SOFTWARE DESCRIPTION

"Intelligent system of dispatching of railway transport"

"05" November 05, 2019

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GENERAL INFORMATION

Program Name: Intelligent Dispatching System (ISD/ISD)

Programming languages: Visual Basic for Applications, SQL, Delphi

Software necessary for the program to function:

- Microsoft Excel version 2013 and older
- Windows operating system version XP and older

FUNCTIONAL PURPOSE

The program is designed to calculate and provide hints to the train dispatcher of Stoilensky GOK for optimal distribution of trains between different sections (version 1.0 includes recommendations on the distribution of trains between the Quartzite Track and the Rock Track).

LOGICAL FRAMEWORK DESCRIPTION

Algorithm for predicting train movements and forming recommendations

The step-by-step algorithm for predicting train movements and generating recommendations is described below

1. Real-time data is received from the CDC on section occupancy/unoccupancy and cargo types for each locomotive and based on this data is determined:
   a. the current location of each TA
   b. current cargo type for each TA
2. In real time data from CDC on current loadings are received and the following parameters are determined for each loading section at Kvartsitnaya station:
   a. Current employment (employed/free)
   b. The type of cargo that is currently loaded in this section
   c. Number of excavator working in this section
   d. Loading start time (if the section is being loaded)
3. On the basis of loading data, the total number and model of dump trucks in each train (excluding motor-driven ones), the number of loaded dump trucks is also determined

4. Based on the data received from CDC, the expected release time for occupied loading sections at Kvartsitnaya station is calculated:

   Expected release time
   = start time of loading
   + expected loading time

   Expected duration of loading
   = standard loading time
   + time for entry and exit and compulsory work after loading
   + allowance for exceedances

   - Normative loading duration is calculated depending on the type and number of dump trucks, type of cargo, excavator model and time of year (loading duration in winter is higher than in summer). Norms are taken from CDK (for use in the program, the norms are uploaded to the "LoadTime" page of the CDK.xlsx file).
   - The entry/exit time is calculated depending on the deadlock. The norms are taken from the CDC (for use in the program, the entry/exit norms are uploaded to the "Correction on loading" page of the main workbook).
   - The overload allowance is calculated, depending on the excavator model (based on historical statistics). The current calculated values can be found on the "Loading Correction" page of the main workbook, starting from line 16.

5. For trains that are currently on the unloading tracks at the ACD, the expected unloading end time is calculated.

   Expected end time of unloading
   = current time + expected duration of discharge

   Expected duration of unloading
   = number of loaded dump trucks x 2 minutes
   + 5 minutes (for entry/exit from the track)

6. For empty trains on Kvartsitnaya run and Skalnaya run, which are either in motion or unloading at KKD, the expected time of arrival at the deadhead for loading at Kvartsitnaya station is calculated:

   a. For empty trains in motion:

   Expected time of arrival at the loading section at Kvartsitnaya station
   = Current time + expected travel time to Kvartsitnaya station

The expected travel time to Kvartsitnaya station is calculated depending on which section the train is on. For each section the average time of its passage is determined on the basis of statistics:

Section transit time
= time of approach to a section - time of approach to the next section along the course of travel

and calculated travel time to Kvartsitnaya station from the moment of entering this section. Travel time is calculated depending on the order of passing sections when moving to Kvartsitnaya station. When calculating the expected travel time, the time elapsed from the moment the train enters the current section is taken into account:

Expected travel time to Kvartsitnaya St.
= Estimated travel time for the current train location section -
Min(time elapsed since entering this section, the norm for passing this section)

b. For trains on unloading, the time of arrival at Kvartsitnaya station is calculated by the following formula:

Expected time of arrival at the loading section at Kvartsitnaya station
= Expected unloading end time
+ expected travel time to St. Kvartsitnaya from the current section

7. After calculating the time of arrival at Kvartsitnaya station, the potential idle time waiting for the face for each train is calculated.

Downtime waiting for slaughter
= Expected deadlock clearance time for this train - expected time of arrival at the loading section at Kvartsitnaya St.

To calculate the expected deadlock clearance time, trains are distributed by loading sections. The distribution starts with the train arriving at Kvartsitnaya station first (or already there waiting for a free deadlock). For this train a loading section is selected, where loading is most likely to be performed, according to the following criteria:

- Correspondence of the type of cargo in the loading section to the track on which the train is located (for the Quartzite track only sections in which quartzite is loaded, for the Rock track - sections in which rock, shale and quartzite are loaded).
- Section activity (sections closed for any reason do not participate in the distribution)
- Allocation starts among the sections that are currently vacant or among those sections that will be vacant by the time the train arrives. Among the sections satisfying this criterion, the one in which

the most productive excavator is located. The train is virtually assigned to this section for unloading.

- If there are no free sections and none of the sections will be free by the time the train arrives, the section that will be free first will be selected and virtually assigned to the train for unloading.

After selecting a section for the first arriving train, the allocation is repeated for the following train. The calculation of the section release time already takes into account that one of the sections has been allocated to an earlier train. The algorithm is repeated until a loading section has been allocated for each of the empty trains and trains being unloaded at the ACD.

8. For all trains on the Kvartsitnaya run, the expected time of arrival at the KDC for unloading is calculated. Similarly to the calculation for arrival at Kvartsitnaya station, the average transit time of each section and the sequence of sections en route to KCD are used, on the basis of which the estimated travel time to KCD is calculated for each section

   a. For trains in motion loaded with quartzite:

   Expected time of arrival at the ACD
   = Current time + expected travel time to the ACD

   Expected travel time = Estimated travel time to ACD for the current train location section -
   Min(time elapsed since entering this section, the norm for passing this section)

   b. For trains under loading:

   Expected time of arrival at KKD = Expected time of loading completion + expected travel time to the ACD from the current loading section

   c. For trains traveling empty:

   Expected time of arrival at KKD = Expected time of arrival at Kvartsitnaya station + Expected downtime waiting for slaughter + Expected loading time + Expected travel time to KKD from planned loading section

   d. For trains being unloaded:

   Expected time of arrival at KKD = Expected time of unloading completion + Expected travel time to Kvartsitnaya station + Expected downtime waiting for slaughtering + Expected loading time + Expected travel time to KKD from planned loading section

9. Calculation of downtime waiting for unloading at the QCD for all trains on the Quartzite run. Downtime waiting for unloading at the QCD ("No ore reception

KCD") are formed taking into account the forecast of ore unloading at KCD, which is provided by the concentrator dispatcher:

$$\text{Idle time waiting for unloading (in minutes)} = \frac{\text{Unloaded ore volume by the time of arrival of the current train (t)}}{\text{Forecast for average KKD ore consumption (t/min)}}$$

$$\text{Forecast for average KKD ore consumption (t/min)} = \frac{\text{Total forecast of ore intake from the current moment to the time of train arrival at KKD, t}}{\text{Time interval from the current moment to the time of train arrival at the ACD, min}}$$

Unloaded ore volume by the time of arrival of the current train (t) =
= Total ore volume to be discharged before the arrival of the current train (t)- Ore discharge forecast at KKD before the arrival of the current train (t)

Total volume of ore to be unloaded until the current train arrives (t)
= Unloaded ore volume in trains on the KKD unloading tracks (t)
+ volume of ore in trains with estimated time of arrival at KKD earlier than the current one (t)

The unshipped ore volume at KKD is calculated using the following formula:

Unloaded ore volume
= Unloaded volume in the previous minute
+ volume of ore in trains that arrived for unloading in the previous minute
- discharged volume for the previous minute

Discharged volume for the previous minute = predicted discharge rate * discharge rate factor

The forecast unloading rate is calculated based on the unloading forecast from the OF dispatcher.

Discharge rate factor:

- 1.0: if the maximum ore volume in all trains being unloaded is (minus) the unloaded ore volume at the previous minute
  < 1000 tons
- 0.25: if the maximum ore volume in all trains being unloaded is (minus) the unloaded ore volume at the previous minute
  < 1,250 tons.
- 0: if the maximum ore volume in all trains being unloaded is (minus) the unloaded ore volume at the previous minute
  > 1250 tons

The maximum volume of ore in all trains being unloaded is calculated as the initial sum of the ore volumes in all trains being unloaded at the KKD.

Expected duration of unloading
= number of loaded dump trucks x 2 minutes
+ 5 minutes (for entry/exit from the track)

If the calculated value is negative, the unshipped volume is equated to zero.

10. Construction of a graph of the ore supply of the KKD. A minute-by-minute table is built for 130 minutes ahead, which displays:

- Initial ore level at KKD equal to unloaded ore volume in trains on the KKD unloading tracks (for the calculation formula see p.9).
- The volume of ore arriving at the BOF. Calculated as the volume of ore in the trains arriving at a given minute.
- Ore consumption by the mill. Calculated based on the ore intake forecast provided by the concentrator dispatcher.
- Balance - amount of ore ready for unloading to the KKD ("on wheels")

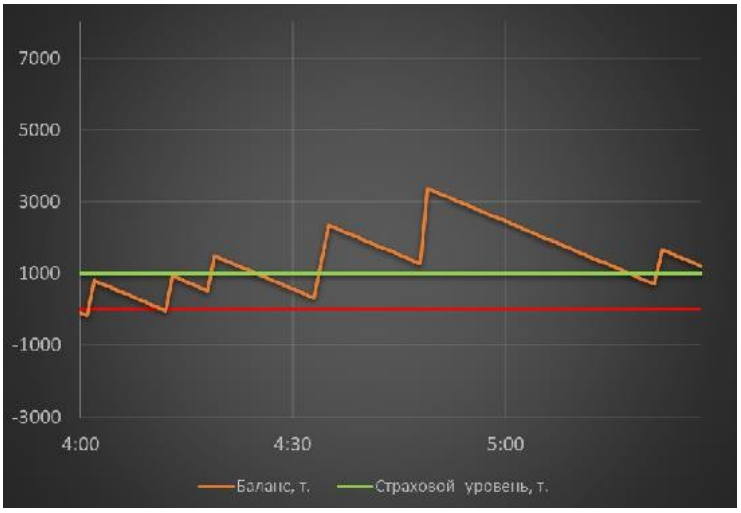
  Balance = Balance of previous minute + volume of incoming ore
  - factory consumption

  The balance for the first minute is equal to the initial ore level on the KKD
- The insurance level is the minimum level of ore ready for discharge that should be maintained when calculating the recommendation.

  The insurance level is calculated depending on the current ore level in the bunkers, or entered manually by the train dispatcher in the appropriate field. The current version of the model uses the following calculation:

Ore level in bunkers	**Insurance level**
0-16,000 tons	250 tons
16,000-24,000 tons	100 tons
>24,000 tons	0 tons

Based on the table, a graph is constructed to visualize the Ore Balance at KKD and the insurance level:



Horizontal axis - time, vertical axis - tons of ore at KKD

11. Development of Recommendation. The recommendation is developed for empty trains on the Kvartsitnaya and Skalnaya way, which are in the interval of 10-20 minutes before arrival to the loading section at Kvartsitnaya station
    a. For trains on Quartzsite Progress:
        1) All empty trains on the Kvartsitnaya run are selected with planned time of arrival at the loading section at Kvartsitnaya station in the range of 10-20 minutes
        2) Among the selected trains, the one for which the time of arrival to the loading section at Kvartsitnaya station is the shortest is determined
        3) For this train the possibility to carry rock is checked (item 1 in Diagram 1). In the current version of the algorithm, the condition of impossibility to transport rock by trains with 115t dump trucks is set. If it is impossible to transport rock for this train, it is recommended to continue working on the Quartzite run. If it is possible to transport rock, we proceed to the next point
        4) The current total expected downtime is calculated = total expected downtime of all turntables on the rock course waiting for the bottom hole + downtime of the analyzed train waiting for the bottom hole and KKD. Next, the total expected downtime is calculated when the analyzed train is moved to the rock run. The difference between the two values is the potential effect on the reduction of downtime when moving the analyzed train to the rocky passage. If this effect is less than 10 minutes, it is recommended to continue on the Quartzite Run (point 2 on Diagram 1). If the effect is more than 10 minutes, we move on to the next point.
        5) Calculates what will be the total "losses" of ACD when the current train is redirected to the Rocky Way (item 3 in Diagram 1) (see below for the methodology of calculation of ACD "losses"). In case the total losses when redirecting the current train to the Rocky Way are not as follows

increase, then a recommendation to redirect to the Rocky passage is formed for this train. Otherwise, proceed to the next point

6) It is calculated what will be the total "losses" of ACD when the current train is redirected to Skalnaya run and at the same time the next empty train is redirected from Skalnaya run to Kvartsitnaya run (item 4 on Diagram 1) ("next" train is the train with the earliest planned time of arrival to the loading section at Kvartsitnaya station, but not earlier than the time of arrival to the loading section at Kvartsitnaya station of the train for which the recommendation is formed). In case the total "losses" of KCD at these permutations are not higher than the initial ones, the current train is recommended to be redirected to Skala (with the expectation that the next empty train from Skala will be diverted to quartzite and "losses" of QCD will not increase). Otherwise, a recommendation is formed to continue working on the Quartzite stroke
7) If a recommendation to continue operation at Kvartsitnaya run is generated for the current train, the algorithm is repeated for the next train arriving at Kvartsitnaya station in the range of 10-20 minutes. Otherwise, no recommendation is generated for the remaining trains

ACD losses

The QCD "losses" indicator is used to assess the risks of QCD downtime without ore. Calculation of KKD "losses" depends on the insurance level set, as well as the current number of trains at the Quartzite operation compared to the optimum. Projected drops in the ore balance at the QCD below the insurance level (see clause 10 of this document) are the potential risk of a QCD downtime without ore in the event that train movements fall behind the design schedule and/or ore consumption at the QCD exceeds the forecast.

Insurance level adjustment

To calculate the recommendation, the insurance level is adjusted based on the current number of trains on the quartzite run compared to the optimum number of trains for the current forecast ore consumption at the QCD.

The calculation of ACD losses is done using the following formula:

KKD losses , t.
= Insurance level, t - Projected ore balance at KKD, t.

If the calculation of losses using this formula is negative (meaning that the ore balance is above the insurance level), they are equated to zero.

Total AAC losses are calculated as the sum of losses for all minutes over the forecast horizon (130 minutes)

- Insurance level = initial insurance level - adjustment for insurance level
- Correction for insurance level = (Number of excess trains on quartzite + 1) * 1000 tons
- Number of extra trains on quartzite = Current number of trains on quartzite run - optimal number of trains at the current forecast
- Optimal number of trains = Forecast for the next 130 minutes in tons / expected capacity of one train per 130 minutes (420 tons per hour / 60 minutes * 130 minutes = 910 tons).

Figure 1: Decision-making logic for trains on the Quartzsite course

b. For trains on the Rocky Passage:

1) All empty trains on the Rocky Way are selected with the planned time of arrival to the loading section at Kvartsitnaya station in the range of 10-20 minutes.

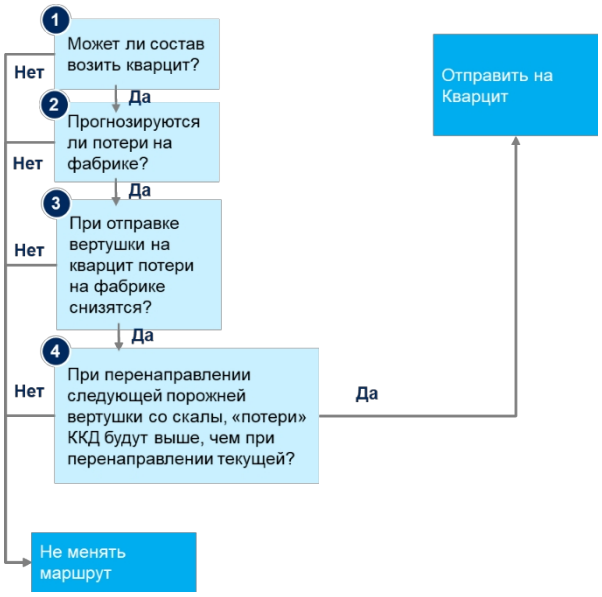
2) Among the selected trains the one for which the time of arrival to the loading section at Kvartsitnaya station is the shortest is determined.

3) It is checked whether there are any losses on the KKD at the current location of the vertices. If there are no losses, it is recommended to continue along the Rocky Way. (point 2 on Diagram 2). Otherwise, proceed to the next point.

4) It is calculated whether the "losses" at the QCD will be reduced if the selected train is redirected to the Quartzite Track (item 3 in Diagram 2). If redirecting this train to the Quartzite Track will not reduce losses, then a recommendation to continue working on the Rock Track is formed for this train. Otherwise, we proceed to the next point.

5) Potential "losses" on QCD are calculated when redirecting not the current train to the Quartzite operation, but the next empty train on the Rocky operation (item 4 on Diagram 2). If the effect (reduction of ACD "losses") when redirecting the next train is similar to the effect when redirecting the current train, then a recommendation is formed for the current train to continue operation on the Rocky way (with the expectation that the next empty train on the Rocky way will be transferred to the Quartzite way). Otherwise, the current train is recommended to be redirected to the Quartzite run.

Diagram 2: Decision-making logic for trains on the Rocky Mountain Course



Elements of the CDK

program.xlsx

A file containing connections to the Microsoft SQL database of the Supervisor IS system, through which online data are retrieved from the CDC system. For more details, see "Interaction with other programs and systems" item

LOG.xlsx

A workbook used to record recommendations issued by the program and to record user actions. The workbook has 2 tabs:

- "Recommendation" - when updating the calculations, this tab is used to record all recommendations that were formed at the moment of updating and details of the movement forecast for the train for which the recommendation was formed
- "Actions" - this tab is used to record user actions, when manual movement of trains between panels on the user form takes place. In addition to specifying the number of the train and the panels between which the move occurred, the recommendation that was in effect at the time of the move for this train is also specified

ISD vX.XX.xlsm.

A workbook that contains the VBA code of the software.

- The "Main" tab. This tab contains the "Start ISD" button, which is used to start the *result* subprocedure from the *Main* module, which is the starting subprocedure of the program.

- ETO Paths tab. This tab lists the IDs of the sections that are standard for ETO. This list is used to issue a warning if the train is on one of these tracks and has no downtime due to maintenance/equipping.

- Downtime Reasons tab. This tab lists combinations of idle ID (IDLETYPEID) and cargo ID (LOADTYPEID). Downtimes that satisfy these combinations are included in the downtime statistics for the current shift on the main page of the program interface

- Tab "Stat Kvartsitnaya". This tab contains statistics on travel time to Kvartsitnaya station, used to calculate the arrival time of trains to Kvartsitnaya station.

    - Column "A" - station where the section is located (not used in the program)
    - Column "B" - section for which the traffic norm is calculated. In the lower part of the file sections are replaced by station names. If for any section no traffic standard to Kvartsitnaya is found, the standard for the station specified in this part of the file is used.
    - Column "C" is the section that is next in line of travel
    - Column "D" - norm for the time of passing the current section
    - Columns "E-N" - standard on travel time to the corresponding dead-end at Kvartsitnaya station from the moment of entering the current section

- The "ACD Stat" tab. This tab contains statistics on the travel time to the QDC, used to calculate the arrival time of trains at the QDC. Columns "A-E" are similar to the "Stat Quartzite" tab

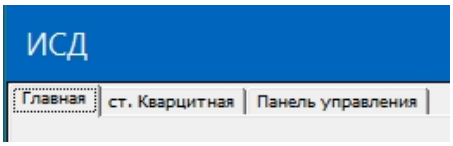
- Tab "TA". This tab contains numbers and IDs of locomotives that are accounted for in the program. Locomotives that are not on this tab are not taken into account. If a new locomotive appears, it must be added to the list on this tab.

- The "Correction on loading" tab. On this tab, for each loading section the norms for entry/exit from the loading section and additional actions before/after loading are indicated. In addition, the allowance for exceeding the standard loading duration, depending on the excavator model (starting from line 16).
- KKD forecast" tab. This tab is used to calculate the KKD ore supply forecast, generate a graph and calculate potential losses to form recommendations.

Interface

The ISD interface is implemented using standard user forms
Excel VBA and consists of three main pages: "Home", "st. Kvartsitnaya" and
"Control Panel" and the "Recommendation" page called from the page
"Home". Switch between the main pages by clicking on the corresponding tab at the top of the screen (Figure 1).

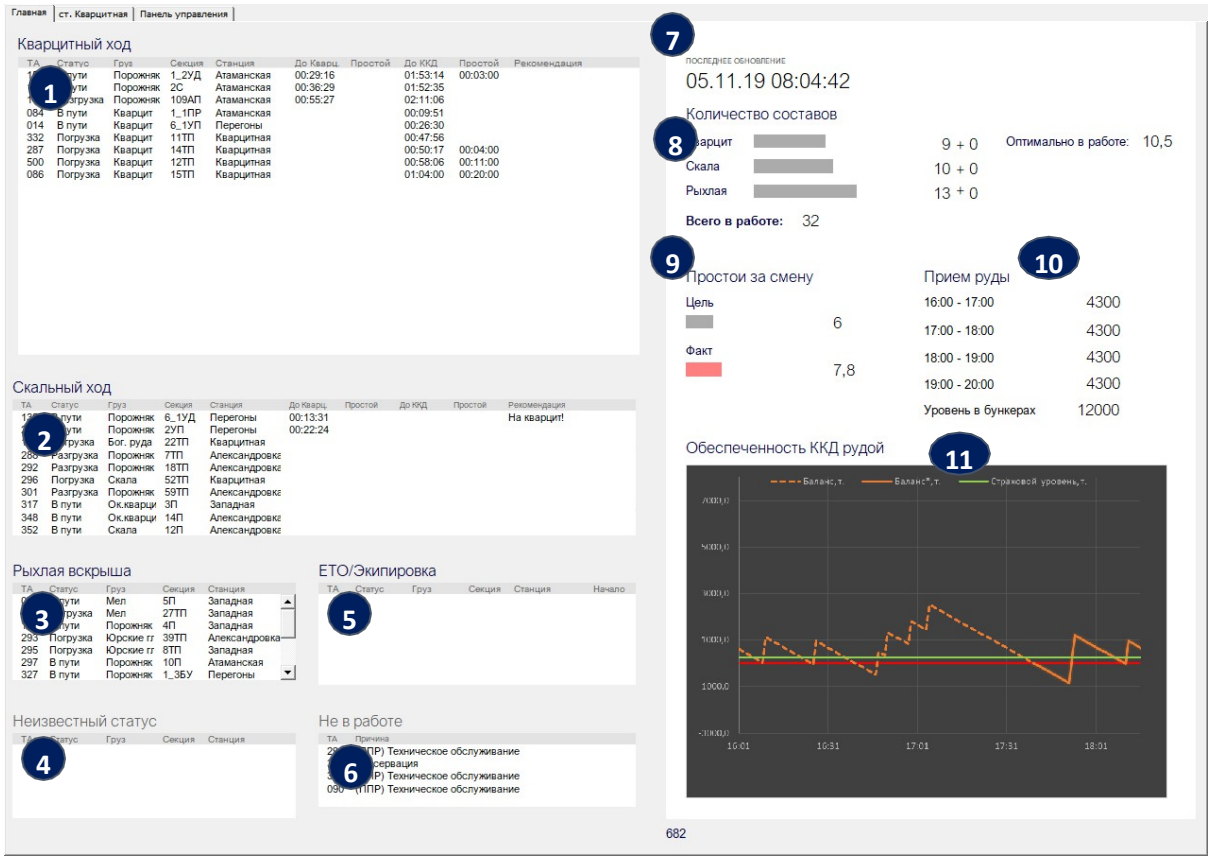
Figure 1



Home" page

This page displays the basic information required by the train dispatcher and a recommendation on the optimal distribution of trains between quartzite and overburden. Figure 2 shows the general view of the user interface of the "Home" page.

Figure 2.



The interface consists of the following elements:

1. A panel showing the locomotives on the Quartzsite run. This panel shows:
   a. "TA" is the number of the traction unit,
   b. "Status" - loading/unloading/in transit
   c. "Cargo" - type of cargo
   d. "Section" is the last section occupied by the composition
   e. "Station" means the station at which the train is located

f. "To Kvrts." - estimated time after which the train will arrive at the unloading dead end at Kvrtsitnaya st. (for empty and unloading trains)

g. "Idle" - estimated idle time at Kvartsitnaya st. waiting for the loading deadlock (for empty and unloaded trains)

h. "To KKD" - estimated time after which the train will arrive for unloading at KKD

i. "Idle" - estimated idle time while waiting for unloading at KKD

j. Recommendation - the route recommended by the program for this train: "OK" - leave on the Quartzite passage, "To the rock!" - transfer to the rocky passage

2. Panel displaying locomotives on the Rocky passage
(The Rock Course includes combined rock overburden, shale and oxidized quartzite):

a. TA" - number of traction unit

b. "Status" - loading/unloading/in transit

c. "Cargo" - type of cargo

d. "Section" is the last section occupied by the composition

e. "Station" means the station at which the train is located

f. "To Kvrts." - estimated time after which the train will arrive at the unloading dead end at Kvrtsitnaya st. (for empty and unloading trains)

g. "Idle" - estimated idle time at Kvartsitnaya st. waiting for the loading deadlock (for empty and unloaded trains)

h. "Pre-ACD" - not used

i. "Simple" - not used

j. Recommendation - the route recommended by the program for this train: "OK" - leave it on the rocky passage, "To quartzite!" - transfer to the rocky passage

3. The panel showing the locomotives that are in the areas of loose overburden, rich ore and other types of cargo. The columns on this panel are identical to the first 5 columns of the Quartzite and Rocky passages panels

4. Panel showing locomotives for which no status or group is defined. Columns are identical to the first 5 columns of the Quartzite and Rocky moves panels

5. Panel showing trains under outfitting or daily maintenance. Columns 1-5 are identical to columns 1-5 of the Quartzite and Rocky passages. Column 6 ("Start") shows the start time of outfitting or daily maintenance inspection

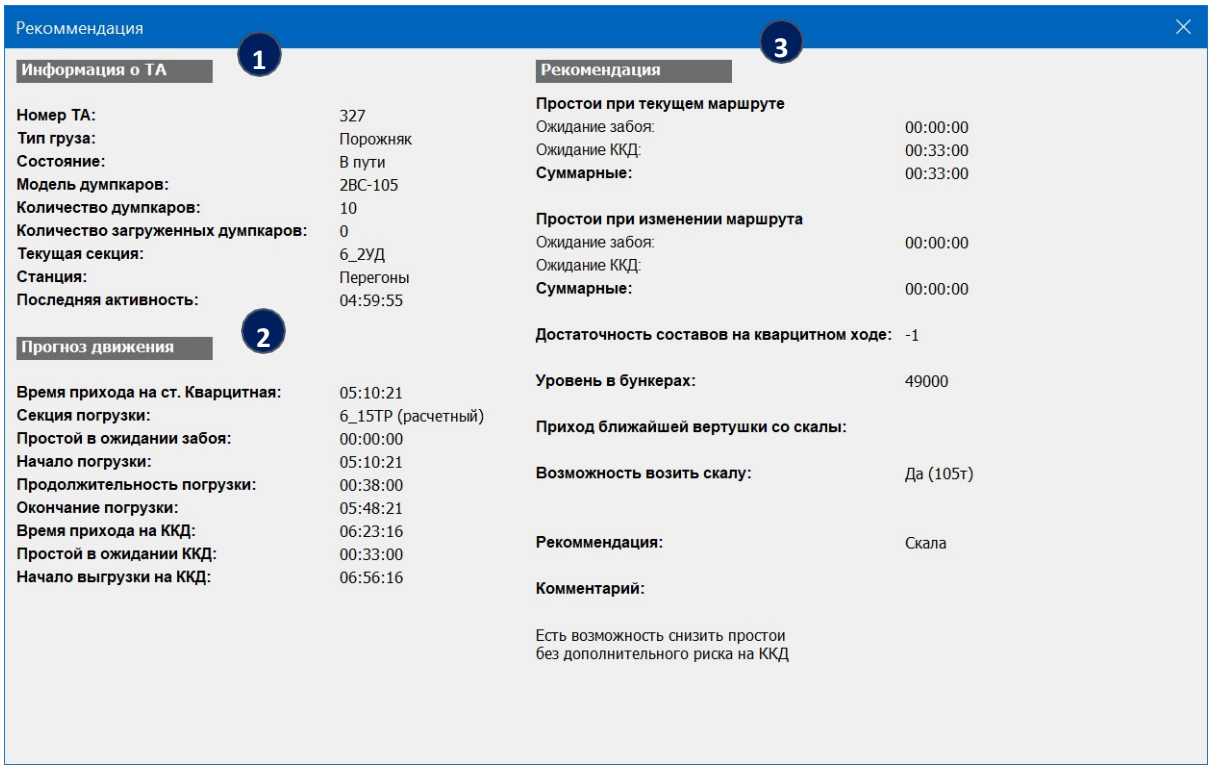
6. A panel displaying compositions that are not in operation:
    a. "TA" - number of traction unit
    b. "Reason" is the reason why the compound is out of service
7. The date and time of the last data update.
8. A section that shows the current number of trains on the quartzite, rock and friable runs, as well as the optimum number of trains on the quartzite run.
9. Section, which specifies total downtime due to the absence of a face at Kvartsitnaya station (by cargo type quartzite, rock, shale and ok.quartzite) and due to non-receipt of ore at KKD from the beginning of the current shift in hours. The target amount of downtime for these reasons per shift in hours is also specified
10. Section showing hourly forecast ore intake at KKD (in tons) and total ore level in parabolic hoppers (in tons)
11. A graph showing ore arrival and consumption at the KKD, depending on the time of arrival of trains and forecast ore consumption:
    a. The horizontal axis of the graph is time
    b. Vertical axis - ore volume

"Balance, t." - line showing the volume of ore (in tons) that is at the BOF and ready for unloading. The balance includes trains that are already on the unloading tracks, as well as those trains that will be standing in front of the entrance to the KKD, ready for unloading. At the time of the planned arrival of a train at KKD, the balance is increased by the volume of ore in this train. Further, the balance gradually decreases as the planned ore consumption by the concentrator.

"Insurance level, t" is a line representing the current insurance level. The insurance level is the minimum level of ore in tons that the algorithm calculating the recommendations for redirecting trains tends to keep ready for unloading at the KKD.

For more information about each locomotive and a comment on the recommendation, double-click on the line with the locomotive, depending on its location in Panels 1-6. After clicking, a panel with detailed information will appear (Figure 3).

Figure 3



This panel consists of 3 sections

1. Information about the traction unit. Detailed information about the current traction unit is provided
2. Movement Forecast. A detailed forecast of the movement of this train for the current run is presented
3. Recommendation:
   a. "Downtime on current route" - prediction of what kind of downtime this train will have if the current route is maintained (Rocky move or Quartzsite move).
   b. "Downtime in case of route change" - forecast of what downtime this train will experience in case the route is changed (for trains on Quartzsite run - in case of redirection to Rocky run, for trains on Rocky run - in case of redirection to Quartzsite run).
   c. "Level in bunkers" - current total ore level in parabolic bunkers (in tons)
   d. "Arrival of the nearest empty train from the Rocky way" - for trains on the Kvartsitnaya way this line indicates how long before the nearest empty train from the Rocky way arrives at Kvartsitnaya station. Only those trains, which will arrive at Kvartsitnaya station later than the current one, are taken into account
   e. "Ability to carry rock" - indicates whether this train can carry rock (depending on the type of dump trucks)

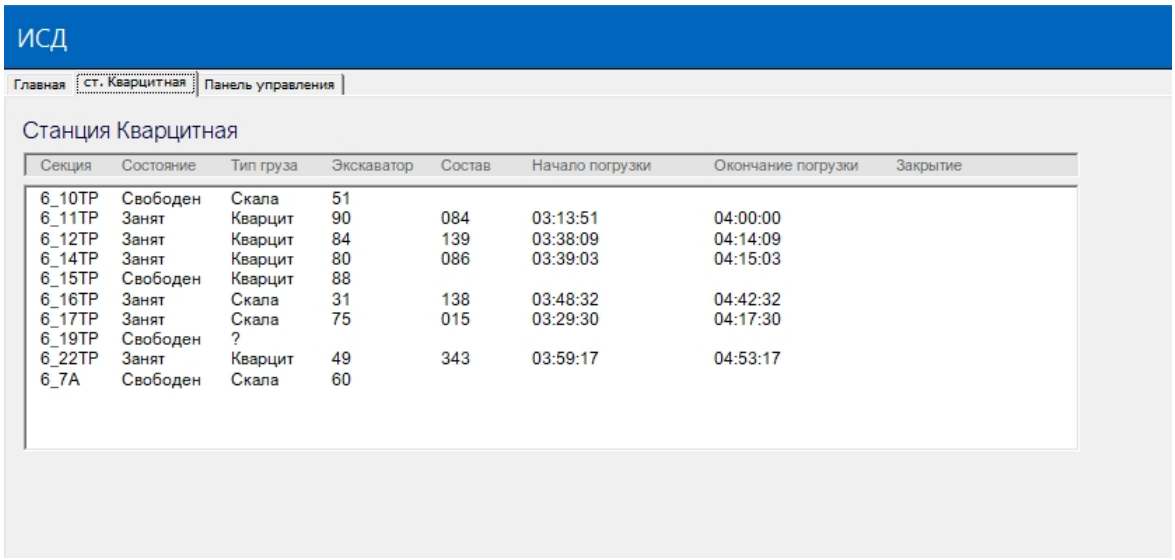
f. "Recommendation" - recommendation on the choice of route for this train

g. "Comment" - a comment in text form on the reasons for granting this recommendation

Kvartsitnaya st.

This tab displays the status of deadlocks at Kvartsitnaya station and provides manual control of cargo type, excavator number and deadlock occupancy, if necessary. The page interface is shown in Figure 4.

Figure 4.



The interface consists of a panel presenting the loading sections at Kvartsitnaya station:

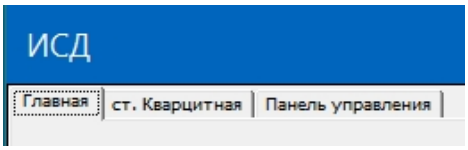
1. "Section" - boot section identifier
2. "State" - current state of the loading section (occupied/free)
3. "Cargo type" - type of cargo to be loaded in this section
4. "Excavator" is the number of the excavator that is loading in this section.
5. "Composition" - number of TA located in this section (if it is occupied)
6. "Start of loading" - time when loading was started in this section (if it is occupied)
7. "End of loading" - predicted time of end of loading in this section (if it is occupied)
8. "Closed" - an indication that the section is out of service

Control panel

This tab manually controls the forecast of ore intake at the AAC, the ore level in the parabolic hoppers, and the insurance level setting at the AAC, as well as setting the turntables that can/cannot haul quartzite

You can switch between tabs by clicking on the tab name heading at the top of the screen (Figure 1).

Figure 5



INTERACTION WITH OTHER PROGRAMS AND SYSTEMS

Obtaining data from the CDC

The ISD requires real-time data retrieval from the CDC IS system. Data retrieval is performed through queries to the Microsoft SQL database, which is part of the Head IS system, which are then translated into the Oracle DB database, which is part of the CDK IS system. The queries are performed through the Excel file "CDK.xlsx" using the created ODBC data source.

The CDK.xlsx file consists of the following tabs, each of which is a connection to the corresponding Microsoft SQL database element:

- "SecMove" - data on section occupation/unoccupation and current cargo type
- "LoadingDumpcars" - data on loading operations
- "LoadSection" - data on which sections are loading sections and on the excavators in these sections
- "UnloadSection" - data on which sections are unloaded (not used in version 1.0)
- "ShovPlanState" - data on planned loading volumes by excavators (not used in version 1.0)
- "TrainDumpcars" - data on the number and type of dumpcars in trains
- "LocoIdles" - data on idle trains
- "ShovLocation" - data on cargo types and distribution of excavators by deadlocks
- "Bunkers" - data on current ore level in parabolic bunkers
- "OreReception" - data on projected unloading volumes at KKD

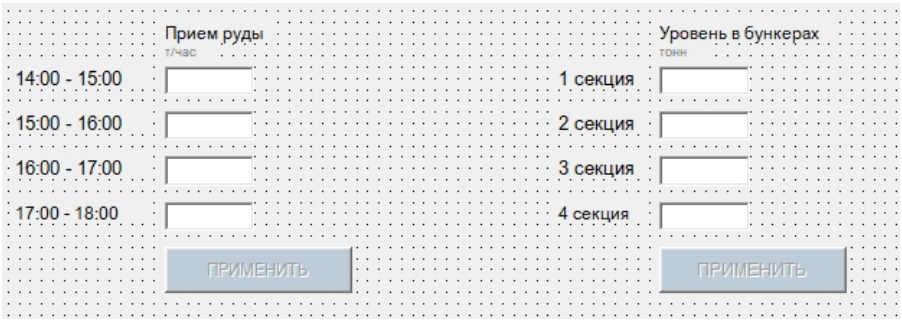
- "LoadTime" - loading norms (static tab, has no ODBC connection and is not updated)

Periodic updating of data on the tabs is performed by calling VBA function Workbooks.Refresh in the book "CDK.xlsx".

Utility to enter forecast ore intake and hopper levels

The correct operation of the ISD requires a forecast of ore intake at the BOF and data on the current ore level in the parabolic hoppers. These data are entered by the concentrator dispatcher through the utility. The utility has a one-screen interface (Figure 6).

Figure 6: Utility interface for enrichment plant data entry



On the left side of the screen there are text fields for entering the forecast of ore intake for the next 4 hours (current hour + next 3 hours). The right side of the screen contains fields for entering the ore level in the parabolic bunkers.
By clicking the "Apply" buttons, the entered data are written to Oracle DB (CDC), and, subsequently, are used to run the algorithm.