Evaluating Different Maintenance Policies Through A Digital Copy Of The Manufacturing Process

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A global player
Business Integration, Consulting, Outsourcing, Products & Solutions

Management Consulting
unit of the Engineering Group

We help customers improve their
Decision-Making Process

Our distinctive approach is
Modeling & Simulation

50
Offices worldwide

9,000
Professionals

9%
Market share in Italy

1,000
Large accounts

934.6 MM€
Total revenues
SELECTED CUSTOMERS

- gsk
- Chiesi
- Pfizer
- Typer
- RFI
- Trenitalia
- Prysmian Group
- JRC
- Banca d'Italia
- CNH Industrial
- Mopar
- M/Y Montecarlo Yachts

ACADEMIC PARTNERS

- Università Cattolica del Sacro Cuore
- Università Bergamasca

TECHNOLOGY PARTNERS

- The AnyLogic Company
- AnyLogic
- anyLogistix
The project | The customer

Agricultural & construction equipment • Trucks • Commercial vehicles • Buses • Special vehicles • Powertrains for industrial and marine applications

Global leader
In capital goods

63,000 employees

64 manufacturing plants

43 R&D centers

180 countries presence in

12 brands
Iveco, New Holland, ...

Exor
The project | The background

• Manufacturing processes are becoming increasingly digital, in accordance with the new trend promoted by Industry 4.0, commonly referred to as the fourth industrial revolution.

• In this context, companies are looking for technologies that enable the transition towards the concept of smart factory:
  - **modular structured factories, within which cyber-physical systems monitor physical processes, create a virtual copy of the physical world and make decentralized decisions.**

• As a big player, CNH Industrial wants to exploit benefits from the advent of digital solutions and identified maintenance processes as a promising area where to start considering the introduction of **Digital Twin** capabilities.
The project | The challenge

- The challenge was to prove the benefits of in silico experiments as a tool to make informed decisions, in the maintenance field.

- We proposed the realization of a **prototype**, conceived to reproduce the functioning of a manufacturing line and return key performance and financial indicators about the potential added value of investing in new generation maintenance policies (e.g. predictive maintenance).

**Business requirements:**
- Capability of testing different maintenance policies for welding guns:
  - SCHEDULED MAINTENANCE
  - CONDITION BASED MAINTENANCE
  - PREDICTIVE MAINTENANCE
- Capability of testing maintenance policy resilience to different production plans.

**Project boundaries:**
- Focus on a single manufacturing line, dedicated to the application and welding of the body of **Iveco Daily vans**.
- Modeling the operation of the main buffers and stations of the identified line.
- Modeling of the most critical robots (**welding guns**) of each identified station.
The project | Why the focus on maintenance? (1/2)

World Class Manufacturing – WCM

• WCM is a road map to continuous improvement, plotted through the elimination of waste, whether it be time, quality or material.

• The objective of zero defects, zero failures, zero accidents and zero inventories aims at a general reduction of the costs of the plant.

• The main driver of WCM is actually **cost deployment** → issues are addressed on the basis of their economic impact.

• To certify improvements, a system of periodic audits evaluates a selection of WCM pillars, forming an overall score for each plant (three achievement levels: Gold, Silver and Bronze).
The project | Why the focus on maintenance? (2/2)

• Failures lead to downtime and downtime lead to costs, both visible and hidden.
• It has been estimated that, in the automotive industry, **downtime costs** can amount up to **22k$ per minute**(*).
• Considering these figures, improving maintenance processes in order to reduce downtime can be a critical success factor.
• Moreover, it is important to identify the most critical areas, for which there is convenience in investing in more sophisticated maintenance techniques.

The project | Line modeled

Mascherone line of Suzzara Plant

- Entering the side components
- Entering the bottom components
- Automatic welding station
- Buffer
- Manual welding of roof components
- Automatic welding station
- Buffer
- Automatic welding station
- Buffer
- Automatic welding station

Electrodes
Lamellar pack
The project | The choice of anylogic®

Professional Agent Based Modeling

- Bring models from traditional areas (e.g. manufacturing) to a new level of flexibility and accuracy.
  - We opted for a pure Agent Based approach (even for describing a discrete process) in order to capture the unique composition and complex relationships of the entities involved with less effort.
  - No need to resort to heroic assumptions or tricky workaround to reproduce the customer heuristics.

Extensions and customization

- Create flexible models that fully configure themselves from external data source when they are run.
  - Production sequence, welding point per van type, robot life cycle curve and other data are imported from external sources and automatically red by agents at runtime.
  - Easily change the model structure by easily changing input data.

- Extend models with java.
  - No limits to model capabilities: if you can imagine it, you can do it.
  - Enhanced user experience, thanks to customized and intuitive GUI.

Model export and integration

- Export and deliver the model as a standalone java application.
  - Provide the customer with a tool that can be easily run on every machine with NO runtime license required.
The project | Agents modeled

**VAN**
- Van agents flow along the different steps of the manufacturing line.
- Every agent is characterized by a specific type (the type of van to be produced).
- Different types require different handleings (i.e. different lead times, different welding points etc.) and thus different types involve different robots.

**WORKING STATION**
- The manufacturing line consists in a sequence of working station agents.
- Each agent in the line receives the vans and carries out the necessary work depending on the van’s type.
- It is regulated by particular rules, that can be customized for each working station agent.
- It contains a specific number of robots, varying from station to station.

**ROBOT**
- Each robot agent is linked to a specific prognostic (PHM – Prognostic & Health Management) model, focused on predicting the robot degradation, according to usage, if no maintenance is performed.
- Pre-fixed thresholds on the degradation curve have been used to manage both failure events and particular maintenance policies (condition based and predictive maintenance).
- Prognostic models have been modeled starting from actual data collected by sensors.
The project | Predictive models

- Development of a methodological adaptive framework for the prediction of the evolution of the future degradation of the considered components and estimation of their **Remaining Useful Life – RUL**.

- Input: resistance is measured as degradation indicator.
The project | Innovative features

1. Connection:
Exploitation of data collected through sensors.

2. Digitalization:
Use of information to feed the Agent Based model and develop agent-specific prognostic models.

3. Intelligence:
Informed decision making, also powered by an embedded scenario comparison tool.
The project | The tool at work
The project | Benefits achieved

CUSTOMER PERSPECTIVE

The Control Tower prototype helped CNHi in increasing awareness on how to achieve Maintenance 4.0 potential benefits, in terms of:

- Economical benefit evaluation;
- Digital twin technologies awareness;
- Data awareness.

The three above areas generated further need of progress in terms of analysis, tools, processes and procedures, in order to gain more advantages and benefits.

While Maintenance 4.0 technologies are certainly highly promising, their actual benefits and ROI must be carefully evaluated taking into account the areas of benefit and potential sources of cost reduction (e.g. plant availability loss costs etc.).

FAIR DYNAMICS PERSPECTIVE

- Possibility of introducing anylogic® and the benefits of simulation to address some of the main issues related to Industry 4.0, trending topic in all of the main firms nowadays.
- More and more in-depth exploration of machine learning techniques (integrated with anylogic®), thanks to a successful and consolidated partnership with academic domain experts.
• Consolidation of the results provided by the prototype, in order to improve and extend its benefits to other manufacturing lines and enable CNHi to:
  • Identify an optimal data acquisition strategy (data collected through sensors), i.e. selecting the data to be acquired in order to improve the quality of the analyses without unnecessarily increasing the amount of data stored.
  • Estimate key performance and financial indicators to facilitate decision making process for evaluating maintenance strategies.
• Implementation of a cost deployment approach to effectively evaluate costs related to downtime events in the manufacturing lines. This should enable management to take strategic decisions on the necessary investments for the improvement of the line depending on the economic return.
• All these steps should take to the actual implementation of the so called Maintenance Control Tower, a multi-tiered framework combining Prognostic Maintenance and Simulation Modelling in a Virtual Production Lab where operations are evaluated and tuned in a continual improvement process by comparing actual, simulated and desired performances.
Thank you | Contact us for additional information

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