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Bernard Yannou, François Cluzel, Romain Farel. Capturing the relevant problems leading to pain and usage driven innovations: the DSM Value Bucket algorithm. Concurrent Engineering: Research and Applications, 2018, 26 (2), pp.131-146. 10.1177/1063293X16666311 . hal-01377034

HAL Id: hal-01377034

https://hal.science/hal-01377034

Submitted on 6 Oct 2016

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Yannou B., Cluzel F., Farel R. (2016) 'Capturing the relevant problems leading to pain and usage driven innovations: the DSM Value Bucket algorithm', Concurrent Engineering - Research And Applications (CERA), pp. 1-16, doi: 10.1177/1063293X16666311

# Capturing the relevant problems leading to pain and usage driven innovations: the DSM Value Bucket algorithm

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**Abstract:** The Dependency Structure Modelling Value Bucket (DSM-VB) tool is integrated into Radical Innovation Design (RID) methodology in order to explore the front end of innovation in need seeker mode. The determination of innovation opportunities, here called value buckets, has been automated by matrix representations of dependencies between problems or pain points, usage situations and existing solutions. Three matrices are built along the problem setting stage of a RID process. The first matrix expresses which problems occur during usage scenarios, the second how far existing solutions cover problems, and the third to what degree existing solutions are useful in usage situations. Combining these three matrices results in a matrix of value buckets, which represents the combinations of important problems which occur during characteristic usage situations and for which few existing solutions are useful or efficient. This outcome allows focused creativity workshops to be run, resulting in usage innovations with a high likelihood of market success.

***Keywords***: *Radical Innovation Design, RID methodology, front end of innovation, need seeker innovation, value bucket, dependency structure modeling, usage driven innovation, pain driven innovation*

## 1 Introduction

The *Dependency Structure Modelling Value Bucket* (DSM-VB) is a tool integrated in our *Radical Innovation Design* (RID) methodology. RID is a structured process for exploring the front end of innovation in need seeker mode. Indeed, the problem setting stage starts with reframing an ideal need, comparable to a box inside which useful thinking is performed in addressing two domains: the domain of problems or pain points, and the domain of situations or usage scenarios. The two spaces – problems and usage scenarios - are populated with real world situations. For this purpose, some modeling techniques such as causal graph representations and usage storyboarding are used. A first "ideal performances matrix" of the DSM-value-bucket tool allows problems to be crossed with usage scenarios to express in which usage situations people are subject to pains. Next, existing design solutions – commercial solutions or patents - are identified and their coverage of the two spaces is modeled. Here the DSM-VB tool represents the coverage effectiveness and efficiency of both problems and usage scenarios by two appropriate

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matrices: the Solution-Problem matrix and the Usage-Solution matrix. Multiplying both matrices calculates the likelihood for the existing solutions to satisfactorily answer any problem arising during one usage scenario. Subtracting this matrix from the "ideal performances matrix" results in a final "value buckets" matrix, highlighting which problem is worthy of being addressed in an innovation project. The last step of the RID problem setting stage is to select a subset of opportunistic value buckets to consider further in the problem solving stage, so as to ensure radical innovation on "blue ocean" – i.e. not yet explored – usage and problem situations. The DSM-VB tool has been successfully applied to more than 20 innovation projects in more than 15 companies over the past 3 years. In this paper, the DSM value bucket tool is illustrated in the search for radical innovations for a champion handitennis wheelchair. Two important value buckets are detected as crucial to improve the likelihood of victory. It is then shown that creativity workshops starting from these two value buckets lead to several convincing innovations. The DSM value bucket tool opens the possibility of automating radical usage-driven innovations along with systematic investigation and representation of problems or pain points and usage scenarios.

## 2 Exploring the front end of innovation

A lot of research has already been undertaken in design engineering for monitoring the design process of a new product. Quality Function Deployment (QFD) and the matrix flow approach of Nam Suh systematic design [1] have been extensively used to organize the design process in a data driven manner, from needs to product and process parameters. For instance, a unified information and mapping paradigm for concurrent product/process design is proposed in [2]. But such design methods do not particularly prompt practitioners to explore the causes of needs in different user contexts, and are not especially well-adapted to foster ideation at the time and place it is necessary. They provide frameworks to store data, but no strong frame for innovating.

The tools proposed in TRIZ methodology [3] perform root-cause analyses, starting from existing perfectible products (not services) with apparent contradictions. But here, end-user contexts and markets (competitors, existing solutions) are quasi absent. TRIZ is adapted for a class of innovations as little is done to characterize the need opportunities especially in the light of what the other existing solutions are efficient or successful at.

For these reasons, the authors also explored the literature in marketing and business administration about the *front end of innovation*. The *front end of innovation* is the earliest moment before entering a formal product development process where people try to discover and assess the relevance of innovation opportunities, sometimes called *growth territories*.

Booz and Company stipulates that firms follow at least one of three innovation strategies: Need Seeker, Market Reader, or Technology Driver, depending on whether the focus is on the customer, the market or the technology. In their 2012 innovation report [4], they offer the following definitions:

- Need Seekers, such as Apple (US), Dyson (UK) and Decathlon (France), "*make a point of engaging customers directly to generate new ideas. They develop new products and services based on superior end-user understanding. Their goal: to seek out both articulated and unarticulated needs, and then to try to get their new products to market first*."
- Market Readers, such as Hyundai, Caterpillar and Loréal, "*use a variety of means to generate ideas by closely monitoring their markets, customers, and competitors, focusing largely on creating value through incremental innovations to their products. This implies a more cautious approach, one that depends on being a "fast follower" in the marketplace.*"
- Technology Drivers, "*such as Google and Bosch, depend heavily on their internal technological capabilities to develop new products and services. They leverage their R&D investments to drive both breakthrough innovation and incremental change, in hopes of meeting the known and unknown needs of their customers via new technology.*"

According to this study (see [4]), "*following a Need Seekers strategy, although difficult, offers the greatest potential for superior performance in the long term. Fifty percent of respondents who defined their companies as Need Seekers said their companies were effective at both the ideation and conversion stages of innovation, compared with just 12 percent of Market Readers and 20 percent of Technology Drivers. These are the same companies, by and large, that consistently outperform financially.*"

Being predominantly Need Seeker is not easy, and can be done in two ways:

- Using lead-users (see von Hippel [5]), their insightful refreshing ideas and dreams and their testimonies on usage and pain points. This is the case of Decathlon in France for sports and outdoor equipment.
- Having a visionary leader like Steve Jobs (Apple) or James Dyson (Dyson), company growth and the number of product references being limited by the imagination and controlling power of a single brain.

There is thus a need for a methodology which investigates growth territories or strategic value niches that generate disruptive innovations beyond current customer expectations. This must be done in a cooperative, multidisciplinary and secure manner. After Motte et al [6], it can be done thanks to adapted organization and special methodologies and processes. In terms of organization, Millier [7] insists on the necessity of managing antagonism and finding a balance between exploration and exploitation of new idea territories. Christensen [8, 9] notes that for disruptive innovations to succeed, companies must not put too much emphasis on customers' current needs, and need to work on how to adopt new technologies or business models that will meet customers' unstated or future needs. In terms of methodology, Christensen [8, 9] proposes the jobs-to-be-done concept, defined as "*a framework which is a tool for evaluating the circumstances that arise in customers' lives. Customers rarely make buying decisions around what the "average" customer in their category may do — but they often buy things because they find themselves with a problem that they need to solve. With an understanding of the "job" for which customers find* *themselves "hiring" a product or service, companies can more accurately develop and market products well-tailored to what customers are already trying to do.*" For this and other works on innovations, Clayton Christensen has been designated as the most influential management thinker in the world (see The Washington Post paper [10]). Ulwick [11] has extended it in a principle of design-outcome segmentation instead of a conventional a priori customer segmentation. Another recent and popular method for designing a value offer along with its business model is the *Business Model Canvas* developed by Osterwalder and Pigneur [12]. The authors recently refined the process of designing the value offer by designing the fit between a customer profile and a value map (see [13]). A customer profile is defined by three components: pains, gains and jobs (similar to the *jobs-to-be-done* mentioned above). A value map is made of pain alleviators, gain creators and job contributors. In the following, RID methodology puts the emphasis on pains needing alleviation.

Inspired by these ideas, Yannou *et al* [14] and He *et al* [15] have adapted this user-centered perspective to model the market demand model in a design engineering platform through the representation of usage contexts. It is called the Usage Context Based Design (UCBD). Yannou et al [16] also proposed the *Design by Usage Coverage Simulation* principle for evaluating how much a new product or product family [17] may cover a number of characteristic usage scenarios . New coverage indicators have been developed. They show that innovative designs may be proved to be dominant i.e. ranked first because performing better, on a subspace of usage situations. These designs are then naturally in a "blue ocean" (after Kim and Mauborgne [18]) which is almost a guarantee of success when launching an innovative offer. A similar principle of satisfactory coverage of usage situations has been followed by Bekhradi *et al* in [19]. Indeed, in the context of fatal falls of elderly people, they simulate how much a product-service design concept can usefully cover most of fall situations while alleviating at best the consequent pains – deaths, lowering of life expectancy, loss of autonomy… -.

## 3 Examples of pain and usage driven designs

Let us illustrate how pain driven design processes may lead to successful innovative products. We took three recent innovations from Decathlon and Groupe SEB (France). Each time, let us start with unsatisfactory usage situations corresponding to a clear boundary of experience or needs.

The first example is the need to learn how to ride a bike for children. Biking is a widespread leisure activity, and learning how to ride a bike for children corresponds to a widespread social practice. Observing the existing usage situations today, one may notice that the most common current practice is to start biking on a small bike with fixed or removable side wheels for added stability at any time, the pedals being fixed on the front wheel axle or linked to the back wheel by a transmission chain. When asking people what pains exist in different usage situations, they often fail to mention the main pains and always have trouble to quantifying them. However, simple observations of children and parents in public spaces suggest that:

- As soon as removable side-wheels are dismantled:
  - Children fall, cry, are wounded, and lose confidence.
  - Parents run after the child, in a bent position, they are anxious and sometimes fall themselves.
- Learning with side-wheels takes a long time and does not teach equilibrium.
- In addition, traditional children’s bikes around the world (see Figure 1.a) have uncomfortable brake handles articulated with the handlebar through a vertical rotational axis, resulting in a braking system that is both too bulky for children’s small hands, and too difficult for a young child to activate. Most of the time, brakes do not deliver an effective service for children.

In 2013, Decathlon designed the Woony bike[1] (see Figure 1.c) and protected it with 3 patents. They started from the idea that the most efficient manner to learn equilibrium is the old principle of draisin (see Figure 1.b). A lot of draisins are sold today, but Decathlon’s innovation is to accustom children to a draisin and to add, as quickly as in 15 seconds, the two pedals and transmission chain instead of accustoming children to a full bike plus side-wheels. In doing so, a child who trusts his/her draisin may decide by him/herself to add the pedals once the equilibrium is acquired. The result gives immediate confidence with the draisin frame and instantaneous learning of how to pedal. In addition, one patent concerns hand brakes articulated with handles by a horizontal rotational axis, permitting a small hand aperture and weak efforts.

(a)

(b)

[1] See video on https://www.youtube.com/watch?v=prAj7K9_hE0

(c)

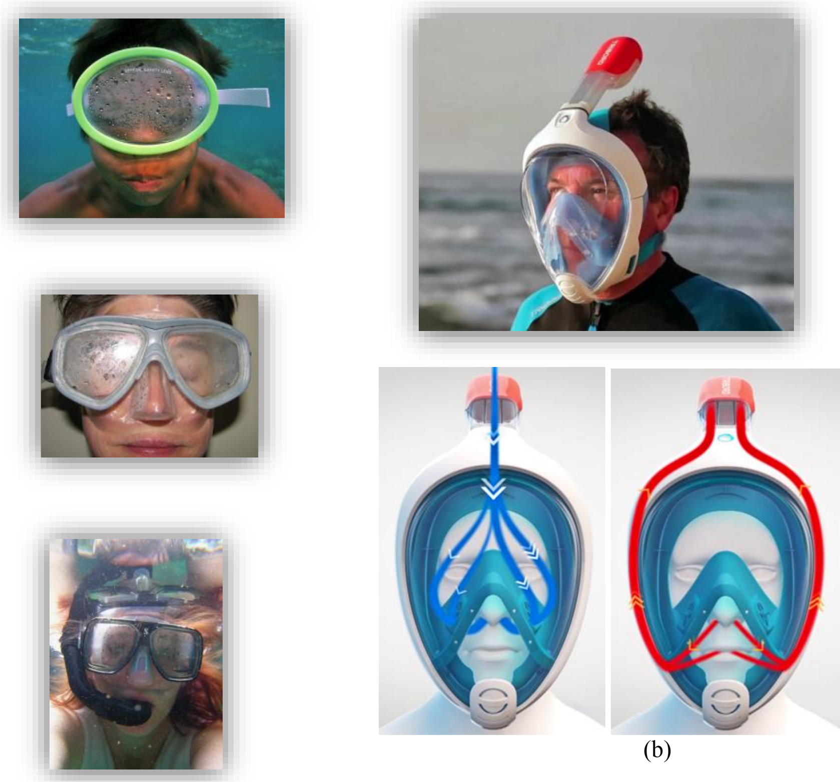
**Figure 1** The children's bike: (a) traditional bike with fixed or removable side wheels (b) the 19th century dandy horse or draisin (c) Decathlon Woony with adaptable pedal and transmission chain system

What can we conclude from this example? First, that a need seeker oriented design company such as Decathlon starts its design process with observations of typical usage situations and tries to make explicit what people have difficulty expressing because such situations are so natural for them. Second, that it is also very unusual to qualify pains in terms of measurable pain indicators that may be turned into functional specifications. For example, the average number, or distribution of child falls during his/her apprenticeship, the number of parent races, the average number and seriousness of children's injuries, the average total time to learn how to ride a bike. Third, when important pains are detected, a root cause analysis must be systematically completed before starting to design, so as to understand deep pain causes such as, here, the lack of equilibrium when the side wheels are removed.

The second example concerns the practice of snorkeling. After statistical investigation, the pain points turn out to be mask condensation, lack of natural inhaling (inhaling through the snorkel with open mouth provoking mouth and tongue dryness), a narrow vision, facial deformation provoked by mask pressure, low visibility of the diver from boats, global anxiety provoked by breathing through the mouth. A root cause analysis of the condensation phenomenon reveals that the air compartment inside a conventional mask, if not renewed, warms on contact with the face causing condensation on the cold surface of the glass or plastic mask. In addition, a lot of people do not try snorkeling despite a desire for underwater exploration due to claustrophobia or a first bad experience. In Blue Ocean Strategy methodology [18], understanding the motivations of these non-clients is a major strategy for innovation without the pressure of competition, because new market territories are always to be conquered.

The solution to the whole set of pains has been found with the Decathlon Tribord Easybreath[1] mask and snorkel set (see Figure 2.b). Two air compartments separate the eyes (up) and nose and mouth (down). They are separated by valves that allow air flow renewal of the upper eye compartment, forcing the expired hot and humid air out by another external exhaust circuit. Natural breathing by nose or mouth is thus enabled, the air flow from upper to lower compartment preventing the built-up of condensation (Figure 2.a). The product is described in users' blogs as amazing with, in addition, increased visibility and a comfortable sealing joint on the face.

[1] See video at https://www.youtube.com/watch?v=lwf3SOiKo2g#t=18



(b)

(a)

**Figure 2** Snorkeling solutions (a) Condensation and mouth breathing are common when practicing snorkeling (b) Decathlon Easybreath mask and snorkel set avoids condensation while permitting nose breathing and wide vision.

The third example concerns the cooking and eating of French fries. The pains can easily be listed by reference to the traditional fryers which use open or sealed frying of potatoes in an oil reserve (see Figure 3.a). These traditional fries are too fatty and unhealthy; the oil reserve must be changed regularly at the risk of intoxication; oil smells bad even with sealed fryers; fryers always present risks of fire, skin burns and child accidents (see Figure 3.b).

Groupe SEB invented Actifry fryer[1] (see Figure 3.c) which demands only one spoon of oil per cook. A new heating principle has been developed along with a continuous move of fries. Healthy fries are now possible without bad smells, oil storage and burn risks.

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[1] See https://www.youtube.com/watch?v=nvy6KYPld9k


**Figure 3** Cooking French fries (a) traditional fryers designed as oil reserves (b) pains are smelling, oil hygiene, risks of burns and fatty fries (c) Groupe SEB Actifry fryer needing as little as one spoon of oil

## 4 The RID methodology and process

Albert Einstein said "*If I had an hour to solve a problem and my life depended on the solution, I would spend the first 55 minutes determining the proper question to ask, for once I know the proper question, I could solve the problem in less than five minutes.*" Following that maxim, Yannou et al [20] structured the RID process in two macro stages of *problem setting* (see Figure 4) and *problem solving* (see Figure 10). Radical Innovation Design® is a methodology for a number of reasons. It is based on structuring principles as well as a stage-and-gate process (see also [21-23]) which is highly detailed in the early problem setting following Cooper [24].There is a list of 9 expected templated deliverables throughout the process. It makes use of two computerized tools, namely the *DSM-Value-Bucket* tool described in the present paper and the *UNPC-monitor* tool [25]. We are pleased to report successful implementation in various company contexts since after more than 35

RID innovation projects with 25 companies, several innovations are in the process of being launched on the market.

The goal of RID methodology is to maximize the potential value creation within a legitimate design perimeter called *ideal need*. RID is a systematic exploration/exploitation process of value creation opportunities through a series of stages making the inventory of usage situations (or *scenarios*) and pain points (or *problems*) users may experience. RID uses simultaneously 3 perspectives:

- The perspective of an economist: design is considered as a probabilistic theory of value creation,
- The perspective of an industrial designer: design starts with the know-how for observing users – their usages, pain points, needs…- and inventing new usages,
- The perspective of a design engineer: knowing how to measure utilities to create, gather evidence and bring serious proofs of concept using the most suitable/appropriate technologies.

Yannou *et al* showed in [20] that the more the design team completes the successive RID deliverables, especially in problem setting, the more likely the innovation outcome will be successfully launched on the market. To that aim, they use monitoring with four proofs to consolidate along the design process: Usefulness, Novelty, Profitability and Concept. This is the UNPC model described in [25].

The problem setting starts with the reframing of the *initial idea* submitted by the innovation project initiator into an *ideal need*. Let us take the example of need seeker innovation on the wheelchair of a handitennis champion – an example free of confidentiality rights. It was the actual innovation project initiated by a 22-year old handicapped female student who is nearly ranked 30th in the world, and who set the objective of winning in the Rio-2016 Paralympic Games. She came with the initial idea of "*to develop the lightest possible handitennis wheelchair*". Such a goal would have led to a carbon fiber high-tech wheelchair. But making the wheelchair lighter is not an objective in itself, so this was reframed into the following ideal need: "*to achieve high-level performance for point in all game situations.*" This ideal need is a "box perimeter" inside which thorough investigation must be pursued. Contrary to most people on creativity, the authors do not believe that to "*think outside the box*" is the must, but it is more efficient to "*think inside the box, providing the box is large enough and sufficiently well-defined*."

Continuing with the RID process, two domains (or *worlds*) are investigated concurrently within the *ideal need* perimeter (see Figure 4):

- The domain of problems. This consists of inventorying, quantifying and causally ordering the miscellaneous pain points, counter-performances, dissatisfactions, and needs, that users may experience.
- The domain of situations. This consists of inventorying, qualifying and dimensioning the usage situations that users experience and in which problems occur with more or less intensity.

Once these two domains are populated with pains and usage situations, a series of matrices (see Figure 5) are built for systematizing detection and prioritization of value buckets worthy of further exploration in creativity sessions. These matrices are filled or computed in the so-called DSM-Value-Bucket algorithm.

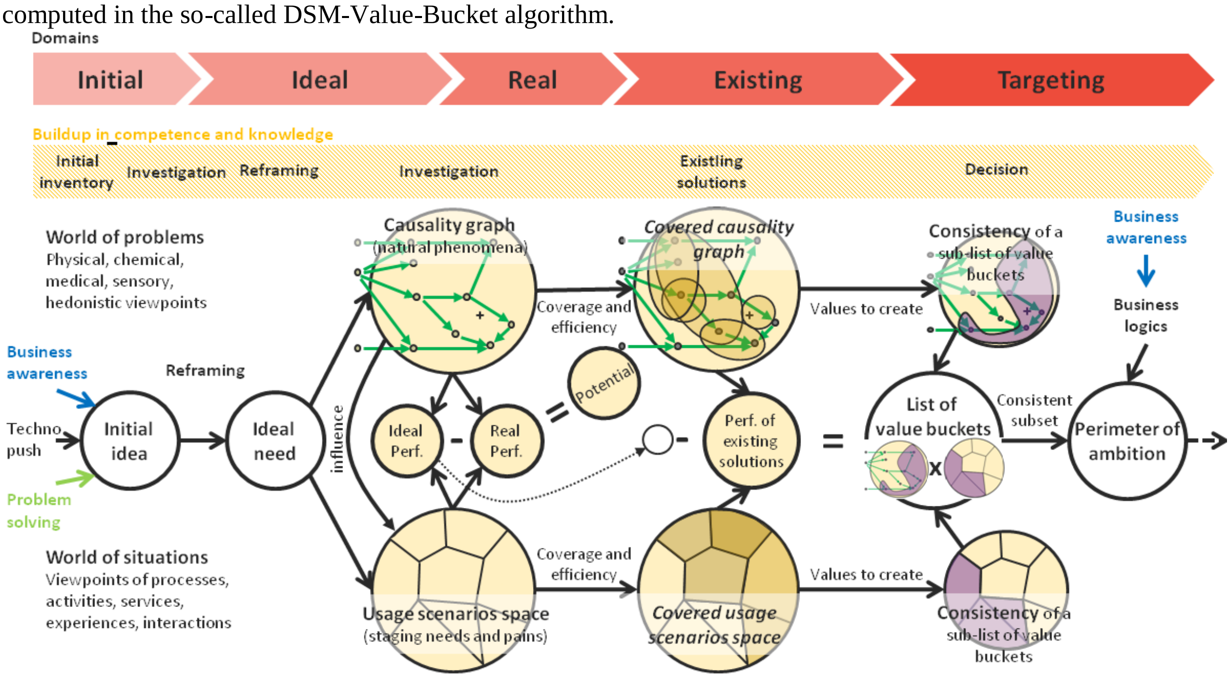


**Figure 4** The *problem setting* macro-stage of Radical Innovation Design® methodology

Defining the *real* world consists of building a *causal graph* (of problems) and a *usage scenarios space* of characteristic usage situations (see Figure 4). Next, as *existing* solutions may partially cover problems in usage situations, a *covered causality graph* and a *covered usage scenario spaces* are derived from the careful analysis of the conditions (usage scenarios) and of the effectiveness and efficiency of service delivery (problems/pain points more or less relieved). Next, in the final *targeting* stage of problem setting, a list of weighed value buckets is derived. This represents the combinations of important problems occurring during very characteristic (frequent) usage situations and for which few existing solutions exist or are really effective/efficient. From this list of value buckets, a perimeter of ambition is defined by the project team, including a) a subset of relevant value buckets, b) other (problems x usage-situations) currently covered by existing situations but that consumers consider as "must have", c) these previous choices being compatible between them and with the present offer portfolio and customer segmentation of the company (represented by “business logics” in Figure 4). This process of resulting in a list of prioritized value buckets is summarized in Figure 5.

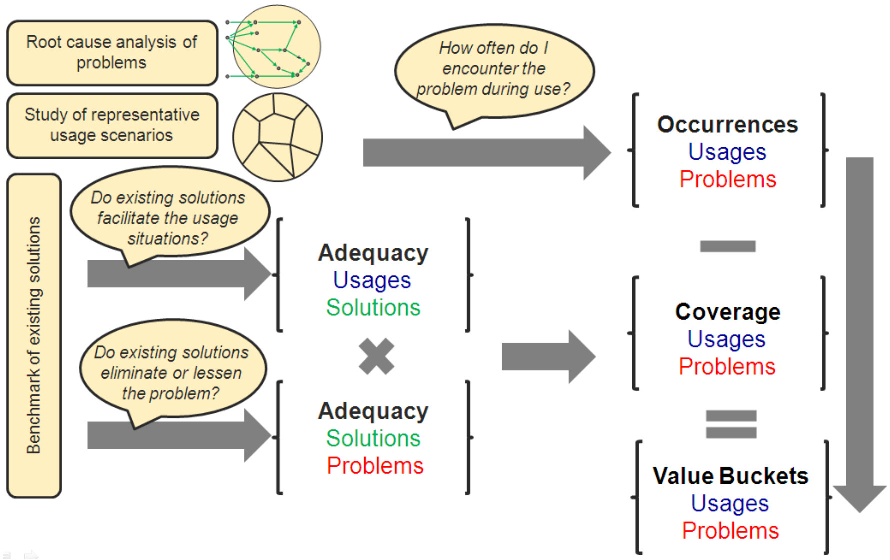


**Figure 5** The principle of the DSM Value Bucket tool for detecting and prioritizing value buckets worthwhile to further explore in creativity sessions. See also Figure 8 on the example of the handitennis wheelchair.

## 5 The problem setting stage for the handitennis wheelchair

The determination of value buckets has been partly automated by a matrix representation of dependencies between *problems*, *usage situations* and *existing solutions* and by handling of three matrices leading to the *DSM-Value-Bucket* tool. This approach and tool may be affiliated to *Dependency Structure Modelling* approaches [26].

In Figure 6, the causal graph is represented as causal paths leading to a *point loss* problem and it is further graphically covered by four existing solutions. Here, some modeling techniques of causal graph representations are borrowed from the system dynamics practice (see for instance [27]). For simplicity, we only retain 4 problems out of 16, namely: *time loss* (moving), *injury of the racquet hand*, *loss of ball power* and *extended tiredness* during the match.

In Figure 7, a graphical tessellation of typical usage situations during a match is represented. Proximity of two usage situations means a high probability of time precedence (or in other cases, proximity of user types). For simplicity, we only retain 4 usage scenarios out of 8, namely: *serve*, *shot while on the move*, *ball reception* and *starting to move* to hit ball.

Practically, a pre-screening of problems is undertaken and a first version of the causal graph of problems sketched. Next, the list of typical usage situations is established and, for each usage situation, an observation protocol is designed and followed to (a) get a deep understanding of the pains/problems possibly occurring in this usage situation, (b) measuring them (frequency, repeatability, importance, consequences) and (c) carrying out a *root cause analysis*. It goes far beyond the classical *personas method* storyboarding usage situations with weak rationale of situational representativity and no measurements of pain points. For instance, here, the serve situation was carefully studied: gestures were recorded and analyzed, ball speed was measured as well as service accuracy, ability to serve aces, and the double fault rate. In addition, it was observed that a back and forth translation as well as a rotational twist of the wheelchair occurred during the serve. This is obviously due to the translational freedom of the four wheels and the rotational freedom of the two caster wheels. An additional investigation in root causes led to experiment the advantages in blocking the four wheels during serve (+30% in ball speed) or of only blocking the rotation of caster wheels (+20% in ball speed).

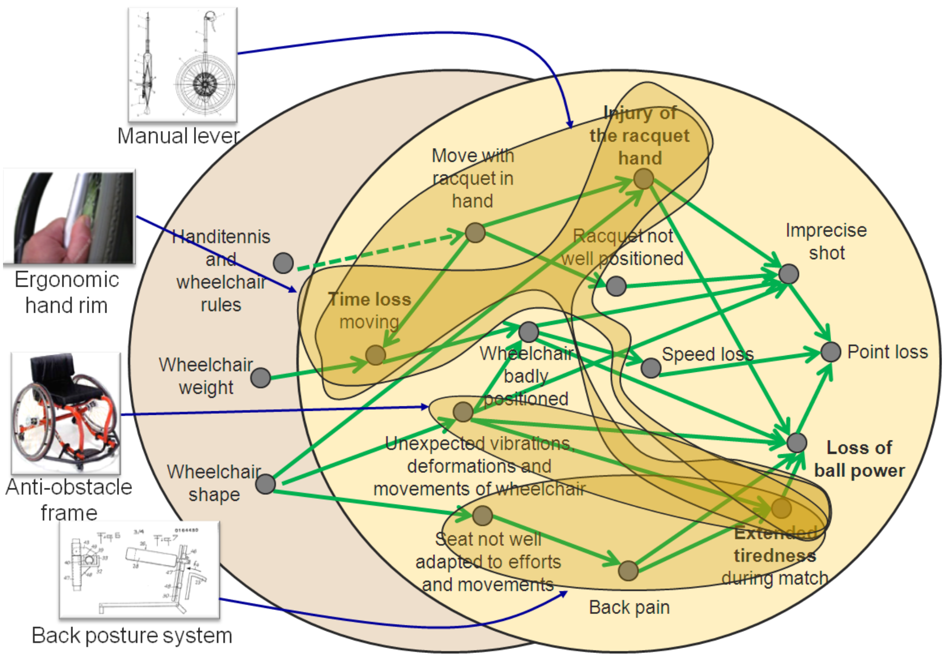


**Figure 6** The *covered causality graph* for the handitennis wheelchair issue (refer to Figure 4)

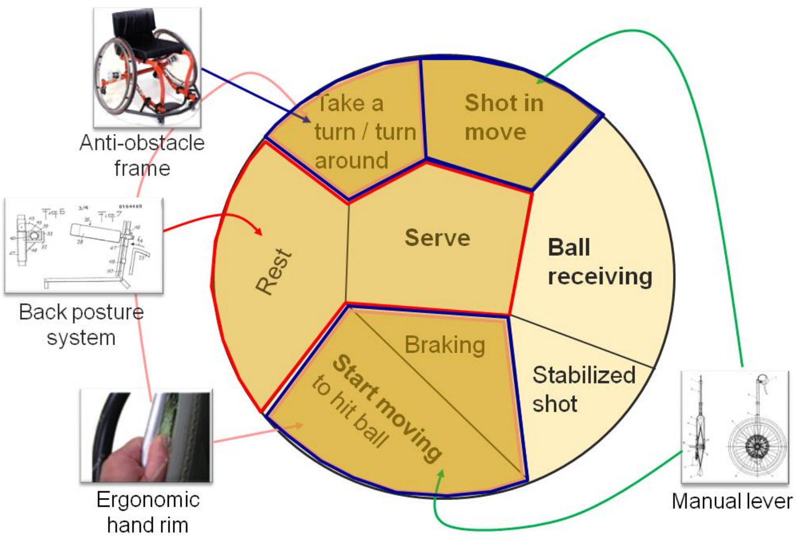


**Figure 7** The *covered usage scenarios space* for the handitennis wheelchair (refer to Figure 4)

## 6 The DSM Value Bucket algorithm

The determination of value buckets is automated by matrix representations of dependencies between problems, usage scenarios and existing solutions (see simplified Figure 5). Three matrices A, B and C are built along the problem setting stage of the RID process described in previous sections. The first matrix A (see Figure 8) expresses which problems occur during usage scenarios, the second (matrix B) how far existing solutions cover problems and the third (matrix C) to what degree existing solutions are useful in usage situations. Combining these three matrices results in a matrix E of value buckets: this indicates the combinations of important problems occurring during characteristic usage situations and for which few existing solutions are useful or efficient.

Matrix A is named the "Ideal performances matrix" and links problems (columns) and usage scenarios (rows) with an intensity scale from 0 to 5 for expressing how much (or often) a problem occurs in a usage scenario. The intensity scale runs from 0=null; 1=weak; 2=moderate; 3=average; 4=important; to 5=very important. For instance (see Figure 8, matrix A):

- The *racket hand injury* mainly occurs when the player *starts moving*, pushing with her hand to propel the wheelchair, grasping the racket and the hand rim at the same time.
- There is significant *power loss* during *serve* due to an uncontrolled twist of the wheelchair.

Matrix B is the "(solutions X problems) matrix" and expresses the relevance of an existing solution for a given problem with the same qualitative scale from *null* (0) to *very important* (5). For instance (see Figure 8, matrix B):

- The *ergonomic hand rim* is highly relevant for avoiding *racket hand injury*.
- The *ergonomic hand rim* also partly avoids *time loss*.
- Both the *back posture system* and the *manual lever* are good for relieving *generalized tiredness*.

Matrix C is the "(usages X solutions" matrix" and expresses the relevance of an existing solution in a given usage scenario with the same qualitative scale from *null* (0) to *very important* (5). For instance (see Figure 8, matrix C):

- The *manual lever* is very efficient during a *start moving* situation and moderately so during *shot in move*.
- The *back posture system* is efficient during the *serve* situation.

At this stage, an "Intrinsic Value Buckets matrix" D is computed as the subtraction between the "Ideal performances matrix" A expressing the importance of problems to solve in usage situations and the matrix multiplication C x B expressing the average relevance of existing solutions in (usage, problem) cases. Of course, this difference is normalized so that each number on both sides of the subtraction has a value between 0 and 1. Moreover, one introduces a "bucket filter" BF, a real number comprised between 0 and 1 (0.5 by default), to eliminate the least important (usage, problem) cases, following formula (1).

$$\mathrm{IVB_{ij}} = \mathrm{Max}\left(0, \frac{\mathrm{A_{ij}}}{\mathrm{Max_{kl}(A_{kl})}} - 2 \times BF \times \frac{\mathrm{CB_{ij}}}{\mathrm{Max_{kl}(CB_{kl})}}\right) \quad (1)$$

Finally, the *importance* of problems (relatively to the ideal need) and the *size* of usage scenarios are assessed, again using the 0 to 5 intensity scale (see Figure 8, *size* and *importance* introduced in the surroundings of matrix D). The rationale for weighting problem importance and usage size must be captured. The RID framework encourages keeping the traceability of exploration/exploitation and decision-making. For instance, the logic for justifying problem importance may be:

- Ball power loss and time loss moving should be significantly improved for the player.
- Tiredness and hand injury are second order issues for the player.

The rationale for justifying the size of usage scenarios may be the scenario frequency (comparing the number of times serving and shooting while in movement) and of its importance for winning a point (80% of serves in handitennis are winning points).
Assessment of relative importance of problems and size of usage is based on designers' assessments. In practice, for both weight vectors to come up with, the authors advise to use any kind of pairwise comparison method for transforming multiple pairwise comparison matrices filled by decision makers – designers and/or experts – into a unique weighting vector which is further projected into a 0-5 scale (see for instance [28, 29] or [30]).

A final “Normalized value buckets matrix” E is computed to augment intrinsic value buckets with importance of problems and size of usage scenarios, following formula (2).

$$NVB_{ij} = IVB_{ij} \times size_i \times importance_j \qquad (2)$$

The whole *DSM Value Bucket* process is summarized in Fig. 8. Table 1 shows the influence of the Bucket Filter for filtering more or less the value buckets while acting like heat maps. For instance, with a BF of 1.0, only two value buckets are highlighted whereas with a null BF, 12 value buckets are highlighted. The real values contained in the *Normalized value buckets matrix* have no practical meaning, no unit. This is a ratio scale, they may be relatively compared within a matrix of a given BF value.

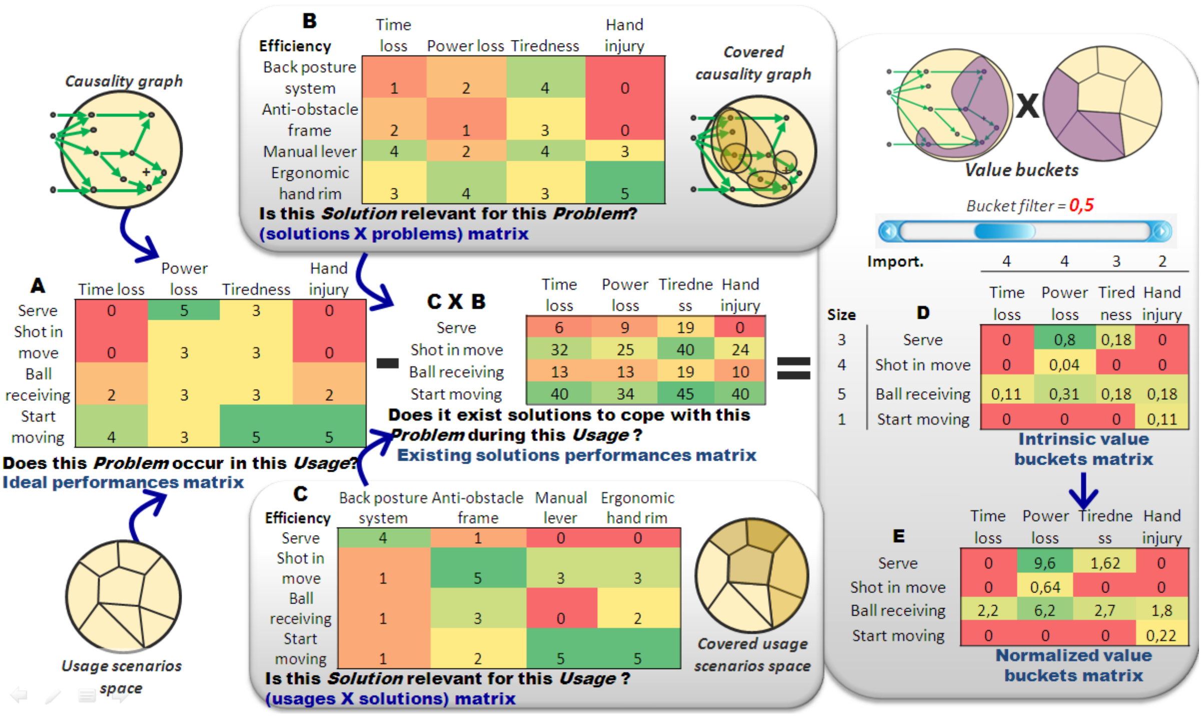


**Figure 8** The *DSM Value Bucket* data streaming and computation mechanics (refer also to simplified Figure 5)

**Table 1** Influence of the Bucket Filter on the *Normalized value buckets matrix*

BF = 0.0

| E | Time loss | Power loss | Tired ness | Hand injury |
|---|---|---|---|---|
| Serve | 0 | 12 | 5,4 | 0 |
| Shot in move | 0 | 9,6 | 7,2 | 0 |
| Ball receiving | 8 | 12 | 9 | 4 |
| Start moving | 3,2 | 2,4 | 3 | 2 |

BF = 0.25

| E | Time loss | Power loss | Tired ness | Hand injury |
|---|---|---|---|---|
| Serve | 0 | 10,8 | 3,51 | 0 |
| Shot in move | 0 | 5,12 | 1,92 | 0 |
| Ball receiving | 5,2 | 9,2 | 5,85 | 2,9 |
| Start moving | 1,44 | 0,88 | 1,5 | 1,12 |

BF = 0.5

| E | Time loss | Power loss | Tired ness | Hand injury |
|---|---|---|---|---|
| Serve | 0 | 9,6 | 1,62 | 0 |
| Shot in move | 0 | 0,64 | 0 | 0 |
| Ball receiving | 2,2 | 6,2 | 2,7 | 1,8 |
| Start moving | 0 | 0 | 0 | 0,22 |

BF = 0.75

| E | Time loss | Power loss | Tired ness | Hand injury |
|---|---|---|---|---|
| Serve | 0 | 8,4 | 0 | 0 |
| Shot in move | 0 | 0 | 0 | 0 |
| Ball receiving | 0 | 3,4 | 0 | 0,7 |
| Start moving | 0 | 0 | 0 | 0 |

BF = 1.0

| E | Time loss | Power loss | Tired ness | Hand injury |
|---|---|---|---|---|
| Serve | 0 | 7,2 | 0 | 0 |
| Shot in move | 0 | 0 | 0 | 0 |
| Ball receiving | 0 | 0,4 | 0 | 0 |
| Start moving | 0 | 0 | 0 | 0 |

Two important value buckets were revealed for the handitennis wheelchair project; their matrix coordinates are (1,2) and (3,2) (see Figure 8). The designer team was asked to verbally interpret them and they came up with these natural justifications:

- Value bucket #1 (1,2): The *loss of power* during *serve* is partly due to the (observed) wheelchair twist.
- Value bucket #2 (3,2): The champion player is late into position for *receiving the ball*, and consequently she returns the ball with *power loss*; this is due to her right hand grasping the tennis racket and at the same time moving the wheel.

## 7 The problem solving stage for the handitennis wheelchair

For brevity, these two revealed value buckets are chosen to compose the *ambition perimeter*. One major characteristic of Radical Innovation Design® is to have a two-stage ideation process (see Figure 9) and to straightforwardly initiate the *problem solving* stage with as many focused *scenario creativity* sessions as value buckets in the ambition perimeter. For each value bucket, a brainstorming is done, composed of a divergent and a convergent part. The selection of ideas in the convergent part and the monitoring of idea maturities are aided by the so-called *UNPC monitor tool* (see [25] for more details). A set of four metrics is used to dynamically investigate the probability of ideas having high impacts on Usefulness, Novelty, Profitability and Concept (UNPC) and increase likelihood for the idea to be transformed into an innovation success on the market. Then ideas are combined into consistent scenarios. For each consistent scenario, a brainstorming is performed, resulting in one or several consistent design concepts. The problem solving macro-stage of Radical Innovation Design® methodology can be summarized by the process shown in Figure 10 which includes the two creativity sessions, a process that is comparable to that of problem setting in Figure 4.

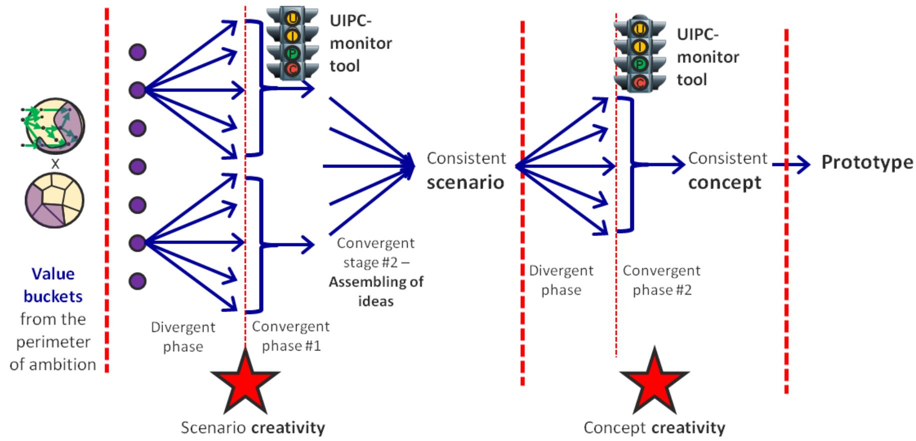


**Figure 9** The two-stage ideation process starting from the value buckets included in the perimeter of ambition

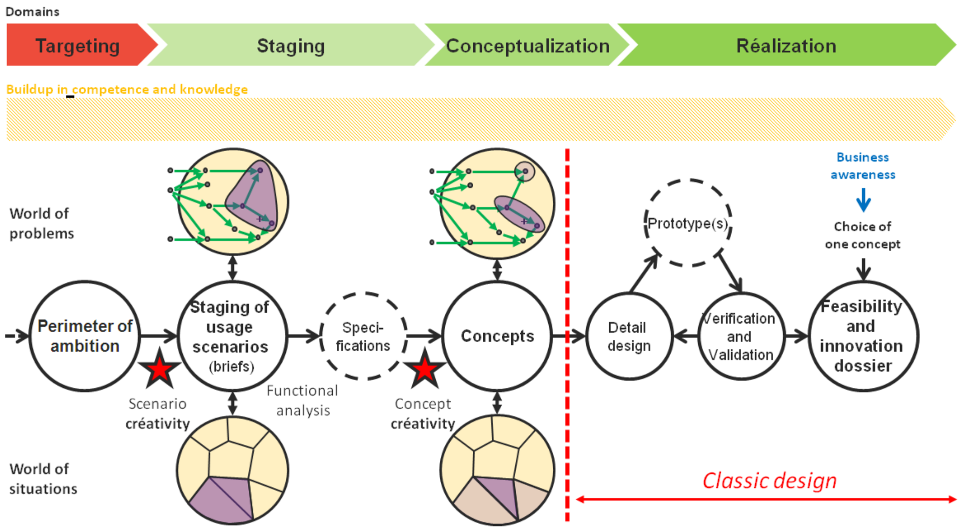


**Figure 10** The *problem solving* macro-stage of Radical Innovation Design® methodology

Applied to the handitennis wheelchair problem (see Figure 11):

- From value bucket #1 (1,2): 1 usage scenario has been finally selected leading in turn to one design concept.

From value bucket #2 (3,2): 2 usage scenarios have been finally selected leading in turn to two design concepts.

For Value Bucket #1, the preferred staging of usage scenario is that "*The champion positions herself behind the baseline and prepares to serve. She activates a system for blocking the rotation of the two caster wheels. The serve does not provoke any twist but automatically releases the blocking system, allowing her to push the hand rims propelling her on the court.*" Such a usage scenario must be at this stage a kind of fairy tale, staging the situation with relieved pains and augmented performances – the essential values. The concept creativity provided several architectural designs. The one depicted in Figure 11 has been designed with a CAD tool and is based on the following principles: "*The champion activates by a lever two yokes which slide and come in place on either side of the small front caster wheels. A pawl immobilizes the caster wheels during service. The serve generates a torque that deforms the yokes and releases them; they automatically slide up with a spring.*"

For Value Bucket #2:

- The first preferred usage scenario is based on the following story: "*Suddenly, the champion does not have the racket in hand anymore when it comes to seize the two hand rims of the chair. The racket disappears temporarily.*"
- The second preferred usage scenario is based on the following story: "*The champion is able at any time able to detach her right hand from the right hand rim and then to rest her hand holding the racket or positioning her racket for a shot while*

*allowing the left hand to control both wheels accelerations and decelerations.*" This usage scenario led to a design concept of a two-rim system for the left-hand wheel, the outer rim controlling the right wheel via an axis between wheels. After verification, it seems that solution has already been patented.

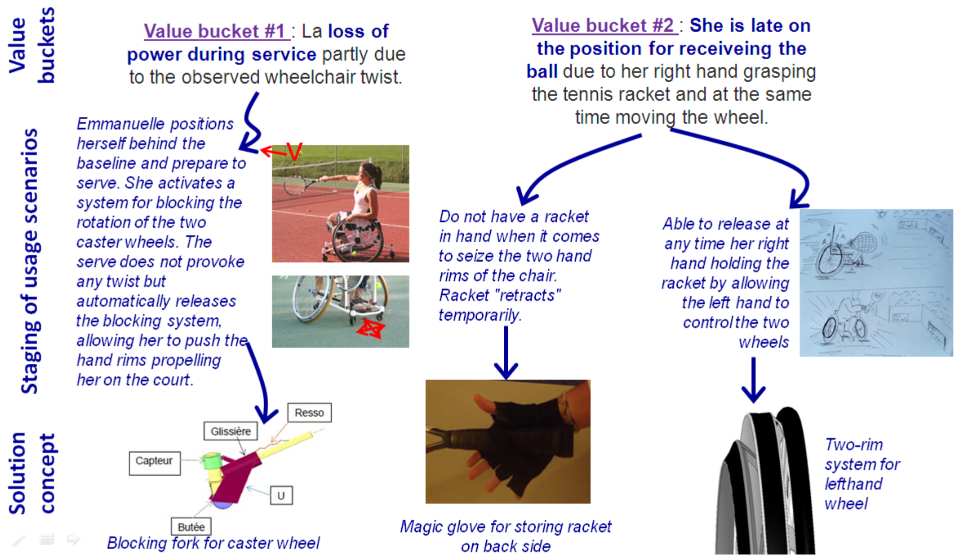


**Figure 11** Illustration of the two-stage ideation process (scenario creativity and concept creativity) starting from the two value buckets identified for the handitennis wheelchair

## 8 Conclusions

In this paper, we propose a method for structuring and automating the discovery of value buckets during the front end of need seeker innovations. The interest of need seeker innovations was first revealed by, amongst others, Christensen [8, 9] and Ulwick [11], but these ideas had not been implemented into a design engineering process.

RID methodology may be compared to well-known innovative design methodologies (see Table 2) like TRIZ, QFD or axiomatic design and design thinking. Compared to TRIZ, RID uses a causal graph to represent the problem structure, whereas comparable substance-fields representations in TRIZ are used for representing imperfect solutions. In the same manner, QFD and axiomatic design may be used to represent the propagation of the voice of the customer into the product components and design parameters, but little is done to characterize problem opportunities, especially in the light of what the other existing solutions use to efficiently perform or "cover". Finally, RID demonstrates that there are other methods than the design thinking prototype-and-learn experimental loop, RID proposing a more systematic and set-based thinking manner to investigate usage and pain driven innovations.

**Table 2** Comparison of RID methodology with known design methodologies

| | Jobs-to-be-done [8, 9] and design-outcomes segmentation [11] concepts | Design thinking | QFD | TRIZ | RID |
|---|---|---|---|---|---|
| Modeling of usage situations | Yes | More or less (persona method for instance) | Too coarse in the first QFD matrix | No | Yes |
| Modeling of pains or problems or contradictions | Yes | No systematic investigation in problem setting | No (needs instead) | Only on existing systems | Yes |
| Root cause analysis | No | Not systematic in problem setting | No | Only on existing systems | Yes |
| Detection of Value buckets for starting focused creativity | By hand | No | No | No | Yes |

The DSM Value Bucket tool was designed three years ago and has already been applied successfully to more than 20 innovation projects with 15 private companies, as well as the "handitennis wheelchair project" presented in this paper (the authors have no non-disclosure agreement). The DSM-VB modeling process and algorithm is a core component of the Radical Innovation Design® methodology. Future research will validate the relevance of the most rated resulting value buckets in the light of effectively launching the corresponding disruptive products.

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