

Automation of the process transportation temperature-dependent goods

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***Annotation.** The process of transportation temperature-dependent goods need accordance with specific criteria such as temperature and humidity. Non-observance required condition of transportation temperature-dependent, as rule, lead on как правило, приводит to reduce sell-by date dozens of times. It can lead to the situation when the non-conforming goods are delivered to the store. As a rule it happened because of drivers failure or insufficient technical equipment of the refrigeration. Controller refrigeration units, currently on the market, inadequate to monitoring during transportation. According to the statistics 12% of goods transported with the violations of conditions of transportation and the non-conforming goods are delivered to the store.*

Improvement of quality transportation temperature-dependent goods may be based on automation of the process transportation aiming to excluding the human factor. It is needed to create special system which united all technological processes of transportation. Incorporation such system can keep transport company costs' down and cut down the time to service the transports.

***Keywords:** intelligence system, transportation of food, refrigerator, refrigerating-heating appliance, automation of monitoring process.*

Transportation temperature-dependent goods is represented technical process, which need rapid monitoring and automation of the process to improve quality of goods' delivery. To identify the process which needed automation firstly, it is necessary to do functional simulation of transportations process temperature-dependent goods. Functional simulation represents compilation of diagram IDEF0 [1,2].

Picture 1: The context diagram of working shipping service temperature-dependent goods. It consist of:

Input:

- cargo data (weight, size);
- order data (loading point, route, unloading point).

Output data:

- delivery of goods to the customer;
- movement documents.

Control:

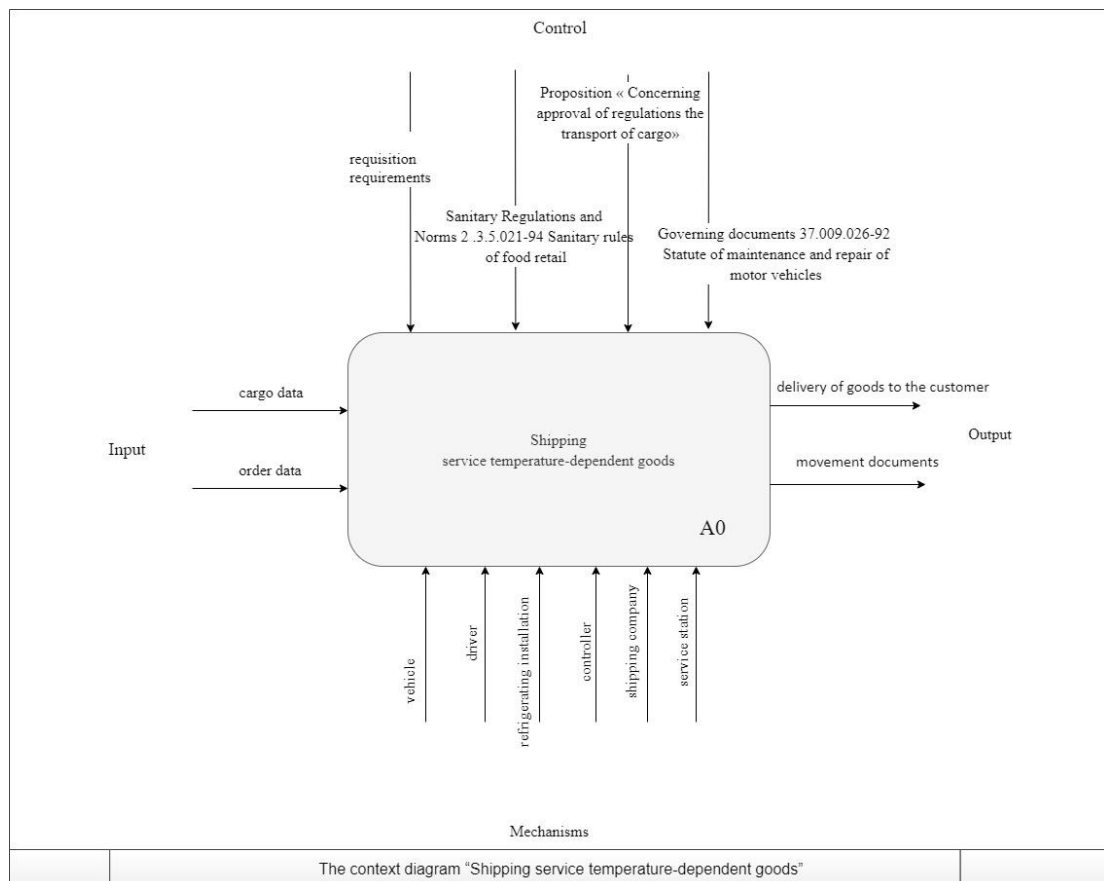
- Sanitary Regulations and Norms 2.3.5.021-94 Sanitary rules of food retail;
- Governing documents 37.009.026-92 Statute of maintenance and repair of motor

vehicles [3];

- Proposition « Concerning approval of regulations the transport of cargo» [4];
- requisition requirements

Mechanisms, the implementation and realization

- driver;
- vehicle;
- refrigerating installation;
- controller;
- shipping company;
- service station.



Pic.1 - The context diagram “Shipping service temperature-dependent goods”.

It consist of:

All of the transportation process divided in 4 main groups:

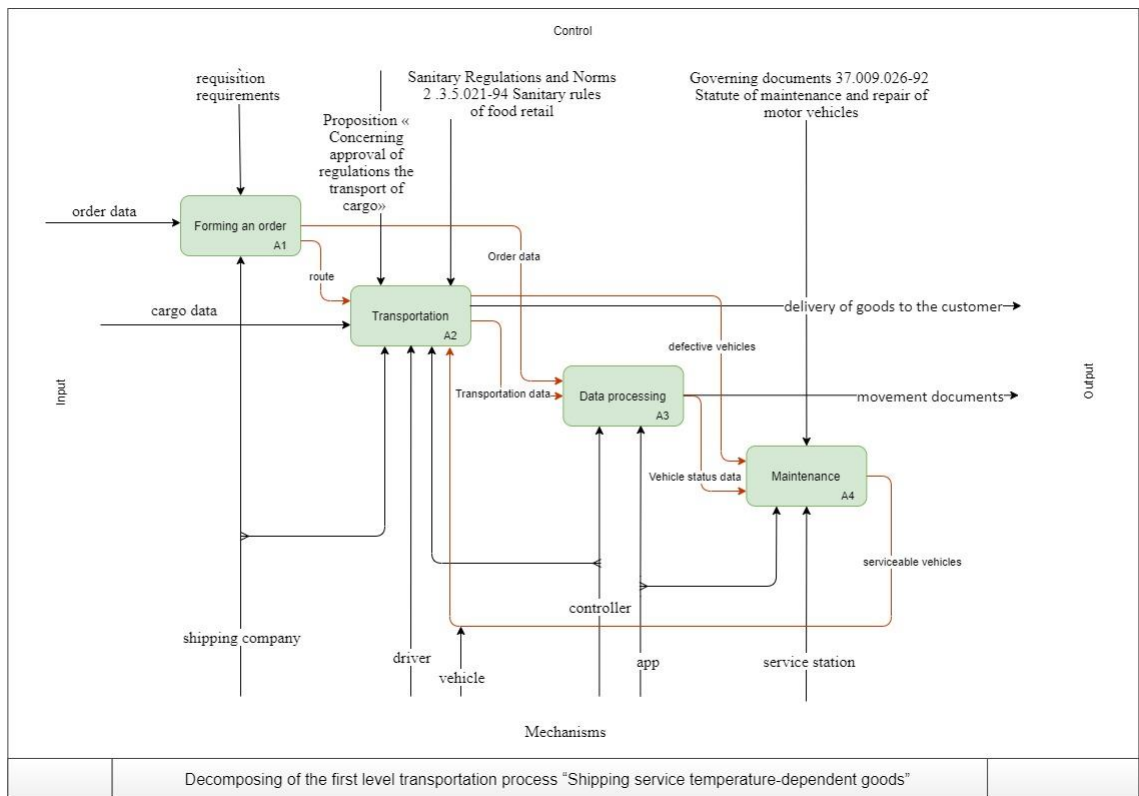
- order formation;
- transportation;
- data processing;
- maintenance at service stations, unplanned repairs or planned maintenance.

The process of order formation starts from interaction between producers and shipping company. The route of transportation is indicated. The received order is entered by the shipping company into the register, a number is assigned to it. By this identifier, any employee of the shipping company can find out what kind of cargo it is, its weight and other technological information, as well as the time of departure, the allocated transport. The transportation data is transferred for further processing and recording in a data log file.

The transportation process begins after the goods are loaded onto the vehicle. During transportation, the operator controls the entire fleet of vehicles, receives technological reports from each vehicle, monitors and makes important decisions on scheduling repairs, maintenance and operation of the vehicle fleet [5]. The operator carries out the processing of data during the trip.

This employee chooses the time of maintenance and scheduled repairs of the vehicle fleet, starting, if necessary, the maintenance process at service stations.

Decomposing of the first level transportation process presented on the Picture 2. It consist of detailing actions of order formation, determining the route of transportation, preparation of shipping documents, transportations, data processing and maintenance.



Pic. 2 – Decomposing of the first level transportation process “Shipping service temperature-dependent goods”.

The based on the structure were identified main system’s functions [6].

1. Main system’s functions, which need automation of the process:
 - tracking of transportation parameters in a refrigerating installation in real time (temperature, humidity);
 - monitoring the operating parameters of the refrigeration and heating device in real time (refrigerant pressure, refrigerant temperature, engine speed, errors).
2. Residual functions which need automation:
 - monitoring tracking the transportation route in real time (time, speed, transit).
 - registration on maintenance.
3. Functions for the future automation:
 - predicting faults;
 - report listing the parameters of transport to the customer.
4. Functions which not practicable to automation:
 - cargo handling;
 - transportation.

The developed system will reduce the human factor in setting up and operating the system. Operational control is carried out using a mobile application, with duplication of information in the AWP of each interested participant in a particular transportation [7]. The

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The system assumes the replacement of the standard controller of the refrigeration and heating device (in the process of revision of the equipment already in operation or at the time of the assembly of the refrigeration and heating device at the manufacturing works) and consists of software and hardware.

Hardware part consist of:

- microprocessor controller STM32;
- modular block GPRS/LTE;
- modular block GPS/ GLONASS;
- permanent memory store temperature recording device ;
- power contour;
- cabin modular block;
- modular block CANx2, K-line, 1-wire, Bluetooth, RS-485, i2c;
- transistor outputs (N-channel, galvanically isolated) 10 pieces (50V, 50A);
- output 5V, 1A;
- SPI invertible low-current inputs (+/-), with stabilization and overvoltage protection;
- transistor outputs (N-channel, galvanically isolated) 16 pieces (50V, 1200mA);
- 4 relay switch NC и NO with stud;
- 10 analog inputs (+ \ -), with overvoltage protection;
- sensors for temperature, pressure, humidity, Hall sensor.

All controller outputs are protected against short circuit, overload and wire breakage. The device has IP67 waterproof connectors. It has vibration resistance, frost resistance, anticorrosion, anti-tamper security. Operating temperature range from -40 to +85 C.

The implementation of interaction with the refrigeration and heating device for the driver is greatly simplified through the development of a mobile application and an intelligent assistant integrated into it. The mobile application will run on iOS and Android operating systems. A web version of the application has been developed for the operator. The JavaScript language will be used to implement the server-side and interactive elements of the client-side [8].

The application requires the following software to function:

- operating system GNU/Linux;

- JavaScript framework– React;
- data base management system – PostgreSQL.

Through the use of such artificial intelligence methods as decision trees, bagging and random forest in the architecture of the system, the system becomes a model of self-learning artificial intelligence. This will allow, without human intervention, to quickly respond to system changes and implement adaptive control.

The introduction of such a system will lead to an increase in the quality of transportation of temperature-dependent products, a decrease in the costs of transport companies, and also reduce the time spent on servicing transport.

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