

# INTERFACES FOR IMPROVEMENT CRANE MOVEMENT TRAJECTORY

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*Abstract: The paper describes operator – overhead crane – surrounding interfaces of measurement for improvement the device movement trajectory. Both evolution of crane - operator interfaces from traditional to automated, as well as integrated decision making interface have been discussed.*

*Keywords: interfaces of measurement, overhead crane*

## 1 INTRODUCTION

The enterprise functions are more and more integrated through human and technical resources and human – machine interactions. New dimension of reality needs the introduction of technologies that minimize used devices energy consumption and exploitation expenses, as well as introduction of technologies which are able to convert information into knowledge for effective decision making and understanding the effect of human psychology and social sciences on decision-making process.

Material handling systems need to be more effective and to overcome the present negative image of low productivity resulting from lower stack heights, lower moving speed of equipment, etc. For the modern manufacturing the introduction of information technology and intelligent handling system based on overhead travelling cranes is crucial in order to achieve higher productivity and cost saving. Today crane challenges determination is possible to describe like: human-machine interface, reduction of exploitation cost and environmental impact, improved process control, and rapid assimilation of operator knowledge and skills. The paper describes operator – crane – surrounding interfaces of measurement for improvement the device movement trajectory.

## 2 EVOLUTION OF CRANE –OPERATOR INTERFACES

The traditional crane – operator interface was based on operator skills and knowledge supported by his vision and hearing (Figure 1), which have been additionally disrupted by surrounding factors. The operator based on transport needs and identification of transported goods have been making the control decisions resulting with the drive mechanisms movements. The crane and the railway technical states have been evaluated periodically by special maintenance service.

Modern material handling devices represented by overhead cranes are more complex, especially their control subsystem [1]. The automated crane – operator interfaces are presented at Figure 2.

Based on the transport needs, transported goods identification, optimal designed movement trajectory and real crane technical state operator (or virtual men) make the device controlling decision. New technology and management implementation into cranes leads to improve the device automation with human – machine interface [2]. In the measurement system intended for identification of the device technical state two types of errors (the first and second type) may occur [3]. The first and second errors type results with usage of proper strategies of identification (monitoring) and operational device parameters tolerance zone design, negative and positive effect of stress of the operator, and training of the device operator.

Transported goods position is identified (goods database) by vision system in 3D-plant space, and which is accessible by operator in electronic format. The present and future destination of the goods (*transport needs*) is easy to convert into the their movement trajectory in 3D with respect the existing plant ground virtual map (TP – trajectory planning) [4]. The goods transport process planning is assisted by the computer-aided system (with in-built decision making strategy) and the optimisation criteria are time and crane operation unit cost. The above linked via Internet should be a part of a concurrent enterprise.

Correctly composed goods movements are supported by crane mechanisms. The proper goods movement quality is possible to obtain, when the technical state TS of the device and railway subsystem is acceptable [1]. The technical state of the technological device is possible to evaluate on the basis of analysis his exploitation characteristic  $q$  change. The device technical state is acceptable,

when deviation from nominally characteristic  $q_0$  does not exceed acceptable value  $\pm\Delta q$ . Device exploitation characteristics is a function of device exploitation parameters  $a$ , which are weighting with errors  $\pm\Delta a$ :

$$q = f(a \pm \Delta a), q \in \langle q_0 \pm \Delta q \rangle \quad (1)$$

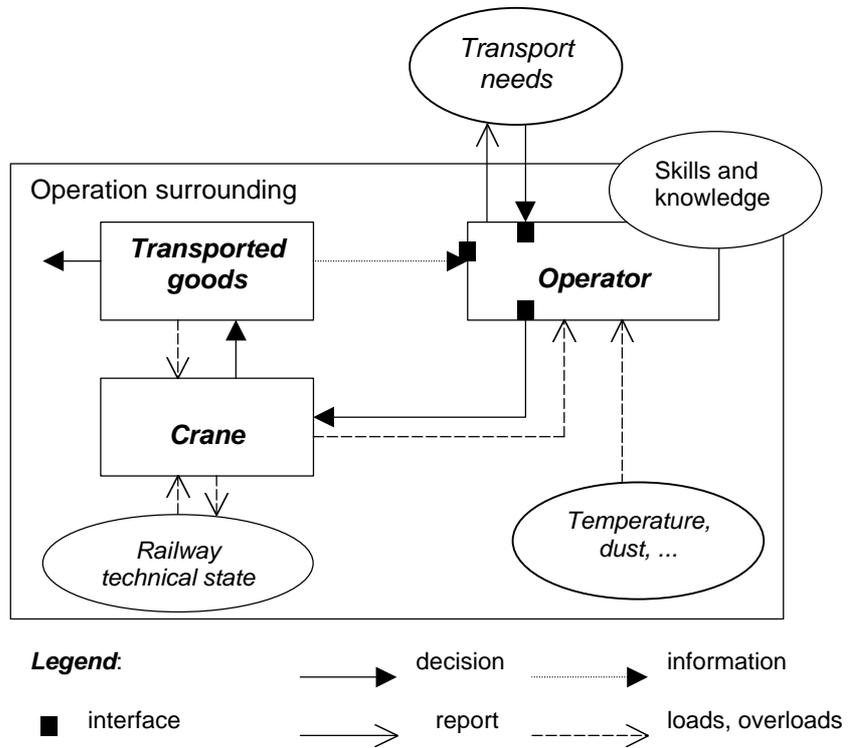


Figure 1. The traditional crane – operator interface

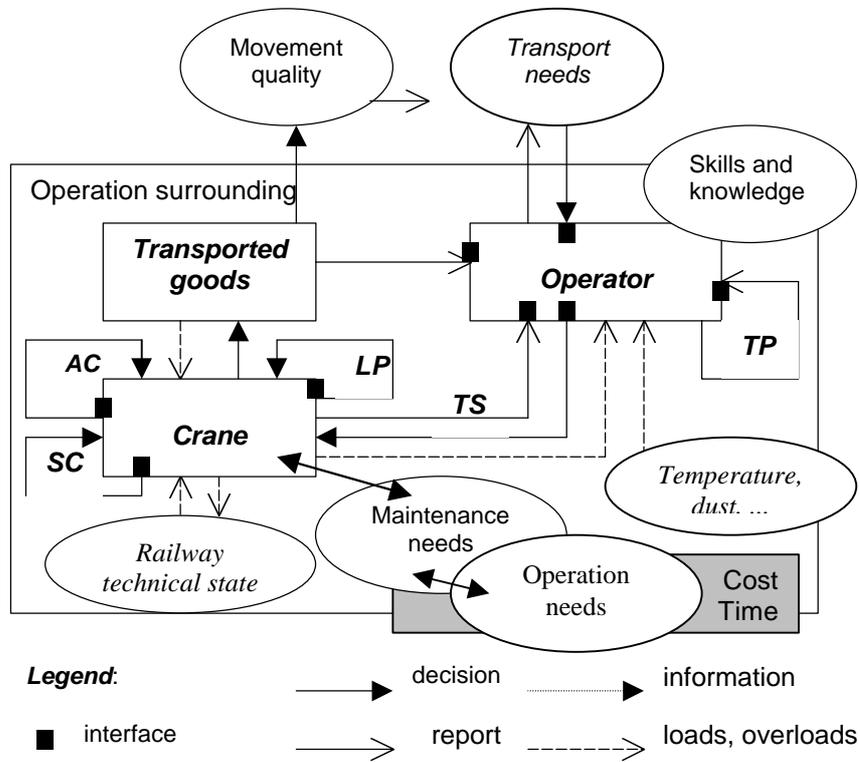
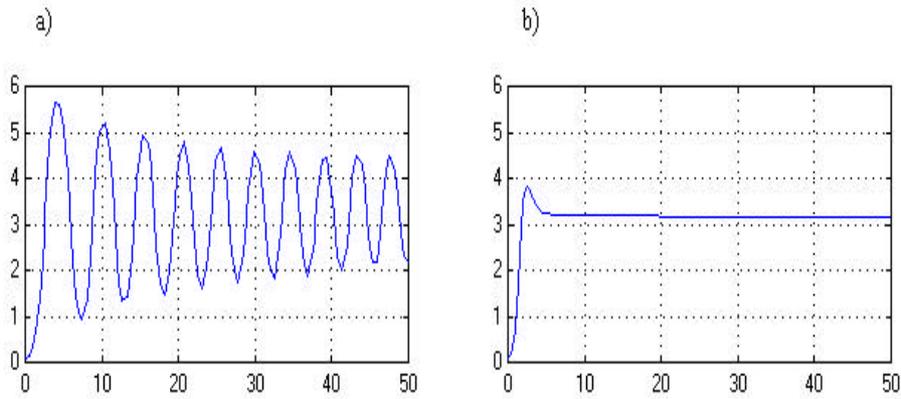


Figure 2. The automated crane – operator interface

The accepted characteristic's changes of a device  $q$  are a function of the exploitation parameter error's sum. For each exploitation parameter, formulating the allowable change area is a very complex problem, because of not linear dependence between them. Determining the exploitation parameters requires the series of tests on device. Moreover, the result of exploitation parameter's influence on device characteristics should be tested. Methodology of those tests was presented in paper [1,5], also in Taguchi's publications.

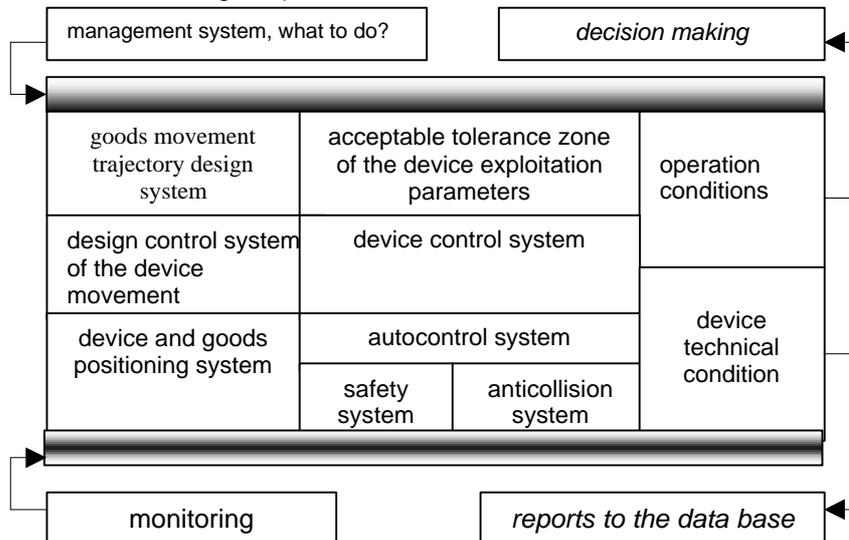
The device is equipped also with the following controls units (Figure 2): LP – unacceptable loads and unloads protection (safety system), AC – device and their subsystem anti-collision unit, SC – auto-control unit. The self-controlling unit aim is to minimize the transverse movement of the crane bridge, as well as his angle revolution round the device center of gravity. The control system is based on multibody device model supported by the DADS, Patran/ Nastran and Matlab Simulink software [6]. Secondly to the self-controlling unit the fuzzy based controller have been implemented [7]. The aim was to choose such acceleration value, which could enable to minimise rope (with goods) swings to zero. The exemplary results for hoisting winch without anti-swing system and with fuzzy controller applied were shown in Figure 3.



**Figure 3.** A goods swing angle changes under unfixed movement of the crab (in displacement Cartesian co-ordinates): a) without anti swing system, b) with swing system implementation

### 3 INTEGRATED DECISION MAKING INTERFACE

To better protect the crane operator from surroundings factor influence we have been making efforts to give intelligence and sharing our energy to give a *heart* to the device (Figure 4) [2]. The decision making integrated system included the following modules: goods movement trajectory design system, device and goods positioning systems, design control system of the device movement mechanisms, acceptable tolerance zone of the device exploitation parameters, safety and anticollision systems linked with autocontrol system, device control system, operation conditions, device technical conditions. The system have inputs (from management system and monitoring) and outputs (reports to the database and decision making unit).



**Figure 4.** The integrated decision making interface

#### 4 FINAL REMARKS

The order *to move the goods from one point to the new one by overhead crane* needs the human operator decision related to the above activity: what, where, how. Answering at question what and where, the goods identification and transporting conditions are taken into the consideration. Question how is addressed to the technical state condition of the crane, as well as the transportation criteria: safety, reliability, accuracy, energy consumption, exploitation cost.

To improve the device movement trajectory two level of interfaces of measurement are necessary to implement crane – surrounding, and operator – crane – surrounding, which have been discussed in the paper. Also the implementation of new technology into the crane structure and operator cabin are the important factor, which help to increase policy of continual improvement (quality, safe and health environment, risk).

The presented interfaces have effects to the human – crane interaction which results with:

- decreasing the device overloads,
- increasing device safety, reliability and movement accuracy,
- slimming the device construction and mechanisms,
- low exploitation cost,
- increasing maintenance quality,
- better human working condition.

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