Article

History defines future progress

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Dr. Dirk Ortloff

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Dr. Ortloff discusses a measure by which the high-tech manufacturing industries can help shorten the development time of manufacturing technologies, make development more sustainable, save money and cushion the economic downturn by Covid-19. Much of what is needed to achieve this has already been learned and developed in previous crises. It is important to use this experience and to translate it into appropriate measures to meet the current challenges.

In this article you will read about how comprehensive, centralized knowledge management can foster innovation and improve the resilience against knowledge loss and inaccessibilty of R&D organization in preparation for crises and knowledge drain.

1 Introduction

It is no secret that the semiconductor industry has suffered in the first quarter of 2020, with a 3.6% drop in sales compared to the previous quarter, according to the SIA figures [SIA 2020]. Moreover, the full impact of Covid-19 is not even visible in these figures. Furthermore, the declines are in part very different from region to region. For example, semiconductor manufacturers in Europe are particularly hard hit, with declines of over 10% in some cases. Innovation, and not just cost savings, is essential, especially in difficult financial times. Now, more than ever, new information management and analysis strategies must be implemented to meet the challenges of developing high-tech manufacturing processes. The use of intelligent software support is one possible solution and offers many advantages. However, important development information and important knowledge can get lost in the ocean of collected data, as shown in Figure 1. Therefore an intelligent solution for digital transformation in engineering must be applied.

Figure 1: The search for knowledge often resembles the search for the proverbial needle in a haystack [Troscianko 2020]

2 Market pressures

Shortening the time from the product idea or manufacturing invention to the market launch and reducing development costs are crucial for all companies. This is particularly true for high-tech industries, which are suffering from the current economic climate. The main challenge for engineers is that new technologies are becoming increasingly complex and at the same time have to be developed in a much tighter timeframe at an increasingly competitive price. Over the last twenty years, the emphasis has been on reducing cycle times and, as a result, the widespread use of various statistical tools such as “Design of Experiments”. These have helped to keep up the pace, but there are physical limits, and the semiconductor industry in particular is fast approaching them. One symptom of this is that the famous “Moore’s Law”, i.e. doubling the number of transistors approximately every two years, seems to be unattainable. If we want to remain at least very close to the rapid developments of the past or to benefit from the ever more intelligent and yet cheaper silicon chips, new methods,

new technologies and new materials must be used to overcome the next hurdle or make the next innovative leap.

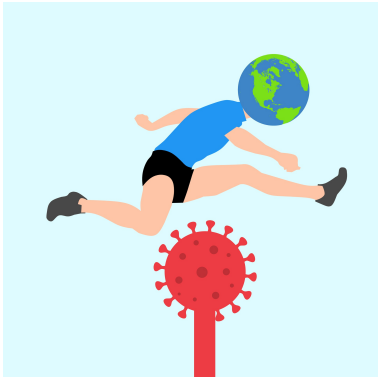

Figure 2: Overcoming the current Covid-19 hurdle to make the next innovation leap

The development methodology of silicon-based technologies has obvious room for improvement, e.g. by better sharing and reusing existing knowledge, by further reducing the number of experiments to be performed through methodologies such as systematic design of experiments, and by simulating the remaining experiments first instead of performing them physically immediately. In this sense, a more thorough planning together with the additional use of new methods can reduce the time needed for prototype iterations and the use of valuable resources. Furthermore, this approach opens up the possibility of a more sustainable development in terms of the Sustainable Development Goals.

The pandemic crisis currently requires, as in previous crises, that we strive for the lowest possible development costs, yet still bring innovations to the market. We need to establish new approaches to collaborate due to the limited availability of colleagues. These requirements are easy to understand, but difficult to achieve within tight time frames and without the use of additional methods and tools. In addition, the complexity of technology development is increasing day by day. More technology options, more material and supplier options make the development tasks even more complicated. The interruption of supply chains by the current pandemic situation increases the pressure and could imply the need to change material systems, to choose other suppliers with different characteristics and thus to implement new manufacturing approaches extremely quickly.

Since I became aware of the problems resulting from collaborative knowledge management that needed improvement, I tried to find a software product to solve these problems in the early 2000s. However, there was nothing that offered an end-to-end solution for accelerating technology development and providing companies with tools for improved collaborative learning and controlled knowledge sharing. So, more than a decade ago, we founded Process Relations GmbH to address this problem by looking at ways to limit the number of experiment cycles required to make a manufacturing process work. We also focused on more effective information & knowledge gathering, sharing it effectively to increase the efficiency of R&D departments and entire innovation systems.

The solution we have developed is a specialized software named XperiDesk of the type Process Development Execution System (PDES) [**Wikipedia** 2020b]. Tools of this category can accelerate technology development and thus reduce costs by following three basic rules: better sharing and easier reuse of existing knowledge, learning in other ways (e.g. first through simulations and then through experiments) and gaining more information & knowledge from the experiments performed.

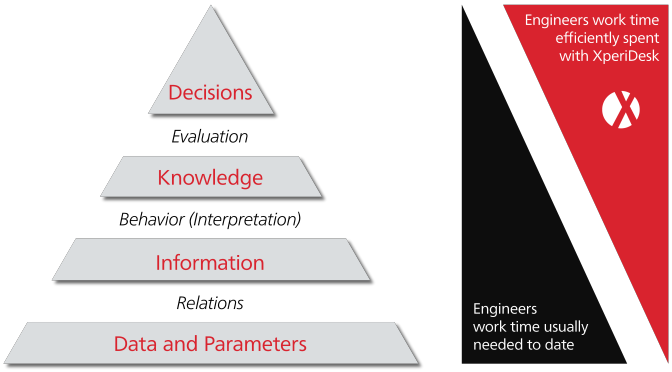

Figure 3: The knowledge pyramid and the distribution of engineering time before and after the introduction of a PDES

3 Know what you know

Once you have learned something before, there is no point in learning it again. However, the required knowledge is not always readily available when it is needed. This becomes more and more visible right now, because a lot of knowledge of companies is not or insufficiently documented or only exists in the heads of engineers. Since many engineers are not personally accessible at the moment but work in their home offices, access to existing knowledge is currently much more difficult. Data, information and knowledge (see Figure 3) should be exchanged between individual engineers and teams, even across locations and companies, so that everyone can learn from this accumulated knowledge. Given the complex supply chains of today's global economy, sharing across the entire supply chain becomes even more important. In difficult times, success is based on collaboration and flexibility in the innovation ecosystem. In mass production, this was made quite clear by the blocking measures due to the Covid 19 pandemic. But the same is true for technology development. The necessary flexibility in the innovation ecosystem can be achieved with a PDES. Software systems in this category structure data into information and make this information and the underlying data easily accessible; this avoids the need to conduct experiments that have already been conducted in the past or by another ecosystem partner. This saves companies valuable time, money and material resources.

Once the experiments are properly planned and defined, optimized and performed, the benefit of the results obtained can be maximized. Historical knowledge, information and data must be recorded and exchanged, otherwise the mistakes of the past will be repeated. It is essential to document everything - every idea, every project, every experiment, every meeting and every conclusion. It is of particular importance to document results that look like "failures" to the outside world. Because the only way to learn something new or become better is to prove that your assumptions are wrong by "failures". If the documentation and retrieval of historical information can be carried out easily and successfully, engineers can draw optimal results from the extensive collection of data, information and knowledge. New and existing information can be correlated and this way new knowledge can be revealed. For example, a PDES can create a semantic network of information that not only benefits current developments, but will also be useful for future technological developments.

As soon as the testing and development process was completed and the first prototypes were

successfully produced, a Manufacturing Execution System (MES) [Wikipedia 2020a] was to be introduced for production in order to provide extensive support for the production process. However, an MES is only as effective as the handed over experiment and production plan. If the program and the factory are cluttered with unnecessary experiments, the cycle time will inevitably increase. One of the main advantages of implementing a PDES system such as XperiDesk is that fewer experiments have to be carried out in parallel with production, thus relieving the burden on the production control system and the factory. It also significantly improves collaborative learning and knowledge management within the company. As a result, it releases valuable resources, saves money and makes research and development more sustainable.

4 Remember what you have already learned

As history teaches us, we must learn from the past to move forward. I remember a project where we worked with a major development organisation. One of the senior engineers of a parallel, traditionally organized multi-million dollar development project left the company. Most of his work documentation was in his lab book. The problem was that it was written in Kanji, so it was not easy to use for an organization in the US. Unfortunately, this development project failed in the end due to the missing or hard to find information. If the results and conclusions of the past are not properly documented and passed on, this will prevent future, potentially successful projects or reduce the speed at which we can move forward.

This experience applies to the development of many different technologies. The introduction, training and systematic use of new methods and software systems to improve collaboration and collaborative knowledge management will result in better, faster and less costly technology development cycles. This may be one component in overcoming the crisis triggered by Covid-19.

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