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RESEARCH ARTICLE

Applying a multi-criteria decision methodology in the implementation of tenders for the acquisition of the infrastructure of logistics systems

Gábor Kovács / *Krisztián* Bóna
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Abstract

The study begins by questions of the necessity of using tenders, then, continues detailing the implementation of tenders starting from the preparation of the call for offers up to making the final decision. Meanwhile, it elaborates the practical experiences of tenders for the acquisition of warehouse logistics systems. It emphasises the application of multi-criteria pre-decisional algorithms in the assessment of offers received for tender. To this end, it demonstrates a self-developed system. Finally, it evaluates the effects of the applied tender algorithm in brief.

Keywords

tender · multi-criteria pre-decisional algorithm

Gábor Kovács

Department of Transport Technology, BME, H-1111 Budapest Bertalan L. u. 2. Building Z, Room 604, Hungary
e-mail: kovacsg@kku.bme.hu

Krisztián Bóna

Department of Transport Technology, BME, H-1111 Budapest Bertalan L. u. 2. Building Z, Room 604, Hungary
e-mail: kbona@kku.bme.hu

1 Introduction

The preparation and support of the actual implementation of warehouse-logistics technologies is gaining on importance in today's practice of consulting and logistical system management. The reason for this is that consigners expect with good reason from consultants to see bigger and more complex projects through, from system mapping and system design, right to its implementation (often including installation). These exciting phases of consulting work – despite their numerous pitfalls – set a major challenge for consultants. This study demonstrates a complex methodology which had been used by us on many occasions with success, and which is efficient enough to help choose the optimal contractor(s) and supplier(s).

2 The implementation of tenders for the execution of the infrastructure of warehouse-logistics systems

2.1 General statements

In our experiences, the key to the successful implementation of tenders is a customised tender procedure which is based on hardware-independent expertise, constant communication, and control. Therefore, we believe it is important to present the underlying procedure, which – by its complex nature in allowing plenty of feedbacks at many stages – can help choose the optimal contractor/supplier. What does hardware-independence mean in this context? Hardware (i.e. tool)-independence is one of the chief (if not the principal) assets of an exigent consulting and professional logistics system manager. Among others, this is precisely the reason why the involvement of an independent expert in the tender process is beneficial for the consigner. The statement that to one problem there exist multiple solutions is almost a commonplace. This is particularly true for the planning and realisation of logistics systems. Should we wish to find an abstract model for this problem, (either in case of system design or system implementation) we could say that each good solution is some kind of a local optimum. In this pre-implementation phase, the task is to find the best solution i.e. the "global optimum", out of a number of good solutions i.e. "local optimums". The expertise of independent professionals in the matter could give a chance that relevant local optimums

be more or less mapped; and from these, the global optimum is chosen with an appropriate selecting methodology.

Almost always, the *tender process* is based on a model which has been proved in many cases, and which has developed gradually out of experiences (Fig. 1). However, it must be noted that almost every tender has some distinguishing feature which requires the basic structure of the process to be customised.

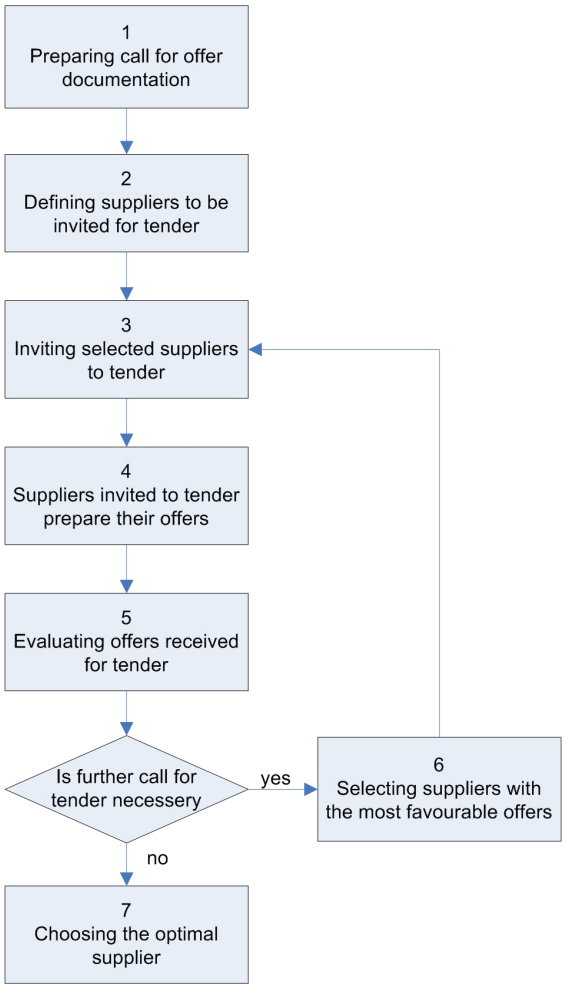

Fig. 1. Basic structure of the tender process

Fig. 2 shows the *time demand* of the individual *phase segments* in relation to each other (This is rather variable depending on the complexity of the logistics system). The numbers correspond to the phase segment numbers shown in Fig. 1.

2.2 Preparing call for offers documentation

Preparing the call for offers (RFQ or RFT) documentation is perhaps the most important part of the tender process. The thorough compilation of this is a basic criterion for the possible suppliers to make an offer which is assessable both technically and economically. In order words, it enables a relevant system solution or system version to be realised. This documentation specifies the actual logistics and/or warehouse system which is to be executed. It needs the gathering and systematization of all relevant input information which the company, who prepares the offer, will need. Where do these data come from? As we mentioned before, the establishing of such complex systems is a multi-stage process. The tender process must be preceded by the phases of logistics system design. Our experiences show that right input information can only be gathered from a logistics system plan which is properly done and validated many times by the consigners. In case of a complex tender, basic *input information* could be the followings:

- Drafts specifying the logistics system to be realised: plotting, layouts, layout plans with necessary cutaway views, and different section plans (e.g. pallet racking). These contain storage-and logistic technologies, material routes, technological dimensions, and all drawing/image components which are indispensable for preparing the technological offer.
- Basic features of stored/moved units: unit forms, weight, size (in case of variable weights and sizes: their minimum and maximum values), load equipment, type of packaging, aggregation factors, other significant parameters and peculiarities.
- Exact features of storage-and material moving tasks: short description of tasks, clarifying task limits, specification of needed tools for storage/material moving, estimated number of machines, other peculiarities.
- In case of special material handling tasks: parameters of equipment or intermodal units to be used (e.g. swap-body containers) description of establishments, tools, and equipment used at the place of handling.
- If possible, photos about some elements of the existing logistic system, about the loads to be stored/moved, storage aids (if there exist any), machines used to handle/transport material.

A systematized and complete listing of the above data is primary to avoid misunderstandings, and to eliminate system solutions that can not be assessed technologically. Sadly, in spite of this, unsatisfactory solutions are still made. One of the main reasons for this is that a possible supplier has to invest a lot of energy to prepare a proper offer, and this is a time-consuming and laborious task. Therefore, the timing of the tender process is extremely important, and likewise, that applicants are given a sufficiently long lead time with regard to the individual phases.

Systematic input is guaranteed by a call for offer documentation with the right format. In it, references have to be made regarding the requirements for format of the offer to be submitted. In order to support this, and to make the evaluation easier later, it is expedient to "trick" the applicants, as far as the obligatory parameters and information is concerned. It is thus usually recommended to pre-design some summarizing and *ordering charts* where one might as well search for data relating to the offer in an automatic way in the evaluation phase. Similarly, such data could be transferred into the evaluation system. As such, a properly prepared documentation includes:

- related source data as specified above, internal references to information;

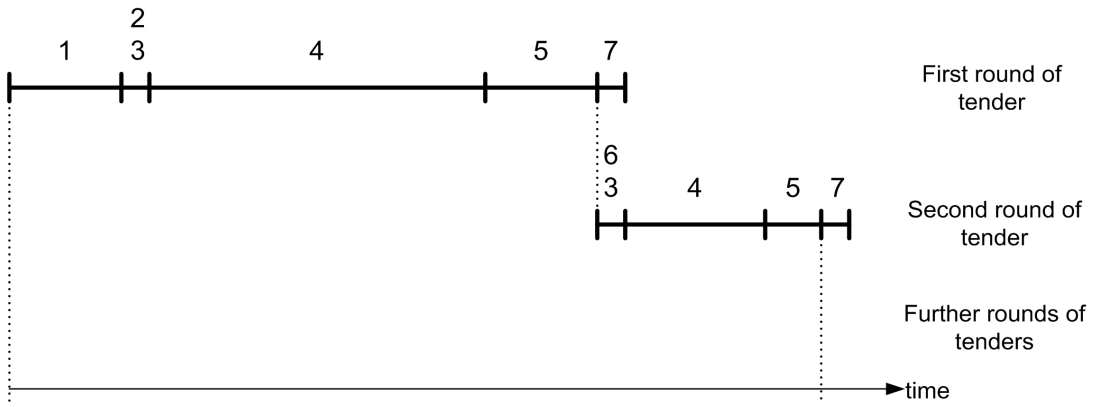

Fig. 2. The temporal structure of the tender process

- optional, supplementary elements of the storage/material moving technology;
- a list of required alternative solutions to the storage/material moving technology in question;
- compulsory and optional system factors, elements;
- information on implementation;
- rules for making offers;
- documents to be submitted;
- data charts to be filled in which refer to the technological/economical parameters of the offer ;
- technology of handling offers (paper-based and electronic documents, information sharing);
- timing of the tender process (deadlines etc.);
- way of liaising.

From the above – whereby we do not intend to be exhaustive – we would like to highlight one point: the technology of handling offers; as this is a key element in tenders' data protection as well as in "excavating" the data of the offers which will be evaluated, and are necessary for multi-criteria analyses. The solution we use is the result of a long-term learning process. We have tried out a lot of methods. The internet or the application of FTP based technologies has proven to be the most efficient, because they enable to handle data quickly, systematically, professionally and in an adequately protected way. Communicational protocol (access, uploads and downloads) has pre-defined rules, along which these systems operate. Developers are currently making efforts to find out how to match the basic data needed for evaluation (and which are directly or indirectly within the offers that had been submitted) with the data charts of the multi-criteria analysing system, using automatic data exploring technologies. This could considerably shorten the time of the evaluation, since in all cases; one of the most time-consuming tasks is the gathering of such data as well as their "trimming" for the multi-criteria analysis system.

2.3 Defining possible suppliers, invitation to tender

According to experiences, in case of such complex assignments, it is difficult for consigners to define that potential scope of suppliers who would implement the planned logistics system. One of the most important reasons for this is that they are not aware of neither the suppliers, nor their competencies and skills. Hiring independent experts in such cases could thus be advantageous, since they are competent and skilled enough to cope with the problem. Experiences show that – depending on the type of the assignment – it is suggested to invite 10. . . 15 companies for similar tenders; then, they need to be provided with the call for offer documentation, as described above. Naturally, invitations to tenders have set rules, too, which must be drawn up in accordance with the rules of the procurement team of the consigner.

Some advice on the process (not complete):

- in the invitation for tender, it is recommended to clearly define the way of access to the call for offer documentation;
- it is suggested to briefly sketch the applied protocol, handling instructions for the applied offer handling system;
- one must specify the types of documents to be found on the server (plans, data charts, call for offer documentations, photos, etc.);
- it is important to draw the attention to the deadlines, as well as restrictions on contents and format;
- it is recommended to ask for an e-mail feedback once the offer had been uploaded onto the server (in certain cases, state-of-the-art offer handling systems generate this automatically).

2.4 Preparation of the supplier's offer

The time span for the preparation of the supplier's tender may vary according to the complexity of the logistics system to be implemented. In our experiences, this requires a minimum of two weeks, considering the whole tender process. Practical experiences prove that despite an exact, precise and well-prepared invitation for tender, continuous communication with the possible suppliers in the offer preparation phase is vital. This requires the comprehensive and thorough knowledge of the logistics system plan and the tender, as a number of questions might come up

in connection with the system or the supplier, which – lacking the necessary competence – could mislead the suppliers. Nevertheless, it had actually happened before that despite the careful preparation of the tender, the supplier pointed out problems which had been overlooked in the phase of the tender preparation. It may also happen that some suppliers have unique system solutions, which bring up further questions. In such cases, quick decision-making is crucial so as not to endanger the implementation of the tender.

At the end of the offer preparation phase, suppliers invited for tender prepare their offer, which then they upload to the designated server using adequate protocol and technology. During this preparatory phase, suppliers are in constant contact with a competent expert who had been assigned to make the tender. Consequently, during this phase, one can get learn of some valuable information about tricks of implementation, or other technological matter. Such information is profitable for upcoming tenders, and could benefit current and possible future consigners, too. Further, this incites the development of the implementation of tenders, and of the evaluation methodology.

2.5 Evaluating offers

It is crucial, and almost a commonplace that, when evaluating offers, one should apply more criteria. Often, we experience that this is not applied at all, or just in part. Reasons are hard to explore, but, based on a survey among consigners we can say that one of the most important problems is acute lack of time (situations when decision-making is urgent or necessary). Likewise, lack of adequate competency, of thinking in systems, or of the ability to make multi-criteria comparisons, is not rare. As practising analysers we can say that in cases when such complex issues are concerned, it is not easy to implement an exact evaluation system which meets the requirements of system-based thinking. To establish a system like this, thorough mathematical and methodological help is needed. The mathematical apparatus supporting multi-criteria analyses is the *decision-preparation method*, well-known in the field of operational research for years [1], [2]. It served as the basis for us, too, while developing our evaluation system.

Choosing the *evaluation aspects* in this phase should not pose a problem anymore, since already in the phase of tender invitation, great care must be taken to define the parameters of the individual offers in a controlled way, and to ask them to be submitted in a structured form. Thus, the aspects defining the suitability of a logistics system are already laid down. The most important factors include (the list is not complete):

- Total Cost of Ownership (TCO):
  - price parameters: price of each alternative, price of options that can be chosen;
  - delivery costs;
  - assembly/installation costs;
  - maintenance costs (e.g. 18000 working hours for forklifts);
- maintenance, solutions to ensure continuous operation;
- delivery deadline parameters;
- required time for assembly/installation;
- warranty, post-delivery warranty;
- terms and way of payment;
- other technologically and economically specific tasks.

Time-consuming is the gathering, structuring and trimming of the input data, which is necessary for the multi-criteria analysis, and which had been received from the offers and relate to the alternatives on offer. The automation of this process is in the focus of current developments of data management, and are hoped to be introduced in the near future.

One of the chief values of our system is the automatic application of multi-criteria evaluation methods that are well-known from textbooks, but may not be used enough in practice. We have developed a mathematical method called *multi-criteria decision-supporting algorithm, (MDA)* [3] which we use for evaluating tenders [4], [5]. *MDA* enables to determine the weights of evaluation aspects under examination in mathematically correct way. To this, one must set the importance ratio of the evaluation aspects based on discussions and agreement with, and validation by the consigner. This is a vital step, as these settings create the internal, mathematical input, which generates the weights of evaluation aspects. In determining weights, consistency is underlined, because in case of inconsistency (there is contradiction in the importance of evaluation aspects in relation to each other) the evaluation system could give a false picture about the alternatives. Therefore, consistency, as well as the permitted level of inconsistency is controlled by an inner checking routine. Offers received can be arranged in an order of "usefulness" (exactly calculated); based on the value they get from the pre-defined evaluation aspects, as well as the generated weights of the aspects. The arranged offers get a value between $0 \ldots 1$, where the most favourable offer has the biggest value. (If an offer proves to be the most favourable in all aspects, it will get the performance value 1.) Performance values can be interpreted in a percentage context, meaning how "good" they are in relation to the "optimal offer". It happens fairly frequently that the difference between two or more solutions is very small. In such cases, a sensibility analysis must be carried out, which examines what happens to the order of offers if weights are changed.

One must examine what happens to the best offer when changing the weights. (We change the relative weight of one aspect between $0 \ldots 1$; the weight ratio of other aspects remains the same.) Four aspect types can be determined:

- changing the weight does not affect the best alternative ($E - 1$);

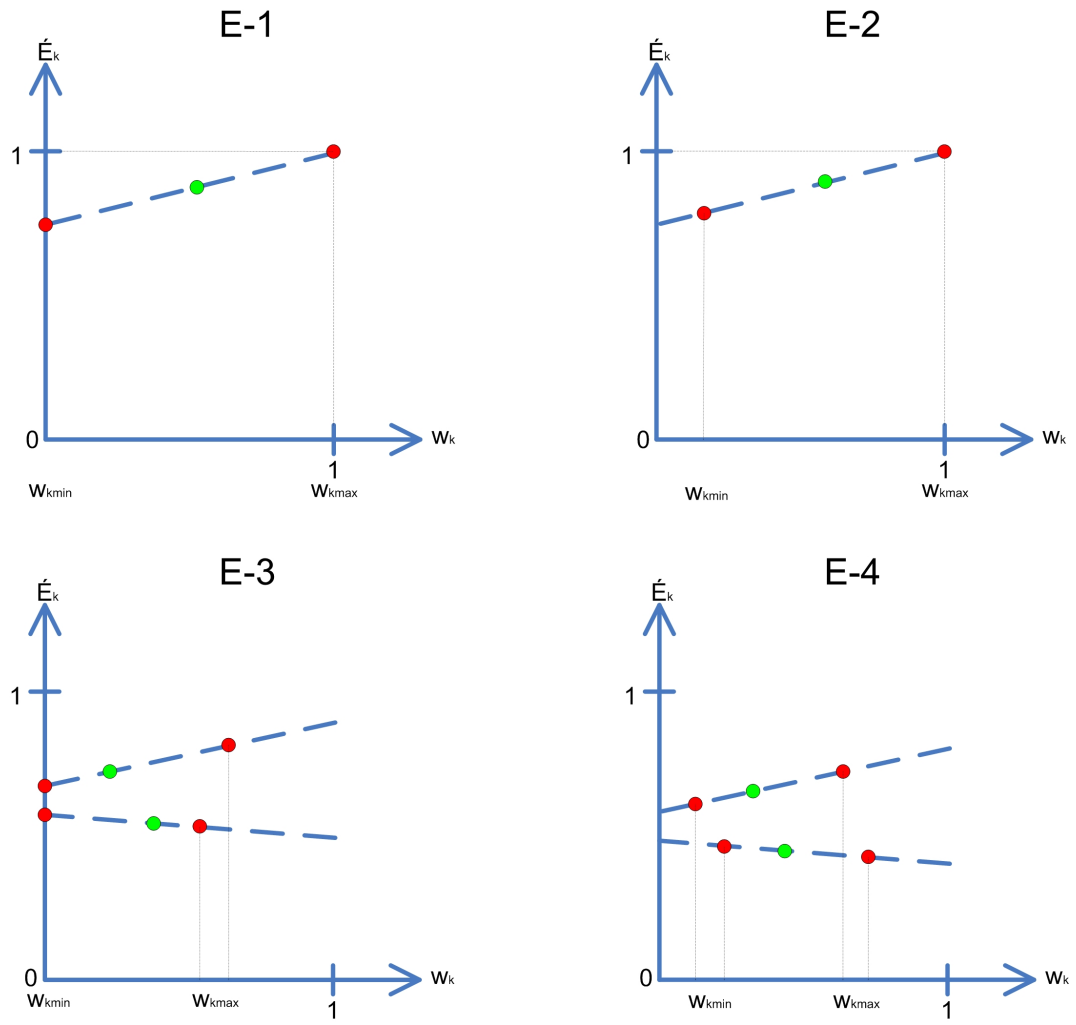

Fig. 3. Basic cases of sensitivity analysis of weights, change of the performance value of the original optimum alternative

Main aspects			Sub-aspects				Offers and their values								
Ser. No.	Name	Weight	Ser. No.	Name	Weight	Interpretation	1	2	3	4	5	6	7	8	Ideal
1	Price	0,574	1	Price (euro)	1	K	114315	140880	102000	81030	150000	136780	126021	110490	81030
2	Delivery deadline	0,115	1	Delivery deadline (week	1	K	8	6	4	8	8	8	8	6	4
3	Assembly	0,115	1	Assembly (week)	1	K	9	14	9	30	22	23	30	14	9
4	Warranty	0,082	1	Warranty (year)	1	N	5	1	2	1	1	2	2	2	5
5	Payment	0,115	1	Deposit (%)	0,5	K	0,00	0,30	0,30	0,00	0,40	0,3	0,00	0,3	0,00
			2	Deadline (day)	0,5	N	30	30	30	30	8	8	15	15	30
1	Price	0,574					0,71	0,58	0,79	1,00	0,54	0,59	0,64	0,73	1
2	Delivery deadline	0,115					0,50	0,67	1,00	0,50	0,50	0,50	0,50	0,67	1
3	Assembly	0,115					1,00	0,64	1,00	0,30	0,41	0,39	0,30	0,64	1
4	Warranty	0,082					1,00	0,20	0,40	0,20	0,20	0,40	0,40	0,40	1
5	Payment	0,115					1,00	0,50	0,50	1,00	0,13	0,13	0,75	0,25	1
					Ser. No. of offers		1	2	3	4	5	6	7	8	
					Points		0,776	0,554	0,775	0,797	0,446	0,490	0,580	0,633	
		Final order of offers			Ser. No. of offers		4	1	3	8	7	2	6	5	
					Offer value		0,797	0,776	0,775	0,633	0,580	0,554	0,490	0,446	

Critical aspects and their critical weight, along which the current results (offer No 4 is the most favourable) is valid:

Main aspects	Lower limit	Upper Limit
Price	0,52	1
Delivery deadline	0	0,14
Assembly	0	0,13
Warranty	0	0,1
Payment	0,06	1

Fig. 4. Example for *MDA* generated report

- the weight has a minimum limit, below which the best offer changes ($E-2$);
- the weight has a maximum limit, above which the best offer changes ($E-3$);
- the weight has both maximum and minimum limits, this could mean a change in the best offer ($E-4$).

Fig. 3 shows the effect change in weights (w_k) has on performance value ($É_k$).

The *sensibility analysis* is to determine those weight limits of aspects, which prove the same offer to be the best which had been the most favourable along the original weights, too. In our system, this examination can be done automatically, too. Based on this, it is recommended to choose the final order after several changes in weights. *MDA* is an MS Excel and Visual Basic Application (VBA)-based system. By its pre-decision making nature, it generates reports that help making well-founded decisions (Fig. 4). However, one should not forget that even the interpretation of results is not trivial in many cases. Consulting an expert in this is highly recommended, as he can explain the content behind the numbers. A thorough tender evaluation procedure should – in all cases – finish with a consultation of such kind.

2.6 Further calling(s) for tenders, decision-making, choosing the supplier

Decision-making is often a challenge even with methodological and professional support. There is a tendency among consigners that they are incapable of coming to an agreement owing to problems in their organisational structure or some limitations on responsibilities or simply because of changing investment&development strategy. It often happens that the evaluation phase is ready for months, but the actual decision-making about "what next" will just not come about. We lose on precious time, and the tender process may become irrationally long. That is to say, based on MDA results, it is suggested to invite the first two (or maximum three) potential suppliers to further tender(s), partly to further specify the offers technically, and partly to get more favourable terms. It may also be useful to make a reference visit at the potential suppliers; in a warehouse which – in terms of equipment – resembles the technology specified in the tender. In this phase of the tender, the multi-stage installation of the storage/material moving system as the subject of the tender can be considered (especially in case of big investments). This is also when negotiations about the purchase price begin, which – according to experiences – have a high potential for savings. However, due to the time constraints mentioned above, further tenders are often left out of the tender process. Frequently, it turns out in mid-process that there is no time left for further calls whereby in may cases, consigners miss out on considerable savings, not mentioning the problems it generates later during the implementation.

Somehow or other, the last step of the tender process is in all cases the final decision based on the multi-stage selection process, namely, choosing the supplier(s). It may well happen that two different contractors win the implementation of the storage and of the material moving system. In such cases, one must cater for the compatibility of the two systems, and this could mean further problems, as well as new challenges for experts and system developers.

3 Summary

The tender process described in the article is the result of an evolution or continuous research and development, whereby we made efforts to combine years of experiences in tender processes with the long-standing and existing methodologies. During our practical work and the testing of the developed process and algorithms, we have encountered numerous problems, from the acquisition of racks worth only a few million Forints, to the tendering of complex storage/material moving systems worth nearly half a billion Forints.

We have invited tenders for diverse storage technologies: from painting the place of the takeover, setting up modular shelving, pallet racking or drive-in pallet racks, right through to the most peculiar storage systems (gallery-art storage with shelves, special deep racks, etc.). In respect of material moving systems, we have prepared the set-up of different systems by applying the above specified tender process. Such systems include: systems with periodical operation (e.g. hand pallet trucks, electric counterbalance trucks, reach trucks, and order pickers), systems with continuous operation (roller track for production).

Experiences show that the system is working properly, and its efficiency is measurable. However, there is no doubt that the above mentioned directions of development may well hide some potential, undiscovered opportunities, which could further enhance the efficiency. In the end, it is important to note that tenders could generate further assignments for those companies that had been chosen during the processes: if the consigner is satisfied with the end-result and the ensuring of constant operation, he may hire the same contractor to equip his other warehouses/parts of warehouses.

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