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ROTEC DIGITAL SOLUTIONS

PRANA (Predictive Analytics)

Predictive analytics and remote monitoring system

The first Russian predictive and remote monitoring system that enables the identification of deviations in the functioning of industrial equipment in real time and detects potentially dangerous situations before the probable fault.

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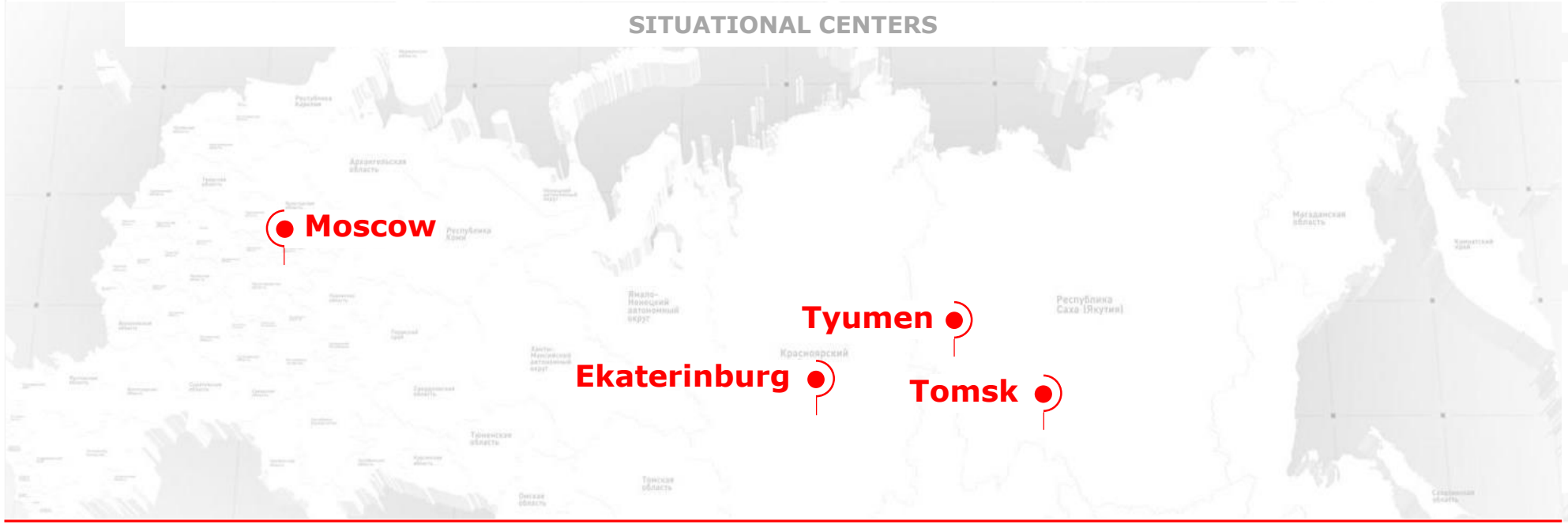
GEOGRAPHY AND ACHIEVEMENTS

SITUATIONAL CENTERS



SITUATIONAL CENTERS

1. RDS (Moscow)
2. SIBUR Holding (Moscow)
3. Gazprom (Tomsk)
4. UTZ (Ekaterinburg)
5. Gazprom Neft (Tyumen)

5 SITUATION CENTERS

27 CONNECTED STATIONS

9 CUSTOMERS

CUSTOMERS

RusHydro (Moscow/Krasnoyarsk)
SIBUR Holding (Moscow)
T Plus
Gazprom (Tomsk)
Gazprom Neft
UTZ (Ekaterinburg)
APPM (Arkhangelsk)
PAVLODARENERGO (Pavlodar)
TGK-2 (Yaroslavl)

>50%
reduction of accidents and damage

30+
patents

>3
research institutes and universities

>8
specialized departments

<2 years
payback

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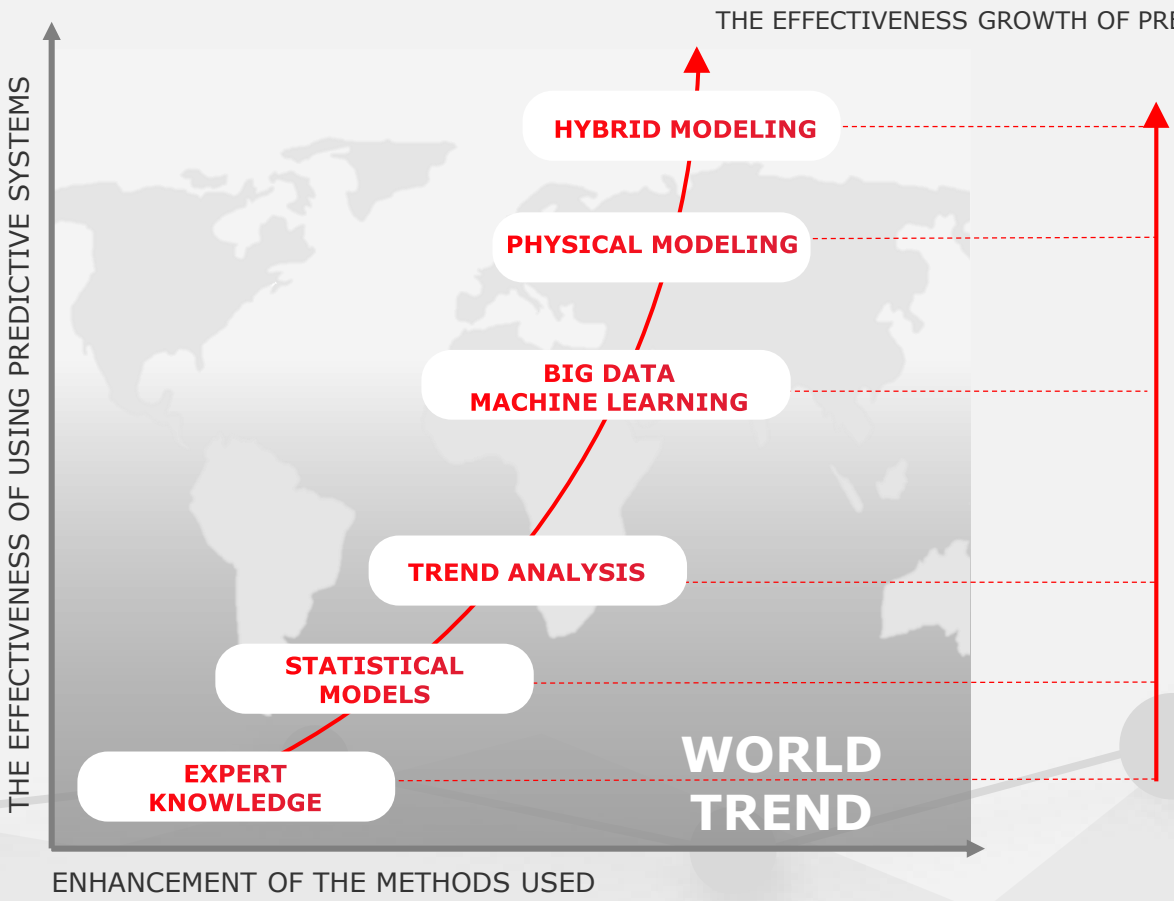
WORLD EXPERIENCE IN ASSESSING AND PREDICTING THE TECHNICAL CONDITION OF EQUIPMENT



- Combining methods and knowledge
- Mathematical models of aggregates taking into account physical relationships
- Methods for detecting anomalies based on the MVSM algorithm (multivariate vector statistical model) with Hottelling maps
- Neural network modeling methods
- Regression analysis methods for predicting technical condition
- Averaging over an ensemble of events
- Diagnostic rules
- Integral assessment of the technical condition

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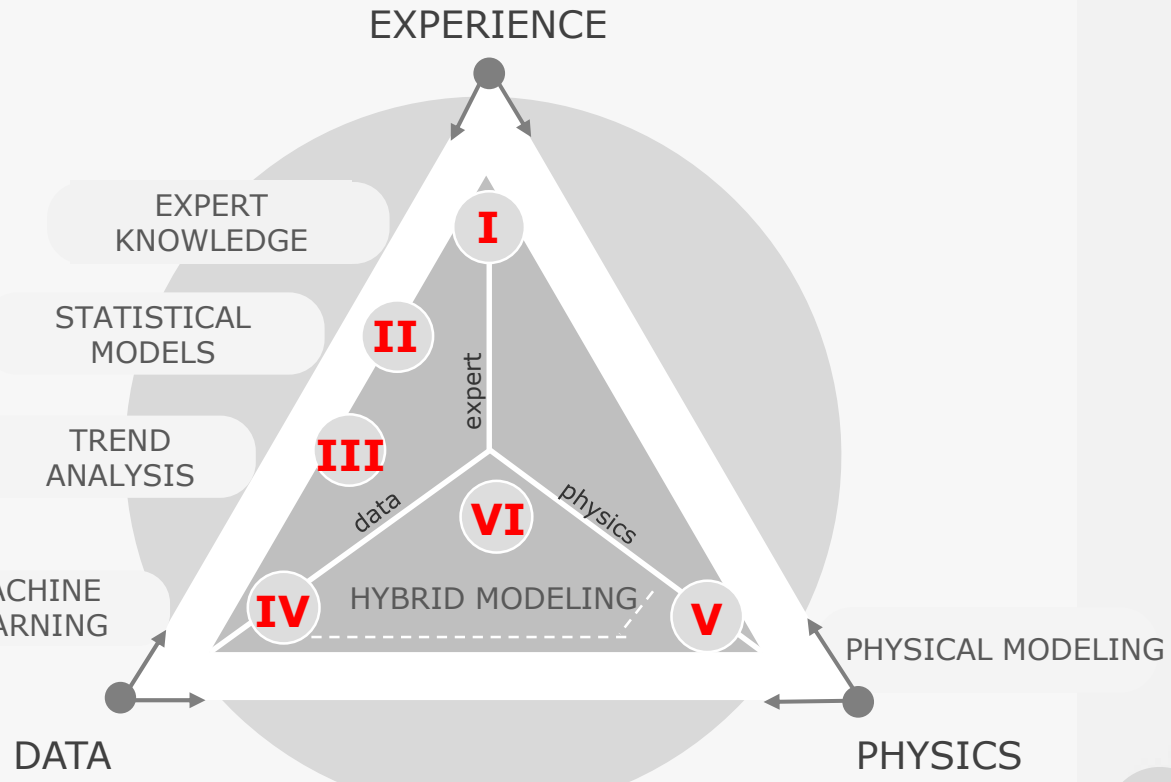
BALANCE BETWEEN APPROACHES IN THE PRANA FUNCTIONALITY



I
- Calculation module
- Defect log
- Diagnostic Rules Editor

II
- Condition forecast
- Trend analysis

III
- Modeling based on statistical methods

IV
- ML - DL modeling methods
- Neural network agents

V
- Modeling based on physical principles

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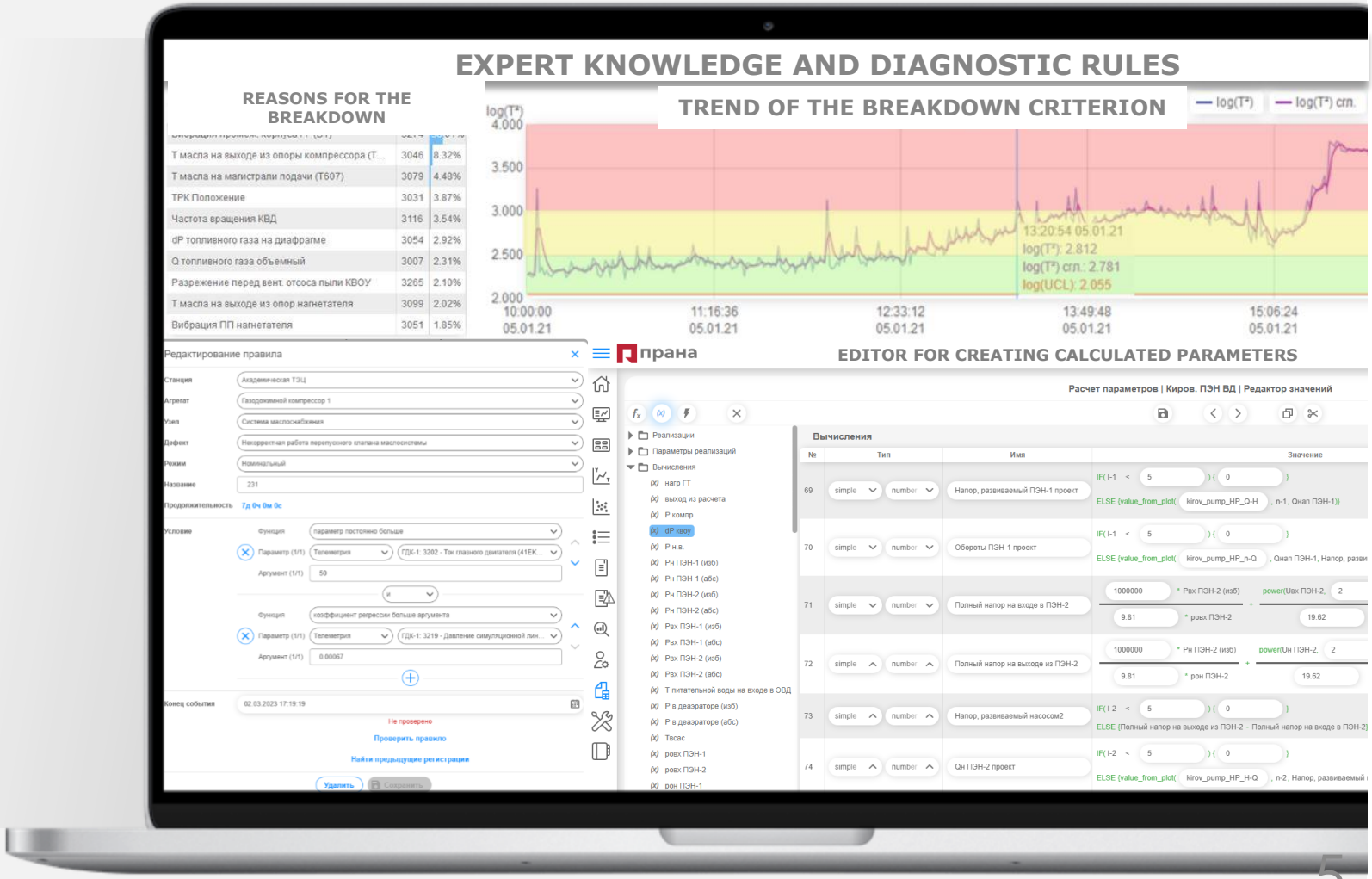
MACHINE LEARNING METHODS AND EXPERTISE

MODEL FOR DETERMINING THE TECHNICAL CONDITION

MODEL OF DIAGNOSTIC RULES



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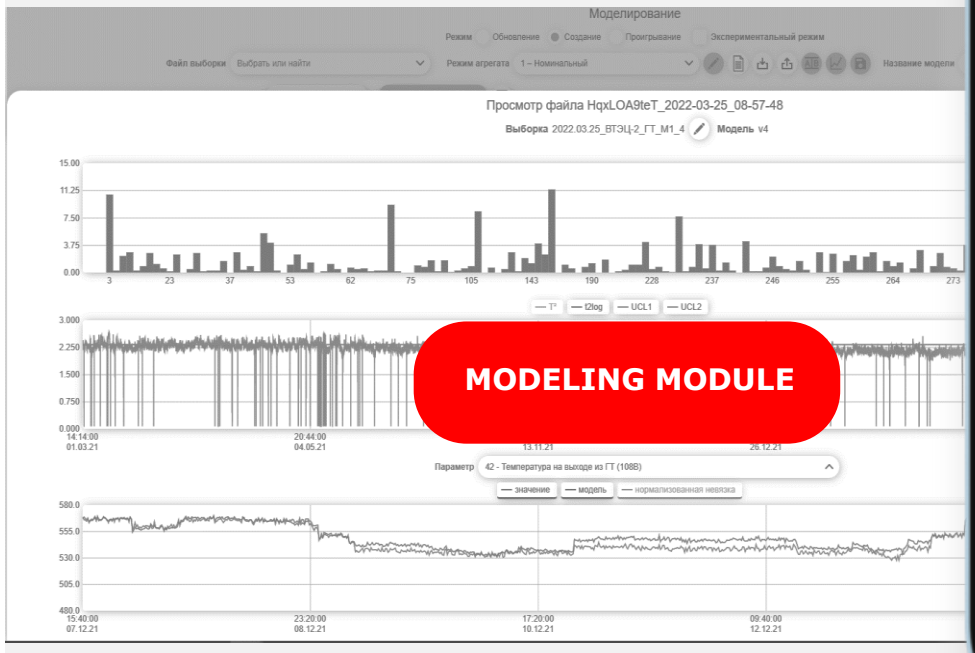
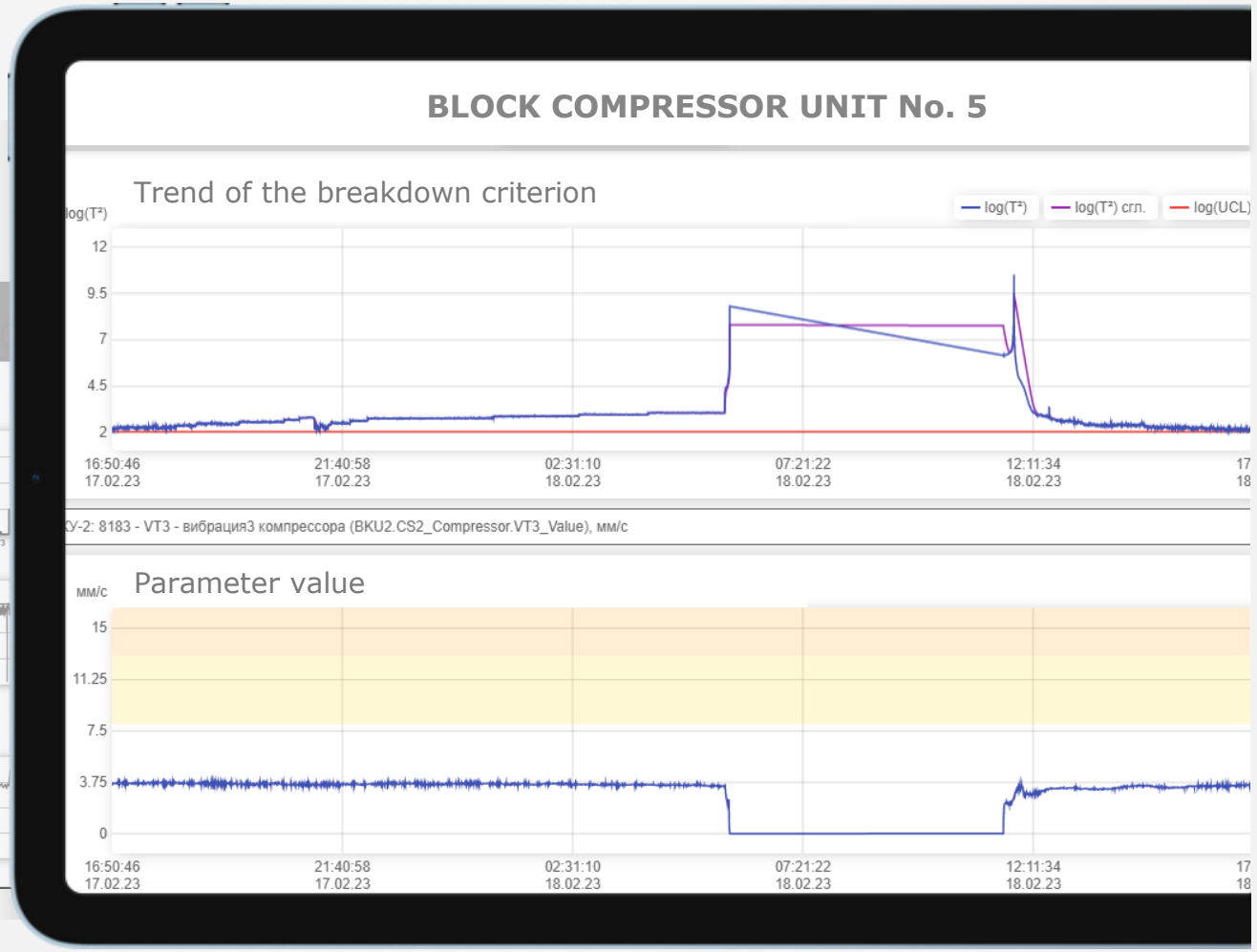
MACHINE LEARNING AND TREND ANALYSIS IN PRANA

- Warning of an emergency stop due to sensor failure





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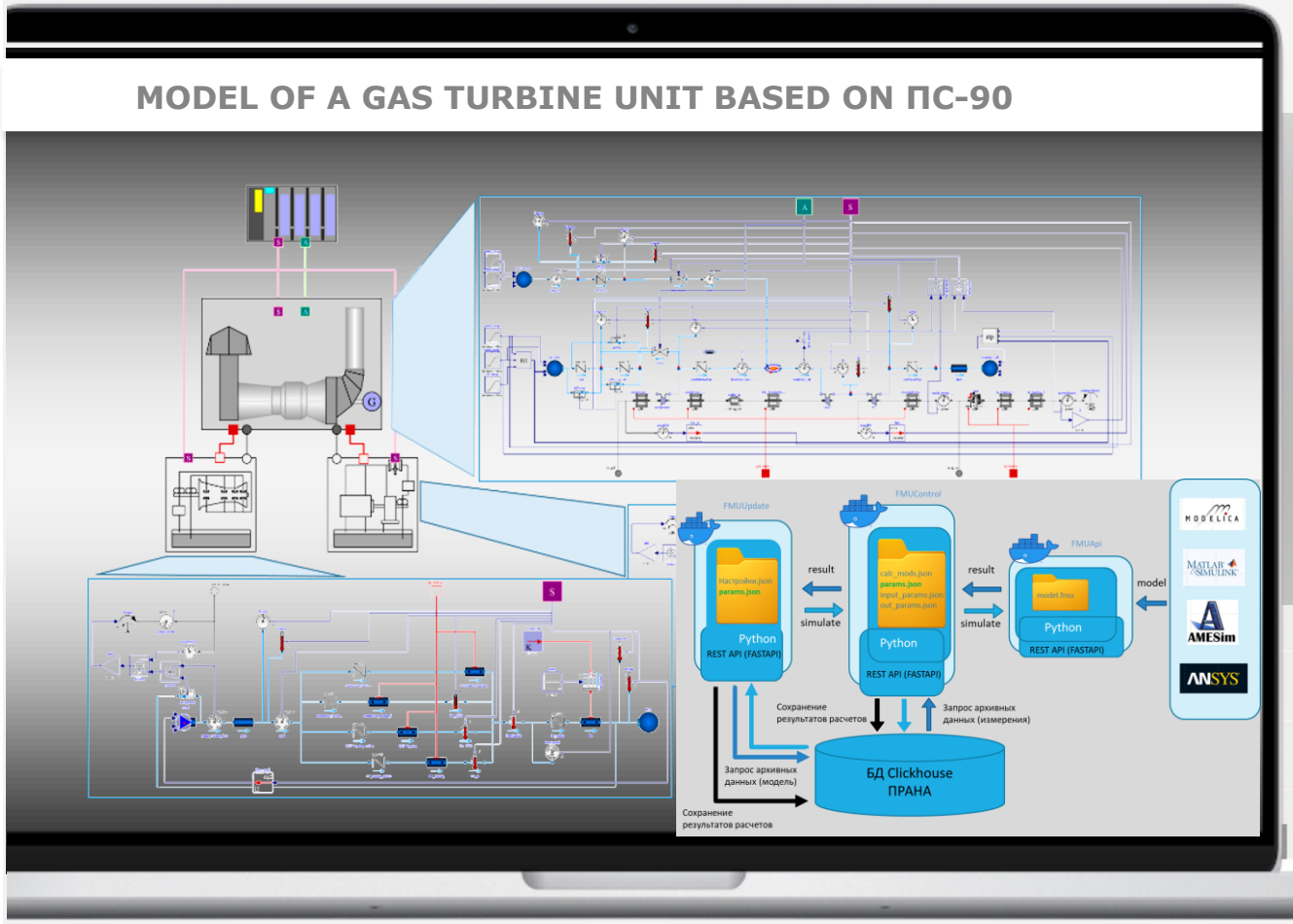
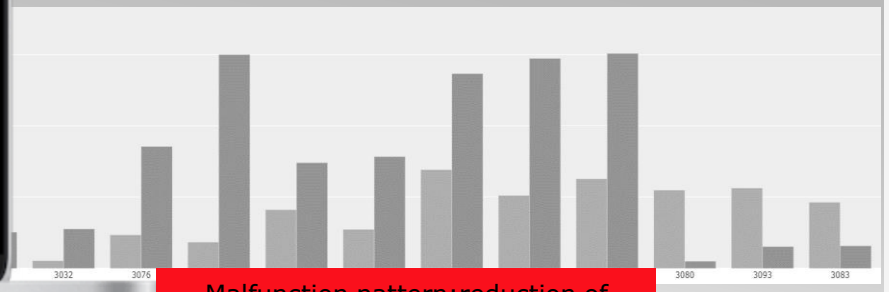
PHYSICAL AND MATHEMATICAL MODELS



- Creation and implementation of physical and mathematical models of the main power equipment based on OpenModelica open software
- Determination of deviation from normal technical condition
- Generating data of an object's faulty state
- Development of a unique PranaModelica library: models of gas turbine engine assemblies, steam turbines, etc.



Malfunction pattern:reduction of compressor efficiency by 2 %

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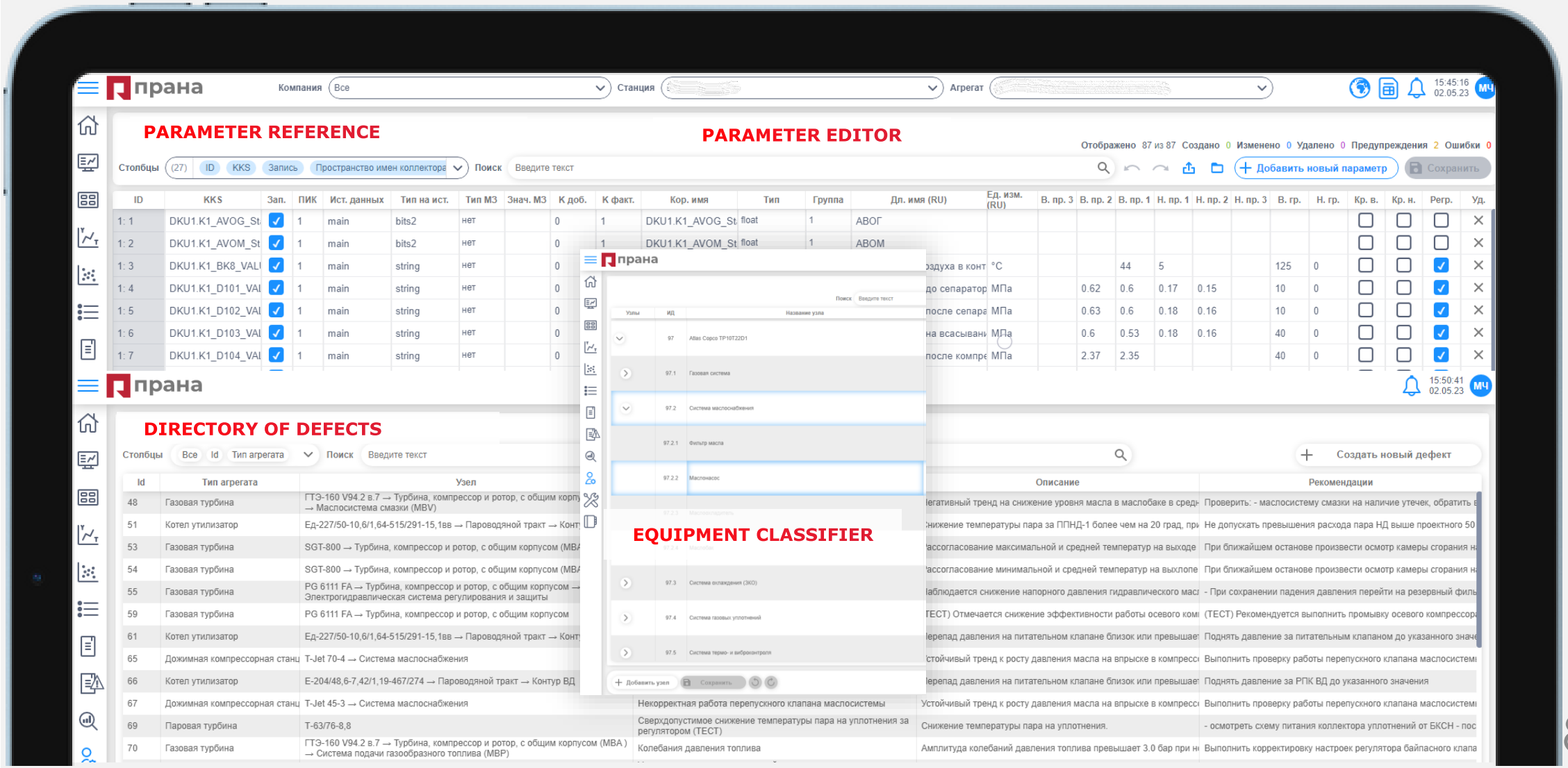
REFERENCE INFORMATION ON THE UNIT



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PREDICTION OF EQUIPMENT FAILURES

REGRESSION MODEL

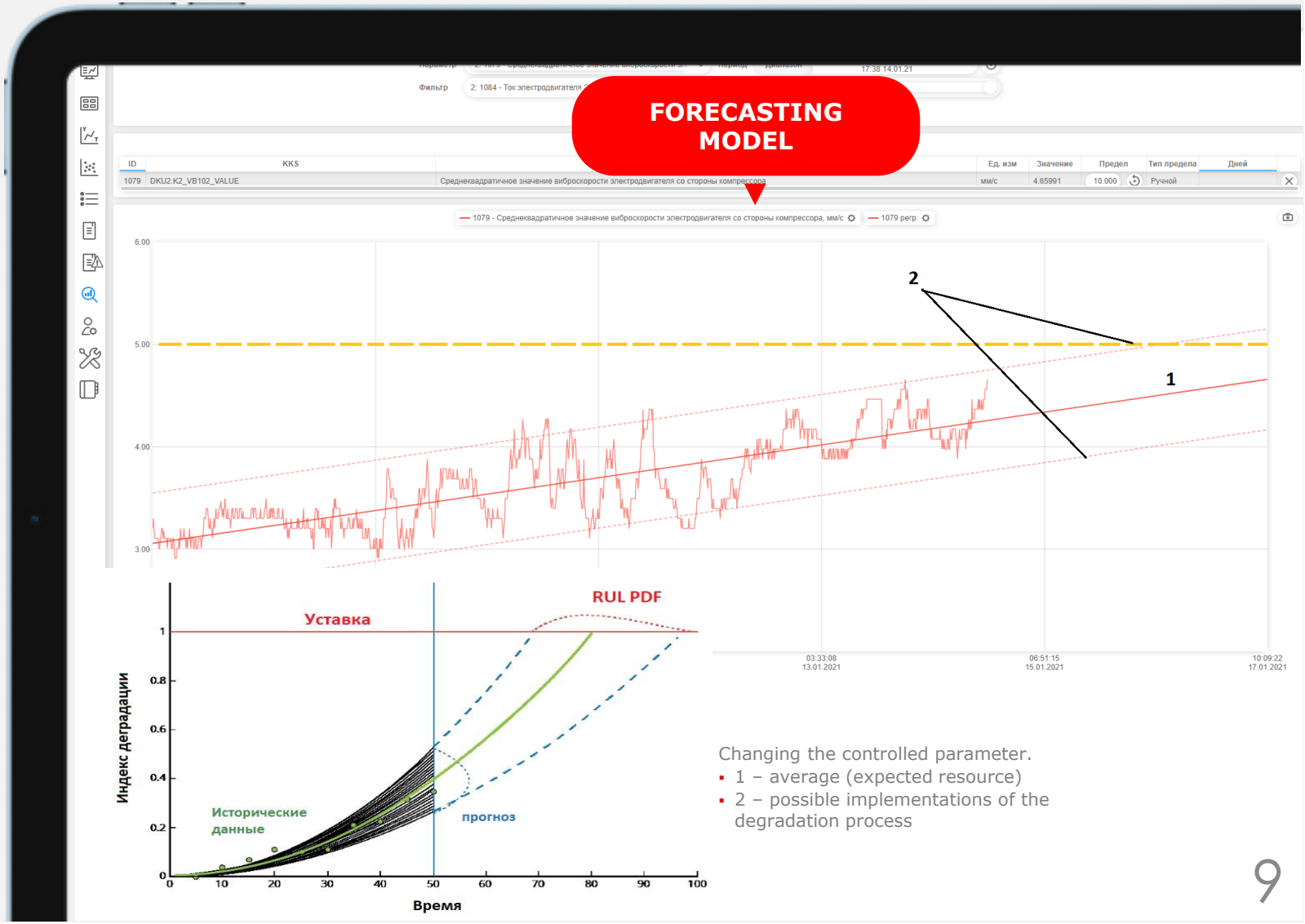
The possibility of predicting the value of the residual resource is provided with the simultaneous presence of the following conditions (РД 26.260.004-91):

- the parameters determining the technical condition of the equipment are known
- there are criteria for the limit condition of the equipment

Principle of work:

- linear, polynomial, exponential regression models
- time calculation to reach the limit state

FORECASTING MODEL



Changing the controlled parameter.

- 1 – average (expected resource)
- 2 – possible implementations of the degradation process

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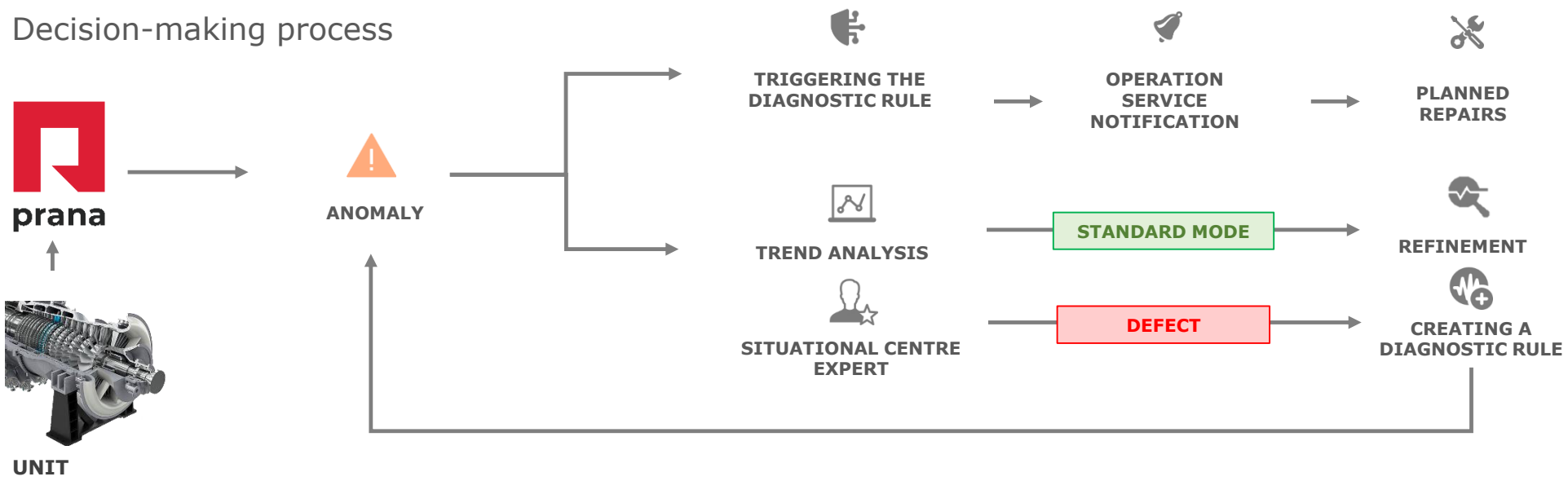
DIAGNOSTIC RULES

Detection of defects with previously defined distinctive features

- control of changes in the behavior of the object according to the specified criteria
- localization of the origin of the fault in the early stages
- flexible approach to creating rules

Decision-making process



TARGET FUNCTIONALITY

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TRANSITION TO OPERATION ACCORDING TO TECHNICAL CONDITION

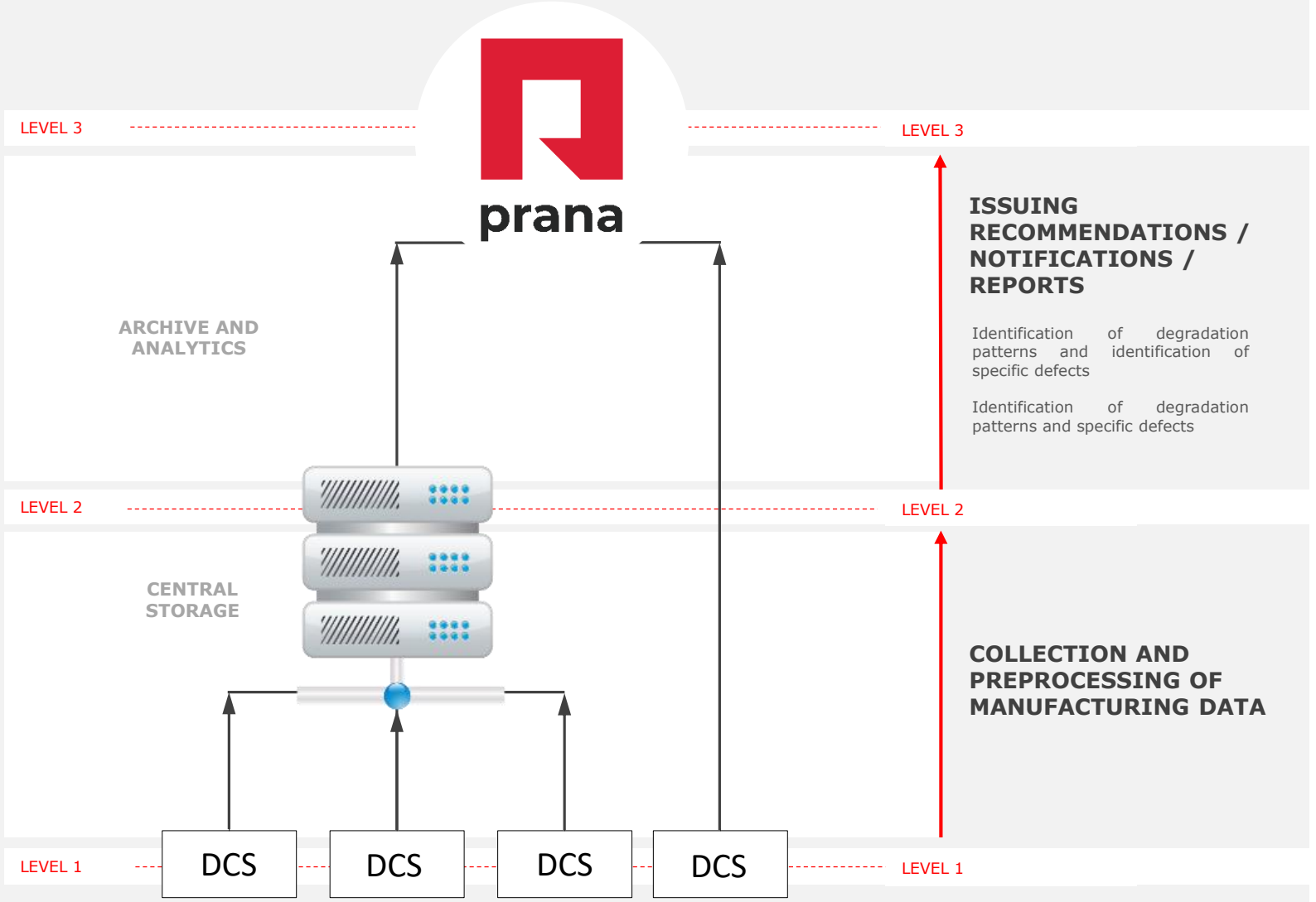
- Minimizing the number of unplanned repairs (the number of repairs should be planned based on the technical condition)
- Determining the scope of repair work individually
- Flexible prioritization of repairs based on PRANA data
- Diagnostic rules based on the manufacturer's factory techniques and the expertise of the operating services
- Archived data for post-analysis in an agreed volume is available to all participants of the cooperation (operation, equipment manufacturers, service companies, etc.)

REQUIRED SYSTEM FUNCTIONALITY

- The unit of initial data formation for the analysis of technical conditions
- The monitoring unit of the technical condition of the equipment
- The unit for maintaining general and historical information on equipment
- A reporting unit configured according to the user's stock

KEY SYSTEM REQUIREMENTS

- The system can be deployed in the Customer's IT perimeter
- The ability for the Customer independently modify algorithms and methods for assessing the technical condition of the equipment



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SYSTEM DEVELOPMENT

2022

ARCHITECTURAL CHANGES

- The system implements all the necessary functionality for deployment on the customer's side
- Integration with AD and KeyCloak (SSO)
- The system has been switched to a service architecture and can be deployed both in containers and in the Kubernetes environment
- The logging system according to information security requirements has been expanded

FUNCTIONAL CHANGES

- Modeling parameters are available to users for display on graphs and use for calculations and diagnostic rules. Physical and mathematical models support.
- Visualization of equipment-related events
- The «equipment tree» has become the main navigation tool
- Mail notifications for diagnostic rules
- The ability to switch between mnemonic diagrams
- Support for bitmask encoded signals
- Integration mechanisms OPC UA, ODBC, Kafka

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SYSTEM DEVELOPMENT

2023/24

1

A UNIVERSAL ROLE MODEL

Currently, the role model in PRANA is limited to several predefined roles and the ability to create groups based on an organizational structure. The new functionality will allow you to create any number of roles, which will allow you to flexibly use them when integrating with corporate systems.

2

ADVANCED FUNCTIONALITY

CONTROL OF DEVIATIONS FROM THE MODEL PARAMETER VALUES WITH A DESCRIPTION OF THE DEVIATION LOGIC

A simplified mechanism for controlling and marking events based on the analysis of the behavior of signals relative to their model values. It will allow you to write diagnostic rules based on the behavior of parameters in a sliding window.

3

INTEGRATION WITH ZYFRA

At stage 1, it is planned to implement support for the Ziiot platform as a data source. Further steps for integration are currently being worked out.

4

CASE MANAGEMENT

A tool that allows you to group different events, such as changing signal values, triggering diagnostic rules, operational log events, etc. This grouping will allow us to consider the whole picture of what is happening. Including in third-party systems.

5

TEMPLATES

EQUIPMENT

Templates should become an effective tool for replicating PRANA elements when connecting the same type of equipment.

CALCULATIONS

The mechanism will facilitate the transfer of calculations between different units of the same type of equipment.

DIAGNOSTIC RULES

The rules will make it easy to replicate the rules between objects and different pieces of equipment.

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CASE STUDIES

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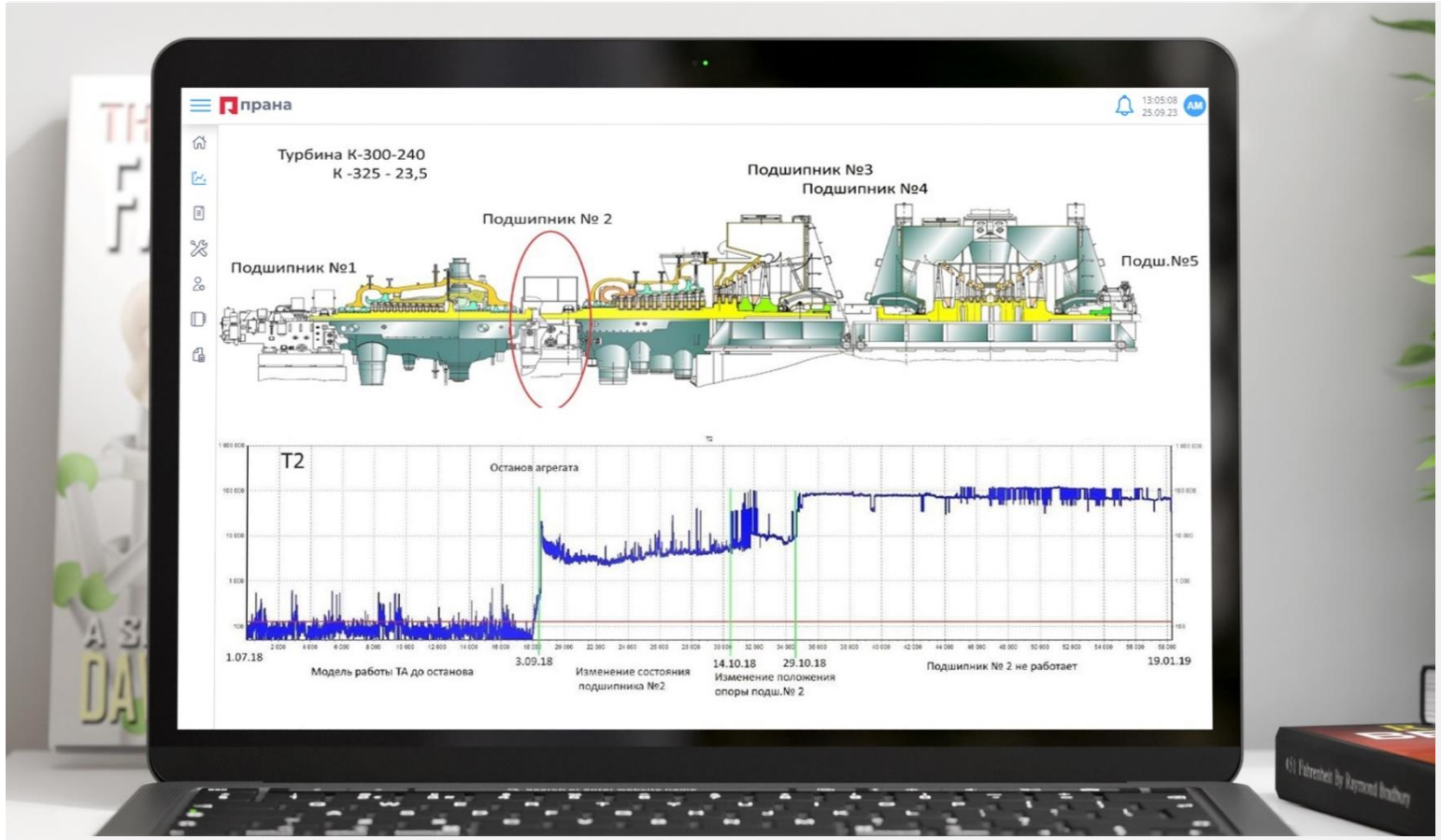

IDENTIFICATION OF DEVIATIONS

on archived data

in the operation of the bearing
3 months before the emergency stop

A.

Abrupt changes in the position of the bearing pedestal slope

B.

A jump in vibration of the rotor of the intermediate pressure cylinder relative to the bearing pedestal

C.

Changing the temperature of the bearing babbit

LAUNCH
after the launch, the level of the T^2 deviation criterion changes

DETECTION OF ANOMALIES
the system notifies of a change in the T^2 vibration level of the WL rotor (03.09.18), a change in the babbit temperature of the bearing No. 2

TREND ANALYSIS
by the PRANA Expert Group

DEGRATATION GROWTH
A.
B.
C.

prana — **2 min** — **90 days before the emergency stop**

DCS — throughout the entire period, the DCS displays the normal operating mode

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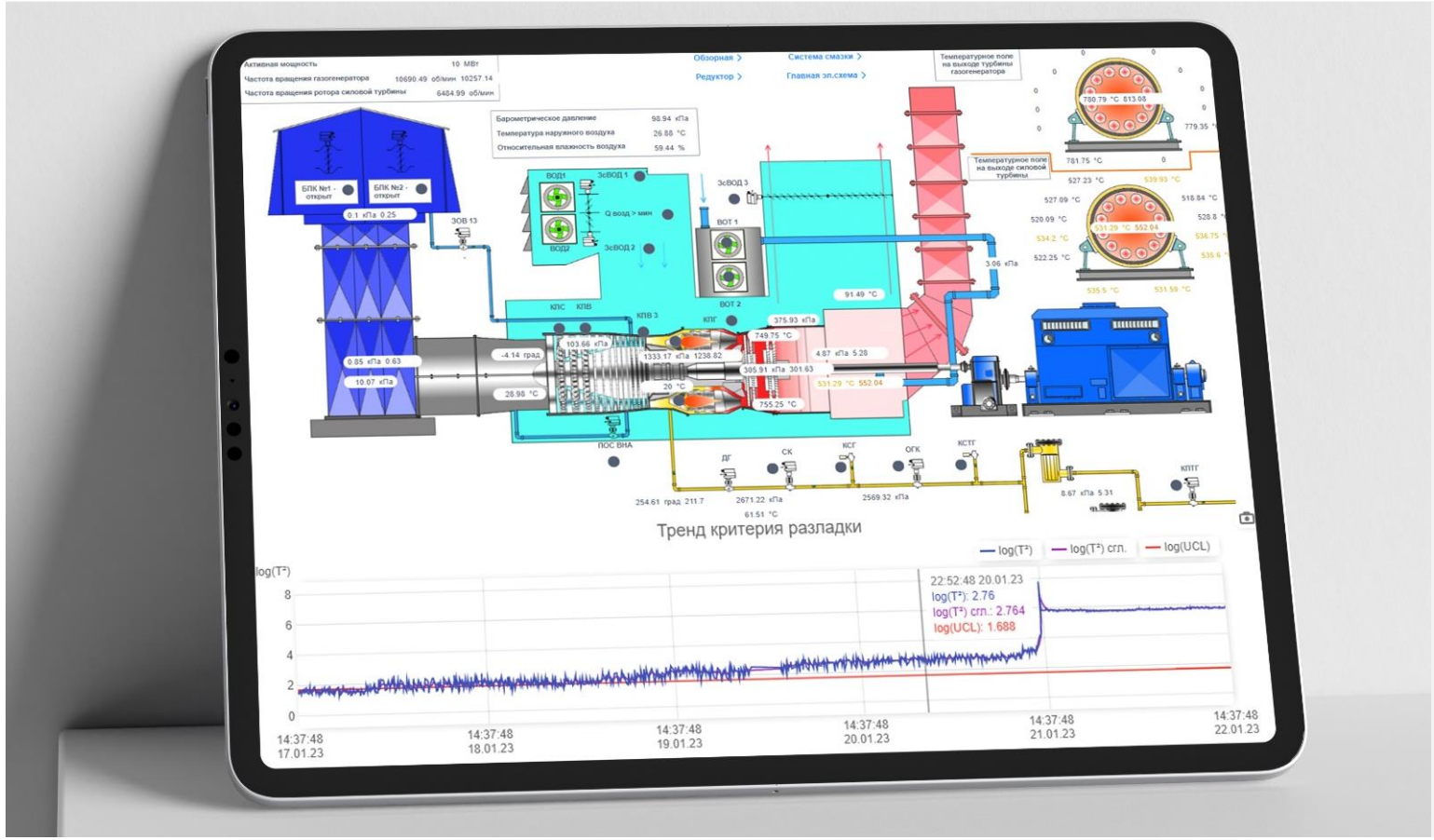

IDENTIFICATION OF DEVIATIONS

in the operation of the oil system 10 hours before the probable malfunction

A.

Reduction of oil pressure at the gearbox entry

B.

Reducing the oil pressure at the generator entry

C.

An increase of the oil temperature on the drain

1	2	3	4	5	6	7	8	9
DISORDER An increase in the T2 criterion in excess of the standard value of 0.8	**DETECTION OF ANOMALIES** lowering the oil pressure in the gearbox lubrication manifold	**TREND ANALYSIS** by engineering and technical staff	**TRIGGERING OF THE DIAGNOSTIC RULE** according to the criterion of reducing oil pressure	**NOTIFYING THE SHIFT ON DUTY** and making recommendations to take control and check the equipment	**SWITCHING TO THE RESERVE** when the pressure decreases further	**TRIGGERING THE DIAGNOSTIC RULE** ↑ **A.** **B.** **C.**	**NOTIFICATION OF THE SHIFT ON DUTY** and the formation of a recommendation	**REPAIRS WITH REPLACEMENT OF PUMPS ARE PLANNED**

prana — 2 min — in 10h

DCS — throughout the entire period, the DCS displays the normal operating mode

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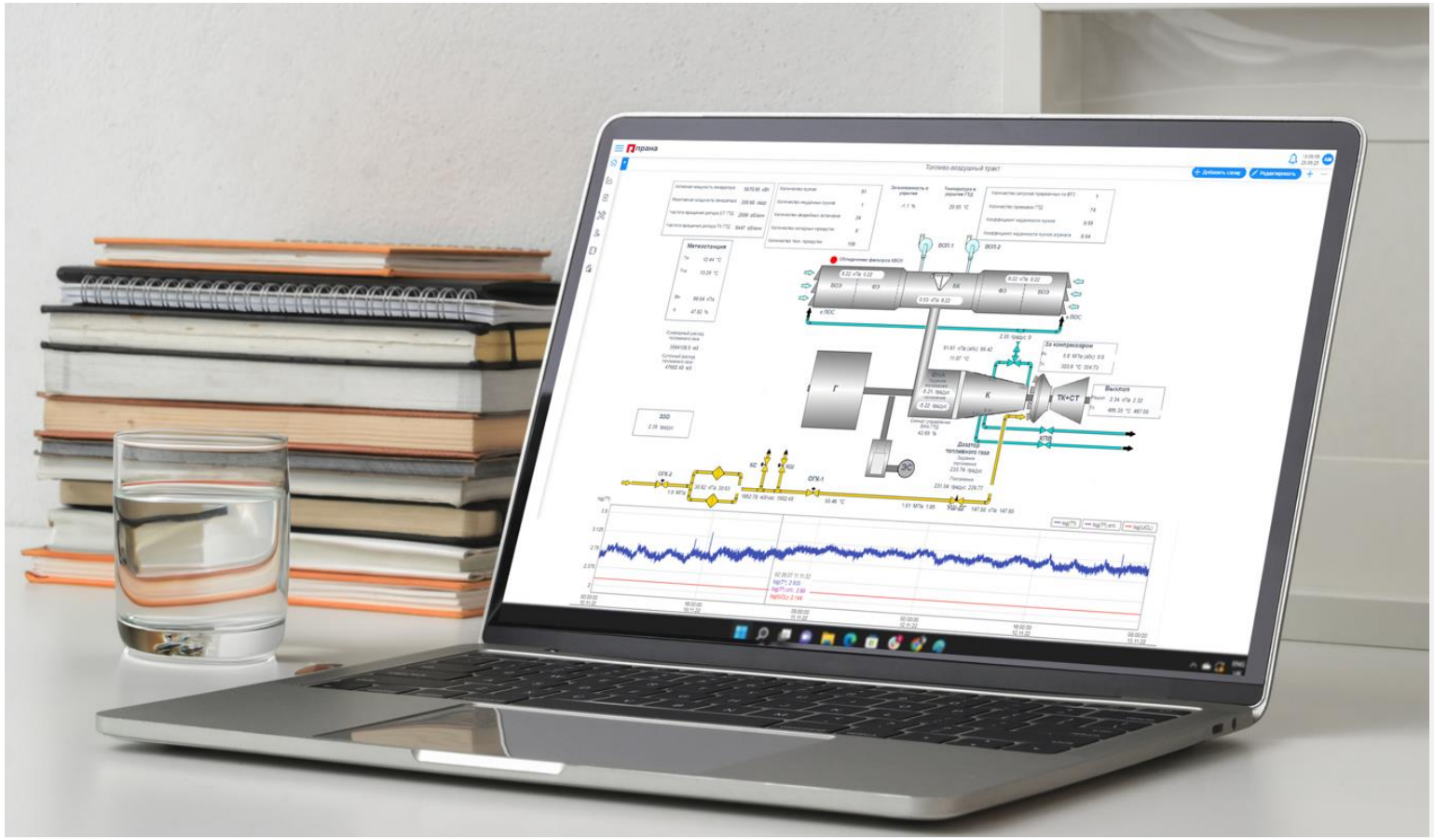

IDENTIFICATION OF DEVIATIONS

in operation of the control unit of compressor inlet guide vane

14 days before the probable malfunction

1	2	3	4	5	6	7	8	9
DISORDER An increase in the T2 criterion in excess of the standard value of 0.8	**DETECTION OF ANOMALIES** Increase of the Control signal parameter from 44 % to 64%	**TREND ANALYSIS** by engineering and technical staff	**TRIGGERING OF THE DIAGNOSTIC RULE** for exceeding the criterion	**NOTIFYING THE SHIFT ON DUTY** Recommendations of taking control the compressor inlet guide vane control system	**TO SUBMIT A REPAIR REQUEST** when the parameter is further increased	**TRIGGERING OF THE DIAGNOSTIC RULE** Increasing the control signal parameter above the standard value	**NOTIFICATION OF THE SHIFT ON DUTY** and the formation of a recommendation	**REPAIR PLAN WITH REPLACEMENT OF COMPRESSOR INLET GUIDE VANE CONTROLS**

prana — 10 min — in 14 days

DCS — throughout the entire period, the DCS displays the normal operating mode

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Thanks for your attention !

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