the works [1,2]. In paper [3] as an example, a model of production planning is constructed, in which the foreign market value of resources coincides with internal objectively determined resource estimates. In paper [4] penalty function for the implementation of the plan compensation y is presented in the form

$$\psi(\omega, x, y) = y(g(\omega, x) - b(\omega)).$$

The difficulties associated with analysis of two-stage problems in general is determined by the need to choose the best of the preliminary plan of the original problem x, which would guarantee the existence of residual compensation for all implementations of parameters of uncertainty ω. Construction of complementarity (4), (5) for the second stage in a new production of non-linear two-stage problem of stochastic programming problems (6), (4), (5), (3), which is presented in paper, is ensures the solvability of the problem for the positive semidefinite matrix $B = B(\omega)$, if positive definition of matrix $B = B(\omega)$ than it is a unique solution $y = y(\omega, x)$ in all implementations of ω and x.

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Models and Approaches for Planning the ISS Cosmonaut Training

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Among all the problems that arise in cosmonautics, particular attention is dedicated to the planning problems. For scheduling the operations during the flight and for the trainings before, it is necessary to maximize the efficiency.

As it is formulated in Cosmonaut Training Center [1] the subject of activity of the cosmonaut is onboard system or complex (e. g. systems of manned spacecraft, scientific experiments, flight operations). In general, three crew qualification levels for each onboard system are defined; a *user* level, an *operator* level and a *specialist* level. For a given flight program, a set of minimum qualifications for each onboard system is given (e.g. one specialist, one operator and one user).

Each crew member, while being a specialist for some systems, will be an operator or only a user for other systems. Consequently, the training program for each crew member is individually tailored to his or her set of tasks and pre-defined qualification levels.

Whole planning of the ISS cosmonaut training can be logically divided into two stages: the problem of volume planing and the calendar planing.

Volume planing.

The data for the volume planing problem is a set of onboard complexes and the required number of cosmonauts of different qualifications of each onboard complex. The objective is to distribute the training in qualifications of onboard complexes between cosmonauts so that the total time of training was minimal. It can be formulated in different ways [2]:

$$(\max_k \tau_k - \min_k \tau_k) \to \min, \quad k \in \mathcal{K}, \tag{1}$$

$$\max_k \tau_k \to \min, \quad k \in \mathcal{K}, \tag{2}$$

$$\min_k \tau_k \to \max, \quad k \in \mathcal{K}. \tag{3}$$

where $\mathcal{K}$ – set of cosmonauts, τ_k – total time of training of cosmonaut k.

For this problem, two algorithms are presented. The first one is a heuristic which iteratively by onboard systems choose such qualification to train that provide optimal objective value. The second one consists of a heuristic and exact parts, and is based on the n-partition problem approach.

Calendar planning.

The next important step of the planing is a calendar scheduling. Once solved the volume problem for each cosmonaut defined set of tasks which they should do. The objective of calendar planing is not defined but now we use the next: minimizing time of preparation of the first crew to start. Planing should comply with resource constraints and deadlines of the preparation of other crews. The problem is formulated as resource constrained project scheduling problem (RCPSP) and integer programming problem.

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Two-station single track railway with a siding scheduling problem

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A railway connection of two stations by a single railway track is usually found on branch lines of railway network and is very common in various manufacturing supply chains. One of the earliest research of single track scheduling problem is the publication of Szpigel [5]. Since this work scheduling problems, where trains are using a single railway track, remained the subject of intensive research. In 2011 Lusby et al. [2] published an article with a survey of publications on railway scheduling methods and models with a section on single track scheduling problems. A literature review on the single track railway scheduling problem can be found in the Ph.D. thesis of Oliveira [3] which is concerned with application of constraint programming method. Sotskov and Gholami [4] considered single track scheduling problem with several stations and proposed heuristic algorithm. The reduction of the two-station single track railway scheduling problem to the single machine scheduling problem with setup-times can be found in recent work of Gafarov et al. [1].

Our paper is concerned with a scheduling problem for two stations with a single railway track with one siding. On single-track railway sidings or passing loops are used to increase the capacity of the line. The problem involves two stations which will be referred to as station A and station B. All trains are split into two sets. The trains, constituting set N_1, need to travel from station A to station B. The trains, constituting set N_2, need to travel from station B to station A. All trains are available at the beginning of the planning horizon and have an equal constant speed. The single track, connecting station A and station B, has a siding – a short track at the side of the main railway line that allows two trains to pass each other when they are moving in opposite directions. Since the length of the siding is relatively small, it is assumed that trains pass the siding instantly.

In the schedule it is necessary to specify for each train its departure time.