Icos Insight:

Predicting operational issues,

optimizing operations and reducing environmental impact of the industry

Icos Capital's view on market potential, scale-ups in this field and developments up to now

1 page summary. This report summarizes the research conducted by Icos Capital for its limited partners and corporate partners

Predictive maintenance ("PdM") is a set of techniques helping to assess the condition of in-service equipment and determine when maintenance is needed. The goal is cost saving over routine or time-based preventive maintenance, as maintenance tasks are only performed when required.

Predictive maintenance has existed mainly in oil & gas, power, especially wind energy, and aerospace sector so far. The most common technique applied is so-called "condition monitoring" for critical assets where vibration, use of oil, thermographic or ultrasound analysis is monitored as an indicator to potential problems. The goal is to identification (potential) problems and fix them before they can disrupt critical processes. Other key benefits include elimination of unnecessary maintenance tasks; reduction of replacement cost and unplanned downtime; and extension of asset life.

Major research and consulting firms are projecting substantial growth for predictive maintenance markets, including one study by Roland Berger projecting it to be an €11 billion market by 2022. According to this study, the key technologies to drive further growth such as IoT, machine learning and industrial automation are already in place.

Icos has reviewed 110 propositions in this market in 2018. We consider this market interesting and potentially attractive but not yet at fast growth stage. The vast majority of propositions are still in early growth stage with large IT corporations not getting it right as yet and waiting to acquire early market leaders. At the same time, firms like IBM, GE have developed platforms for startups and corporates to build on it.

The leading propositions we are witnessing so far, are mainly software oriented and allow for scalability across processes, factories and across industries. However, plug & play or quick configuration solutions, including for complex industrial devices essentially do not exist because data alignment takes substantial effort and time. Today, this seems to be the biggest challenge in this field, not only for predictive analytics but, generally, for almost all Artificial Intelligence ("AI") driven solutions.

Despite the early stage of this market, we have witnessed several exits and acquisitions already. With AI driven solutions in early growth stage, access to AI talent seems to play an important role in such M&A activities. In medium term, we expect to see leaders emerging that are targeting specific industries with tailored product propositions to deal with complexity of various industrial processes in different industries. The leaders in this sector will be well positioned for 100 M € plus M&A transactions when they have industrial offerings that can be implemented quickly and are backed by success stories.

About Icos Capital

Icos Capital is an independent Venture Capital firm that invests in enabling software & technologies firms in early growth stage in Europe in areas of industry 4.0, (bio-based) chemicals, AI / big data, food technology and other innovations targeting the manufacturing sectors and specifically the Agri-food & Chemicals sectors. Icos Capital has close collaboration with leading corporates in these sectors including Swiss based Bühler Group, Dutch cooperative Royal Cosun and specialty chemicals firm Nouryon.

What is predictive maintenance

Predictive maintenance ("PdM") is a set of techniques helping to assess the condition of in-service equipment and determine when maintenance is needed. The goal is cost saving over routine or time-based preventive maintenance, as maintenance tasks are only performed when required.

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The Manufacturing industry is interested in adopting this approach as well and move from reactive and planned maintenance to a more predictive and preventive approach.

As more sensors are embedded into machines, and more data is being collected from these sensors, there is scope for better predictability by better understanding data generated from sensors. With machine learning or artificial intelligence, it should be possible to learn about the behavior of machines and systems and then improve predictions on their future behavior as well.

The next generation solution in Predictive Maintenance is prescriptive analytics that allows for running different scenarios with changes in operational settings in order to determine what scenario leads to better planned maintenance approach.

Market expectations

Major research and consulting firms are projecting substantial growth for predictive maintenance markets, including one study by Roland Berger projecting it to be an €11 billion market by 2022. According to this study, the key technologies to drive further growth such as IoT, machine learning and industrial automation are already in place.

Another report, published by CXP Group, focused on Predictive Maintenance trends in Europe, quoted GE Digital validating that "investment in predictive maintenance initiatives creates tangible ROI. Our customers have reported metrics such as 2-6% increased availability, 10-40% reduction in reactive maintenance and 5-10% inventory cost reduction, to name just a few. This translates not only to huge reduction of costs, but the opportunity to exploit new business models." The study further mentioned that 93% of companies described their maintenance processes as not being efficient enough and about 55% of these companies are running pilots.

Leading strategies

Two primary strategies are currently being deployed are holistic data approach of condition monitoring, looking and learning for anomalies in time series and often AI-driven, and system modeling approach. The system modeling approach tries to model normal behavior of systems and alert when systems deviate from the "normal" – this is not AI-driven. Condition monitoring is all about measuring signals from specific sensors / IoT and then predicting issues in particular equipment on the basis of anomalies detection. These can be thermal, acoustic, electricity or other mediums. Equipment makers like Siemens, ABB and GE have traditionally implemented such solutions in their machines in the past. However, scalability of such approach, from machine to process and from process to factory, is an important concern.

Within the system modelling approach, there are three types of approaches to model "normal behavior" of machines, processes and factories:

- Empirical modelling: building insight from historical data from assets
- Physics-based modelling: leveraging insight on how assets ought to behave
- Experience based: using aggregated data from similar assets and analyzing them with the help of deep learning or other smart algorithms.

Our frame of reference

In evaluating the market spectrum, we have engaged with our corporate partners to identify key features / functionalities that we believe to be required by manufacturing sector customers. The most important considerations are the following:

1. Solution ought to focus on processes rather than devices / machines. This is required because factories are obviously connected all over and one part of the factory can easily impact performance on other part. So essentially, data collection should be comprehensive and across the process.

2. Solutions need to be scalable across processes and factories rather than being point solutions. This is often an issue with condition monitoring solutions or hardware driven solutions. Also, historical data driven solutions can be limited by existing data, which is often problematic in this approach.

3. Solutions have to be accurate and timely. Predicting a problem to happen far enough before it actually occurs, is essential in the concept of predictive maintenance. There must be enough time left to make meaningful actions in response to such predictions. This is often an issue in complex and critical processes where testing potential issues is not an option. Data driven systems can run scenarios and models but they need to be proven with data that is often now available.

4. Solutions need to include adequate data management. While sensors and systems in principle provide accurate data, internal business practices might not be optimal to ensure accurate data management.

5. Solutions for monitoring systems need to be continuous and continuously learning to adapt to changing environment and generate new insights.

Big players in the market

IBM: The Watson IoT Platform can serve a broad range of advanced IoT use cases. However, some reports indicate that Watson is not yet well integrated with analytics engines. It remains a platform that requires substantial application / systems to be developed on top for it to be valuable for customers.

GE: Predix enables remote monitoring and advanced predictive and edge analytics. It has functionality to develop digital twins of physical systems allowing customers to test new capabilities of connected assets like wind mills and airplane engines.

Microsoft: This offering includes preconfigured solutions for predictive maintenance and remote monitoring to help customers implement IoT solutions efficiently.

Other major software firms such as SAP and also engineering firms like Siemens have also introduced predictive maintenance solutions.

The biggest name in this category to emerge from scale-up spectrum is Uptake, a US based unicorn. Uptake is using AI to analyze data and build predictive capabilities by tapping into equipment sensors and even hand written maintenance records.

Finally, IT consulting firms are extensively engaged in building custom predictive analytics systems. This is also where most revenue is generated for now.

Relevant propositions reviewed by Icos team

Icos Capital reviewed over 110 propositions in predictive maintenance.

Total companies, out of which:	**110**
European / Israeli firms	68
Early stage / early growth firms	57
Firms with proprietary technology / appliances	13
Firms with condition monitoring mainly	14
Other firms (IoT)	14
Serious predictive maintenance propositions	29
Very early stage	5

Since customers mainly works with complex and multiple devices and interdependent business processes, the need is mainly for scalable solutions that can adapt to different devices, with own or third party sensors / IoT. The solution should also be capable of working across multiple industrial processes. We found limited number of solutions that can measure up to this requirement.

We also noticed that very few companies have industry specific solutions that seem to be required by potential customers.

The leading propositions are mainly focused on AI / deep learning. However, most companies with strong solutions along this approach are still in quite early stages of development and have only limited market penetration.

The ideal solution in the eyes of most customers in the Manufacturing are plug & play or quick configuration solutions, including for complex industrial equipment and processes. However, such solutions essentially do not exist today as data alignment usually takes quite long time. This seems to be the biggest challenge in the market, not only for predictive analytics but also for most AI driven solutions.

There are, however, several startups quickly adapting to customer demands, working closely with industry specialist parties to realize market leadership. We expect this market to quickly develop in the next couple of years with leadings realizing €5-10 in sales.