Abstract – For semiconductors industries, mastering each new technology ramp-up is a key component of success on this grueling marketplace. This article presents the use and the deployment of operational risk concept to master the industrialization phase. Paper’s propositions focus on experience feedback and operational risks during this critical period which can compromise a plant’s future.

Keywords – Operational objectives control, experience feedback management, risk management.

I. INTRODUCTION

The theme of this paper is industrial performance during the industrialization of a production. Even if available data are not numerous, during first productions, products and production systems have to be ironed out. To overpass this lack, a feedback loop from operations must be functional. Knowledge acquired from previous productions have to be also mobilized during this period.

But before entering in more details into this work, lets precise boundaries of the “industrialization” concept.

Industrialization, a new plant project: In chemical industries, Auroy [1] and Dalpont [2] present the industrialization process as a project starting from an idea to a full built out facility able to deliver required chemistry. Figure 1 illustrates this process.

They propose its declination at the co-development of a product and process in an industrial exploitation perspective. Characteristics like stages and milestones names, their numbers, their organizational boundaries can vary from chemical to pharmaceutical industry or fine chemical, and agro industries.

Dalpont [2] opens this process at other industries like mechanic, automotive, aeronautical, by combining the IVAT typology, illustrated in Fig2. He also takes the view of project management and underlines that its management is guided by the overlapping of each of these phases. In case of massive concurrent overlaps, management can become a hard task to perform. In case of a fully sequenced process (also called a snake project), staff motivations can disappear after each milestones, compromising the entire project.

In another sector metallurgical industry, Astier [3] emphases industrialization as a project. He presents a six steps method, without overlapping due to the capitalistic investment into metallurgical facilities: “(1) evaluate process concept stakes (2) define and validate the process at a small scale (3) identify and define the associated technology to the process (4) construct a pilot plant (5) construct and exploit a demonstration unit (6) built an achieved and full capacity plant.”

In the pharmacology industry, Robin [4] proposes a list of items to check, before the introduction of the first lot. This list contains in part, the provisional capacity, planning interference check between production and this lot, an operational problem solving team for each lot emergency. The project management mode is required for this introduction.

From these senior managers, project management and work organization seem to rule the practice of industrialization.

Industrialization or the production ramp-up: Other researches associate industrialization to the ramp-up phase. Terwiesh and al [5] underline the industrial importance of industrialization. However, they observed few publications about this subject. They placed their research in hard drive industries and identified particular organizational forms. The project mode seems again rules the practice in these industries. There is also a specific organization dedicated to the yield and cycle time improvement. This is also confirmed by [4] and semiconductor industries case study.

Work position: This article defines industrialization as the transfer process from the creation process to the offer
process as stated in AFNOR X50-176 [6]. In this paper, examples will be provided from semiconductor industries.

In this industry, around each 2 years there is a new transistor family development and introduction in the market. The local business term employed for designing these basic elements – transistor, resistance, capacitors, and connectors- is technology [7]. As example, the technology CMOS090 represents the range of transistor CMOS with a gate oxide length of 90nm. Integrated circuits built with this technology are used in a large range of applications: cell phone, computers, breaks control system… A detailed description of these concepts, their associated process flow and tools are presented by Bassetto [8].

New transistors with submicron dimensions involved a 1000 engineer’s project for a cost over one Billion Dollars. In parallel, the market windows for these new products is very tight: between 2 and at most 5 years. By the way, being able to sell in volume and in quality electronics product is vital and a recursive challenge for these industries. One key element becomes the master of yield [9] and scraps. The contribution of this paper will just be limited at this goal. Cycle time issues during ramp-up can be investigated with the read of [10].

Problem: This article is focused on the fact that operational indicators don’t reach their expected goals during ramp-up. Negative events occur and disturb plans. The main difficulty of industrialization is to prevent risks prior to their occurrence and their following negative impacts toward operational goals. These risks, potential during the production system design, become real during the ramp-up. This article is focused on how to get more reliable preliminary risks analyses (PRA) for having a more robust industrialization?

The reliability of choices during ramp-up relies more on experts than on the few data coming from production.

Article outline: This article presents a track of solution by organizing experience feedback around risk management. It aims to furnish: (1) an integrated method of operational risks management, connecting PRA to events happening during ramp-up (2) Previously reuse of these information during new technology design. After this detailed introduction, the article provides a literature review about experience feedback, learning curves. The third part presents our proposition and its implementation in an industrial case. Results are provided in this part. Perspectives are then issued.

II. LITTERATURE REVIEW

Non conformity management, experiences return and best practices management are well treated fields. This article tends to articulate them in the perspective of production ramp-up. The literature review will cross four ways. Dealing with operational goal improvement, the first of it will be learning curves during ramp-up. The second one will be more focused on how are people organized to achieve their goals? The third will be experiences return, which should brings back expertise at people who need it during preliminary risks analysis. The last aspect of this review, central for this article, is the risk management.

Learning curves: the learning principle has been observed and formalized in industry in 1936 by Wright [12] in aeronautical sector. It presents a decreasing unit cost over the cumulated production output. This notion has been popularized with Towill [13] and Argote and Epple papers [14]. Their work underlines notably several sources of deviation of the learning rate. Towill underlines prevision difficulties with learning curves [15]. He issues, with Price [16], the difficulty to find an organization which insures learning so as reaching operational goals.

Many works deserve to be noticed on learning curves. Nevertheless, this article will keep two of them:
(1) Yelle describes [17] how operators’ knowledge and production organization mediate learning rates improvement.
(2) Terwiesch [18] deeps interaction between organization and yield learning curves during ramp-up.
This research share also this view: better understand the learning mechanism of risk mastering and act on it for speed-up ramp-up.

Industrial organization: In semiconductor industries, organizations recommended by Benfer [19] for performances are already setup and intensively active in 2006. In our study case, an organization is dedicated to improve scraps. It is composed of 30 engineers. Its mission is to react in a prompt mode and improve yields curves. For achieving these goals, the organization relies on its members’ expertise and also on its information system. However at the earlier stage of manufacturing, few data (2 or 3) are available for each operation. Albeit data collection potential seems high (62000) for a new product, for each operation of its process plan, first lots are not fully characterized with relevant data. As data are employed to improve analyses quality, their lack must be compensate during the ramp-up phase.

Experience feedback (REX): One goal of this discipline is to bring back relevant information from past experiences when it is needed. Thus, returning business knowledge during preliminary risks analyses is beyond REX scope. Several industrial examples have been related about this topic. Branet [20] presents the MERE reasoning which enables requirements book improvement. Many others industrial cases relate uses of REX. : EDF [21], Bombardier [22], Air France [23], ONF [24], ALCAN [25]… An exhaustive synthesis can be found in the thesis
of Rakoto [26]. From those reports, the paper reminds two major elements:

1) the managerial involvement under several forms (help for trainings, develop the research of past cases…)

2) difficulties are encountered when it is needed to bring closer current situation and past ones. REX is often focused on file construction and electronic documents archive. This point transforms often REX in a fastidious task.

This paper emphasis documents about risks. This subject of research has been intensively treated. A global overview of the domain can be found in [27]. This paper considers that a negative effect, stored under an electronic format, is only the instance of a class of risks already (or not) analyzed. This view is also shared by Chevrau [28]. They adapted the ARAMIS method for a pharmaceutical plant. They describe how to maintain risks analysis up-to-date about events which happen in the manufacturing line. One interesting point of their consideration is their unified view of risks around the bow-tie representation. With this definition, they propose a retroaction loop.

Fig 3. Retroaction loop based on risk analysis (Adapted from [28])

By this loop, these authors get analyses:
1) Up-to-date from real events
2) Useful during root causes analysis.
In this way risks analyses are more operational.

As conclusion of this short literature review, preliminary risks analysis seems to be a key enabler for having immediate industrial rewarding: good performance during first productions. Feeding this step with previous expertises is then crucial and helps experts of the organization to base their purposes on facts. Orient REX on that point seems a good start for operational goal achievement.

III. PROPOSITION AND RESULTS.

During this study, a methodology of risks elicitation and management has been settled in order to manage and prevent quality issues in a semiconductor plant. This paragraph explains in more details this procedure and its results.

Proposition: Our proposition is to join together experiences returns and risk analysis. The preventative risk analysis is then updated on a regularly basis preventing its obsolescence. It can be used to iron out the manufacturing in a reliable manner.

Risk analyses have been performed within the FMEA framework. This method infers documents required by our industrial partner for its customers. Each quality issue which happens in the manufacturing plant starts a problem solving process which:
- identify the problem origins
- describe it and freeze its progression (secure the process)
- analyze root causes
- perform corrective actions and if possible permanent ones on problems enablers, preventing its reoccurrence.

This reasoning is called 8D. In the FMEA formalism, this is translated by the identification of one particular line. This integration is presented Fig 4.

By unifying risks analysis format and centralizing them, the first component is ready for capitalizing events. This strategy is in the REX reasoning presented by Rakoto [26]. This practice contributes to better information sharing among the organization services – a production plant can host more than 4000 employees.

At a mid term view, this capitalization helps at best practices recognition and validation check list constitution for preventing manufacturing disturbances. It is then possible to be based on preliminary knowledge to master industrialization as mentioned by Terwiesch and Bohn [18].

Results: These developments are realized in a microelectronics research and production center in France. More than 15000 risks have been issued over 2004, 2005, 2006. A prototype, presented in Fig 5, has been developed. It allows the automatic capitalization of (1) non conformities stored into MES during
(2) There is a delay between the effective action and the impact on the curve. Often employees involved in quality improvement groups are also in cycle time improvement, final yield, and have other operational tasks like maintaining good cooperation with their suppliers. They must share their load of work and slow down the improvement implementation.

(3) Unusual problems are not well analyzed (big disturbances in performances see Fig.6.) and thus not mastered properly. Their predictability is not mastered for the moment.

(4) The reuse of information contained in risk analysis is still a difficult task. It doesn’t exist yet a fully automatic process plan generator taking in account best practices (and associated control in particular) associated at risk experiences stored in this database. Improvements still pass through the organization in charge of one indicator, and the ability of its management to obtain resources to implement actions.

V. CONCLUSION

During the ramp-up phase of a modern production units and in particular in semiconductors ones, organizations possess all expertise necessary to achieve its operational goals. However integrated management of these functions is still open to improvements. This article proposes a unified risks analysis method and its application at a semiconductor research and production plant. From this application, the paper infers analyses about effects on learning curves.

This article presents the connection between preliminary risk analysis and operational event in production (non conformities, yield issues...). This method improves the data quality on risks for future developments. It also contributes to get more robust the production means. The integrated risk management tool can also be a sharing point between several organizations. It gives a vision to industrialization engineers about their belief in tool robustness and quality indicators.

Nevertheless, beyond these positive aspects, questions stay open. Results on performances are not those expected with raising our on-going research interests:

Risks analyses have been done under the FMEA formalism. But how this vision of the risks interacts with analysis quality? FMEA are not focused enough on typology of risks. How better integrating this notion so as to proceed to risks analysis in a more systematic manner? FMEA orients also the risk evaluation with “business ranking grid”. How getting these ranking more generic? FMEA analyses are still fastidious to perform and reuse, even if an organization is dedicated to this task. How over passing these drawbacks? How connecting or integrating risks analysis and best practices?
REFERENCES


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