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Operations

IR2



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Introduction

IR2 is an Italian company that acts in the robotic market. It has been in business for several years and it's become famous for its quality level. The company was born having as its main objective the customers satisfaction. Following this objective, IR2 has become an important company on the national scene. The long-term goal is the expansion in the European market.

The products

IR2 actually produces 2 kind of robots for a domestic usage:

- Dolly: the robot vacuum cleaner
- Molly: the mop robot

These robots are very similar each other in terms of architecture, design and also have several mechanical/electronic components in common.

Currently on the market there are the line S, released some years ago and near to the end of its life cycle, and the line X, the spearhead of the company.

Dolly and Molly of the line X are more powerful, more accurate and smarter with respect to the line S. Of course, the production focus is on the last line released, but we are still producing a huge amount of product of the line S.

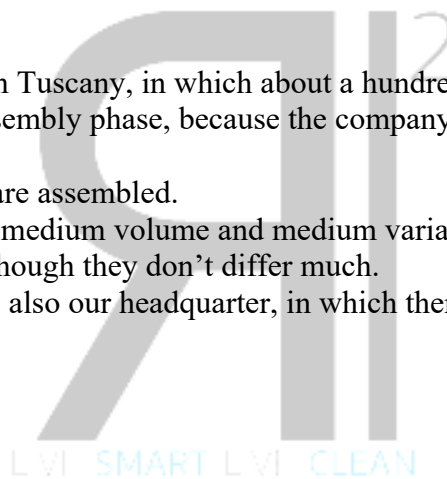
The activity

Our company has a factory based in Tuscany, in which about a hundred of people are employed. This factory deals only with the assembly phase, because the company has agreements with several firms for the supplies.

There both the two lines of robots are assembled.

Our production is characterized by medium volume and medium variability: because we have substantially 4 distinct products although they don't differ much.

Moreover, near the factory, there is also our headquarter, in which there is all our management, the R&D and our development team.



Product Flow & Layout

The production of IR2 is characterized by:

- Medium-High Volume: if we consider the market of domestic robots, our volume is not so high with respect to our competitors, because we aim to produce less but emphasizing the quality
- Medium-Low Variability: we produce 4 different products in terms of characteristics but the production is similar in several aspects.

Considering the previous statements, our company is in this situation:

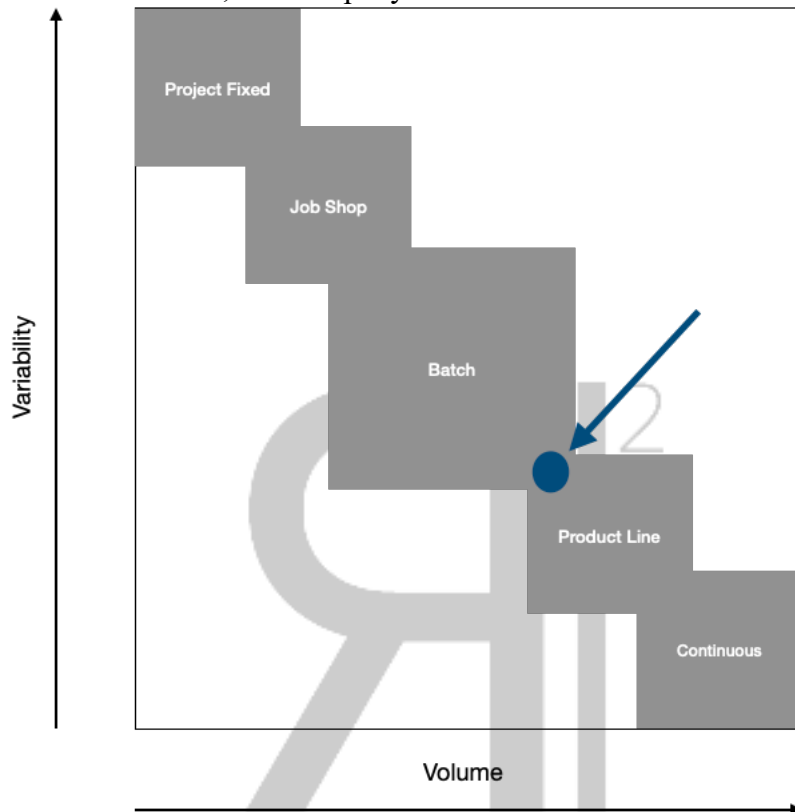


Figure 1: Volume-Variety Chart

So, we have adopted a hybrid between batch environment and line process: the group technology. The principle is that many problems are similar and by grouping similar problems, a single solution can be found to a set of problems, thus saving time and effort.

We can adopt this solution because there are some parts in the assembly phase that are very similar each other and use similar machinery, but we maintain a throughput higher than the batch process. According to this, the manufacturing of our company is organized in a Cellular Layout. The machines are grouped according to the process requirements for a set of similar items that require similar processing.

Workers in cellular layouts are cross-trained so that they can operate all the equipment within the cell and take responsibility for its output.

It's very often used in assembly phase.

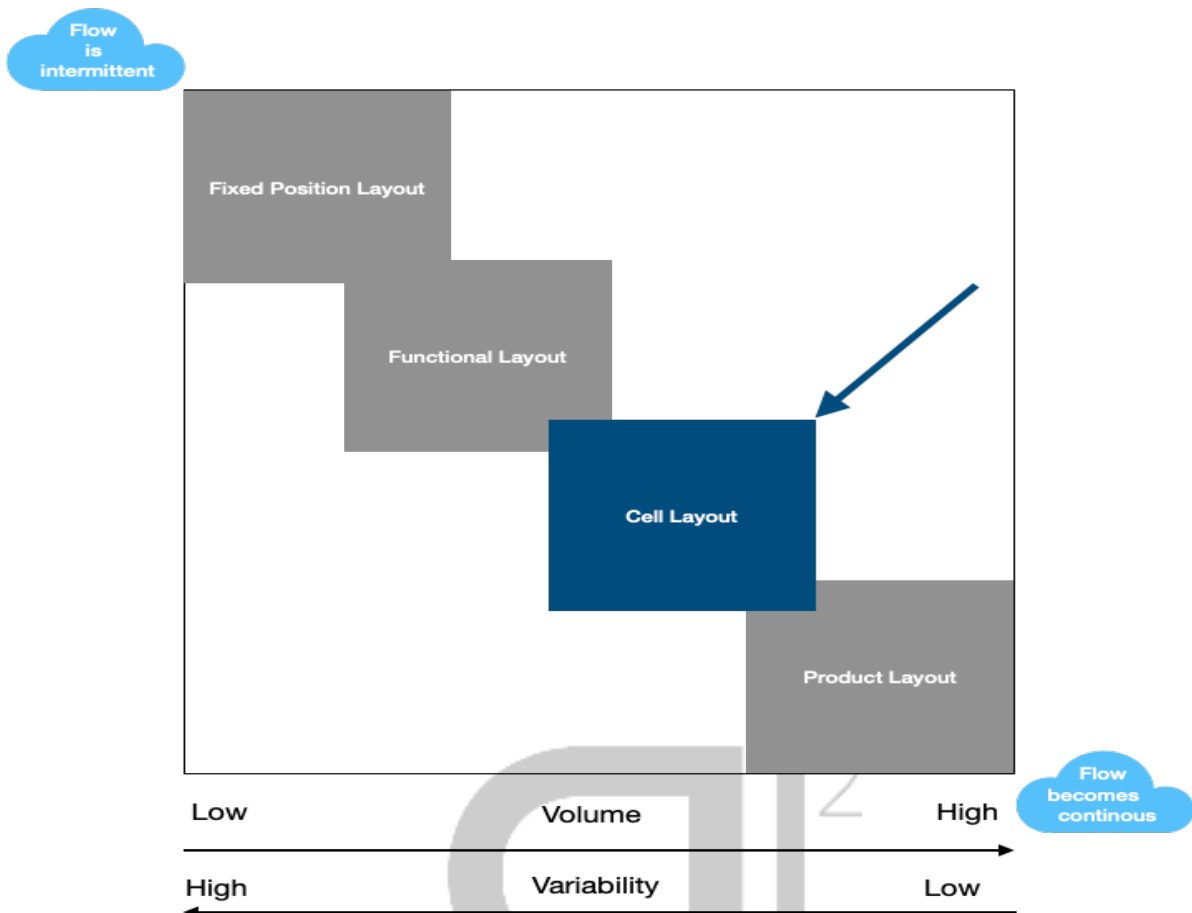


Figure 2: Layout

Production Details

Our machinery and our employees provide us to assembly up to:

- 3077 Dolly X per month (about 750 weekly)
- 2963 Molly X per month (about 750 weekly)
- 1846 Dolly S per month (about 450 weekly)
- 1778 Molly S per month (about 450 weekly)

The production is organized in 2 shifts of 8 hours. This means that the overall hours of work in a month are 320, if we consider a month composed by 4 weeks.

About 45 employees work in each shift, in each of which there are:

- 14 people which deals with testing
- 5 people quality responsible
- 2 people responsible of warehouse
- the others work on the cells

Planning of delivery

The delivery for the products destined to go to Mediaworld is monthly, while the ones destined to the customers that have bought in the website are delivered as soon as possible.

Mediaworld, as part of the agreement, books orders month by month, so at the beginning of the year, we do a production planning based fully on forecasted sales.

This forecasted sales take in consideration the forecasted orders of Mediaworld, based on the last year orders and other parameters to be as accurate as possible, and the forecasted orders on our

website. Month by month, as we receive the order by our main retailer, we update all the production plan for the rest of the year taking in consideration also booked orders.

Production Planning

Our production is based on a mixed plan: we vary both the production and the inventory tuning the capacity of our machinery. This choice was made in order to have the production a minimum flexible to the demand, keeping the inventory as low as possible.

On the other hand, we cannot be full based on the demand, because we want to vary the production by limiting ourselves to increase / decrease the work of the machinery, while not affecting the work of our employees. This line of thought comes from one of the ethical principles of our company: IR2 has a high regard for its employees and it knows that a succession of layoffs / hires can undermine the morale of the workers and can also be complicated because of the Italian legislation.

Master Production Scheduling

The MPS done for 2020 plan is in the attached document. We take in consideration only the forecasted demand for the reasons specified before.

Material Requirements Planning

The MRP done for 2020 plan is in the attached document. It's based on the following considerations:

- the lead time of the components is 1 week
- there is a security stock value for all the components: the orders are placed so as to have as far as possible the stock of each component away from zero.
- A large number of components are present in a single robot, for this reason some of that are aggregated in "mechanical components" and "electronic components"

Supply Chain

In order to assembly a robot, we need several mechanical and electronic components:

- Engine
- Wheels
- Frame
- Actuators (ex. Aspirator)
- CPU
- Motherboard
- Sensors
- Body
- Accessories (e.g. bags, brushes...)
- Battery
- Power Supply
- Other mechanical components
- Other electronical components

These components are provided by **external** suppliers. This decision was made taking into account that suppliers have specialized research and know-how: they can provide us very high-quality components. Moreover, we couldn't exploit well the economy of scale producing these components by ourselves. It's not convenient from an economical point of view and the future volume are uncertain: the technology evolves quickly, and the requirements can change drastically.

Instead the assembly is fully internal: it's a way to guarantee a higher quality of the product and we want to install and configure the software by ourselves, in order to keep the secret of its details and eventual limits.

Our suppliers

We can divide all our suppliers in the following categories, based on the supply:

1. Critical products: products that are in those markets in which the risk is very high, from the point of view of relationships and performances. As critical product we have the sensors, because we want to customize them and to obtain very good performances. Moreover, we need a high volume of this component.
2. Leverage products: our company needs a high volume of these, but the risk is quite low. We can consider the bodies as leverage products; we need high quantity and we want to customize them but there is high competition in this market, and we have more purchasing power than the supplier, so the overall risk is quite low.
3. Routine products: we have some of the suppliers from which we need to order low volumes, but the risk is quite low, because this firms have less purchasing power than us and there is a lot of competition in that market. Several mechanical components of our robots are routine products.
4. Bottlenecks products: those products can be very customized, difficult to produce, very specific. We need low volume of them but for the previous reasons, the markets are very risky. Several electronic components of our robots are bottlenecks products.

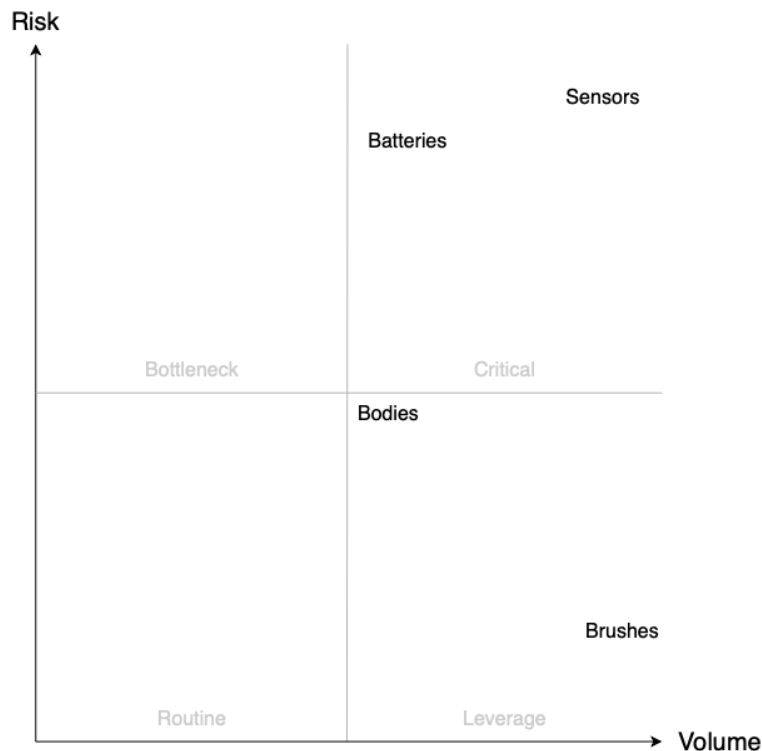


Figure 3: Kraljic Matrix

For the critical products there is a “one source” policy, we established very detailed contracts with:

- a company that produces very accurate sensors, this company is at the forefront in this field.
- a company that produces durable battery and the power supply

These contracts provide that the design phase of the pieces is shared between our company and them. In this way we can take advantage of the output that comes out of our research system.

We share the designing of the component also with the company that supplies us the bodies.

Vendor Rating Model

In deciding the supplier for each product, an evaluation model was built based on some parameters to which weight was attributed.

In particular, for the choice of the supplier for the sensors, the parameters used were:

Parameters	Weight
Quality	0,40
Price	0,1
Lead Time	0,2
Trust	0,30
1	

For the critical products the parameters and the weights are similar to the previous table.

For the leverage products the focus is more on the price and on the lead time.

Supply Development Policy

From the beginning, we made sure to build a partnership with the critical products suppliers. For this reason, we entered into agreements with companies that had long-term projects fairly aligned with ours. Moreover, over the years, we have aimed to direct their production more and more towards our needs. For the partners it was difficult because we have had also the necessity to act even in their interests.

Instead with the suppliers of leverage products, we tried to direct their production towards our needs in a more direct way, in order to:

- reduce lead time

- reduce costs
- increase quality

Research Institutes

Our company focuses heavily on research, we think constantly to the future. In order to pursue this scope, we have several agreements with different research institutes, especially in the field of the university. These institutes, as part of the agreement, do research on particular electronical or mechanical topics that are problematic for us. They organize teams that are in a very close collaboration with our R&D department. Together, they find high-tech solution to our problem and produce prototypes, design and report of their work.

This agreement gives us the advantage to be always ahead in the technology development and to have always the latest innovations.

On the other hand, this collaboration is very suitable also for the research institutes:

- we contribute economically to their researches
- we consent to researchers to present their discoveries in our stands during the most important exhibitions in Italy and Europe. This increase the popularity of their institute.



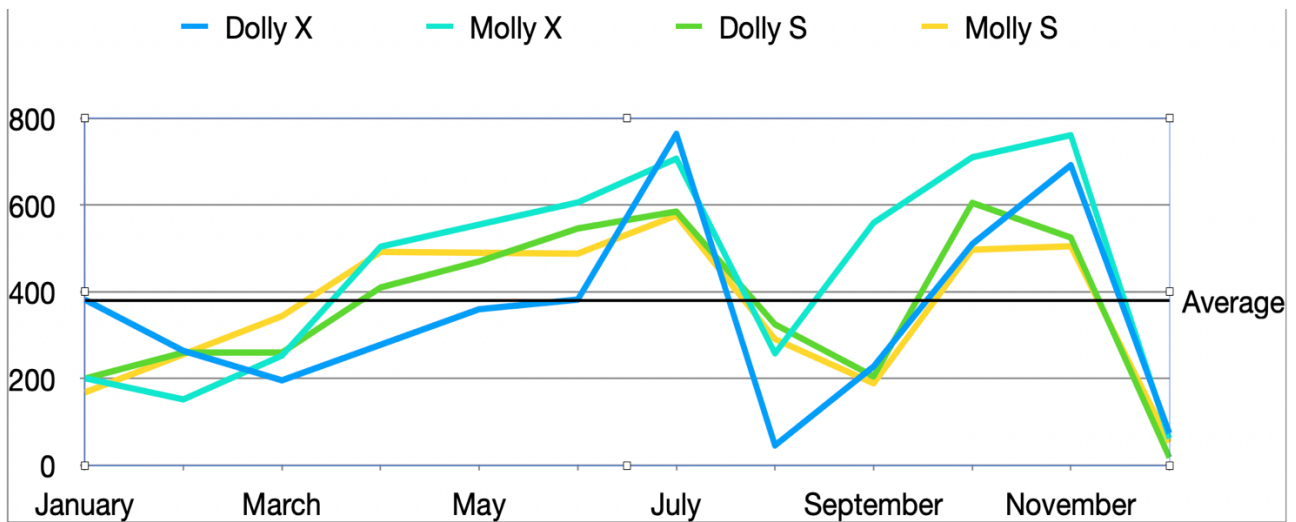
Inventory Management

IR2 keeps three types of inventory:

- final product stock
- half-processed
- raw materials

Final Product Stock

Here we can see the levels of the inventory forecasted during the 2020.



Final Products

	Dolly X	Molly X	Dolly S	Molly S
January	382	201	200	168
February	264	152	260	256
March	196	253	260	344
April	278	504	410	492
May	360	555	470	490
June	382	606	546	488
July	764	707	585	576
August	46	258	325	291
September	228	559	205	189
October	510	710	605	497
November	692	761	525	505
December	74	62	18	53

	Dolly X	Molly X	Dolly S	Molly S
Medium Stock	348	444	367	362
Medium Stock Value	114.380,64 €	141.271,92 €	98.717,51 €	93.931,15 €
Warehouse Rotation	94,61	58,31	37,92	31,31
Average Stock	4 days	6 days	10 days	12 days

For example, a Dolly X, is on average only 4 days in the warehouse.

These values are quite positive because:

- obsolescence is avoided
- the inventory level is kept low

Half-Processed Inventory

This inventory is kept very low because the productions cells are well balanced and a half-processed has to attend very few times between two different processes.

For this reason, we are organized to keep the half-processed very near to the next cell where they are going to be processed.

Raw Materials

Our suppliers have an average lead time of a week. There is a minimum order that is specified in the contract. Our supply-chain management takes under control:

- forecasted demand at the beginning of the next week
- booked order at the beginning of the next week
- predicted inventory at the beginning of the next week
- security stocks

Based on these parameters, they place the order minimum to comply the requests of the next week. In this way, the inventory remains as low as possible, but a security stock is always maintained. The average stock of raw material will decrease in 2020, according to the forecasting about the production.

Quality Control

IR2 is a company that has the quality of its products and manufacturing process as its main characteristic. IR2 improvements are focused on the customers' needs.

Our customers want robot characterized by:

- high accuracy
- smartness
- durability

The defects could rise up from poor quality of input material or software tests that do not verify all possible cases.

We have to ensure:

- high quality for input material
- an intensive testing phase for the software
- close to 0 defects in the assembly phase

Suppliers Quality Management

For each supplier, in the phase of integration into the development process we discussed about:

- our quality requirements
- the quality assurance system of the supplier

We have established all the phases, all the checks and the frequency of the inspections.

The inspections are more frequent for the suppliers considered "critical".

In the contract with the suppliers there is a detailed section about the penalties in the case of non-compliance with quality requirements.

In the contract with the suppliers, we have established two type of sampling plan:

- single sampling for the supplier less reliable: the entire order is sent back if it has the defect level in a sample batch higher than a threshold established by contract.
- double sampling for the most reliable suppliers: in this case, if a sample batch has the defect level higher than the threshold, another analysis, taking in consideration another sample batch, is done.

Internal Quality Management

Our company, and consequently all our suppliers, respects the ISO9001 standard.

According to this standard and to our philosophy we don't limit ourselves to keep this level of quality, but we do a great effort to increase it more and more.

Quality Assurance

In order to assure quality, our products have been projected with a robust approach: they are projected to be kept under control from the statistical point of view.

It consists in finding the right combinations of parameter in the project phase in order to make the production process insensitive to variation or to the influences of disturbing factors as much as possible.

This approach provides us products with:

- higher quality level
- higher flexibility in terms of improvement
- less control costs

Quality Assurance Metrics

Our company uses the following quality assurance metrics:

- Defect Severity Index: defects are divided in category and to each one is associated a weight.

$$Defect\ Severity\ Index = \sum_{c \in categories} \frac{number\ of\ defects_c \times weight_c}{total\ number\ of\ defecs}$$

We take under control this number and when it increases rapidly, we address it immediately.

- Defect Leakage: $\frac{number\ of\ customer\ found\ defects}{total\ number\ of\ valid\ defects}$

Quality Control

The quality control is done in critical points of the production process by specialized employees. They use check-sheets and control charts and when a defect is found they investigate in the source using the 5-whys analysis.

At the end of each day of work, they write up a report that resumes all the controls of the day.

If one day, the report underlines a highlighted non-compliance, they are able to communicate with the management to address the problem quickly acting on the source.

Testing

Despite all our effort of quality assurance and control, it's also provided an intensive testing of the components and of the full product. The test of the full product is very important to ensure that the behavior of the robots is the expected one. It has been elaborated for each type of robot a set of specific tests to cover all the possible problems that can happens. When a behavior not covered by the set of tests is found in any process phase, the test set is updated.

In this way there is a continuous improvement of our testing phase.

Also, for testing, there is suitable staff, responsible of doing physically the test and to write documentation.

In the case of robots that fail one or more test, the testing is repeated. In the case of another failure, the robots are put aside to be analyzed, in order to understand the problem.