Variability is an intrinsic feature of many real-life environments, which can be observed not only in human activity domains, but also in modern manufacturing, transport and service systems equipped with machines. In general, we can distinguish positive and negative changes. The first case is highly desired, since it is related with increasing efficiency of a system, which can be manifested for instance by decreasing completion times of tasks (jobs) or increasing production outcomes and financial profits. The second group refers to a deterioration of a systems, which usually has negative impact on its condition and can also decrease its efficiency. Examples can be found in many processes such as reduction of the concentration of chemically active cleaning substance, blunting CNC machine tools, discharging and aging of battery electric vehicles (cars or drones).

Deteriorating has a visible impact on a system performance, in a longer time horizon it often leads to a machine breakdown. Therefore, to reduce the mentioned negative effects or to restore machine condition maintenance activities are performed, which usually require additional time or cost. In general, we can distinguish two main types of maintenance activities called preventive and predictive. The first group is based on objective information about a machine and its service life, which determines inter alia predefined time periods or working hours for regular maintain and repair of a machine and its parts to prevent failures and downtimes. On the other hand, predictive maintenances (nowadays often related with industry 4.0 and more accurate monitoring possibilities) differ from preventive maintenances, since they rely on the actual machine condition, rather than average or expected life statistics, to predict when maintenances are required.

Undoubtedly, maintenances play an important role in modern enterprises. Furthermore, they involve additional time and resources, which usually transfer into significant financial costs. Therefore, it is highly desirable to minimize such expenses and at the same time to keep up or improve other company objectives. It can be done by scheduling of jobs as well as by planning maintenance activities taking into account dynamically changing conditions to optimize defined criteria. However, the discussed issue has a complex nature, therefore, intuitive methods have low efficiency due to their limitations for greater number of parameters and variability of environments. On the other hand, application of advanced decision support methods, which have greater possibilities to face the discussed problems, require construction of dedicated algorithms and development of related mathematical models describing crucial aspects of reality. However, the existing models do not reflect precisely important aspects of reality, thereby decision support methods constructed on their basis have significant drawbacks and crucial limitations for modern systems.

Therefore, we will fill such research gaps by the development of more accurate scheduling and resource management models that better reflect practical aspects of the discussed dynamic environments. On their basis, we will derive theoretical properties and construct efficient data structures to represent schedules and resources that are fundamental for the development of optimization methods. It is worth noticing that they will have various configuration depending on involved settings and parameters. Namely, robust and computationally efficient representations for models covering partial predictive maintenances and deteriorating job processing times can be different than for models including preventive maintenances and time dependencies between jobs. Finally, the aim of this project will also include the design and construction of time and memory efficient optimization algorithms. They will be based on so called intelligent search through the multidimensional space of possible solutions to optimized the given criteria at the same time holding required constraints. Although the main purpose of this project is to contribute a theory (operations research, computer science, management), but the obtained results will constitute a solid background for the future research and their potential extension to be used in decision support systems.