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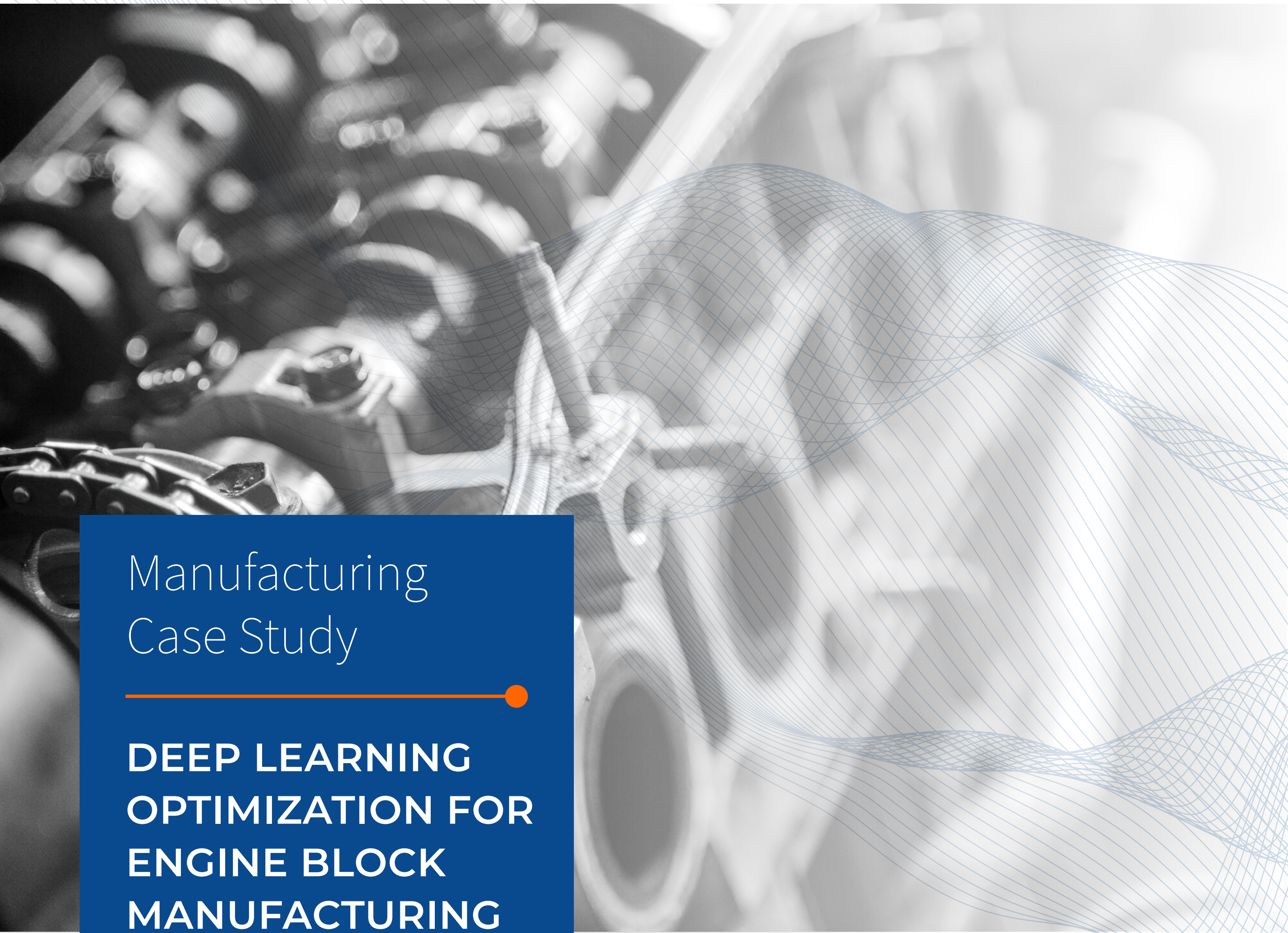

Manufacturing
Case Study

DEEP LEARNING OPTIMIZATION FOR ENGINE BLOCK MANUFACTURING

INTRODUCTION

Our client is a world-leading foundry with a presence in over forty countries across two continents. As the world's largest manufacturer of cast iron engine blocks and cylinder heads—they supply globally for the commercial, agricultural, and heavy vehicles automotive industry.

This industrial's manufacturing processes range from sand molding, core making, pouring, finishing, and — if required — the machining of the component parts produced. Our customer works with cast iron alloys like gray and ductile iron, but also with next-generation compacted graphite iron (CGI), which it has mastered the utilization of. Their one industrial plant alone has a melt capacity of over 400 thousand metric tonnes annually.

Seeing the potential value of AI to further enhance process control to reduce baseline scrap, our client acquired DataProphet's services through a partnership with Kaitronn, our representative for Latin America.

THE CHALLENGE | **REDUCE BASELINE SCRAP**

Despite the highly sophisticated equipment of advanced foundries, an extra competitive advantage with respect to production capacity can be elusive. This, in large part, is due to the sheer weight of information process engineers now have access to, which they must parse in order to choose an ideal from millions of possible plant setpoint combinations.

As a demonstration, DataProphet agreed to target a couple of products upon their horizontal mold line producing in the order of over 5,000 engine blocks per week. This production pipeline is composed of three feeding sections producing Cores, Molten Metal, and Molds, respectively.

Production quality in foundries is truly measured by monitoring the scrap produced during normal production. The objective of our installation, therefore, was to discover an optimal production paradigm and to generate enhanced control plans for plant operators. If successful, the executed control plans would deliver more optimized production output for the products on the line. The result would be consistently less generation of scrap for both products.

TECHNICAL CONSIDERATIONS FOR THE **MANUFACTURING CONTEXT**

External defect reporting is, by nature, slow and unreliable. As such, we would need to account for the source of as many internal defects as possible during the extraction and parsing of industrial data—this way, optimal parametric prescriptions could be generated to proactively reduce internal defects. On this point, however, it was also born in mind that DataProphet had previously confirmed strong correlations between internal and external defect rates in the foundry space.

DataProphet PRESCRIBE, our AI-as-a-Service solution, seeks to reduce defects through the optimization of process parameters. Its deep learning models are able to parse vast quantities of process data pertinent to a manufacturing line, along with the line's associated rolling average defect rate. In our client's case, such raw process data was available for green sand preparation; core sand preparation; core painting; furnace control; chemical composition; metal transfer ladling; mold production; mold painting, and pouring.

Process-caused defects can be avoided with our contextualized prescriptive analytics—by pre-emptively recommending changes to production parameters. This is not the case for operational defects. A related and equally important consideration for our AI-driven deployment was, for this reason, to prune away non-process-related defects from the equation. Thus, defect types included in the scope that were not related to the line's processes were excluded from the service. Additionally, it would be necessary to factor in the subset of defects that could be either process-related or operation-related (e.g., a broken core, or excessive paint on a mold).

Finally, due to operational constraints, it is often not possible to shift the entire production process to a new control plan immediately. To address this problem for our client, PRESCRIBE would need to provide operators with actionable insights to move towards the BOB (Best of Best) operating region systematically —a few rank-ordered process parameter prescriptions at a time. This way, an optimal control plan could be achieved as quickly as possible while not interfering with production.

THE SOLUTION
TRACING THE PROCESS

DataProphet PRESCRIBE AI algorithms learn the interactions and interdependencies between industrial processes and their parameters. The AI works by sculpting low-dimensional representations of complex, high-dimensional production data. For the purposes of this installation, DataProphet integrated with our client's quality database—to obtain logs of historically scrapped engine blocks on the line, together with a breakdown of defects.Historical process data were obtained via the Kaitronn IP system's database, as well as from a few of our client's own industrial sources.

An exhaustive list of over fifty process-caused defects on the line was generated. The list included porous core; hot fracture; swelling; leakage; deformation, and chemical composition deviance.

For processes upstream from the molding line, DataProphet implemented a software traceability solution. The objective was to track sand cores from the core shop to the molding line. The solution allowed for a reasonably estimated time window around each process step, as well as expected delays between process steps.

Next, we produced a dataset from a historical time window linking every individual engine block on the line to its relevant process parameters. Additional engineering was performed to enhance the provided data—this included the removal of anomalous values; the creation of new features, and several methods for the handling of missing data. The final training set consisted of over 150 thousand engine blocks, each with greater than 70 process parameters.

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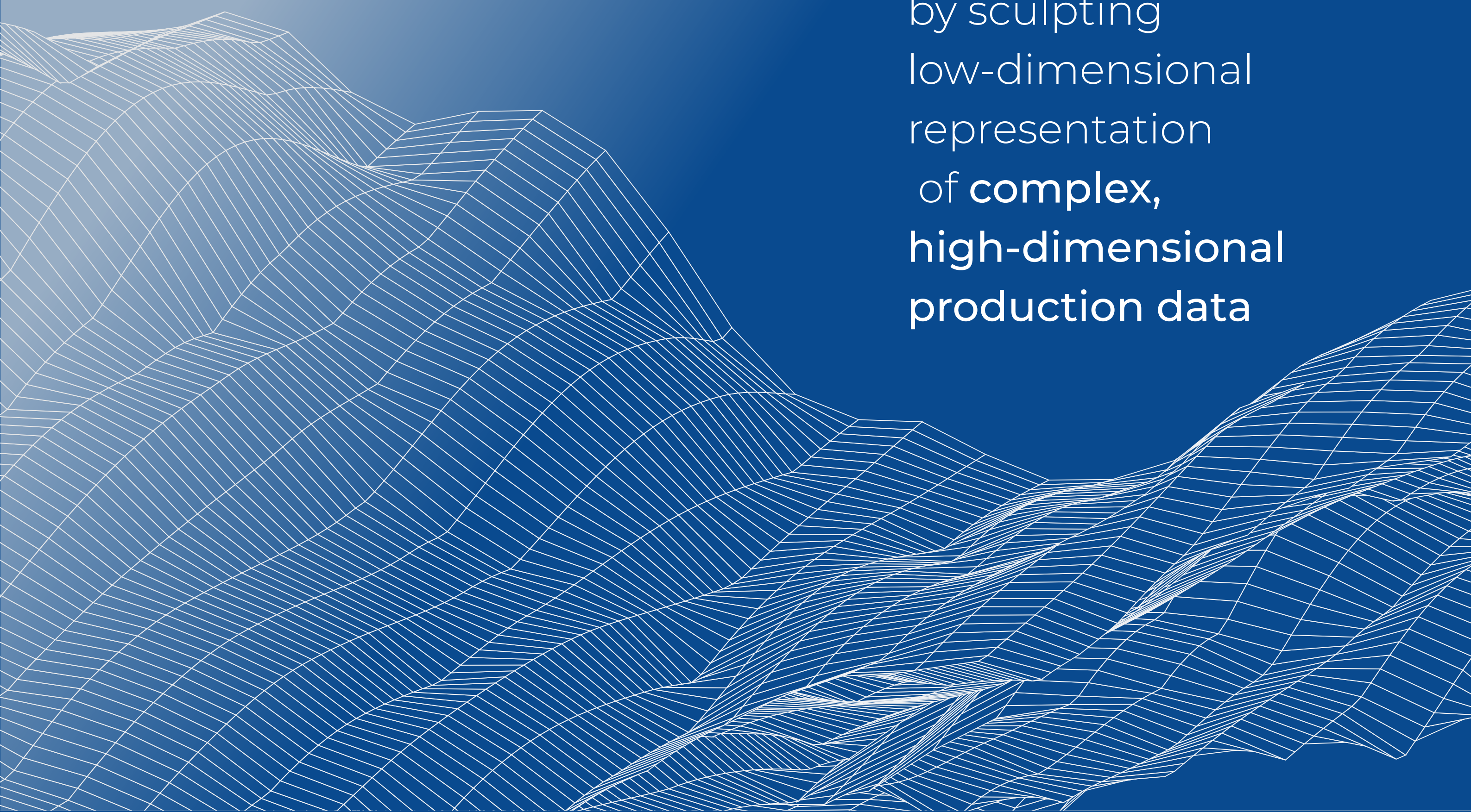

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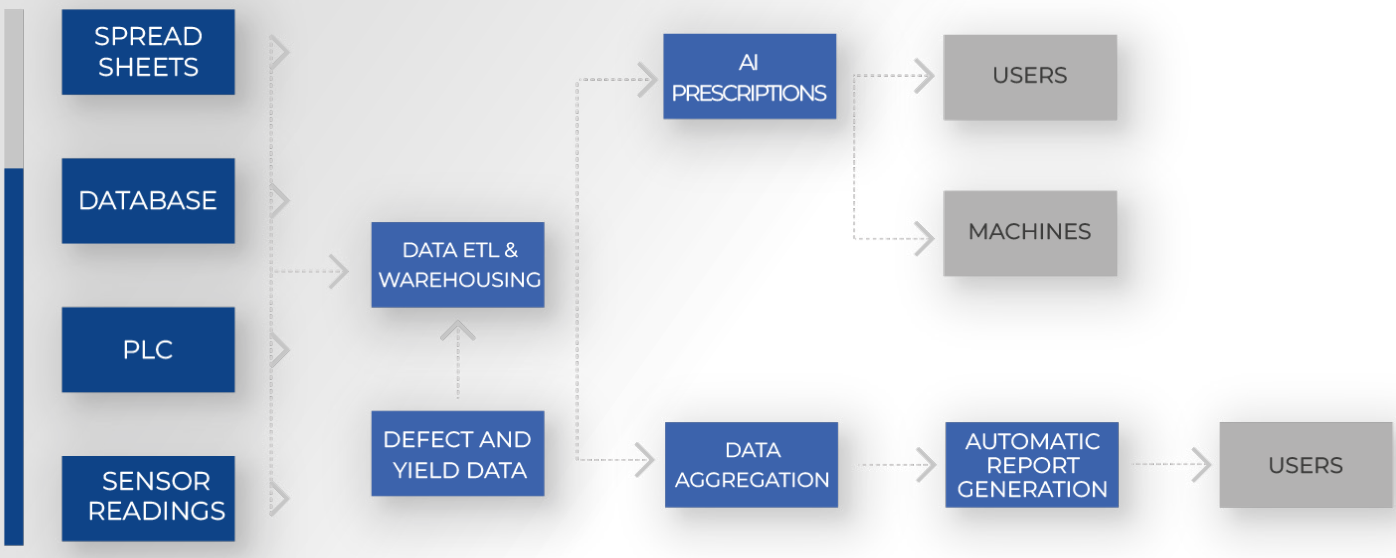
THE SOLUTION
PRESCRIBING THE BEST-OF-BEST (BOB) REGION

Given the set of process-related defects, we investigated production quality in the different operating regions that our AI identified. DataProphet's algorithms discovered a region that corresponded to historical production—where both a low defect rate (quality) and a sufficient number of blocks (density) were observed. However, an alternative high-quality cluster also had to be targeted, without violating any operational constraints of the isomol parameter from the sand core painting process.

For the purpose of the demonstration, a focused set of key modifiable process parameters was targeted. Viable BOB regions having been identified according to the agreed parameters for the two products on the line—a non-disruptive path to an optimal control plan was laid. This path was based on ensuring production parameters were kept within the ranges our machine learning analytics prescribed. The commissioning test was performed over a two-week period. Below is an example of how DataProphet PRESCRIBE ingests live and historical data from multiple sources—and generates prioritized AI-driven prescriptions for users to enact.



THE **RESULTS**

The rank-ordered, pre-emptive insights for process parameter adjustments were delivered via the PRESCRIBE web interface, configured for our client as part of the installation. The front-end listed optimal parameters in a sequence to guarantee the actual largest step towards the BOB region. This rendered the insights actionable for operators and enabled them to focus on only a few parameters at a time—as they navigated during production from the current suboptimal operating conditions to operating conditions within the BOB region.

The objective of our client commissioning test was to evaluate the impact of the DataProphet prescriptions on process-caused defects for the line. The statistical validity of this test was calculated with a Mann-Whitney U test. The 95% confidence interval satisfied us that the pre-test conditions were similar to those during the test.

THE KEY RESULTS OF DATAPROPHET PRESCRIBE FOR OUR CLIENT'S COMMISSIONING TEST WERE AS FOLLOWS:

- **CORRECT IDENTIFICATION OF OPTIMAL PRODUCTION PARADIGMS** GIVEN AGREED-ON CONTROLLABLE PROCESS PARAMETERS.
- PRODUCTION CONSTRAINTS **SUCCESSFULLY ADAPTED TO.**
- **OPTIMAL, ACTIONABLE PRESCRIPTIONS** EXTRACTED FROM THE IDENTIFIED PARADIGM.
- ENGINEERS GUIDED TO REDUCE PRODUCTION VARIABILITY **—TO CONTINUALLY SUSTAIN OPTIMAL PRODUCTION CONDITIONS.**
- A **55% REDUCTION** IN **DEFECT RATES.**

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