

The Disruptive Technology of Safe Resource-Saving Operation and Maintenance of Machinery

Why is it called Disruptive? If you implement this Technology at your refinery, lots of usual actions will have no further purpose, however let's be consistent... The main causes of unexpected costs and losses in downstream are well-known, there are accidents and fires caused by equipment failures in operation; downtime of refinery units due to equipment breakdowns; extended turnaround time duration as the exact information about the damages of equipment is unknown, and as the maintenance staff find additional hidden defects often just at the repair stage; high maintenance expenses because of significant quantity of both planned and unexpected maintenance's orders due to sudden breakdowns; substantial quantity of spare parts in the storage because of large quantity of equipment types and continuous spare parts delivery time.

Within last 70 years the reliability strategies have repeatedly changed since run-to-failure to RCM, and most of them are based on probability assessment of failure instance. However, the probability assessment does not give a possibility to eliminate any of the sources mentioned above. There are two usual cases: the PM or RCM techniques that are used. You get equipment out of operation before or after some critical time point. In first case (Fig.1) you do not utilize possible machine's life time and respectively you don't receive all benefits you have from previous investments into the asset. In the second case (Fig.2) you lose your asset due to significant damage and fire, or, if you are lucky, just to increase maintenance costs.

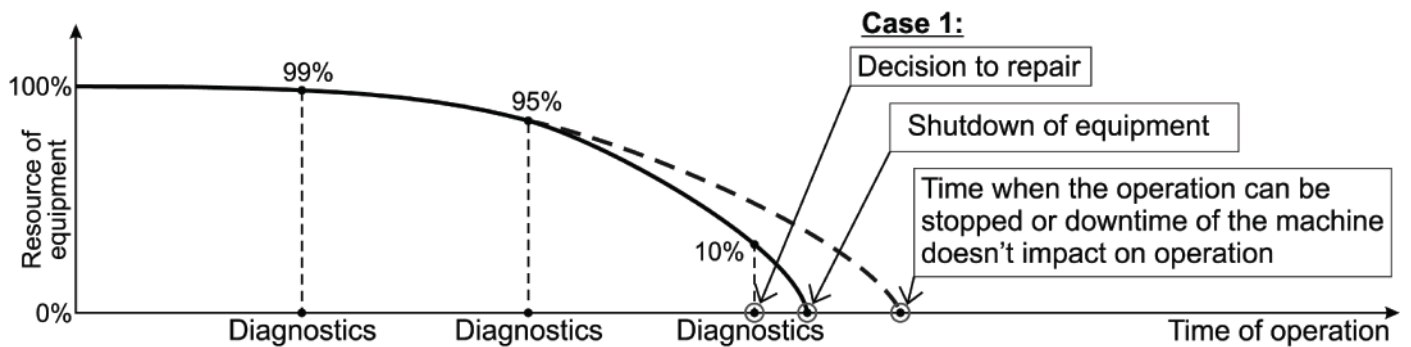


Figure 1. Equipment shutdown before most profitable time point

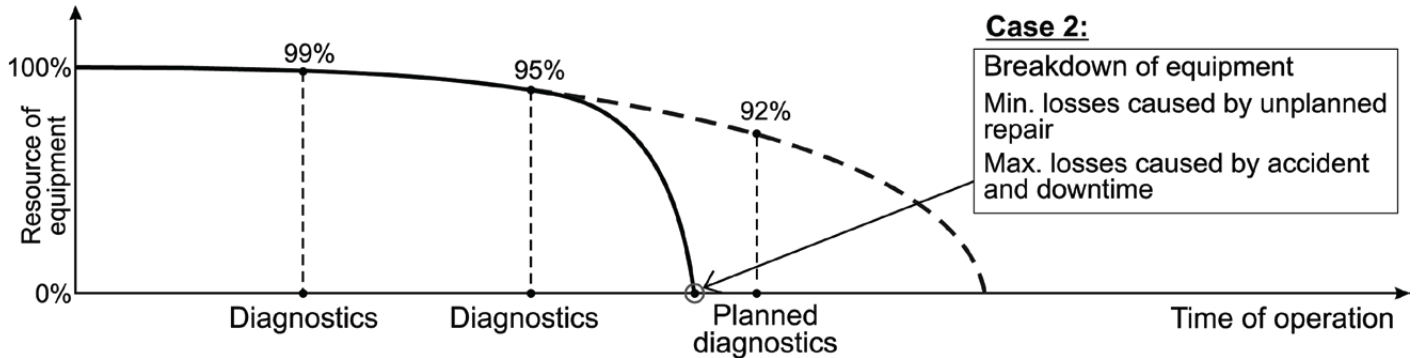


Figure 2. Equipment shutdown after an accident is happened



Total amount of expenditures caused by breakdowns, directly depends on early failure detection and efficiency of personnel actions under conditions of various velocities of machinery lifetime's losses. Consequently, the period of diagnostics is the basic factor to decrease the amount of unplanned expenses and

losses, as well as to increase the reliability and safety of the refinery operation. Therefore, the interval 1 (Fig.3) is appropriated only for considerable decreasing of unplanned expenses and elimination of losses caused by equipment failures.

DEPENDENCY OF COSTS AND LOSSES FROM THE MOMENT OF A DEFECT DETECTION

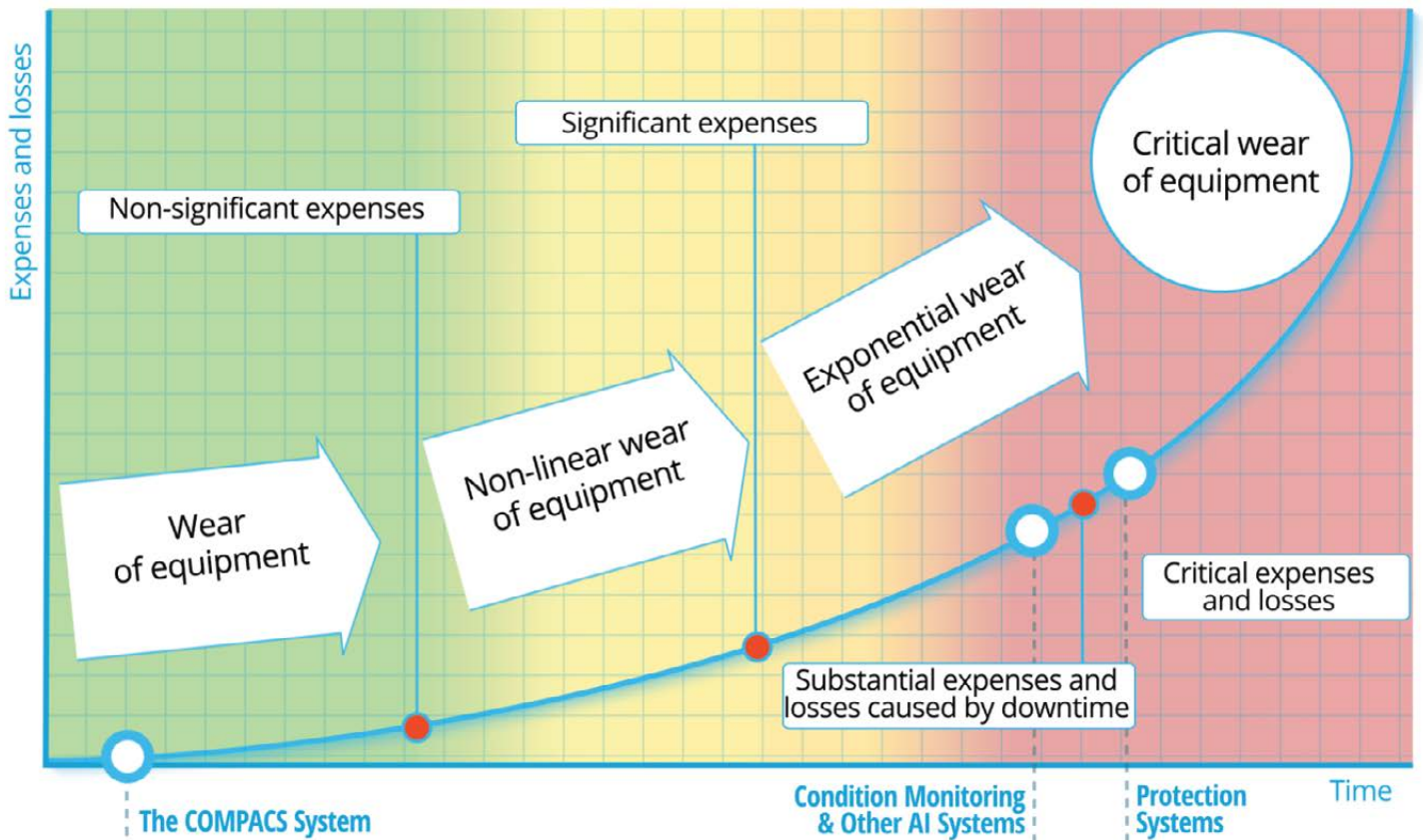


Figure 3. Expenses and losses within different defect development time points

As you can see from the figure above, even if you find out the failure development at the early stage you need to localize its impact on expenditures before the critical time point passes. Therefore, we have developed the Technology of Safe and Resource-Saving Operation and Maintenance of Machinery. Nowadays we offer the SROMM-Technology, which significantly cuts duration of equipment

health improvement at each stage of decision making (Fig.4). Implementation of the SROMM-Technology means that you start using the following on regular basis: management of the objective real-time information about machinery health, efficiency of machinery operation modes, quality and timeliness of fulfilled maintenance actions, efficiency of root cause reliability analysis at the refinery, etc.



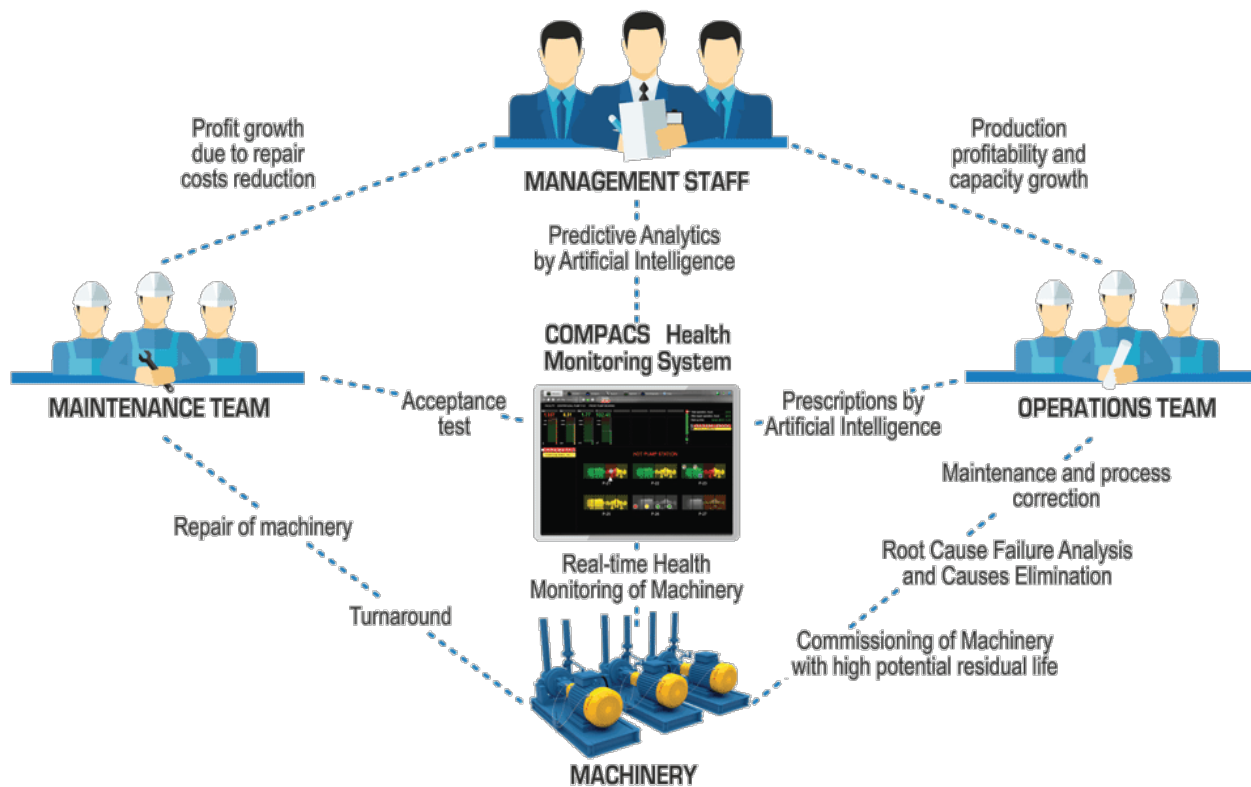


Figure 4. SROMM-Technology flowchart

Using current machinery health information, you can figure out a failure, its cause, what should be done to prevent expenses, what kind of actions were done or weren't done, by whom these actions should be done, etc. So, this objective information provides the trust basis between all personnel including the management, reliability and maintenance, operation staff of the refinery. It gives a possibility to move the responsibility of processing safety from the top-management to operator's level. The main advantage of the Technology is that personnel become the real team because of extremely high level of visibility and trust to each other. Because of elimination of asymmetric information, the personnel achieve safe and reliable refining, maximum possible uptime, as short as possible turnaround, as efficient maintenance cost and low power consumption as possible.

The critical element of the SROMM-Technology is the real-time diagnostic COMPACS System which provides everyone at the refinery with the

objective information about machinery health and nearest urgent actions required to prevent particular failures. On the one hand, the system considerably cuts machinery diagnostics interval and makes its duration less than failure development time. It gives a possibility to eliminate destructive forces and to prevent almost any failures without significant cost. On the other hand, the system provides very fast feedback to the involved personnel and management about the efficiency of the fulfilled actions. It provides visibility of efficiency of every involved employee without any restrictions regarding their position in the refinery hierarchy.

As operation staff receives the COMPACS prescription they must immediately initiate nearest urgent actions to increase a particular machine lifetime (Fig.5). Each refinery Unit usually has a maintenance budget which should be used in case the maintenance actions were done efficiently according to the machinery health assessed by the COMPACS System. The same



requirement should be assigned for commissioning of new or repaired equipment. As machine is operated under "action required" or "unacceptable" states for a long time, or it has been repaired too many times, the reliability team has to analyze the COMPACS System data to

provide the root cause reliability analysis and give the recommendations to eliminate found causes. Some of our original software can be used for automatic analysis of reliability and mechanical readiness as well.

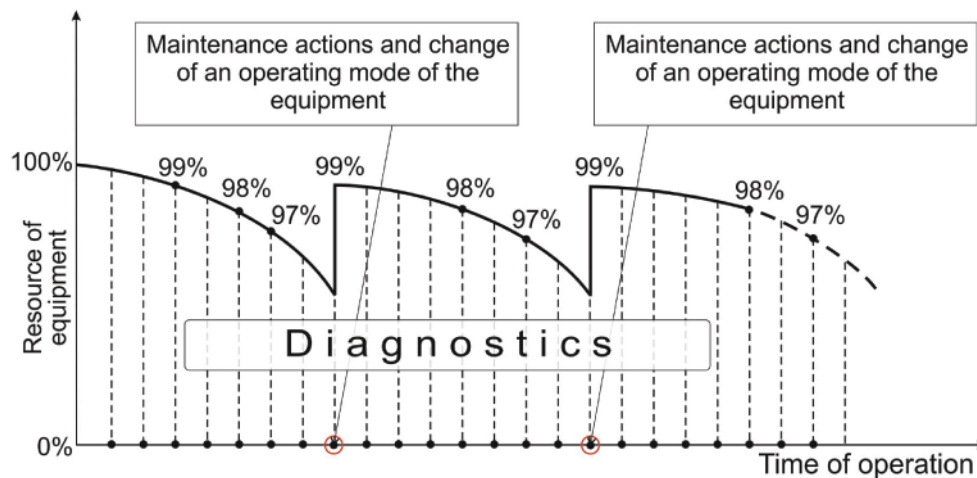


Figure 5. Renewal of equipment lifetime without shutdowns based on reduction of destructive loadings by timely changes of operation mode and focused maintenance actions fulfillment

If the prescriptions issued by the system are fulfilled accurately and in time, you see usual pictures of maintenance action distributions placed below. You can see both typical distributions of repairs which were done at the workshops and quantity of maintenance actions which were done to machinery in operation. Usually, in half a year the quantity of maintenance

actions in operation rises twice (Fig.6), but at the same time the quantity of costly repairs drops significantly (Fig.7). And finally, if you significantly drop the general level of all machinery vibration at the Unit, according to our customers' feedbacks, you achieve the considerable - not less than 7% - reduction of total power consumption of the unit.

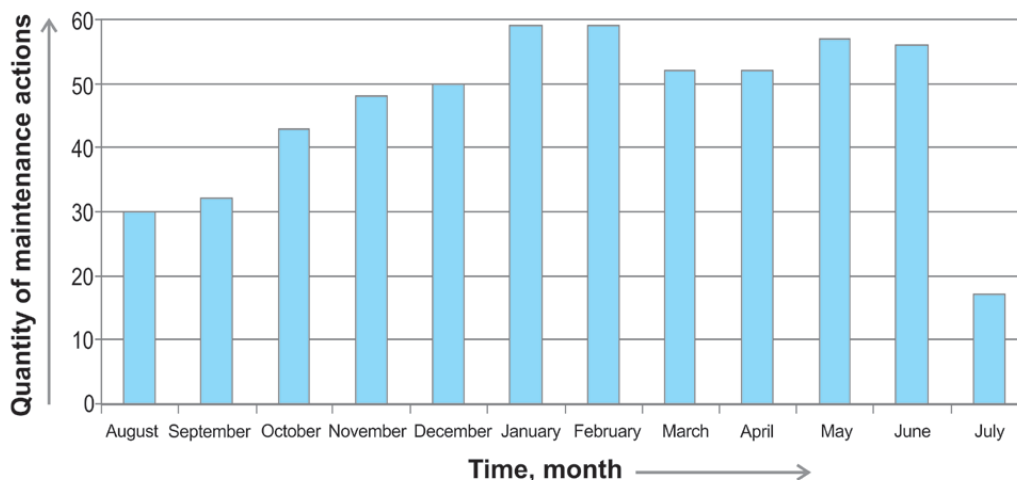


Figure 6. Double growth of focused maintenance actions within operation since the COMPACS System was implemented at FCC Unit



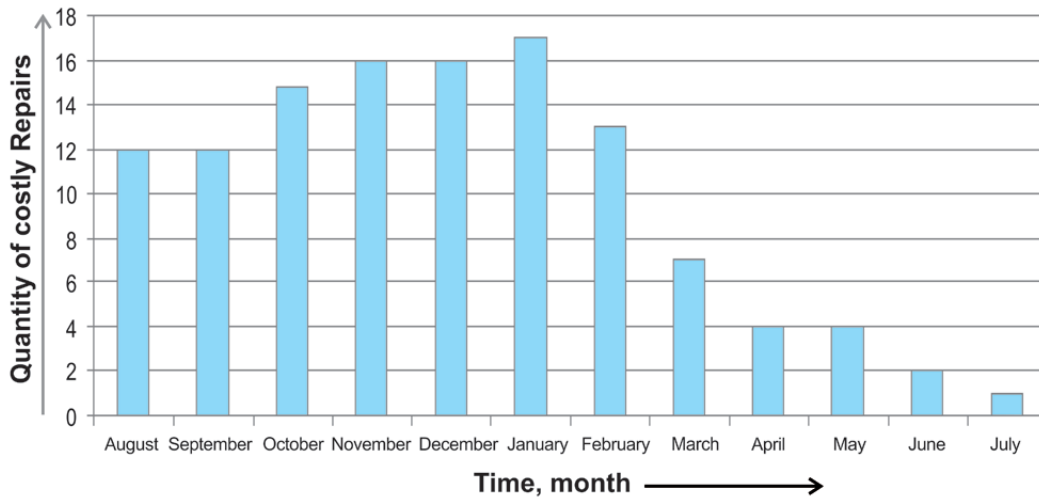


Figure 7. Significant drop a quantity of costly repairs at workshops in 6 months since the COMPACS System was implemented at FCC Unit

To achieve significant and valuable outcomes of the Technology, we have developed a unique algorithm of machine failure detection. We have managed to decrease the diagnostics error at the COMPACS System from usual 30-40% to unbelievable 1%. It provides almost total elimination of failure omission possibility. It is reasonable to select machines that should be equipped with the system in accordance with the Risk Matrix shown in Figure 8. Category 1 and 2

machines must be under real-time diagnostics to eliminate their failures that affect the safety and operation efficiency of the Unit and refinery as whole. Besides, the information from the systems should be collected and presented at all levels of refinery management in the same time using the COMPACS-Net plant diagnostic network. It provides visibility of machinery health and efficiency of machinery operation and maintenance (Fig.9).

Failure probability	Limiting risks due to failure omission		Technology-related hazard
High	1st Category Risks: 1) Accident; 2) Downtime (capacity reduction) 3) Repair/replacement of machinery	2nd Category Risks: 1) Downtime (capacity reduction) 2) Repair/replacement of machinery	Yes
Low	3rd Category Risks: 1) Repair/replacement of machinery	4th Category Risks: 1) Negligible	No

Figure 8. Machinery position's Risk Matrix



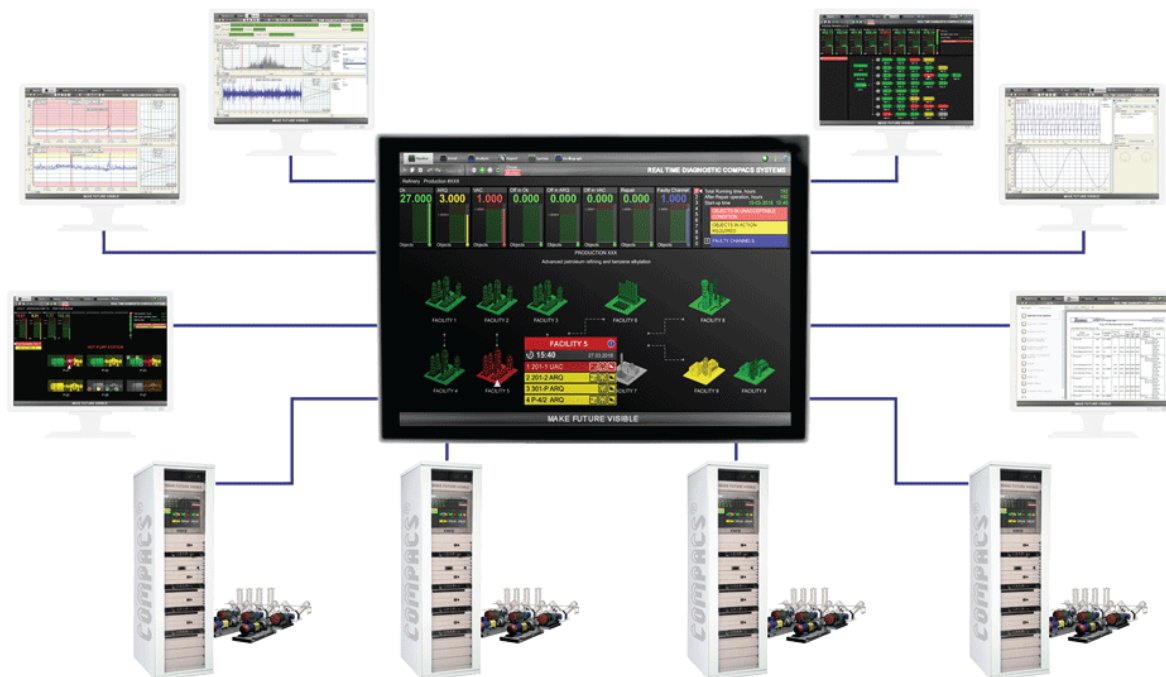


Figure 9. The COMPACS-Net plant diagnostic network

In conclusion we would like to present the outcomes of the SROMM-Technology implemented at the Aromatics Unit of Omsk Refinery, where it made a huge positive impact on the overall unit performance (Table 1). According to our customer's published testimonials the economic benefit of the COMPACS Systems and

the Technology of Safe Resource-Saving Operation and Maintenance of Machinery is not less than 10 US dollar per 1 US dollar of investments. The usual payback period of investments is less than 6 months, but sometimes it is less than just one month.

Table 1. Best Practice Maintenance Benchmarks at oil refinery

No	Indicator	Best World performance 2016	Aromatics hydrocarbon unit under the COMPACS System monitoring
1	Total Maintenance Cost/ Total Manufacturing Cost/	<15 %	14,9 %
2	Maintenance Cost/ Replacement Asset Value of the Plant and Equipment	<3 %	0,6 %
3	Planned Maintenance	>85 %	100 %
4	Reactive Maintenance	<15 %	0,0 %
5	Availability: Available Time/Maximum Available Time	>97 %	≈ 99 %

