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BUILDING VALUE PROPOSITION FOR SYSTEMS AND SERVICES BY ADAPTING AFFORDANCE-BASED DESIGN

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ABSTRACT

In early design stages, firms need to assess their value propositions. Although both business developers and systems engineers capture customers' needs to build the value proposition, they suffer from inefficient business and engineering processes interactions. Moreover, they lack methods to elicit the needs in a structured way and to explore the best value propositions.

We propose to adapt the affordance-based design for systems and services in order to formalize the elicitation and the capture stakeholders' values. Hence, affordances – which describe what system provides to other systems and stakeholders – help to frame the context. Today, affordance-based design is mainly used for artifact design. We transpose this approach to systems and services and complement it with a focus on stakeholders' activities and external systems' stages. We also propose an extended ontology to highlight the relationships between needs, affordances, system or service, and value proposition.

We then illustrate the method on an AIRBUS Defence & Space innovative project to build up the value proposition.

1 INTRODUCTION AND MOTIVATION

It may be very difficult to identify added values for the customers when defining the value proposition of a system or service. For example, the CNES (Centre national d'études spatiales) considered mostly the economic operator from the first level, like the satellite operator [1]. The CNES now wants to innovate in usages and investigates all possible sources of social utility in various domains such as health, transports, agriculture, etc. The problem formulation is then a key design activity [2]. Cross says designers should put effort, not on extensive problem definition and analysis, but rather on problem framing and on structured approaches to gather information.

To support this activity, we extend affordance-based design to systems and services as desired affordances describe the potential benefits for a stakeholder that arises from either the interaction of a system and a stakeholder or the interaction of two or more systems. Affordance modeling abstracts the problem and system benefits, whereas functional modeling abstracts the system.

Norman describes the affordance-based design as a user-centric approach, "in which the needs, wants, and limitations of end users of a product are given extensive attention at each stage of the design process" [3]. Our goal, in this paper, is to adapt the affordance-based design in an activity-centric approach in order to elicit stakeholders' values.

Section 2 overviews the main approaches in system design and the limits of function-based approach, as well as value proposition methods. Section 3 explains the design research methodology. Section 4 presents the method. Section 5 illustrates the method applied to a use case. Section 6 highlights the benefits of the proposed method, as well as the limits, and draws conclusion and future work.

2 PREVIOUS WORK

2.1 Value proposition

In his high-tech business marketing book, Moore (2002) provides a five-part template for a 'value proposition

statement': (1) Target users; (2) Unmet needs; (3) Proposed product; (4) Key benefits to users; (5) Differentiation from competition. It can be challenging to define all the elements that constitute the value proposition (VP) and to frame the problem the VP tackles.

Osterwalder and Pigneur [4] put the VP at the center of new business opportunities. For them, the VP describes the bundle of products and services that create value for a specific customer segment. It solves a customer problem or satisfies a customer need. In this sense, the VP is an aggregation of benefits that a company offers to customers. The authors propose to use the value map to first identify pains, gains and jobs of the customer to then map them to the VP. However, the method, based on post-it generation, does not help to trace these elements. The definition of the VP can be even more challenging when dealing with complex systems and services where many pains, gains and jobs co-exist and are interlinked.

2.2 System design

Many studies highlight the importance of problem formulation in engineering design [5]. Spending more time on problem scoping and information gathering results in better designs with expert designers, as reports Atman et al. in their in depth study of engineering design processes [6].

Functional representations are often used in the conceptual stages of design because they foster system engineers to focus on the intended use and purpose of a system rather than the physical solution. Function modeling expands the solution search space and guide concept generation [7]. However, the type of information modeled within function-based approaches is limited [8]. Stakeholders needs – which are statements from a target stakeholder and can be identified through interviews, focus groups, and analysis of existing artifacts – have a much broader scope [9].

Apart from function modeling, value analysis gathers a variety of value-focused analytical techniques to better understand how stakeholders exchange value. Value analysis focuses on the identification of the end-to-end value creation from the stakeholders' perspective. But it presupposes the problem is formulated, for example, via the specification of the customers.

One main source of design failure from getting adopted by the end users comes from the lack of knowledge about the users and their needs. Hence, the research domain of user-centered design [10] develops a wide range of methods to study users. But user-centered approaches are criticized for their static view of the stakeholders [11]. Norman states activity-based methods supports the capture of the users' behaviors through the underlying tasks and activities they perform, while user-centered design only emphases on the person.

2.3 Affordance-based design

The term affordance first arouse in perceptual psychology [12]. Gibson says "the affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill." It was created to describe what a system provides to another system. Norman [3] extends the term to artifact in his book the design of everyday thing. Maier and Fadel [13] introduce the concept of affordance to engineering design and define it as a relationship between two artifacts in which potential behaviors can occur that would not be possible with either system in isolation [14].

Affordances is playing an increasingly role in design. Maier and Fadel [15] use affordance to structure user needs once they are gathered and understood. To formalize the design problem, affordances, once identified, create an affordance basis [16]. While Galvao et al. [17] define a process to relate tasks, functions, and affordances: Step 1: understanding, gathering, and expressing user needs in terms of affordances. Step 2: apply generic affordance structure template. Step 3: prioritize affordances. Step 4: organize the affordances into a structure. In addition, affordances can be an evaluation tool to identify potential hazards and failure modes in design [18,19]. And Cormier [16] makes the link between the affordances an artifact provides to a user and its willingness to pay for it. But current research does not investigate the relationship between the value proposition and affordances.

Some authors started to extend the affordance-based design to other systems and services than artifacts. For e.g., Kim et al. use affordances to describe services, structures, and space. They analyze user activities to determine perceived affordances of a building lobby [20]. But literature does not provide examples of affordance-based design applied to more complex systems.

As affordance-based design arrived recently in design, it suffers from clear structure. Pols [21] investigates what an action is and proposes a categorization of affordances in 4 levels of granularity: opportunity for manipulation, opportunity for effect, opportunity for use and opportunity for activity. Bærentsen and Trettvik [22] combine affordances with activity theory. A goal may remain constant, while the ways to achieve it may differ according to circumstances. Bærentsen and Trettvik adapt the concept of affordance to all three levels of activity (activity, actions and operations), introducing hierarchical levels of affordance. El Amri et al. draws first encouraging conclusions on the usefulness of affordance-based design in marketing [23] for the categorization, evaluation and adoption of new hybrid products (NHP) by consumers.

3 RESEARCH DESIGN

Our study takes root within AIRBUS Defence & Space. The Figure 1 shows the main research design activities we did to develop and validate the work presented in this paper. The activities are detailed in Table 1.

Activity	*Description*
Interview internal stakeholders on early design stages issues and difficulties	Input: *Internal documentation of previous advanced projects, business and engineering in-house processes; Interview questions*. Activity: In 2014, we did a documentation analysis to capture state-of-practice within the firm. We then interviewed two business developers, 8 system engineers. We followed Eckert et al. design interview protocol. The interviews were recorded, transcribed and coded using MAXQDA 11.0, a Computer-assisted

Activity	*Description*
	qualitative data analysis software (CAQDAS), in order to insure rigorous data gathering and analysis. We identified their needs in early design stages. Output: *Issues mapped to in-house processes. Among them, need to improve stakeholders' needs elicitation and added-value elicitation.*
Review literature	Activity: We reviewed literature on value elicitation methods. Output: *State-of-the-art of value elicitation methods*
Apply method version 1 (affordance-based design for system/service definition)	Activity: We developed a first version of the method, adapted from Cormier's work [16], that we applied to a first use case on a new on-orbit sattelite service. The goal was to elicit added-values for target customers. We will not give project details due to condifential issues. Output: *The as-is/to-be stakeholder value network helped to consider indirect impacts of stakeholders on the customer value proposition. However, the elicitation of affordances was limited by only considering stakeholders and external systems.*
Apply method version 2 (activity theory)	Input: *Stakeholders; affordances.* Activity: We listed stakeholders' activities, with a focus on target customers. As the on-orbit service targets another company (Business-to-Business), we looked at the whole value chain of the target customers to identify direct and indirect values. Output: *We identified new affordances in terms of flexibility during customer's value positioning. These affordances then need to be validated by interviewing the customers. However, as our service implies interactions with other external systems, even in the conception stage, we needed to consider the systems' life cycle stages.*
Apply method version 3 (system life cycle)	Input: *Stakeholders, affordances, external systems* Activity: We took into account the stages of the external systems such as the satellite. We explored in what extend the on-orbit service could impact the external systems during their development, production or use stages. Output: *We identified new affordances taking into account co-creation design activities between the stakeholders.*
Apply method (1-day workshop)	Activity: We applied the method described in section 4 to another project, ELPIS. Results are in section 5. Output: *ELPIS value proposition*
Validate value proposition	Activity: We pitched our business model in font of the steering board for go/no-go. More details are in section 5. Output: *The steering board agreed to pursue further value proposition refinement.*

Table 1 Research design activities details

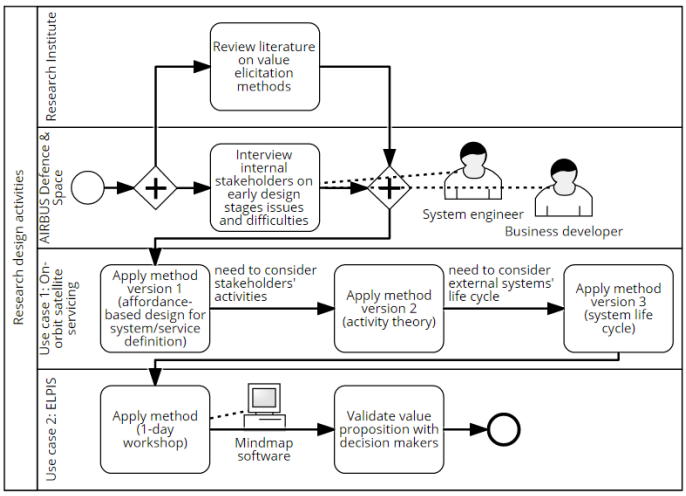

Figure 1 Research design activities

4 PROPOSED METHOD

The method we propose consists in identifying and characterizing the stakeholders, then identifying values in term of exchanges between the stakeholders. These exchanges are represented with stakeholder value network (SVN) we enrich semantically to depict the impacts of the VP regarding a referential situation.

Then, we deepen the elicitation of values by adapting the affordance-based design to systems and services which implies to investigate stakeholders' value streams, external systems and services, as well as their stages. We then represent hierarchically the elicited affordances of three types: system-stakeholder affordances (S-SH-A), system-system affordances (SSA) and system-environment affordances (SEA).

Finally, after prioritizing the affordances, we generate the value proposition of the system-of-interest (SoI) per stakeholder from the most valuable affordances. Figure 2 illustrates the iterative process.

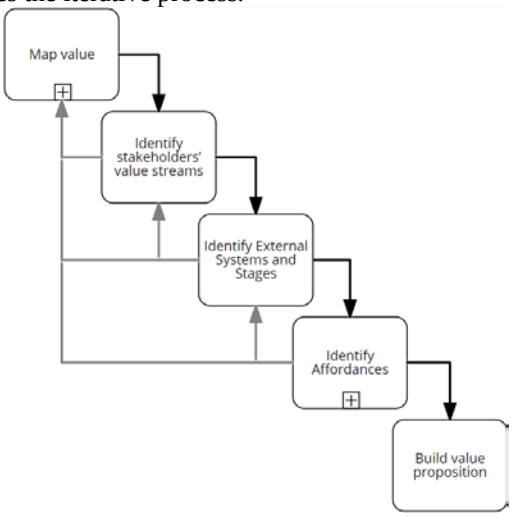

Figure 2 Building value Proposition for systems and services by adapting affordance-based design – method process

4.1 Map Value

Value maps depict the values exchanged between the stakeholders. The Business Architecture Book of Knowledge (BABOK) defines the value map as "a visual depiction of how an organization achieves value for a given stakeholder or stakeholders within the context of a given set of business activities" [24]. Several types of models exist such as the value chain [25], the value stream and the value network. We propose to start with the value network as the stakeholders' activities may not be identified.

4.1.1 Identify and Characterize Key Stakeholders

The Business Architecture Guild [24] defines a stakeholder as "an internal or external individual or organization with a vested interest in achieving value through a particular outcome".

Here we want to identify the key stakeholders, not only for the project, such as decision makers, but also the stakeholders of the customers. To do so, we ask the following questions:

- What stakeholders will benefit from the VP (customers, customers of customers, users, etc.)?
- With whom each already identified stakeholders interact?
- What stakeholders contribute to deliver the VP (partners, suppliers, etc.)?

For each identified stakeholder, characterize the stakeholders: what are their goals, constraints, preferences, pains and environment? The technique library lists over 150 techniques for problem solving [26], and among them ones to identify and characterize stakeholders.

The activity of identifying stakeholders is widely described in literature. But we take a broader scope of analysis. Many methods only consider the project's stakeholders, for e.g. with Feng et al. where their stakeholder value network reference project's stakeholders [27,28]. We go beyond by taking each stakeholder's viewpoint.

4.1.2 Map Value Flows between Stakeholders

We use stakeholder value network (SVN) [24,29] to identify, understand and analyze the values exchanges between the various stakeholders. The SVN only depicts the stakeholders and the value flows between them, not the associated activities. Value arises from the exchange between two stakeholders. A successful exchange takes place when the outputs of the stakeholder meet the needs of the beneficial stakeholder, and the outputs of the beneficial stakeholder meet the needs of the other stakeholder. This model enables to identify direct as well as indirect value flows. Allee gives an illustration [30].

Initiate the as-is SVN with the stakeholders identified in previous step. Identify what the stakeholders exchange in terms of policy, technology, knowledge, goods and services. Identify the stakeholders who contribute to deliver value. The VP will be built up upon this reference in order to describe the added values.

Then, model the to-be SVN. Identify the impact of the VP in terms of decreased, increased, new or destroyed value flows.

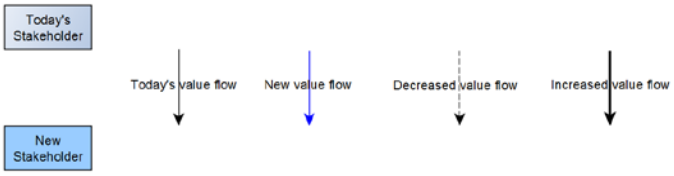

Figure 3 To-be stakeholder value network caption

These models give the helicopter view of the stakeholders' ecosystems. We model delta values by setting a reference and enriching the SVN to represent added and destroyed values. In his Business Model ontology, Osterwalder identifies the customer segments and the partners [31]. We go beyond and model the whole ecosystem of stakeholders.

4.2 Identify Stakeholders' Value Streams

Identify current stakeholders' activities that create and support value. What activity do the stakeholders realize to reach their goals? Gupta et al. [32] describe how to do a job and task analysis.

In the case of business-to-business, we suggest to use the value stream defined by Lanning and Michaels [33] which lists the activities required for a firm to choose the value, provide and communicate it.

To identify the activities of customers, or customers of customers, we propose to use the customer buying life cycle which includes: Awareness, evaluation, purchase, after sales.

In this step, we refine the understanding of stakeholders' goals, their realization, and the orchestration of exchanges among the stakeholders.

4.3 Identify External Systems and Stages

Identify external systems that are currently involved in stakeholders' activities and that might interact with the SoI.

Identify the stages of the external systems' life cycle. A system's life cycle consists of a series of stages. Moving from one stage to another may involve system's maturity decisions. The SEBOK makes the distinction between phases and stages [34]. The term stage refers to the different states of a system during its life cycle; some stages may overlap in time, such as the utilization stage and the support stage. The term phase refers to the different steps of the project that support and manage the life of the system; the phases usually do not overlap. We can use system life cycle models, like the Vee model. These models differ from how they group systems engineering activities.

By not only identifying the external systems but also their stages, we raise awareness on how systems' stages are interlinked.

4.4 Identify Affordances

Dourish draws the link between affordances and activities. For him "an affordance is a three-way relationship between the environment, the organism, and an activity". Pols et al. distinguishes four hierarchal levels of affordances, among them the "opportunity for activity" defined as social action [21]. Hence affordances can arise for the possibility for different activities. Moreover Vyas et al. insist on the importance to also

capture one-to-many relationship with affordances, not only one-to-one interaction [35], especially for systems in large context with many stakeholders. As Bærentsen et al. combine affordance-based design with activity theory applied to products in Human-Computer Interaction (HCI) [22], we propose to extend this approach to systems and services.

We adapt Cormier's definition of desired affordance [16]: an affordance is a relational benefit for a stakeholder provided by a system. By 'relation', we not only refer to the mere physical contact between objects, but to the broader meaning.

Hu et al. compare several attempts to categorize affordances in the fields of design, Human-Computer Interaction (HCI), Artificial Intelligence, psychology, and philosophy. We categorize the affordances based on their proposed taxonomy, except we do not make the distinction between happening-affordances and doing-affordances which specify the direction of the action [36]: system-stakeholder affordance (S-SH-A), system-system affordance (SSA) and system-environment affordance (SEA).

4.4.1 Identify System-Stakeholder Affordances

We adapt the definition of artifact-user affordances from Maier and Fadel [15] to define the system–stakeholder affordance (S-SH-A) as a relational benefit provided to the stakeholder that arises from the interaction of a system and a stakeholder. The template to define a SSA is: [SoI] *affords to* [Stakeholder], *during* [Stakeholder's activity], *the ability to* [affordance].

Example: [ELPIS] *affords* to [AIRBUS Defence & Space], *during* [sales promotion], *the ability to* [channel AIRBUS geo intelligence portfolio].

Look at stakeholders' activities and how the SoI will impact them. Identify what affordances afford the stakeholder to do its activities.

In our approach, we structure S-SH-As hierarchically which helps to refine the elicitation of affordances and embed them in the context of the stakeholders. Redström asks: "what would happen if we used our knowledge about current practices not to answer certain questions by our design, but to avoid answering them?" [37]. The author highlights the difference between stating 'this chair is for sitting' and 'this chair affords sitting (to a user)'. While the first statement imposes the function the objects, whereas the second suggests one possible use among the various possibilities [38]. Like Redström, we advocate for the benefits of considering activities and users in the design process, because it opens up the design space.

4.4.2 Identify System-System Affordances

We define system-system affordance (SSA) as a relational benefit provided to the stakeholder which results from the interaction of two or more artifacts systems. The template to define a SSA is: [SoI] *affords to* [Stakeholder], *during* [Stakeholder's activity] *activity, the ability to* [Affordance] [external system], *in* [external system's stage] *stage*.

Example: [ELPIS] *affords to* [sponsors] *during* [resource allocation], *the ability to* [share across sponsors cost of] [Geo data], *in* [geo data purchase] *stage*.

By considering all the stages of the external systems, and not only their utilization stage, we can explore the possible impacts of the SoI in their whole lifecycle. For example, the SoI can impact the development time of an external system. We can then take into account possible co-creation activities. Frow et al., in their co-creation design framework [39], identify 11 categories of co-creation forms, such as co-conception of ideas, co-design, co-production, co-pricing, co-experience, etc. The SoI can impact such co-creation interactions among stakeholders. Prahalad and Ramaswamy exhibit the variety of co-creation through heterogeneous interactions [40]. By scanning value streams of the stakeholders, we allow to identify these interactions. Grönroos et al. analyze the co-creation of value for services [41]. They state "co-creation is a function of interaction". Customers and suppliers interact directly or indirectly. With our method, we are able to capture such direct and indirect impacts by widening the horizon of possible interactions, from operating activities to value streams, in order to elicit value-in-use opportunities.

4.4.3 Identify System-Environment Affordances

Artifact-Environment Affordance (AEA) represents the interactions between artifacts and environmental entities that are neither stakeholders nor systems/services such as "substance, medium, and natural objects" [36].

These affordances help to consider constraints related to the environment like weather conditions.

4.4.4 Represent Affordances

We built up a concept map, on Figure 4, to represent the affordances.. Davies [42] makes the distinction between mind map and concept map. Mind mapping or "idea mapping" is defined by Biktimirov et al. [43] as "visual, non-linear representations of ideas and their relationships": the main purpose is to make associations between ideas. Whereas concept map is more formal and can be used to depict relations between concepts.

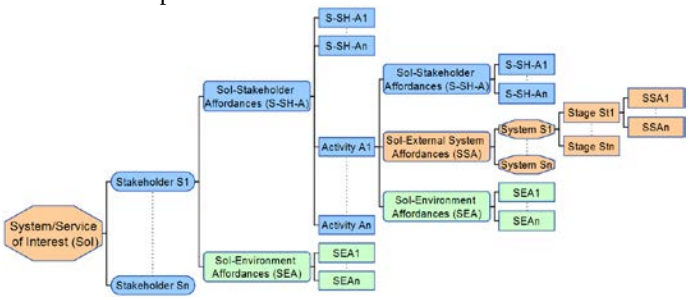

Figure 4 Affordance representation concept map

Representing affordances in a structured way helps to focus on affordance discovery. We advocate structured approaches to gather information help to frame the problem [2].

4.4.5 Prioritize Affordances

Identify affordances with highest positive impact for each stakeholder. The Kano model can be used to classify and prioritize customers' affordances based on their satisfaction. Four categories are defined: (1) *Must-be* affordances, if they are

absent, the stakeholder is extremely unsatisfied. (2) *One-dimensional* affordances provide linear incremental satisfaction, i.e. the more, the better. (3) *Attractive* affordances are not expected by the customers but can bring great satisfaction. And (4) *indifferent* affordances do not interest the stakeholders. Customer surveys can be used to capture their preferences.

4.5 Build value proposition

Hassenzahl makes the link between needs, goals and affordances [44]. We take up a part of its framework and merges it with Osterwalder's ontology. Figure 4 draws our proposal to link the value proposition to the desired affordances and the SoI.

We define the value proposition as a *set of* [offerings] *describing part of* [products and services] which *afford* [desired affordances] *to* [target customer] who *has* [needs].

Write a VP for each stakeholder from the selected affordances.

More and more affordance-based design is considered as a good approach to capture users' needs. For example Bardenhagen et al. [45] describe affordances in Human Center Interaction (HCI) as "the functional potential of environmental features that carry meanings and values in how they support human usage". In this work, we extend the notion of affordances to more complex interactions, by incorporating activity theory, to contextualize the interactions between the stakeholders and the environment.

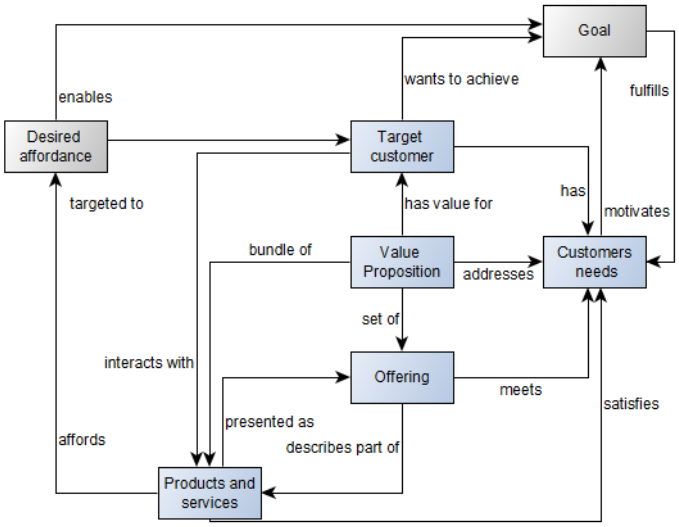

Figure 5 Relationships between value proposition, affordances and SoI

We did not treat the VP differentiation from competing offers.

5 CASE STUDY (EXPERIMENTATION)

The case study inherits from the D-BOX project (Demining tool-BOX for humanitarian clearing of large scale area from anti-personal landmines and cluster munitions), sponsored by the European Commission under the FP7 programme. The project aims to support demining stakeholders – such as on-field operators, mine action centers, international organizations like the Geneva International Centre for Humanitarian Demining (GICHD) – in the detection of anti-personal landmines and cluster munitions remaining from armed conflicts. This "smart" toolbox, illustrated in Figure 9**Erreur ! Source du renvoi introuvable.**, integrates various demining solutions to help operators and end users to prepare and execute demining activities, from priority setting to land field clearing [46–49].

Based on B-BOX project lessons learnt, three of the authors of this paper submitted a project proposal, called ELPIS – the Greek name of the goddess of hope – through the Airbus Space Systems internal 'Innovation Pipeline'. This process, where employees are invited to submit their ideas, aims to collect technological proposals for feasibility studies and proof of concepts. The team was composed of the D-BOX project manager, the AIRBUS United Nations customer relationship manager, and the system engineer who developed the proposed method.

ELPIS targets non-profit organizations as main customers. In such case, the system or service recipient is not the payer. The financer risks to become the main customer while the recipient becomes a mere receiver. To overcome this issue, D-BOX applied a user-centered approach: All the stakeholders were involved in the definition of the system specification.

During the Innovation Pipeline 4-month programme, we attended to three training sessions on business model generation, based on Osterwalder's method and design thinking [4,31]. We then did the market research, and generated a first version of the Business Model. The VP was: "ELPIS is a platform which brings access to valuable information for humanitarian missions, like demining land fields, developing agriculture, rescuing people after main disasters. Our platform could be used by international organizations working in post conflict countries and un-developed countries like the UN which need information from the operations fields to manage humanitarian missions and to assign funds." This first VP was deemed unclear and unprecise by the Innovation Pipeline coaches.

After, we did a 1-day workshop to apply the proposed method.

5.1 Map

5.1.1 Identify and Characterize Key

Humanitarian action involves a wide ecosystem of actors. Starting from demining stakeholders, in 2 hours, we defined four generic stakeholders, applicable for all humanitarian sectors, see **Erreur ! Source du renvoi introuvable.**. We also got inspired by humanitarian stakeholders' networks [50,51]. We grouped types of stakeholders to simplify the ecosystem of stakeholders ant make it more understandable. Then we described their goals:

- The *local population* (user) can face emergency situations and need to raise rapidly the alert. According to the United Nations Development Programme (UNDP) – which supports global sustainable development of countries –

insists on the major role of early warning to reduce disaster risk, which means involving the population at risk [52].

- The *national authorities* (user) refer to the national institutions like governments which are in charge of the country socio-economic development.
- The *sponsors* group (customer/user) various types of financing like international organizations (UN, EC, etc.), donors, NGOs.
- The *national authorities* (user) group entities such as national governments, etc.
- The *field operators* (user) refer to the operators who will prepare and execute the intervention on the field.

5.1.2 Map Value Flows between

We modeled the as-is SVN, based on the return of experience of the D-BOX project. We represented the sequential value flows between the stakeholders to better understand the dynamics of flows. To better understand the sequence of flows, we numbered them, see Figure 6**Erreur ! Source du renvoi introuvable.**. To ease the comparison between as-is and to-be situations, we used stakeholder value networks we deemed more readable, instead of sequence diagrams. Although dedicated value network tools exist such as e3value® which supports an ontology to model networked value constellations [53], we preferred to model the as-is situation with the graphical tool yED Graph Editor® for its ease-of-use [54].

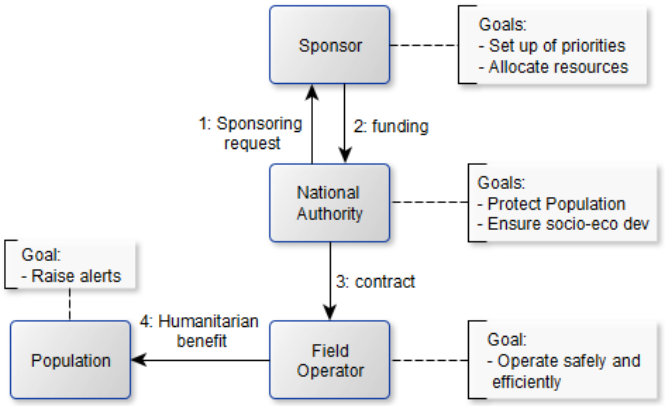

Figure 6 ELPIS As-is stakeholder value network

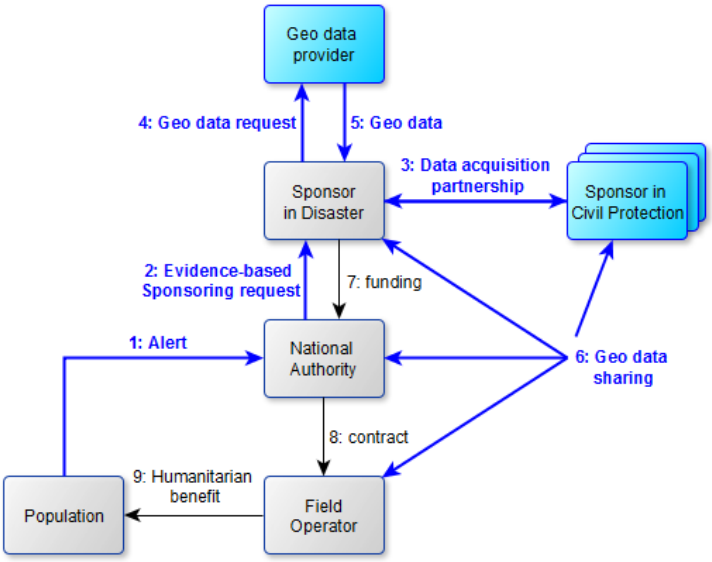

Figure 7 ELPIS To-be stakeholder value network

The to-be SVN, in **Erreur ! Source du renvoi introuvable.**, results from several iterations between the stakeholder value mapping and the affordances identification. The links in blue indicate the added-value delivered by ELPIS. See Figure 3 for figure's caption. New stakeholders are involved: the geo data providers and sponsors from other sectors.

- *AIRBUS Defence & Space* (supplier) delivers space assets for humanitarian actions.

The *Geo data provider* (supplier). We did not consider this stakeholder due to a lack of time. We only focused on the users, the customers, and AIRBUS Defence & Space.

These models were presented to the steering board. At a glance, they were able to understand ELPIS' expected impacts in the stakeholders' ecosystem.

We enrich SVN semantically to both model as-is and to-be situations to understand referential situation, picture VP impacts, and keep everyone on the same page.

5.2 Identify Stakeholders' Value

For each stakeholder, we identified their main activities through document analysis, interviews and return of experience. The sponsors mainly need to set priorities and allocate resources [55]. The field operators prepare, execute and report about their intervention. The national authorities are in charge of the protection of the population and the coordination of humanitarian actions.

In order to find internal investors within AIRBUS DS, we used the Lanning and Michaels' value stream to identify how the SoI could bring value to the company.

5.3 Identify External Systems and Stages

We identified different means the field operators and the sponsors could use to get geospatial data. For e.g., ground and airborne sensors, satellite imageries. We explored space assets for humanitarian actions [56,57]. We built a portfolio of

valuable AIRBUS geo intelligence products and services for humanitarian activities.

To take into account systems' life cycle stages, we used the Customer Buying Cycle. We ask ourselves: Are the stakeholders aware of the valuable geospatial data? Are they able to compare the offers? What are their barriers to purchase such products? Are they satisfied after sales?

As we expect to change stakeholders' acquisition and use of geospatial data, we need to understand current processes to do so. By considering stages, we are able to think of the whole customer buying cycle, not only the use stage. We broaden our thought on external systems' impact.

5.4 Identify Affordances

We identified the affordances during a 3-hour brainstorming session. We used the tool Mindjet MindManager® 15 which offers advanced search functionalities, a user-friendly interface and good import-export options. We wrote down all ideas and hypotheses in tree structure, notes or floating topics form. See Figure 11. We categorized the affordances afterwards, as well as making the distinction between activities and system-stakeholder affordances. We identified more than 20 affordances based on D-BOX return of experience. Indeed, the software D-BOX offers plenty of functionalities to operators, sponsors and national authorities.

5.4.1 Identify System-Stakeholder Affordances

We identified 16 system-stakeholder affordances. We listed the opportunities for activities and use, as Pols et al. call it [21]. Taking into account the level of granularity of the affordances helped us to better frame the problem.

5.4.2 Identify System-System Affordances

We identified 9 system-system affordances. By taking into account stages, we described in more details ELPIS differentiation in terms of geo data acquisition and use.

5.4.3 Identify System-Environment Affordances

We did not discover system-environment affordances. We focused our analysis on the two previous types of affordances.

5.4.4 Represent

The affordance models per stakeholder are represented in Figure 8, Figure 11, Figure 12, Figure 13 and Figure 14. By structuring the affordances, we understood how ELPIS will impact current stakeholders' activities and external systems/services.

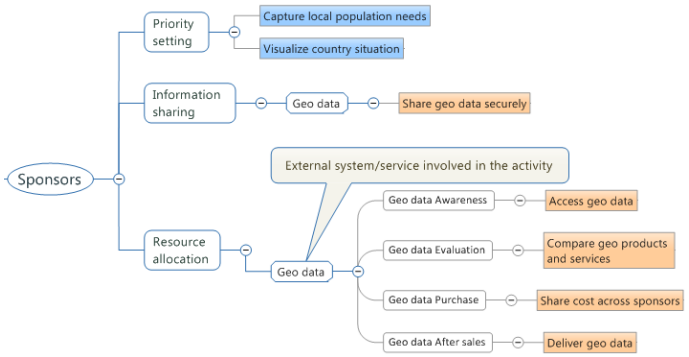

Figure 8 Desired affordances for Sponsors

5.4.5 Prioritize Affordances

We prioritized the affordances based on our market research and D-BOX return of experience which confirmed the increasing interest of humanitarian actors to collaborate across sectors. The Conference Board of Canada® insists on the need "to support effective cross-sector partnerships" [58], while the European Commission recognizes the need to "strengthen the link between info production and collective decision-making" [59]. Regarding competition, many geo data solutions exist for humanitarian actions, but we did not find solutions to create synergies across sectors. Hence, we identified the main value for sponsors as the ability to share geospatial data costs across sectors. This affordance, on AIRBUS Defence & Space viewpoint, represents the primary source of revenues.

Thanks to the affordance representation structure, we discovered, among the large amount of affordances, the one that distinguishes us form competition and bring most value to customers.

5.5 Build value proposition

We generated the value proposition per stakeholder (end users and customers) based on affordances prioritization.

We framed the problem as follows: All humanitarian actors need access to geospatial data. But high-technology products, such as high definition images or UAVs, remain costly. ELPIS will create an affordable global network to access and share geospatial data. The benefits per stakeholders are presented in Table 2.

Beneficiary	Benefits
Population	➢ Alert on emergency (1)
National authorities (Gvts, …)	➢ Capture local needs ➢ Coordinate national actions (horizontal network) ➢ Request funding based on evidence (2)
Sponsors (UN, World Bank, NGO, Donors, …)	➢ Set priorities based on local population needs ➢ Share geospatial data costs across sectors (3) ➢ Access and integrate geospatial data (4 & 5) ➢ Share information (horizontal and vertical network) (6)
Field Operators	➢ Delimit area of intervention

AIRBUS	➢ Support worldwide humanitarian actions ➢ Support AIRBUS corporate social responsibility ➢ Develop new business in humanitarian markets ➢ Channel AIRBUS Geo Intelligence portfolio

Table 2 ELPIS value propositions per stakeholders

We also produced a two-minute video, with the support of a communication supplier, to illustrate the main benefits for each stakeholder. The video shows how the stakeholders could use ELPIS. We used the value proposition to write the storyline. See annex for video voice-over.

Then we presented our project to the steering board who validated the interest of the VP and actions were taken to refine it. The organizers of the Innovation pipeline composed of innovation managers and business professors, who followed us during this 4-month program, valued the great progress made to clarify the VP.

6 CONCLUSION AND FUTURE WORK

In this work we advocate for an affordance-based approach to elicit stakeholders' needs and values to then build up the VP. We extend affordance-based design to system and services which implies to broaden the definition of interactions, and take into account hierarchical granularities.

We draw the relationship between affordance-based design and VP which we express for each stakeholder in terms of most valuable affordances.

Our method helps to think of SoI's usages during stakeholders' value streams. During the iterative process of VP building, we explicitly list the assumptions taken in the elicitation of affordances and their prioritization.

Another benefit is that, as the problem and solution co-evolve in design, the designer keeps track of problem scoping, hypotheses and gathered information. Our method allows to frame and reframe the problem, by changing boundaries setting, for e.g. if affordances priorities evolve or technical issues arise. The method supports business model design which is an iterative activity where business developers, hand in hand with designers, explore in parallel the problem and the solution spaces.

Our approach also helps to identify possible divergent stakeholders' expectations and increase stakeholders' system's adoption. As affordances allow to capture stakeholders' view, this approach is useful to combine several customer segments and investigate several VPs.

We also take into account co-creation design in the possible interaction among the stakeholders by carrying out the temporal dimension of value creation. We extend the elicitation of values through the whole value steam of the stakeholders. With complex systems, value cannot be defined only around the customer segment. Many stakeholders are involved and can benefit from the value proposition. Focusing only on the direct customer can be too simplistic. Value depends on the stakeholder and varies over time. Thinking of the overall lifecycle value broadens the scope of the value elicitation, and extends possible utility of the SoI not only to the operating stage. Hence our approach helps to identify new modes of value creation, through stakeholders' collaboration. This approach is particularly suited to build Business Models for NGOs which look for economic and social values. Our approach helps to identify value creation through collaborative business models.

We also extend the lexicon of affordances by adding –ilities. De Weck et al. define -ilities as "the properties of a system that are not necessarily part of the fundamental set of functions or constraints" [28]. Affordance-based design is well suited to identify the possible impacts of flexibility, adaptability or versatility of a system.

We identified the following tracks for future work:

- Manage alternatives: early design stages implies the ability to explore many options in terms of problem scope and solutions. This activity needs to be computer-aided to store alternatives, visualize viewpoints, track changes, and ensure consistency between models.
- Prioritize affordances: What are the adapted preference elicitation methods to prioritize the affordances?
- Evaluate the quality of affordances: Identifying the existence of an affordance is not enough to quantify the value proposition. For e.g., a sofa and a stool both afford seat-ability but not with the same comfort.
- Compare value proposition to competing offers: a part of the VP is to differentiate the offer from competition. How to compare systems and services that do not afford the same affordances?

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ANNEX A

ELPIS RESULTS

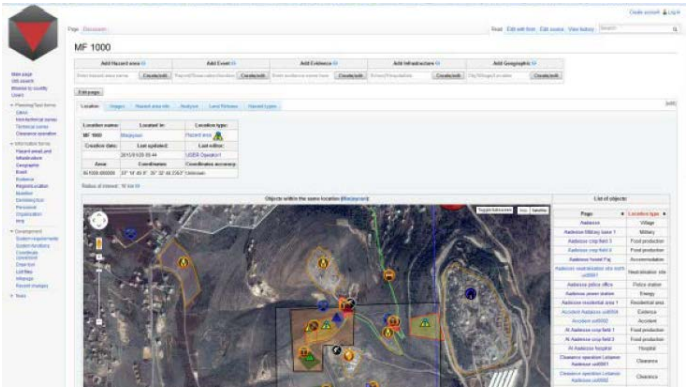

Figure 9 D-BOX software interface, from [49]

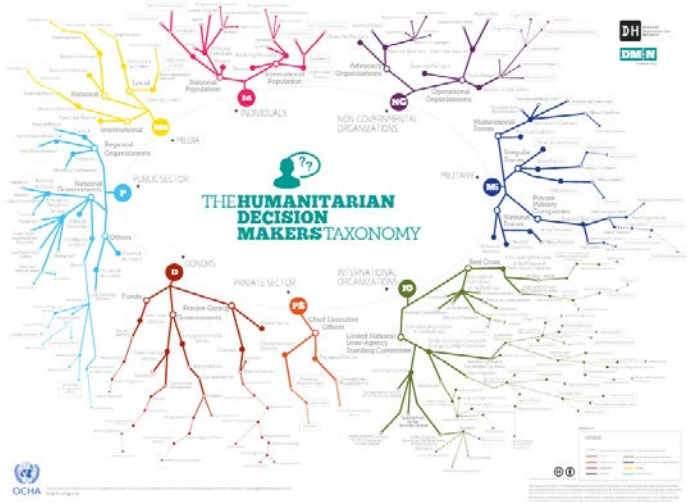

Figure 10 The Humanitarian Decision Makers Taxonomy from [50]

Figure 11 Desired affordances for Population

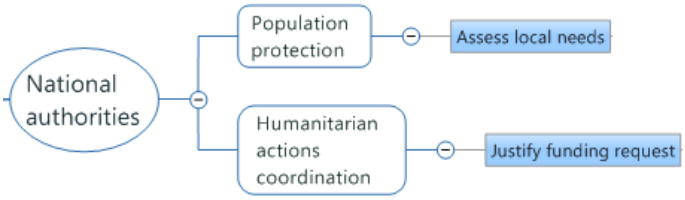

Figure 12 Desired affordances for National Authorities

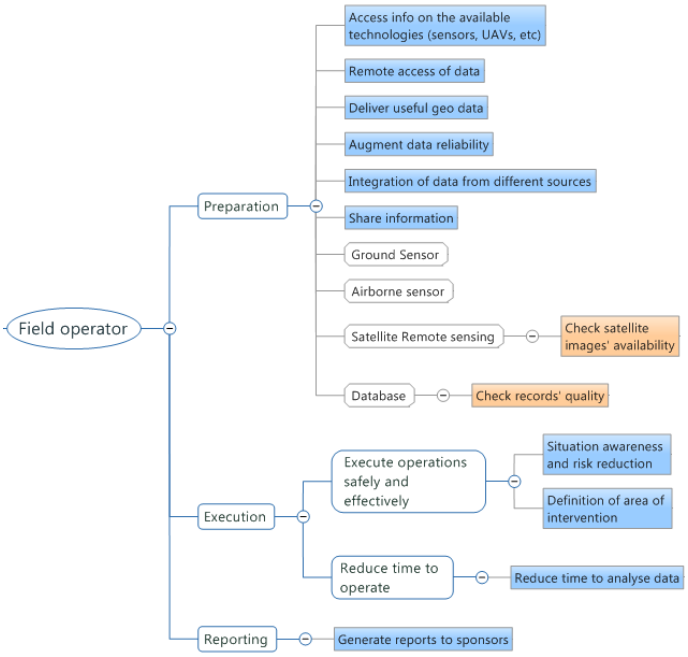

Figure 13 Desired affordances for the operator

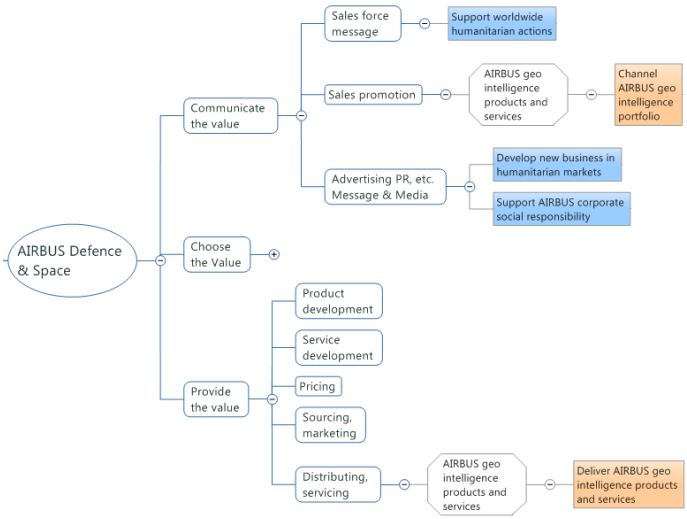

Figure 14 Desired affordances for AIRBUS

Video voice-over:

"ELPIS connects the population, the national authorities, the sponsors and the field operators. Let's see how.

People are in danger. They need help. They alert the authorities right away with the ELPIS user terminal.

The authority captures local alerts from the whole country thanks to ELPIS. ELPIS helps the authority merges alerts with geo information. The authority delimits the area of intervention. The authority sends requests to international organizations to

rapidly receive resources and help people in the area of intervention.

The sponsors receives requests from all over the world. They assess the risks and damage to set up priorities and allocate resources. Geo Intelligence is crucial to manage crisis, and reduce risks. But high-tech products remain very costly. ELPIS enables sponsors to share the cost of geo data. Here the TerraSAR-X damage assessment map is very valuable in supporting rescue operations.

ELPIS creates an affordable global network to access and share geospatial data. ELPIS. Help each other for peace."

Figure 15 shows the possible use of alerts merging by the authorities to request funding based on evidence.

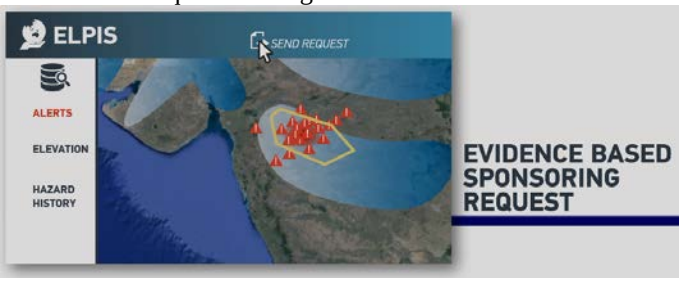

Figure 15 ELPIS video screenshot - Evidence based sponsoring request