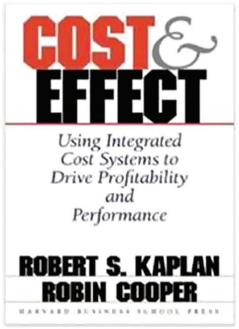
Two-dimensionally measured **state variables** very often **enter into relationships with one-dimensional flow variables** expressed in physical or money units. This also applies to the **ROI**, calculated as the **ratio of the profit to the employed capital.**

Since time immemorial the **natural basic financial principle** is respected – the **proportionality of the money yield to the amount of used financial resources and time of their use**. This principle **applies in general**, even **for processes within the enterprise, defined for individual products**, and for the **enterprise as a whole**. Amount of used resources and time of their use are together measurable by the definite integral in money-time units of measure (more on p. 15 and 16).

Application of the principle for processes according to products fundamentally **alters the traditional financial evaluation of products** and their **process alternatives**, including the **resource structure**. From the roots it **changes** traditional **management thinking** and factual **financial management of an enterprise**. The principle is used for the **first time systematically in PPROI**, coincidentally at the turn of the 2nd and the 3rd millennium

FROM TRADITIONAL MANAGEMENT ACCOUNTING TO PPROI

2ND MILLENIUM



3RD MILLENIUM

Management accounting is focused on the structure of the product price, divided into cost and profit, and on calculation of cost. Derived ratio **cost effectiveness = profit / cost** is used as **financial criterion** of products. Processes for a given product are assessed by cost. This is a **basic error**.

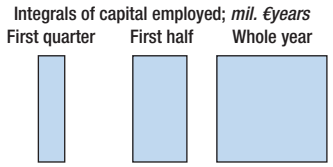
PPROI extends variables of management accounting by **capital employed and ROI in** the **processes by products**. This **enables** to **manage products, their processes and resources for maximum efficiency and growth of an enterprise.**

Ignoring employed capital in management accounting, and in management generally, **leads to many contradictions, mistaken decisions and irrational behavior of an enterprise**. This **key defect** is **multiplied by conceptually incorrect product cost calculations** most often by overhead surcharges to the detected direct materials and wages. **PPROI** in the quantification of employed capital and costs in processes according to products **consistently records specific objects generating both employed capital and costs**. This, with unique follow-up steps, **ensure high accuracy of all financial information** about products, their processes, and resources, including ROI.

APPLICATION OF THE INTEGRAL FOR THE WHOLE ENTERPRISE IN FINANCIAL ACCOUNTING

Application of the **integral of capital states is meaningful and functional at the enterprise level** too. It **directly ensures the comparability of ROI values defined for periods of different lengths**.

Period of the year	Average capital employed *mil. €*	Integral of capital employed *mil. €years*	Profit *mil. €*	ROI *mil. € / mil. €years*
First quarter	400	100	7	0,07
First half	404	202	15	0,0743
Whole year	410	410	28	0,683



Therefore, application of the integral allows to interlink management and financial accounting.

APPLICATION OF DEFINITE INTEGRALS EXPRESSED IN PHYSICAL UNITS OF MEASURE

Application of the definite integral allows to solve not only chronic problems of the financial management, but also chronic problems of physical management of the enterprise. The **definite integrals** allow **calculations of production plans which are in real time leveled in its claims on workers according to the territories of their activities** and which **do not overload the work centers** or **production lines**.

The classic production plan, **MRP, does not meet these essential requirements** and is therefore **unfeasible**. But without the application of the integral, characterizing the continual states of the operators over time, the problems of MRP have no solution (more on p. 24).

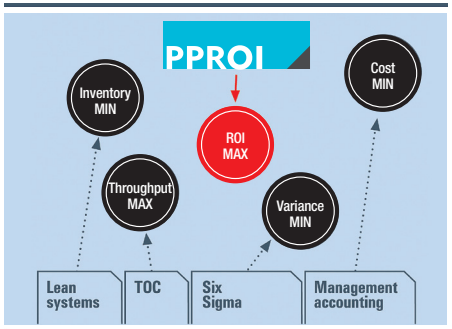
08 OPTIMAL FORMATION OF THE ENTERPRISE BY PPROI

KEY IMPORTANCE OF ROI AS AN OPTIMIZATION CRITERION

The optimization theory and practice have this basic experience: **"what criteria – such results."** Therefore if you evaluate and manage products, processes and resources according to criteria other than ROI, you are choosing mostly other alternatives than those leading to the maximal ROI value.

Example 1	Process	Criterion
Which process is better for the given product? Which is an improvement of the process? A → C or C → A	A B C	Cost MIN Lead time MIN **ROI MAX**

Example 2	Product	Criterion
Which of the products is the most advantageous? Expand which production, cut which?	X Y Z	Profitability MAX Labour productivity MAX **ROI MAX**



Different management theories focus on **maximizing or minimizing different partial variables** that are often in trade-off relationships. That leads to **different "best alternatives"** and to **conflicts of theories**. Values of **partial variables** should not be maximized or minimized but **optimized to maximize the ROI's enterprise value**. PPROI it enables by projecting all partial variables in their link into the ROI of an enterprise.

A very **dangerous method** generating big financial losses are **subjective "balanced scorecards" of partial variables**, called sometimes "key performance indicators". The **true, natural balanced scorecard is the ROI**.

PPROI AS AN ENTIRELY NEW, CREDIBLE MIRROR OF REALITY

Product	Price (€)	Cost (€)	Profit (€)	Profitability (€/€)	Capital employed (€year)	Capital turnover (year)	ROI (€/€year)
a	8	7,2	0,8	0,1	10	1,25	0,08
b	10	10,4	–0,4	–0,04	20	2,00	–0,02
c	15	14,4	0,6	0,04	5	0,33	0,12

Correct calculation of traditional variables — *New variables*

PPROI brings a **new quality of information** through **new variables** and the **right calculations** of all variables.

ROI *VERSUS* PROFITABILITY; CAPITAL EMPLOYED *VERSUS* COSTS

PPROI's information of processes and resources per products is obviously unique by **new variables,** the **capital employed** and **ROI** derived from it. Usual evaluation criteria considered to be self-evident are **costs** when evaluating process alternatives for a particular product, and **profitability** when evaluating different products. But these are **big mistakes**. Even **medieval merchant** knew that for financial merit of different type of goods the **turnover time of each kind is** also **important**.

Capital turnover times for **different products** as well as for **processes for a given product differ between enterprises** and even **within the enterprise** for various reasons. In the previous table, the **capital turnover in processes for the product a** is **four times longer** compared with **product c**. Then the **ROI for product c** is **1.5 times higher**, while the **profitability** is **2.5 times lower than for product a.** One possible reason could be much **broader processes for product a**. (See below for other factors.) Similar situation occurs when evaluating process variants for a given product by **costs**: these may be **lower in** the process **variant a B**, but due to **larger employed capital**, the **ROI may be in this case worse than in variant c C.** (in first picture). So, the **ROI forms the enterprise in a new** and **right way**.

ACCURATE SPECIFIC INFORMATION *VERSUS* VAGUE, DISTORTING OVERHEAD

The specificity and accuracy of PPROI information is depicted in the **following table**, characterizing the components of the **direct processing costs** for a BOM part. ERP systems, with the exception of direct labor, do not provide any further data on direct processing costs, and the **management accounting** replaces the accurate data related to specific resources by **overhead** surcharges to direct labor. This is principally flawed because all the direct **cost components** are **independent**, they have different values in different operations and cannot match any set-up overhead for direct wages. This also applies to direct fixed costs and indirect costs that PPROI calculates for specific resources. Standard costing would also fundamentally distort ROI values. PPROI quantifies the cost of specific resources not only for the sake of data accuracy, but also because it is necessary to **manage specific resources**, not vague overhead.

Part number. 3300728

Linked operations	Direct labor	Depreciation of machines	Depreciation of tools & jigs	Cutting tools	Machine electricity	Machine gas	Cooling water
10–40	3,2	3,87	0,64		2,45		
50–65	2,5	0,94	0,11	0,95	1,32		0,21
70	1,5	1,08	0,08	0,24	0,42	2,68	
80–120	3	4,91	0,25		3,41	5,65	2,08

TERRITORIALLY LEVELED AND SYNCHRONIZED PLANS *VERSUS* MRP

The **most painful** practical **weakness of ERP systems** is the **inability** ot their MRP plans to **generate** a **feasible production plan** in objective standards **in real-time** – what, when, where, with what number of workers to produce. The result is permanent chaos and large losses. **PPROI also solves this issue by a new conception,** the so called **territorially leveled and synchronized plans** (see previous page).

BEYOND THE CONSTRAINTS OF TRADITIONAL PRODUCTION PROCESSES

PPROI information, unlike ERP systems, is **not limited by traditional**, operationally separate **production processes** and their standard parameters. PPROI **fully supports more progressive processes** and **attributes** that have gradually emerged in practice. E.g. the above table describes the financial **parameters** of linked operations in **lean production**. PPROI is in some aspects designed as **modular**. Its **users** only **apply** those **parts of the system** that are **relevant to their process types**.

09 IMPULSES AND APPROACHES TO PPROI DEVELOPMENT

IMMINENT PRACTICAL NEED

Systematic development of PPROI has **started in 2000** after approximately 10 years activities of Central European Productivity Center's consulting team which led projects of **restructuring enterprises** in different industries, especially the introduction of **lean manufacturing** and **teamwork**. The basic problem following introduction of the physical parameters of lean processes was **how** to **describe, standardize, plan and control these processes in the information system**. ERP systems were not usable at all. And relatively simple procedures of standardization, scheduling, and control of lean processes in Toyota running outside the information system are not applicable to manufacturers of a broad portfolio of final products that change every day and, moreover are not assembled in the final assembly lines. Also the **information on financial parameters of lean processes** was **necessary**.

We have seen that **ERP systems did not satisfactorily work** even in **planning and control** of the **traditiona**l, operationally separate **production**, before its restructuring. The reality differed from ERP plans often in more days. Nobody was able to explain why. Permanent financial losses from underutilisation of capacity of workers and workplaces were at a deeper view clear, but information on financial parameters of processes did not exist, and **production managers did not think financially**.

THEORETICAL BACKGROUND

Our **knowledge outfit** for **contentual and mathematical solution of the problem** was **very good**. Not only we **knew well the main trends of management in the last decades of the 20th century** from the literature and visits to leading companies worldwide (Toyota, GE, ...), but we ourselves have organized **training programs** in this direction, including programs within the **Center of Executive Education** (**CEE**) of Prague School of Economic (leading Czech economic and management school).

The basis of all CEE programs was a **unique proprietary program** dedicated to the content and linkages of **economic variables, including the integrals**. The other programs not only presented the contents of popular theories but identified their conceptual **strengths and weaknesses** and open and hidden **contradictions of individual theories**; among others TOC vs. Cost Accounting, Six Sigma vs. Over-Processing, OEE vs. Overproduction, MRP vs. Leveling, Balanced Scorecard vs. ROI. The **criterion of assessment of** all unilateral and contradictory **theories** was just the **ROI**, as a natural, objective "balanced scorecard" of everything. This also **applies to lean production**. Overrating the "one piece flow" and minimal inventories leads to excessive amount of low exploited machines and dead fixed capital that can negate reduced capital in inventories. And also machine costs can grow unnecessarily.

The director both the consultancy firm CEPC and CEE was **Professor Milan Matějka**. Graduated in statistics in his professional career he devoted mainly to the research, which he directed also within the whole faculty. His unique competence consisted in deep knowledge of **economic variables** whose properties and relations he described from **mathematical aspects** in the textbook. Another his book, well known to practitioners, described the structures of **indicators** and **methods** for assessment and control the **effectiveness of enterprises**. Naturally, he became the **head of** a narrow **team developing conceptually new information system, the PPROI.**

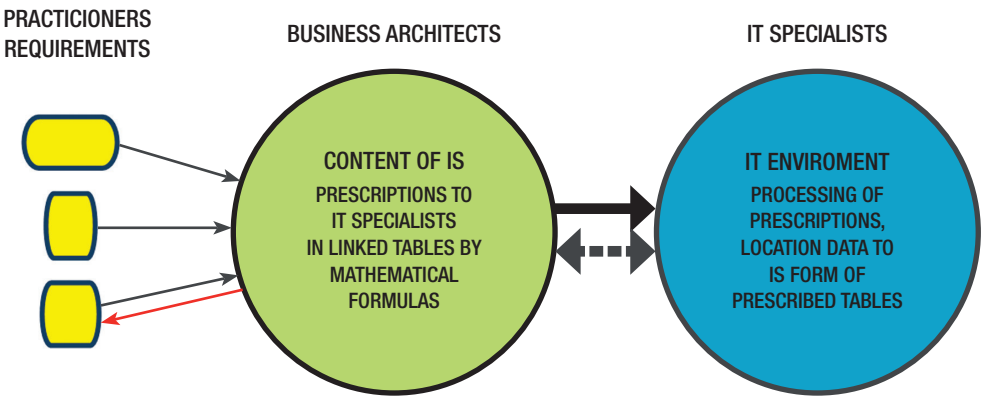
AS SIMPLY AS POSSIBLE WITHOUT SIMPLIFICATION

The **basic reason** why the **management theory models and** related **information systems do not work in practice**, is **oversimplification**. First we **refused Pareto's rule** that in business management, it is enough to solve problems at 80%. The count of follow-up mathematical formulas in PPROI achieves a four-digit number. If each formula would apply only to 80%, the system would be worthless. We have **respected Albert Einstein's words:** *"Everything should be made as simple as possible, but no simpler."*

PPROI solves problems without simplification by **deploying the basic apparatus of science**, atomization, classification and generalization, through mathematical functions, in the way and scope previously unimaginable in the enterprise information systems. It has been **enabled by the current IT**.

THE DIVISION OF TASKS AND RESPONSIBILITIES

In the development of PPROI, **three groups of actors** and their tasks are clearly distinguished.



The **basic structures of the PPROI architecture**, presented at p.04, were designed by **prof. Matějka.** In addition, he **defined** most **variables and their linkages into many tables**, **by mathematical formulas**, with appropriate comments. The same procedure is applied by architects who design and control PPROI variants for different types of processes within the framework of the PPROI core structures shown in the diagram on page 04. **Part of formulas** is defined by the architects themselves, based on their knowledge of the issue, part is **inspired by the requirements of practice**. **Business architects** always **judge these requests** in broader context and rejects incorrect ones (see red arrow in chart).

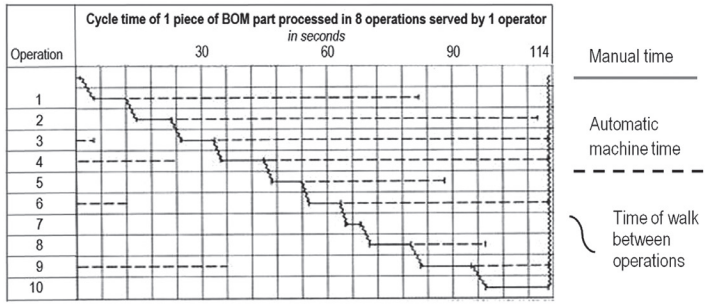
The **formulas** create **prescriptions for processing to IT specialists.** They should **process assignments** within the information structures **optimally** - the **fastest calculations, user friendly**. **After processing** the **tasks by IT methods** they **place the processed data into** the columns of the **specified tables** and business experts cross-check the accuracy of the processing. If data discrepancies are detected, IT specialists check the correct execution of the prescriptions. If they detect an error, they remove it, if processing is OK, the submitter detects and removes error in the prescription. (In the chart the double-sided arrow). The errors sometime appear later in specific configuration of input data. **Any detected error** is **in the end removed**.

All **PPROI tables and columns** are **named contentually**, the **logic of each step of system making** stems from prescriptions and is **explainable** if someone asks for an explanation.

10 LEAN STRATEGY – THE COMPREHENSIVE SUPPORT BY PPROI

THE LEAN PRODUCTION AT TOYOTA

Conventional organization of production defines processes for BOM parts and divides them into operationas performed at locally isolated work centers where the given part has different processing times. This concept has alternatives of which mostly mentioned is the **lean production**. Its **features** are illustrated in **next table** with graphic part copied from the book **Kanban, Just-in-Time at Toyota**.



One operator handles all 10 operations on BOM part in 10 work-centres arranged in U-line. After completing the work at the 10th work center, the operator returns to the first work center, where he starts the work on the next piece of the production lot. **Cycle time = 113 seconds**. In this case **it represents** also the **operators time per piece**, i.e. the **direct labor productivity**.

After automatic processing by machines, the parts are waiting on the operator.

If the **production lot = 100 units**, the **lead time of the lot** = 11300 seconds, ie **187.3 minutes**.

PARAMETERS OF CONVENTIONALLY ORGANIZED PRODUCTION

The same production process organized conventionally has substantially different parameters.

Operation	Manual time	Auto time	Total time
1	9	70	79
2	8	87	95
3	8	84	92
4	10	92	102
5	7	34	41
6	7	62	69
7	4		4
8	10	17	27
9	13	54	67
10	15		15
Process			591

The time of operators per piece equals to the sum of total times of all operations i.e. 591 sec. **In comparison with the lean production** above, it is 591/113 = 5.23 times longer. In other words the **labor productivity is more than 5 times lower**. The reason of such shocking ratio is that the **operators** are **attached to isolated work centers** and have to **wait** for the **automatic work of machine to be carried out**.

The **lead time of production lot** for the **whole process** is usually **longer than sum of the lot times in operations**. The reason is **waiting of lots between operations in queues.** That's why we can expect in given case **more than ten times longer lead time** of **production lot than in lean production**.

Multiple lead times mean **multiple inventories**. These require **handling and storage**. In comparison with lean manufacturing, **logistical costs** and the **capital employed in inventories**, **logistics equipment** and **storage space dramatically increases**. Figuratively speaking, **conventional production** is in many ways **obese** in comparison with lean production

EFFICIENCY VERSUS DISSEMINATION OF THE LEAN STRATEGY

The principles of lean production are recommended in the generalized application even **beyond the production boundaries**, sometimes under the term "**lean strategy**". Well known is also the term "**lean thinking**" which was used as the title of the bestseller book. However, this contrasts with the **small spread of lean production in practice**. It is documented by a survey of American authors in the "**Lean Machines**" **brochure**. Under the headline "**A Lean Strategy is the Only One That Has an Across-The-Board Impact**" they present **survey information** from which we extract the following:

	Assets				Estimate of Penetration
	Cost	Plant & Equipment	Inventories	Quality	
Lean Strategies	●	●	●	●	less than 5 %
Cost Reduction Programs	○				100 %
	Black circle means full impact, white circle is partial impact				

There are several **reasons** for such a **small spread of lean strategy**. As the main ones we see:

- **Managers do not perceive large reserves of labor productivity** when operators wait for machines, especially if times of operations are short, as in the previous table, where the total times of all operations are shorter than 2 minutes.
- **Lean processes require fundamental changes** in the layout of workplaces, in the flow of material, and in the deeply rooted **way of operators work**, which always gives rise to **massive resistance**.
- **ERPs** are **not able to describe, standardize and plan the lean processes**. Toyota procedures outside of ERP are applicable only in specific situations, in practice rather rare than prevailing.
- If the processes for different parts are variable but partly share the same machines, the layout of all machines into lines specific to each type of process could lead to a **high number of machines** needed and their low time utilization. The financial consequence would be excessive demands of processes on employed capital, depreciation and some other costs associated with machines. ROI could even fall in comparison with conventional production. Conventional concept of production processes remains rigid in most companies also because of worries about these consequences.

PPROI´s COMPREHENSIVE SOLUTIONS

Optimal solution of the last problem above requires that **only some of work centers** relevant to the processes **for a particular type of BOM parts** are **included into the same line**. Also, **solitary centers are not excluded** if cheaper machines includable into the lines would be inefficient. An example of such a solution is given in the **table on page 05**, where from the 12 operations of the process for a particular part, three groups of operations are realized in different lines and one operation is realized in a separate work center. Also such compromise solutions considerably increase the labor productivity and production efficiency compared to conventional processes that are generally divided into operations on isolated work centers. **PPROI can describe, standardize, plan, record and overall control all** the **variants of lean production**. Since, it is theoretically possible that all operations are carried out in isolated work centers, PPROI can control **conventional production as a special case of the lean production**.

The **PPROI company** employs also **lean manufacturing experts** who can well advise companies interested in the PPROI information system about optimal layouts of work centers and other physical process parameters from a financial point of view. Therefore, **PPROI** is a potential **supplier** of a **comprehensive solution resulting in the maximum value of the enterprise ROI.**

I. WHY PPROI

11 PPROI AS GENERAL CHALLENGE

SYSTEMATIC ENFORCEMENT OF BUSINESS LOGIC

The **PPROI concept** formulated in the motto "**Aligning Products, Processes and Resources to Maximize ROI**" in conjunction with the picture of PPROI as a compass **contains the definition**

- **Enterprise goal** – Maximizing ROI value
- **Means** by which the **goal can be achieved** – Products, processes and resources
- **An instrume**nt that **aligns and navigates the means towards the goal** – Information system

This is the **formulation and systematic enforcement of the generally valid business logic**.

If any of these three attributes in enterprise management **does not exists**, an **enterprise behavior contradicts the Basic Business Law**. This situation was before PPROI at **all levels of enterprise management**. Its main source is the **management theory** and consequently the attributes of **enterprise information systems. PPROI** is therefore **general challenge** to everybody everywhere.

MANAGEMENT OF ENTERPRISE BEFORE PPROI

The CEO

The **CEO** has primary responsibility for the enterprise behavior in compliance with the Basic Business Law and thus **respects the interest of investors**. To the CEO **all departments of an enterprise** are subordinated, and each of them must be **forced to ensure its processes** systematically **contribute to** maximizing the **enterprise value of ROI**. Above all, the **CEO himself/herself should think and act properly**. But that has **never been and is not yet**. The situation is well expressed by the recent revival of **John Kenneth Galbraith words**: *"If you create an organization geared to produce perfumes, dairy products, or aircraft fuselages, those who make it up will, if left to their own devices, tend to concentrate their efforts on producing more and better perfumes, dairy products, or aircraft fuselages, rather than thinking primarily of what will make the most money for the shareholders."* The situation does not change even if the **CEO is the owner of the enterprise**. In this case, the person concerned **in the enterprise management acts against his own interest**, i.e. schizophrenically.

CFO and his/her Financial Departments

The **ROI** is, or should be, the subject of regular attention in **monthly reports**. But these are **posthumous** numbers, which additionally **do not say anything** about the **key factors of ROI**, i.e. on **parameters of products**, their **processes and resources** in the past period. As such it is almost **worthless**. The **efforts of the financial controllers** are also **ineffective**, mainly because they are unilaterally **focused on costs**, and moreover because **information on product costs** is very **rough and distorted**.

Also, **ROI calculation** in the form of **Internal Interest Rate** or **Net Present Value**, when assessing the effectiveness of investment in machines and equipment, is **misleading**, because the **savings in operating costs can be calculated** only **through the information system** informing perfectly on **all types of machine costs for the planned portfolio of products** within the scheduled period. **ERP systems do not provide this information** and the **rough estimates or calculations outside of the IS** are provably **out of reality** already for the first year of longer term IRR or NPV calculations.

Production Management

Production managers cannot have better financial information than the financial department, and in practice they **work with financial information rarely**. Their **priority** is to **produce planned products**, which is not easy in the permanent chaos caused by MRP weaknesses. They therefore **create reserves** in **standards**, **capacities of people and equipment**, which all **decreases** the potential **value of ROI**.

ERP SYSTEMS

Weaknesses of ERP systems are **well known** to people whose job is to physically or financially control the enterprise products, processes, and resources. The **production schedulers** and **financial controllers** create **substitution tools in Excel** or other spreadsheets, replacing ERP. The content of these tools depends on individuals' **subjective considerations**. The **data** of the **different specialists** within the enterprise are **not well related**, and the **practices in different enterprises vary**. Yet, considering ERP, this is a **certain** progress and **help**, otherwise people would not do it. The question is **why ERP systems did not react** to this situation conceptually when major ERP suppliers employ an army of IT specialists. The explanation is easy. The **role of IT experts** is to efficiently process the content assignments**, not to fundamentally change** assignments, more so when it comes to the basics of **management theory**. If the IT firms wanted **to do it**, they should hire **business specialist** who **reveal the weaknesses** of the **existing theory** and **replace it** with **a mathematically formulated alternative,** as was the **case with PPROI.** But where can IT companies find such a person?

MANAGEMENT THEORY

The basic problem of **management theory** is its **fragmentation into many differently focused disciplines**, the **absence** of an **enterprise description as a structured system**, whose **interlinked structures have to follow the same objective**. T**he physical processes** in which the **capital in resources is transformed into products** and where the **capital value is increased should be described s**ubstantially **deeper**. The direction of the breakdown of processes into operations initiated by the Industrial Revolution and formalized by Scientific Management in the first decades of 19th century cannot be rejected, as Reengineering Corporation book claims. That would be the end of efficient production. Just the opposite. **Operations should be atomized into more detailed phases**, each of them **capturing** the **resources** and **their parameters** as a **base** of subsequent **optimization of everything**. The atomization of items and following synthesis into new qualities is a general trend of science and management theory should not avoid to it. **Attention** should be paid to the role of **all** of enterprise **departments in support of direct processes and their other contribution to ROI Max.** In each of them **resources** and generated **costs** and **employed capital** should be recorded. These values in **indirect territories** should be **properly allocated on direct processes** by products to properly calculate **products ROI** and to achieve optimal management of products, processes and resources. Efficient provision of these and other tasks requires **much wider use** of the **classic science and current IT apparatus**. Management theory should move in both directions just like other fields of science, at the expense of needless verbal ballast. The **enterprise information system** itself should be perceived as a **quantified management theory**, a **picture of its state as a science**.

WELCOMING PPROI OR RESISTING A CHANGE?

PPROI concepts and procedures can be **welcomed as an eye opener or rejected** only due resistance to change. We have already stated in the foreword the **positive acceptance** of PPROI concepts by many **management theory experts**. But restructuring the whole management theory can face resistance.

The most provable are the **theoretical benefits of PPROI** in the form of **attributes of the information system** and **comparison with** the **attributes of ERP.** This reveals weaknesses of ERP. Once the **first** of **major ERP vendors accepts the PPROI challenge**, **others** will quickly **lose** their **competitiveness**.

On enterprise level the **PPROI** should be most **welcomed by** the **shareholders and top management**. **Resistance** to PPROI may arise especially in some **people who partially substitute weaknesses of ERP** with **calculations in Excel**, for fear of losing their privileged status and current work. **Those** who accept the challenge and **learn to operate the PPROI** will be of **great benefit to the company**.

12 PPROI AS MOST EFFECTIVE INVESTMENT

SUMMARY OF MAIN INFORMATION BREAKTHROUGHS OF PPROI

Already in the overview text on the previous pages, the main attributes of PPROI were mentioned and briefly commented. Concentrated summary in the following table indicate that PPROI changes the previous information situation in all directions that determine the properties of the information system and, potentially, the properties of the enterprise itself.

ATTRIBUTES	BEFORE PPROI	PPROI
Navigation of an enterprise to its objective goal	NO; The goal is not reflected neither in the name nor in the content of ERP	YES; The goal is reflected both in the name and in the content of PPROI
Measurement of products, processes and resources	Fragmental, distorted, variables weakly linked	Comprehensive, accurate, variables fully linked
Execution production plan	MRP UNFEASIBLE; no coordination of the plan tasks with capacities	REALIZABLE; Territorially leveled and synchronized
Support of information system to different types of processes	NO; ERP limited to traditional processes	YES; Full support to different, progressive processes
Necessity of records and calculations outside information system	HIGH; Time demanding, subjective, with unsatisfactory results	LOW; Application of methods of science; Use of current IT potential

PPROI AS AN INVESTMENT

It is expedient to perceive **acquisition of PPROI** as an **investment in a particular machine** (PPROI is in fact a sophisticated computing machine) **and** to ask what is the **ROI of this investment**. Because the **synergistic effect of the PPROI attributes** is **enormous and steadily growing,** its exact quantification is impossible. However, the calculations of the **partial financial benefits of PPROI in the short period after system implementation** already indicate that the **ROI of the PPROI acquisition** is so **extremely high** that it is almost impossible to find another comparable investment.

ROI OF INVESTMENT INTO PPROI FINANCIAL

A mass of completely new financial information about costs and employed capital in product-based processes becomes the basis for strategic decision-making about the product portfolio, the attributes of processes, and resources. Existing solutions undergo thorough revision, new solutions should be optimal. This also applies to product prices. Companies, prior to the introduction of PPROI, have often offered customers the prices of their products well below actual costs, because of dramatically distorted "overheads". In such cases, difficult negotiations with customers on price increases or cancellation of contracts is necessary, based on convincing data.

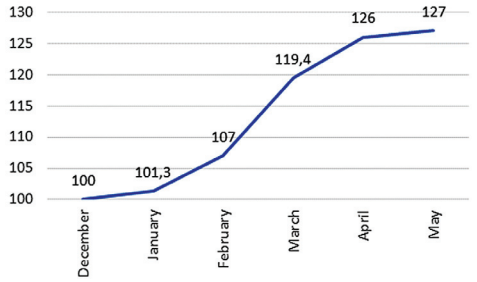
"The introduction of PPROI has, among other things, revealed heavy financial losses due to low prices of some of our products, which we considered to be good per previous cost calculations. E.g. the price of a financially important product sold to a foreign customer should be increased by at least 30% to dispose of the loss. After difficult negotiations in which we proved detailed direct costs of our progressive processes and adequate indirect costs of given product our customer has accepted the price increase. He understood our situation and he had no better price offer from other suppliers than our price after increase. Our annual financial benefit from the price increase per given product was higher than our regular annual investment into PPROI.

CFO, Enterprise producing parts for trucks and trains

ROI OF INVESTMENT IN PPROI PHYSICAL

The PPROI's potential and its successful use is well characterized by the following reference.

MONTHLY GROWTH IN LABOR PRODUCTIVITY



"The PPROI information system has fully supported the introduction of lean manufacturing in one of the production halls, and has ensured its comprehensive management, from the setting of detailed process standards, via the creation of execution schedules, the interim records of reality in kiosks, daily reporting of fulfilment of schedule by teams and individuals to subsequent calculation of bonuses to operators. ***Our productivity after half a year*** *since PPROI implementation has* ***increased by 27%."***

CEO, Enterprise of automotive industry

Let us assume an annual investment in PPROI = € 100 000, the same as its annual costs, default number of workers = 200, default annual labor cost per person = € 24 000, increase of wages = 1/3 increase of productivity. Then **ROI of PPROI investment = 5.67** i.e. **567%**. Given the average **ROI in well-performing businesses around 0.1,** the **ROI of the investment into PPROI** is **astronomical**.

Annual investment in PPROI	Increase of productivity %	Default number of workers	Default annual labor cost per person	Default annual labor costs totally	New number of workers	New annual labor cost per person	New annual labor costs totally	New annual labor costs totally	ROI of PPROI
100 000	27	200	24 000	4 800 000	158	26 160	4 133 280	566 720	5,67

It may be argued that the reason for productivity growth was the introduction of **lean manufacturing**, not the **information system**. However, these **cannot be separated**. Even lean manufacturing without its perfect standardization, planning, and overall control involves great losses. We found this in another advanced enterprise where losses were around 40%. And in **the presented example** the **productivity** of lean production **grew gradually** (see chart) and **could be maintained** under the **inexorable pressure of the PPROI.**

THE USE OF PPROI POTENTIAL → ROI OF INVESTMENT INTO THE SYSTEM

Losses in the direct labor is the **one of capital wastes** which **PPROI** can **reveal and remove.** There are **many others**. The **control of lean production** dramatically **decreases capital employed** in **inventories** and in related **areas and equipment** and also **reduces logistics costs**. **In general** only **PPROI allows to**

- **Optimize the products portfolio** and **pricing** of products
- **Optimize** the **scope of processes** within enterprise (make or buy), and **parameters of processes**
- **Optimize resources**, e.g. minimize unnecessarily expensive and low utilized equipment and buildings
- **Fully support continuous improvement** in all enterprise areas by detailed, specific information

By fully exploiting PPROI's potential, a ROI of investment in PPROI above 1 000% is realistic. But **even the 100% is fascinating**.

13 SCIENCE IN INFORMATION SYSTEM VS PRACTICES IN EXCEL

CLOSE LINKS OF ERP TO SCIENTIFIC MANAGEMENT OF 20TH CENTURY

Critics of ERP sometimes point to its rigidity, long-term immutability despite its known shortcomings for managing the prevailing classic organization of production, and the inapplicability of ERP in lean manufacturing. The **main reason** for the **immutability of ERP** core concept we see in its **close connection with** the principles of **scientific management of industrial production**, formulated in the first two decades of the **20th century**. These principles were **incorporated into all computer information systems at their birth in 50's**. All information systems also have taken over a tool of multi-week production planning whose computational algorithm was formulated by J. Orlicki in the 60's under the name **Material Requirement Planning** (abbreviation MRP) and of which **inputs are variables** defined by **scientific management** (more on p. 23). This situation persists in ERP to the present day because management theory has never systematically disputed the principles of scientific management, and no alternative to these principles exists in a comprehensive information system (except the PPROI).

This statement does not disregard the importance of initial scientific management. We greatly appreciate the contributions of the creators of the principles of scientific management, the spouses Frank & Lillian Gilbreth, Frederick Taylor, Henry Gantt, Ford Harris, and others who gave systematic directions to the previous spontaneous and subjective manufacturing practices and thus significantly contributed to the growth of labor productivity and to the reduction of production costs. But it was an early phase of science in management and some of its postulates require reconsideration concerning their incompleteness, one-sidedness and thus incorrectness. This is also true for the very term "scientific management" which its author Louis Brandeis identified with focus on reducing business costs, and which survived in financial education and thinking of managers to this day.

INTERCONNECTION OF PPROI WITH THE INNOVATIONS OF THE SCIENTIFIC MANAGEMENT

Reputable author of bestsellers in management **David Burkus** praised in 2010 the **concept of PPROI** as an "**updated scientific management**." This opinion has positively surprised us, because the close connection of current information systems with scientific management principles defined early in the 20th century is now almost forgotten and we ourselves have not explicitly expressed this connection in the first PPROI presentation material in 2010. But in fact, **in PPROI development we have primarily reconsidered the main postulates of scientific management** and we see interconnection between its innovation and PPROI.

Innovations of verbally defined **postulates of scientific management are the basis of PPROI content**, and **PPROI information, characterizing innovated postulates using numbers,** give the management an **irreplaceable attribute of advanced science** which is **essential** to its **practical use**.

As stated on page 3, the management information system **"must have" scientific innovations** which **unwind** from the **enterprise's mission – Maximizing ROI**; this must be **reflected in management of products, processes and resources** – instead of focus on minimizing costs. This conception subsequently generates the need for **innovation** of **metrics** – application of the definite **integra**l, innovations of the **initial information** – increase of their **details** and **accuracy**, innovations of the **variables links** – **change of computational** algorithms, etc.

This means we have tried to **remove the weaknesses of ERP by innovations of scientific management** and not by the rejection of scientific management as such. **Management should not become the only area** in which the **importance of science is underestimated** and which **favors "proven" practices**. Unfortunately, such a situation currently exists and it has no perspective.

MASS SPREADING OF MANAGEMENT INFORMATION BY PRACTICES IN EXCEL

Managers and other specialists respond **to the weaknesses of ERP's** control information mostly by **substitutes**, created **in Excel**. This is true for both **physical, and financial information**. This phenomenon is of a mass nature. We conclude this based on a large number of responses of **production planners** and **financial controllers** from various branches of industry on the series of articles "Management by ROI" mentioned on p. 02. The responses are well characterized by the following quotes: *"Although I am familiar with work in an ERP environment, including SAP, I have never got from them a real production plan. I had to rely on my own Excel file and years of experience. In this approach I see the risk of human errors." "We have always failed to get from MRP information that would allow us to manage human resources. With Oracle we have so far failed to control lean manufacturing. We have to use our own information in Excel." "Our various big customers are forcing us to calculate the cost of our products by their methods prescribed for Excel. However, each calculation model leads to different cost of the same our product. We are confused as to where the truth lies, if anywhere."*

The possibility of simple well-arranged numerical records and easy fast calculations from existing data lead to applications of **Excel** in **different areas of the enterprises**, in **different contexts**. However, **partial applications** are usually **isolated**, the procedures are not scientifically substantiated, **contradictions** exist **between them**, and **no system** is created.

BLIND BELIEF IN THE CORRECTNESS OF THE PRACTICES OF A PARTICULAR ENTERPRISE

Concerns of subjectivity and thus incorrectness of practices in Excel expressed by a planner in the first quote above are rather in minority. **Practices** once developed within a **particular enterprise** are usually **stable** in the **long term** and **managers** are **convinced of their correctness**.

But reality is the just the opposite. **Weaknesses** of information in the **partial Excel files** and the **non-existence of their links**, i.e. the **absence of a system, generate huge losses**. Among other it lacks timely coordination of production plans of different production centers and material supply. Only during the first shift, at regular morning meetings of the staff of various departments, it is examined what can be produced and included in the plan for that day. The **utilization** of both **workers** and **equipmen**t is **unsatisfactory**, but the **excess capacities** of all types of resources **do not prevent** the **fulfillment of customer orders**. For **short-sighted** production **managers** this is the **only goal** that **cannot be achieved differently from their practices**.

Informatics in some enterprises are interested in **replacing their Excels with an information system**. They usually want to **preserve existing information**, only **change the form** and include all information **under one roof** for overall control. If this happens the **result** is a **deeper conservation of incorrect practices**.

FROM THE PRACTICES TO INNOVATED ENTERPRISE SCIENTIFIC MANAGEMENT BY PPROI

An attempt to implement PPROI without changing the enterprise atmosphere described in the previous paragraph is unlikely to succeed. More the less so if PPROI is presented as a tool for advanced scientific management. **People believing their own practices** usually **do not like** the **theory** and **science**, do not understand it and are **not able** to **professionally communicate**.

The ideal industrial enterprise for implementing PPROI, in which most people **favor advanced science**, is hard to find. But this **must be** the **case for decision-makers**, i.e. **top executives** or **key investors**. Their role is crucial for decisions on the implementation of PPROI and for **overcoming** lethargy or **resistance** of others **during** the **implementation** of the **system**. The successful implementations of PPROI have confirmed this.

From the PPROI side enlightenment is necessary: **publications**, understandable **marketing** and **education of employees in enterprises introducing PPROI.** Comprehensive education of managers of different enterprises requires **public programs,** with **new content and form** (see next page).

14 NEW ERA OF EDUCATION IN MANAGEMENT THROUGH INFORMATION SYSTEM

RE-EDUCATION IN MANAGEMENT OF ENTERPRISE FROM THE BASE

The application of science has only worse alternatives in all areas of human activity. **Science** requires **understanding, describing** and **respecting the laws of nature**. If physical laws are not respected, the results of human activities are not functional. If economic laws are not respected, the results of human activities are worse than they could be. This fully applies to the management of enterprise. **Ignoring both kinds of laws**, which is common in practical business management, unwinds from the same **weaknesses of management theory**. **Invalid**, contrary to the laws of nature are even some **basic postulates** of partial **management disciplines**. These postulates **must be rejected** and **replaced by truly scientific alternatives**. And both should be **reflected** by the **re-education of managers**.

The **fundamental defect of financial management of intra-company entities** is the **focus** on **relation** of **effect to costs**, which **for given product** means generally accepted **aim of cost reduction**. E.g. in the eighth edition of the prestigious management accounting textbook, the only necessary feature of the discipline is stated as: *"No constraints other than **costs in relation to benefits** of improved management decision."* Because the financial effect of business processes is profit, the **financial criterion in decision making of managers** is the ratio of profit to the cost, so-called **cost effectiveness**, or the **profitability**, defined as the ratio of profit to the price of products. **Both ratios are consistent and substitutable** as decision criteria. However, this procedure is **contrary to the natural basic financial principle**, **valid since the birth of money** (see next p.) and as such is **the economic law**.

When comparing **roles of** two main **accounting disciplines**, the **management accounting** has *"**behavioral implications for intracompany entities** and **future orientation**"*, while *"**financial accounting** serves to **investors** and informs on **history** of the **enterprise as a whole**"*. But **ignored is the discrepancy between** the **criterion of management accounting**, i.e. **profitability**, **and the criterion of investors** and **whole enterprise**, which is **ROI**. All **intracompany entities** are **managed in contradiction with** the **investor's interest and aim of enterprise**

System	Capital, ROI	Products, processes
Financial accounting	YES, but	No
Management accounting	No	YES, but
PPROI	YES	YES

Financial accounting records **capital** and **ROI** only in **past period** for the **enterprise as a whole.**

Management accounting does not record **capital** and **ROI** and its **information on cost of products and processes** are **distorted.**

PPROI solves all these fundamental problems.

Contradictory and misleading are **criteria of all specialized management disciplines**, as **every one of them follows different aim** and **none follows ROI MAX** (see p. 08). It is therefore **necessary to rethink all the traditional management education**.

EDUCATION IN MATHEMATICAL ASPECTS OF ENTERPRISE MANAGEMENT

As has been repeatedly mentioned, the basic prerequisite for proper enterprise management is the application of a definite integral. **Knowledge of managers** must therefore **exceed** the **standard framework of primary schools mathematics**. For the understanding of economic variables also knowledge of **set theory** is important. This allows to understand the characteristics of costs which in themselves exclude their usability as a decision criterion (see p. 19). **Overall education in** the **types and characteristics of economic variables** (usually called **indicators**) from a **mathematical point of view** is needed.

For the correct application of mathematics and statistics also the knowledge of **operations with economic variables** is needed, especially **aggregation**, **allocation** and **comparison of values of individual variables**, **types of functions of different variables** and **decompositions of synthetic variables**.

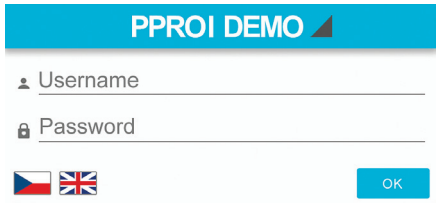
Knowledge of the **mathematical properties of economic variables** and their **content** go **hand in hand**

TEACHING THROUGH INFORMATION SYSTEM

The **reevaluation of incorrect postulates of management theory** and **identifying and solving key unnoticed problems by theory**, the **assessment of ERP systems properties** and subsequent **formulation** of the **"must have" requirements for an information system** that supports a truly scientific management of an enterprise (p. 03) were the **basis of forming PPROI**. Various aspects of this problematics are **described in** the pages of **this document** which **serves as a textbook**. Thus, the reader can even now assess the relevance of the problems and the correctness of their solution.

The **existence of information system** that characterizes the **enterprise as a scientifically managed organism** creates the possibility and the need for a completely **new approach to education**; the **teaching** of managers **through** the **information system**. The need for this approach stems above all from the logical and mathematical **links of all variables**: The influence of a given value of partial variable on the ROI of an enterprise depends on values of the other partial variables. **Nothing in enterprise is isolated**. Exceptional importance for decision making bear the **trade-off** relationships of **partial variables**, i.e. the situation where better value of a particular variable is conditioned by worse value of another variable or by worse values of several other partial variables. For the correct decision-making between alternatives, in these cases, **values of all variables must be projected into** the **ROI enterprise value**. This possibility is offered **only PPROI, among** many **other unique properties** necessary for effective management of enterprise with which qualified **managers should be familiar**.

DEMO PPROI VERSION AND TEACHING METHODS



Teaching is accomplished through **DEMO PPROI version** that in accordance with the structures of PPROI architecture contains:

- **set of products, BOMs parts** with **their parameters**
- **set and parameters of resources**
- **structure and parameters of enterprise territories**
- **classic and lean processes with parameters**
- **prices** and **external inputs of calculated variables** and **computational algorithms**

The **demo version** serves as a main **teaching tool for lecturers** and for **independent work of individual participants**. Lecturers present a comprehensive system and its modules, teach participants to control the system, assign tasks to them, assist them and evaluate their results. During the program days **participant**s have **access to the system through their hardware**, notebooks, tablets, resp. smart phones in combination with other HW. Individuals can **independently experiment with input data, run calculations**, etc.

They are guided are not only by the **lecturer's instructions**, but also by the **interactive workflow**. Everyone can thus become familiar with the application of a breakthrough information system for effective management of a changing enterprise organism.

TYPES OF PROGRAMS AND THEIR PARTICIPANTS

Programs are **differentiated** in terms of **depth and specialization**. The **basic program**, in which only main features of PPROI are presented by a lecturer, is intended for **all interested in PPROI**. The program should be sufficient for **investors and top managers to judge the PPROI's usefulness for their enterprise**.

For the sake of overall review the basic program is also intended for people interested in PPROI from a **user point of view**. Those in the follow-up programs **work using the above mentioned procedures**.

Specialist programs are focused on **physical** and on **financial management of products, processes** and **resources**, in line with the PPROI structure – Physical and Financial parts**. The first one** is devoted mainly to **production planners and managers**, the **second** to **financial specialists and traders**

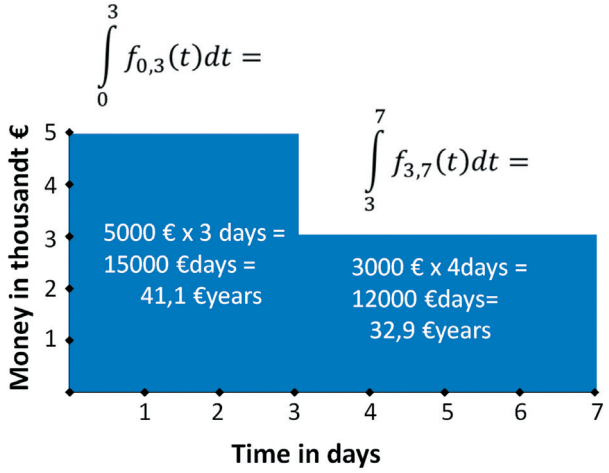
15 BASIC FINANCIAL PRINCIPLE IN ENTERPRISE MANAGEMENT

LESSONS FOR BEGINNERS

Professor Zarihul Hoque, in 2010 at the time the editor of "The Journal of Accounting & Organizational Change" (Australia) responded to the first PPROI presentation material in the following words: "*This **can be used in undergraduate accounting class**. As this is an **innovative idea**, develop the paper to demonstrate how **PPROI enhance our current knowledge** and **suggest** future **directions of research**.*" Similar reactions were more. Because since then, apart from the mentioned series of articles in the Czech version of MM Industrial Spectrum, we haven't published anything about the issue, we must start here "from Adam". Since these are the very foundations of financial thinking it makes sense to debate the suitability of teaching the issue in elementary schools, as is the case with set theory, which in management can serve eg to understand the mathematical properties of the costs.

INTEGRATION OF MONEY AND TIME SINCE FOREVER

Since the birth of money and its lending, the logical assumption is the **proportionality of the lender's yield** from the loan **to the amount of money** lent **and** to **the time** of the loan. Mathematically, both can be measured simultaneously by a **definite integral** of the **money states in a certain period** expressed in **moneytime units** and **graphically** presented by **the area**.



This **principle** is **applied** in the **banking industry** though few people realize that they count integrals. **Times** of deposits usually **registered in days** are **converted to annual values** and **from** values of **integral in moneyyears** eg from €years is **calculated the yield** according to the actual **interest rate**.

The lender's return on the loan, expressed in money unit, is a function of the integral and a predetermined rate of return on the loan for a period of one year.

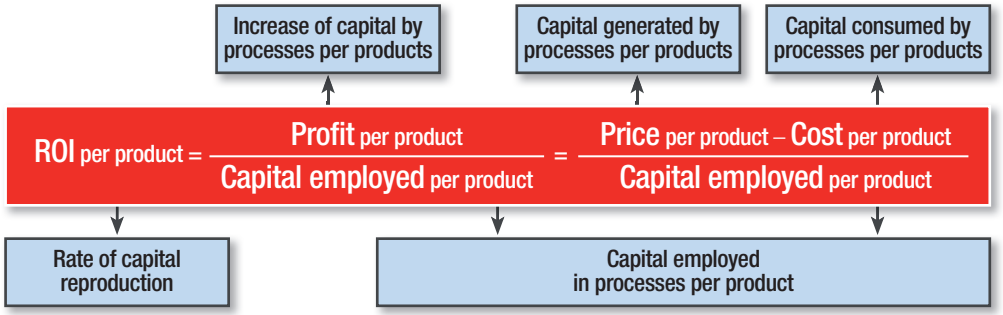
Essential is the actual rate of return on the loan, which occurs in the borrower It is unknown in advance, the debtor realizes it in its own processes and strives to be higher than the rate of return for the lender. If that is the case, part of the actual yield remains borrower, if it is not, the borrower is unable to repay the loan the interest, which may have fatal consequences for him.

This basic financial principle is universal; As such is in force in enterprise management too.

Dates	Period	€	€days	€years
1. 1. – 3. 1.	1	5 000	15 000	41,1
4. 1. – 7. 1.	2	3 000	12 000	32,9
1. 1. – 7. 1.	Total		27 000	74,0

THE FUNCTION OF THE BASIC FINANCIAL PRINCIPLE IN THE ENTERPRISE

Business processes mean the **reproduction of capital** in which **its forms repeatedly alternate**; one form expires, another arises. **Key term of management theory**, especially under capitalism therefore should be the **capital**. The more so that **all financial variables** are possible and useful to interpret as **parameters of capital**. This also well applies to the ROI and the variables from which it is derived.



Price, cost and profit are measured in **money units, capital employed** as an integral in **moneytime units**. Aggregate value of capital employed per individual product is as sum of partial integrals which characterize states of capital for certain periods of time in items related to processes per particular product. The definition of the objects that generate the definite integrals of capital employed, the example of calculation of the integral and illustration of integrals in graphic forms is given in the following page.

ROI values in processes for different products vary because of **specific values** of their **costs** and **capital employed**. Also prices of different products differ. Values of these **absolute variables** are manageable and **have to be managed in a way, which result in ROI maximum**.

MAIN ENLIGHTENMENTS

From the above presented formula, each manager should draw and remember two main conclusions:

1. The **Basic Financial Principle functions** on the level of **processes** defined **for individual products**. **Ignoring this fact** both in theory and in practice was the **biggest flaw in the history of enterprise management** by the end of the second millennium. Without any exaggeration, it must be stated that the **management of the business as a whole** was therefore **misleading**.
2. Ensuring that the Basic Financial Principles bring maximum ROIs requires **recording and optimizing two variables in the course of processes for each product**s – **costs and capital employed.** Costs are very important because together with price determine the effect of processes. But cost or price cannot replace a capital employed in the denominator of the ROI, similarly as profitability cannot replace the ROI, for more reasons, which we comment further. Now we mention one and quite sufficient: **The expectation of the specific yield from any variable without time dimension is nonsense**. And the use of **integral is the only way out**.

16 INTEGRALS OF CAPITAL EMPLOYED ACCORDING PRODUCTS

TYPES OF OBJECTS MEASURED BY DEFINITE INTEGRALS

Employed capital is included in **three main types of objects**

- Buildings and grounds
- Movable property
- Inventories of materials, semi-finished and finished products

Most of capital operates in processes on the parts of the BOM and in relation to the product is direct. The capital contained in indirect territories has to be allocated to direct processes. This is described further. Now we demonstrate an application of the integral on production machines and inventories.

CALCULATION CAPITAL EMPLOYED IN PRODUCTION MACHINES; EXAMPLE

Part	Process	Operation	Machine price €	Piece time minute	Capital in operation €year	Time use of machine %	Capital total €year
124	Production	10	150	0,5	0,0713	0,28	0,2546
124	Production	20	250	0,7	0,1664	0,38	0,4378
124	Production	30	200	0,6	0,1141	0,32	0,3565
125	Production	10	150	0,5	0,072	0,28	0,2571
125	Production	20	250	0,4	0,0951	0,38	0,2502
125	Production	30	200	0,6	0,1141	0,32	0,3565
224	Assembly	10	50	0,6	0,0285	0,18	0,1583
224	Assembly	20	30	0,7	0,02	0,22	0,0909
Final					0,685		2,1623

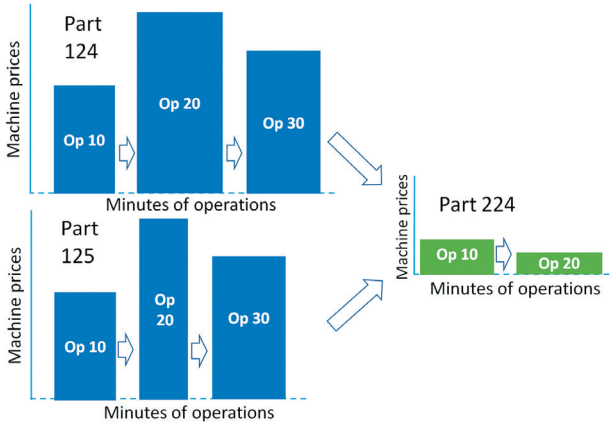
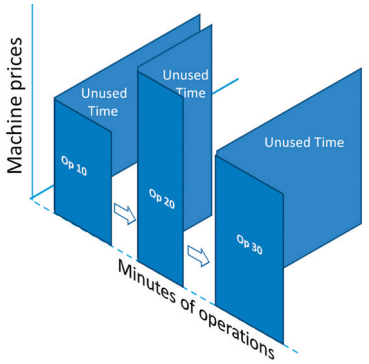


Figure can illustrate one type of contradictions between cost and capital employed:

If an **enterprise purchases parts 124 and 125** and only assembles them, the **capital employed** in machines for given final product will be about **15 times lower** than in the case of production of parts. But the **cost** of the purchased parts and of the **final product** should be **higher** because potential **supplier of parts** will sell them in price which include their **cost plus supplier profit**.

TIME USE OF MACHINES, EQUIPMENT AND HALLS

Very important is the time utilization of machines, which is less than 50%, in one-shift or two-shift mode on working days. Other machine time loses are common within working shifts.



In **calculating the capital employed in machines for product**, it is necessary to **increase the integral in active time by integral** in **unused time** that is inversely proportional to time use of a particular machine. This integral is shown in the graph on the Z axis. The whole chart relates to part 125.

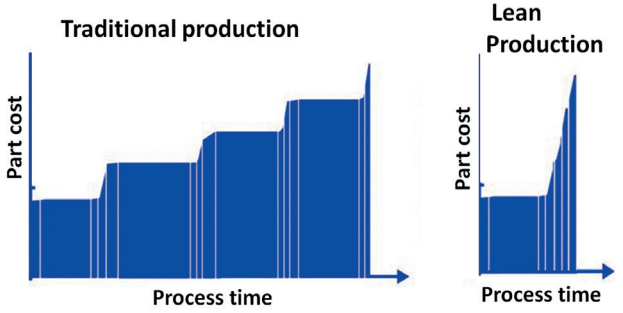
The same applies to capital employed in the **parts of production hall** where the machines are located. **Separate calculations** of the same kind are required for **robots** and **other asset items** which function in **direct production processes**

DIRECT CAPITAL IN INVENTORIES

Direct capital in relation to certain product is logically **employed** in **inventories of product itself and in its BOM parts**. Value of **moment capital states** is usually expressed by **cost** of item that grows in jumps or linearly. **PPROI** can **increase cost of inventories** of semi-finished products and work in process by calculation of **adequate profit**, created in preceding processes.

Most of the total time of the items is in **inventories of processed batches**, on **storage sites between operations** and in **warehouses**.

The **lean production reduces capital employed in inventories** by **eliminating waiting times between linked operations.**



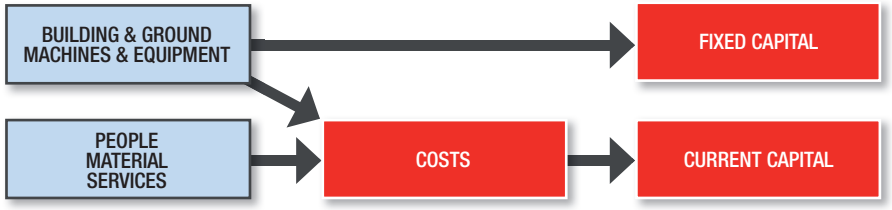
GENERAL APPLICATION OF DEFINITE INTEGRALS

Application of an integral in enterprises is not limited to quantification of capital in moneytime units. **It is** also **important** when it is necessary **to characterize states of objects in volumetime units.** Further we present its importance in calculations of **leveled production plans**. The need for and benefits of **integral applications goes beyond corporate boundaries**. The axiom that the "**state variables** can be in time periods characterized **only b**y a chronological **average"** appears as **false**.

17 TYPES OF RESOURCES AND PROCESSES IN FINANCIAL VARIABLES

TYPES OF RESOURCES, COSTS AND TWO TYPES OF CAPITAL

As shown in the following diagram, the resources of enterprise in terms of their impact on financial parameters are of a dual nature. Only buildings & land and machinery & equipment are projected into fixed capital, which typically accounts for majority of the employed capital. All types of resources are reflected in costs, i.e. in the consumption of capital for the product, and through the costs into the current capital which is contained in the inventories of material, work in process, semi-finished products and finished products. The relevant components of the current capital, expressed in moneytime units, are not proportional to the components of the costs, as the times of the individual cost components in the processes for a particular product are different.



The clear logical consequence of this is that **processes for a given product**, which have the **same costs** but **lager shares of machines and equipment**, contain **more fixed and total employed capital** and their **ROI** is therefore **lower.** These processes are therefore **less effective**.

OPTIMAL STRUCTURE OF RESOURCES IN TRADITIONAL AND LEAN PRODUCTION

Individual types of resources are reflected differently in financial variables, including ROI, depending on the types of processes. Significant differences exist between traditional and lean production. **Lean manufacturing utilizes workers much better** and therefore **their substitution by machines is less effective than in traditional production**. We demonstrate the problem in the example of robotizing on the right side of this page. First, however, in the following table, we summarize the main differences between traditional and lean production as presented by classical literature.

Objects	Parameters	Traditional production	Lean production
Machines	Layout	Machines grouped by types	Machines grouped in process sequence, mostly U shape
	Performance	Maximize! Mostly large, expensive machines with independent piece times	Optimize! Mostly small, cheap, easily serviceable machines with similar piece times
Operators	Work	Operationally specialized	Multioperational work
	Time use	Mostly low; waiting on the finish of automated work of machines	High; walking across and work on operations in process sequence
BOM parts	Movement	Stocks between operations	One piece flow inter operations

Lean manufacturing is often associated with automatic quality control of process (poka yoke), quick tool change (SMED) and with other attributes that are relevant also to traditional manufacturing. And it is not necessary to restrict the lean production by the size of machines (as in the table above).

THE CASE OF ROBOTIZING LEAN MANUFACTURING

Robots should reduce number of operators, not only **manual work** with the **increase of operators unutilized time in work centers** or in **production lines**. This often happens, labor productivity stagnates and ROI decreases. This applies both to traditional and lean production.
In the first of the two following tables, the data of example in book "Kanban – Just in time at Toyota" is adopted. **One operator operates line** with 9 workplaces in a **tact time derived from demand = 113 sec**. Second table contains calculations of amortization and capital employed in the robots per tact time when the operator is replaced.

Before robotizing

Operation	Workplace	Manual time	Walk time to next machine	Total time of operator	Automatic machine time	Tact time
1	CE-229	9	2	11	70	113
2	LA-1306	8	1	9	87	113
3	LA-1306	8	2	10	84	113
4	LA-1101	10	1	11	92	113
5	DR-1544	7	1	8	34	113
6	SP-101	7	1	8	62	113
7	MM-122	4	1	5		113
8	HP-657	10	1	11	17	113
9	BR-410	28	2	30	54	113
Process		**91**	**12**	**103**		**113**

After robotizing

Operation	Robot time *sec*	Tact time *sec*	Robot time utilization	Robot price *€*	Robot lifetime *years*	Amortization per tact time *€*	Capital employed per tact *€years*
1	9	113	0.079	200 000	8	0.0895	0,358
2	8	113	0.071	200 000	8	0.0895	0,358
3	8	113	0.071	200 000	8	0.0895	0,358
4	10	113	0.088	300 000	8	0.1343	0,537
5	7	113	0.062	200 000	8	0.0895	0,358
6	7	113	0.062	200 000	8	0.0895	0,358
7	4	113	0	200 000	8	0.0895	0,358
8	10	113	0.088	300 000	8	0.1343	0,537
9	28	113	0.248	500 000	8	0.2238	0,895
Process				**2 300 000**		**1.0294**	**4,117**

Amortization of all robots per hour of working time = 1.0294*60/1.833 = 33.70€. This must be further increased by amortization in nonworking time of the enterprise. If working mode is 2 shifts in weekdays amortization = 33.70*3/2*7/5 = 77.07€. This is much more than current hourly labor cost in industry of any European country. Robot costs must also include direct variable cost, ie electricity, maintenance, programming, etc. **In the example the robotizing is generally unacceptable**. The **acceptability** of **robotizing in different countries is different in dependence on the wage levels**. The **acceptability** of **robotizing in terms of ROI depends on demanded ROI value**. When it is 0.1 the hourly cost reduction of robotizing in our example should be 0.5*2300000 / (365*24) = 131.28€. This cost reduction by saving worker is impossible. The prices for robots would have to be much lower than the estimated prices in the example.

18 MANAGEMENT OF ROI AND CAPITAL PORTFOLIO BY PRODUCTS

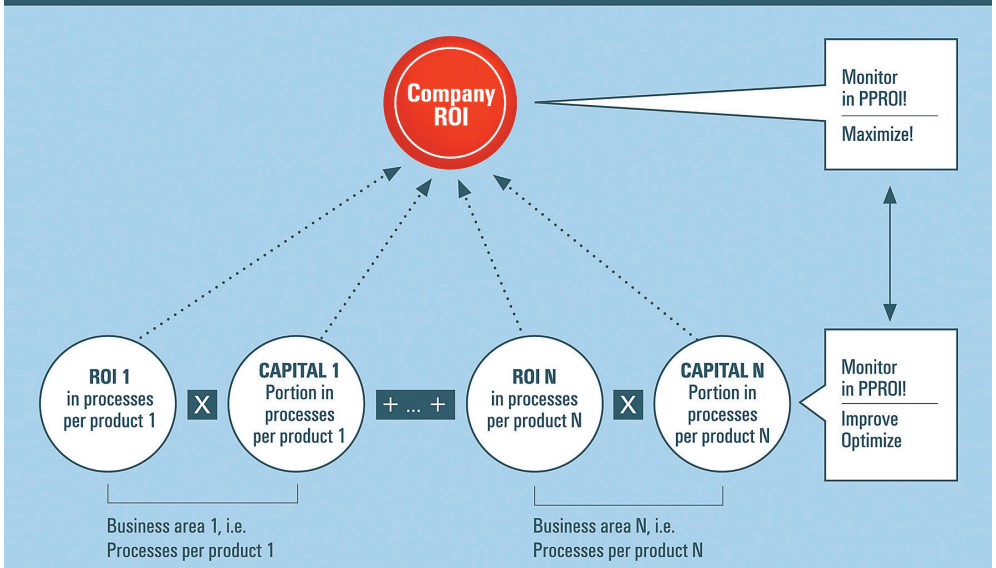
PRODUCTS AND ENTERPRISE VALUES OF ROI AND CAPITAL EMPLOYED

An enterprise's ROI value – ROI_E, is **defined by**

- **ROI values** delimited according to **individual products** – ROI_i
- **Amounts of capital employed in processes** specified **by products** – C_i

as weighted average of **ROI´s partial values**, according to formula $\mathbf{ROI_E = \sum ROI_i * C_i / \sum C_i}$

Schema of company's ROI maximization



From the formula projected to the chart, it follows that the **ROI value of the company** should be **managed by ROI values for each product** and by **structure of capital employed per products**. In principle**, partial ROI values** should be **maximized**, the **capital structure according to products** needs to be **optimized**, while tracking the **implications** for the **ROI value of the enterprise**. It is expedient to perceive **processes for individual products as in-house business areas**.

Amounts of capital in processes specified by products are **defined by**

- **Capital employed** in processes **for natural units of measure of individual products** – C_{ui}
- **The quantity of individual products** in the period considered – Q_i

as a multiple $\mathbf{C_i = C_{ui} * Qi}$

The structure of capital by product should therefore be **managed through the product structure.**

AN EXAMPLE

Product	ROI_i	C_{ui}	Q_i	C_i	$ROI_i * C_i / \sum C_i$
a	0,08	10	100	1000	0,02133
b	-0,02	20	200	2000	-0,01066
c	0,12	5	150	750	0,02400
Enterprise				3750	0,03466

The lower weighted average of ROI = 0.03466 compared to a simple average = 0.06 is due to the **large weight** of the **capital employed in processes** for the loss **product b**.

The large weight of capital in processes **for product b**, symbolically C_b, is **caused by the highest capital demand of this product unit**, C_{ub} = 20, and the **largest quantity of this product,** Q_b= 200.

THE THINKING OF MANAGERS = THE ENRICHED THINKING OF INVESTORS

Portfolio investors who invest their capital **in different businesses**

- are **watching return of investment to each of the companies**
- by purchases and sales of shares **govern the structure of the capital invested**.

In the **management of companies by ROI,** managers act **in the interest of investors**, so as to ensure for them **the highest ROI** of their capital **in each enterprise**. When managing the structure of capital the managers proceed in a way that is analogical to the way investors behave; but they **manage the structure of capital on a deeper level.**

Portfolio investors do not have the opportunity to directly control partial ROI values, which are, from the investors' point of view, the company's return on investment. Conversely, for **company's managers controlling partial ROI values is a basic obligation**.

Another important difference is that while the **financial parameters of the different companies**, in which portfolio investors invest their capital, are more or less **independent**, there is **dependence of the financial parameters of the various products within the enterprise**. This is due to the partial **sharing of resources by processes for different products**.

The thinking and procedures of portfolio investors in the management of companies according to ROI are thus insufficient, and it is necessary to enrich them substantially. However, **essentia**l is the **ability of managers to think and behave** in management of companies in same way **as investors** and the managers have such opportunity in the first time in the history **through completely new information**. Before, even the investor in the role of manager thought and acted against his own interest.

MANAGING THE VALUES OF ROI FOR INDIVIDUAL PRODUCTS

As already stated in the formula on page 03 the ROI value in the processes for a certain product is determined by the price of the product, costs, and capital employed in the processes relating to the product. Therefore the **management of partial ROI values** is based on the **management of prices, cost, and capital employed** in their mathematical relations as set forth in the formula**.**

That does not mean the solution lies in operations with financial numbers. **Financial figures** – costs and capital employed – **are largely determined by the physical parameters of products, processes and resources in their interrelations. Proper financial management** therefore **involves perfect physical information**. This also applies to pricing. However, to **properly evaluate the physical alternatives of processes**, there is a need for relevant and **accurate financial information.** Thus the requirements for **perfect physical and financial information** go **hand in hand**.

19 CONTENT AND MATHEMATICAL ATTRIBUTES OF THE "COSTS"

FALSE AXIOMS

The flaws of traditional financial management of enterprise products, processes and resources lie not only in the absence of information on capital employed and ROI according products, but also in the lack of clarity of the content and mathematical attributes of the concept of costs. From the beginning of the products costing is considered a matter of course, that

- **Product cost is an attribute of the product**, similarly as the price
- **Decrease of product cost is always positive**, increases profitability and **brings money**

But this is **not generally true**, these are only **false axioms**.

PRODUCT COST AND ORGANIZATIONAL DELIMITATION OF ENTERPRISES

The **product cost is** not the property of just this object. Their value is **related to an enterprise that** produces and **sells**, or just buys and sells**, the product**. The **cost of the products are changing** considerably In the course of **organizational changes of the enterprises**, ie their merging and division, even if the real processes do not change at all.

Let us suppose, for example, that the management of the corporation merges two of the subordinate enterprises into one, and from the original enterprises will start the plants. Everything else will remain in the old. For convenience, we can also make the products and their relations as easy as possible.

As a starting point, enterprise 1 manufactures product A that sells to enterprise 2. In enterprise 2, purchased item A becomes a material processed in product B. Other products are not produced.

Annual values of physical and financial indicators before and after merger are shown next four tables.

Table 1: Enterprise indicators before merger

Enterprise	Product	Volume *thous.*	Price *€*	Sales *thous.€*	Material Costs *thous.€*	Other Costs *thous.€*	Total Costs *thous.€*	Profit *thous.€*	Profita-bility
1	A	10	200	2000	800	1100	1900	100	0.05
2	B	10	400	4000	2000+800=2800	1000	3800	200	0,05
Aggregates				6000	3600	2100	3700	300	0,05

Table 2: Enterprise indicators after merger

Enterprise	Product	Volume *thous.*	Price *€*	Sales *thous.€*	Material Costs *thous.€*	Other Costs *thous.€*	Total Costs *thous.€*	Profit *thous.€*	Profita-bility
3	B	10	400	4000	1600	2100	3700	300	0,075

Table 3. Products indicators before merger

Enter-prise	Product	Price *€*	Cost *€*	Profit *€*	Profita-bility
1	A	200	190	10	0,05
2	B	400	380	20	0,05

Table 4. Products indicators after merger

Enter-prise	Product	Price *€*	Cost *€*	Profit *€*	Profita-bility
3	B	400	370	30	0,075

The sharp **increase** in product B's profitability from 0.05 to 0.075 does not bring money, but **mystifies.**

DEPENDENCE OF COSTS ON COOPERATION OF ENTERPRISES

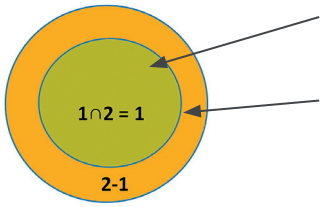
The data in the tables may reflect the parallel reality when the same final product B arises

- through cooperation between two enterprises 1 and 2
- within the enterprise 3

and all the physical parameters of the production are identical in both cases.

Mathematical explanation lies at the **intersection of sets of monetary units of different enterprises.**

Sales of the enterprise 1 and costs of the enterprise 2

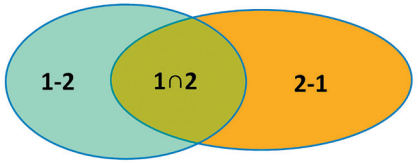


Intersection of the set of monetary units of sales of the enterprise 1 with the set of monetary units of costs of the enterprise 2.
The value transferred from enterprise 1 to enterprise 2

The difference between the set of monetary units of costs of the enterprise 2 and the set of monetary units of sales of the enterprise 1.
The cost of the enterprise 2 without transfer value (purchases) from the enterprise 1

In practice, in the production of a given product, the finalizing enterprise usually co-operates with multiple suppliers. The degree of cooperation vary. Sales of enterprises-suppliers and the costs of a particular enterprise-customer therefore have different intersections.

Sales of the enterprise 1 and costs of the enterprise 2 at a lower intersection



where
1 again denotes a set of monetary units of sales of the enterprise 1
2 again denotes a set of monetary units of costs of the enterprise 2

Removing an influence of **duplicates** on product costs in general is not possible because it is a **basic feature of costs** to be respected. However, practically all **cost-based** assessments and **decision-makings lose relevance**. And the "cost accounting" should not be called "management accounting".

PROBLEM SOLVING BY ROI

The problem of duplications disappears in the financial measurement of products and processes by the natural comprehensive measure that is the ROI. **Capital employed**, as well as the effect i.e. **profit**, do **not content** any inter-company **duplicates** of their values; see the continuation of the example below.

ROI before merger

Enterprise	Product	Profit	Capital employed	ROI
1	A	10	100	0,1
2	B	20	200	0,1
Aggregates		30	300	0,1

ROI after merger

Enterprise	Product	Profit	Capital employed	ROI
3	B	30	300	0,1

20 PRODUCT PRICING AND SETTING FINANCIAL TARGETS

C ONTRADICTIONS OF CONVENTIONAL PRODUCT PRICING

As a convention, the management practice assumes the **proportionality of the product price to the product costs**, i.e. an **increase in product costs by standard value of the profit-to-cost ratio**.

Price of product = **Costs** of product + **Costs** of product * **(Profit/Costs)** *standard*

In this price formula, the **factor of time** is **totally ignored**, which **violates the basic financial principle**. Expecting a particular yield from the amount of money irrespective of the time of money in the processes is senseless, but in case of the standard Profit / Costs ratio this exists and nobody, not even in theory, criticizes this absurd concept.
The consequence is logical contradictions. Physically identical processes for a product generally result in the following situations: **The greater the proportion of purchased material in an enterprise finalizing a particular product**, **the higher the price** and the profit for **the product**. This is due to **calculation of profit from costs of purchased materials**, which is only **transferred value from supply companies.** Assume in previous example on pg. 12 standard value of ratio Profit / Cost = 0.1. Then the **price of product B = 417.9 when produced in enterprise 2**, before merging enterprises 1, 2,

Enterprise	Product	Material costs	Other costs	Total costs	*Standard* Profit/Costs	Profit	Price
1	A	80	110	190	0,1	19	209
2	B	209 + 80 = 289	100	389	0,1	38.9	417,9

while **when** the same product is **produced in enterprise 3**, after merging enterprises 1, 2, **price = 407.**

Enterprise	Product	Material costs	Other costs	Total costs	*Standard* Profit/Costs	Profit	Price
3	B	80 + 80 = 160	210	370	0.1	37	407

The scope of processes for products in the enterprise may depend not only on inter-company cooperation but also on the complexity of products manufactured from the same material. Example are piston rings, whose processing is finished by grinding for low demanding engines, while more demanding engines require additional honing, lapping and special finished coating. In these cases the conventional product pricing in terms of ROI favors simpler products with shorter processes

Product	Material costs	Process phases	Process costs	Total costs	Profit/Costs	Price in conventional pricing	Profit in conventional pricing	Capital employed	ROI
P	500	1	200	700	0,1	770	70	500	0,14
Q	500	1 + 2	400	900	0,1	990	90	1000	0,09

Chaos in product costing

In addition to the misconception of conventional product pricing, there is a chaos in costing products. The lack of comprehensive information on product costs in ERP systems led controllers of **some large corporations** to create their own **calculation formulas** by which potential **suppliers** of their products **must calculate costs**. Calculation formulas vary in overhead surcharges, each leading to **different outcome.** One supplier of the same product to several corporations, who is forced to perform more different calculations, is confused about **where the truth lies**. **It is nowhere in these calculations**, because through overheads it is impossible to uncover the truth about actual product costs.

BASIC FINANCIAL PRINCIPLE IN THE PRODUCT PRICING

The basic financial principle implies that the **profit for the product**, i.e. the yield, should be **directly proportional to the capital employed** for the product. From this follows the **price formula**

Price of product = **Costs** of product + **Capital employed** for product * **ROI** standard

The price thus determined is **not dependent**, inter alia, on the definition of the enterprise making the product, or **on the enterprise's co-operation** in the manufacturing of the given product **with other enterprises**. In the previous example, if the ROI standard = 0.1, **the price of product B = 400,** when produced **in enterprise 2, the same as in enterprise 3,** i.e. before and after merging enterprises.

Enterprise	Product	Material costs	Other costs	Total costs	Capital employed	*Standard* ROI	Profit	Price
1	A	80	110	190	100	0,1	10	200
2	B	200 + 80 = 280	100	380	200	0,1	20	400

Enterprise	Product	Material costs	Other costs	Total costs	Capital employed	*Standard* ROI	Profit	Price
3	B	80 + 80 = 160	210	370	300	0,1	30	400

In case of differently complex products manufactured from the same material, the new pricing concept eliminates the conventional distortion of prices in favor of simpler products, due to the greater share of costs created by the transferred value. (Compare prices of products P, Q in both approaches.)

Product	Material costs	Process phases	Process costs	Total costs	Capital employed	*Standard* ROI	Price
P	500	1	200	700	500	0,1	750
Q	500	1+2	400	900	1000	0,1	1000

The basic financial principle should be reflected in product pricing also from other than stated reasons.

SETTING FINANCIAL TARGETS

Actual prices of products cannot be equal to prices calculated in a particular enterprise according to some price formula because different **enterprises produce comparable products with different effectiveness**. The market does not accept high prices of inefficient manufacturers assuming a standard ROI, and on the other hand accepts lower prices of efficient manufacturers, even if these prices allow them to achieve ROI values well above the standard. However, the **relevant pricing formula** and PPROI's ability to **properly calculate costs, capital employed and ROI** per product are important for setting financial **targets**. Let us return to products a, b in example on p. 05. Achieving ROI = 0.1, when set as a standard, is possible by **price increase** and/or by **reduction of costs** and/or **capital employed**.

Product	Price	Cost	Profit	Capital employed	ROI actual	ROI Standard	Price target	Cost target	CE target
a	8	7,2	0,8	10	0,08	0,1	8,2	7	8
b	10	10,4	-0,4	20	-0,02	0,1	12,4	8	

If the cause lies in too low price in case of efficient processes, price increase is unavoidable; see the case listed on page 06. On the same page, there is an example of increasing production effectiveness. **Changes in prices, costs and employed capital can be optimally combined**. In the table above, changes in employed capital alone cannot ensure efficient production of product b. However, combined with cost reductions, the reduction of capital employed makes sense. **The worst approach is ignoring the problem**.

21 RELATIONS OF PARTIAL VARIABLES

INFLUENCE OF PHYSICAL ALTERNATIVES ON FINANCIAL INDICATORS

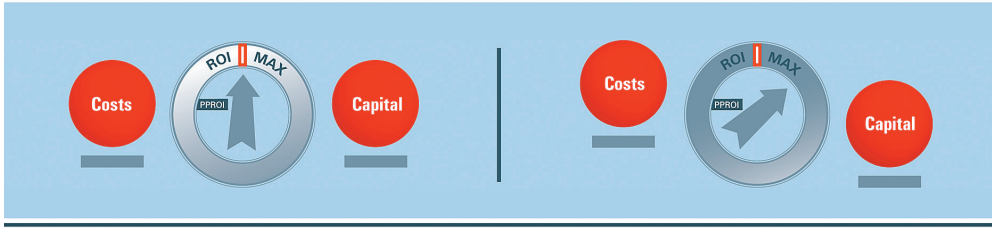
A variety of physical solutions to the kinds of problems identified from different aspects is always more. This applies both to strategic decision-making options with longer-term implications and to variants in the context of continuous improvement. Individual **variants** can be **evaluated in opposite directions** in terms of **costs and capital employed**, and even in demands on components of costs and/or components of capital employed. That are so-called **trade-off situations**. In the interest of proper evaluation and decision making, it is therefore necessary **to quantify the partial financial consequences of physical variants** and to **project them into the ROI enterprise value**. This is also useful in trade-off free situations where the opposite relations of partial indicators do not arise.

Full and systematic provision of this task outside the information system is impossible. PPROI procedures are explained in the next section of the document. However, already in this general part of the document, we consider it useful to point out the main types of trade-offs, in the interests of proper framework thinking of managers, and to fill one of the blank pages of management theory.

BALANCING COSTS AND CAPITAL EMPLOYED TO MAXIMIZE ROI

Balanced costs and capital

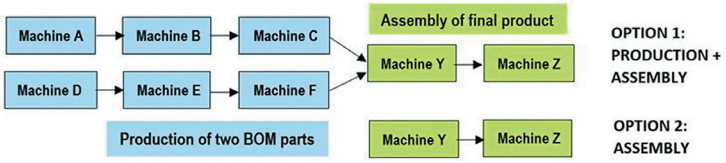
Unbalanced costs and capital



The right-hand part of the figure illustrates a situation where, compared to the situation on the left, lower costs due to higher capital result in a lower ROI. However, this kind of **compensation** is possible only in cases where **the cost of the product is lower than the price**. By the following pictures, we present the types of decision making in which the probability of this kind of trade-off is very high.

MAKE OR BUY

In deciding whether a particular object or activity is financially more effective to realize with its own resources or to buy an attention is usually focused on BOM items.



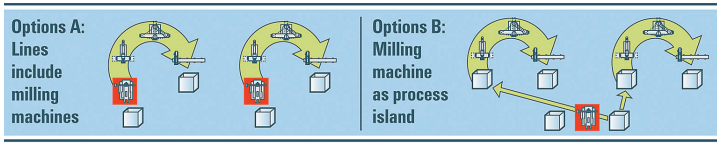
Option 1 with production of parts in the enterprise is much more demanding on capital employed but should have lower costs than option 2 where parts assembled are purchase.

This applies also to logistics, maintenance and administrative activities.

LEVEL OF MECHANIZATION, AUTOMATION AND ROBOTICS

Capital employed in variant 2 is higher while labor costs and probably overall costs are lower than in variant 1

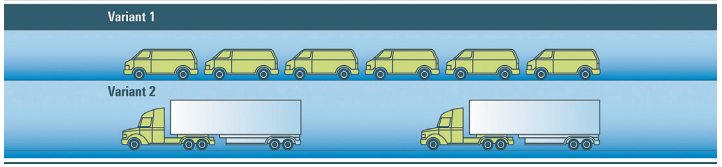
NUMBER AND LAYOUT OF MACHINES IN LEAN PRODUCTION



One low utilized milling machine moreover in option **A** whose price exceeds value of extra inventory in option **B** makes option **A** more capital demanding.

Labor, logistics and total cost of processes can be higher in option B.

FREQUENCY OF DELIVERIES

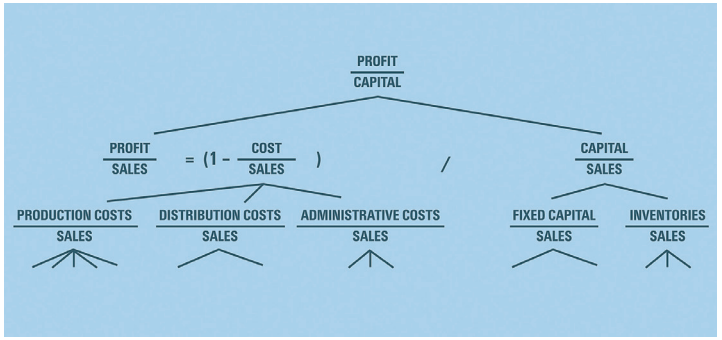


Variant 1 of deliveries leads to lower capital employed in inventories.

Variant 2 has lower delivery costs and maybe total costs exceeds value o.

CONTENT AND APPLICATION OF THE PYRAMIDE OF FINANCIAL RATIOS

ROI's synthetic nature, its superiority over all other financial quantities, the necessity of evaluating the **financial demands** of production i**n terms of costs as well as employed capital,** are striking in so-called **"pyramid of financial ratios"**. Pyramid exists in multiple variants, particularly at lower levels.



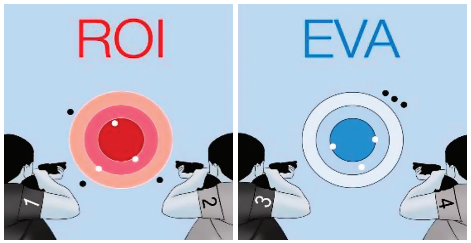
The pyramid is filled with **enterprise data** from **financial accounting**. The comparison in time should identify where and how much the enterprise improves or worsens, inter firm comparisons to reveal the strengths and weaknesses of individual enterprises.

Pyramid applications **does not meet expectations**, because all data is **enterprise averages** from process data for individual products. Pyramids do not inform about these root causes. And **relations** of **indicators in horizontal level** are **unknown**. Isolated assessment of each indicator makes no sense.

22 APPROPRIATENESS AND PRECISION OF COMPREHENSIVE CRITERION: ROI VERSUS OTHER

THE FINANCIAL ALTERNATIVES OF ROI

On page 08, we graphically compared the **focus of partial management theories** on maximizing or minimizing different variables to **aim at different targets**. Each partial theory aims elsewhere and none of them on the ROI. The **same problem** exists in the case of **financial variables defined by prices, costs and employed capital**, but **according to other mathematical formulas than the ROI**. The theory recommends the "**economic profit**" as such financial criterion, and recently also its modification under the name of "**economic value added**" with abbreviation "**EVA**". Important is not only the **appropriateness of the focus**, but also the **precision of aiming**, which means the **accuracy of information on given economic variable**.



The figure on the left illustrates 4 cases:

(1) **Focus** on ROI as **right target** and **good precision** of focus – white hits the target

(2) **Randomly imprecise focus** on ROI as **correct target** – black misses the target

(3) **Focus** on EVA as **incorrect target** and **good precision** of focus – white hits the target

(4) **Systematically biased focus** on EVA as **incorrect target** – black misses the target

PRINCIPAL DIFFERENCIES BETTWEEN ECONOMIC PROFIT AND ROI

Economic profit is defined as the **difference** between the **accounting profit** and the **hypothetica**l **profit** generated by the **same capital** at the **hypothetical ROI value**. Such value was originally the ROI of **alternative investment opportunity**; currently prevails the value of **ROI expected by investors**. The product of the capital with hypothetical ROI value is called "**cost of capital**" though it expresses **profit.** The sum of accounting cost with cost of capital is called "**economic cost**". The economic profit can be expressed by these formulas:

Economic profit = Operating profit – Cost of capital = Capital ope. * ROI ope. – Capital ope. * ROI hyp.

Evaluating a given set of different **situations** by **economic profit and ROI differs** for several reasons:

1) Economic profit allows for **universal compensation of higher costs by lower capital**, whereas ROI only if the price > costs; see p.21

2) Economic profit depends on the **size of the capital**, ROI expresses the profit per unit of measure of capital

3) In addition to the ROI, the **economic profit** also **includes a hypothetical ROI value** that affects not only the absolute amount of economic profit but also the ranking of the assessed situations

Different assessment of the same situations is illustrated by the example of two different products. Product A arises from both manufacturing of parts and their assembly within the enterprise, product B is assembled from purchased parts. Product A is 10times more demanding on operating capital than product B.

Product	Capital ope.	Cost ope.	Price	Profit ope.	ROI ope.	ROI Hyp.	Cost of capital	Economic cost	Economic profit	Ranking by EP	Ranking by ROI
A.	50	78	80	2	0,04	0,1	5	83	-3	2	1
B.	5	81	80	-1	-0,02	0,1	12,4	81,5	-1,5	1	2

The **ROI prefers the product A** which **generates real profit**, while **product B generates loss** and its **ROI** is deeply **negative**. But **according to the economic profit** the **ranking of these products is just opposite**; the negative value of the economic profit is twice higher for product A than for product B.

EVA: ADITIONAL BIG PROBLEM TO THE PROBLEMS OF ECONOMIC PROFIT

Problems of the economic profit applies also to the "economic value added", and within this variable the problems **grow**. Main reason is **inappropriate combination** of the **financial parameters** of the **operational activities** of the enterprise **with** parameters of **financing the enterprise by debt**.

Under the term "weighted average cost of capital" or "WACC" the average of the required (hypothetical) value of ROI for equity and of the interest rate on debt (lent capital) is calculated. Multiplication of WACC by total capital creates absolute value of "cost of capital", which reduces operating profit. We do not quote income tax as it does not change the key problem.

WACC = (Equity * ROI required + Debt * Interest rate on debt) / (Equity + Debt)

EVA = Operating profit – WACC * (Equity + Debt)

Since the required ROI value from equity is logically always higher than the interest rate on the debt, the **higher the debt** within total capital, the **lower the WACC**, which conversely **increases** the **EVA value**. This variable therefore **prefers the debt before equity**, which results in **unacceptable values**. The following example illustrates the problem.

Variant	Operating profit	Operating capital	Operating ROI	Equity	Debt	Interest rate	ROI required	WACC	Cost of capital	EVA
A	100	2000	0,05	2000	0	0,05	0,08	0,08	160	-60
B	100	2000	0,05	1000	1000	0,05	0,08	0,065	130	-30
C	100	2000	0,05	0	2000	0,05	0,08	0,05	100	0

The values of the operating variables are the same in all variants. The **best**, zero **EVA** value, is in **variant C**, where all operating capital is funded by debt. But there the operating profit only covers interest on the debt and the enterprise's financial profit = 0. Such **business has no sense**. The **worst**, deeply negative **EVA** value is in **variant A**, which operations are **covered by equity**; both **operating** and **financial profit** and ROI are acceptably positive.

RESPECT FOR ECONOMIC NATURE, PERMANENT LOGICAL MANAGEMENT OF AN ENTERPRISE

The **basic financial principle**, given by the **economic nature** since the birth of money (see p. 15), has **unswerving logic** and has become **timeless**. Maximizing the ROI reflects this principle in the categories of capitalist economy. **PPROI** enables to **implement the basic principle into permanent planned management of the enterprise** through the management of products, processes and resources in their links. Prior to PPROI, ROI as a management tool was applied only in the form of an **internal rate of return** in the preliminary assessment of **investment projects** over the estimated useful life. Information on **ROI** from **financial accounting** has only registered the **history** of the **enterprise as a whole**.

Replacement of ROI by **economic profit** or **EVA**, eventually by other artificial constructions, **denying** the **basic financial principle**, is a denial of business logic. These indicators **fail in logical tests** as illustrated in previous examples.

PRECISION OF APPROPRIATE FOCUSING IN PPROI

Management by ROI, i.e. the **appropriate focus**, is **not enough**. **Also essential** is **precision of ROI values**. It assumes **precision** of information about **costs** and the **employed capital**. During PPROI development was necessary, among other things, to solve the chronic problem of management accounting – a large distortion of the cost of products. Ensuring **precision** of **ROI values** requires **(1) completeness** and **accuracy of input information** and **(2) their correct processing**. **PPROI is unique in both aspects**. Unparalleled is the detail of description of products, processes and resources parameters, and their projection (along with other input parameters) into costs, employed capital, and ROI in processes according to products using a large set of mathematical functions. The conceptual aspects of solving these problems are described in part III of this document.

23 WEAKNESSES OF SCIENTIFIC MANAGEMENT IN ERP SYSTEMS

THE CONTENT OF ENTERPRISE INFORMATION SYSTEMS

The information systems for industrial enterprises contain two kinds of information

1. Data which **serves to production planning** and control
   This group of data is based on the **theory of "scientific management"** from first decades of the 20th century **completed by the MRP** production planning in the 1960s
2. Data which **serves to the records of state and movement of different kinds of items**
   This group of data is partially determined or limited by national or transnational legislation

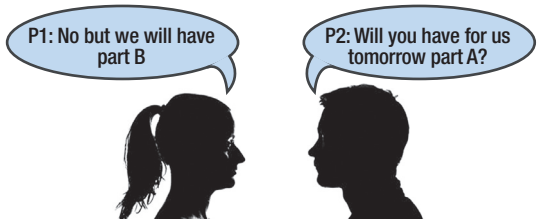
TWO TYPES OF INFORMATION IN ERP SYSTEM

PRODUCTION PLANNING & CONTROL	ITEM STATUS AND MOVEMENT *in physical and/or monetary parameters*
Direct material & labor costs ↑ MRP plan ↑ "Scientific management procedures"	**Human resource** states, reruitment, dismissal **Warehouse items** inventories, receipts, deliveries **External** orders and supplies of items **Long-term assets** in purchase price and book value, acquisition, disposal **Financial accounting** **etc.**

Originally separate groups of data (Financial accounting, etc.) were offered by specialized vendors. Currently is all offered as a whole under the ERP roof. The main advantage is the use of unified dials and thus enable easier communication between the parts of IS. But it has not changed the content of the parts which remain more or less independent. ERP is a simple grouping of different types of information under one header without links of parameters of items in different groups. The decisive influence on the quality of the enterprise management, its financial results and its competitiveness have the attributes of the "Production planning & control" part of ERP systems.

CRITICISMS OF THE MANAGEMENT PART OF ERP SYSTEMS

As we have already noted on p. 02,, ERP system users most often complain about the low quality of ERP production plans and insufficient financial data relating to products. Criticisms also contains literature. E.g. the book **Equalized & Synchronized Production** of 2000 by **Toshiki Naruse** at al. writes.



"***Management of companies have to free*** *themselves* ***from informal methods that depend on people and establish methods that work systematically***. *Many of companies* ***have not achieved the anticipated results because they use ERP systems*** *based on rigid principles of Material Resource Planning (MRP) that have remained almost unchanged for 30 or 40 years. This may be* ***one of main factors*** *that* ***keeps*** *various* ***manufacturing companies from being able to reform their production***."

SCIENTIFIC MANAGEMENT AND MRP PROCEDURES

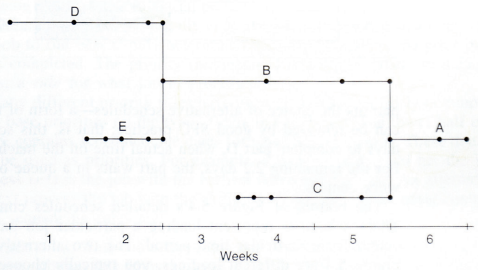
Last quote, which the whole ERP equates to its control part, mentions two principal weaknesses of ERP:

1. **ERPs** are not able to control production, so it **have to be** subjectively **controlled by people**
2. ERPs **s create barriers to** the introduction of **progressive production processes**

Both are true, and the **root cause** of both is the **theory that ERP systems reflect**. Scientific management respected the division of labor from the Industrial Revolution, the **fragmentation** of manufacturing **processes on parts of BOM into specialized operations in separate workplaces** and focused on the **productivity of people's work**. The Motion Studies of Mr. and Mrs. Gilbreth inspired methods determining detailed time standards (currently MTM, MOST), and aggregates of times of partial motions create base of standard times for operations. Ford Harris published the principle of determining the **economic production lots** of BOM parts. From **processing time standards per piece**, **setup time standards per lot**, both specified for operations, **number of pieces in** the **lot** and from additional **inter-operation times** was **calculated lead time** per lot of **BOM part**, graphically illustrated by Gantt chart.

Such calculated **fictitious lead times**, which in reality cannot exist, because are based on fictitious inter-operational times of lots in queues, are **inputs of MRP plan**, designed by Joseph Orlicki. And this plan is calculated separately for parts of BOM of individual final products. There is **no coordination of plans for parts of different final products**, no coordination **taking into account the shared capacities of workplaces and workers by operations on given and/or different parts of BOM**.

Lead times of parts of the final product



Part D routing

Operation	*Work center*	*Run time*	*Setup time*	*Move time*	*Queue time*	*Total time*	*Rounded time*
1	101	1.4	.4	.3	2.0	4.1	4.0
2	109	1.5	.5	.3	2.5	4.8	5.0
3	103	.1	.1	.2	.5	.9	1.0

Total lead time (days) 10.0

These principles are **unchangeable** in both **planning textbooks** and **ERP systems.** The table in the left figure from the book **"Manufacturing Planning & Control Systems"** demonstrates the calculation of the lead time of one part of BOM based on fictitious queue times, the Gannt chart above illustrates the links of the lead times of BOM parts in MRP plan for a certain final product.

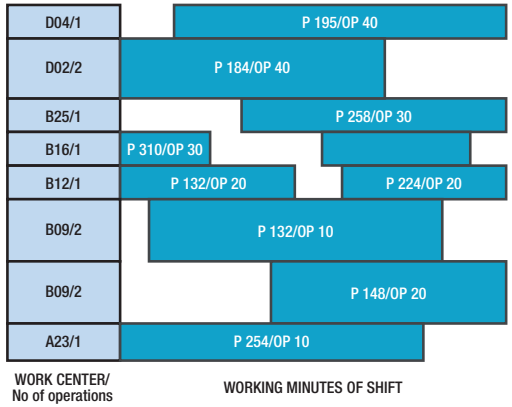
These conceptual defects cannot be removed by partial improvements or by additional modules, such as capacity planning. **At the outset**, it is **necessary to abandon the a priori determined inter-operation times** and **start planning the parts of all final products together with capacities concurrently**.

The MRP plan is not a semi-finished product that just needs to be com-pleted. If that was the case, in ERP systems should be MRP plan replaced by the functional finished plan. 50 years since MRP birth has been a long enough time for it. The necessary **first step** is the **revision of planning theory**.

24 PHYSICAL TARGET: TERRITORIALLY LEVELED AND SYNCHRONIZED PRODUCTION PLAN

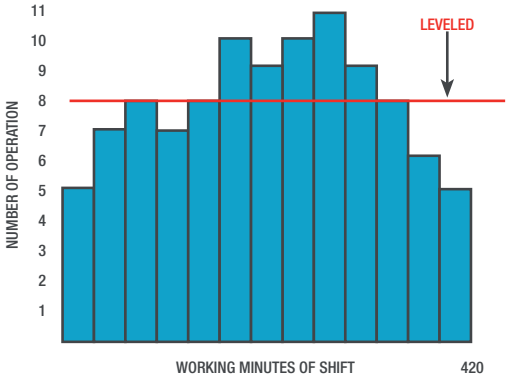
FLUCTUATION OF MRP PLANS DEMANDS ON OPERATORS

In the literature, we find assertions that production plans generated by ERP systems are already unfeasible at the time of issue of individual orders. It is true. The main reason is **huge fluctuation of the plan demands on operators in real time** This is caused not only by **independently determined inter-operational times of individual BOM parts** but also by **independently determined BOM part lots**. In proving as well as solving problems, it is again necessary to work with **definite integrals**.



The picture on the left characterizes the **requirements of the MRP plan for operators during work shift** by 420 work minutes **in a particular manufacturing center**. The MRP schedule sets the run-times of lots of BOM parts for individual operations. In the example, according process standards, 1 or 2 workers work in operations. The times of operations at the border of the shift extend into subsequent shifts. The states of operators during individual operations are constant functions, **areas (rectangles)** under functions are **definite integrals measured in humanminutes**.

By summing the partial integrals across the operations at moments of real time, **the integral of the aggregate demands on the operators during the shift** is generated; See the following figure.



Period	Number of operators	Minutes	Human-minutes
1	5	32	160
2	7	31	217
3	8	31	248
4	7	35	245
5	8	31	248
6	10	31	310
7	9	26	234
8	10	25	250
9	11	42	462
10	9	45	405
11	8	21	168
12	6	31	186
13	5	39	195
Total		**420**	**3328**

Such a **plan** is obviously **unrealistic** because of **great fluctuation of its demands on operators during** the **shift**. And even greater MRP weakness are the **differences** of the **integral values in the succeeding days**.

THE CAPACITY CONSTRAINTS OF WORK CENTERS AND FINITE PLANS

Another problem with the MRP plan is the occasional **overload of workplace capacity**. In the example, there is an overload of the workplace B 09, where the time requirements of the plans of operation 20 for the part P 132 and the operation 10 for the part P 148 are in the sum greater than the available 420 minutes of the shift. This problem is well known and should be solved by so-called **finite planning**, by time shifts of the respective operations. However, this is a **wasted step because the assumed overloading of the workplace will never occur**. The actual times of the operations necessarily differ from the MRP plan because of **production managers response to the unleveled demand of the MRP plan on operators**. Some operations must be done earlier, other later than in MRP plan.

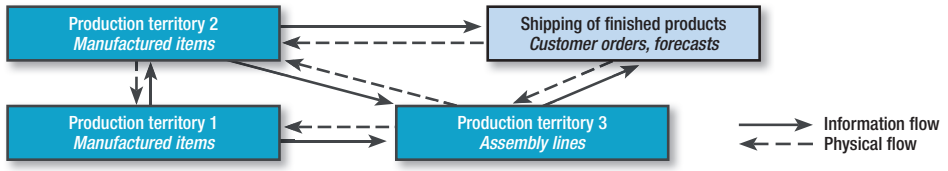
WHAT IS TERRITORIALLY LEVELED PLAN AND WHY IT IS NECESSARY

Operators of larger enterprises are **divided into production territories** where they provide production **as teams**. These territories are called differently: workshops, production centers, etc. The **number of operators** in a territory within a shift **depends on the demand for the territory** expressed in the normominutes of operators in the outlook of the plan. Stability of the number of operators is usually at least for a month. During actual months, it is changing when demand changes rapidly. Important is the **balancing between the stability of operators and inventories**. In any case, however, it is necessary to ensure the **sameness of integrals of humanminutes in the production plan with integrals in the plan of workers**. If, in our example, the monthly plan of operators in a shift for a certain territory = 8, then their shift capacity = 8 * 420 = 3360 humanminutes and this capacity must be daily and evenly filled by the production plan. **Otherwise**, there is a **physical contradiction between the two plans** and **subjective and chaotic production management by people is necessary.**

INTERTERRITORIAL SYNCHRONIZATION

The production plan must be covered by BOM parts entering the produced parts as lower parts. In case of parts manufactured in other territories, the **plans of** these **supply territories must respect the volume and time needs of customer territories**. In a pull **system "Make to stock"**, the creation of **leveled plans in customer territories must precede** the **creation of plans in supply territories**. Plans should have a sufficiently long horizon, and their daily updates must be fast.

Flows of information and physical items



ESSENTIAL TARGET OF PRODUCTION MANAGEMENT AND FEASIBILITY TEST

The existence of a **territorially leveled & synchronized plan in objective standards** is a **prerequisite** for the **systematic physical management of the industrial enterprise**. The **primary task of production management** is to **ensure such a plan**. The **PPROI contains more variants of such a plan adequate to different types of processes**. Whether the **above described attributes** have the other planning systems (APS) is a **basic test of** their **feasibility.**

25 ALTERNATIVES TO CLASSIC CONCEPTION OF PRODUCTION PROCESSES

ORIGIN OF CLASSIC CONCEPTION OF MANUFACTURING AND SCIENTIFIC MANAGEMENT

The same product from the same materials can be made by **principally different processes. The principles of production processes depicted in ERP** were **born during the Industrial Revolution** in the 18th century and form a **coherent conception** that has survived to date and can therefore be called **classic**. The conception linked to the division of labor contains the following **interrelated principles**:

1. **Specialized types of work centers** (pressing, grinding, etc.) and **specialized workers**, trained for the types of work centers.
2. **Splitting of final products into parts**, of **processes on the parts into operations** defined in terms of work types, and **assignment** of **operations** types to the **corresponding work centers**.
3. **Changing parts** or operations on a given part **within a given work center** requires **modifications of the work center** (tool change, etc.), which is considered to be **unproductive**. In the interest of work productivity, parts are produced in **large production lots** (batches) into **warehouse stocks**, from which they are gradually drawn for higher BOM parts or for expedition.

The scientific management of the first decades of the 20th century **has provided rules and methods to this conception** by introducing **quantitative standardization of parts** (economic lots) and **time standardization of operations** (set up and processing times). It also laid out the **basics of production planning**. Also, the later **MRP plan** and all information in current ERPs relate to the **classic production conception.**

MAIN PROBLEMS OF THE CLASSIC CONCEPTION

This conception is mostly criticized for **demanding logistics processes** and resources that **do not add value** – from the removal and insertion of parts from and into the containers at the beginning and end of each operation, through waiting of parts in batches during operations, between operations, and in warehouse inventories, to transfers of batches between operations, warehouses and production areas, and handling in warehouses and storage facilities. The negative economic consequences are **high logistics costs** of production, **long lead times** of the parts production and **high circulating capital**, as well as **high demands on logistic spaces and facilities** – components of the **fixed capital**.

A well-known problem of manufacturing in isolated work centers is also the **low utilization of operators** when they do not have anything else to do during automated machines work and just wait for the processing to end.

ALTERNATIVES TO PRINCIPLES OF THE CLASSIC CONCEPTION

In current practice, **each principle** of the classic conception has an **alternative** that can be more effective.

- **Processing operations** are not **defined** for parts of the BOM, but **for different combinations of BOM parts**; this **reduces manual handling** and / or **demands on production equipment**
- **Production processes** do not take place in isolated work centers with different times of operations, but **at closely connected work centers of different kinds at a same tact time**. There are **no inventories** in containers between these follow-up operations **and no associated logistical requirements**
- **Workers** are **multi-operational**; one worker can provide more operations of different kind in a process sequence; the time **utilization of operators and productivity is increasing**. The **number of operators** in the interconnected operations and sometimes in isolated operations may be **different, with different divisions of labor and time standards**; production processes can **flexibly react** to **changing demand**
- In production systems **"Lot for lot" and "Make to order"** the **lots of parts** within the finals are not specified for each part independently on the EOQ principle but **correspond to relations in the BOM**; **parts do not enter into intermediate stores**; they move only within production halls.

In production **"Make to stock"**, the **lots of the given part** are **not fixed**, but they **vary according** to the **short-term requirements**; **inventories are declining** and **resource capacities are better utilized**

FIRST COMPREHENSIVE ALTERNATIVES TO CLASIC CONCEPTION – FORD AND TOYOTA

Overlapped in time with the development of scientific management, a comprehensive alternative to the classic **production conception** was created in **Ford's production empire**. Emphasized was the focus on the **short lead time** of production processes, the absence of standing material and manufactured parts in inventories, "**everything in motion**". This involved not only the assembly of a car on a moving belt, but previous processes. The **mass production of one type of car** has **eliminated the problem of the batches size** and the **adjustment of the workplaces for the various parts**, all was produced continuously.**The use of people** and all **other resources** was probably the **maximum**, the **cost and capital employed** were **minima**l, which allowed for the wide availability of the car at a low price. As it is often stated, this production of "one type of car in black" was hit by falling demand and ended in a crisis. But **continuous assembly on a moving belt** has **spread to all major automotive companies** and **some other manufacturing industries**.

Ford's **accent on the flow production** was **followed by Toyota** in different way after several decades, whose **TPS system**, often described in literature, is a living legend. **Sequencing of different types of cars on the assembly line**, **multi-operational work of the operators disconnected from the machines** in **the linked work centers**, **derivation of tact times of assembly and production lines from demand** and with it associated **changes in time standards** that sometimes require **changes in the number of workers in assembly and production lines**, special emphasis on **leveled plan**, control of production lines tasks in real time by **pull system using kanban** and the method of **processes quality assurance** have become **examples** of procedures called "**lean manufacturing**". But **as a whole, TPS still remains** almost **exclusive for Toyota**. Moreover, the weight of some procedures is declining as a result of increase in the proportion of parts purchased from suppliers, who can produce parts in partially different way than Toyota would do. Among others, the tacts of production lines at the supplier can be quicker than at Toyota, which increases work productivity and also ROI (see more on p. 40).

MULTIFACETED REALITY, ERP APPLICATION LIMITS AND COVERAGE OF REALITY IN PPROI

Current production processes are **multifaceted** even **in** terms of their **principles**. If there is **one or more principles beyond the classic conception of production** in the enterprise**, ERP procedures are unusable as a whole**. An example can be processes partially defined for combinations of BOM parts. **PPROI covers wide range of manufacturing processes**, whose principles are **partially or completely beyond the classic conception**. While preserving the basic structure of the system shown in the architecture diagram on page 04, PPROI **captures the diversity of reality efficiently using two ways**.

a) In order to minimize the number of variants in the information system PPROI **displays complicated cases**, and it **includes simple cases into the complicated ones as their special cases**. Among other:
   – An individual part of the BOM is perceived as a special case of a combination of different parts
   – An isolated operation is perceived as a special case of linked operations
   Combination of only simple cases is allowed. E.g. displaying processes on different parts of BOM in linked operations automatically allows you to display processes on individual parts of a BOM in separate operations. **Procedures beyond the classical production are thus applicable within its framework**.

b) **Variants that exist even after applying step a**) are **recorded within the relevant information groups**; these are groups within rectangles in the PPROI architecture diagram. An example is variants of generation of lots (batches) of process parts. **In the PRROI application such combination of variants is used that is relevant to the particular enterprise**.

These approaches are more specifically explained in part III of this document.

26 CONCEPTIONAL ALTERNATIVES OF QUALITY CONTROL; SPC AND 6 SIGMA?

PRESCRIBING QUALITY PARAMETERS OF PRODUCTS AND PROCESSES

In order for **products to fulfill the expected functionality**, the **product designers**, and/or other specialists**, prescribe the technical parameters of the products** which **production processes have to ensure**. The shape and dimensional parameters of the products, respectively of their parts, are shown **in the drawings**; other technical parameters, in particular the properties of the material, are prescribed only **numerically**. Most parameters are listed in the numerical range, the so-called **tolerances**. Their **optimal value** is important. While **excessive tolerances disrupt the functionality of products**, **excessively small tolerances unnecessarily increase the economic demands of processing**; this aspect is highlighted by Toyota that includes "excessively high precision" among the main types of waste. Finding optimal tolerances is done by testing variants.

The required properties of industrial **products are created by resources in processing operations**; within a particular enterprise **from purchased materials and components**, some qualitative parameters of which are subject to **entry inspection**. More sophisticated products are divided by **production technologists** into parts of the **process BOM**, sometimes identical, sometimes different from parts of the design BOM, for each part they define a **sequence of processing operations assigned to the work centers** and **prescribe the parameters of the resources in the processes**, so that the **results** of the processes **are the required qualitative parameters of the products**. Prescribed parameters of machines and tools vary by their type. In case of manual processing, in addition to prescribing procedures, staff training is applied for the required procedure.

DEFECTS

Product parameters that occur **in real processes** either **meet or exceed** the **prescribed quality parameters**. In the latter case, these are **defects** that are either **repairable or irreparable**, i.e. scrap. **Scrap** is much more serious because it **devalues the results** not only of the relevant operations but **of all previous work**, including the purchased items. **Both types of defects increase the costs of products** and their demands on **employed capital and reduce ROI**. In order to create the **planned quantity of final products**, it is necessary to **increase the number of manufactured parts and purchased items in comparison with the BOM**, depending on the **rate of scrap of the individual operations in their sequence**. **For each operation**, the **ERP records standard percentages of defects and repairable defects**. **PPROI** goes deeper than MRP – it **records both types of defects according to the microphases of operations**. The **standard rates of defects are reflected in the production plan**. **Deviations of true defects from standards complicate real-time production control**. Defects are therefore a very undesirable aspect of production.

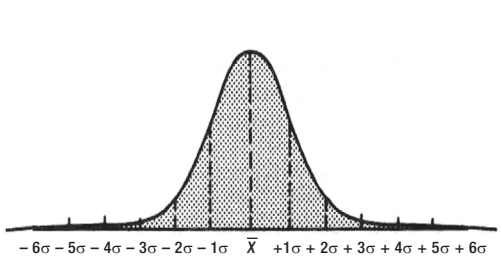
ALTERNATIVES OF QUALITY CONTROL OF REAL PROCESSES

Conceptual alternatives of the quality control of real processes can be defined from **multiple aspects**:

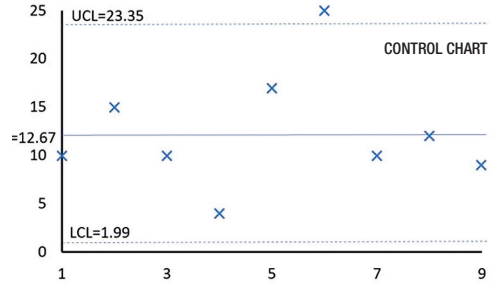
1. **Frequency of checks of individual items after completion of operations**
   a) **Checking each item** after completion of the operation, i.e. **full control**
   b) **Regular check of each n-th piece of the production lot**, where n>1, i.e. **selective control**
2. **Depth of identification of causes of defect and following reaction**. Once the fault is detected, it follows
   a) **Detection of the defect and removal of its immediate cause**; e.g. a worn or broken drill bit and its replacement, or operator error and its immediate rectification; the **same error repeats** itself over time
   b) **Determining the root cause of the defect and implementing measures on resources** that either **prevent the occurrence of a defect** or **signal an abnormality of resources before it causes a defect**; these procedures are described in the literature most commonly under the term **Poka-yoke**
3. **Statistical Quality Control**
   This seemingly scientific approach is assessed on the right side of this page

APPLICATION OF STATISTICS IN QUALITY CONTROL

J. W. Shewhart and other experts already in the 1920s recommended sample inspection and assessment of the production process quality by applying **statistical characteristics**, assuming **a normal** (Gaussian) **distribution of the monitored variable values** and their **randomness in follow-up observations**. As a quality control tool, they designed a **control chart**. It has practical sense for **tracking the values of a particular quality parameter for individual pieces of a particular part in** a **particular operation** within the **production batch**. The normal distribution and the control chart are presented by the following graphs taken from literature. In the control chart, C is the symbol for the mean, LCL = C-3σ is the lower control limit and UCL = C+3σ is the upper control limit.



NORMAL DISTRIBUTION OF DATA



ITEMS OF THE PRODUCT PART IN PARTICULAR OPERATION

PROBLEMS

Normal distribution was found during mass observations of some natural phenomena. However, **for quality parameters of the production process it is not relevant**. The random fluctuation of values of a certain quality parameter, shown in the above control chart, does not occur in practice; there is **dependence of the values for subsequent pieces** of a particular part in a particular operation. **Changes in the values** of a certain quality parameter have **specific causes in the sources** – machines, tools, materials, etc., and the cause usually lasts from the moment of its creation. **Defects in the downstream pieces** very **frequently repeat**, if their cause is not removed. Therefore, in a usual selecting inspection, e.g. of every 10th piece, **if a defect is found** then all **previous pieces in the reverse sequence are checked up to the first one that meets** the **tolerances**. And consequently corrections of resources – machines and tools etc. – ensure the required tolerances of the part quality parameter. If the values of quality parameters were random, this procedure would not make sense.

The non-existence of normal distribution of quality parameters in production processes was found early on. Authors of SPC have responded by questionable separation of so-called "**common causes**", which are random, and "**special causes**" attributable to sources. The recommended procedure is complicated and it **cannot** in time **detect defects**, since the control chart does **not work with the tolerances** prescribed by designers. A **mix of common and special causes excludes** the **normal distribution assumed by the Six Sigma method. Invalid** are therefore also statements on **percentages of defects** in the ranges specified by numbers of σ.

Monitoring the quality of **all parts in all process operations by SPC** is in most enterprises unacceptable due to **workload**. This **also** applies to the **Six Sigma method**. But if the quality management does not use these procedures that does not mean that it gives up science. The **statistics as a science** clearly **defines the presumptions of application of its procedures**. If the underlying **assumptions are not met** then **applying corresponding procedures** means **denying the requirement of science** and **procedures are not working**.

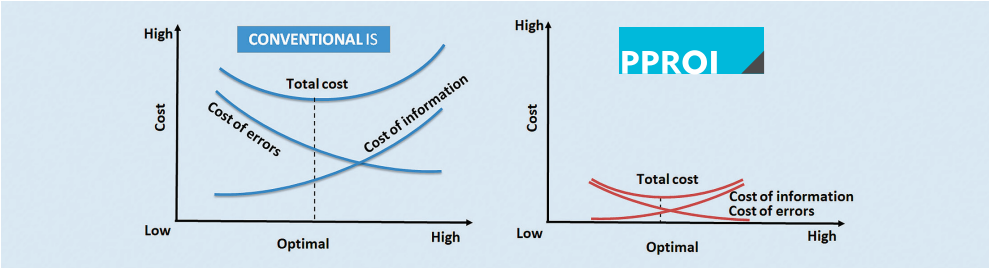
III. PPROI's STRUCTURES AND PROCEDURES

27 MUCH BETTER INFORMATION FOR LESS MONEY

PRINCIPAL DENIAL OF THE INFORMATION AXIOM

Among the many misguided axioms of management theory, i.e. generally accepted improper assertions, one of the top position belongs to the following **information axiom**: "**Missing or inaccurate information generates business management errors** that increase objectively necessary **business costs**. But **improving information**, i.e. increasing its quantity and accuracy, **requires increased costs** of providing the information. **Optimal is such information**, where the **sum of these two cost components** associated with the information **is minimal**." This **axiom is often demonstrated by** the type of **graph** below on the left containing three functions:

1. The decrease in costs, i.e. in the enterprise financial losses, caused by information errors, through increasing the quantity and accuracy of information. (Financial losses are traditionally identified as excess costs, and losses due to excess capital employed are not taken into account.)
2. Increasing the cost of information with increasing quantity and accuracy of the information
3. The total costs generated by information as the sum of the two previous cost components



The optimal quantity and accuracy of information is in the graph at the point corresponding to the vertical (dashed) line. **Precise functions in the graph cannot be defined** because there are **no data to determine shapes and parameters of functions**. Additionally, the information is sometimes mistakenly identified with measurement and only the accuracy of information is accentuated - the completeness of information is forgotten. Therefore, we can see more variants of this type of chart in the literature.

However, **PPROI** rejects and practically **denies traditional philosophy**. **Compared to conventional systems**, headed by ERPs and their various superstructures, PPROI by conceptually new procedures provides considerably **greater amount and accuracy of information, with lower cost for obtaining information**. Optimal total cost of information in PPROI is lower than the minimum cost of information errors in conventional IS. It illustrate the graph on the right and its comparison with the graph on the left.

A concrete example of substantially increasing the detail and accuracy of information while reducing the cost of obtaining information through unique PPROI procedures documents the following quotation. ***„PPROI's characteristics exceed all imaginable criteria. We economically described our production processes with amazing precision****. We have to break down operations into microphases and to set detailed physical and financial parameters for each of them. To me, this meant millions of hand data records into the IS, an absurd target. The problem has been solved in PPROI very effectively, but* ***not by procedures that are traditionally used****. Methods encompassed science – mathematics in particular, in a way* ***we had never heard of, had never thought about, had never dreamed of****."*
Radek Páleník, CFO, in the first in the presentation material of PPROI from 2010

LOSSES GENERATED BY CONVENTIONAL INFORMATION

The basic types of **weaknesses of conventional IS**, especially ERP, and their negative consequences for the performance of an enterprise are partly described in the previous text, others will be addressed on the following pages of this section III of the presentation material. For now just a **summary**.

1) **All variables are one-dimensional**; **missing measurement by definite integrals**, causing:
   – **Products, processes, and resources cannot be managed in the interest of the enterprise's objective, maximizing ROI**. Management grope between different, often contradictory, goals. **All** kinds of **strategic decisions** that are usually focused on minimizing costs can be **wrong**.
   – It is **not possible to create realizable production plans** territorially leveled concerning claims to workers; the **basic instrument of operational control of production processes is not working**.
2) **Insufficient detail and specificity of existing information**. Among others, lack of information on machines and equipment in processes and on spatial requirements of the processes. **Information** on **process and product cost** is therefore **distorted**. **The financial results of an enterprise cannot be controlled on their root causes**.
3) **Distortions and contradictions of the standard processing times of operations** (key ERP input data) which arise by various procedures of standardizers outside of ERP and are **affected by uncontrollable subjective factors**. The **negative consequences are multifaceted**, e.g. for the feasibility of production plans, motivation of workers, and accuracy of financial calculations.
4) **Insufficient links of information through mathematical functions**. ERPs and their superstructures are **rather sets of data groups than systems** in the basic concept of this term. **Some** of the partial **mathematical functions used in the ERP** are, moreover, **incorrect** and **generate misleading data**.
5) **Designed for the production of individual parts of the BOM in independent, constant production lots for stocks**; **processes** are **divided into isolated operations**. For other types of processes ERPs are irrelevant and are a **brake to the introduction of lean manufacturing** and **to other effective solutions that have been developed in practice**; if enterprises apply these progressive procedures, they need other management tools than ERP.
6) **The contents of all fields** (columns) **of ERP is defined "a priori"**, the user has no option to introduce into ERP the parameters of products, processes and resources and their links that are specific and crucial for management of the particular enterprise. The **true customization of information for the enterprise** in the context of ERP is **impossible**.

Together, these **ERP weaknesses create a tremendous synergy of financial losses** of enterprises.

NEW PPROI STRUCTURES AND PROCEDURES

PPROI not only solves the problems of ERP, but also in comparison with other available information allows you to get **new and better information** about the products, processes and resources **from multiple aspects**.

- **Content** – greater **width** and **depth** of information – and greater **accuracy of information**
- **Links** – consistently reflecting **cause and effect relationships** (see PPROI architecture schema)
- **Variants** – developed for different types of production processes, and for other sorting aspects
- **Customization** – possibility of introducing specific parameters of products and resources, as well as their functions relevant to given enterprise

These **unique properties** are achieved very **efficiently through new IS structures and methods** applied within the structures. The information is arranged in a **large number of related tables**, called **entities**, enabling **maximum information** to be obtained **by processing the necessary minimum input data through large system of mathematical functions** often containing many **"what-if" conditions**.

28 APPLICATION OF METHODS OF SCIENCE

PHENOMENA, CONCEPTS, VARIABLES AND TERMINOLOGY

The **basic step** of traditional **science** is the **observation of natural phenomena** and the **definition** of **their content through verbally defined concepts**. The usual **next step** is **quantification** of the properties of the respective phenomena, i.e. the **transfer of verbally defined concepts into numerical variables**. Both unambiguously defined concepts and corresponding variables should be assigned **uniform terms** (names).

The **problems of management theory** and follow-up **information systems** lie **in both phases**. The definitions of commonly used concepts are mostly insufficient or even absent, and quantification of the given concept is often different and sometimes missing completely; in addition, the same variables have different names in different ERP systems. **PPROI addresses all kinds of** these **problems** concerning both **financial and physical phenomena, concepts and variables. In the literature financial concepts** are usually **not defined** at all, their content is considered self-evident. This results in incorrect interpretation and application of these concepts, among others expectations of profit from costs or the confusing connection of concepts, such as „cost of capital". In fact, **all basic financial concepts** are and should be defined and interpreted as **parameters of the capital**, ie the characteristics of the **capital state**, **consumption**, **creation** and **increase in** its **reproduction within enterprise.** And the **ROI** as a **rate of capital reproduction** (see p. 15).

Inseparability of financial concepts from an enterprise as an organizational unit becomes **clear** when **quantitating concepts by numerical variables**. As already explained (on page 19), the **costs** of products and costs of whole enterprises **change** even with **changes in the definition of enterprises** (their divisions or mergers) and their **cooperative relations**, even though the **real items and processes are unchanged.**

The previous text also clarified the **breakthrough role of tools of mathematics** – the **definite integral** and **concepts** of **set theory** – to a proper measurement and understanding of financial variables. However, these tools do not ensure **accuracy of information** about the **financial parameters** of **products, processes**, and **resources**. In this regard, a complete and accurate description of their physical parameters is necessary, which, among other things, requires **introduction** of a number of **new physical concepts**, previously unused in theory and information systems. These concepts and **corresponding variables** defined through a **new terminology** are described in the following pages of this document. They serve not only for the accuracy of financial variables but primarily for **proper physical management** of **products, processes and resources.**

CLASSIFICATIONS

Individual enterprises and also objects within a particular enterprise differ. PPROI reflects these differences by **classifications,** the oldest method of science. **Unlike ERPs in PPROI:**

- **Classifications** are used in **broader contexts** and in **deeper structures**; **classified are** not only products and resources but also **processes and their phases**,
- **Sorting aspects** are **defined by PPROI users** so that they are **relevant to the particular enterprise**. PPROI enables this by user **freedom** to **determine the scope and content of sorting fields of the information system**. Thus, **customization** takes place in the **early stages** of **the IS creation**.

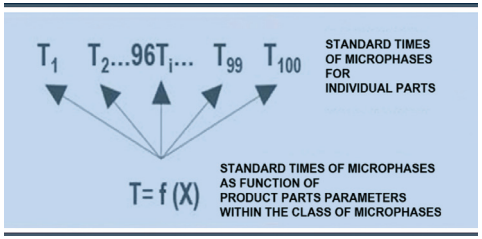
Classifications allow and at the same time limit the **application of effective procedures** that make sense only **within the objects classes**, thus **contributing to the accuracy** of the **information** and to **low demands on** their **acquisition**. They significantly **serve** creation of **process routings**, **time standards** and **production plans**, i.e. the main steps of the physical management of the enterprise. Classifications are also important for **structuring** the **financial data** in the plan and in the reality, from several relevant aspects.

BREAKDOWN OF EXISTING PHENOMENA AND COMPOSITION OF NEW PHENOMENA

Another well-known method of science is the **breakdown (atomization) of existing compound phenomena into elementary homogeneous items**, the **description of properties of these items** and their **composition into completely new phenomena**. This method has proven to be a **breakthrough** also **in the development of PPROI** – in the **breakdown** of standard basic phases of production processes, i.e. **operations, into microphases** formed by immutable resources in terms of their structure and properties during processes (see p. 32). The **introduction, classification** and **parameterization** of **microphases** and the follow-up **compositions of microphase parameters** through **mathematical functions** have lead to a **huge amount** of completely **new physical and financial information**

1. **For microphases of operations PPROI generates normative** (standard) **times by deterministic or regression functions from product and resource parameters**. These functions are applicable **within microphase classes**. From normative times and other standard parameters of microphases PPROI in the **next step** automatically calculates by deterministic functions the exact **standards for linked operations**. These physical standards are calculated **in variants for permissible numbers of operators** while r**especting** the **bottlenecks of processes**. Variants allow **flexible standard speed of** the **processes** important for production plans. They are **applicable** for both l**ean** and **traditional production**.
2. With **close links to physical information**, **financial information for microphases is generated**. Recording specific resources, their standard times and other parameters in microphases is the **basis of** quantification of **integral states of capital** and of the **costs in direct processes according to products** generated by **particular resources** – thus replacing traditional misty and distorted production overhead.

Only through the introduction of microphases it is possible to **practically realize** the **requirements** of the **scientific management** formulated on page 03, i.e. to quantify the physical and financial parameters of the products, processes and resources with their links, to ensure accuracy of the information and its applicability beyond the limits of traditional production – all with **high efficiency of obtaining information**. An example:



Within the microphase class, 100 different product parts are produced. Microphase times for individual parts depend on the values of a particular parameter (or more parameters) of the parts. When this **dependenc**y is expressed **by** a **mathematical function**, the **standard times for individual parts** are set by the **function values**. This eliminates the common practice of measuring time for each individual part in independent observations that is demanding and can lead to contradictory values.

Similarly, **parameters** of particular **resources** within microphase classes **determine**, **through mathematical functions**, the **parameters of microphases for individual product parts**.

NEW CONCEPTIONAL AND TECHNICAL SOLUTIONS WITHIN GENERAL ASSUMPTIONS OF SCIENCE

In **improving** or **fully replacing** any **existing system** by a system with substantially better properties, it is always necessary to **distinguish (1) Conceptions**, **(2) Techniques** ensuring the functionality of the used conceptions in practice. **PPROI**, therefore, hand in hand with the **new conceptual solutions of the enterprise information system** contains **new technical**, i.e. **mathematical-informational procedures**, which **generate completely new specific information**. In the formulation of these procedures the general basic assumptions of science are always respected, emphasized already in the previous text, i.e. **respecting natural physical and financial laws** and the **simplest possible problem solving** but **without simplification of problems.**