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Research Paper

Startup of new plants and process technology in the process industries: organizing for an extreme event

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In the startup of new process plants or in the introduction of new process technology, even minor installation work can cause plant downtime. On the other hand, the increased income from compressing time schedules for the introduction of new process technology or launching of associated new products on the market surely offers an incentive for securing efficient startups, which is the purpose of this study. A review of publications in the area of startup of process plants shows that organizational issues are scarcely discussed. A new conceptual framework has therefore been developed for organizing startups and the modelling of alternative startup organization structures. Four types of organizational models have been depicted, derived from information from the literature survey and the author's own first-hand experience of startups. They include a "fully integrated" type of organizational model for startups together with a profiling of startup contexts. How to organize a startup is, however, only one aspect that will determine the outcome of a project, and other influencing factors ought to be further explored. The framework must be tested and validated in real-life startup situations and in further empirical research. The information from the literature survey, the alternative types of startup organizational models and determinants can already be deployed by firms in the Process Industries, triggering discussion and providing guidelines in their selection of preferred startup organization.

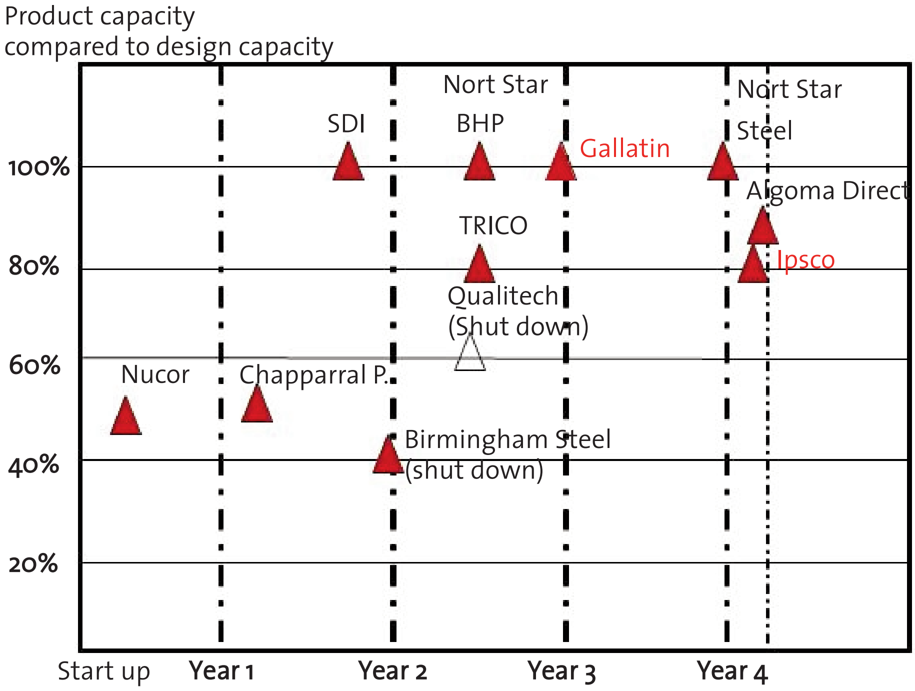
1 Introduction - preparing for an extreme event

The Process Industries, including many different sectors like minerals and metals, pulp and paper, food and beverages, chemicals and petrochemicals and pharmaceuticals, constitute a large part of all manufacturing industry. To err a little on the conservative side, one can say that about 30 percent of the most R&D-intensive firms worldwide belong to the Process Industries (Lager, 2010 p.23). In the startup of new process plants or in the introduction of new or improved process technology in existing plants, even minor installations or modifications can cause disruption of the process and/or plant downtime. Such disturbances not only result in loss of production volume but often seriously affect product quality from the production unit. Calculations of the cost of process disturbances or unnecessary downtime associated with startup stumbles often give frightening results (Leitch, 2004a). On the other hand, the increased income from compressing the overall project time schedules by excellence in introducing new process technology and/or launching of associated new products on the market surely also offers a strong incentive for securing smooth and efficient startups.

1.1 What is the problem?

Some experience from startups in the Steel Industry can serve as an important introduction to the problems of practical implementation of process technology. Experience from introduction

Figure 1 Startup of 11 steel plants between 1995 and 2000 in the USA*



* The data provided by Bagsarian have been further compiled and presented in the form of a diagram (Bagsarian, 2001).

of partly new, novel and untested technology and from startups of large-scale steelmaking projects between 1995 and 2000 was generally dismal (Bagsarian, 2001). Figure 1 shows that none of the plants had reached design capacity within one year, and only one after two years.

These slow startups were mainly attributable to investment in new and untried process technology and other managerial and organizational issues.

> *Companies that expected startups to last months were still trying to get the mills working smoothly years after the first heat. The more new technologies a mill installed, the longer the startup took. … Some mills also had the wrong people in place. Despite the millions of dollars companies spend on the most modern systems, new furnaces, casters and rolling mills, putting the right people in charge of starting up a new mill is paramount (Tom Bagsarian, 2001).*

The experiences reported by Bagsarian are unfortunately not solitary events! In a fairly old but interesting study of 24 steel industry process startups the duration, as measured by the amount of time required to achieve steady-state productivity, varied from 2 to 42 months (Baloff, 1966). Comparable durations were also found in the glass, paper and electrical products industries. In a large case study covering 41 process plants in the area of extraction of base metals, including flotation plants, leaching plants and smelters, the poor startup performance for many of these plant installations was scary (McNulty, 1998). The organizational aspects of those startups were not discussed explicitly, but it was hinted that for the group of low-performing projects, hands-on training of the workforce was lacking, supervisory staff were inexperienced, and technical support during commissioning and startup was inadequate.

A smooth startup is however of interest not only to firms in the Process Industries, but also to equipment suppliers, contractors, consultants and suppliers of raw materials and reagents. Successful introduction of their technology and startup at a customer's plant is of an importance second to none (Lager and Frishammar, 2010).

Startup of plants in the Process Industries may have interesting similarities with startup of plants in other kinds of manufacturing industry, but there are also many differences. The most important difference is probably that process plants often have continuous (or semi-

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continuous) material flows which make them not only difficult to start up but also difficult to shut down and restart, e.g. blast furnace operations. From the outset the need for 24-hour shift operation, sometimes also combined with complex physical or chemical reactions of a phase transformation character (e.g. petrochemical crackers, boilers in the forest industry), often makes a startup in the Process Industries an extreme event.

Startups of new process technology and production plants in the Process Industries are consequently very important corporate activities which unfortunately are often discussed simply in terms of "plant commissioning" (Horsley, 2002), and such general guidelines for startups are many (Gans, 1976, Gans et al., 1983). Startup performance in a wider context is only sparingly discussed in the literature, which could tempt the author to draw the conclusion that success depends solely on following such proper startup procedures. However, referring to the previous presentation, experience tells that there are many other factors that influence the outcome of startups. In such a typical engineering startup context, however, the fact is sometimes overlooked that startup is very much about people interacting with technology! Because of that, organizational aspects of startups do not always get the attention they deserve in firms; sometimes, indeed, they are almost entirely neglected. The purpose of this research was thus, focusing on the organizational issues of startups, to develop a theoretical platform for further empirical research.

1.2 Research approach

In the light of this introduction, the following research question was formulated and has consequently also guided the development of the new conceptual framework:

RQ1. In a "work process perspective", what alternative types of organizational structures can be outlined, and which potential determinants can be identified for their selection in startup of process plants and new technology in the Process Industries?

A literature search was initially conducted with a view to establishing a theoretical knowledge base. Since this indicated that this topic has not been very well researched recently, the author, using his own first-hand personal knowledge of startups, began to develop a conceptual framework for alternative types of startup organizations. The input was based on the author's own practical experience of starting up base-metal plants and a large iron-ore production plant in West Africa, and additional information from a handful of experienced startup leaders in the author's personal network.

This approach is in line with Doty and Glick (1994).

> *"Organizational typologies have proved to be a popular approach for thinking about organizational structures and strategies. Authors developing typologies, however, have been criticised for developing simplistic classification systems instead of theories. Contrary to this criticism, we argue that typologies meet the criteria of a theory".*

The author's own startup experience gave him a status of not only researcher but informant, inputting first-hand knowledge of startups in the Process Industries into this study (Yin, 1994 p.84). Such a research approach also resembles "innovation action research", not because of the aspect of implementing research results, but as action research in a conceptualisation of his own hands-on startup experience (Kaplan, 1998). This is also a recommended research approach when theory is nascent or intermediate (Edmondson and McManus, 2007).

> *"Before collecting extensive quantitative data, the researcher wants to be confident that the key hypotheses are sensible and likely to be supported. This requires extensive conceptual work to develop the ideas carefully, obtaining considerable feedback from others, and refining the predictions before data collection."*

This article is "started up" with an identification of *contextual* determinants for startups. Afterwards a formal startup work process has been outlined as a *processual* perspective on startup activities. Using this template, four alternative *structural* organizational models are afterwards developed, followed by a final review of the startup more *relational* teambuilding activities. Managerial implications are put forward and suggestions for further research are presented.

2 Organizing for startups – the development of a conceptual framework

Organizational matters are usually high on firms' agendas for achieving good performance. The traditional functional or departmental organization is still most common for production, sales and marketing, and R&D in many sectors of the Process Industries, but is sometimes complemented with cross-functional work processes and networks (Bergfors and Lager, 2011, Mintzberg, 1999). A matrix organization is nowadays still also a fairly common solution that captures the best features of functional and project organizations. Lean production focuses on more efficient resource utilization and eliminating factors that do not create value for the end user (Liker and Meier, 2006). In a similar vein, a "lean startup organization" concept could be defined and utilized as deploying better functioning organizational solutions and work processes for startup, aiming at the creation of more value for the firm for less input of startup resources.

In this context one should not overlook the installation and startup of even minor equipment integrated in large plants because, regardless of size, there is always a potential of major process and production disruption. Consequently, when things do not go according to plan, which is often the case during startup, this may influence not only the internal and external production environments, but customer satisfaction with delivered products. Regrettably, in preparations for the plant startup, the importance of the process and product dimensions are sometimes neglected because of too much focus on the engineering dimensions and commissioning. That is to say, and it is argued, that the final outcome and related success in startups is not the successful plant commissioning as such, but the delivery of products (within or above set specifications) from a well-functioning production process (delivering design product volumes at target production cost).

2.1 Profiling the startup situation – a contextual perspective

Depending on different project characteristics, one could imagine that alternative organizational solutions are more or less functional for startups. That is to say, a small project introducing well proven technology probably requires a different startup organization compared to a startup of a large new production plant using new technology and producing new kinds of products?

Identification of potential contextual determinants

In the selection of a startup organization there are a number of possible determinants that could be considered for the guidance of such a selection. One is the novelty dimension of the selected process technology (Bagsarian, 2001, Leenders and Henderson, 1980). One tool in the discussion of technology newness is the "S-curve" concept (Foster, 1986). For further discussion on the newness of process technology see for example (Tushman and Anderson, 1986, Utterback and Abernathy, 1975). The newness of technology was also singled out by Agarwal as one of the most important factors to consider in startups in the Process Industries (Agarwal et al., 1984, Agarwal and Katrat, 1979). Apart from the newness of technology, a number of other potential determinants are also presented in the following.

Newness of process technology

For categorization of the newness of process technology, the dimensions from a process matrix developed by Lager (2002) were selected, where newness is considered in the two dimensions of "newness to the world" and "newness to the firm".

Newness of process technology to the world

The degree of newness of a process technology to the world can sometimes be related to whether the process can be patented, but since new processes are sometimes not patented but kept secret, the newness can also be estimated by how well it is described in professional publications.

- *Low*: The process technology is well known and proven (can often be purchased).
- *Medium*: The process technology is a significant improvement on previously known technology (incremental process technology development).
- *High*: The process technology is completely new and highly innovative (breakthrough or radical technology development).

Newness of process technology to the firm

There are several possible ways to define the degree of newness of a process technology to a firm, but before a firm starts a process development project, one of the most important considerations is how easily the process technology can be implemented in the company's production system.

- *Low:* The process technology can be implemented and used in existing process plants.
- *Medium:* The process technology requires significant plant modifications or additional equipment.
- *High*: The process technology requires a completely new process plant or production unit.

Newness of product(s)

In a study by Booz Allen & Hamilton and further presented and used by Cooper, the newness of products is positioned in a product matrix of which the following scales for the two dimensions have been derived (Booz Allen & Hamilton., 1982, Cooper, 1993).

Newness of product to the world

- *Low:* Minor product improvement.
- *Medium*: Major product improvement.
- *High:* Completely new product that may create a new market.

Newness of product to the firm

- *Low:* Existing type of product within an existing product line.
- *Medium*: New product within existing product line.
- *High*: New product and a new product line.

Complexity of technology

The survey of project management literature provided an important aspect that well suited the classification of the startup context. The system scope dimension proposed by Shenhar & Dvir provided an important missing link (1996). Their original trichotomy has been modified to suit the Process Industry startup context better:

- *Low*: Only one process unit operation.
- *Medium*: A process system including a number of unit operations,
- *High*: A super-system of process systems (large production plant).

Size of installation or process plant

The size of the process installation could also influence the selection of the most appropriate organizational solution. A small installation may thus only require a more ad hoc organization compared to a startup of a very large production plant. Nevertheless, even small startups integrated in a very large production environment may cause serious problems if not prepared and executed well, as has been pointed out in the previous presentation. The following classification is only tentative, and each firm should develop its own scale.

- Small: < €100 000
- Medium: €100 000 – 100 000 000
- Large: > €100 000 000

Supplementary project specific determinant(s)?

For each new installation there may be some project specific aspects that ought to be considered in the selection of a startup organization. Such determinant(s) can naturally be included as well.

Profiling the startup context

In Table 1 the selected potential determinants have been put together and used in a characterization of the startup context. The importance of each determinant can thus first of all be estimated for each project and afterwards the position of the project on each determinant can be made. The resulting "snake plot" can afterwards be used in further discussions related to the selection of an appropriate startup organization.

The results from a profiling of the startup context and the analysis of the contextual situation bring us further to the issue of how startups are carried out; a processual perspective related to a startup work process.

2.2 Outlining a formal startup work process – a processual perspective

There is nowadays general agreement that the development and use of more formal work processes can often facilitate repeatable industrial activities of different kinds. It is often claimed that carefully crafted and continually improved innovation work processes, like a

Table 1 Defining startup context*

Contextual startup determinants	Importance of determinants to the project (low =1; high = 5)	Project Characteristics		
		Low (small)	Medium	High (large)
Newness of process technology to the world			●	
Newness of process technology to the firm				●
Newness of the product to the world		●		
Newness of product to the firm		●		
Complexity of technology				●
Size of insallation of process plant			●	
Supplementary project specific determinant(s)?		●		

* The profile for a startup has tentatively been illustrated. For the characterization of each determinant a round symbol (thee point ordinal scale) connected by a “snake plot” has been used. For the importance rating of each determinant, a five point ordinal scale is suggested.

product development work process, are useful tools not only for improved efficiency but also for improved organizational learning (Cooper, 2008). In the framework of such work processes, technology transfer has long been recognised as a weak area (Holden and Konishi, 1996, Leonard-Barton and Sinha, 1993, Levin, 1993). This is a noteworthy fact since successful startups in many instances often rely on efficient technology transfers. In a study of success factors for process development (Lager and Hörte, 2002), the importance of technology transfer was also recognized and “using the results from process innovation” received by far the highest ranking points in that study. A review of late publications in the area of project management literature indicates, however, that focus nowadays is more on the issue of reduction in project cycle time (Hastak et al., 2007, Hastak et al., 2008) rather than on startup organization as such. For further reading about work processes see for example (Hammer, 2007, Malone et al., 2003, Margherita et al., 2007). It has already been pointed out by Leitch (2004a) that an integrated work process and upfront planning for the startup are recommended actions.

Innovation in the Process Industries, be it product or process innovation, will in its final stage often involve modifications of existing production equipment, new process installations or even the erection of a complete new production plant. The product development work process starts with ideation and development and finishes with the launch of the product on the market outside the company (Cooper, 2008). In a similar vein, the process development work process also starts with ideation and development and finishes with the startup of the new process technology, but then inside the company, see Figure 2.

A startup of new process technology in a production plant environment can thus be looked upon as an analogy to a product launch on the market in product innovation. In the development and implementation of new (and older) process technology, it is thus essential in a work process perspective to secure that startup will not be the weakest link in the long chain of activities and cause project disturbances or even failures.

In a work process perspective, startups could be considered as a sub-work process of the total “construction and erection work process” in which the “startup work process” must be well

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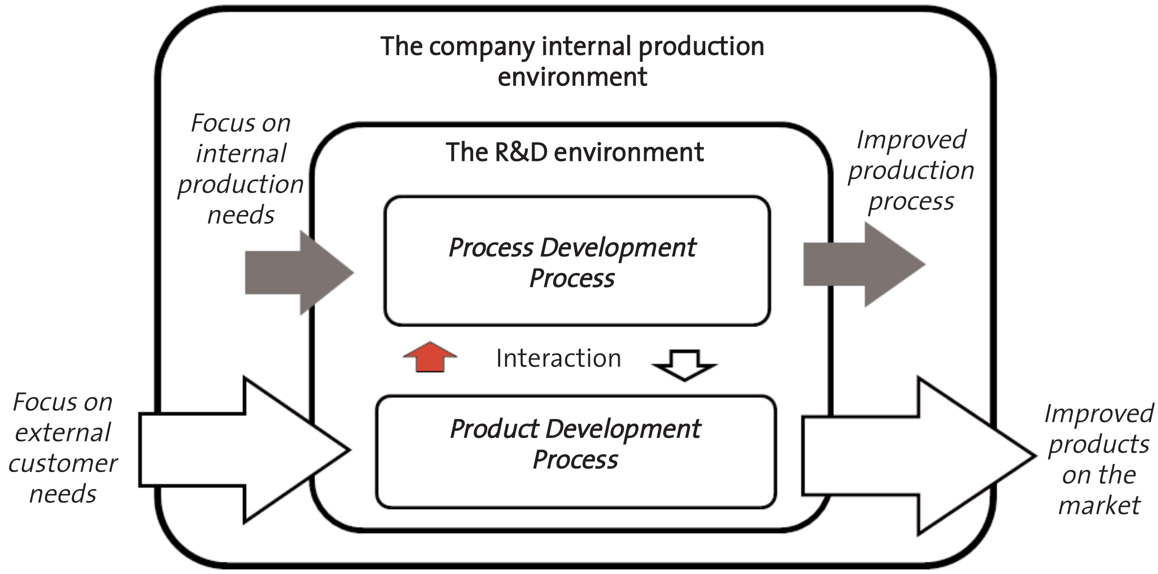
Figure 2 A simplified model of the product development work process and the process development work process in the Process Industries*



* The horizontal arrows symbolise that the two processes start with different customers and end up with different customers. The vertical arrows indicate an interaction between product and process development (Lager, 2000)

integrated. This has been the selected perspective for the development of this conceptual framework for the startup and the delineation of alternative organizational models. To initially clarify and operationally define the concepts used in this article, startup will be referred to both as the *startup point of time* and the *startup space of time*, see Figure 3. Startup point of time is here defined as the time when pre-commissioning without material is complete and commissioning with material, often on a shift basis, begins. Startup space of time, on the other hand, is defined as the time frame from start of pre-commissioning until the new technology (production plant) has been fine-tuned and tested on completion. Naturally, the startup space of time should always be preceded by pre-startup preparations and followed up by post-startup improvements.

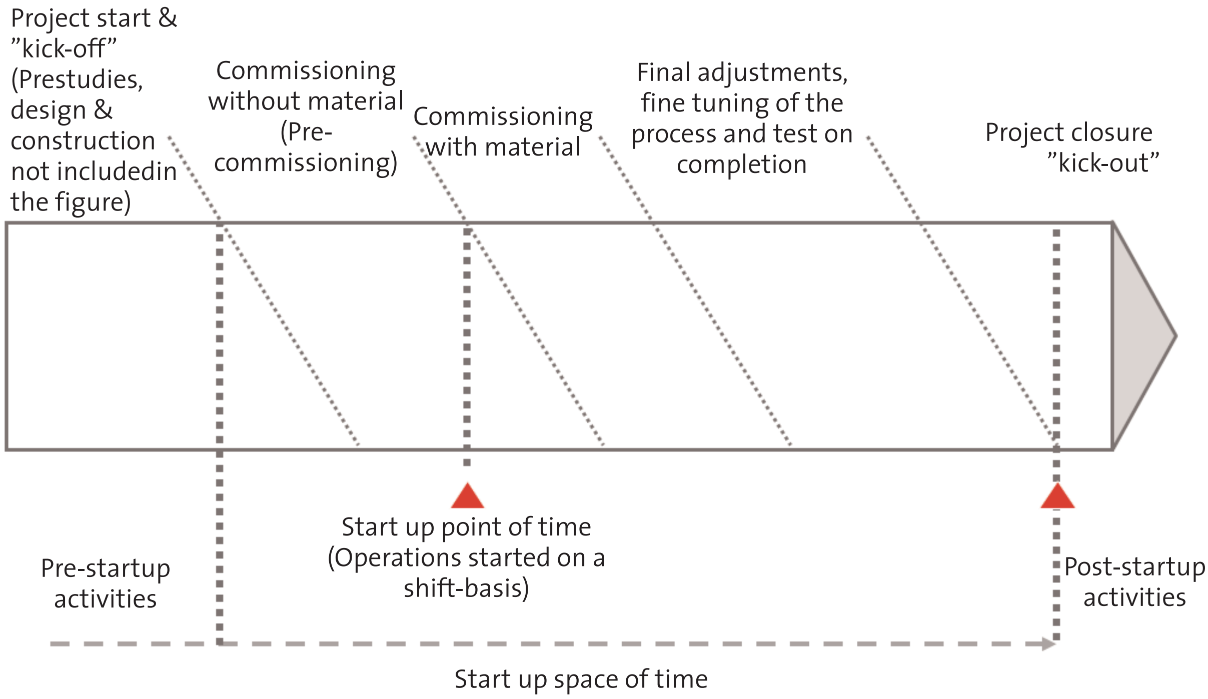
In Figure 3, the overall main phases of a startup work process from pre-commissioning to steady-state operation are outlined in a rather simplified manner and in a time perspective. The three sub-phases included in the startup work process are (1) commissioning without material; pre-commissioning, (2) commissioning with material, and (3) final adjustments and fine tuning of the process and test on completion. Only a small part of an installation is thus illustrated in the figure: pre-studies, design, construction and erection are consequently not included. The inclined lines in the figures symbolize that pre-commissioning, commissioning and even startup often constitute a very much overlapping exercise when different parts of a larger installation are successively brought on stream.

This simplified map of the “startup work process”, was afterwards used as a template for the development of alternative structural organizational models which are presented in the following section.

2.3 Clarifying organizational responsibilities and interfaces – a structural perspective

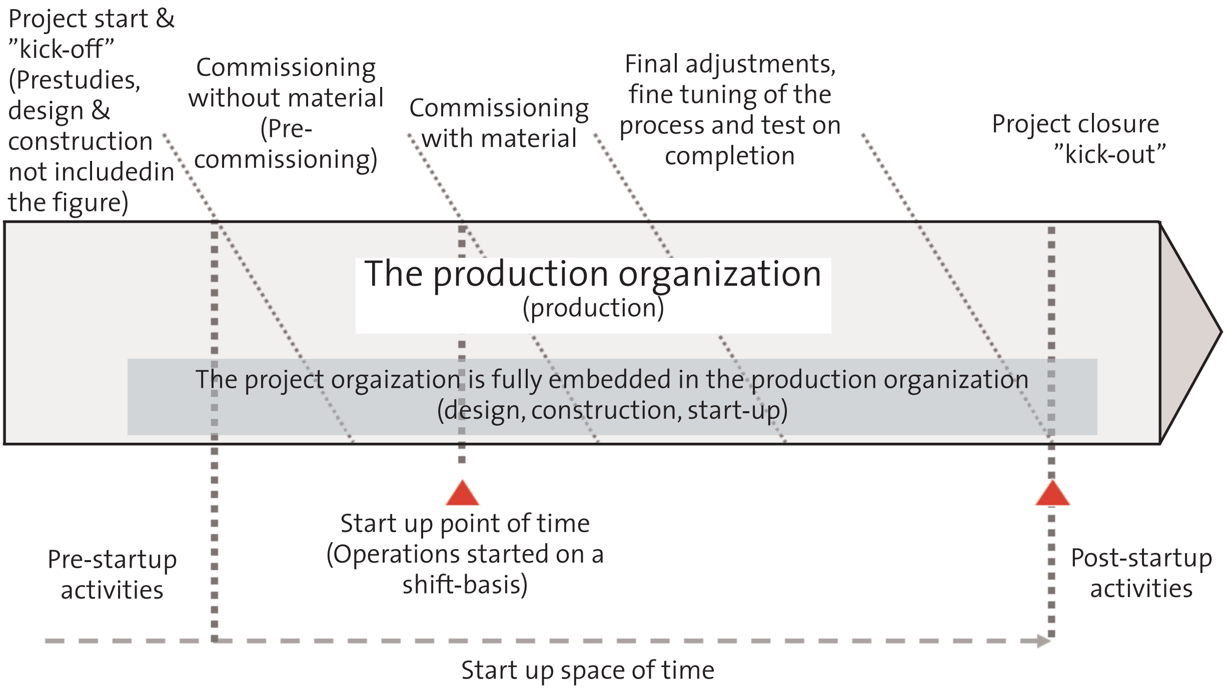
The startup of new process plants and new process technology, if not carried out entirely within the production organization, is an activity where two different forms of organization meet – where a project organization, normally in charge of such an installation, transfers responsibility for the plant or new installation to an operational line organization. Organizational interfaces often have a tendency to create problems, and the issue of successful startup is thus not solely within the domain of project management but also most certainly within the even larger context of operations management and sometimes also innovation

Figure 3 An outline of the "startup work process"*



* The three sub-phases included in the startup work process are (1) commissioning without material; pre-commissioning, (2) commissioning with material, and (3) final adjustments and fine tuning of the process and test on completion.

Figure 4 Organizational model No 1



management.

As pointed out, problems often occur in handovers and in organizational interfaces, and this interface is no exception. Sometimes one imagines that management is hoping that startup is just a matter of "pressing the button", after which everything will run smoothly from the word go and that there is consequently no need for any special arrangements. Referring to the previous presentation, nothing could be more wrong, since startup is and always will be an extreme event which consequently demands well adapted organizational solutions. Referring to the previous section, experience suggests however that the organization of startups is not given proper attention in connection with investments in new products, process technology or in new production plants.

Modelling alternative startup organizations

The need for a separate project management organization before startup is often well recognised, and the consecutive takeover by a production line organization is only natural, but how to manage and organize the "fuzzy-in-between" startup phase?

Organizational model No 1: Production organization fully responsible from "kick-off" to "kick-out".

The model presented in Figure 4 is most likely feasible only in smaller installations under a limited frame of time, and even then it cannot be done without the assistance of subcontractor/supply chain specialists. One can expect an easy and fast handover after startup with a minimum of paperwork. Nevertheless, this model may possibly also be used successfully even in fairly large installations of well proven technology, if additional project and other expert resources are sub-contracted (Frazier et al., 1996). However, it is not often that a line organization has the necessary resources to manage a large investment project, and there is consequently a certain risk for project mismanagement with this model.

Organizational model No 2A: Project organization is responsible until startup and project handover; production organization is responsible for startup.

A presumably fairly common organizational solution, presented in Figure 5, is a handover from the project organization to the line organization when the pre-commissioning is finished and when it is time to "press the start button" and run the process on a continuous shift basis with material (Bodnaruk, 1996). Such handovers sometimes work, but are often a source of startup problems. Commissioning with material invokes the production organization's permit-to-work system when systems "go hot".

If the line production organization has not been involved in the design and commissioning, its people are often not familiar with the new equipment, and the startup may run into problems. At the same time the project organization sometimes has a tendency to disappear too soon after pre-commissioning is finished. The situation has been well described as: "They leave us with an unfinished plant; the voice of production. Production will never let us go and wants us to stay forever; the voice of the project (Eriksson, 2008)."

Organizational model No 2B: Project organization is responsible during startup; project handover when the plant is operating well.

This organizational alternative, presented in Figure 6, relies fully on the project organization during startup, which allows the project manager to assume the role of startup leader. The project organization will then be in charge of plant operation during pre-commissioning, commissioning and subsequent final adjustments and tests on completion. When the plant is operating smoothly, it is handed over to production. The solution of letting the project organization remain in charge during startup is sometimes complicated because of union or other organizational problems with the "ownership" of equipment. In one alternative, plant operators are recruited by the production organization but are "borrowed" during startup by the project organization; in another alternative the project contractor uses his own crew. This is a model often used in some "turnkey" installations. The project usually has some production organization "implants" who can check that their specifications have been complied with. If not, this model may end up in tears. Experience of this model was not very encouraging for IPSCO, and in their lawsuit against Mannesmann it is stated (Bagsarian, 2001):

"Not only was the completion of the project delayed for an extraordinary and wholly unanticipated amount of time, but neither the

Figure 5 Organizational model No 2A

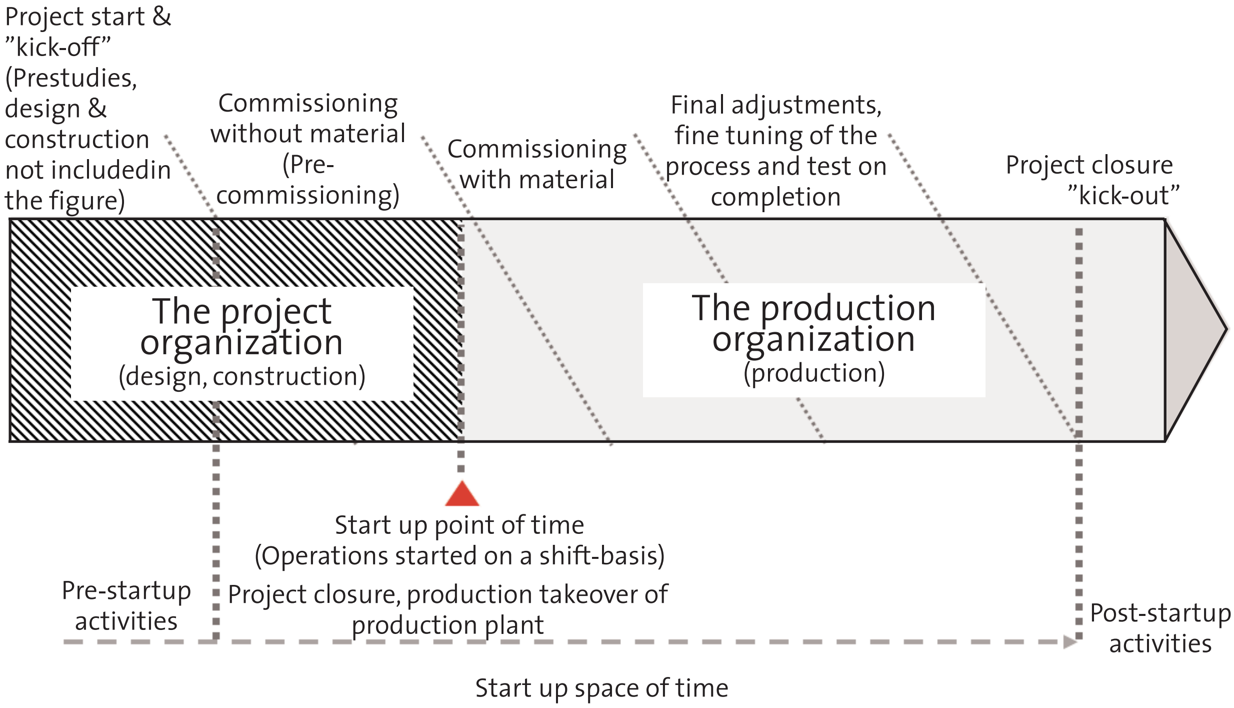
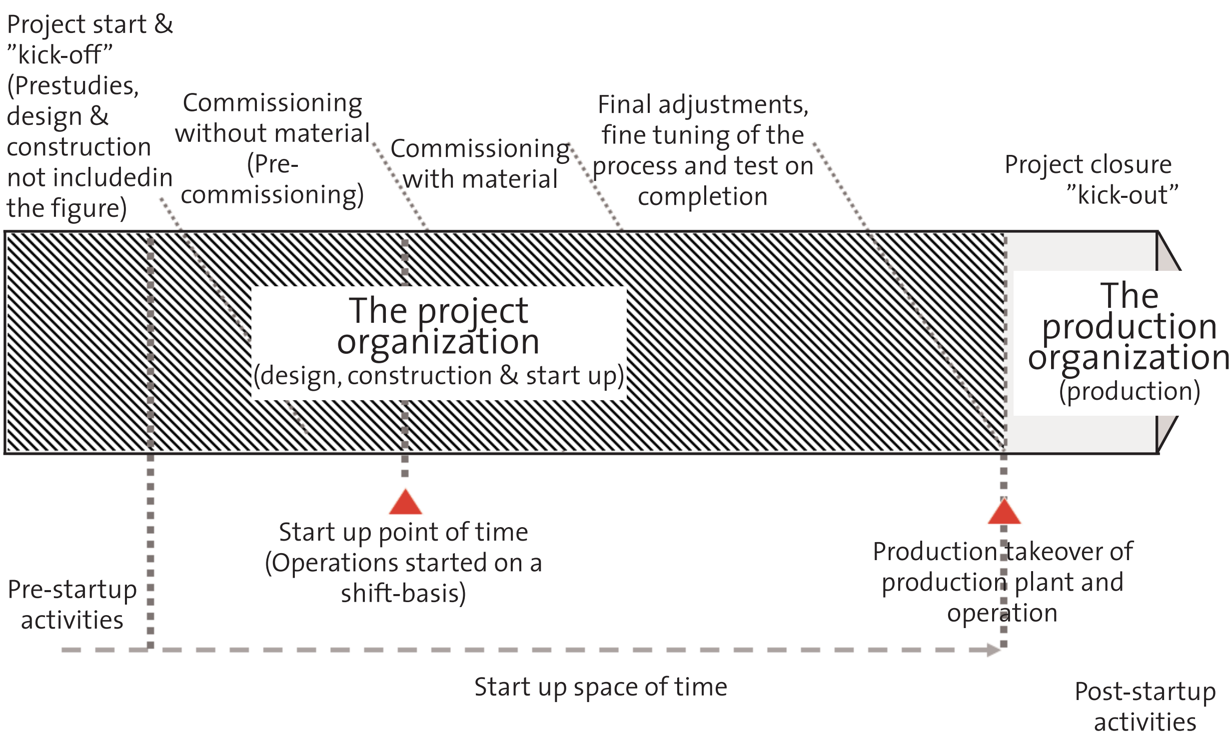


Figure 6 Organizational model No 2B



facility components, nor the plant in general, has the quality, fitness for purpose, productivity, and performance as represented, warranted, and guaranteed."

Organizational model No 3: An intermediate, fully integrated type of startup organization (project together with production) is formed to assume responsibility from pre-commissioning without material until the plant is operating well.

A study of the transfer of new biotechnological processes from research and development to manufacturing also highlights the importance of a more closely integrated technology transfer team with membership from development, manufacturing, engineering, quality and validation (Gerson and Himes, 1998). In this model, Figure 7, the two organizational structures, project organization and production organization, are supplemented by a very distinct and formal intermediate startup organization (Lager, 2010 p.256). From the start of pre-commissioning activities, and naturally in preparations long before startup, the intermediate organization takes full responsibility for all startup activities. In such a merger of the project organization and future production organization, the startup leader is fully in charge of an exceptionally strong and well-integrated organization. It is often reinforced with internal and external resources, and there should be no mistake about who is in charge. The team is gradually mobilised before and during pre-commissioning, and at full strength when commissioning with material starts. This startup organization then stays in operational control until the plant is running smoothly. It may take a few days, weeks or even a few months (hopefully not years). When agreed performance criteria have been met, the production organization takes over operation of the plant. After the plant has been in operation for some time and the list of outstanding construction items has been seen to, the production organization finally and formally takes over the production plant from the project.

3 Building a startup organization – a relational perspective

Regardless of whether the production organization or the project organization is fully responsible for a startup situation, or whether handover takes place in the middle, or whether a fully integrated organization is created, a startup team must always be mobilised for this event. In the planning and preparation for startups, the importance of completing a risk analysis before plant commissioning is stressed by Cagno & al. (2002), but one should not conclude that complete risk avoidance is the proper route to follow. When new technology is introduced, preparations before startup can, however, considerably reduce associated risks.

3.1 Pre-startup and post-startup activities

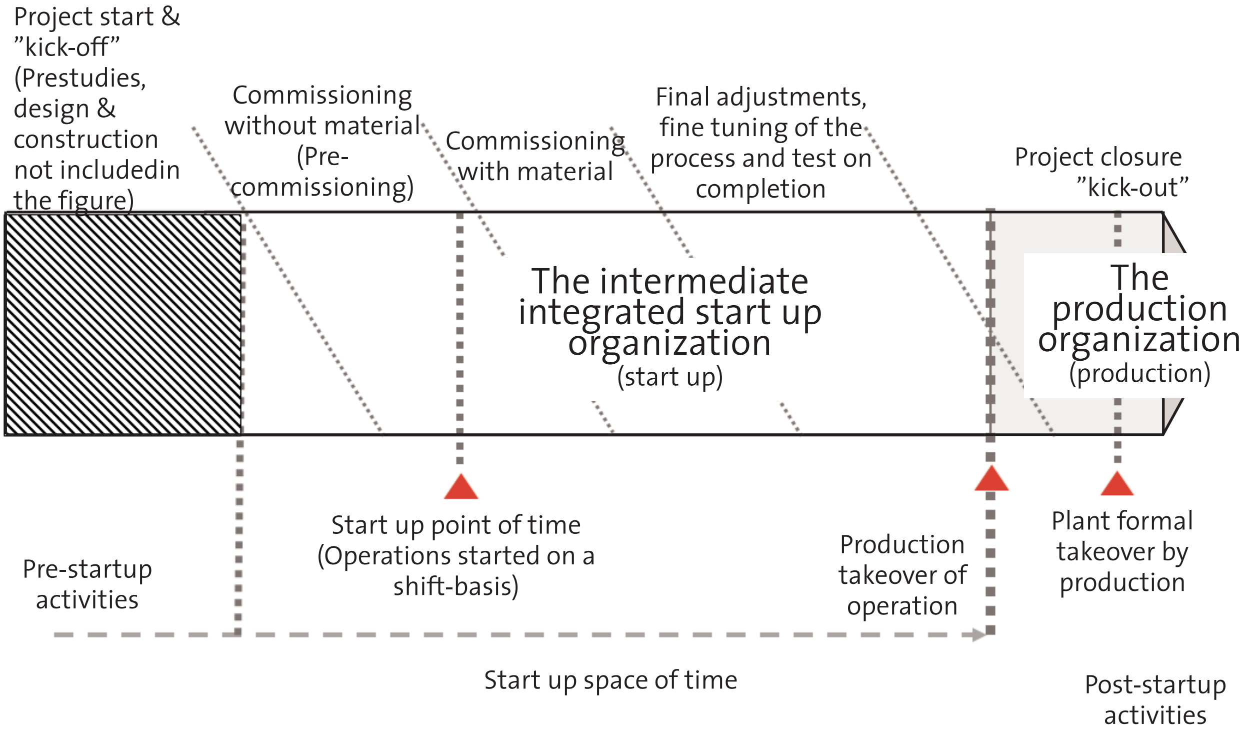
One can recognize, in a work process perspective, that many issues must be addressed well before startup (Leitch, 2004b), e.g. pre-studies and mechanical completion. On the other hand some must be addressed just before the startup, while some must be addressed during or even after startup. In collaboration between equipment manufacturers and process firms over the life cycle and installation of process equipment, Lager & Frishammar (2010) have recognized the importance of such collaboration well in advance of startup:

> *The collaborative solutions and selected organizational structures and mechanisms must not only be adapted to the situation but also facilitate management of the technology transfer between the equipment supplier and the process firm. ... It is therefore important that both parties agree at a relatively early stage of the procurement phase on how the equipment is to be put on stream .*

Good planning before a startup is thus extremely important and has been reported as a success factor of the highest rank (Callow, 1991, Meier, 1982, Leitch, 2004b).

This also emphasizes the fact that success in startups is also related in many cases to decisions already taken during the pre-studies of an installation. The startup leader and startup organization are thus not always to blame if things go wrong; the fault may also be traceable to management decisions which have failed to allow sufficient resources (time and training) for rehearsing the startup of this type of process. Other factors may influence startup performance, and taking new plants, production processes, minor unit operations or even a single item of equipment on stream is not only a production and financial risk, but an activity that is also a safety-critical endeavour (Agarwal et al., 1984). The importance of post-startup activities is seldom touched upon in the literature. This too, however, is an area that

Figure 7 Organizational model No 3



should deserve more attention; the conclusion from the startup of Temple-Inlands' Paper Mill No. 5 was that they managed the planning and startup well, but they could have done better on post-startup activities (Ferguson, 1995). There may thus be many factors influencing the success and performance of startups. Referring to the quotation from Bagsarian, one factor to consider is how to select and set up a proper startup team.

3.2 Building a startup organization

Preparations before startup like recruitment and training of people, mobilisation of external resources, preparing for efficient communication before and during startup, and selecting a proper startup team are issues that ought to have high priority when successful startups are desired. It is thus not the knowledge of individuals in the firm that counts, but knowledge shared and executed as a joint effort that is the hallmark of a professional and successful startup organization. As such, excellence in startup is a good example of successful corporate organizational learning (Nonaka and Takeuchi, 1995). The importance of building a resourceful startup organization that is well prepared to handle the extreme environment associated with startups appears paramount. The published literature relating to startup organizational issues is however surprisingly scarce, and the issue is only sparsely discussed in some publications (Bodnaruk, 1996, Bowdoin.K.A, 2001, Mueller et al., 2002, Powell, 1999).

Selecting the startup leader(s)

Choosing the chief operating engineer (startup leader) is claimed to be 90% of the successful approach to good startup, since he will be faced with the overall planning for the startup, as well as the day-to-day decisions (Gans, 1976). In the discussion of the roles of the process development group and manufacturing in biopharmaceutical process startup (Goochee, 2002), the importance of selecting startup leaders is stressed. The recommendation there is to select process development and plant startup leaders nine months prior to startup. The importance of giving new management "ownership" of the facility is often stressed, and it is considered a grave mistake to transfer a manager to the startup and then move him to another facility (Bagsarian, 2001). As leader of the technology transfer team, Gerson (Gerson and Himes, 1998) points out that the project transfer champion is required to take a proactive role. It must also be crystal clear what responsibilities the leader(s) should have during startup, to whom they should report and their availability during startup. Because of the need for quick decisions and action during this period, shift-working startup leaders are sometimes preferred. If the project manager for pre-studies, design and plant erection can later assume responsibility for being the startup leader and afterwards become the plant superintendent, that is often a good organizational solution to be pursued.

Assembling the startup crew

Referring to the quotation at the beginning of the first section, securing the availability of an experienced startup crew is crucial. Forming a startup team well in advance, including mill engineering staff, consulting engineers and chemical suppliers who were able to develop working relations in a low-stress environment prior to startup, was a success factor for the Rainy River plant startup (Frazier et al., 1996). The importance of securing a team including manufacturing, process development, engineering, facilities, quality control and quality assurance is stressed by Goochee (2002), and that the need for individual talent is at least matched by the need for team harmony. It is often also recommended to organise a problem-solving task force (Agarwal et al., 1984), sometimes called a “flying squad”, of very experienced personnel on standby to be used when major problems are encountered during a startup.

Training before startup

Training of plant operators, maintenance crews and supervisors is naturally of the utmost importance, but it is also vital to map in advance the kind of training the startup organization needs for each specific project. Apart from many different kinds of startup training, it is necessary that the operators also gain a conceptual understanding of the new process, so that unexpected problems can be quickly assessed and appropriate responses made (Agarwal et al., 1984). Another matter is how the training should be organised. Traditional classroom training with engineering professionals doing slide presentations does not always work well alone, but may provide the foundation for other associated activities outside the classroom. There are a number of alternative training approaches, the main difference being whether the training takes place on the job or in a classroom in a different environment outside the plant (Agarwal et al., 1984). The opportunity to involve equipment and raw material (reagent) suppliers in these activities should not be overlooked, and the use of dynamic simulation for training is another approach that is gaining stronger and stronger importance (Frazier et al., 1996, Rutherford and Persard, 2003).

In summary

Since the startup leaders’ qualifications and personalities to a large extent will influence the climate during startup, it is recommended to begin all activities by such an recruitment. Because a startup is often an extreme event, it is recommended that both a startup leader and an assistant startup leader initially are recruited. They can, depending on the startup context, either share this responsibility each on a 12-hour shift basis or if the startup period is extended, relieve each other on a weekly or on a monthly bases. The startup leaders are afterwards to select the organization for the startup and, depending on the startup context, build a more or less resourceful team. Experience thus tells that it is not good enough to use the normal number of shift operators and supervisors, but that a “doubling” of operators and supervisors on shift is recommended using resources from the previously mentioned different kinds of organizations. After the structural organization has been set up, the training can be planned and scheduled in accordance with project goals and needs. A proper mix of classroom and on the job training is here strongly recommended when the startup team can begin to establish good personal relations and collaborations.

4 Discussions and two theoretical propositions

In the literature review on plant startups in the Process Industries one finds many important early publications around the seventies and eighties that are certainly still of interest not only to scholars researching this topic but also to industry professionals involved in startups. Interest in the topic seems, however, to have declined during the past two decades, possibly because of a stronger interest in emerging new industry sectors and a stronger focus on non-process industries. This is a rather unfortunate state of affairs, because the Process Industries constitute a large part of all manufacturing industry, and startup of new plants and process technology is nowadays an important part of corporate activities, especially in the further exploitation of natural resources. The influence on startup performance of pre-startup and post-startup activities – pre-studies, technology selection, training, process improvements after startup, etc. – has however only been touched upon in this article. Because of that, a retrospective literature survey of startups has already been initiated, where general aspects of startups will be structured and presented in more detail in a forthcoming article.

In the light of the problem description in section one, the results from the literature survey and the development of the framework two theoretical propositions are put forward:

Proposition 1: In the startup of new process technology or process plants in the Process Industries, the selection of the most appropriate startup organization is one success factor for achieving good startup performance.

Proposition 2: The newness of process technology, newness of products, the complexity of installation and size of the project are important determinants in the selection of appropriate startup organizations in the Process Industries.

5 Managerial implications and further research

The presented information from the literature survey and the alternative types of startup organizational models can already be deployed by firms in the Process Industries in their discussions and their selection of alternative startup organizations. It is first of all strongly recommended that firms initially should profile each startup context in order to build a solid platform for the selection of a proper startup organization. For smaller, not too complex projects using proven process technology the production organization may be the preferred organizational choice. On the other hand, the fully integrated startup model is recommended for large complex startups of new technology. In such an instance the startup organization should be a total mobilisation of all necessary and available resources within and outside the firm. It is not difficult to demobilise such resources if the startup runs very smoothly, but on the other hand, it is very difficult to mobilise more resources during startup if and when problems occur. The alternative use of the other two “in-between organizations” with either a handover before commissioning with materials, or a handover after commissioning with materials and fine tuning, must be carefully considered because of the previously presented bad startup experiences sometimes related to those organizational settings. Finally, smooth implementation and startup of new or improved process technology or complete production plants is “money in the bank” for any firm in the Process Industries.

In further empirical research it is important to recognise the difference between descriptive and prescriptive research results. That is to say, visiting companies in different sectors of the Process Industries to enquire about what type of startup organizational model they are currently using does not necessarily give prescriptive answers, since the model they are now using may be, more or less, dysfunctional. A more fruitful approach may be to employ this framework for a classification of different kinds of startup contexts and to further enquire which of the different types of organizational model (or suggested alternative models) they believe would provide them with the best startup result and overall success. If such an inquiry were instead deployed in a larger survey, including many different sectors of the Process Industries, a statistical analysis of different sectorial behaviour could be an interesting outcome. Another alternative research approach could be to make in-depth interviews in some selected firms supplying equipment to the Process Industries. Their frequent experience with startup of new installations could then give interesting new perspectives and opportunities for learning. If a firm is testing the fully integrated startup model in a real startup situation, it could naturally be a rewarding exercise to follow such a startup in the form of a single case study. Such a research approach would then also have attributes related to “action research” methodology.

6 Conclusions

When new technology is introduced in the Process Industries, it is first of all important in a pre-startup perspective to ensure that such technology is properly tested in advance in pilot plants or in demonstration plants and that that design solutions are professional and robust. Nevertheless, despite following proper procedures, implementation and startup of new technology will always be an extreme event associated with a degree of uncertainty. It is noteworthy that past experience of startups does not make very pleasant reading, and the reasons for startup delays and stumbles appear to be many and varied. Reviewing publications in the area of startup of process plants and new technology is strangely enough revealing, in that managerial and organizational issues are scarcely discussed at any depth.

As a consequence of this, four types of startup organizations have first of all been depicted, relying on the fragmented information in those publications and on the author's own personal startup experience. A number of potential determinants for a better definition of the startup context have also been developed. The conceptual framework gives some initial insight and a platform for further empirical research, but can already be deployed by firms in the Process Industries in their discussions of alternative startup organizations. Finally, it is argued that organizational aspects should be more in focus in the planning of startups, and selecting and building a proper startup organization as such could be one important success factor in getting new plants and process technology on stream in a more efficient manner.

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