Advanced Logistic Systems – Theory and Practice, Vol. 17, No. 2 (2023), pp. 36-45.
https://doi.org/10.32971/als.2023.014

INCREASING POSSIBILITIES OF THE RELIABILITY OF LOGISTIC PROCESSES

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Abstract: *A very important word of our days is the consumption, which requires the general availability and low price of the goods, however it causes significant changing in the reliability of the different devices and appliances, especially in industrial aspects. There are also important role of the reliability in the logistic processes, but not only at the technical side, it appears also in different logistic activities. In this paper, an overview is presented about the logistic aspects of the reliability, outlining those elements and development possibilities which can help to increase the reliability of the logistic equipment and logistic systems.*

Key words: *reliability, logistics, system elements and relations.*

1. INTRODUCTION

One of the most important words of our days is the consumption. Societies based on the consumption require the general availability and low price of the goods. These aspects cause significant changing in the reliability of the different devices and appliances, because the mass production statistically results significant amount of operation problems. So decreasing of the reliability is an actual problem, especially important at the industrially used devices.

There are also important role of the reliability in the logistic processes, but not only at the technical side (e. g. loading devices, transport equipment), it appears also in different logistic activities (e. g. the reliability of the supplier companies).

As we can use different machine types for the different handling tasks of the goods, it is a very important aspect, how the structural and operation characteristics of the devices can influence the reliability of the whole handling system.

In this paper an overview is presented about the logistic aspects of the reliability, outlining those elements and development possibilities which can help to increase the reliability of the logistic equipment and logistic processes.

2. RELIABILITY ASPECTS OF LOGISTICS

There are different definitions for the reliability, mainly from the technical side, however from general point of view, an element (physical device or system element) is reliable if it fulfils the requirements determined by the related process.

In the logistics, the reliability appears in three different aspects:

- reliability of the technical equipment used in logistics,
- reliability of the logistic elements (activities used for realizing the logistic tasks) of different systems,
- reliability of the whole logistic system.

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2.1. Technical reliability

Classical meaning of the reliability is related to the technical aspect, but we can use different definitions [1] for it, e. g.

- reliability is an ability of an element (product, system, etc.) for operating in previously determined conditions until a predefined deadline or working cycle or
- reliability is a probability of the sufficient operation (functional working without errors in a determined loading range) of a product or a system in a predefined date or duration, in given environmental and working conditions.

In generally, if the above mentioned situations cannot be realized, the product, device or system has operation problems, failures and decreasing in the reliability.

The technical reliability of a device depends on two different process types, the first involves deterministic effects (wearing, natural degradation, etc.), the other contains all non-foreseeable effects (inherent defects, operator faults, etc.). Because of the second group of the effects, the reliability of a device cannot be determined exactly, it is only a probability function which is affected by many stochastic factors (see Fig. 1).

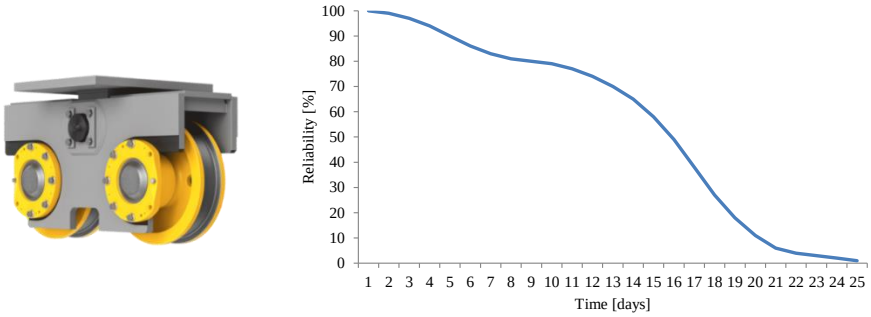

Figure 1. Typical reliability function of a general device (crane wheels)

At the beginning industrial era, the reliability of a device was identified as only the operation probability, however, in the middle of the seventies of the last century other notions linked to it: the reparability, the maintainability, the durability and the storability [2].

Nowadays, the standards – e. g. MSZ IEC 50 (191) [3] – defines the reliability as a collective notion, used for the description of the usability and their influencing factors, which involves trouble-proof operation, maintenance and maintenance supply. Based on the above mentioned definition, the reliability of a technical device is determined by the trouble-proof operation probability, the used maintenance process and the sustainability of the maintenance system (element supplying, knowledge, etc.).

In the logistics, the technical reliability can be used mainly for the handling devices (loading, transport, storing equipment, etc.) and other technical elements (e. g. sensors, actuators, IT devices), however it influences the whole handling system and many other elements of the supply chain.

Main types of the equipment used in logistic processes:

- handling machines (transport and loading),

- storing equipment (racks, pallets, etc.),
- packaging and unit-building devices,
- sensors, tracking and tracing devices,
- identification elements (readers, tags, etc.),
- other IT devices (control, guidance, etc.), etc.

The technical reliability has the most important role during the material handling activities, because the failures and operation problems significantly decrease the efficiency of the handling and other logistic processes.

2.2. Reliability of the elements of logistic systems

In the aspect of reliability theory, system element is an individual system component with specified reliability character, which can be identified and analysed independently from the whole system [4].

The reliability appears as an individual parameter of the given element, however as the element is a part of a system, its behaviour influences the reliability of other system components and also the whole system.

Logistic system elements are activity groups used for realizing logistic tasks and appears as parts of the internal or external logistic systems (e. g. supply chain) or sub-systems (supplying, production, distribution systems, etc.) (see Fig. 2).

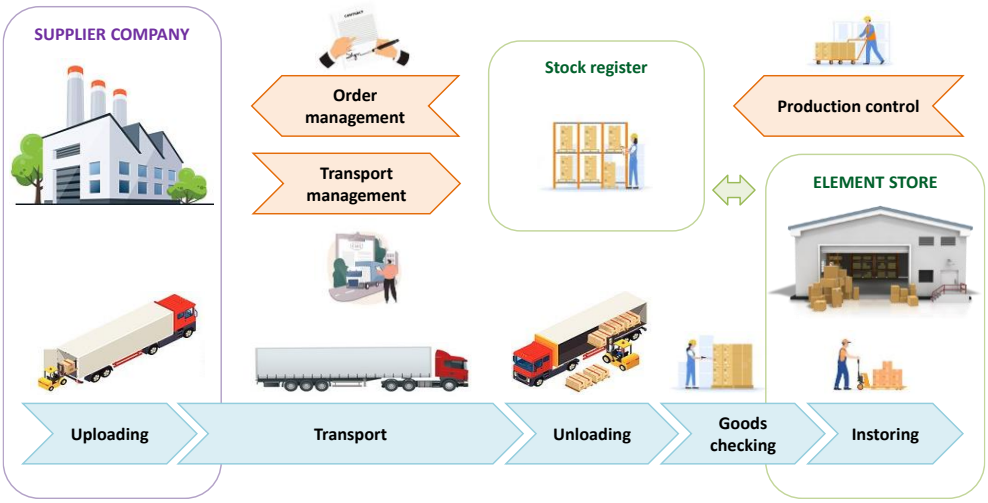

Figure 2. Elements of the supplying logistics sub-system

The reliability of the logistic system elements means the probability of the fulfilling of the physical and management activities required by the given system part. The fulfilling of tasks related to the given elements is normally expected from all partner authorities and described in official contracts, only stochastic effects (weather, traffic situations, failures, human faults, etc.) can influence the reliability of the system elements.

The reliability of the system elements is basically depends on the internal structure, the operation parameters and the environment, where a critical factor is the reliability of the

human resources. In certain cases, strategic decisions or non-correct activities of the partner companies (e. g. violation of contract) can cause the failure of the tasks, which can highly reduce the reliability level of the system elements.

2.3. Reliability of logistic systems

Naturally, the reliability of the whole system is based on the reliability of the system elements; however, the relations among the system elements can modify this level.

Logistic system means a group of logistic tasks and activities, which work together to reach a given objective (e. g. distribution logistic system). In the aspect of the geographic range and task types we can count internal logistic systems, external logistic systems, logistic networks and other logistic systems [5].

The most important factors, which influence the reliability of a logistic system are

- the reliability of the system elements,
- the characterisations of the relations of the elements,
- the influencing environmental effects, etc.

The relations of the system elements have different parameters [6] which largely influences the system structure and operation character (see Fig. 3), but usually their effects to the reliability can be predefined (e. g. uncertainties of the see transport).

Figure 3. Example for the relations of a distribution logistic system (green arrows – low risk, yellow arrows – medium risk, red arrows – high risk)

The environmental factors can be counted into different categories, which determines their effects to the reliability:

- weather effects,
- traffic characterisations and uncertainties,
- related logistic systems,
- effects of the politic and economic environment, etc.

3. INCREASING THE RELIABILITY OF LOGISTIC SYSTEMS

The suitable operation of a logistic system is based on the faultless and correct operation of the system elements, so the reliability of the system elements is a key factor, which involves the reliable operation of the logistic devices and also the suitable realization of the management and administration activities.

3.1. Increasing the reliability of logistic devices

The reliability of the technical devices can be increased mainly by using of advanced maintenance systems. Maintenance is a group of activities, which realize the control, maintain and repair tasks related to given equipment (machines, devices, vehicles, etc.) [7].

Some decades ago, maintenance was a simple, internal task within the production hall, which was realized by special teams, settled close to the manufacturing machines [8]. Size and location of the maintenance facilities were depending on the parameters of the activities and the production area. An important characterisation of the maintenance processes was the direct link to the production process, which significantly influenced its operation.

In the last quarter of the twentieth century, diagnostic methods appeared in the maintenance processes, which opened new directions in the control of the machines. Next step of the development was the Reliability Centred Maintenance (RCM), which is based on the reliability of the machines and their elements, and means a new point-of-view, at first mainly in the aircraft production. The last concept is the Total Productive Maintenance (TPM), which - similarly to the Total Quality Management (TQM) systems - tries to give the responsibility for certain tasks of the maintenance (keeping, observing, etc.) to the handling operators and introduces a general system concept for the maintenance to avoid malfunctions and crashes [8].

Nowadays, the application and operation of suitable and advanced maintenance systems are principal conditions for the reliable operation of technical equipment used by different logistic processes, but because of the stochastic effects the reliability of the machines cannot reach 100% in the practice.

The failure of a logistic device can result the blocking of the whole production or service procedure, so their reliability is a very important factor. The maintenance of the material handling machines is a complex task, because a handling system in generally contains numerous, different equipment which can be maintained together.

The maintenance of the handling equipment is influenced by their structure and operation characteristics [9]. Based on the principal characterisation of the machine types, we can describe four different groups in the aspect of the maintenance, related to the handling solutions:

- discontinuous, independent mobile handling units,
- discontinuous, track guided mobile handling machines,
- continuous transport equipment, linked to two objects,
- complex, continuous handling systems.

The maintenance of *discontinuous, independent mobile handling units* (e. g. manual forklifts) is an individual task, all machine can repair and maintain independently from the others. During the maintenance, the machines can be removed from the handling system and any kind of repairing activities can be applied for them (machines can be transported to

the maintenance workshop if it is necessary). To sustain the operation of the handling system the machines can be substituted by other machines or solutions, so the maintenance process does not influence the efficiency of the production or service procedure. This kind of handling systems usually contains the same or similar machine types, so the maintenance activities are also similar.

In this case, the reliability of a handling system can be easily increased by the number of the handling devices.

The maintenance of *discontinuous, track guided mobile handling machines* is similar to the previous cases, because the handling machines can repair and maintain independently from the others, but the realisation of the maintaining activities can disturb the operation of the handling processes (removing devices from the line trucks can block the other machines). In some cases, this handling scheme applies only one, or low number of machine in the system (e. g. bridge crane), so the handling process is stopped during the maintenance. Other important parameter is the size of the machines; big machines cannot be transported to the repairing workshop. Beside it, the line trucks also require maintaining activities from time to time.

In those cases, where the handling system use numerous track guided mobile units (e. g. AGV- Automated Guided Vehicle - system), the reliability of the system can be increased by also the number of the handling devices (see Fig. 4).

The application of guided trucks limits the number of the mobile units, because they can disturb each others on the common lines sections (e. g. cranes), so in these cases only the developing of the machine parameters can help to increase the reliability.

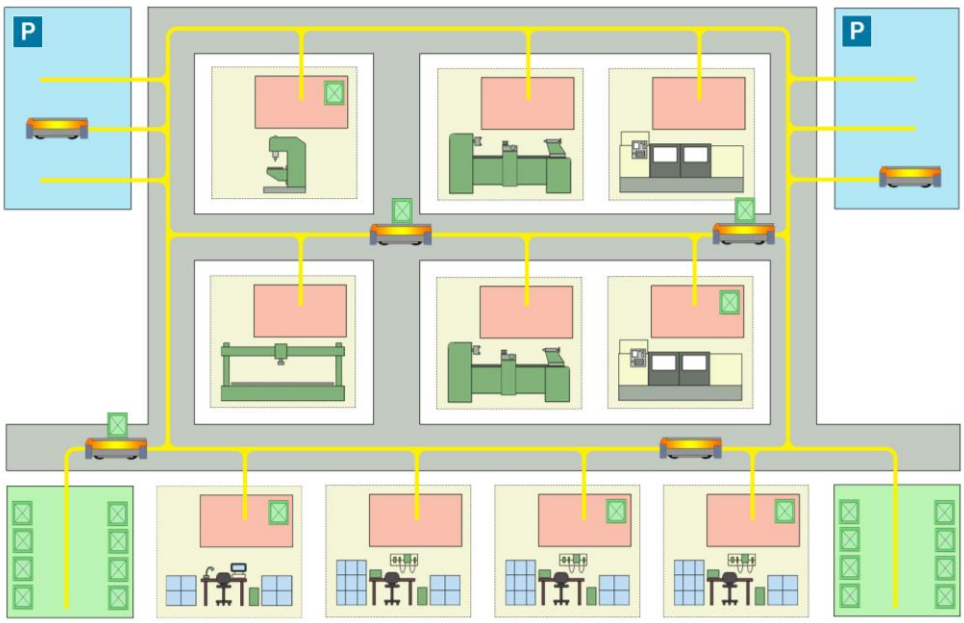

Figure 4. Example for handling system using discontinuous mobile units (AGV)

In case of continuous transport equipment, two different variations have to be taken into account in the aspect of the maintenance. Some machines *link only two objects*, the first is

the source, the second is the destination of the goods (e. g. transport screws). During the maintenance process they have to be stopped, so the production or service procedure is blocked. The machine elements are usually simple, so the reparation procedure is short in time, but at large machines (e. g. external belt conveyors) the repairing operators need much more time for walking along the transport line.

At these machine types, only the developing of the machine parameters can help to increase the reliability.

The other group of the continuous transport equipment can *connect several source and destination points* (e. g. trolley conveyor), so the maintenance process is different. There are two cases for the realization of the maintenance of these machines. If it is possible to divide the transport line into separate sections and the repairing tasks also can be linked to the sections, the maintenance process can be realised without the blocking of the whole transport system. Using of substitute machines (e. g. mobile units) can help to secure the performance requirement. If the maintenance process has to be realised on the whole handling system, we cannot avoid the outage in the production process, but because of the simple machine elements the reparation procedure is usually short in time.

For the increasing of the reliability of these handling systems, the modular, separable system structure is the most effective solution (see Fig. 5).

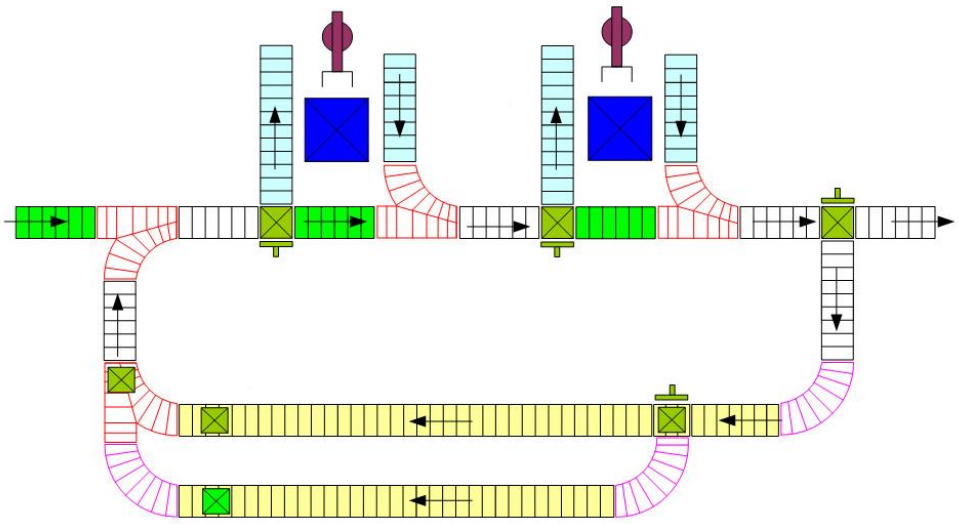

Figure 5. Example for handling system using continuous, separable line sections (roller conveyor).

3.2. Decreasing the operation uncertainties of the elements of logistic systems

Beside the reliability of technical devices, the efficiency of the elements of logistic systems is depends on different uncertainties during the operation:

- structural problems (e. g. low capacity),
- human mistakes (e. g. unskilled operators),
- errors in the operation strategy (e. g. wrong priorities),
- negative effects of the internal environment (e. g. production uncertainties), etc.

For the reduction of the operation uncertainties, optimal logistic solutions must be applied in all field of the logistic systems [10]. The most often used methods and procedures to find optimal solutions for advanced logistic processes are

- layout planning with optimisation,
- simulation of handling systems (see Fig. 6),
- automation of the handling machines,
- computer control and tracking of the goods and handling devices,
- computer aided planning of the production and handling system, etc.

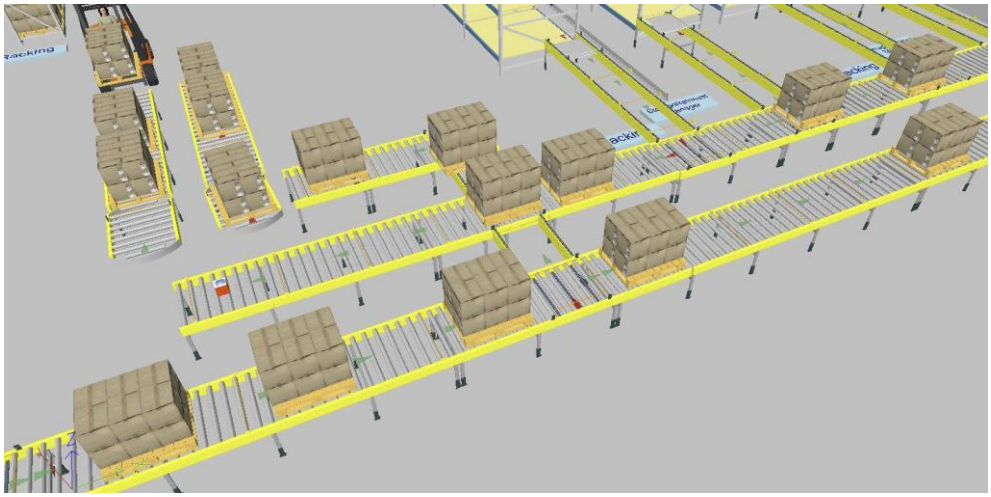

Figure 6. Example for the simulation of handling systems (Demo3D) [11].

At certain system elements, where the reliability of the partner companies can influence the operation of the logistic system elements, special methods must be applied to avoid the operation problems (e. g. supplier selection methods based on reliability factors [12]).

3.3. Decreasing the operation uncertainties of the whole logistic system

Beside the parameters of the system elements, there are two more aspects, which can influence the reliability of a logistic system:

- the relations among the system elements,
- the influencing environmental effects.

The relations among the elements have principal role during the building of the system structure, so their parameters are endowment. If a parameter of a given relation causes uncertainty during the operation, two solutions can be used:

- searching and using a new relation with better parameters (e. g. new transport route or method),
- if we cannot change the given relation and its parameters, the application of special rules and conditions can increase the reliability (e. g. using more strict transport conditions).

For the determination of the reliability of the individual relations, effective analysis must be done, for which the best method is the simulation analysis of the whole logistic system, where different variations can also be examined (see [13]).

The environmental effects can influence one object, one relation or certain part of the logistic system (e. g. different objects and their relations in a given geographical region).

In the aspect of the operation of the logistic system, the best solution is the termination of the problematic environmental effect (e. g. avoid transport across a political region), however, many of them cannot be dissolved (e. g. the effects of the climate in a region).

At certain environmental effects, it is possible to use alternative relations (e. g. transport routes), but the analysis of their reliability is not an easy task. If we have possibility to apply alternatives with different reliability levels, risk based analytic methods can be used for the evaluation of the negative environmental effects [14].

As a consequence of the Covid-19 pandemic, the selection method of the elements of the supply chain is changed, against the global solutions, many companies look for local suppliers, which are not so sensible for the global effects, so they can increase the reliability of the logistic systems [15].

4. SUMMARY

Societies based on the consumption require the general availability and low price of the goods. These aspects cause significant changing in the reliability of the different devices and appliances, because the mass production statistically results significant amount of operation problems.

There are also important role of the reliability in the logistic processes, but not only at the technical side (e. g. loading devices, transport equipment), it appears also in different logistic activities (e. g. the reliability of the supplier companies).

The failure of a logistic device can result the blocking of the whole production or service procedure, so their reliability is a very important factor. The maintenance of the material handling machines is a complex task, because a handling system in generally contains numerous, different type of equipment which can be maintained together.

In this paper an overview about the logistic aspects of the reliability was presented, outlining those elements and development possibilities which can help to increase the reliability of the logistic equipment and logistic processes.

As a result, we can say that there are advanced maintenance methods for increasing the reliability of the technical devices used in the logistic processes, but to sustain the effective, reliable operation of a logistic system we also need to apply computer aided optimisation, simulation and risk analysing methods.

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