Model of a system for monitoring and managing the efficiency of a construction object

O. F. Danilov¹, I. K. Nikitin²*, A. M. Osipenko¹, and V. O. Domankij¹

¹Industrial University of Tyumen, 625000 Tyumen, Russia
²RCCC Smetny Alyans, 625022 Tyumen, Russia

Abstract. The effectiveness of the construction organization largely depends on the competent design and implementation of the business model and the functional production model. In the process of organizing construction, it is necessary to make a huge number of operational decisions, analyze information and form tactical tasks, and build a production management strategy. The article examines the model of the working time monitoring system formed by the authors using smart helmets trackers, the interface of the created solution for the engineering and technical personnel of the construction site "Digital Worker", a dashboard for viewing reports on the work of the "Architect-Web" organization for company leaders.

1 Introduction

In order to visualize the flow of a business process within the boundaries of the work time monitoring system, BPMN 2.0 notation was used - a language for modeling business processes, which is an intermediate link between formalization or visualization and the implementation of a business process. The algorithm is shown in figure 1.

Fig. 1. System operation algorithm. Eight fragments considered below.

* Corresponding author: igornikitinpgs@yandex.ru
This algorithm implies the operation of 4 "pools":

- worker;
- working time monitoring system;
- engineering and technical worker of the construction site;
- company management.

Accordingly, for the functioning of the working time monitoring system, it is necessary to interact with the direct employee, whose monitoring is carried out using the tracker, with the engineering and technical worker who exercises operational management at the work site, and also with the management - the manager analyzes the statistics received by the system in the form structured reports and, based on them, performs the functions of tactical and strategic enterprise management.

This algorithm describes the following processes.

At the beginning of the working day, an employee who is registered in the system for monitoring needs to receive a tracker and inspect it for damage. If you can see with the naked eye that the tracker is damaged, you need to put it into a separate basket for defective products and take another free device.

For authorization in the monitoring system, the Infokiosk system is used. This system identifies an employee using biometric data, scanning and face recognition using a built-in camera.

Having made identification, the system displays the last name, first name and patronymic of the identified employee. Next, you must either confirm that the recognition occurred without errors, or enter your data manually, if the system was unable to correctly identify the person on its own.

After that, the tracker is applied to the RFID-tags reader and then the system reads the unique key of the tracker. Thus, the data from the tracker is linked to a specific person.

The fact of self-authorization excludes any claims - the employee bears responsibility for incorrect authorization. The described fragment of the algorithm is shown in figure 2.

After successful authorization, the system saves the employee's photo to the database, deleting the older photo, which allows for the variability of a person's appearance over time, such as the growth of stubble in men.

After the employee has logged in, he can start work. The system records the start time of his working day, which allows him to identify the level of discipline and use this data to encourage especially punctual and punish violators of labor discipline.

At the moment of fixing the beginning of the working day, the system analyzes the planned participation of the employee in accordance with the work schedule and his actual presence at the given construction site. This is necessary in order to identify situations where there is a discrepancy between the planned participation of a certain number of personnel and the actual involved. For example, it becomes impossible to hide the fact that fewer people are employed than are reported on the timesheets.

Working time monitoring begins with a certain delay, which takes into account that before starting work, there is a receipt of tasks from engineering and technical personnel (figure 3).

It is possible that an employee left the construction site for lunch after handing over the tracker and returned before the end of lunch time. Then the system also does not monitor until the end of lunch time, allowing you to rest in a designated place and prepare for the upcoming work.
The use of this monitoring system adds some additional responsibilities for the foremen and foremen of the construction site: Full functioning of the system requires monitoring the situation through the "Digital Worker" application and entering the causes of the anomalies that occur.

Therefore, for the convenience of the engineering and technical personnel, who can quickly monitor the occurrence of problems at the construction site, the system divides the working day into periods of twenty minutes. During these periods, the readings from the sensors are taken every minute. The system operates with average values for five minutes, because the use of average values minimizes the probability of receiving erroneous readings from the tracker sensors. The anomaly is recorded only if the readings from the sensors are outside the normal range in all four five minutes of the fixed twenty-minute period of the working day.

If during a twenty-minute period the system detects three five-minute intervals of the sensor readings outside the norm, but at least one, even the last five-minute interval shows that the readings are normal, then the system records that the employee's readings were normal during the period under consideration.
Such an assumption, on the one hand, avoids unnecessary labor costs for engineers and technicians, who are obliged to check the causes of anomalies, and on the other hand, it reduces the accuracy of identifying problem situations, or, in other words, “anomalies” in the work of personnel.

Figure 4 below shows an example of a system splitting a day. Each hour is divided into periods of 20 minutes. Each period for smaller ones - 5 minutes. The first period of 20 minutes is automatically recorded as normal, unless a delay is detected.

The time from 12 noon to 13:00 in this example is a lunch break, during which the definition of indicators is not carried out.

In accordance with the scheme, the third five-minute interval of the twenty-minute period is being fixed (16: 10-16: 15). In the period from 11:40 to 12:00, none of the five-minute intervals was recorded as normal, therefore, in this twenty-minute period, the system recorded an anomaly in terms of activity, which required the engineer and technical worker to enter the cause of the anomaly.

![Fig. 4. Breaking the working day into periods.](image)

Monitoring is carried out according to two indicators - location and activity. For both indicators, a separate fixation of the anomaly occurs, which makes it possible to track the occurrence of problems according to these two criteria separately, according to the scheme shown in Figure 4.

So, if the employee's activity level determined by the sensors does not correspond to the norm, then the system registers an anomaly for this indicator and in the "Digital worker" application a function opens to enter the cause of the anomaly for this indicator in a particular employee.

If the location of the worker is determined outside the working area, then the anomaly is determined by the indicators of the location sensor, which also requires entering the cause of this anomaly. Fragments of the algorithm for fixing anomalies are shown in figures 5 and 6 [4].
Looking ahead, it should be noted that during the monitoring process, workers are displayed on a map in the Android application "Digital Worker".

An individual's mark on the map is circular and divided into two semicircles. The upper semicircle corresponds to activity indicators, and the lower semicircle corresponds to location indicators (figure 7). If, according to a certain indicator, a deviation from the norm is recorded in the current five-minute interval, then the semicircle corresponding to this indicator turns yellow. For the foreman or foreman, this is some signal that the employee may have some problems, and if you pay attention to this in time and take an operational management decision, then the anomaly will not be recorded - this way the system allows you to get rid of the problem even before it occurs.

If the indicator is within the normal range, the semicircle remains green. But, if according to the indicator, not a single five-minute interval of a twenty-minute period of a working day is recorded as corresponding to the norm, then the corresponding semicircle becomes red, and the engineering and technical personnel need to determine the cause of the anomaly and enter it into the system.
The system operation algorithm associated with the work of engineering and technical personnel is shown below, in figure 8:

![Algorithm Diagram]

**Fig. 7.** Labels of workers on an interactive map.

**Fig. 8.** A fragment of the algorithm work related to the work of an engineer and technical worker.

The process of monitoring indicators from the tracker does not stop until the employee checks in at the end of the working day using the "Info kiosk" (figure 9).

The end of the working day procedure is many times shorter than the authorization at the beginning of the day. In order to record the end of the shift, it is enough to simply swipe the tracker over the RFID-tag readers, in the same way as the intercom key is applied to open the entrance.

The reader instantly identifies the tracker number and unites it from the employee, which is accompanied by a short beep. Hearing a characteristic sound signal, the employee is convinced that the procedure was successful and the tracker is returned to one of two baskets - one is intended for devices in good working order, the other is for devices that have defects visible to the naked eye, such as plastic chips caused by a fall on a hard surface.
Fig. 9. Fragment of the system algorithm associated with fixing the end of the working day.

After the data about the employee for the past working day has been received, the system compares them with the planned indicators (figure 10), which is reflected in the report according to this criterion.

Fig. 10. Fragment of the algorithm of the system for generating a report.

For the head of the organization, a special interface "Architect-Web" is provided, which reflects all the information about the actual situation at the construction site.

Statistical data are formed into easy-to-read and analyze reports, having studied which, the head corrects the work of the enterprise. He makes strategic and tactical management decisions, thereby increasing the efficiency of the enterprise (figure 11).
For example, according to the reports provided by the "Architect-Web" system, the manager found that a significant number of problems recorded at the construction site were associated with the delivery of a low-quality cement-sand mixture: the mixture has high mobility and low workability. For this reason, bricklayers spend more time on masonry work and are outside the working area.

Analyzing this information, the manager can decide to change the supplier (mortar-concrete unit) to another, and after a while pay attention to the statistics on this problem. By adjusting the activities of the organization, the manager can achieve a significant increase in the efficiency of work production.

![Image of the algorithm related to the work of the manual.](image)

**Fig. 11.** Fragment of the algorithm related to the work of the manual.

In addition to direct management of the organization, the "Zodchiy-Web" interface is useful for the HR department, personnel managers, accounting, as well as for the site manager.

Recording the actual working time worked (taking into account violations of discipline, overwork) allows you to determine the most fair wages, paying extra for overwork to especially hardworking employees and deducting money from wages for violation of labor discipline.

A useful factor is that the calculated malicious violators of labor discipline will be under the control of the relevant structures of the organization, which will allow you to have a conversation with the employee on time, helping to eliminate the cause of discipline violations, or say goodbye to him, without unnecessary spending of the wage fund.

**References**


