# A categorization of customer concerns for an OT front-end of innovation process in an IT/OT convergence context

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# A CATEGORIZATION OF CUSTOMER CONCERNS FOR AN OT FRONT-END OF INNOVATION PROCESS IN IT/OT CONVERGENCE CONTEXT

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***Abstract**: Operational Technologies (OT) are designed to monitor and control plants. OT are increasingly mixed with Information Technologies (IT) in global solutions. A conventional customer inquiry is no more sufficient to get enough data about Customer Concerns (CC). Indeed, an IT OT solution is the nervous system of a company; it intertwines people processes and functions. For specification step, one must now capture negative perceptions in the interrelationships with other actors of the customer company. The paper creates a database of CC describing dissatisfactions between several involved personas.*

***Keywords**: front-end of innovation, IT OT convergence, customer concerns, personas analysis*

## 1. Introduction

Introducing a new product or service could induce conflicts of interests between actors of a same company. These discrepancies imply a rejection of the concept by concerned actors. Rejection means a refusal to invest or to use this novelty. Front-end of innovation methods do not have showed a real ability to limit this phenomenon. The general aim of this work is to improve these methods by an approach based on the analysis of stakeholders and their pains in contexts of the same kind. A specific context illustrates the authors' contributions: design of new concepts connecting *Information Technologies* (*IT) with Operational Technologies (OT)*. The authors propose tools and successive steps in order to extend a front-end of innovation methodology pre-existing to this study and used as a reference process. Firstly, this paper defines *IT OT convergence.* This part also describes its consequences on emergence of conflicts leading to concept refusal. Thus, involved actors by a concept should be considered in the design of new concepts. For that purpose, methods to elicit pains or *Customer Concerns* (CC) are studied. A definition of CC is proposed and methods intended to collect users' CC are evoked in order to better understand the benefits of their description in a design methodology. Then, *personas* dimensions are discussed as a way to take actors concerned by CC into account. Several methods outline descriptive variables to analyse these actors' characteristics in design. After describing the adopted methodology and tools for this paper, results are presented. They contribute to the development of a new concept that most fit the involved actors in the context of *IT OT convergence.* Finally, the authors propose a way of using structured data about CC and *personas* to generate ideas and to test them. They also propose a way to validate propositions.

## 2. Research context

### 2.1. Technological context of *IT OT convergence*

*Operational Technologies* (OT) are control-command systems composed of hardware and software aimed at monitoring and controlling plants and equipments. They comprise among others sensors, PAC (Programmable Automation Controller), PLC (Programmable Logical Controller) and different units symbolized by dotted circles in the Figure 1 [Gartner 2014]. The main function of OT is to send action orders to production means and to collect feedbacks on progress of industrial processes [Groover 2007]. *Information technologies* (IT) are information systems whose function is to collect and to process enterprise information [Bracchi 2009]. Information systems are used within a variety of businesses duties as marketing, sales, manufacturing, logistics, purchasing, finance or human resources [Laudon 2009]. This article focuses on information systems managing information generated, used and transformed by manufacturing and logistics processes. Enterprise Resources Planning, or Computerized Maintenance Management System are examples of information systems.

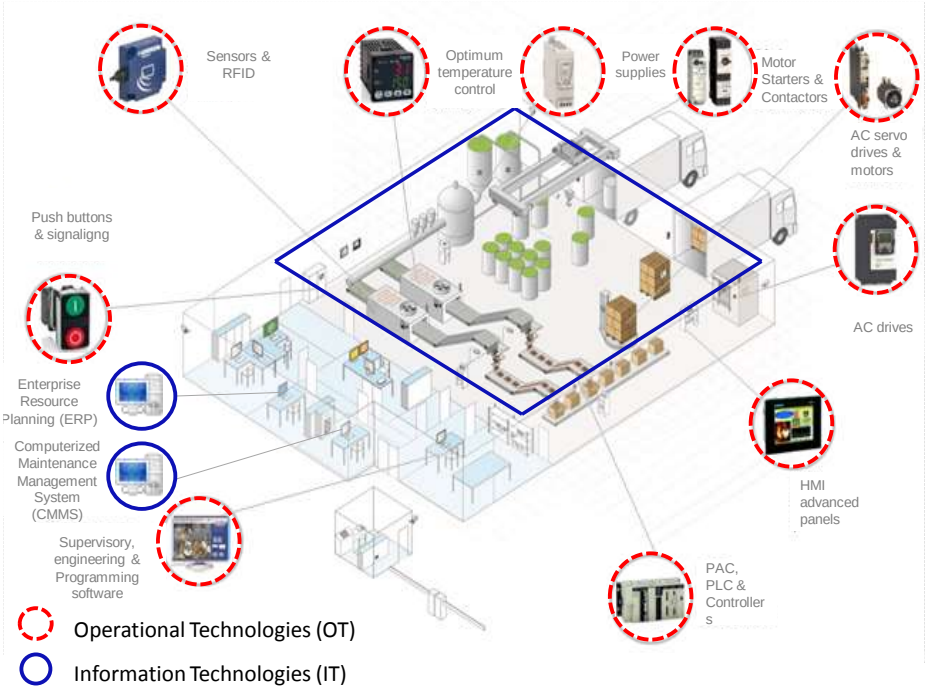


**Figure 1. Example of a manufacturing factory with IT and OT systems**

Figure 1 shows IT and OT systems in an industrial context. They both play an important role to run the operations in an industrial site. Two different kinds of actors are required to use or set up both of these technologies. For example, OT maintenance designers modify OT hardware and software, while a production manager schedules factory activities. On the IT side, a *Chief Information Officer* (CIO) elaborates IT policy and indicators. Then, he communicates them to the IT manager who organises the IT infrastructures accordingly.

Nowadays, IT and OT are more and more intertwined [Sambamurthy 2003]. This trend is called *IT OT convergence*. This convergence enables IT to make data such as production orders or material stock available for machines in real-time [Intel 2014]. A direct application is for machines to benefit the data processing capabilities of IT systems for optimizing the production.

New product or service concepts contribute to this convergence. They involve different stakeholders according to proposed solutions. For example, a production manager has an issue: anticipating failures on a machine. He might need to monitor the operating time of the asset. If an automation provider offered

a product concept that connects *Controllers* to a *Computerized Maintenance Management System* (CMMS), CMMS could generate a maintenance order when the operating time exceeds a threshold. The production manager would need to give the IT manager access rights to the machines' data. And the OT maintenance designers would be required to use the machines' specification to configure a connection to the product concept. However, the production manager would in most cases be reluctant to allow it because this would create cyber security breaches. It is the production manager's prerogative to preserve OT data integrity. This would be a trigger to reject the product concept and highlights the conflict of interest between these two actors of the company. These hurdles are illustrated in Figure 2.

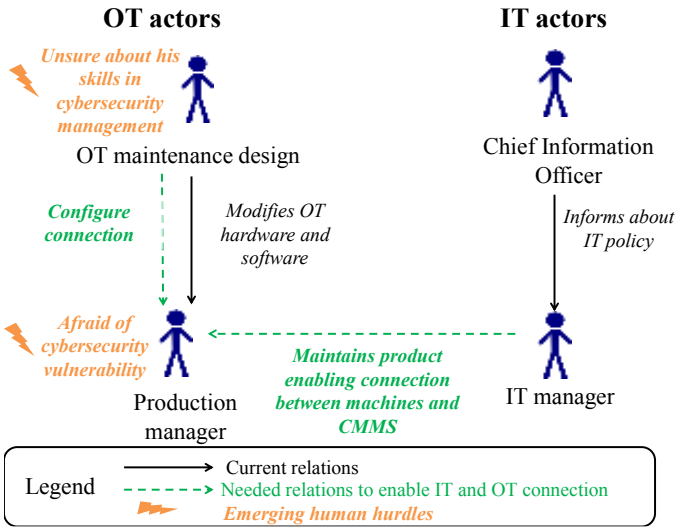


**Figure 2. Example of human hurdles emerging about a product concept**

IT-OT convergence environment is simply a perfect illustration of situation in which the technical innovation induces an organisational change. So, conditions are those in which we are interested in this research. In such a context, designing a new concept requires to identify the stakeholders of the concept. The aim of the method highlighted in this article is to underline the conflict between the various stakeholders' expectations. The list of the stakeholders can be established by listing all the people who have a link with the reason that originated the concept. Then, it is assumed that the design phase will need to include the following tasks listed in order: name the issue or *Customer Concerns* (CC), identify the people and assets affected, propose a solution concept, identify the stakeholders of the new solution concept, and refine the solution concept to avoid stakeholders' rejection. Literature proposes methods to help to complete these tasks.

### 2.2. Methods to elicit *Customers Concerns* (CC)

*Customer Concerns* are defined as users' perceptions about dissatisfactions in reaching their goals [Markkula 2011]. Some authors have characterized perceptions as the ways users or generic stakeholders determine and explain a given problem. Concerns are the negative expressions of those perceptions [Rizzo 2015]. Other researchers called these concerns *user's emotions* related to dissatisfactions [Mogendorff 2013]. [Zhan 2007] associates CC to sentences extracted from online customers reviews or interviews in order to evaluate their positions (negative or positive) related to product features. [Hussain 2012] identifies dissatisfactions of customers to adjust services parameters and structure. This thorough capture and understanding of customers' annoyances helps to design new products or services which are considered charming, attractive and distinctive by customers [Kuehn 1962] [Dale 1994]. In all the cases, CC have been essentially used for design purposes. They help define customer needs which are then transformed into innovation design specifications [Berkovich 2011]. Upstream phase of design methods begins with a first step of problem setting. Then, a new product or service concept is tailored to solve specific pains. For example, *House of Quality* (HoQ) elicits a list of pains turned into customer needs [Franceschini 1995]. Then, solutions are designed to answer these needs. But, pains are not

associated to people who feel them. They are not used to anticipate relations the designed solution will create between actors. Thus, stakeholders of the new solutions are not identified and described. *Failure Mode Effects and Criticality Analysis* (FMECA) is a method to prevent from failures occurrences during a system design [Jun 2012]. FMECA has the same limitations as QFD. Failures are potential issues which are qualified and quantified independently from company's actors. *Creative Problem Solving* (CPS) is a method facilitating ideas generation to solve an identified problem [Kirton 2013]. Creativity tools are used. Ideas enable to solve problems. However, designers do not know who feel them and no tools is proposed to identify and describe stakeholders involved by each idea.
In any case, methods to elicit *Customer Concerns* deal with elaborating a concept to solve them without identifying involved actors and their characteristics.

### 2.3. Methods to describe stakeholders

Taking human characteristics into account is essential in a design process as the new solution concept has to fit with customers values and buying motivations. Customers may be embodied by different actors with different roles and expectations [Cantamessa 2015]. [Cooper 1995] has first introduced the concept of *persona* to support decisions making in design. *Personas* are precise fictitious characters describing goals, behaviours, desires, and limitations of a group of users. They are *hypothetical archetypes of actual users*. Describing them with details (picture, name, skills, motivations, what they want to achieve) makes them becoming real specific individuals in the minds of designers and helps them defining the specific functions of the future product. *Personas* method describes independent individuals (represented by *personas*). It does not emphasize relations between actors involved by the concept. This focus could enable to anticipate concept refusals and limit back and forth with customers to refine a concept. MACTOR is another method to describe stakeholders with their *purposes, motivations, constraints, means of actions* [Godet 1991]. It also clarifies their position regarding stakes. An example of stake may be: regulation and standards reinforcement concerning noises around airports. This tool can underline divergences of interests depending on these positioning. Nevertheless, design context is not adapted to its use. Indeed, it constitutes a support to decision making at a strategic level. Customer needs are not elicited. On the other hand, ethnographic studies propose several approaches to understand stakeholders' behaviours around a system use. Unfortunately, these studies are time-consuming. They imply to attend focused humans' activities during a long period (one year minimum) [Llobera 2003]. In addition, no model enables to guide descriptions of actors and their dissatisfactions about a system. It is assumed that all the lacks mentioned before can constitute a cause to concept refusals. **The assumption for this work is: CC descriptions linked with *personas* descriptions and to their interrelations facilitates concept elaboration.** The approach developed in this paper consists in elaborating models to describe *Customer Concerns* (CC) and stakeholders. It deals with listing descriptive variables for *personas* who interact with a new concept around *IT OT convergence*. They can have an influence on its success and on its conversion into a marketable product. It also deals with listing descriptive variables for CC in order to perceive the link with actors.

## 3. Research methodology and tools for data collection

An empirical approach has been chosen and consists in collecting data from an automation provider and its customers through successive steps in order to validate the previous assumption. First, engineers identified as industrial experts within the automation provider are interviewed. Based on their experiences, representations are created (step 1 and 2). These representations help to build up tools to select *personas* and to conduct their interview within customers industries (step 3). Results from these customers' interviews (step 4) enable to meet the aim of this paper.

### 3.1. Step 1: Representation of a front-end of innovation process used by an automation provider (OT provider).

Such a process is chosen as a basic model. This model has been used as a reference due to its capacity to process descriptive customers' data [Pizelle 2014]. At this step, the aim is to describe this process in

order to point out the lack of CC described with *personas*' dimensions but also the lack of descriptions for *personas* involved by a CC. For that purpose, two engineers who are experts in deploying this process in the same automation provider have been interviewed. Figure 2 in section 4.1 summarises the result of this step.

### 3.2. Step 2: Association between *personas* within customers industries and OT lifecycle steps.

The objective is to census the archetypal stakeholders or *personas* present for each step of OT lifecycle. The presence and interrelations between *personas* depend on OT lifecycle step. Highlighting these interrelations enable to reach three targets for the research approach. First, it emphasizes new possible variables to describe a CC as: *step of OT lifecycle* and *personas* who express these CC (see Table 1). Then, it helps to identify *personas* to meet and interview in order to list and describe CC related to *IT OT convergence*. Finally, it enables to identify a list of stakeholders potentially related to a new solution concept. The Figure 3 was built up with 5 industrial engineers who are experts in this OT lifecycle deployment. They are all project managers in an automation provider company and they support customers for the different steps. Then, this representation was validated during the step 4.

### 3.3. Step 3: Creation of templates to describe CC and *personas*.

The aim is to build up templates of CC and *personas* concerned by *IT OT convergence*. Building up these templates means putting forward descriptive variables which are instantiated during the customers' interviews of the fourth step. So, these variables constitute a framework which guides data collection during interviews. These templates are elaborated based on literature review in section 1. [Pizelle 2014] proposes 6 variables to describe a *Customer Concern*: *title (*it enables to answer the question: "what is the expressed difficulty?"), *cause* (it explains the reason, the origin of the concern. It answers the question "why does it happen?"), *impact* (it describes the effect or consequences of the concern), *palliative* (it is the solution that an user sets up to solve his own problems), *criticism of palliatives* (it consists in describing pains felt by an user around this palliative solution), *associated verbatim* (it is the sentence the interviewee said to describe his pain). These variables are currently exploited in the reference front-end of innovation process (see Figure 2).The following new CC descriptive variables are suggested in order to complement the six last ones. Their selection is justified in Table 1. They enable to adapt CC description to *IT OT convergence.*

**Table 1. New descriptive variables for CC template**

| Variables | Descriptions | Justifications |
|---|---|---|
| *Involved persona* | People affected by the specific concern. | Difficulties during OT lifecycle can now be felt by various actors coming from different areas. Identifying these involved personas helps to deduce all the stakeholders related to a concept. It then enables to develop a concept suitable for all of them. *Personas* description is essential for that (see Table 2.). |
| *Involved step of OT lifecycle* | Steps of an OT lifecycle concerned by the considered *Customer Concern*. | CC depend on the step of OT lifecycle which imply different personas to take into account for design of a new concept (see Figure 3.) |
| *Involved market segment* | The three market segments considered are: manufacturing, industrial processes and infrastructure. | As technological systems supporting OT or IT functions depend on the three market segments considered, CC also depend on these segments. In the reference process (see Figure 2.), *concept elaboration* is performed for a specific market segment targeted at the beginning of the process. So, this descriptive variable enables to filter CC to focus on to create a concept. |

| | | |
|---|---|---|
| *Companies* | Enterprises where the considered CC is encountered | Listing companies enables to figure out how representative the CC is. This list can be modified during self-improvement process of CC data base. |
| *Impact on customer architecture* | Position of the concerns on IT and/or OT technological systems. It deals with answering: "what technological functions are sources of dissatisfactions?" | Because of the convergence, dissatisfactions can be found out at the interface between IT and OT functions. |

As discussed in 1.3, some authors propose descriptive variables to characterize a *persona* like name, picture, skills, goals [Cooper 1995]. The authors propose complementary variables to build up personas models. Their selection is justified in table 2.

**Table 2. New descriptive variables for personas templates**

| Variables | Descriptions | Justifications |
|---|---|---|
| *Title* | Generic name of the persona. | It enables to refer to a specific function in the company. |
| *Biodata* | *Age*, *qualification* (diploma and studies), *experience* (role the persona had before in the current company or in other ones), *function* (the current title in the company), *digital readiness* (list of reactions when evoking new digital technologies). | It enables to anticipate rejections due to the fact that the user does not have the too specific skills required by the concept. |
| *Influences* | Topics for which the *persona* can challenge or have the final decisions in the company. | This category of data is essential to target actors to interview in order to test parts of the concept which are related to the mentioned topics. So, their requirements are priorities for these specific topics. |
| *Aims/Goals* | Actions the person wants to achieve in order to perform one's professional role or function | During the ideation phase (see Figure 2.), it is possible to refer to it and wonder if the created concept enables to achieve these goals. |
| *Means of actions* | Actions or resources *personas* can deploy in order to reach their own *Aims/Goals*. | The concept can adapt, substitute or add to current means. Comparing the concept with the current *means of actions* enable to anticipate on how valuable the concept is for the persona. |
| *Constraints* | List of all fixed variables in the company on which the persona has no influence. | *Constraints* are part of personas' environment and have to be considered in order to design a new product or service which will be integrated into this environment. |
| *Drivers for action* | Indicators the *personas* want to optimize in order to reach their goals or their desires. These indicators could be relative to their role, their professional environment or company investments. | It is possible to anticipate on the positive or negative feedbacks from *persona*s and refine the product or service to take these drivers into account. |

### 3.4. Step 4: Creation of lists of CC and *personas*.

The aim is to instantiate templates elaborated during the step 3. 14 industrial companies have been visited and 27 interviews have been carried out. Based on the information richness method of data collection [Pizelle 2014], 20 interviews guarantee a minimum 90% of the total information that can be gathered on a given list of *Research objectives.* Two lists of 28 CC and 7 personas have been elaborated. An example of CC and persona are given in the section 4.3. These lists enable to modify the process used as reference (see Figure 2) by positioning CC and personas descriptions within the sequence of tasks. This modification is discussed in section 5 of this paper.

## 4. Results

### 4.1. Front-end of innovation method used by an automation provider

The enterprise uses a process where *Start* and *Discovery* steps enable to collect users' expressed difficulties and to describe them in a *Customer Concerns book*. Then, a step of C*oncept elaboration* enables to create a concept to answer targeted CC. A *Concept test* aims at validating the concept value with the stakeholders involved by the CC within customers companies. Depending on the results of this test, the concept is refined or further developed.

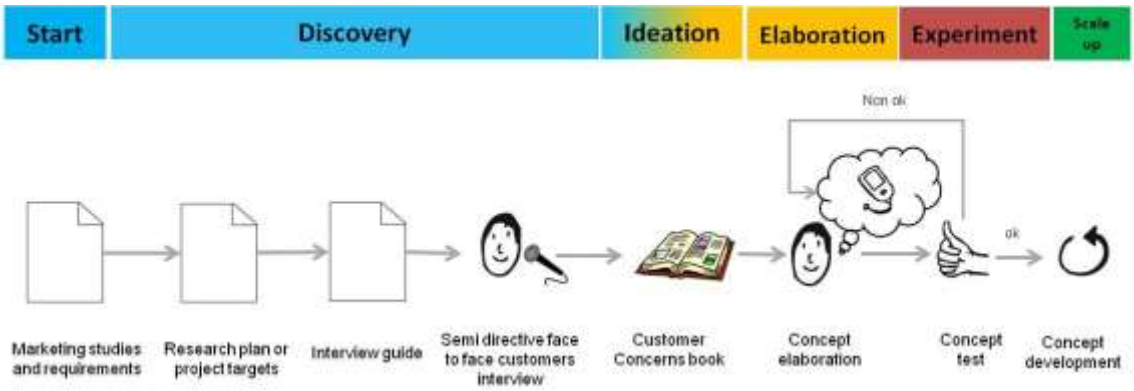


**Figure 3. Front-end of innovation method used by an automation provider**

However, there is no list of CC specifically related to the context of *IT OT convergence* and no method enables the census and description of *personas* involved by each CC and those related to a new concept.

### 4.2. *Personas* associated to OT lifecycle steps

This section focuses on the way *personas* intervene within OT lifecycle.

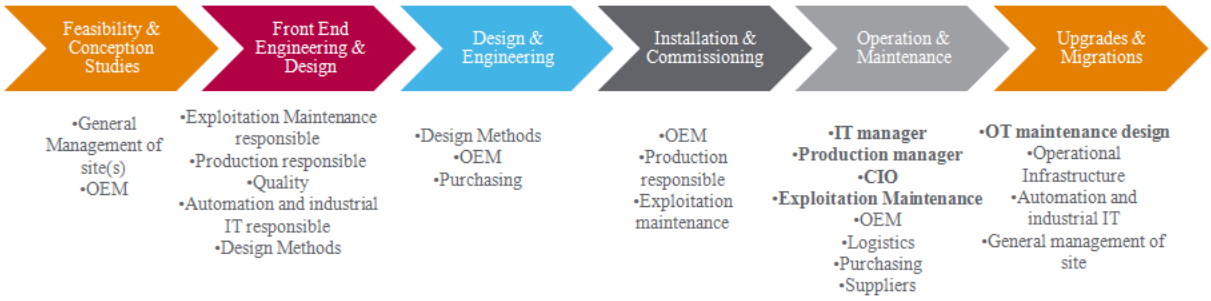


**Figure 4. Steps of an OT lifecycle with *personas* associated for a manufacturing environment**

This Figure 3 helps to structure interviews to describe *Customer Concerns* (CC). It also helps to identify *personas* to describe. For instance, in *Operation and Maintenance* step, *IT* manager allocates and maintains *IT* infrastructures for production operations in the company. Now, devices supporting TCP/IP or Ethernet fit with production requirements. It was not the case twenty years ago where equipments designed for *Chief Information Officer* (CIO) purposes were not an option for OT. So, *Exploitation Maintenance* fixes breakdowns on devices integrating IT technologies (supported by *Original Equipment Manufacturer* (*OEM*) if necessary). Moreover, *OT maintenance designers* make production infrastructures evolve to avoid failures and ensure continuity of services. Consequently, technological systems are now managed by a typology of person and used by another one. This is a typical illustration of *IT OT convergence*. Thus, establishing Customer Concerns means to interview and describe the following *personas*: *IT manager, Chief Information Officer, Production manager and OT maintenance design.*

### 4.3. Examples of instantiated *Customers Concerns* and *personas*

Here are examples of *Customer Concerns* and *personas* obtained through interviews within customer industries (see Step 4).

#### *4.3.1. Customer Concerns example*

**CC 1 : Difficulty to schedule maintenance actions**

« We tend to make a lot of preventive actions. Operating time meter would be great to know how the machine aged. » (***Production manager*** *from* ***Company X)***

•**Cause :** No visibility of operating time of assets prevents from anticipating failures.
•**Impact :** Time between machines stops is not optimized
•**Palliatives** : Manual data entry about operating time
•**Criticism of palliatives** : Risk of human error
•**Involved personas** : Production manager
•**Involved step of OT lifecycle** : Operations and maintenance, Upgrades and migrations
•**Involved market segment** : Industrial processes, Manufacturing, Infrastructure
•**Companies** : X,Y,Z
•**Impact on Customer Architecture** : machines and CMMS

**Figure 5. Example of a CC**

#### *4.3.2. Personas example*

Persona **«Production manager »**

**Biodata**
•**Age**: 50
•**Qualification** : Engineer in Inudstrial Engineering
•**Experience**: machines designer
•**Fonction** : Production manager
•**Digital readiness** :
•«Cloud is not secure. I don't want my machines fail because of IT »

**Influences**
•**In the company**: choices of OEM to work with and priority OT data

**Aims/Goals :** Schedule operations to satisfy customer orders.

**Means of action :** Budget to extend his factory (purchase of new machines)

**Constraints**
•**In his function:**
-Specialized automation skills of actors he works with
•**In the company** : Policy of IT elaborated by *CIO*
•**Regulations (Governmental standards…)** : Traceability constraints are strengthened.

**Drivers for action**
•**Related to his role**: OT data integrity, production process continuity
•**Related to his professional environment :** Product traceabaility (food and beverage companies espcially)
•**Related to investments**: simplicity (ex. files format as csv), flexibility of technologies, price

**Figure 6. Example of a persona "Production manager"**

Another result of this study is to position CC on interrelations between *personas* in order to answer the identified lack identified in the section 2.3. During an oral exposition, this part can be developed.

## 5. Results use and validation

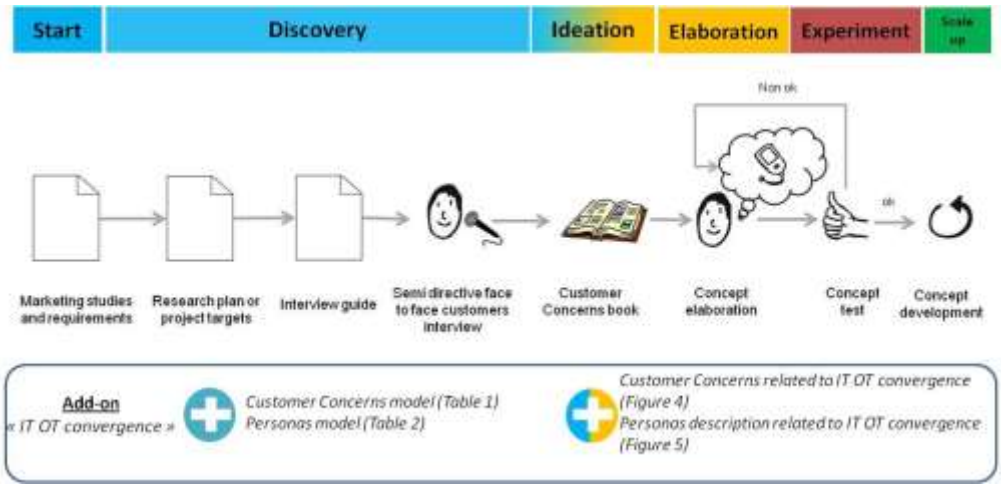


**Figure 7. Extended front-end of innovation method used by an automation provider**

These new data bases containing combinations of *personas* and CC may extend the ideation phase complementary to the *Customer Concerns* book. Creativity workshops for *concept elaboration* can then be fed by descriptions of concerns and *personas* to ensure a matching between elaborated concepts and difficulties expressed by several *personas* who have different expectations and characteristics. During *concept test*, people targeting to test customers' interest for a concept can consider all stakeholder*s* identified as involved by CC and the concept.

In order to validate the approach by pair of CC and *persona*, a constructivist approach is achieved. More precisely, the method is considered as pertinent if practitioners are able to promote the methodology outcomes by creating new concepts or by making decision. Usefulness and efficiency of the approach is tested. Thus, an observation has been conducted within the automation provider company. It was observed that during a creativity session, a concept emerges. It is a solution which enables to send data (like assets' operating time) from *Operational Technologies* like Programmable Logical Controller (controlling an asset) to IT software like *Computerized Maintenance Management System* (CMMS) and vice-versa. This IT function is aimed at managing and scheduling maintenance activities and resources. It covers a *Customer Concern* in the data base as "*Difficulty to schedule maintenance actions*". This issue is felt by the production manager. The elaborated concept has to fit with personas' characteristics in relation with him such as *Chief Information Officer* or *IT manager* for example (see Figure 4.). In order to send data, a 3G communication was integrated into the concept to consider the *means of actions* (skills) of the persona *OT maintenance designer.* 3G communication is manageable for him. This connection must be direct and IT functions (CMMS) must be available to *production manage*r. Indeed, such a connection enables to reduce budget intended for *IT manager* whose *aim* is to manage all the functions of IT systems. Now, communications feeding industrial machines are under control of the persona *Production manager* whose requirement is to monitor operating times of assets. This need fits with one of his *drivers for actions* which is production process continuity. Moreover, the link between CC and *personas* enable to highlight stakeholders which are involved by a concept and so actors within customers companies to interview during *concept test* step (see Figure 2.). *Concept test* step is still needed to be done.

Others concepts were designed before in the considered automation company using the regular front-end of innovation method. A mock up was achieved for one of these concepts for test step. The lack of consideration of *personas* dimensions implied the concept rejection during *concept test*. The concept was aimed at sending data from OT to IT functions. OT personas' skills (*Production manager* or *OT maintenance designer* for instance) were not sufficient to be able to install and use the product. Thus, the innovation was not adopted.

## 6. Conclusion

This paper shows a lack of consideration of interrelated *personas'* characteristics to identify CC but also to create and test a solution in all situations where a concept makes conflicts of interests emerge. A concept will be validated by *concept test* only if all relevant stakeholders agree on its adoption. So, identifying *personas* involved by the concept and formulating requirements related to *personas* characteristics with a comprehensive approach is essential for ensuring adoption of generated concepts. This work aims at contributing to the debate by proposing a way of describing *Customer Concerns* and personas. Then, the authors linked the two models in order to foster success of a new concept. So far, no one has simultaneously linked multi-*personas* characteristics with CC and has considered relations between *personas* to design a new concept. The rationale behind the method is that products will be designed quite narrowly around the perspective of several interrelated *personas*.
The CC and personas has been integrated into a front-end of innovation method used by an automation provider. This extended method has been tested in the same automation provider through a *concept elaboration*. Results obtained have been very interesting. In comparison with other projects, they allowed the firm to create quickly a concept. So, the exposed case study validates the assumption of this paper. In order to totally validate these results and refine the contributions, the described extended front-end of innovation method should be used by other practitioners. So, further research lies in deploying the extended method within other companies facing situations similar to *IT OT convergence.* This can contribute to extend the list of described CC and *personas*.

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