## Enabling system-level diagnostics

# System-level diagnostics through the system lifecycle

The high-tech industry is facing an increasing demand from customers to deliver performance and availability-based contracts. This pushes the high-tech industry to change its traditional diagnostics tasks as seen in service and repairs towards an efficient strategy that optimizes system productivity over the full lifecycle. Facing this change, the high-tech industry is simultaneously challenged by the increasing complexity of its systems. This turns the development of a diagnostic approach into a difficult engineering task.

**"Towards a digital assistant to make the lives of service technicians easier."**

For these reasons we need to develop techniques to assist in efficiently diagnosing a complex system to minimize downtime, and new methodologies to assess the diagnosability of a system in an early stage of the design.

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## Assisted Diagnostics Methodology

Together with a number of our industrial partners, we developed a model-based methodology supporting diagnostics during the design of a system as well as when the system is in operation. The methodology employs Hybrid AI, bringing together system engineering and data science techniques.

The diagnostic models are created in an object-oriented manner using a domain-specific language. This allows a compositional approach of defining the system and re-use of component definitions across different parts of the model.We also connect to other model-based systems engineering methodologies to automatically build the diagnostic models from the design information that is already encapsulated in existing models.

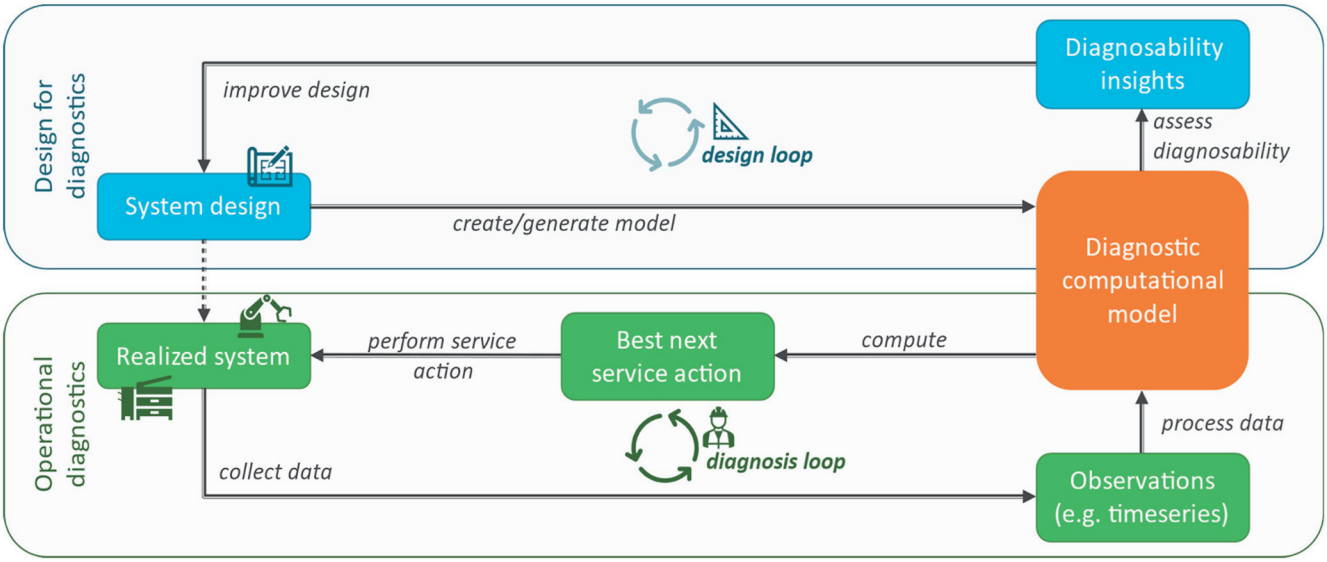


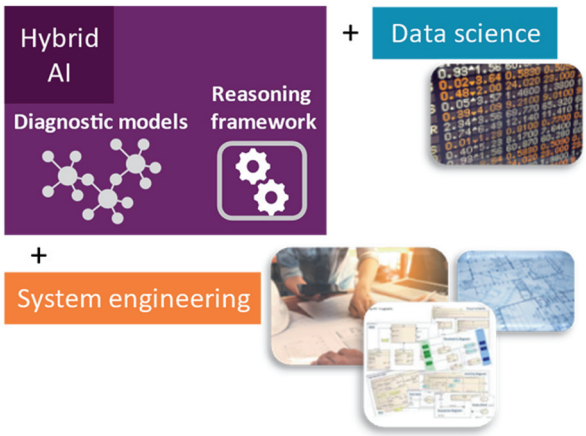

Figure 1 The diagnostics model is central in the workflows both during system design and operation.

Diagnostic models and a probabilistic reasoning framework based on Bayesian networks are at the core of the methodology. The diagnostic models are derived semi-automatically from design artifacts. The reasoning framework allows for computational analyses.

During the design of a system, assessing the diagnosability of a system is a complex task. Such a task is currently often human-centered and review-based. By using a model-based approach the failure observability can be derived algorithmically and the degree of diagnosability can be computed automatically. This analysis provides valuable input in the exploration or sensor placement during the design.

The generic nature of the methodology allows for application in many different fields in the high-tech system landscape. The application of the methodology in several case studies in the high-tech industry created positive results and further development.

Figure 2 Our methodology uses Hybrid AI, combining techniques from system engineering and data science.




## Guiding the service engineer

Once the system is in operation, the methodology provides assistance for the service engineer. The diagnostic reasoning uses logged data from the running system and the design knowledge that was used to construct the model. Based on the data logged by the system, the model computes the next best service action, which can be a repairing or replacement action, or a measurement action to acquire new observations from the system. By iteratively adding new observations to the model, the model will guide the service engineer to one or more repair actions that need to be done to get the system back in business.