Renewal strategies in the IPM Group: the role of the new research centre

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Abstract: The IPM Group has become one of the leading company in the telecommunication industry in Italy in the last 40 years. A study carried out by A.T. Kearney [1] identified the IPM Group as one of the three best performing medium-sized companies in the South of Italy. In the early stages of the company's growth, the IPM engineers and technical management were able to dramatically innovate its products, the public telephone terminals. But, in the last five years, as a consequence of the end of monopolies in the national telecommunication markets, IPM faced a number of serious problems relative to the product and its commercialisation in the international markets. The growing attention to the users' needs by the national public telephone service providers and the need to meet the particular specifications of the product required by the international customer on the one side, and the constraints imposed by some local governments that require that foreign companies make use of companies of the country to manufacture components and parts and assemble the final product on the other side, induced the management of the IPM Group to modify the process of product development and the organisation of the manufacturing environment. This renewal process is still under way. The paper, after a description of the story of the IPM Group, analyses and discusses some of the issues posed by the new course of action. Information reported here relative to IPM Group SpA and its strategies is updated to the end of 1998, the time the authors completed the writing of the case.

Keywords: R&D management; telecommunication industry; knowledge management.

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Pier Carlo Ravasio has been a member of several international scientific bodies and standardisation organizations. He has also been a member of the Board of Directors for many companies and research institutions. Until the end of 1999 he was the Director of the R&D Department of the IPM Group and the project manager in the start-up of the new R&D centre. During his career, before joining IPM, he held positions where he was responsible for the R&D and Engineering in Elsag Baileys, Olivetti, Italtel Telematica. Now he is a freelance consultant in the area of venture capital. He graduated in Electrical Engineering from the Polytechnic University of Milan.

"Because [a company's] purpose is to create a customer, the business enterprise has two – and only two – basic functions: marketing and innovation".

Peter Drucker, People and Performance

1 The start-up of the IPM Group

In 1958, Remo De Feo, an Italian technician and manager in a Swedish multinational company active in the telecommunication industry, Ericsson, decided to leave the company and to start his own business in the area of Naples, in the South of Italy. The company was called IPM, Industria Politecnica Meridionale. The mission of the new entrepreneurial company was the maintenance and rejuvenation of the public telephone equipment and terminals of the SET, the company at that time concessionary for the administration of public phone services in Southern Italy. He had employed and personally trained people who had previously worked as farmers in the fields where the building of the company was settled. The company, which was high technology oriented for that time, employed more than 100 people.

In the 1950s, the public telecommunication services were administered by several local companies rather than a unique great monopolistic company. Therefore, IPM provided its maintenance services only locally. But, in 1965 the administration of public telecommunication services was nationalised, and a new company, named SIP, became

the unique concessionary administering the public phone service for the country overall, absorbing the old companies STIPEL, TETI, SET, TELVE, TIMO, which were concessionaires of different regional areas. Therefore, shortly after the beginning of its operations, it became urgent for IPM to revise its strategy, modifying the organisation and its business scope. The new mission of the company was to manufacture telephone equipment, telephone parts and components, telephone counters for the new national company, by adopting the electromechanical technologies of that time.

But, the dream of Remo De Feo was short as he died only five years after the foundation of IPM. IPM was the first and most important of the several units that would have formed the IPM Group over time (see Section 2.6).

After the death of his father in 1963, Paolo, a young graduate student from the School of Engineering of the University of Naples Federico II, the older of the three children of Remo, abandoned his university studies and entered the company, thus beginning his entrepreneurial adventure and setting the base for one of the few companies widely acknowledged as being excellent in Italy [2].

Recently the School of Engineering of the Second University of Naples bestowed the Laurea Honoris Causa in Electronic Engineering on Paolo De Feo, who illustrated the story of his company and the latest successes to a large audience [3].

2 Major challenges for the IPM Group: evolutionary steps of the IPM Group strategy

2.1 The steady growth phase (years 1962–1987)

In the early 1960s two brothers of Paolo entered the company, Marco who took charge of the financial management of the company and Carlo, a graduate in electronic engineering, who was more actively involved in the technological innovation issues of the company.

IPM grew steadily over the years. Its turnover passed from 300 millions Italian Lire in the 1962 to about 200 billions Italian Lire in 1987 with an average annual rate of 31.12% in 25 years. During the same period, the company enriched its asset of technologies, products and services offered to its customers, which were no longer limited to low value added services of maintenance and rejuvenation of old equipment: i.e., electromechanical parts, electronic components, software, final products, data transmission equipment, electronic boards, telecommunication networks. As a consequence, over the years several new divisions were formed in IPM. But the conviction of the top management was that the size of the company should be kept small in order to save efficiency, flexibility and agility in the market. Therefore, when the divisions grew beyond a critical threshold size, they were transformed into separate companies through spin-offs. Each company was focused on a specific technology and product. The IPM Group henceforth developed through a network of small-medium sized separated companies coordinated and controlled by the IPM company. In the eighties, TELECONTROLLI (hybrid circuits), CELM (plastic film and tantalio capacitors), MELTEM (assembly, test, and repairing of phones), IPM DATACOMM (design and manufacturing of data transmission equipment) and NOVATEL (manufacturing of electronic boards) were formed (see Section 2.6). Moreover, low value added processes (i.e., varnishing, shearing) had been externalised to companies not belonging to the group.

The IPM Group was entirely dependent on its unique customer, SIP. Indeed, the IPM Group made 99% of its total turnover selling products and services to the Italian public concessionary for the telephone services. In this situation strategic marketing was a task of the concessionary, while the manufacturer was only charged with some marketing of the product. Moreover, SIP, due to its monopsonistic position in the industry, gave rise to competition among its suppliers. The IPM had only a direct competitor, URMET, a medium sized company located in the North of Italy. Anyhow, the competition between IPM and URMET was fair and 'collaborative', as public telephones were assembled with parts designed and manufactured by both companies. For instance, URMET holds the patent for the present system to read prepaid magnetic cards, while IPM holds the patent of the ROTOR system (see Section 2.2). This characteristic of the market offered several advantages to IPM and URMET too. In particular, the certainty of orders from SIP, the possibility to plan easily and almost precisely the production capacity every year, and, what was more relevant, a substantial lack of need to conduct strategic analysis.

In 1962 IPM manufactured its first public telephone terminal (the S119 model) according to a design of SIP. This telephone allowed only local calls, and could receive only one counter at a time. In 1964 IPM undertook on contract the design and manufacture of a telephone for local and long-distance calls. This telephone used a mono-channel feeding system for the counter. In 1978 a new telephone was introduced by IPM and URMET, which had greater flexibility than its predecessors. Indeed, a multi-channel system made it possible to use coins and counters.

2.2 A successful product: the Rotor© public telephone terminal

At the beginning of the 1980s, both technological innovation and the new demands of the users induced a new direction in the public telecommunication market in Italy. Indeed, the old telephone terminals utilising coins or counters of the mid 1970s were unable to respond to the new needs.

In April 1984, as a consequence of the decision of the Italian government to introduce the '*lira pesante*' and the necessity to use a growing number of coins rather than the conventional counters, the SIP company placed an order for the design and manufacturing of a new public telephone terminal to its two suppliers.

The realisation of the new product presented a number of problems to be solved. In particular: the introduction of different types of coins, coin recognition, the management of coins, the taking/return of coins. In 1986 two prototypes of the telephone were presented, one by the IPM Group and the other one by URMET. But, the telephone terminal proposed by IPM – the ROTOR – met the specifications of SIP more than the other one:

> "The new telephone terminal designed by Rodolfo Bonetto for the IPM, shows a new course in the world of telephony. It is an intelligent terminal with remote programming, autodiagnostics and predisposition to interface the new numerical telephone exchanges. [...] it has a sorting for the counters and coins that allows it to work with both of them at the same time. [...] a liquid crystal display shows the amount deposited and the number of the user called. [...] the design is the result of a formal and ergonomic search, paying a particular attention to the features that a public product should have: easy use, strength, and wear and tear endurance. The terminal was built utilising steel, light alloys, tecnopolymers, and the SMT electronics, without protuberant elements [...]."
>
> Industrial Design [4]

Two major innovations were behind the ROTOR terminal: the rotor mechanism, and the modular design.

- the rotor system was soon revealed to be an efficient mechanism compared to other alternative solutions proposed by IPM or its competitor. It allowed the use of coins and counters introduced in a single channel;
- the modular design made it possible to design, manufacture, and test the single modules before assembling them in the final product. A second advantage of the modular design was in the maintenance of the terminal. When a failure occurred in the telephone working, only the damaged module was removed and substituted.

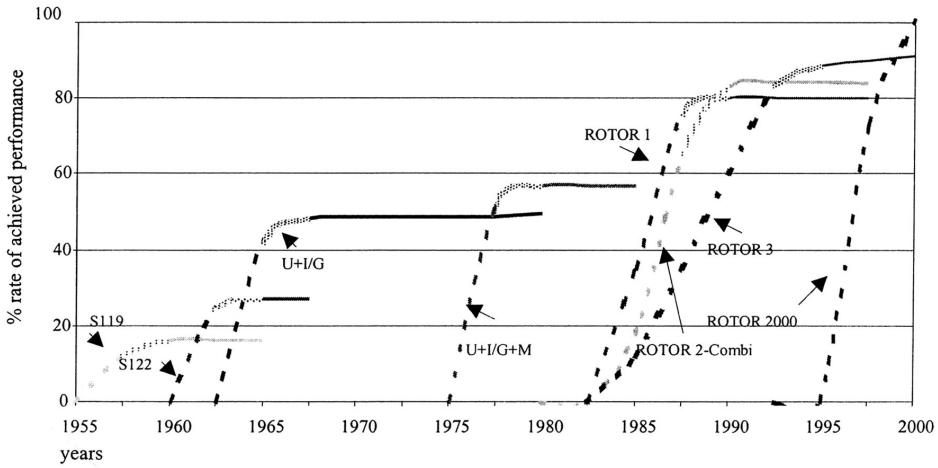
Furthermore, the subsequent telephone equipment presented a greater number of functionalities compared to the old models: i.e. auto-diagnosis of failures, history of failures, collection of data relative to the number of pieces deposited, number of counting impulses. Those new functionalities made the IPM telephone equipment more and more competitive though small product innovations.

The ROTOR telephone gave origin to a generation of telephone terminals:

- the telephone using coins (in 1987);
- the telephone using both coins and pre-paid cards (in 1989);
- the telephone using only pre-paid cards (in 1992).

These successful products contributed to the growth of the IPM Group in the last decade. At the same time this generation of successful products made by IPM shows that continuous product innovations represent a powerful tool for a company to become more competitive and to maintain its competitiveness for long time [5]. Figure 1 shows the life cycles of the main telephone terminals produced by IPM.

Figure 1 The S-shaped curves for some of the IPM products



2.3 The first moves toward the internationalisation of the Group (1987–1993)

During the period of the development of the several versions of the telephone terminals with the ROTOR systems (1986–1993), the IPM Group moved towards the international markets.

In 1987 a subsidiary of DATACOMM, POLITEL, now called IPM International, was opened in Geneva to commercialise in Europe the products for data transmission. That was the first step toward the internationalisation of the Group. In 1990 IPM GB was formed in London with the aim of creating a privileged observatory within a market for telecommunications which had already been deregulated. Moreover, IPM began to participate in international tenders. The launch of a telephone for internal environments designed to be sold in these markets offered the opportunity to experience conformance tests in several countries.

Between the end of 1992 and the beginning of the 1993, the Group incurred several difficulties in regard to:

- the saturation of the national market (in the last ten years IPM and URMET provided SIP with nearly 430,000 telephone terminals);
- the new purchasing policy of SIP, in part determined by the discussions about the deregulation of the Italian market, which will be formalised in 1998;
- the threats of international competitors entering the Italian market.

These new conditions of the environment, together with the need to preserve the average annual rate of growth of the company, and the general economic crisis which affected almost all the industrial sectors, induced the management and the ownership to redefine the market strategy of the Group. The same problem was faced by URMET, but URMET and IPM followed two different strategies to face the challenge of the new context. While URMET, already in the interphone market at an international level, mostly focused both on the Italian market of private telephone terminals and public telephone equipment, IPM decided definitely to enter the international markets. Table 1 reports the main international competitors in the public telephony market.

Table 1 Major international competitors of IPM (public telephone terminals)

Competitor	*Country*	*Product*	*IPM Product*
ASCOM Monetel	France	IPT100	Rotor New
AT&T	Chile	Card&Coin	Combi
		Outdoor coinphone	Rotor New
ELCOTEL	Morocco	IPT-9120	Combi
		IPT-9100	Rotor New
	USA	IPT-9120	Combi
		OCT-9250	Combi
		IPT-9100	Rotor New
		OCT-9500	Rotor New
FMN	Morocco	Coinphone	Rotor New
GPT	UK	Sapphire	Combi
	Hong Kong	Sapphire	Combi
	Spain	Topaz	Rotor New
	Thailand	Sapphire	Combi
LANDIS&GYR	France	Comet 15	Rotor New
PROTEL Int.l	Morocco	Card&Coin	Combi
TATUNG Telecom	Belgium	Outdoor coinphone	Rotor New
	Germany	Outdoor coinphone	Rotor New
	Morocco	Coinphone	Rotor New
TELKOR	Chile	Outdoor coinphone	Rotor New
URMET	Chile	Plurima 2	Rotor New

Source: IPM Marketing

2.4 The present scenario of the telecommunication industry

Till the early years of the 1980s there was the conviction in most of the governments of European countries that public monopoly was the best way for the public interest to provide telecommunication services [6]. But the imbalance between the advantages following the rapid pace of technological innovation, and the increasing inefficiencies and tariffs, induced the European Commission to promote policies aimed at fostering harmonisation and competition in the market. Liberalisation of the market for telecommunication services would have as a consequence a higher quality and benefits for the users. The first actions of the EC had the purpose of diffusing technology and common standards through collaborative R&D programs. But, it was in 1987 that the European Commission intervened to modify the rules of the telecommunication market in Europe. The Green Paper of 1987 proposed directives aimed at:

- establishing European standards;
- opening in the near future the terminal equipment market to competition;
- opening progressively the telecommunication service market to competition;
- separating the regulatory units from the operative ones.

The attempt to create a competitive market of telecommunications revealed itself to be a more difficult task than planned. After several years of negotiations between the governments of the European Commission member states, the European Council agreed to deregulate the telecommunications market by 1 January 1998.

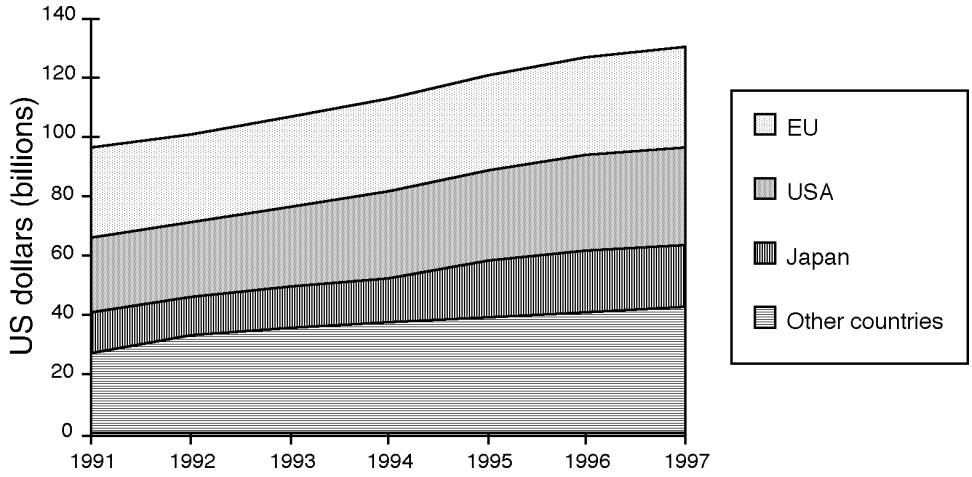
With the new European Commission policies, together with the acceleration of the pace of technological innovation, the changed political conditions, the prevailing of new market rules, and the growing globalisation of the world economy, the effects on the telecommunication industry had heavy implications on the telecommunication market in Europe: the end of national monopolies, the opening of national markets to international competition, the entrance into the market of new actors born from an intense activity of mergers and acquisitions of companies of the same industry or of contiguous industries.

The companies were administrating the telecommunication services with the aim of reducing tariffs. The transition from a monopoly to a full and effective competitive market was a critical challenge both for the administrators of service, policy makers and the suppliers of telecommunication equipment.

Figure 2 and Figure 3 show respectively the world market of telecommunication equipment and services in US dollars from 1991 to 1997.

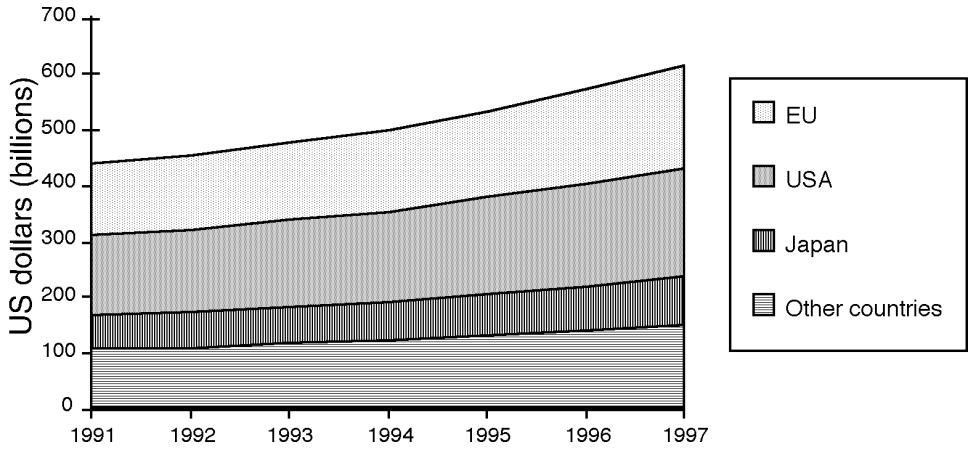
From both Figures it emerges that the telecommunications industry has become a fast developing sector, with high growth rates. At present the Italian market amounts to 4% of the total.

Figure 2 The market of telecommunication equipment (years 1991 to 1997)



Source: ANIE [7]

Figure 3 The market of telecommunication services (years 1991 to 1997)



Source: ANIE [7]

2.5 The new course of action in the IPM Group: the search for new markets (years 1993–1995)

Until 1994 the company followed the evolution of the Italian telecommunication market, which was a protected market where only one company, SIP, operated. In 1994 SIP and some other telecommunication companies were incorporated into one single company,

named TELECOM ITALIA. IPM had therefore only one customer, SIP and after 1994 TELECOM ITALIA, and only one competitor, URMET in Turin, with which it shared the Italian market. Until 1995 99% of the IPM turnover was the result of the good relationships established with SIP at the beginning and then with TELECOM ITALIA.

Since 1993 the IPM Group began the thorny way towards the globalisation of markets through considerable investments. In the following three years, the number of total employees of the IPM Group grew from 922 to 1100.

IPM International, the old POLITEL, was formed in Geneva with a commercial office in Shanghai. That allowed IPM to enter the Far-East markets (Malaysia and Thailand, where 50,000 and 35,000 telephone terminals were installed respectively). A new market was opened in the South of America. At the same time the management of the IPM Group aimed at diversifying the range of products and services offered.

In 1995 IPM Communication was founded for the administration of the public telephony in the UK.

IPM moved from a protected market as the Italian one, where there were a unique customer-administrator and only two competitors, to highly competitive markets both on the supply side, and the administration side. For instance, in Thailand there are three telephone administrators, each with its needs and requirement, and 16 international competitors, each with its technologies, products, and services. In these markets the assignment of supplies is done through the adjudication of international tenders. As a consequence, a company has to compete by offering a low cost but at the same time high quality product. For instance, for a product the price of which is 525 US dollars, a company can fail to win the tender for a 5-10 US$ rebate only.

The globalisation of markets led the IPM Group to face a number of serious problems relative to the product and its commercialisation in the international markets. The growing attention to the users' needs by the national public telephone service providers and the need to meet the particular specifications of the product required by the international customer on the one side, and the constraints imposed by some local governments that require that foreign companies make use of companies of the country to manufacture components and parts and assemble the final product on the other side, induced the management of the IPM Group to modify the process of product development and the organisation of the manufacturing environment.

The solution pursued by the company was to revise the product design stressing its modular architecture, which was also made possible by the larger and larger amount of electronics embedded in the final product. Thus, while the older telephone was made in only one module which was manufactured on a unique production line, the new telephone terminal, sold also in the international markets, was a set of several modules, each of them adapted every time to the technical specifications, and manufactured on different production lines.

Undoubtedly, the advantages of this new approach were an increased flexibility and a reduction of the response time of the company to making an offer for an international tender.

Of course an innovative company while it is managing the second stage of the evolution of the innovation rate has to start to design new products, and to enter new markets with the old products.

At the end of 1995 two new companies were formed to become part of the Group, INCARD, close to the headquarters of the Group, for the design and manufacturing of chip cards used as electronic money, and IPM Communication in the UK for the

administration of the public telephone service [8]. This market was not completely new for the Group, as since early 1958 IPM SpA had manufactured counters and administrated telephone terminals for public environments.

The new strategic commandment, in the words of the management, became: "to renew the product line in the core business of public telephony, enriching its range with electronic payment systems and maintenance services, and at the same time, starting from the domestic market, to develop an offer in different sectors such as the banking industry and public administration."

2.6 The re-organisation of the Group and the creation of the R&D Centre (years 1995–present)

While at the beginning of the 1990s 99% of total sales of the Group derived from the national public market, in 1996 the share of the national public market decreased to 60.3%. This new situation together with the decision of the management to derive 35% of its turnover from the new market of electronic money, and the increased competitive pressure in the international market and the technology evolution determined an urgency to redefine the overall organisation of the Group and the single units.

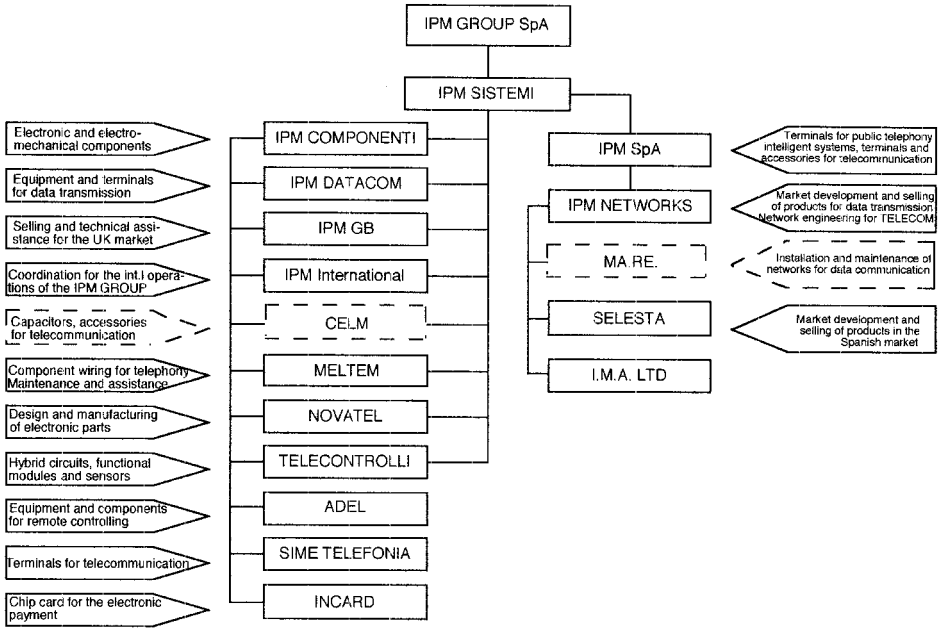
The Group re-designed its structure, splitting the sales function from the product marketing function, and assigning to the latter the commitment to identify products and services for a global market and no longer design for the specific needs of a single customer. From an analysis in depth of the needs of the public telephone service providers carried on in recent years, it was possible to come to the definition of a design architecture of products offered, which was modular in its physical or, at least, in its logical layout whenever cost or ergonomy constraints required different divisions or fittings.

As a third step, it was necessary to intervene to modify the organisation and the processes able to develop and do maintainance of products. The concepts of ISO 9000 and Total Quality Management were introduced in the companies of the IPM Group since late 1993. Furthermore, the following procedures were introduced: the management of the process according to the internal customer-supplier perspective, reliability in product design, simultaneous engineering, a systemic approach to design, customer-orientation in design, activity-based/management costing. Furthermore, great attention was given to the strategic re-definition of the life cycle of product families.

At the end of 1995, in order to carry on the renovation project of the IPM Group, the top management decided to concentrate the research efforts of the Group into a unique research centre.

Still today the top management of the IPM Group believes that it is better to manage the coordination of several companies, rather than to manage a single large company. Figure 4 reports the present organisation of the IPM Group.

Figure 4 The present organisation of the IPM Group



Companies indicated by dashed lines no longer belong to the Group.

3 The creation of the R&D Centre in the IPM Group

3.1 The R&D management in the IPM Group before 1995

The research activity necessary to the Group was conducted until 1995 within four research laboratories located in four companies of the Group: IPM SpA [9], IPM Datacom (ex Tidata), Novatel and Telecontrolli. The four laboratories employed 110 researchers. Two major advantages derived to the Group from this organisational architecture of the R&D. The most important was the need to have several teams capable of achieving the diverse tactical goals privileged in the Group strategy; the second one was the need to have a high rate of creativity through the availability of excess R&D capacity to meet the requests of several customers at the same time.

In the new scenario of the telecommunication industry, there was a clear strategic vision in the IPM Group management of the importance of offering an integrated product to the market. The supply of the single product was no longer winning as the customer asked for a fully integrated solution, eventually including some sort of after-sales service. Furthermore, there was the awareness of the weight that the technology and the technological competences had in the culture of the companies belonging to the Group.

3.2 The decision to create a unique R&D Centre

A number of specific reasons induced the management of the IPM Group to create an R&D Centre concentrating and uniforming its research and development assets:

- the need to use in a more efficient way competences and to reduce the development costs of the new products;
- the need to make the service centres linked to R&D management more efficient;
- the need to create a shared vision, more business-oriented, by all the 200 researchers of the Group.

It was evident that by specialising the research and development teams according to the different markets and family products, a certain duplication of competences had been generated over the years. This lead to a proliferation of parallel similar projects that not only caused an increase of the costs, but, in some cases, induced scale-diseconomies. That was the case, for instance, in the choice of different families of microchips or chip sets for the ISDN terminals done in some research laboratories of the Group. Of course, these decisions had serious implications not only on the times and costs of product development, but also on the purchasing power of the Group in the relationships with the electronic component suppliers.

A further reason was the need to create a vision shared by the researchers, in a moment when it was necessary to re-orient to business some companies which were historically used to work as suppliers to satisfy long-term orders of public companies.

From a logistic point of view, the constitution of the IPM Research Centre means the joining of four major research and development laboratories which are now located in the companies of the Group which sell to the market. A new building, close to the headquarters, should host the R&D Centre. Indeed, there is the belief in management that the physical concentration of the competences into a single place is absolutely indispensable to a rapid amalgamation of the working teams, each of them having its different culture.

The organisation of the IPM Research Centre privileges the group as an aggregation of assets and functions: technological competence groups, development groups, integration groups, testing groups, product maintenance groups, service centres, knowledge transfer groups. The identification of groups of technological competences required the re-design of several issues: the chain of activities relative to mechanical working parts, the production of software, and the informatisation of the document flow integrated with the Group Information Systems. The R&D Centre structure has staff units, development groups, and technological competence groups. It is a matrix structure with staff units. In the old laboratories there was not this distinction between competence and development groups, but there was a unique group working on long-term and short-medium term projects.

The IPM Group resorted to competences diverse for their nature (i.e., methodologies of TQM and ABM), for geographical area (university researchers and professors from US Universities and from the University of Naples), but most of the time emphasising the local components with the aim of increasing the linkages between Industry and Research Centres, private or public ones. Moreover, the basic work done to analyse the existing processes, the project competences of the R&D Centre Director, and the diverse internal competences used to re-design the great number of specialised micro-processes were used for the functional and organisational design of the R&D Centre.

4 The analysis of the case

The story of the IPM Group offers some interesting insights for a wide reflection on the role assumed by the management of technology – and, more specifically, the R&D management – in the globalisation strategy of a medium-size company.

The issues that the case raises are – to tell the truth – very numerous and various, and concern at the same time the organisation, operations and strategic areas of management: organisation design, change management, coordination, new product development, learning, human resource management, strategic management, etc. However, we will dwell upon a limited number of subjects, emphasising both those aspects that more than others seem to be useful for identifying the factors that allowed the growth of the IPM Group, and the issues that offer the opportunity to discuss critical problems related to the management of technology faced by a company acting in a turbulent or even chaotic market, for the continuous and rapid changes of the technologies, consumer behaviours, and policies and regulations imposed by governments.

The new technologies provide a wide range of opportunities. However, they represent also a potential treat for the companies which are not able to face the transition. The technology and competence assets of a company can soon become obsolete [10]. That is what happened to the companies in the telecommunication industry in the early 1980s, consequent to the shift from the old electromechanical technological paradigm to the electronic-computer based one. The strategic answer of companies to technological change has been the focus of many studies carried out in the last few decades [11,12]. A number of questions arise when a company has to deal with a new technology. But, a critical question is the following: since the success of a strategy of change will be strongly affected by the organisation structure designed by the management of the company, which organisation structure is more effective for the company?

Therefore, we want to emphasise and discuss two major issues emerging from the IPM story:

1 the weight that the particular architectural design of the Group organisation had in enhancing the growth of the same while following the evolution of the market and technology;

2 the different models adopted to develop and manage the technological knowledge over time, and their role in the renewal strategy of the Group.

4.1 The architectural design of the Group organisation

Since the late 1970s the IPM Group has grown, externalising part of its productive activities, first to companies not belonging to the Group, then forming new ventures strictly linked to the parent company, IPM SpA. Thus, the Group has assumed a network architecture, with a wide range of ties between units of this network, in terms of their strength and nature: strong ties linking the companies of the Group, less strong ties linking the Group and selected specialised supplier companies, and weak ties between the companies of the Group and occasional small firms which supply only productive capacity. The idea was to concentrate the own resources and competences of every company on a few set of activities (and technical and market problems) where it could perform at best. Indeed, a network architecture allows to serve customers substantially

better in terms of quality and time, simultaneously decreasing risk and size, while increasing flexibility and agility, and improving cost control. Furthermore, a network organisation supports also cost and technical efficiency through the focus of technical competences on precisely limited technological domains, innovative flexibility through multiple sourcing, and market stability through market diversification [13]. The term 'network organisation' has been widely used to embrace a great variety of new organisational forms, including flat and horizontal matrices, inter-firm alliances, intra-firm cross-functional teams, etc. [14]. These various forms substantially differ as to the way they have to be managed and in their purpose. The IPM Group privileged a network organisation based on a satellite-planet system architecture with the parent company, IPM SpA, coordinated the activities of a system of companies. This architecture allowed the Group to preserve flexibility and, at the same time, to maintain centralised control of IPM SpA, not limiting the autonomy of the business units. Since the foundation of the company, the resort to simple forms of decentralisation of some of its operations had allowed IPM to keep a certain level of flexibility of its productive capacity, thus satisfying the peak of demand of the unique customer. However, under the pressure of the market and technology evolution, this orientation to the externalisation of part of the operations became stronger and stronger, until it evolved, through continuous experimentation, towards an architecture of a network-company, characterised by great specialisation of the units belonging to the network. Undoubtedly, behind this shift from an integrated structure to a network-company there was the strategic intuition of the family De Feo, coming from an extremely clear vision of what the telecommunication market would become in the next decade. That acquires a particular relevance, if we think that the reflection about the network organisation architecture was not yet a major concern of management scholars. In the words of Dr. Paolo De Feo:

> "… the Industria Politecnica Meridionale (IPM) was formed with the mission of the high-tech company, especially devoted to the development of the telephone industry. From the original electromechanical technologies, through a continuous push of the R&D, the IPM creates the first integrated network of companies fully owned by Italian private entrepreneurs – with decision making centres and intelligence in the South [of Italy] – acting in the 'Information and Communication Industry'. As the activities carried over by the IPM find acceptance in the market, the single divisions and the departments having greater potentiality are transformed into new ventures, each of them with its productive identity and market mission, avoiding any solution suggested by the fashion of the industrial giantism typical of the 60s and 70s. The inspiring principle was and remains the belief to not overcome the dimension of the medium-sized company, the model of efficiency, the human trait, the agility that only the 'light' structures are able to preserve. In this way, we were able to build the tissue of economic relationships and local supplies which [our] settlement area was almost lacking at the beginning. Long before it became an accepted and diffused approach, we gave origin to an integrated network organisation in the telecommunication market …."

Two major advantages derive to the IPM Group from the network architecture adopted, besides saving a degree of productive flexibility. First, the possibility to explore new market niches thanks to the specialisation of the satellite companies, without interfering with the major activity of the Group. Second, the acquisition of a special capability to create and manage decentralised independent business units, which will become a core competence of the Group in its globalisation strategy. Even though, over time, the need

of a greater centralisation (of Marketing and R&D management) became more critical, the paradigm of the network company remained still dominant, as now it belongs to the culture of the Group.

Table 2 compares the integrated architecture with the network architecture in terms of pros and cons of each organisation solution.

Table 2 Main features of the centralised and network organisational architectures

Integrated architecture	*Network architecture*
exploitation of scale economies	higher capacity flexibility
direct control of activities	higher innovation capability
strong identity of the company	higher strategic agility
inefficiency in the coordination of the internal business units	major focus on technical and management problems
inefficiency due to the flow of information	higher control of cost and performance indicators
inertia in decision making	reduced presence of the Union in each company
high weight of fixed assets	improved communication across units
	lack of a shared strategic vision
	coexistence of several cultures and management systems
	inefficiency due to redundancy of activities

4.2 The different models adopted in the Group to develop and manage the technological knowledge over time

Until 1997, research and development was dispersed across the companies belonging to the IPM Group. Particularly, there were four laboratories in which R&D was carried on to satisfy the specific needs of these companies. But, in 1997 the Board members and the top management of the IPM Group decided to concentrate this activity in only one place. This decision goes in the opposite direction to a common trend, which led to the restructuring of centralised corporate R&D units and the distribution of research activity among the business units in many companies in order to respond to their immediate needs [15]. However, it was consistent with the choice to become an actor in the global market. With the entrance in the global market, the approach to new product development is radically changing in IPM Group. In particular, the following three issues merit attention and a deep analysis:

1 The characteristics of the new model for R&D management, and – more broadly – the development of new products;

2 How the management of technological knowledge in the IPM Group will change;

3 The critical aspects and implications for management of the model adopted.

4.2.1 The characteristics of the new model for R&D management, and – more broadly – the development of new products

The IPM Group is moving from a logic of managing R&D projects in a reactive manner (the carry over approach) to a logic of managing them in a proactive manner (the shelf-innovation approach) [16,17]. The logic of carry over is based on the re-use in the new project of components which were developed for old projects or are used in parallel projects [18]. In some cases, the re-use can concern not only the components, but also the architecture of the old product [16,19–21]. The carry over approach is typical of traditional engineering design in which a methodology of constrained optimisation is applied, with the aim to obtain the highest level of product performance within some cost constraint or the lowest cost for a product meeting a minimum performance constraint. This approach leads to a product design made of highly integrated, tightly coupled component designs [16]. In the traditional approach product design is an iterative process. Indeed, specifications of input and output interfaces between components must reflect the idiosyncratic features of each tightly coupled component design. Therefore, a change in the design of one component is likely to require extensive compensating changes in many interrelated components. As a consequence, product design requires intensive managerial effort and resource consumption.

On the contrary, proactive policies try to formally plan the R&D projects, portfolio well in advance, while taking into account the interdependencies that will occur among the components of the products of the different families aiming at maximising the re-use of the same components. This alternative design approach intentionally creates loosely coupled component designs by specifying standardised component interfaces which define functional, spatial, and other relationships between components. The shelf-innovation approach uses modular components [22,23]. Once specified, modular components are not permitted to change during a planned period of time that may range from key stages in the development of a new product architecture to the entire commercial lifetime of a product family [16,24]. A modular architecture can be extremely flexible [15]. Product variations can be obtained by substituting different modular components into that product architecture without having of necessity to redesign the other components. "This loose coupling of component designs within a modular product architecture allows the mixing and matching of modular components to give a potentially large number of product variations distinctive functionalities, features, and/or performance levels" [25, p.53].

Particularly, the shelf innovation approach privileged in the IPM Group R&D Centre consists of the anticipated development of components and technological solutions in order to create an asset of innovations that can be used in the future. According to this approach, the introduction and the development of new components are separated from the development of specific products:

> "Our orientation is to go towards a 'meccano organisation'. ..[...] Rather than carrying over the design of the final product, our aim is to carry over the design of the components of the meccano to be used to assembly quickly – depending on the tactical needs of the market – the product …. Therefore, we are identifying common modules that can be re-used for all the design needs to satisfy the possible orders coming from the market, but reducing the development time....[...] The concept of module is this. Our future systems will be modular systems in which moving physical or logical modules it is possible

> to customise the product to satisfy the requirements of a country. If we had to design the entire system starting from the beginning, we would lose too much time with high costs. ... [...] some modules are universal, some others are the customisation of certain functionalities that are required every time …[...] a product is customised for *n* customers. But we could have modules prepared for *n* product-families. For instance, a module for video-telephone terminals that could be used both in the public and in the home video-telephone terminal. … [...] markets are becoming more and more complex because there is a greater evolution of products that companies are offering and a growing request for customisation. The idea to have standard modules, less standard modules, ad hoc modules, this kind of different bricks … makes possible to have a great speed of design and, at the same time, a high flexibility."

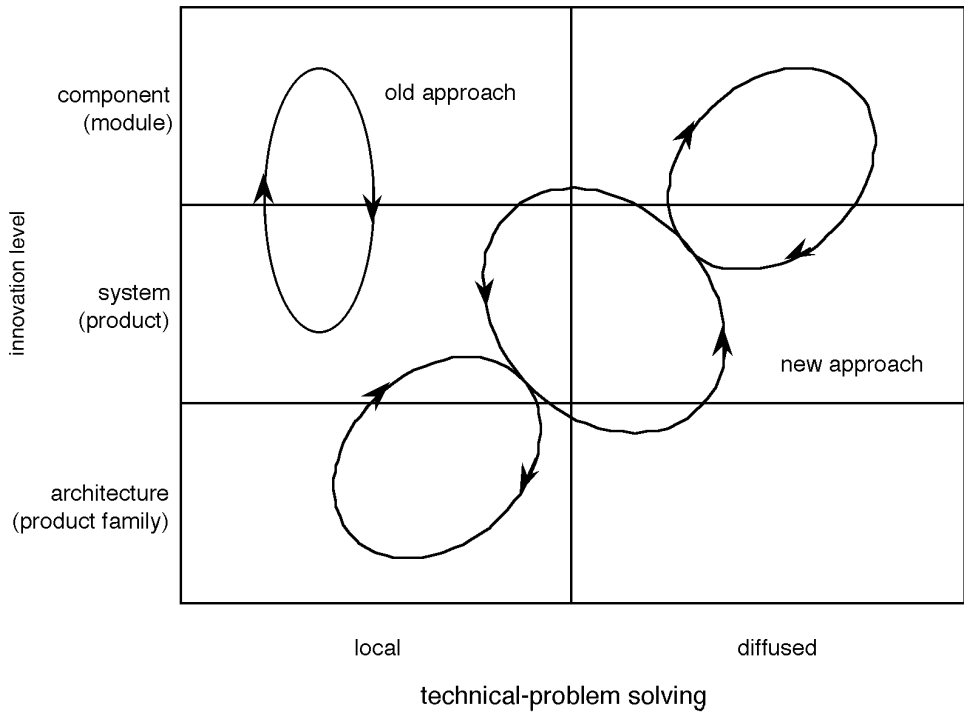
A similar approach has been adopted in several industries by many companies [25]. Wheelwright and Clark [17] report the successful experience of Hewlett and Packard where this design methodology was called 'Pizza Bin Approach', as the components are developed and put at the disposal of the different product development projects that combine them in the most effective architecture, just if they were ingredients of a pizza.

As scholars suggest, modular product architectures can be an important source of strategic flexibility [16,25]. First, by quickly introducing product variations based on new combinations of new or existing components, they enable a company to respond promptly to the changing needs of the market and to the evolving of technology. Second, the standardisation of component interfaces in a modular architecture enables the coordination of a network linking companies geographically dispersed.

4.2.2 How the management of technological knowledge in the IPM Group will change

In the traditional approach of design engineering, as the organisation of product development was sequential, the engineers focused first on the component having the greatest impact on the other component design. As the process was iterative, the R&D laboratory developed new technical knowledge about components and their interaction at each stage, transferring technical information to the next stage to proceed for a new iteration. The process was repeated until all components and their interfaces were fully specificated. Technical problem solving was fundamentally localised in the knowledge domain of the specific component, while learning occurred jointly both at the system and component level [26–28] (see Figure 5). Thus, the architectural knowledge of the product was only available, as an output, at the end of the development process. Furthermore, the old model was based on a strong specialisation of competences and knowledge. Indeed, in the old logic the knowledge and competences required to manage the integration of the different components were implicitly embedded in the sequential organisation of the developmental cycle of the new product. This asset of knowledge was henceforth embedded in consolidated organisational procedures, coordination mechanisms, and norms which defined the culture of each company of the Group.

Figure 5 Technical problem solving in the two approaches to new product development



In the shelf-innovation approach to new product development a different model for managing learning and knowledge takes place. In fact, in the new approach to R&D management, new product development projects can be thought of as programmed innovation in which the company develops new products by applying existing knowledge and creating new knowledge about modular components and their interactions:

> "… we use certain technologies, but are not a part of the process which determine their evolution. We are going towards an 'industrialisation of applied research'. Our goal is how to realise the greater number of product family along the same productive line in the quickest and most economic way. The true goal is not to accumulate new knowledge, except for procedural knowledge, ... [...] but the goal is to organise an R&D process involving also the Design Department to reduce times and enhance the possibility to apply in a flexible manner what we find."

This approach is characterised by a complete definition of the information structure that specifies the features of component interfaces before the development of the components will begin. The critical task for the IPM Group R&D Centre is then to develop an asset of architectural competences to manage the integration of the different modular components:

> "… the added value lies in the capability to put together things that are well known. The newness is not what is done or how it is used, but how it is done. In how much time and how much does it cost. [Our added value is in]...the efficient and quick customisation of a product. ... [...] therefore the new thing is the organisation of the activities. The centralisation becomes critical, as if we maintain an R&D decentralised it reduces to a set of specialised techniques."

Indeed, to create the information structure of fully specified and standardised component interfaces in a modular product architecture requires a high level of architectural knowledge about how components function and interact in a product [25]. Diffused technical-problem solving is required to build the architectural knowledge basis [26–28] (see Figure 5). Therefore, together with the traditional form of incremental and radical learning, two other forms acquire relevance, the modular and the architectural ones [29]. The modularity allows the decoupling of the architectural and component levels of learning with several advantages for the company [16,25]: learning at the component level can be insulated from disruptions caused by unexpected changes in product architecture occurring during product development; component suppliers may be more efficiently involved in product development as the information structure provided by the specifications for standardised component interfaces allows for better coordination of the loosely coupled activities of component developers; the company can accelerate its learning about markets by introducing a great number of variations of a product at a greater speed and reduced cost.

Table 3 reports the comparison of the two approaches to R&D management for the development of new products.

Table 3 Main features of the old and new models of R&D management in the IPM Group

Old Model *'R&D dispersed across units'*	*New Model* *'R&D concentrated in a unique place'*
hierarchical structure (three layers of management)	lean structure (two layers of management)
researchers work on a few and similar projects	researchers work on many and different projects
research funds generated as a flat tax on the business unit	research funds generated as a contract from the business unit
emphasis on product innovation	emphasis on component innovation and part integration
emphasis on individual work	emphasis on team work
sequential organisation of activities	parallel organisation of activities
focused technical problem solving	wide technical problem solving
emphasis on sequential flow of activities in product development	emphasis on parallel flow of activities in product development
traditional approach adopted in product development	shelf-innovation approach adopted in product development

4.2.3 The critical aspects and implications for the management of the model adopted

The model adopted by the IPM Group for R&D management with the creation of the R&D Centre appears to be much more complex than the old model. In effect, the shelf-

innovation approach presents several technological and organisational concerns.

The most relevant difficulty is how to plan the potential uses of components, and to carry on the shelf innovation activity in a manner that the components save flexibility and integrability in the next products the company will develop. Also critical is defining a product innovation planning in order to develop families and portfolios of products in a long range period including target business markets, the objectives of product innovation, and specific programs of activities:

> "… our problem is in the optimisation and synchronisation of the project portfolio, because for the single project we do our reasoning on the business plan, it closes on itself … the size is not so big. On the contrary, it is the cloud of small projects, so unstable, … because having fixed resources that should be saturated … a careful daily management. … People who have to manage the part-time resources assigned to an order makes a tremendous effort to meet all the commitments because of the lack of an information system and the planning culture."

Generally, companies have limited planning horizons and the environmental turbulence increases this narrowness. Marketing and R&D should work very closely. Critical processes become how market needs and opportunities are scanned, monitored and uncovered. Good strategic decision making will help to merge successfully the functions of R&D and Marketing [30,31]:

> "As a cultural matter, we lack the 'market-driver'. This lack has conditioned the choice of the CEO who comes from the Market. All of us, including the shareholders, feel that as a lack. Above all as a need of the global market. When the Company had only a customer, it was necessary to obtain the consent of the unique customer about which we knew everything. When the market has become global the competitors have become rather a few and the potential customers more and more numerous. Therefore, it was absolutely urgent to develop the capacity to interpret and anticipate both of the behaviour of the competitors and the potential customers. … […] the identification of product families, the features of the product came from the market. The Marketing function of our Company is not centralised. Every company of the Group has its mission, its product lines, its marketing...[…] In the last year we are undergoing a centralisation process. … […] the IPM Marketing function is not strong … because, for historical and cultural issues the large customer has always had its strategic and product marketing functions. The IPM Marketing function was a Product Marketing function which act as an interface between the IPM and the Customer. It was involved in the tactical and not strategic phase with the aim to define the features and functionalities of the product."

The model adopted by IPM requires that the company devote resources to develop an intelligence and scanning capacity in the technology markets. One of the new challenges for the IPM Group will be the outsourcing of complementary technologies and competences through collaboration. Therefore R&D management should develop special capabilities for external technology acquisition and transfer. Technology acquisition includes monitoring, selection, transfer of technologies from outside, improving or adapting these technologies through in-house R&D, and exploiting them in developing new products. The development and implementation of explicit and measurable technology transfer processes become critical for success, both political and technological. More and more often, the search for new markets requires the capability to transfer technical knowledge abroad.

Systems, tools and methodologies become critical in supporting the new model of R&D management: the systems used to support communication between teams involved in the development of new products and modules; the methods of total quality management in the design and engineering process in order to enhance the quality level of the innovation process. Literature provides a great number of tools and systems, including quality function deployment (QFD), design for manufacture, creativity techniques, simulation software, compensation systems, communication tools [32–35].

The role and the status of the Chief R&D Manager in the organisation becomes pivotal for the success of the endeavour. His major tasks will be to address strategic, process, resource, and organisational dimensions of technology management in order to:

- manage different projects at the same time;
- manage the linkage between the corporate-market and the technology;
- direct the technology integration, transfer, and commercialisation having the responsibility for maximising the value added for the Group.

His task will be hard because it requires that he alter the equilibria in the company, and has to deal with different cultures, organisations, experiences, which need to be amalgamated to work together.

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