

8 Huawei's R&D Management Transformation

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8.1 INTRODUCTION

In 2012, Huawei overtook Ericsson and became the largest telecommunications equipment manufacturer in the world. Its strong technological capabilities, which allowed it to attain this leading position, did not come about quickly but were built through long-term investments and continually evolving R&D management structures and practices. Five years after it was founded in 1987, Huawei started to place an emphasis on conducting R&D, and it began to invest at least 10 percent of its annual sales revenue R&D every year (in most years, more than 10 percent). This strategy was also enshrined in the constitution of the firm, which was enacted in 1998 as the Huawei Basic Law and has been in effect ever since. Huawei's R&D expenses totaled 101,509 million CNY in 2018, accounting for 14.1 percent of the company's annual revenue. In terms of its workforce, Huawei continually allocates no less than 43 percent of total employment to R&D positions, which emphasizes how important R&D is to the firm. In 2018, the number of R&D personnel was more than 80,000, accounting for around 45 percent of its total employees (Huawei, 2019). When the rival firm Cisco sued Huawei for infringing on a Cisco patent in 2003, Huawei realized even more the need to develop its own intellectual property through R&D.

As the scale of R&D efforts increased, Huawei continually encountered problems with its organization of R&D and felt that it was necessary to transform how it conducts R&D. This chapter focuses on the transformation of Huawei's R&D management, which underwent three major accomplished transformations from 1991 to

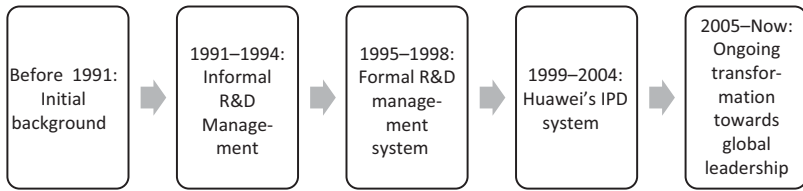


FIGURE 8.1 The five stages of Huawei's R&D management transformation

2004, as described in Figure 8.1. We also sketch the initial background of R&D management transformation before 1991 and discuss the ongoing transformation since 2005.

In the third transformation, Huawei created an integrated product development (IPD) process, which was the most important transformation because it fundamentally reshaped how Huawei conducted R&D. Our goal is to analyze why and how Huawei implemented changes using a four-step transformation management framework as our theoretical guide. In the end, we summarize the analysis and attempt to determine some of the implications of Huawei's R&D management transformation cases.

8.2 THEORETIC FRAMEWORK FOR TRANSFORMATION MANAGEMENT

To survive and gain sustainable competitiveness in a highly dynamic business world, it is crucial for firms to manage organizational changes successfully. As defined by Moran et al. (2000), transformation management is "the process of continually renewing an organization's direction, structure, and capabilities to serve the ever-changing needs of external and internal customers." In some cases, although firms undertake tremendous efforts in organizational changes, they fail. Why do such failures of organizational transformation occur again and again? Scholars have attributed failures of transformations to ill-defined transformation goals, potential conflicts of interest, lack of necessary transformation management skills, and insufficient involvement of top managers. Kotter (1995) argued

that companies that fail in organizational transformation often underestimate the difficulties of changing and thus do not have a powerful guiding coalition consisting of senior executives and other members. He also stated that without a sensible and clear goal, transformation efforts can easily become confusing and incompatible projects that can lead the organization in the wrong direction or nowhere. Hannan and Freeman (1984) argued that structural inertia, including internal and external constraints, could generate resistance to organizational transformations; in particular, if stable routines form the foundation of reliable performance, then the risk of failing in organizational transformations is increased. Given that conflicts are inevitable, they can disrupt change implementation, especially if the scope of the change has impacts on roles, boundaries, and resource allocation (Raza, 2011). Due to the importance of organizational transformation, its management greatly requires managerial skills (Senior, 2002). Anderson (2000) suggested that organizational transformations usually fail when a whole-system approach is lacking, and the need for inner shifts in consciousness and culture is overlooked.

Although Pettigrew et al. (1993) argued that there are no universally applicable methods for transformation management, several scholars have proposed models for firms to manage changes in multiple steps. For example, Kotter (1995) suggested an eight-step model for transformation: (1) establishing a sense of urgency, (2) creating a powerful guiding coalition, (3) developing a vision and strategy; (4) communicating the change vision, (5) empowering others to act on the vision, (6) planning for and creating short-term wins, (7) consolidating improvements and producing more change, and (8) institutionalizing new approaches. Despite the significant academic influence of this model, Kotter's eight-step model still has some limitations. First, Kotter argued that the eight steps should be implemented in sequence, and each step is a prerequisite for the next (Appelbaum, 2012). However, in the real business world, these proposed steps sometimes do not occur strictly in such a sequence;

instead, these steps often occur in parallel, and some steps are even embedded in other steps to improve the efficiency of transformation. This fact can be demonstrated well by Huawei's R&D management transformation cases, in which steps one and three in Kotter's model often occur simultaneously because the need for transformation and the vision of change are verified mutually. Thus, it has been criticized that some transformations do not need to or cannot undergo all eight steps (Appelbaum, 2012), such as establishing new functional departments. In addition, although Kotter's model considers communicating the change vision, it merely relies on the viewpoint of executives for how to lead transformation and thereby fails to provide help for when companies face many difficulties in implementing transformations. In particular, the telecommunication industry in which Huawei operates is a highly dynamic industry with some unique features, demonstrating the importance of particular stages, such as dynamically improving the transformation process based on evaluations and feedback.

In this chapter, we purposefully employ a four-step, process-based model as the theoretical framework to analyze different R&D management transformations that have occurred in Huawei's development history, as illustrated in Figure 8.2. This process-based

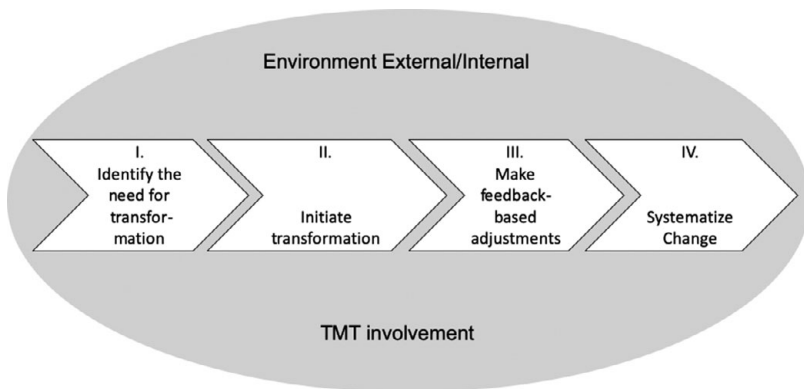


FIGURE 8.2 Theoretic framework for transformation management

model consists of four steps: (1) identify the need for transformation, (2) initiate the transformation, (3) make feedback-based adjustments, and (4) systematize changes.

The first step is to sense, identify, and seek the motivation for transformation, which could be a response to crises, a failure, or substantial opportunities in the external business environment and internal organizational context. The need for transformation can be divided into external triggers (such as business environment turbulence, technological changes, and government regulations) and internal triggers (such as strategic shifts and internal crises). Since the need for transformation usually arises unpredictably, it seems to be discontinuous, reactive, and mostly driven by organizational crisis (Burnes, 2004). Importantly, this need should be understood to help to create a sense of urgency so that transformation can be initiated under sufficient authority and credibility (Kotter, 1995).

The second step is to initiate the transformation, with a focus on attempting to find a starting point and establishing the target of transformation. The starting point of transformation can be a pilot area or the whole system, indicating that changes can be made in one step if the managers are rather confident in good results that the changes will cause. However, to avoid the risk of failure and to mitigate organizational resistance to change, they can choose an incremental manner, starting from a pilot area, such as the periphery of the system, and then spreading to other units (Luecke, 2003).

The third step is to make the necessary adjustments after receiving feedback from staff and relevant departments. After making changes in structure and process, managers can proactively monitor the transformation process and receive feedback from relevant departments. This feedback tests whether the changes have achieved the expected results (Ford et al., 2008) and can facilitate the making of further adjustments. This step is important for firms in highly dynamic environments because they should continually align the transformation with actual conditions.

The final step is to institutionalize the changes and extend them from the pilot area to other possible areas of the company. Institutionalization can be achieved through policies, procedures, systems, routines, and structures to consolidate the success of pilot experiments (Luecke, 2003).

The last three steps often involve continual routinization and de-routinization. De-routinization is the process of breaking up long, preexisting routines, while routinization is the process of experimenting with and establishing new routines. Established routines can be considered a source of resistance to organizational transformation (Edmondson et al., 2001). Changing routines usually require authority structures to coordinate an implementation project (Edmondson et al., 2001). Therefore, we emphasize the role of executive management teams in the transformation model, especially for steps 2 and 4.

It is worth noting that steps 3 and 4 are not always implemented. For example, firms implementing transformations directly at the level of the whole system do not need to include step 4, and firms that do not need to make improvements after initiating transformation can also skip step 3.

The theoretical framework outlined above will be utilized to analyze three major R&D management transformations. We will articulate how Huawei conducted organizational changes step by step. To elucidate the initial background of the transformations, we will first examine the early years of Huawei.

8.3 BEFORE 1991

Initial Background of R&D Management Transformation

For the first four years after its formation, Huawei did not have an organizational unit dedicated to R&D. We first describe these early years as a prequel to subsequent R&D management transformations and articulate the problems that Huawei encountered, gradually leading to the establishment of a dedicated R&D unit.

Starting as a Simple Agent Business

In 1987, as a small agent, Huawei started to sell business PBX (private branch exchange) produced by a Hong Kong company. China was less open at that point, and the telecommunications market presented enormous potential because it lacked a well-developed telecommunications system, as described in Chapter 1. Entrepreneurs who were able to procure PBX products from more developed places such as Hong Kong, mostly through the back door, could earn large profits by selling these products on the Chinese inland market, where major international telecommunications equipment providers were not active. In this manner, Huawei accumulated some capital over several years. In years two and three, Huawei expanded its business and established a nationwide sales network. However, simply buying and selling telecommunications equipment did not require strong technological capabilities. Many other firms entered the market, and Huawei soon faced fierce market competition. Zhang reported that, in Shenzhen alone, there were a large number of start-ups within one month (Zhang, 2012, p. 8).

Huawei also bore substantial risks in its business. It bore financial risks because it had to prepare orders with Hong Kong-based manufacturers, and the equipment often had long delivery periods. Furthermore, prompt customer service could not be guaranteed due to the lack of spare parts. Since private branch exchanges (PBXs) used in business, such as hotels, became very popular products, the production of manufacturers could not keep pace with the market demand. Therefore, Hong Kong-based manufacturing companies more frequently could not make timely deliveries after receiving deposits (Zhang, 2012).

A Struggle for Survival

To address these supply chain problems, in 1990, Huawei produced its first self-branded product, the BH01, by merely assembling products with components bought from Chinese state-owned companies. This

process enabled the company to ensure the supply of spare parts, improving technical responsiveness and the quality of customer service, while it also helped to reduce the company's working capital requirements. With its own branded and self-produced products, Huawei did not need to spend money to acquire a dealer license from the Hong Kong company or to prepay deposits when fulfilling orders. By developing domestic agencies and charging agents' fees, Huawei could also improve its cash flow.

Although Huawei's products were not superior to what other competitors offered, its superior customer service and lower prices made the BH01 a very popular product on the market. Ren summarized that although Huawei relied on advanced technologies in later years, in the early days, it lacked advanced technologies, and product quality was not high. It was a responsive network consisting of thirty-three customer service centers that compensated for the deficiency in technological sophistication (Cai, 2009).

However, these advantages also observably created hazards for Huawei. The competitive price offered by Huawei attracted far more customers than the company had ever predicted, and the abundant orders immediately overwhelmed the company (Ru-chy, 2015). Unfortunately, because the component suppliers also manufactured and sold their own products, Huawei's supply often could not be met on a timely basis. Subsequently, the supplier's back orders took a heavy toll on Huawei's deliveries to customers, which created another dilemma. Sometimes, Huawei received money from customers when they ordered products, but the company could not provide products to them. In the meantime, tightened government policies on credit and equipment importation increased Huawei's capital chain risks. The company was faced with a real financial deficit and even money received as advance payment had also run out. If it could not deliver goods on time, the company would go bankrupt. Because Huawei could not rely on its component suppliers to survive, the only way to fix this critical situation was for the company to develop every component itself and to produce its own products, achieving

breakthroughs in the shortest time possible; otherwise, customers would contact them and ask to be reimbursed.

In late 1990, Huawei initiated its first product development project. At that time, there was no R&D department – only one product development team supported by six engineers. Due to near-zero technological capabilities, the only feasible method of achieving this goal was reverse engineering the product. A Huawei team extracted knowledge and design information from the components of the BH01 (the circuit diagram and software) to design a new product with the company's own components. At that stage, Huawei's office was a combination of a product development laboratory and production workshop that was responsible for development of software and hardware, manufacturing and testing. After nearly a year of continuous 24/7 struggle, Huawei ultimately launched its first self-developed product, the BH-03, in 1991, with a network access license from the Ministry of Posts and Telecommunication. In the next year, sales revenue generated from this new product exceeded 72 million RMB, giving Huawei hope for survival (Huawei people, 2006).

8.4 1991–1994

Informal R&D Management

Starting in 1991, Huawei gradually initiated R&D projects; however, all of the R&D projects were controlled by the manufacturing department in the early stages. As technological complexity increased over time, various problems emerged during the “informal” R&D management stage. In 1993, Huawei established a digital unit and employed a new organizational structure to manage part of the R&D projects.

Identifying the Need for Transformation

Due to fierce market competition in the agent business and tightened government policies on credit and equipment importation, Huawei realized it could not succeed in the agent business. Therefore, the

company started the independent development of telecommunications equipment, focusing its strategy on a market segment with low technical barriers: the telecommunication switch market. Although with great difficulty Huawei developed its first product by reverse engineering the components of suppliers, Huawei wanted to become more systematic in its approach. As one of Huawei's former executives, Li Yigai (2016), confirmed in an interview, once Huawei realized the importance of R&D, it strongly and persistently defended R&D's central and strategic role in the company. Even in 1992, Deng Xiaoping's tour of the south suddenly cast a national spotlight on Shenzhen's stock market and real estate development. Many high-tech firms, rather than focusing their resources on technology development, bought shares of other companies on the stock market and diversified into real estate. Huawei, in contrast, with 100 million CNY of assets, resisted the temptation and consistently devoted itself to the telecommunications industry.

Nevertheless, due to the lack of technological capabilities, it was difficult for Huawei to make sustainable progress with its independent R&D. Under these circumstances, Ren actively contacted the top universities in China, inviting professors and top students to visit the company to seek opportunities in technological collaboration. An increasing number of young graduates with technical talent joined Huawei, some of whom became top managers, such as vice president Zheng Baoyong. The number of total employees increased from 200 in 1992 to 1,000 in 1994, almost quintupling.

History proved that this concentration strategy was the correct path for Huawei, under which the annual Huawei's revenue increased from 71.69 million CNY in 1992 to 577 million CNY in 1994. Moreover, its technological capabilities significantly improved during this period. In 1991, Huawei launched its first switches using space-division technology – the HJD48 (also called the BH03U, and the previous product, the BH03, which was renamed the BH03K), which greatly improved the level of integration by utilizing the space of circuits more effectively. Soon thereafter, in 1992, the HJD48 brought

sales revenues to approximately 72 million CNY, boosting the morale and confidence of the entire company. Subsequently, Huawei planned to expand its business from private branch switches to telecommunication operator switches, and it started the JK1000 project in 1992 and the C&C08 project in 1993.

Although it seemed that Huawei grew at an unprecedented pace during this period, there were some hidden problems. Switches for telecommunication operators require much more complicated functions and better overall performance than private branch switches because they must be able to serve thousands of users simultaneously, whereas private branch exchanges can only serve approximately fifty users at the same time. Therefore, the technological complexity increased significantly. Given the increasing technical complexity of new projects and the much larger staff sizes required, Huawei's early R&D management capabilities were no longer adequate.

Moreover, R&D management did not play a decisive role at the time. Product development almost entirely depended on the capabilities and performance of several "masters," who constantly switched from one product to the next to move all projects forward because the majority of R&D personnel were inexperienced graduates from the School of Computing who had little knowledge of telecommunications equipment. Most of them had not even seen a telephone exchange before (Hu, 2009). Normally, they began a difficult process of learning by doing after managers gave them a dozen documents and a brief introduction to the project. When Huawei started to develop the C&C08 switch, all of the R&D staff had to study a red-covered book about domestic standards for program-controlled switches. Due to weak R&D capabilities in both hardware and software, sometimes the employees did not know how to proceed and so had to use trial and error to develop the basic function of making phone calls. However, the implication of this type of informal R&D process was that the senior R&D engineers were always in a hurry to solve the most urgent problems. Second, the management of rapidly changing product versions was chaotic. Sometimes, after receiving urgent feedback from

customers, a single engineer needed to solve a problem and update the temporary product version on the spot, without the involvement of the whole project team. Because the project schedule and plans did not actually work, the “firefighter” who could solve pressing issues earned more respect than the project managers did.

Under these circumstances, a variety of technical problems suddenly occurred. For example, in humid areas, such as Guangdong province, painting with moisture-proof lacquer was not listed in the hardware documents and as a result was forgotten by workers, which caused damage to the products. Consequently, the company urged engineers to paint all of the products themselves.

Initiating Transformation

R&D Structure Goes beyond the Manufacturing Department

Both the BH01 and the BH03 projects belonged to the manufacturing department before 1993. Due to the small number of shipments, only after the company delivered one product did it begin to produce the next product. As shown in Figure 8.3, there was no clear structural division between R&D and manufacturing.

With the rise of the mobile telephone, telecommunications equipment increasingly switched from analog to digital technology. When Huawei initiated the C&C08 project, the first digital program-controlled switch, which became one of its early standout products, was still based on the project in the manufacturing department. However, this plan did not work well because both the team size and the technological complexity of the C&C08 were much greater than those of any of the previous projects. In terms of technology and personnel, the management of the C&C08 project far exceeded Huawei's former R&D management experience. Specifically, nearly 300 R&D people participated in more than fifty subprojects that were conducted simultaneously under the C&C08 project (Zhang, 2012, p. 47).

In 1993, Zheng Baoyong, who previously led the General Engineering Office, which was responsible for product planning and design,

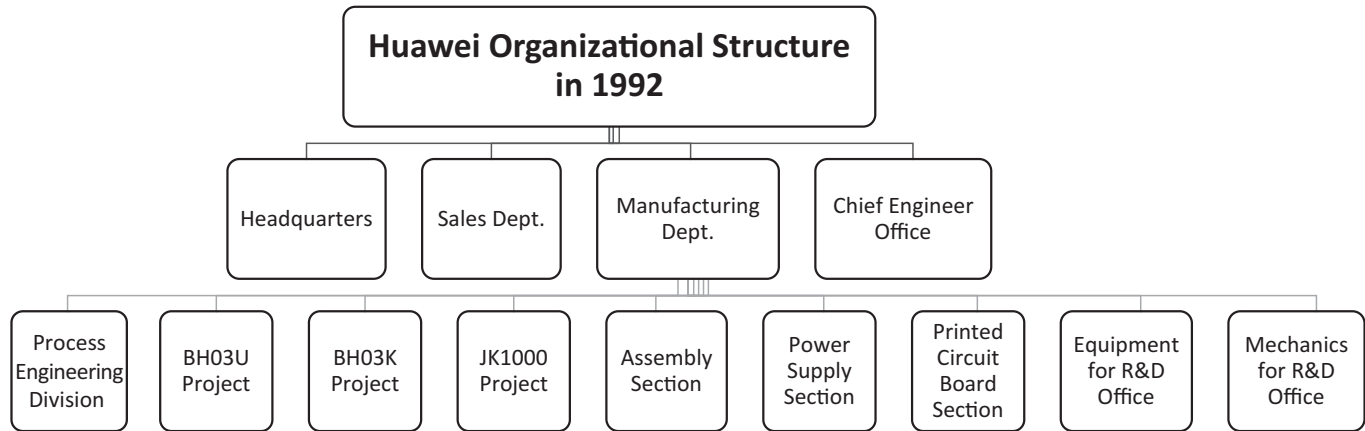


FIGURE 8.3 Huawei organizational structure in 1992 [Zhang, 2012, p. 121]

moved the C&C08 project from the manufacturing department with the approval of the CEO and established the digital unit in parallel with the manufacturing department (Zhang, 2012, p. 121).

Change in Process

In addition to the structural change, Huawei also gradually built an approach of integrating modules after theoretically decomposing products. In the early stage, advanced switch technologies were mostly controlled by foreign companies. If Huawei attempted to make new products, in most cases, managers with solid technical backgrounds would lead the project teams. Starting from theoretical analysis, they would first segment the whole product to be designed into many technical modules. They would build the individual modules. Then, they would test these modules technically by performing experiments one by one. Finally, they integrated these modules into a complete product. For example, when developing the challenging C&C08 product, Zheng Baoyong broke the whole product into seven core technical modules. By theoretically breaking it down into different functions and layers, he was able to turn a big complex problem into many smaller ones that were much easier to solve. After validating that each module would work and determining a difficult integration process, they finally obtained the original product and later received feedback from customers so that further improvements could be made. In general, the R&D process was informal and not institutionalized, ensuring only the completion of product development.

In terms of R&D management, Huawei adopted a straightforward method to manage R&D at this stage, in which a project manager led several engineers. The managers were responsible not only for all technical tasks but also for project management, which requires both high technical capabilities and comprehensive management capacity.

To facilitate knowledge sharing and R&D personnel training, Huawei also employed some informal team learning mechanisms. For example, due to weak technological capabilities, the engineers did not

have professional testing instruments when product development failure occurred, so they simply used multimeters and oscilloscopes to test telecommunication switches. Later, for convenience, the manager of the hardware department wrote a guideline specifically to educate other new R&D staff in how to use multimeters and oscilloscopes in switch testing and maintenance (Zhang, 2012, p. 42).

To criticize suboptimal work performance in the informal R&D process, the company convened an “anti-naïve behavior” meeting. Every core engineer was awarded a special ironic souvenir made of waste materials mistakenly accumulated in the R&D process, such as scrapped boards caused by incorrect design. Management also collected all of the airfare ticket stubs that were the results of the need to engage in “firefighting” missions in the field, and they publicly displayed them as a reminder to R&D engineers to be more diligent in the product development stage.

Making Feedback-Based Adjustments

The success of the C&C08 project proved that the establishment of the digital unit was effective for the R&D management of complex projects. In May 1993, Zheng Baoyong made some major further changes in the digital unit, adopting a structural model similar to the C&C08 project with hierarchical control (see Figure 8.4). A general technology team was responsible for producing the overall plan, technology assessment and technology coordination. There were seven general teams for different technology domains and a number of different project teams. Specifically, the general teams were responsible for technology, including technology trends and technology planning, whereas the managers of the underlying project teams were responsible for project progress, including managing the crews and project scheduling. With regard to project operations, managers attempted to achieve the overall goals by finely subdividing the projects. Two or three engineers were placed on each team because it was believed that these small teams were easier to manage and that they helped to motivate each member (Zhang, 2012, p. 122).

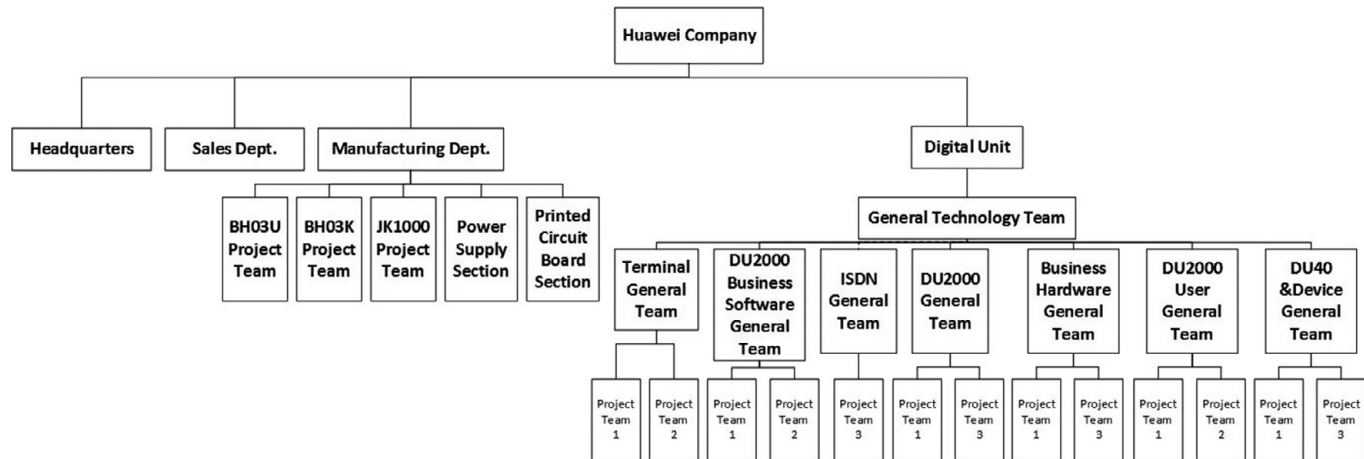


FIGURE 8.4 Huawei's organizational structure after the transformation of the digital unit (Zhang, 2012, p. 122)

Although the operation was more complex, it proved to be the best form of organizing large-scale and technologically complex product R&D. Because it emphasized the layered organizational structure of the overall technology planning and was also aligned with the pursued objective, it enhanced overall product development efficiency.

In 1994, the scale of the digital unit significantly expanded, with a total of more than fifty subproject groups across the seven teams (Zhang, 2012, p. 122). This new R&D management structure, which ensured the efficiency of the R&D system, successfully adapted Huawei to the increasing scale of R&D.

Huawei also built a mechanism of personnel mobility into the R&D process. When new products were developed by a project team, a project manager would also go to the manufacturing department to follow its production and would then transfer to the sales department (the literal translation of the Chinese name is “marketing department”) to take charge of product sales. In 1994, Huawei began to prepare for the large-scale production and selling of C&C08 switches, so R&D staff members who constructively participated in this project were distributed to other departments, such as the sales, manufacturing, and sourcing departments. For example, the project manager of the C&C08, Mao Shengjiang, was transferred to lead the manufacturing department and was later placed in charge of the sales department. Personnel mobility circulated managers who had technical backgrounds across different departments and avoided talent shortages, contributing to Huawei’s development in the early period.

8.5 1995–1998

Establishing a Formal R&D Management System

To optimize R&D management, Huawei established the central R&D department in 1995, integrating all of the project teams into a large-scale, formal R&D team. Furthermore, Huawei established the pilot production department in 1995 and the strategy planning office in 1996 to build a formal R&D system.

Identifying the Need for Transformation

After several years of pioneering work, Huawei experienced rapid growth, with sales revenue reaching 885 million CNY in 1995 and more than 1,200 employees in that year. However, the growth of the domestic telecommunications equipment market slowed at this stage. Especially for traditional program-controlled switches, profit margins had been squeezed tightly because unprecedented competition led to price decreases, and while market demand started to diversify, network service and mobile communications became more important markets. Across the industry, most of the multinational telecommunication equipment vendors transformed their market roles from switch product providers to comprehensive telecommunications solution providers (Cai, 2009). To remain competitive, Huawei began to change its product development strategy from a concentration on switches to the horizontal integration of diverse emerging products.

With the growing number of Huawei's R&D projects, the R&D management complexity rapidly increased. In 1995, based on the technical success of the C&C08 product, Huawei started some new product development projects, such as the C&C08 smart platform, the C&C08-Q ISDN queuing equipment and the EAST8000 digital SPC switch. Moreover, Huawei initiated R&D projects for intelligent platforms, wireless access products and IC design, and these new projects could not be incorporated into the digital unit or the manufacturing department because they belonged to new technology domains, such as wireless telecommunications, and these complex projects could not be managed well in the manufacturing department. Thus, Zheng Baoyong became the busiest manager, responsible for approximately 10 projects simultaneously (Zhang, 2012, p. 123). The challenge was that these projects were not organized in the same manner. Although some were well controlled under the digital unit, early projects still belonged to the manufacturing department (as shown in Figure 8.3), and even emerging projects could not find their appropriate places in the R&D system.

Another existing problem was the lack of technology sharing and collaboration. R&D activities used to be performed by particular product teams, among which there was little communication. Consequently, the same technical problem that arose and was resolved by efforts in product A and soon arose in product B or C, and it cost time and energy to overcome it. Sometimes, the same modules or functions were developed in different products, which decreased the efficiency of R&D.

In addition, Huawei's technological capabilities in different domains varied. In 1995, the strongest domain was switches; however, its technological capabilities in new fields, such as wireless, were somewhat weak. In terms of the development of wireless products, there were several problems. Due to the lack of technology accumulation and experienced engineers, it was difficult to achieve breakthroughs in core technology or wireless products. The teams remained reluctant to use the system software and hardware of the mature switch product because they aggressively prioritized the originality of their products. Overall, wireless product development teams did not perform well in aspects of project management, system design and testing, which led to slow R&D progress.

Initiating Transformation

Establishing the Central R&D Department

In 1995, Huawei reorganized all of the project teams into a large-scale, formal R&D organization and further established the central R&D department in March 1995, optimizing R&D management by integrating the R&D resources of the entire company. The structure of the central R&D department is shown in Figure 8.5.

The central R&D department was divided into the aggregate technology planning office, the personnel division, the material planning division, the basic research division, and four business divisions. One of the principles of dividing the business divisions was whether the division created mature products that already were in production, such as the C&C08 switches in the switch business division and the

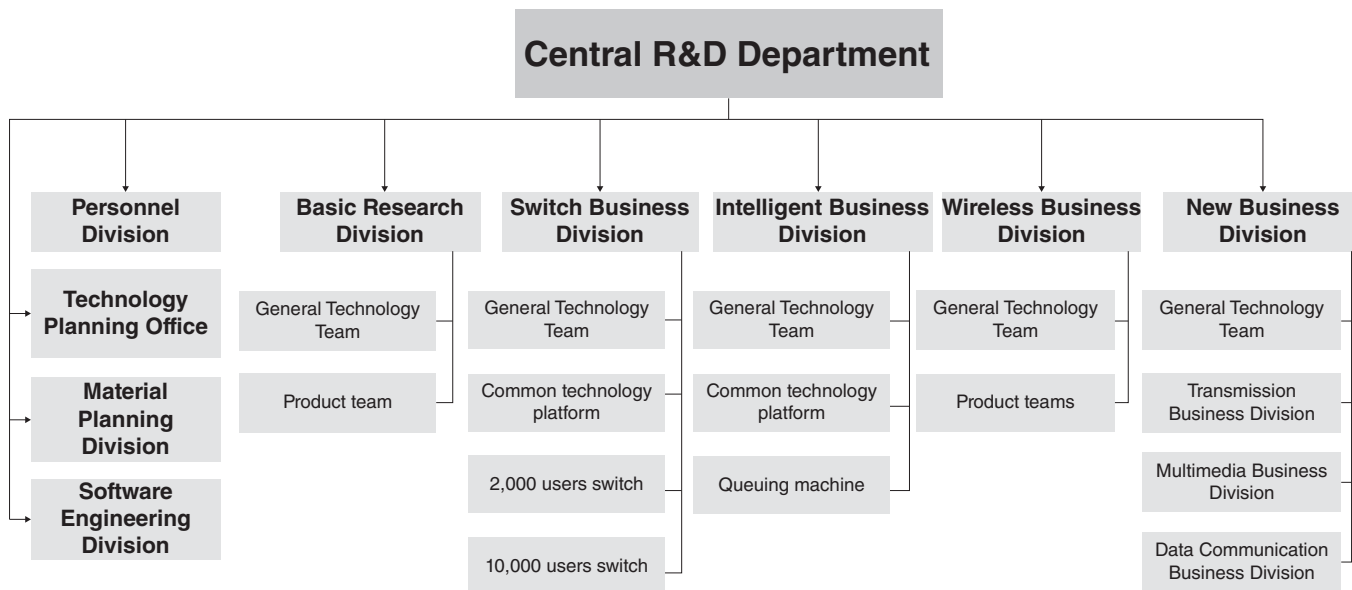


FIGURE 8.5 Structure of the central R&D department in 1995 (Zhang, 2012, p. 124)

C&C08 intelligent platform in the intelligent business division. New business divisions mainly focused on developing new products. Another principle was the technical relatedness of different products, especially the relatedness of the core technologies underlying the products. Each business division was responsible for its products' successes and had to conduct research on forward-looking technology to keep its technology in the leading industrial position in the respective technical domain.

Then, R&D for each business division was broken into one general technology team and several different product teams. The product teams took charge of different product development projects. What was unique was the general technology team, which could be considered secondary technology planning in a particular business division. A common technology platform develops a platform or common technology that can be shared within a business division, which avoids R&D overlaps of functions or modules in different products, such as conducting signaling management research under the switch business division. Moreover, it introduces technology sharing among multiple products, which enables R&D personnel to generate multiple products based on one common technology platform, thus making R&D for new products more controllable and reusable.

To improve the capabilities of software development, in 1994, Li Yi, the software project manager of the C&C08 2000 project team, proposed enacting software coding standards and placing a greater emphasis on software testing, but few people supported this proposal (Zhang, 2012, p. 127). The reason was that every team was more concerned about product output than product quality. Even if problems occurred, by firefighting, they could receive more attention from company leaders. However, to their surprise, the CEO and founder Ren greatly valued the proposal on software testing. During one business trip, Ren unexpectedly appointed Li Yi to direct software engineering. Therefore, the software engineering division was established under the central R&D department in 1995, and it was responsible for coding standards and software quality control.

The personnel division is the specialized human resource department under the central R&D department, and it is responsible for the recruitment, training and promotion of R&D staff and design of salary incentive mechanisms. Since the scale of R&D staff increased significantly over time and the management of these people requires different skills and is more complicated, it was necessary to build a personnel division focusing on the R&D function. For example, the salaries of R&D engineers are generally higher than those of other employees and might sometimes even be higher than those of department managers. People who work full time in the personnel division are selected from the technical leaders in each business divisions.

The establishment of the central R&D department marked a new era in Huawei's R&D management. As product lines expanded, not only technological improvement but also the need to enhance technical management capabilities were required. This type of enhancement was embodied in three aspects.

- (1) Decentralization by delegating more decision rights to each business division and authorizing each division to perform its own technology planning and not simply blindly complying with aggregate technology planning
- (2) Hierarchical control and a clear organizational structure: From top to bottom, the R&D process was divided into three layers: planning, management and control, and implementation.
- (3) Transferring knowledge and expertise from the central R&D department to other parts of the company: The central R&D department became the heart of Huawei's global R&D, supporting product development in other dispersed regions. Turning technologies into saleable products often began in the central R&D department in Shenzhen and then spread to other R&D centers. In addition, the project managers and administrative staff of these centers were also supplied by the central R&D department. Similarly, all of the organizational transformations began in Shenzhen as experimental fields, and they were then implemented in other centers after stabilization.

After the establishment of the central R&D department, intersector mobility was also improved. Managers could organize all R&D resources in a unified manner and further balance the technological capabilities across different technology domains. To support the development of the wireless business division, the leader of the central R&D department decided to transfer some of the best technical experts in the switch business division to the wireless business division. The managers of the central R&D department also required the wireless division to use the software and hardware developed by the exchange sector fully and to enhance the project management by learning from strong divisions. The central R&D department was good at promoting the operating experience of mature business divisions and projects, based on which the wireless division rapidly developed.

Product Quality was Ensured by Pilot Production and Testing

The other significant R&D management transformation in this period was the establishment of the pilot production department. In the early stage, after the development of a product, engineers tested it by themselves, and if there did not seem to be any problems, then the product would be rushed to the production unit. However, the engineers mainly concentrated on new product development rather than testing, and many problems emerged in the mass production stage, resulting in a low first-pass rate of products, which resulted in a high rate of waste. Small problems caused a much larger set of failures that were not anticipated in the product development process. When problems were discovered during the production stage, R&D personnel hurried to solve urgent problems in the production line, turning the production line before delivery into a laboratory to resolve problems.

Thus, in 1995, Huawei established the pilot production department, the purpose of which was to ensure the quality of products and to accelerate the maturity of R&D output. The pilot production department was divided into the trial manufacturing division and

the testing center, which consisted of hardware testing division, software testing division and testing laboratory, with a total of approximately thirty staff in 1995 (Hu, 2009). There were numerous undergraduates performing R&D in the central R&D department, whereas the pilot production department employed many PhDs to ensure product quality, which made the pilot production department the department with the largest number of PhDs.

Changes in Processes

Before the establishment of the central R&D department, everyday R&D management placed high demands on project managers' capabilities. As Huawei's R&D projects became increasingly complex and large in scale, project managers were more likely to be distracted and sometimes could not concentrate on crucial technical details. Existing flaws in their management methods often remained unaddressed, causing problems such as schedule delays or out-of-control costs. In addition, to some extent, this type of management hampered communication and technical cooperation between different projects.

Things improved after Huawei established a dedicated R&D department and used matrix management principles for the R&D operations (see Figure 8.6).

Each business division in the column was responsible for product development and its market success, while R&D supporting divisions in the row undertook efforts in both improving overall efficiency and reducing R&D costs (see Figure 8.7). When business divisions received customer demands and feedback from the sales department or requirements of product design improvements from the pilot production department, they first sought resource support from divisions in the rows. Since these businesses' supporting divisions brought different technical demands or management demand from each business division, they would form professional teams and common technological blocs to assist business divisions in resolving specific difficulties. This type of matrix management in the central

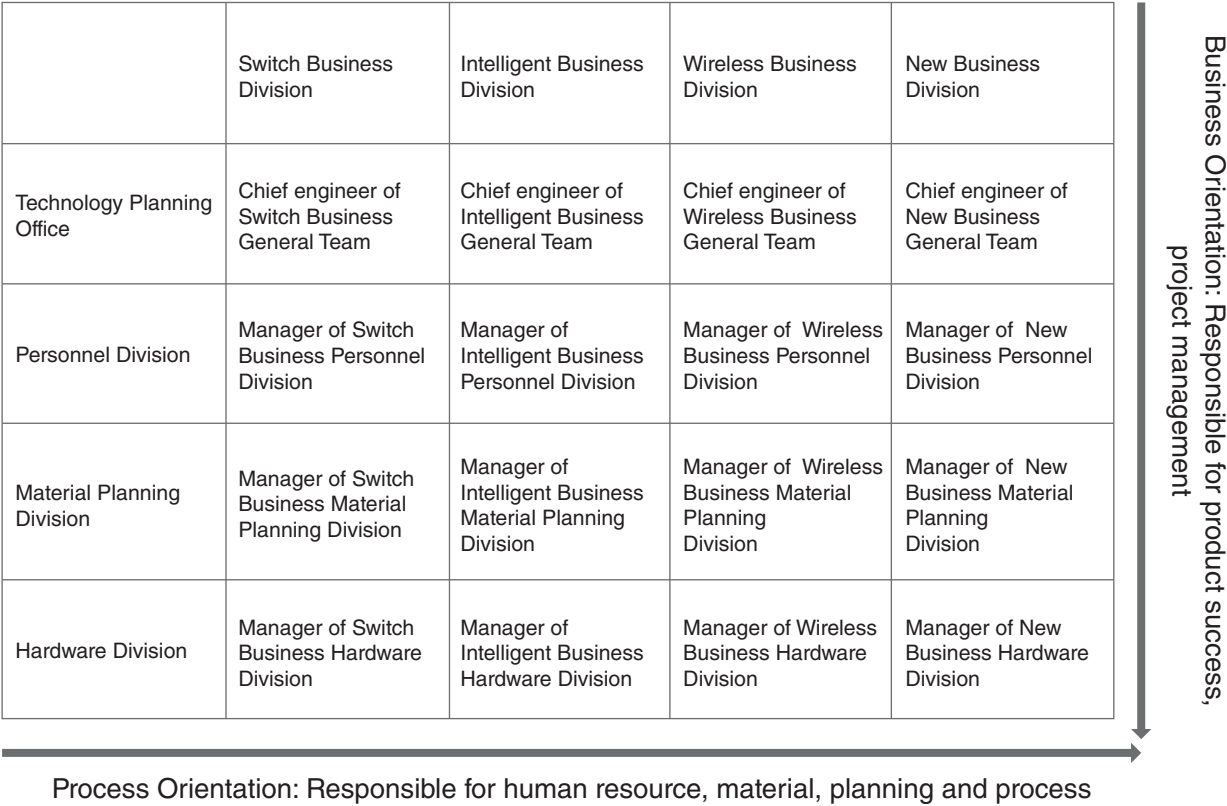


FIGURE 8.6 Matrix management in the central R&D department (Zhang, 2012, p. 238)

R&D department accelerated communication and collaboration and also strengthened organizational adaptive capability.

For important projects that required the joint efforts of different business divisions, the central R&D department would transfer staff from relevant departments to participate in the project. Normally, this staff reported to direct department leaders, but when it came to joint projects, they would be led by the particular project leader. In 1996, as new market opportunities in access networks emerged, Huawei quickly sensed these opportunities and soon formed a specialized project team focused on access network technology by integrating core technical experts from the multimedia division, transmission division, switch division, wireless division, etc. After only three months, Huawei mastered crucial technical problems and developed new access network applications that beat other products in sales in terms of both function and cost (Zhang, 2012, p. 151).

However, many firms failed to implement matrix management due to conflicts arising in cross-department collaboration. There are two formal lines of authority in the matrix structure, which could induce overlapping leadership. Furthermore, the project manager was responsible for the project's success but lacked the corresponding resources. This imbalance in the distribution of rights and liabilities increased the uncertainty of project operation and assessment. To avoid these potential problems, Huawei enacted special institutions for cross-department project collaboration.

First, it established an effective top coordination organization. Since matrix management caused many more coordination problems, Huawei innovatively established an oversight and coordination organization at the top management level for cross-department projects, which was called the leading group and consisted of the president of the central R&D department and managers from each involved underlying division. A project team was created at the same level of each functional department, and both of them were supervised by the leading group. In the access network project, for

example, the president of the central R&D department was the head of the leading group, while group members included the manager of the access network project and leaders from related departments such as the hardware division and switch business division. If conflicts arose in project collaboration, the project leader could directly report to the president, and the whole leading group would later discuss the issue to resolve it.

Second, Huawei considered both project schedules and daily operation routines when undertaking overall time planning and setting priorities for conflicting tasks. Then, it could assess the progress and completion of projects according to planning. Thus, a third fair and sound system of performance assessment was created. For people working in the same functional departments, those who participated in important projects and performed well would be rewarded by higher bonuses and would be promoted more rapidly. The distribution of bonuses would be based on both overall project performance and individual performance. Therefore, it created incentives to participate actively in joint projects.

Despite the above measures, conflicts in matrix management could not be resolved completely, so Huawei promoted a team spirit as part of its organizational culture and assessed the team spirit of manager aspects as an important part of its performance appraisal (see also the chapter on the transformation of HR).

To improve project management, in 1996, Huawei hired 1,000 graduates with management backgrounds, and most of the management graduates joined the central R&D department. These management-trained employees soon helped to build the foundation of Huawei's project management team, and they collaborated with technical experts. They focused on professional management methods, while purely technical experts shared their experiences from practice. This process embodied Huawei's management philosophy of injecting entirely different elements into the original system to maintain balance between different groups and to achieve higher capabilities, referred to as "mixing sand."

Making Feedback-Based Adjustments

As Huawei learned more about the effects of its organizational changes, it made further adjustments by undertaking these actions.

Expanding the Pilot Production Department to Ensure Manufacturing Quality

In 1996, the pilot production department expanded in scale to approximately 300 people, while at the time, there were approximately 600 people in the central R&D department. Although Huawei created preliminary methods and processes for pilot production, the main function of the pilot production department at this time was to resolve the most pressing product quality problems. In general, there still existed many problems, and one significant problem consisted of manufacturing quality issues that occurred during the mass production stage. Huawei realized that in addition to design quality, it also had to improve manufacturing quality. Therefore, in 1996, four new departments were established under the pilot production department: a process testing center, responsible for the process design of new products, focusing on electrical-machining processes and assembly processes; a machine and tools development center, responsible for the development, introduction and integration of automated assembly line; a material quality testing center, supporting mass production with qualified raw materials; and a bill of materials (BOM) center and technical documentation center. The BOM is the basis of purchasing and production, as well as a credible reference for product pricing. Previously, technical documents including the BOM were determined and generated by the central R&D department, and they changed frequently, for example, by adding new components. These changes not only increased the likelihood of mistakes, but they also decreased the efficiency of the purchasing department, the pricing department, and the manufacturing department such that everyone had to follow every change in the BOM accordingly. Once the new BOM Center was established, a BOM would be issued and rigorously

examined by a specialized department; therefore, some potential problems were even discovered and fixed. Moreover, to promote the management level, the BOM center developed institutions to punish R&D staff who did not take the BOM seriously.

After the establishment and expansion of the pilot production department, the quality of Huawei's products significantly improved. Statistical analysis (Zhang, 2012, p. 201) performed by Huawei in 1998 showed that waste materials and products resulting from a large amount of product data errors had cost up to 40 million CNY (0.45 percent of the sales revenue in 1998). The shipping errors caused by incorrect product data also resulted in very large economic losses. In November 1998, Huawei established a data management center in the pilot production department. The product data were the records of the product development process and results, and they became important basic data for diverse enterprise IT systems.

By the end of 1998, the number of employees in the pilot production department had increased to approximately 700, compared with 1,800 in the central R&D department (Hu, 2009).

Creating a Formal R&D System

In 1996, Huawei systematically established the strategy planning office, in parallel with the central R&D department and the pilot production department, as one of the three most important functions of the R&D system. The strategy planning office, which was responsible for research and the output of the overall product strategy, guided the product development direction for the central R&D department. Its aim was to answer the question "What product are we going to develop?" to avoid developing products that the market did not want. The central R&D department was the main locus of product development. Its goal was to "develop products" and to avoid failure in delivering products to the market on time. Once the potential of a product was identified, the central research department would exert every possible effort. The pilot production department existed to

ensure the quality of products. These three departments together represented the early formal R&D system at Huawei.

Early Moves toward Long-Term R&D

Identifying the major technical trends in telecommunications always involves making risky bets due to the long development cycle, large investments, and powerful competitors. Huawei seized the main opportunities, investing in C&C08 switches, intelligent networks, transmission, and access networks during the 1993–1997 period to achieve high returns. However, each year, the company also invested in many technologies that failed. During this period, the development of new products was typically decided by the company's leaders, without careful evaluations of technologies and their market potentials.

The question of what product to develop was simply answered by the strategic planning office. However, merely looking toward the next product was not sufficient for long-term development. In addition, in 1998, Huawei's annual revenue had reached 5.96 billion CNY, it had 8,000 employees, and its business was spread over the main cities in China. As it grew larger, Huawei also attempted to enter the international market and established the international product department in 1998 (see the chapter on Huawei's internationalization). As its market position changed from that of a follower to that of an industry leader, Huawei needed to look further, identifying technological opportunities in the next five years or more.

In contrast, in the past, Huawei merely followed the path of catching up and could not influence major shifts in technological standards of industry. In 1993, when Huawei was developing the C&C08 and the GSM, it exerted great efforts in studying technical standards because it was worried about whether its products perfectly complied with these standards. As Huawei became stronger, it naturally wanted to make a greater impact and exert more control over standard creation, especially with regard to domestic telecommunication standards, to build its long-term market power.

In late 1998, Huawei established the fuzzy front-end department, a subdivision of the central R&D department, which was responsible for research on state-of-the-art, core and forward-looking technologies. Here, “fuzzy front-end” refers to the first steps of the product innovation process, consisting of strategic planning, idea generation, project evaluation, etc. (Murphy and Kumar, 1997). Huawei mandates that funds for fuzzy front-end must account for at least 10 percent of the total R&D expenditures and, accordingly, that personnel account for 10 percent of the total number of R&D staff (Hu, 2009). Huawei spends at least 20 million CNY on fuzzy front-end for new product development each year. In terms of this type of costly long-term investment, Ren (2012) has said, “If one leader cannot properly address the tradeoff between short-term investing and long-term benefits, he is actually not a general. A general must have strategic vision.”

The fuzzy front-end department accepted two types of responsibilities. First, it prepared solid technological capabilities in advance. If the technology has not been tested before product development, the entire development process will be less controllable and more prone to quality risks. The other purpose was to generate more patents and standards, which became a more central strategic goal after the IP lawsuits with Cisco in 2003. People in the fuzzy front-end department extensively participated in international technology forums, related technology associations, and standards organizations to obtain the latest technological information from competitors and to play an active role in discussing and determining standards. Researchers vigorously participated in the process of creating standards, achieving a higher R&D level and moving from being passive users of standards to active shapers of new telecommunication standards.

Establishing a strong fuzzy front-end system significantly benefited Huawei’s innovation and application of new technology; for example, the industry had not yet commercialized 3G networks, whereas Huawei had already begun research on 4G and 5G networks. As is the case with Western technology firms, such as Intel, Google, Microsoft, or its direct competitor, Ericsson, Huawei’s fuzzy front-end

could be regarded as a sort of risk control technique because in the fuzzy front-end phase, it has conducted a thorough analysis of the technologies involved, the partners and the commercial prospects to reduce technological and market uncertainty. Then, the mature output of fuzzy front-end goes to the aggregate technology planning office, a division of the central R&D department that is responsible for organizing technology development. The establishment of the fuzzy front-end system has greatly improved the success rate of new products. To put it simply, the R&D process in Huawei starts from the fuzzy front end and goes to the technology development of technology and product when the company approves and launches the formal development of the concept. As the process goes further, the maturity of projects improves.

In 2009, more than 80 percent of personnel were performing projects that stemmed from the fuzzy front-end department, and others were performing projects that were driven by market feedback. It is not easy to evaluate fuzzy front-end work; thus, the company specifies that the transfer proportion of fuzzy front-end achievements should remain constant at the 70–80 percent level (proportion of total input). A low transfer proportion indicates that the research is too far from the market, while a high transfer proportion might indicate that the fuzzy front-end is too conservative, tending to miss potential technology directions (Zhang, 2012, p. 197).

What types of employees can go to the fuzzy front-end department? In Huawei, only excellent technicians who have been project managers on a mature product team can play a role in the fuzzy front-end department. Inexperienced people without much product development experience are unlikely to obtain a position in the fuzzy front-end department.

8.6 1999–2004

Huawei's IPD System

As Huawei rapidly expanded, more problems arose in Huawei's R&D system. In 1999, Huawei started the IPD transformation and built an

IT support system as part of its attempts to address these problems. Undertaking such a transformation is not easy because many conflicting pressures must be balanced. (Note to the reader: Because this IPD transformation was the first major transformation that Huawei undertook, it is also covered in Chapter 3).

Identifying the Need for Transformation

During this stage, Huawei expanded both in the depth and breadth of the markets in which it operated. It diversified its product portfolio from fixed line telecommunications equipment to wireless products, intelligent networks, data communications, and transmission products. Huawei also broadened its market coverage over time, reaching a large customer base of multiple domestic and foreign telecom operators, rather than a single operator as in the past. Overall, Huawei grew stably, catching up with its competitors. In 1998, its annual revenue reached 5.96 billion CNY, which increased to 7.7 billion CNY the following year. The total number of employees also rose from 8,000 in 1998 to 12,000 in 1999. Especially in terms of the scale of R&D, in 1997, Huawei recruited 4,000 R&D personnel. This sudden expansion made the management of R&D teams more challenging than ever. Specifically, the rapid expansion in scale led to three major problem areas.

(1) Serial development slowed the process: Until 1997, product R&D, dominated by the central R&D department, operated in the traditional manner, from design and development by engineers to feedback from users and improvements. For example, from 1993 to 1997, Huawei launched more than ten formal versions of the C&C08. Although it seemed that Huawei's development speed was fast, it also reflected that new versions lacked foresight and planning (Zhang, 2012, p. 230). R&D personnel merely emphasized functions but ignored operability and maintainability. When the product was delivered to customers, it was found that the maintenance of the product was inconvenient, not only affecting machine operation

but also demanding time to fix the product, which in the long term damaged the image of the company's products.

(2) A long product line reduces market responsiveness: R&D is often passively constrained by the requirements of the market. If the product could not meet the customers' initial requirements, engineers were repeatedly asked to modify it. Moreover, once customers required the addition of a new functionality, the engineers had to work overtime to realize it. As the product line expanded, by 1997, there were hundreds of products being developed simultaneously, which eroded the ability to deliver products quickly to the market.

(3) Due to the rapid expansion of the R&D system, many young students fresh out of universities became core technical engineers, who believed that research achievements were much more important than focusing on effective commercialization. In other words, their awareness of the cost, efficiency, and profitability of many R&D projects was weak, hurting the economic performance of Huawei (Zhang, 2012, pp. 230–231).

At the end of 1997, Ren visited IBM and was deeply impressed by IBM's recent transformation. Combining this experience with Huawei's internal crisis, Ren published a famous article in the company newspaper, entitled 'What can we learn from Americans?', to address management crises when Huawei expanded quickly (Ren, 2003). This article was read and discussed widely, helping to build up support for the coming transformation.

Initiating Transformation

Testing by Pilot Projects

In February 1999, Huawei formally invited IBM to be a consultant in undertaking an IPD consulting project.

The essence of the IPD project was that product development had to be focused on market signals. As a result, product development would not only be driven by the technology department

but also be influenced by market signals, such as feedback and demand from customers.

After one year of research and training, Huawei chose three pilot projects to test the new integrated R&D system – wireless products, broadband products and transmission products – and attempted to build three cross-department PDTs (product development teams). It employed a new matrix-type structure to manage PDTs, as shown in Figure 8.7.

As we discussed in the last section, the R&D department used to take charge of product development, and most product managers came from the R&D department. Departments in the rows all belonged to the central R&D department in the previous matrix, while in the new matrix, departments in parallel with the central R&D department

	Wireless PDT	Broadband PDT	Transmission PDT
R&D Department	Representatives of R&D Department in Wireless PDT	Representatives of R&D Department in Broadband PDT	Representatives of R&D Department in Transmission PDT
Sales Department	Representatives of Sales Department in Wireless PDT	Representatives of Sales Department in Broadband PDT	Representatives of Sales Department in Transmission PDT
Manufacturing Department	Representatives of Manufacturing Department in Wireless PDT	Representatives of Manufacturing Department in Broadband PDT	Representatives of Manufacturing Department in Transmission PDT
Customer Service Department	Representatives of Customer Service Department in Wireless PDT	Representatives of Customer Service Department in Broadband PDT	Representatives of Customer Service Department in Transmission PDT
Pilot Production Department	Representatives of Pilot Production Department in Wireless PDT	Representatives of Pilot Production Department in Broadband PDT	Representatives of Pilot Production Department in Transmission PDT
Supply Chain Department	Representatives of Supply Chain Department in Wireless PDT	Representatives of Supply Chain Department in Broadband PDT	Representatives of Supply Chain Department in Transmission PDT
Purchasing Department	Representatives of Purchasing Department in Wireless PDT	Representatives of Purchasing Department in Broadband PDT	Representatives of Purchasing Department in Transmission PDT
Legal Department	Representatives of Legal Department in Wireless PDT	Representatives of Legal Department in Broadband PDT	Representatives of Legal Department in Transmission PDT
Financial Department	Representatives of Financial Department in Wireless PDT	Representatives of Financial Department in Broadband PDT	Representatives of Financial Department in Transmission PDT

Product line: Responsible for market success

Resource line: Responsible for human and technology development

FIGURE 8.7 New matrix management in the IPD system (Zhang, 2012, p. 238)



FIGURE 8.8 The six phases of R&D in IPD

became involved in the R&D process to build a streamlined R&D system. In May 2000, a wireless PDT was formally established, and the manager of this team had both sales experience and an R&D background (Zhang, 2012, p. 238). Later, in the second pilot PDT, sales staff without any R&D experience held the position of team manager.

In the IPD system, the R&D process is divided into six stages. The first two stages are the concept and planning phases, which aim to clarify market demand to ensure that product development is driven by the market and that it is profitable. The other phases are presented in the following figure.

R&D Resource Sharing with Better IT Support Systems

As a part of the IPD project, the construction of an IT support system for R&D greatly facilitates R&D resource sharing, which is well organized and has a unified interface.

Inexperienced engineers used to follow one experienced engineer; thus, the experience inheritance and help-seeking process mostly relied on “word of mouth,” which was random and spontaneous. If new staff members had questions, they could only consult people with whom they were familiar. In addition, from the perspective of masters, they were sometimes reluctant to guide their apprentices without reservations because of the hidden threat that the apprentices might someday replace them (Zhang, 2012, p. 243).

The establishment of the IT support system improved the situation in two manners.

(1) It improved the help-seeking and help-providing processes. Newly recruited employees need to learn many things, such as how to use the R&D platform and related tools. With the aid of the IT support system for R&D, they could rapidly obtain the help of experts from all aspects of Huawei. The system provides support for employees at three levels. First, experts on duty answer them online in a timely manner. However, if the questions are very complicated and difficult, exceeding their personal ability, the next step is undertaken. They are handed off to a specific group of experts, and their problem is solved by group intelligence. Ultimately, if questions cannot be answered in the second round, they transferred to the external technical support system, and the questions are solved or confirmed outside the company. In general, the IT support system solved 95 percent of questions (Zhang, 2012, p. 244).

(2) Another subject of the system is R&D experience sharing. Support experts must summarize the questions that they regularly confront and compile guidebooks based on common questions. The gathered information is carefully organized and stored in a database for convenient access. This process helps to form an atmosphere of technical study and exchange by encouraging people to share their own valuable experiences. Scattered questions are transformed into structural information, which saves everyone time when seeking solutions.

Making Feedback-Based Adjustments

Before the pilot projects, people were skeptical of the benefits that IPD projects would bring to Huawei's R&D system. Many people thought that IPD simply complicated the entire R&D process. R&D staff resisted IPD because, at many points, they needed to attend meetings with people from other departments, prepare more materials, and write many more documents, significantly increasing their workloads, and even distracting them from their core R&D activities. However, to some extent, the introduction of IPD indeed resolved the problem of rapidly changing product versions because R&D staff

now needed to check and fix things at every stage of the product development and delivery process. Moreover, product information could be tracked through sound documents and records, helping to ensure product quality (Sun, 2016).

Initially, these improvements were not apparent, and salespeople held different opinions about the issue. Before IPD transformation, one version would be brought to market within one month, but after IPD transformation, the time frame lengthened to half a year or even more than one year, which reduced market responsiveness and did not clearly improve product quality. Indeed, IPD would only shorten the time to market over the long term because IPD emphasizes the principle of “get things done right the first time,” that is, preparing well when performing R&D rather than quickly rushing to the R&D stage and then following up with continual fixing and reworking. During three pilot projects, products became increasingly stable, and there were no longer rapid version updates and frequent product recalls, which proved the overall benefit of the IPD system.

Systematizing Changes

After nearly one year of testing, the IPD system yielded remarkable effects on three pilot projects. Led by an IBM consulting team, the IPD system was expected to be implemented across the whole R&D system, but Huawei only rolled it out incrementally across the organization. The IPD system was first employed in 50 percent of all R&D projects, and the number then increased to 80 percent and finally to 100 percent in 2003.

Huawei established a product line management team, and each product has its corresponding PDT (product development team), which incorporates representatives from different departments, including the R&D, sales, finance, purchasing, production and customer service departments, and PDT managers typically come from the sales department. Thus, every PDT can be regarded as a micro start-up company, and it is responsible for the market success of the product.

Huawei faced a significant management challenge at this point: How could the previous long-standing R&D routines, which had been in place for nearly ten years, be broken in a short period of time? In the past, salespeople were not blamed for the functionality problems of products that were caused by the R&D department. Now, they were reluctant to accept more shared responsibility with the R&D department because they might be blamed for problems with products. Regarding the R&D department, it used to hold the inherent idea that R&D is the most important department, based on its previous track record of success and because people considered that the products it developed earned profits for the entire company. In addition, the decision-making process and the work of reporting on product development were both controlled by the R&D department. Under these circumstances, the department would not simply accept the new system, and it needed to be taught how to develop products with staff from other non-technical departments. R&D personnel needed to report to representatives from sales, finance, and other departments, and the next step of product development could be undertaken only after approval from these representatives. Therefore, the power of the R&D department was decreased and reallocated across other departments.

Although conflicts of interest naturally arose in IPD transformation, Huawei attempted to address them proactively. To minimize the impact of conflicts, the CEO gave sufficient authority to the IBM consulting team (Hu, 2009). Ren indicated, "We must break down the barriers between different departments! If anyone, especially department leaders, publicly or secretly object to the IPD project or do not take it seriously, then they should be punished or even directly fired." Under strict rules, the vast majority of the participants gave up resistance to the implementation of IPD, and they gradually became supporters as the benefits became more visible over time. Senior Vice President He Tingbo recalled that in the past, the R&D strategy relied more on individuals and the availability of funds, while the new IPD system placed great emphasis on formal decision-making processes, which were rather inconsistent with the intrinsic beliefs of the R&D

staff. In the software and IC department that she led, some core R&D staff members (approximately 30 percent) were reluctant to compromise on the new system and left the company (Qiu, 2006).

In 2001, Huawei launched the first version of the IPD system, followed by a second version in 2002. Over the course of five years, the IPD system was rolled out to all product development-related departments. While product quality depended on ex post control in the past, it now improved because of a systematic effort to build it into every stage of the development process. Since every activity of the pilot production department had been integrated into the IPD process, it was no longer necessary to establish an independent department. Therefore, Huawei decided to dissolve the pilot production department in 2003 and further distributed its activities across related departments (Hu, 2009).

Moreover, Huawei's R&D capabilities were significantly strengthened. The average time to market decreased from 84 weeks in 2003 to 54.5 weeks in 2007 (Ouyang, 2015). In addition to enhanced technological capabilities, the R&D management capabilities were also clearly improved. Several years ago, Xu Zhijun, the vice president of the company, said that before IPD, Huawei could not effectively manage an R&D workforce of 3,000 people, but now, after the IPD reforms, Huawei could manage an R&D staff of 70,000 with ease (Tian, 2015). Because the IPD process caused the organization to operate according to relational decision-making, it is less reliant on individuals.

8.7 2005–NOW

Ongoing Transformation Toward Global Leadership

Integrating Global Resources by Establishing Worldwide Research Centers

Over the decades, Huawei's role in the industry has gradually shifted from a follower to an international player. In 2005, sales in the international market accounted for 58 percent of total contract sales,

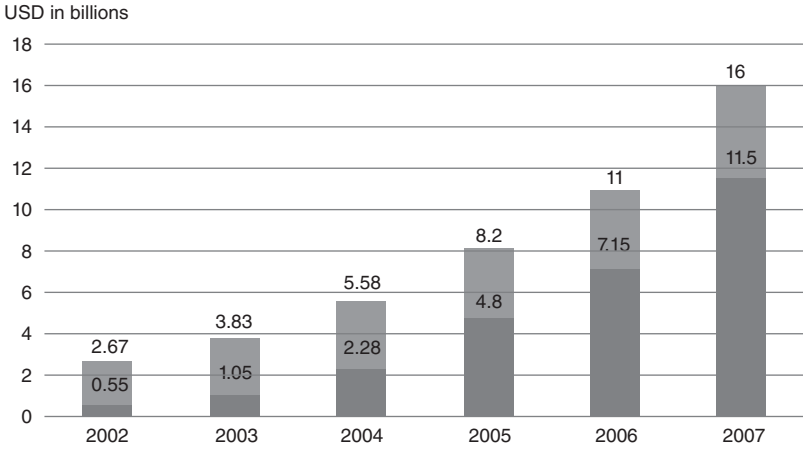


FIGURE 8.9 Huawei's sales from 2002 to 2007

surpassing domestic sales for the first time. As shown in Figure 8.9, international sales have been increasing over time, and they have also become the major driver of sales growth. Under such circumstances, how to maintain consistent growth and further enhance its technological capabilities in the global context have become challenging new issues for Huawei.

In 1991, Huawei started strategically to locate R&D centers around the world, such as in the United States, Europe, and India. By 2016, Huawei had established fifteen R&D centers and centers worldwide (Huawei, 2016). These global R&D centers help Huawei to track the latest technology advancements globally. More importantly, Huawei can take advantage of the highest quality global human and technological resources in this manner.

In a similar way of locating domestic R&D centers as close to talent pools as possible, rather than close to the company's HQ, Huawei also considers the expertise of the country when establishing international research centers, which is evident when we examine the most important international research centers (Ya, 2016) shown in Figure 10.

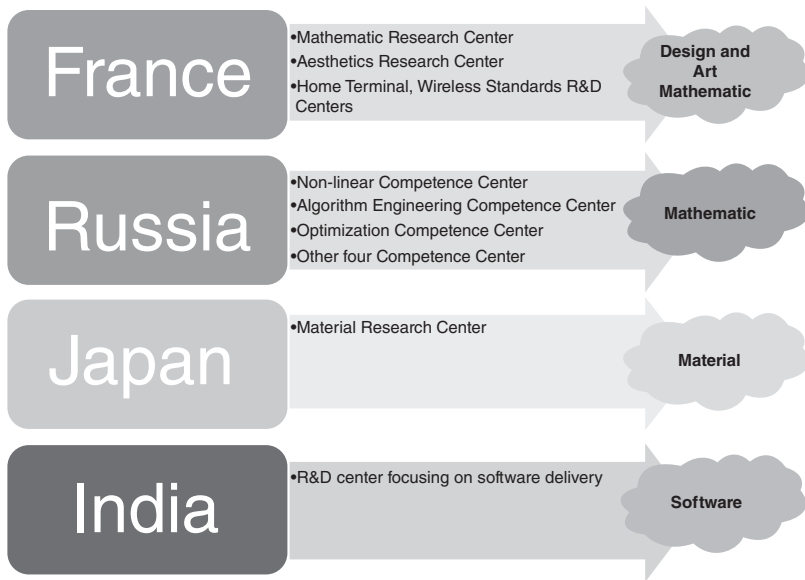


FIGURE 8.10 Main international research centers

In March 2015, Huawei unveiled the Aesthetics Research Center in Paris, one of the leading cities in global design. To date, ten designers actively work on Huawei's brand-new bracelets and watches, composing a small but productive R&D team (Xing, 2015). For mathematical research, Huawei has hired approximately ten world-class mathematicians in Russian research centers, and they have achieved algorithm breakthroughs in 2G and 3G technology, including SingleRAN (single radio access network) technology, which offers significant savings for mobile operators struggling with multiple technologies and services on their networks (Tian, 2015).

The core is that all of the R&D centers, both domestically and abroad, should be arranged in line with business needs, indicating that R&D centers as resource departments should serve business units.

Huawei also actively embraces open innovation by establishing joint innovation centers. In October 2006, Huawei launched the first mobile innovation center (MIC) with its famous customer, Vodafone Group in Spain. Huawei had cooperated with its major clients through

36 joint innovation centers worldwide by 2016 (Huawei, 2016). With more than 100 innovation topics, Huawei's Joint Innovation Center network has emerged as a key platform for enhancing both sides of any strategic partnership.

Building Noah's Ark to Embrace Future Challenges

History shows that incumbents can be beaten by new entrants, especially those who introduce disruptive innovation. Although Huawei's innovation capabilities have become strong over the decades, it has generated much more incremental innovation than disruptive innovation. Despite its substantial number of patents, Huawei still must rely on American firms with regard to core technology, such as chips, operating systems and some core components (Tian, 2015). For large firms, there are few precedents of achieving success through disruptive innovation. Success in the past has hindered the transformation of the culture and business model in large organizations. Upon facing dramatic changes in the mobile Internet era, Facebook and Google have also perceived a great crisis. Although previous fuzzy front-end systems also focused on future technology, top managers at Huawei believe that doing so was not sufficient to withstand future challenges. Thus, new changes are under way inside the company.

Under these circumstances, Huawei has placed a greater emphasis on the fuzzy front-end department and has transformed it into a firm-level department, the "2012 Laboratories" in 2011, independent of the central R&D department (Sun, 2016). It is said that the "2012 Laboratories" were named by Ren Zhengfei after he watched the movie *2012*, and he has said that in the future, information will explode in a flood; therefore, Huawei must build its own Noah's Ark to survive (Zhang, 2012, p. 198). To achieve distinct competitiveness in the future, this new R&D platform functions as the innovation, research, and platform technology development arm of the company. It focuses on long-term research on future technologies, such as machine learning, natural language processing, the fifth generation of communications technology, and new materials. It is run fully

separate from the existing R&D system to nurture disruptive innovation or breakthroughs. Without this separation, management fears that R&D engineers will use previous research as a foundation to create innovative research in the traditional R&D system and will never achieve truly disruptive technologies. The unit is led by Li Yingtao and reports directly to the CEO.

In an interview, Ren disclosed that there are currently more than 700 high-level scientists who work in or collaborate with the 2012 Laboratories and that this number will exceed 1,400 by the end of 2016 (Xinhuanet, 2016). Ren has also strongly encouraged top scientists in Huawei to spend at least one-third or even half of their working time sharing ideas with prominent figures in foreign universities, technology forums, and academic conferences (Tian, 2015). If the “businessman” culture of engineers has contributed to Huawei's enormous commercial success in recent years, then we believe that scientists and engineers jointly construct the strategic blueprint of the future, guiding Huawei to become a global leader.

8.8 CONCLUSION

In this chapter, we developed a four-step model to analyze three major R&D management transformations in Huawei's long history of developing R&D systems. The first transformation, from 1991 to 1995, helped Huawei to establish an informal R&D system from scratch; then, the second transformation from 1995 to 1998 caused the informal R&D management system develop into a formal system with clear structures and processes; and finally, the third transformation greatly changed Huawei into a process-oriented, high-performing organization. We summarize the triggers, motivation, changes and outcomes for each transformation in Table 8.1.

We found that all of the transformations were closely aligned with the firm's market position and its strategic shifts. Huawei in the early stage was forced to make changes to survive fierce market competition. As Huawei gradually grew into an industrial leader with strong technological capabilities, it proactively sought to improve its

Table 8.1 *Content summary of three R&D management transformations*

	First Transformation (1991–1994)	Second Transformation (1995–1998)	Third Transformation (1999–2005)
External triggers	fierce market competition in the agent business; tightened government policies on import and credit	technology changed to mobile telecommunication	technology shifted to newly filed, such as wireless, intelligent networks, etc.
Internal triggers	strategic shift from an agent to an independent developer of products; lack of R&D experience and technological capabilities; obvious problems, such as frequent ‘firefighting’ actions	strategic shift from concentration on switches to horizontal integration of diverse emerging products; R&D management complexity rapidly increased; lack of technology sharing and collaboration	expansion in scale led to many problems that decreased the efficiency of the R&D system
Change in function of R&D department	responsible for the development of products from C&C08 products to most new products	responsible for the success of all R&D projects	only responsible for part of the integrated product development

Change in structure	established digital unit in 1993 (step 2); made major changes in digital unit and adopted a hierarchical structure (step 3)	established the central R&D department in 1995 (step 2); established the pilot production department in 1995 (step 2); expanded the pilot production department in 1996 (step 3); established the strategy planning office in 1996 (step 3); established the fuzzy front-end department in 1998 (step 3)	dissolved the pilot production department in 2003 (step 4)
Change in process	invented a product development approach to integrating after theoretically decomposing (step 2); adopted a straight-line method of managing R&D, in which project managers led engineers (step 2)	employed matrix R&D management within the central R&D department (step 2); established a leading group to ensure cross-department collaboration (step 2)	employed new matrix R&D management that required the participation of all functional departments (step 2); built an IT support system to facilitate R&D resource sharing
Outcomes	created an informal R&D management system from no R&D status	established a formal R&D management system	employed an IPD system to manage R&D activities

R&D system and to learn from advanced business peers. For example, in a recent ongoing transformation, Huawei has even attempted to integrate global resources and place a greater emphasis on long-term R&D to gain sustainable competitiveness.

In addition, we found that the transformations gradually shifted the focus of Huawei from structural changes to process changes. Specifically, the R&D management system evolved from a functional system to a more complicated matrix system and then to a process-oriented system with a focus on the balance between efficiency and flexibility.

The characteristics of the four steps in transformation management can be summarized as in Table 8.2.

As a whole, the first two transformations were not implemented very formally, and most of the changes in these two transformations were associated with structure. In contrast, with the help of an external professional consulting team, the third transformation was implemented in a more systematic manner. Regarding the triggers of transformation, in step 1, the need for transformation was raised by Ren with the intention to evoke a sense of urgency and to help people understand the necessity of transformation. Then, substantial process changes were implemented in the pilot areas, and the feedback from pilot projects convinced people who once had skeptical attitudes toward the transformation. These changes are consistent with the point advocated in our model that starting from a pilot area, such as the periphery of the system, can help to mitigate resistance to change.

Routines that capture changes help us to understand organizational transformation on the microlevel (Nelson and Winter, 1982). Defined as a “repetitive, recognizable pattern of interdependent actions, involving multiple actors” (Feldman and Pentland, 2003), routines are established to improve efficiency and performance (Luecke, 2003), which manifest their roles in organizational stability and resistance to change. Among the three transformations, different authority structures were employed to coordinate the process of changing routines. In the first transformation, core managers, such

Table 8.2 *Summary of characteristics of four steps in each transformation*

Step in transformation	First transformation (1991–1994)	Second transformation (1995–1998)	Third transformation (1999–2005)
Step 1: Identify the need for transformation	the need was urgent, which mattered to the survival of the company	transformation was required for the enhancement of technological capabilities and healthy corporate growth	driven by internal crisis; proactively learned from a successful foreign company by transformation; need was addressed publicly by the CEO
Step 2: Initiate transformation	core managers led changes directly; significant structural changes and minor process changes	significant structural changes and non-trivial process changes; used the authority structure to facilitate the routinization of matrix management	substantial process changes in the pilot areas
Step 3: Make feedback-based adjustments	adjusted the structure after gaining operating experience from successful projects	continual adjustments to optimize the structural setting	feedback from pilot projects convinced people with skeptical attitudes
Step 4: Systematize changes	/	/	expanded to the whole system step by step; granted sufficient authority to the consulting team to resolve conflicts

as Zheng Baoyong, led the transformation. Zheng was designated as the head of the digital unit, aiming to increase the authority of the newly established department. In the second transformation, Huawei creatively established a leading group to ensure cross-department collaboration under a matrix management structure. Further, in the IPD transformation, the CEO ensured that sufficient authority would be allocated to the IBM consulting team. However, conflicts were not perfectly resolved in this type of “hard” way, and Huawei eventually paid the price of losing much of its core R&D staff. Changing routines requires suitable authority structures to coordinate an implementation project (Edmondson et al., 2001), and forcibly punishing or firing people who resist changes is a cost that must be borne if an organization wants to change.

Some of the principles for managing routine dynamics during Huawei’s R&D management transformations have generalizable implications for other organizations, although these principles were created within the transformation history of Huawei. Specifically, when planning and implementing transformations, concrete accountabilities and working processes should be jointly discussed among senior managers and newly promoted managers, while the establishing and abolishing of centers should be dynamically reviewed to ensure that the process is implemented in a scientific and harmonious manner. Managers who are responsible for the transformation must establish new centers and processes before disposing of old ones, aiming to replace the so-called organizational vacuum and to avoid chaos and confusion in organizations, which is why founder and CEO Ren always insists that it would be better to improve incrementally rather than aggressively to introduce a radical earth-shaking transformation.

Huawei’s experience with organizational transformation also highlights the importance of building routines for change management. Prior studies might have argued that organizations that undertake frequent organizational transformations would be less efficient in operations and would even encounter chaos in management (Rieley and Clarkson, 2001). However, as Huawei underwent three major

transformations, it changed its routines of R&D management dramatically and greatly improved its efficiency in technology and product development. This result can be largely attributed to Huawei having purposely established an institutionalized process and strong abilities to renew its organization and core systems without management chaos. As advocated by Luecke (2003), a state of continuous change itself can become a routine. Especially since the IPD transformation, Huawei established a specialized project to initiate and implement the transformation, instead of implementing changes at the will of the top leaders. From passive to proactive and from intuitive to institutional, the way to implement R&D management transformations in Huawei can be regarded as a consequence of the routinization of transformation management. These routines as the repositories of organizational capabilities can prepare organizations for future learning and development (Winter, 2000).

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Commentary on the Chapter 8

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It is impressive to read how Huawei succeeded in transforming itself several times to become a leading global telecommunication company. The chapter titled “Huawei’s R&D Management Transformation” clearly illustrates the key role R&D has played and still plays in the successful growth of the company. The authors of this chapter distinguish five stages of the management transformation of Huawei’s R&D. The first three stages are mostly characterized by substantial organizational changes whereas the fourth stage in particular, i.e., the implementation of the IPD system, is mostly characterized by a different way of working. It is not unusual that the R&D organization in growing and expanding companies goes through similar transformational changes. What is very specific for and impressive about Huawei though is the short time span in which all these transitions took place, combined with exceptionally high growth numbers of R&D staff. According to the authors of the chapter, Huawei built an R&D community, which in 2015 amounted to 79,000 employees, i.e., about 45 percent of the total workforce of the company in a relatively short period of time. Even if part of these employees in the common way of counting R&D staff would not qualify as R&D but as technical support engineers, the number is still impressive. So, Huawei must have recruited massive numbers of fresh and experienced engineers and researchers year after year. This must have been a formidable task. The difficulty is not only identifying so many suitable candidates in the labor market, but even more difficult is to educate new staff, equip them with the right skills and integrate them in the existing workforce. In the chapter titled “The Transformation of Huawei’s HR System” it is explained how Huawei installed a mentorship program to facilitate the integration of new staff. However, this cannot be the full story. A corner of the veil may be lifted by the mix of R&D personnel Huawei has been hiring. In 1996, for example, Huawei hired 1,000 graduates with a management background. This would enable them to quickly build up complete organizational units without the need to internally grow managers from engineers and researchers without any management experience. This enabled

Huawei to hire another 4,000 engineers in 1997 and quickly educate and integrate them.

As described in this chapter, overtime the transformation of the Huawei R&D organization changed from structure-focused to process-focused. Its success can largely be attributed to rigorous execution and senior management ownership. The strong support of Huawei's CEO Mr. Ren Zhengfei himself was essential. The driving force of the transformation was the fierce market competition Huawei was facing. This necessitated a continuous strategic shift of the company and reorientation and reorganization of the R&D organization and its way of working.

Although the chapter in general takes a high-level approach in the description of the various stages of the transformation process, at some points interesting details are revealed about the R&D organization and its way of working. An example of this is what happened in 1994 when Huawei started to prepare for the large-scale production and sale of C&C08 switches. When this started, selected R&D staff were transferred to other departments like manufacturing, sourcing and even sales. This proved to be an effective way of solving talent shortages and created strong connections between the various organizations along the business chain. This is a prime example of creating career opportunities for R&D staff as well as building bridges across the various organizations. Although this practice of job transfer and rotation is implemented by some other high-performance companies it is certainly not a widespread approach.

An important question about the R&D organization, which remains mostly unanswered in the chapter, is about the programming and funding of the R&D organization. How did Huawei implement portfolio management and how does it ensure that at every moment in time the R&D portfolio is linked to the plans of the businesses and the strategic direction of the company? The answer to this question cannot be the implementation of the IPD process, as this mostly deals with the execution of the project portfolio, not its generation. High-quality portfolio management is key to the success of an R&D organization and the ability to turn R&D projects into successful products. Given the success of Huawei in the market they must have a very effective product portfolio management process in place. It would be interesting to learn more about it. A related question is where the budgets for the R&D organizations come from. Do the individual businesses decide on the R&D funding level and also decide on the R&D portfolio for their business?

Or are the R&D budgets decided at corporate level? Or does Huawei use a mixture of the two approaches?

The last transformation towards global leadership is particularly interesting. Whereas many multinational companies, forced by a continuously rapidly changing environment and strong focus on the bottom line, abandon long-term research or shift it to universities, Huawei seems to take the opposite approach. This is evidenced by the creation of the “2012 Laboratories.” To safeguard its long-term orientation, the “2012 Laboratories” are a separate corporate organization independent of the central R&D department. Apparently Huawei is satisfied with the performance of the “2012 Laboratories” so far. Recently Ren Zhengfei disclosed in an interview that the 700 basic scientists in the “2012 Laboratories” will be increased to over 1400 basic scientists by year end 2016. It will be interesting to see what the impact of the “2012 Laboratories” will be on Huawei’s performance in the years to come.

In the last phase of the R&D transformation process Huawei also started to expand its global footprint. In 2015, Huawei had already established sixteen R&D centers around the world, including centers in India, Russia, Europe, Japan, and the United States. This also raises the question about the governance of the R&D centers at different locations. Are these R&D centers satellites of the central R&D department? Or do they belong to the “2012 Laboratories.” And how are the R&D portfolios at the different locations managed? Is this done centrally or does the local management have authority to decide which projects to run? And do the R&D centers around the world focus their R&D on global or local products?

To conclude: The chapter on Huawei’s management transformation gives the reader an unprecedented insight in the way Huawei manages its R&D and the changes that have taken place over the years. At the same time, it is clear that it is not possible to give answers to all the questions that arise while reading this chapter. Some of the questions raised in this commentary are interesting topics for further research. But one thing is very clear. The way Huawei manages its R&D and transformed it over time to keep supporting the strategic direction of the company and its businesses is impressive and provided the basis for its commercial success.