Unified Process for Action Plan Management:  
*Case Study in a Research and Production Semiconductor Factory*

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**ABSTRACT**

This presents a system approach for an action plan management process. Based on the systematic usage of risk evaluation, it helps in actions priorities definition. Several organisations generate actions belonging to separate business goals, sometimes contradictory. Moreover, maintenance, quality, process, research and development organisations use different approaches to define actions priorities. In this case study, more than 400 engineers participate in this process and generating between 20 to 50 action sets monthly (each set can contain around 3 actions). This demonstrates that it is possible to unify action plans management. This has been achieved by developing a model of management system integrating several quality methods. The proposed tool enables local managers to have a clear picture of on-going and planned actions for their areas. For plant managers, it smooths the coordination among organizations.

**INTRODUCTION**

The semiconductor industry is characterized by complex and expensive manufacturing processes, rapid and continuous technologies changes, as well as new technological challenges. This domain settles best in class methods and tools to control in real-time, processes and equipments. Tools to control and detect drifts range from Manufacturing Execution System (MES) to Statistical Process Control (SPC) passing by equipment real-time Fault Detection and Classification (FDC) and sequential regulation loops named Run-to-Run. Preventive approaches are also implemented to minimize dysfunctions probabilities through FMECA [1] usage for example. Literature about proper usage of quality methods [2, 3] and action plan management processes [4, 5, 6], shows that the choice of a method depends strongly on the manufacture domain, quality policy in place, and on targets of operational teams.

In this case study, authors identify that more than 400 engineers generated between 20 and 50 action plans on a monthly basis. Each plan can contain about three actions. This means that organizations have to cope from 60 to 150 actions resulting from these plans and often have to choose among them due to time, budget or human resources constraints.

Although best in class methods are employed (8D, FMECA), they are not integrated and fail to deliver managers a clear picture of actual status and risks belonging to on-going action plans.

There is then an opportunity to integrate these methods, to solve this issue and furnish to managers (from workshop level to the entire manufacture) a clear view of risks and actions in their areas. This is the purpose herein.

This is presented in three parts after the *Introduction*. It follows with the *Industrial Context* and *Proposal*. The scale-1 test in a semiconductor research and production facility is presented, and, discussed in the final section.

**CONTEXT AND PROPOSITION**

**Context**

It can be noticed that in most of the cases manufacturing dysfunctions are treated by risk priority according to their origins and impacts by engineering. The deployment of action plans depends on three majors factors:

- **Operational priorities** (Manufacturing goals in term of costs and quality),
- **The cost of actions** versus resulted cost benefits, and
- **Engineering expertise level**.

Among these three factors, the first depends on high management level and company policy. The management of action plans and the improvement of the manufacturing line have to consider that as a constraint and optimize actions under this context. In the general case, operation management...
manage actions priorities by using the level of risk, cost, and resources. But in the same company, each organization has its own best practices for actions management. Quality, process, and maintenance teams separately develop their actions plans. Links among actions are difficult to establish. Few or no connection tools exist to establish links between decisions taken at different levels or between operational groups. However, high dependencies exist between equipments, products, and processes. For example, the causes of dysfunction of a process can be an equipment drift and can impact product quality, process cycle time, and finally, global manufacturing cost [7]. Previous work [8] shows possible links between risk analyses and engineering action plans at the maintenance level. The study [8] highlights the need for dynamic action plan management based on human expertise and factory events. It presents a methodology to manage knowledge and use equipment history in order to improve quality of actions. But it was applied just for one manufacturing area and no connection with other organizations (quality, R&D, process). The result is that actions priorities are not based on the same scale. High management cannot compare these priorities because they are based on local entity objectives. Various studies highlight the role of risk estimation under actions decision process. This approach is known as a time-consuming task and its deployment require many resources [9]. However using risk level allows minimizing failure probability and improves decision quality. Several approaches based on risk assessment were developed [10, 11, 12] but these approaches treated only the use of risk as a criteria in the prevention process and no links to a common decision process was proposed.

The Proposal

The proposed approach herein consists in the unification of the process of managing actions coming from process drifts, product nonconformities, customer feedback, yield management, and equipment failures. The objective is the improvement of an actual action plan engineering system and the development of knowledge database about all manufacturing events and the related actions. Our approach, based on the classical 8D and FMECA methodologies (Quality methods used by industry in this case study), aims to capitalize knowledge and use it for future action plan definition.

To illustrate the information exchange between risk analysis and the 8D method, Figure 2 shows the connection established between 8D and FMECA processes. Risk definition helps to define the origin of the root cause. It integrates the probability of occurrence for defining most relevant actions. The evaluation of risk level and preventative actions defined in FMECA are used as guidelines for the 7D step. Resulting actions will then reduce risk probability and eliminate the identified root cause (4D).

The integration is four-fold as presented Figure 1:

A. Identify root cause (4D) using risk definition and associated causes occurrence.

B. Manage actions priorities based on Risk Priority Number (RPN).

C. Compare and merge actions issued from risk evaluation and engineers expertise.

D. Describe unified action plan steps.

This unified process also simplifies the definition of corrective or immediate actions by a semi-automatic evaluation of dysfunction causes. This process frames the problem-solving methods of several organizations: maintenance, process, and quality. It connects classical 8D and FMECA methods enabling statistics on action plan management.

This process flow provides an opportunity of a feedback on knowledge about similar events. Unification of risk management process and the events treatment at different levels of the organisation provides a global vision on manufacturing state and operational priorities. On the other hand, this approach simplifies experience feedback usage and information search in a unique environment. Further, this approach allows evaluation of actions results and team performances at different levels in an organisation.

The originality of this work is that engineering expertise (on process, quality, or equipment), manufacturing events...
history and risk level are used to define action priorities. This process unifies the way actions are generated and followed within manufacture. The resulting unified action plan helps to focus on actual line dysfunctions and allow the introduction of an operational keyboard to control actions efficiency.

Generalization of an action plan management is divided in following four steps:

- **AP1:** Define sources of problems;
- **AP2:** Develop actions and their priorities;
- **AP3:** Specify needed resources and actions to be performed; and
- **AP4:** Implement actions and verify results.

These four steps are generic for all organizations but their definition depends on the adopted strategy in the team. The core idea behind this proposition is to develop a unified action management process; centralizing the management of actions priorities coming from multiple sources (process variability, process, customer feedback, yield management and equipment failures), based on the four steps as detailed above. The objective is to improve the quality of action decisions and to develop a knowledge database about all manufacturing events and their related actions.

Idef0 process (Figure 2), based on the case study modified for generality, presents key steps in the proposed process along with information and parametric flow at each step. Four steps are integrated in this process and supported by:

- **Human expertise** during analysis and decision phase.
- **Automated tool** for data and initial priorities management.
- **Two quality tools:** FMECA and 8D.

In this Idef0 process, two principal type of collected information are identified:

- **Data coming from equipment drifts and maintenance,** and
- **Data coming from quality issues** (external or internal customer).

These two sources (or types) of information are treated separately because maintenance data (collected and managed by CMMS) is structured differently than manufacturing or customer feedback data. In the proposed process, maintenance data is treated by an automated tool (A4: Edit data) to allow the classification of data in terms of equipment risks, whereas the rest of the data (quality, process, R&D...) is processed by an intermediate step (A1: Define problem source) to create a unified problem description conforming to the 8D approach. These steps, in addition to automation, also require validation by an expert.

All of the data is required to be transformed and formalized in strict compliance with 8D approach (A5: Edit...
8D) along with risk analyses in parallel; the last step in the process (A6: Update risk analysis) is carried out using the FECA method that allows the allocation of risk level to each event. The output of steps A5: Corrective actions and A6: risk level allows identification of actions priorities by integrating risk level and human expertise. In the last step of this process (A7: Establish unified action plan) priorities are centralized and the action plan is edited, taking into account collected events, human expertise, and risk level. To illustrate the information exchange between risk analysis and the 8D method. Figure 2 shows the connection established between the 8D and FMECA processes.

Development
The proposed process, discussed in The Proposal section, is implemented in a semiconductor manufacturing industry using an automated tool. The process flow, discussed in this section, is based on use cases and roles identified herein; however, the objective is to define in detail the sequence of steps and conditions in the process.

The main steps of the process are:

A. Collect events from different sources

B. Define a unified action plan
   a. Treat data and quantify severity as well as occurrence of the event.
   b. Define action decisions based on previous events, risk level and human expertise.

C. Evaluate action plan and team performances.

The algorithm presents a step-by-step process of action plan management, proposed in the Results section, based on links between the 8D and FMECA processes.

Phase A
Phase A of this algorithm is completely automated and allows the treatment of the information in a unified format irrespective of the source.

Phase B
Phase B is the heart in the algorithm and regroups human expertise with automatic data analysis. In this step, two processes (8D and FMECA) are implemented in parallel but with a continuous exchange of information between the four decision making steps. This method, on one hand, provides robustness in the quality of actions and, on the other hand, risk level control, to provide a global vision in the action plan implementation and common evaluation of priorities in the organization.

Phase C
Phase C constitutes a feedback mechanism on the proposed approach to evaluate efficiency of implemented actions and teams, respectively, on the basis of risk level trend and cycle time of each action plan.

This last step also provides a means to measure the benefits of this approach and carrying out a comparison between old and new approach.

A database is developed in oracle to support action plans data. Application interfaces are developed in PL/SQL and JAVA. The developed application is named “Fair8” (see Figure 3).

The application developed is comprised of five principal modules:

1. Create a new action plan,
2. Search the database for cases,
3. Reports and modify reports under process,
4. Statistical analysis module, and
5. Configuration module (database administrator).

The first module allows the user, with appropriate rights over the application, to make a request for new action plan followed by analysis of an event. This request is validated by the process control owner to optimize the application and authorize only critical events. Modules 2 and 3 provide a user interface to carry out a search of similar events and the creation and modification of action plans.

The fourth module consists of following three levels:

Stat_Level1: check actions priorities at organization level and status.

Stat_Level2: list actions under process at the organization with implementation cycle time.

Stat_Level3: Compare actions priorities, implementation required time and performance between teams.
This structure allows pointing out critical areas within each service of the organization. Priorities based on this process and are being managed at all levels; allow visibility on prioritized action plans and resources required for implementation.

Fig. 4. Example of resulting graphical indicators

RESULTS

The results of application deployment over a period of six months, used by about 400 engineers are the creation of 190 action plans, including 60 closed. This includes action plans related to maintenance, R&D, and quality issues. For all edited action plans, associated risk levels were identified and risk database updated. On this basis, the definition of solutions for future events will be easier (events and risk are classified with the same process).

This graph shows the gap between opened and closed action plans. It also presents the number of opened action plans by organization. Indicators target managers and actions owners, in order to evaluate the reactivity of teams and the portion of current actions by areas; these indicators help in managing action priorities and resources mobilization. They also allow judging the benefit acquired in comparison with realization costs (action costs and risk level).

CONCLUSION

This begins with the disconnection issue between action plans within the same manufacturing plant. It proposes an integration of 8D and FMECA methodologies and allows the unification of action plans management for all organizations and help to simplify management tasks. As the tool is fully deployed over the manufacture, more than 400 engineer's access to Fair8 and first results shows the positive impact on 8D cycle time; it is in constant decrease since the implementation of Fair8.

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