IMPLEMENTING OPEN INNOVATION: CONCEPTUAL DESIGN OF AN INTEGRATED ICT PLATFORM

STRUCTURED ABSTRACT

Purpose: The objective of this paper is to develop the conceptual design of an ICT platform supporting the inbound Open Innovation process within the Technological Developments business unit of Leonardo Defence Systems.

Methodology: After a preliminary phase concerning the context analysis, methodology includes three main steps: (i) conceptualization of functions; (ii) preliminary design; (iii) conceptual design of the System/SW architecture. In each of these phases, we tried to merge evidence from the scientific literature with empirical insight emerging from the field.

Findings: Results report the conceptual design proposal for an process integrated ICT platform supporting the OI. It includes the conceptualization of main functions, the preliminary design deriving from use cases and the proposal for the overall system architecture and data model.

Research limitations: The research focuses only on the conceptual design phase, at this stage the platform has not been still implemented or tested. Also, generalizability concerns may arise from the single-application context.

Practical implications: The out coming conceptual design can be useful for firms that open their boundaries to external partners, as well as for software developers which could draw on it. Firms approaching similar OI challenges can re-contextualize the platforms to their own setting.

Originality: Originality of this research relies on the attempt to show how ICT can support firms in their OI processes and, secondly, to support firms aiming to create a positive environment that encourages people at leveraging existing external technological opportunities and sources of knowledge. In so doing, a systematic design approach to the definition of the conceptual proposal is also pursued.

Keywords: ICT platform; inbound Open Innovation; Conceptual design.

1. INTRODUCTION

Over time, Open Innovation (OI) strategy was considered a “must” for many firms in different industries. Therefore, research on Open Innovation has gained incredible momentum and the scientific literature has begun to analyse OI from different perspectives, encompassing multiple and heterogeneous viewpoints, representations, theories, contexts, levels of analysis, and even research methodologies. One of the most promising perspectives proposed in the extant literature interprets OI as a macro-process (West and Bogers, 2013; Slowiski and Sagal, 2010), where three key processes (sometimes also labelled as modes) can be differentiated (Enkel et al., 2009; Gassmann and Enkel, 2004): the outside-in process, also referred to as 'inbound' process, which consists of accessing the technical and scientific knowledge and competence from external sources in order to integrate them internally; the inside-out process, also referred to as 'outbound' process, which involves looking for partners with a business model better suited to commercialize a technology (Chiaroni et al., 2009); and the coupled process, that consists of a balance of the two previous processes.

While focusing specifically on the inbound OI process, the literature has put in evidence that implementing OI implies the definition of a set of variables: the "who", the "when" and the "how" issues (Aloini et al., forthcoming). The "who" issue regards the selection of partners with whom the collaboration should take place (Laursen and Salter, 2006); the "when" issue concerns the phase(s) of the innovation funnel which should be opened to the external partners (Lazzarotti and Manzini, 2009), while the "how" issue regards matters connected with the implementation of open processes, in that organizations need tools and mechanisms that allow them to fully exploit OI opportunities (Slowinski and Sagal, 2010; Chiaroni et al., 2009). As regards the "how", little attention has still been devoted to the set of tools firms can use to support the implementation of the OI inbound process and, hence, to how firms can create a positive environment that encourages people at leveraging existing technological capabilities outside the boundaries of the organization (Hung and Chou, 2013) or at capturing and benefiting from external sources of knowledge to enhance current technological developments (Huizing, 2011). Within the "how" issue, ICT has much to contribute because of the pivotal role of digital technologies in enabling OI initiatives. ICT, in fact, can foster activities, such as for instance communication among different actors, cooperation, and knowledge sharing and creation.

Preliminary studies regarding ICTs in OI were directed on different subjects: the free Open Source software (von Hippel and von Krogh, 2003); crowdsourcing platforms that gather ideas for new products and services from a large and dispersed "crowd" (Di Gangi and Wasko, 2009; Leimeister, 2009; Majchrzak and Malhotra, 2016) both in the form of one-time contest/multistage tournament or ongoing challenges (Bayus, 2013); web-enabled innovation brokers (Whelan et al., 2012); ICT contribution to absorptive capacity (Chatterjee et al., 2002; Chircu and Kauffman, 2000), as well as new technologies for data mining, simulation, prototyping and visual representation supporting OI in NPD (Dogson et al., 2006). A consistent part of the literature regarding ICT in the OI focused on the transfer of the customers' preferences and knowledge to producers. For instance, Bartl et al. (2012) discusses virtual customer integration methods for transferring customers' preferences and knowledge to producers throughout all the phases of the new product development (NPD) process; Bretschneider and Zogaj (2016) analyse strategies for capturing and leveraging customer's tacit knowledge in customer integration methods, such as Ideas Competitions and Lead-User-Workshops. Gassmann et al. (2010) puts forward examples on how ICT tools can, on the one hand, enable customers to create or configure their own products by means of toolkits or, on the other, enable companies to integrate external problem solvers or idea creators via websites, such as ‘The Sims’ with which an online community of gamers develops add-on packages, or Swarosvski, whose customers can create their own figures. The literature also studied the support given by the ICT tools to online communities (sometimes known as e-communities or virtual communities), i.e. communities of people with a common interest but not necessarily a common geographic location (Koh and Kim, 2004), as drivers of innovation. In their most straightforward manifestation, indeed, online communities build on websites that allow their members to collaborate using Internet tools such as discussion forums, blogs and real-time chat. Internet connectivity coupled with the development of new information standards have enabled an open and almost cost-free exchange of information between users/actors in any market. In one of these manifestations, information networks allow many users to systematically share ideas and create distributed learning systems (Michaelides and Kehoe, 2007) thus possibly contributing to the innovation process.

According to many scholars (Jeppesen and Lakhani, 2010; Mahr and Lievens, 2012), the most viable approach for gaining and integrating knowledge from external sources for innovation activities and hence unlock the OI potential, is through Open Innovation platforms on the Internet: ICT tools in general and especially social technologies which are known as web 2.0, can play an important role in developing an open strategy, while leading to great achievements (Amrollahi et al., 2014). We contend that, similarly to many other organizational processes (Zerbino et al., 2017), also the inbound OI process could greatly benefit from the support given by a unique ICT platform that, while being capable of integrating all its activities and phases and facilitating the flow of information, could avoid the division of the phases which compose the whole inbound process.

On this point, the empirical evidence and the scientific debate move forward with different speed, being undoubtedly the first forward of the second. On the one hand, the empirical evidence shows that platforms have exponentially grown during the last years (see, for example: Innocentive, NineSigma, Yet2come.com). However, on closer view, existing platforms support only specific OI phases or sub-processes, but not the process in its own entirety. For instance, Innocentive is a platform for collecting ideas to solve a given problem; NineSigma provides NineSights.com, an open innovation social media that connects innovators of various sizes with resources and relationships; Yet2come.com offers services such as OI consulting, technology scouting, out-licensing technology, OI portals, patent transactions, but they are designed as separate services. On the other hand, the scientific debate, although recognizing that ICTs can enable the entire inbound process (Awazu et al., 2009) and although analysing the existing platforms (for a review see Tavakoli et al., 2017), has rather disregarded the way firms can support the whole Open Innovation inbound process by means of ICTs (Cui et al., 2015). Also, to our best knowledge, literature does not offer any contribution regarding a systematic design (specifically a conceptual design) of such an ICT platform.

Therefore, the purpose of this manuscript is to develop the conceptual design of a platform supporting all the phases of the inbound Open Innovation process. The Technological

Developments business unit of Leonardo Defence Systems provides the context for the development of the platform.

The remaining part of this article is structured as follows: section 2 provides the theoretical background which focuses on how ICT can support the phases of the OI process; section 3 presents the methodology and specifically the phases of the conceptual design; results are presented in section 4; finally, discussion and conclusion are reported in the end.

2. THEORETICAL BACKGROUND

Despite the potential benefits of openness, firms have encountered difficulties in successfully carrying out OI initiatives (Huston and Sakkab, 2006; Sarker et al., 2012) because significant internal supporting resources are needed to unlock OI's potential (Chesbrough and Garman, 2009). As an important resource with a great penetration in the Open Innovation context, ICT provides the conditions for OI deployment (Cui et al., 2015; Dodgson et al., 2006) and indeed has been shown to positively influence the adoption of OI (Verbano et al., 2013; Chiaroni et al., 2009). For example, firms rely on online communities to actively search for potential external knowledge (Di Gangi and Wasko, 2009), and the virtual environment of knowledge transfer and integration is supported by collaborative innovation systems or communication tools (Zammuto et al., 2007). However, although these examples show how the phenomenal advances in ICT have rendered organizational boundaries so porous that knowledge can be easily transferred inward and outward (Whelan et al., 2012), limited research has theoretically modelled and empirically tested on how firms can mobilize their ICT resources to support OI (Cui et al., 2015). In the following we will review the literature regarding ICT in Open Innovation, focusing on the outside-in OI process. Specifically, we analyse the inbound OI literature to deeply understand the underlying processes, whose implementation is facilitated by the support of ICT tools.

2.1 INBOUND OI

Deciding on the outside-in process as a company's core open innovation approach means that this company chooses to invest in co-operation with potential partners and to integrate the external knowledge gained (Gassman and Enkel, 2004). The outside-in process comprises earlier supplier integration, customer co-development, external knowledge sourcing and integration, in-licensing and buying patents (Gassman and Enkel, 2004). The extant literature on OI has widely investigated the issues connected with the involvement of different partners along the phases of the innovation funnel, following several perspectives of analysis: the number and typologies of involved partners (Laursen and Salter, 2006; Enkel, Gassmann and Chesbrough, 2009; Kneupp and Gassmann, 2009; Tether, 2002); the organizational form of acquisition or commercialization, operationalized in terms of level of integration and time horizon (van de Vrande et al., 2006); and the governance – whether flat or hierarchical – of the collaboration network (Pisano and Verganti, 2008).

Because of the severe challenges many firms face in managing inbound Open Innovation, after a first initial disinterest of the literature on the process through which firms implement open innovation (Chiaroni et al., 2009), recent work has pointed to a process-based understanding of OI in general and of inbound Open Innovation specifically, being the dominance of the outside-in process usually observed (Lichtenthatler, 2011; West and Bogers, 2013; Slowinski and Sagal, 2010; Gassman et al., 2010). Within this understanding, West and Bogers (2013) developed an integrated model supporting the inbound OI process exploitation, composed of four phases: obtaining innovations from external sources; integrating innovations; commercializing innovations; interaction mechanisms, which may occur at any phase of the innovation process. Slowinsky and Sagal (2010) propose, in their the well-know WFGM (Want, Find, Get and Manage) model, a set of interrelated phases, each exemplified with core "good practices", to exploit OI opportunities: once the firms has identified its wants to meet its growth objectives (Want), it has to find, either internally or, if unavailable, externally, the necessary assets to achieve the identified wants (Find) and take steps to get them through collaborative relationships (Get), while managing the OI relationship to success (Manage).

All in all and considering that slight discrepancies in the delineation of the processes appear in the literature, namely in terms of the number and labelling of processes rather than the underlying concepts, in the following, we describe how ICT can enable a decentralized innovation process (Gassman et al., 2010), supporting the three main phases which compose the OI inbound process: (i) *the obtaining phase*, which concerns identifying technologies/innovations (ii) *the integrating phase* in which knowledge/innovations are integrated and (iii) *the managing phase* is connected with the fact that investments in creating and absorbing knowledge from the outside are often accompanied by investments in knowledge management (KM) that enable the relevant internal processes (Von Krogh, 2012). Therefore, the managing phase, while regarding the management of the potential or ongoing collaborative relationships and the knowledge management issues connected with the OI inbound process, can occur at any phase of the OI process, and hence will be analysed within the obtaining and integrating phases. These phases, although presented as discrete, are interdependent and may be overlapping.

2.2 THE PHASES OF THE INBOUND OI

The obtaining phase

The obtaining phase regards the "inbound step of inbound open innovation" process (West and Bogers, 2013, p. 816), i.e. the process of identifying and sourcing innovations (West and Bogers, 2013), while answering to questions like: (i) what are the firm's needs in terms of resources?; (ii) which ones should be internally developed or externally found?; (iii) how can the firm find the external sources of technology and capabilities that fulfil the firm's wants? (Slowinski and Sagal, 2010). Firms can identify or search for external sources of innovation by collaborating with a variety of external stakeholders (Laursen and Salter, 2006) or seeking out specialists with useful knowledge (Ili et al., 2010; Tether and Tajar, 2008) to add to or complement the firm's internal knowledge base (Laursen and Salter, 2006; Witzeman et al., 2006). Firms may also passively obtain innovation that is "pushed" by external stakeholders (Spaeth et al., 2010). Researchers identified many specific sources of external knowledge (Li and Vanhaverbeke, 2009; Gassmann et al., 2006; Lim et al., 2010; Laursen and Salter, 2006), also distinguishing them between sourced (non-pecuniary) or acquired (pecuniary) (Gassmann and Enkel, 2004; Dahlander and Gann, 2010).

As mentioned above, the *managing phase* is a cross-cutting phase which, while interacting with the obtaining phase, answers questions such as which mechanisms could be useful for fostering the obtaining phase? (West and Bogers, 2013, p. 816); what could be the implications of the external sources in terms of knowledge creation and innovation?

The rise of the Internet has enabled searches for external sources of innovation, by facilitating technology intelligence (Veugelers et al., 2010), online communities (Dahlander and Wallin, 2006; Füller et al., 2008), crowdsourcing or broadcast search (Ebner et al., 2009; Jeppesen and Lakhani, 2010), and Internet platforms such as blogs and virtual worlds (Droge et al., 2010; Kohler et al., 2009). Two key interaction mechanisms that encourage innovation creation outside the boundaries of the firm have been identified. The first is *encouraging* external innovators by providing effective incentives, whether monetary (extrinsic benefits) such as awards and innovation contests (Terwiesch and Xu, 2008) or non-monetary (intrinsic motivation), as often found in opensource software. The second is establishing formal tools and processes that provide a platform for external stakeholders to produce and possibly share innovations (Gawer, 2010). While such a platform accelerates the innovation process, this might be combined with the provision of incentives, as innovation toolkits that include awards distributed based on the quality of the submission (Piller and Walcher, 2006). Awazu et al. (2009) and Rohrbeck et al. (2013) suggest some ICT tools that support foresight and technology scouting at Deutsche Telekom, which can be useful in this phase such as: news readers, which extract and aggregate information on predefined topics from a selection of sources; online idea competitions used to broaden the number of innovative and qualitative ideas; and internet-based broadcast search, i.e. platforms for asking online users to suggest solutions to a given problem (Bretschneider et al., 2015).

The integrating phase

The integrating phase regards the full integration of the knowledge/technology into the firm's activities. This phase deals with issues such as: how the firm can evaluate the external sources of technology identified before? Which processes could the firm use to plan, structure, and negotiate an agreement to access external resources? (Slowinski and Sagal, 2010). Also, this phase includes: the assimilation, i.e. the analysis and comprehension of the information obtained from external sources; the transformation i.e. the development and refinement of the routines that facilitate the combination of existing knowledge and the newly acquired and assimilated knowledge (Ardito and Messeni Petruzzelli, 2017); and the knowledge exploitation that requires the sharing of knowledge in order to promote mutual understanding and comprehension (Zahra and George, 2002). This phase requires a compatible culture in the R&D organization to overcome the “not invented here” barriers (West and Bogers, 2013). Organizational culture plays an important role in the willingness and ability of an organization to successfully profit from external sources of innovation (West and Bogers, 2013). In this phase, the development of tools for partners’ assessment and selection could be useful (Aloini et al., 2016).

Again, as a cross-cutting phase, the *managing phase* also applies to cope integration issues regarding, for instance, incentives to motivate people to share knowledge. Sharing knowledge is indeed considered one of the key interaction mechanisms that allow organisations to create value (Garcia-Perez and Ayres, 2010) and foster innovation capability (Hussein et al, 2016).

As regard the support of ICT to the integration phase, two are the main areas. Firstly, ICT can support decisional processes as an example implementing MCDA (Multi Criteria Decision Analysis) (Aloini et al., 2010), largely used to assess the selection of partners and technologies whenever more than one alternative emerged from the obtaining phase. Secondly, ICT can support knowledge sharing: the wikis, for example, are web pages that can easily be edited by anyone and are used to share and collaboratively create knowledge (Rohrbeck et al., 2013; von Krogh, 2012). E-mail and the intranet improve employees’ ability to keep up with changes and new knowledge; the use of Web 2.0 tools or social software inside organisations improves interaction, knowledge sharing and innovation (Jeed, 2008; Garcia-Perez and Ayres, 2010). PDM/PLM systems or document management systems could foster the collaborative knowledge creation, allowing storing electronic documents centrally, to enable working on them collaboratively (Rohrbeck et al., 2013). Also, virtual communities allow members to actively interact for knowledge sharing, on a specific site in cyberspace, with a strong emotional attachment (Koh and Kim, 2004). Effective tools for the retrieval of knowledge are advanced computer storage technology and sophisticated retrieval techniques, such as query languages, multimedia databases, and database management systems (Alavi and Leidner, 2001).

At a more general level, Hussein et al. (2016) contends that information technology is one of the main enablers of knowledge sharing behaviour. This is because ICT ‘forces’ the conversion of implicit knowledge (i.e. knowledge that is not currently declarative but could be made so) to explicit knowledge (i.e. declarative knowledge), so that knowledge transfer, store, recovery and sharing is facilitated (Griffith et al. 2003). The use of ICT on knowledge sharing however cannot be confined only to the codification effort and its implications in terms of storing and dissemination of knowledge (Alavi and Leidner, 2001): other important effects are at play. Firstly, while increasing ‘weak ties’ (informal and casual contacts) between people (Alavi and Leidner, 2001), ICT not only allows them to work together (Lin and Lee, 2006), but also increases the knowledge base available to each individual: by providing a field for interaction among people for sharing ideas and perspectives and for cultivating dialog, ICT may enable individuals to arrive at new insights and more accurate interpretations than if left on their own (Alavi and Leidner, 2001). Secondly, according to Griffith et al. (2003), ICT, while reducing the necessity of closed temporal and physical proximity, diminishes the likelihood that homogenous groups are formed for convenience or for reasons simply linked to collocation of members in the same space or time; therefore, teams supported by ICT tools are likely formed when needed skills are not available locally. Hence, ICT allows knowledge to be shared between less similar members than those who are involved in more traditional groups (Griffith et al. 2003); this knowledge diversity allows the recombination of different knowledge sets, and hence has implications in terms of knowledge creation (Ardito and Petruzzelli, 2017). However, more recent contributions have pointed out that the literature so far has mainly honed in traditional implementations - such as databases, knowledge repositories, expert systems, intranets, etc. - and therefore ask for more theoretical and empirical research in order to understand how Web 2.0 – such as blogs, wikis, collaborative workspaces, etc. – impact on knowledge processes, and if there are cross-industry differences as regards the preference towards traditional vs. Web 2.0 technologies (Von Krogh, 2012).

In the following we dig deeper in the sub-processes which compose the obtaining and the integrating phases. The obtaining phase is composed of two sub-processes, i.e. (i) technology scouting and (ii) external knowledge sourcing, while the integrating phase regards the collaboration establishment, which includes the assessment and selection of external knowledge sources.

2.3 THE SUB-PHASES OF THE INBOUND OI

Technology Scouting

Technology has been recognized as one of the major sources of competitive advantage (Kocaoglu et al., 2001; Edler et al., 2002; Phaal et al., 2006). For any technology-based company, two questions arise: (1) How can it sustain its technological leadership and thus its competitiveness? (2) How can it develop promising new technologies and use them to move into new business fields (Rohrbeck, 2010)? Research on technological disruptions has also shown that discontinuous technological changes threaten the competitive position of incumbent companies, because they are slower to react than smaller rivals (Christensen, 1997; Arnold, 2003; Danneels, 2004). It also has been shown that being aware of discontinuous technological change does not ensure that the company will be able to produce adequate reactions (Paap and Katz, 2004; Lucas and Goh, 2009). Companies are faced with two challenges (Levinthal, 1992):

- identifying, anticipating, and assessing discontinuous change;
- effectively using this information to plan and execute appropriate reactions.

Technology scouting is a systematic approach by companies whereby they assign part of their staff or employ external consultants to gather information in the field of science and technology and through which they facilitate or execute technology sourcing. The technology scouting approach should aim to four major goals: (1) early identification of technologies and technological trends; (2) raising awareness of the threats and opportunities of technological development; (3) stimulation of innovation by combining the technology reports with business potential assessment; (4) facilitation of the sourcing of external technologies by allowing for a direct channel through the network of technology scouts to their sources of information (Rohrbeck, 2010). In a broader sense, the goal of technology scouting is to gain a competitive advantage by identifying opportunities and threats arising from technological developments at an early stage and to provide the technological capabilities needed to face these challenges. Technology scouting can be carried out through two different perspectives: (ì) the internal perspective, searching information inside the company's boundaries; (ii) the external perspective, searching information outside the company's boundaries. Furthermore, the research target can be known, when the enterprise searches a specific technology/application or solution, or it can be unknown, when the enterprise searches technologies that could be interesting/useful in the future, and for this reason they should be monitored (Mortara et al., 2009). Technology scouting can rely on formal and informal information sources, including the personal networks of the scouts. The most widely used technology foresight and scouting methods are using automated search mechanisms to find information in databases. Such methods include publication and patent analysis (Porter, 2005; Daim et al., 2006), as well as trend curves, such as technology lifecycles (Jones et al., 2001), and the S-curve analysis (Sood and Tellis, 2005; Modis, 2007; Phillips, 2007). Using such methods in combination with intelligent data-mining tools (Porter and Cunningham, 2005) makes possible to retrieve useful information and can give appropriate answers in a timely manner.

External Knowledge Sourcing

In the on-going quest for competitive advantage, organizations have increasingly focused on knowledge as a strategic resource (Alavi, 2000), which has led them to adopt a range of knowledge management practices that are intended to help them to compete more effectively (Wang et al., 2014). In this context, the external sourcing of knowledge is taking a more central role in companies. They often seek to manage knowledge through information technology enabled initiatives that enhance the availability of knowledge. Many firms, for example, implement electronic knowledge repositories so that individuals can access explicit knowledge easily (Gray and Durcikova, 2005). Others offer computer mediated communication channels (e.g., email, forums, and Skype) so that individuals can communicate with experts conveniently to exchange or acquire tacit knowledge (Alavi and Leidner, 2001). Web 2.0 technologies are also gaining popularity, complementing formal knowledge repositories and directories and assisting individuals in their knowledge sourcing efforts (Gray et al., 2011; Zhang et al., 2013). Bretschneider et al. (2015) describes Virtual Ideas Communities (VICs) as instruments that many firms (Dell, Starbucks, Google, SAP, Intel and BMW) relied on for the identification and search for external knowledge. In VICs, can post their ideas, vote for and comment on other customers' ideas, and help improve ideas in a collaborative manner.

Collaboration Establishment

A promising challenge in the OI paradigm (Chesbrough, 2003) is building cross-enterprise processes (Deck and Strom, 2002) to leverage the internal strengths with partners' competencies and knowledge to provide new/superior products/services (Mohr and Spekman, 1994), to reduce risk and possibly to open new market segments. Researchers and practitioners have recently paid great attention to technological partnering. The need for technological collaboration is increasing and benefits can be gained from participating in networks. In networks, firms can create linkages between each other in order to obtain common or complementary objectives of innovation (Chesbrough and Teece, 1996; Davidow and Malone, 1992; Rothwell, 1994; Upton and McAfee, 1996). Once the firm decides that a certain technology is to be acquired externally, it needs to assess and select the partner and to identify the most appropriate mode for such an acquisition. As regards the assessment and selection of the most adequate partners, the literature put out that many are the aspects to be considered when assessing a partner. These aspects run from the technological focus (Jolly, 2003; Rohrbeck, 2010) to the technological alignment (Emden et al., 2006); from the strategic alignment (Emden et al., 2006); to the relational alignment (Emden et al., 2006; De Araújo Burcharth et al., 2014; Lazzarotti et al., 2015; De Faria et al., 2010; Ford et al., 2012; Ragatz et al., 1997); from the financial focus (Ellram, 1990) up to the co-design effort (De Toni and Nassimbeni, 2001).

As regards the acquisition modes, a lot of variety of organizational modes can be adopted to access external sources of technology (see, for example, Roberts and Berry, 1985; Chatterji, 1996; Millson et al., 1996; Chiesa and Manzini, 1998). From a financial point of view there is a distinction between equity and non-equity modes of collaboration; the latter ones do not need an equity involvement. Our focus is on non-equity modes of collaboration, which can be:

- licensing, when a company acquires a license for a specific technology;
- joint R&D, when a company agrees with others to jointly carry out research and development on a definite technology (or technological discipline), with no equity involvement;
- R&D contract, when a company agrees to fund cost of R&D at a research institute or university or small innovative firm, for a definite technology;
- research funding, when a company funds exploratory research at a research institute or university or small innovative firm to pursue opportunities and idea for innovation;
- alliance, when a company shares technological resources with other companies in order to achieve a common objective of technological innovation (without equity involvement);
- consortium, when several companies and public institutions join their efforts to achieve a common objective of technological innovation (without equity involvement);
- networking, when a company establishes a network of relationships, to keep the pace in a technological discipline and to capture technological opportunities and evolutionary trends;
- outsourcing, when a company externalizes technological activities and, then, simply acquires the relative output.

3. RESEARCH OBJECTIVE AND METHODOLOGY

3.1 RESEARCH OBJECTIVE

The aim of this research is to develop an integrated ICT-based system supporting the inbound OI process. In so doing this paper tries to contribute mobilizing ICT resources to support Open Innovation processes (Cui et al., 2015) while participating to the academic debate on how ICT research can boost firms at capturing external sources of knowledge to enhance current technological developments (Huizing, 2011).

The research project originates from the need of the Technological Developments business unit (BU) within the Engineering area of Leonardo Defence System, to implement inbound OI process. The aim of the BU was to open the business to the civil market by exploiting dual-purpose technologies (i.e. technologies for both the military and civilian markets).

The context is interesting also depending on the military background of the investigated company, which notwithstanding the necessity to strictly protect the intellectual property and the difficulty in sharing and transferring knowledge, has strongly perceived the compelling necessity to facilitate its openness to external partners.

So far, our research concentrated specifically on the preliminary phase of the design process. Hence in this work, we will present the conceptual design of the integrated ICT platform supporting the different phases and perspective of the inbound OI process.

The relative significance of conceptual design, to support basic design or detail design, is widely recognized due to its influential roles in determining the product's fundamental features and development costs (Umeda et al., 1996). Conceptual design is, in fact, an umbrella term used in design management to indicate an early phase of the design process, in which the broad outlines of functions and form of an artefact are articulated. This includes the design of processes, user interactions, experiences, data structures, etc. which implicitly imply a deep understanding of users' needs and how to meet them with products, services, and processes.

Thus, the expected outcomes from the conceptual design of the investigated ICT platform comprises:

- (i) the definition of the platform's functions;
- (ii) the definition of the relations among the functions identified and the inbound OI sub-processes;
- (iii) the data architectural model, i.e. the definition of the connections among the defined functions of the platform and the external or internal databases.

The conceptual design is a relevant and very resource consuming result which can be considered a crucial output for the research, specifically for the related implication to both practitioners and academics.

As regards the practitioners, the conceptual design is useful for Leonardo Defence Unit, to allow the achievement of the final goal, i.e. the Open Innovation ICT platform. In addition, it could be useful for other firms opening their boundaries to external partners, as well as for software developers: both can be inspired and build on the proposed conceptual design for their own purposes.

As regards scholars, the ideation of an integrated ICT platform could be considered as a step forward in the OI research. The literature on Open Innovation is in fact far from being conclusive in understanding relationship between Open Innovation and the digital transformation. Specifically, the role of digital technologies and platforms in enabling the connectivity and collaboration between actors is felt in the scientific community as a compelling research question which should feed the next research agenda on OI (Bogers et al., forthcoming).

3.2 THE COMPANY

Leonardo is a global high-tech company and one of the key players in the Aerospace, Defence and Security sectors. Headquartered in Italy, the company employs more than 47000 employees worldwide. It has offices and industrial plants across 15 countries, with a strong presence in Italy, the United Kingdom, the United States and Poland, and strategic partnerships in the most important high potential international markets. Leonardo is resulting after a significant process of renewal and transformation, from financial holding company to integrated industrial entity.

The company operates in four sectors – Helicopters; Aeronautics; Electronics, Defence & Security Systems; Space – and is organised into seven divisions:

- Helicopters,
- Aircraft,
- Aerostructures,
- Airborne & Space Systems,
- Land & Naval Defence Electronics,
- Security & Information Systems,
- Defence Systems.

As mentioned above, the research project was carried out within the Leonardo Defence Systems division. The commercialized products are the heirs of a 100-year old legacy of historic Italian factories that still today design, develop and produce artillery, weapons and torpedoes. The continuous technological evolution that the division has consistently applied to these systems over the years, allows Leonardo to offer a highly innovative, technologically advanced portfolio of products and systems able to respond effectively to the new operational land, naval and underwater warfare scenarios. The Defence Systems Division is in fact among the largest industrial partners of Armed Forces around the world and it is among the global leaders in the design, development and manufacture of small, medium and large calibre naval guns that have been successful worldwide.

Following a programme of continuous upgrades, all production is realised with the aim of offering products that allow the uniformity of human-machine interfacing, the same design concepts and, if possible, the same logistics.

The Defence Systems division also holds a niche position in the field of underwater defence systems: the design, production and integration of heavy and light torpedoes, anti-torpedo countermeasure systems for submarines and surface ships, sonar systems for underwater surveillance.

In addition, the division develops both surface and underwater protection systems for naval platforms that could be subject to potential attacks by torpedoes; furthermore, it is also active in the field of underwater surveillance systems for ports, coastal areas and strategic sites thanks to the experience gained in the field of sonar. Selected and employed by various Navies around the world, the underwater systems produced by the division are present in over 30 countries. Besides, the division's research and development is aimed at the design of robotic systems capable of carrying out surveillance and tactical patrolling.

As mentioned, motivation for this research project relies on the need of the Technological Developments business unit of Leonardo Defence System, to catch or open up new opportunities in the civilian market by exploiting dual-purpose technologies. In this aim, implementing an effective inbound Open Innovation process could support the company for pursuing different objectives, as such as 1) identifying new dual-purpose opportunities, 2) finding partners, 3) establishing partnerships and/or non-equity agreements, 4) collaborating in the product/system design and development processes, and 5) commercializing outcomes.

An initial support to the research was possible through external collaborations with other enterprises, universities and research centres, within European and regional funded projects. Later, in 2014, Leonardo Defence Systems started to collaborate with our research team in order to support and structure the existing internal Technology Scouting activities, which were strongly stimulated by the top management to boost company competitiveness. Technology scouting was mostly finalized to get innovative ideas for the improvement of the existent products, and/or to identify innovative ideas exploiting the enterprise employees' competences to be quickly implemented. Soon after, the complexity of such an endeavour as such as the value of an ICT tool supporting the activities implementation were manifested. Thus, the possibility of an integrated ICT platform supporting all the inbound OI sub-processes started to be evaluated for carrying out the articulated network of OI processes in a more structured and efficient manner.

3.3 RESEARCH METHODOLOGY

The research method exploits research opportunities offered by the Leonardo BU in order to define a reference model for guiding the development and implementation of an integrated ICT platform supporting the Open Innovation processes. In particular, the setting could provide us interesting insights to develop a valid and reliable conceptual model for an ICT platform to be possibly refined, customized or extended to other industrial context.

Leonardo Defence Systems is in fact an example of a very complex industrial environment where implementing OI processes is challenging. It is a high-tech industry, where Openness is a key factor for competitiveness, but it also operates in the military market, a context where knowledge and information sharing is hard to conceive.

We tried to combine two different perspectives: on the one hand, a scientific standpoint, which relies on the evidence from the academic literature; and, on the other, an empirical point of view leveraging on evidence coming from the field, i.e. opinions and suggestions of people directly, involved in the firm innovation process.

Summarizing, the research has gone through the following main steps.

Firstly, as (in a preliminary-step), we carefully reviewed the extant literature, and then analysed the company context: the direct observation of the enterprise's environment and the interviews to the company employees specifically working in the Technological Development Business Unit, helped us in understanding the company target and the application context. To ensure an exhaustive literature review, we analysed articles selected from the top 50 most-cited technology and innovation management journals as reported by Linton and Thongpapanl (2004) and specialized articles from the ICT field.

Afterwards, we concentrated more specifically on the conceptual design of the platform, which comprises three different phases: (i) conceptualization of functions; (ii) preliminary design; (iii) conceptual design of the System/SW architecture. In each of these phases, again we tried to merge evidence from the scientific literature with empirical insight emerging from the field.

During the conceptual design development, in fact, the activities of requirements analysis, functional specification and data architectural modelling require a team of developers to converge towards a common vision. For this reason, we collaborated with numerous managers and employees form the Technological Developments business unit within the Engineering area, by combining our ICTs and Innovation Management competencies with the specific competences of the business unit's employees.

Table 1 reports details regarding the objectives, activities, people and periods involved in each of the previous phases.

Conceptual Design - Phases	**Objectives**	**Activities**	**Actors/sources**	**Periods**

Preliminary step: Context analysis	Understand the context and the company's purpose	Analysis of the extant literature and of the context in which the firm operates	- Scopus/ISI web of knowledge - Employees of the firm - Employees of the Technological Development Business Unit	November 2014-December 2014
a)Conceptualization of functions	Identification of the possible information needs and related data gathering processes	Analysis of the extant literature	Scopus/ISI web of knowledge	January 2015 June 2015
		Brainstorming and interviews in order to conceive the use cases	Employees of R&D, Preliminary Design, Technology Scouting and Assessment	
b) Preliminary design	Identification of functions	Aggregation of the use cases in order to identify functions	- Employees of the Technological Business Units - Employees of the ICT function	July 2015 December 2015
c) Conceptual design of the System architecture	Define the overall and, particularly, data architecture of the platform	Identification of the internal/external DB to be connected with the platform and definition of the platform's layers	- Employees of the Technological Business Units - Employees of the ICT function	January 2016 July 2016

Table 1. The phases for the conceptual design.

A more detailed description of the three conceptual design phases is reported below.

a) Conceptualization of functions

Conceptualization of functions aims to produce ideas and to evaluate the pros and cons of their implementation in order to minimize the likelihood of error and get a preliminary evaluation of the proposal and the potential success of the intended project.

In the research project, this phase consisted of two main activities: on the one hand, a literature analysis, and, on the other, brainstorming and interviews with employees to identify use cases. As regards the former, we could lever on the scientific articles identified in the literature review: literature analysis was not confined to Knowledge Management and Open Innovation, but also to OI-related fields in order to identify possible functions of the platform. This analysis was useful to provide examples and stimuli to employees of the technological Development Unit for identifying use cases.

As regard the latter, numerous brainstorming sessions and interviews involved the business unit's employees both from the Research and Development and Preliminary Design in order to detect potential use cases. Use cases indeed, while helping in capturing the behaviour of the platform when it is running /operating, were considered to play a pivotal role to model the platform itself. By means of use cases, analysts could gather requirements of the platforms, get an outside view of the platform, identify external and internal factors influencing the platform performance and show the main interactions among the platform and people.

b) Preliminary design

The preliminary design bridges the gap between the conceptual design and the detailed design, particularly in cases where the level of conceptualization achieved during systems ideation is not sufficient for a full evaluation. In this task, the overall system configuration is defined, and schematics, diagrams, and layouts provide early configuration options. During detailed design and optimization, system parameters can change since the preliminary design focuses on creating a general framework to build the project on.

Considering the output of the previous phase, we worked with the business unit's employees and ICT's technicians to define the overall platform's configuration and the related schematics and diagrams. In particular, the preliminary design builds on use cases and aggregates them to identify the overall network of functions that the platform should implement. The aggregation was brought about at different levels. At a first stage, the aggregation was performed at sub-process level. Then, inside each sub-process, the aggregation followed different criteria. As an example, in the technology scouting and external knowledge sourcing sub-processes the aggregation was based firstly on the typology (formal or informal) and position (internal or external) of the identification source, and afterwards on the specific objective of the activity (identification, selection and assessment). At a second stage, the aggregation process was assessed crossing the three OI sub-phases in order to possibly merge or combine common functions or activities and find optimization opportunities.

c) Conceptual design of System architecture

The System architecture is usually a three-tier architecture including the following layers: the data layer; the function layer; and the presentation layer. These layers can communicate through internet or extranet, depending on the type of communication and on the different levels of privacy required.

- The data layer includes the internal application databases (e.g. PDM, PLM, etc…) and the connections/interfaces with external information systems and DBs (such as International Patent Repositories, Publication DBs, others) required to enable the research functions within the inbound OI sub-processes. It might also contain external databases for backup, recovery and storing of historical data.
- The function layer comprises the platform's applications/functions needed to accomplish the objectives of the inbound OI sub-processes and their relations or connection interfaces with the internal and external databases.
- Finally, the presentation layer concerns the clients and consists of browsers and more in general Graphic User Interfaces (GUIs) supporting the applications, e.g. data inputs, creation of reports, etc.

At this stage of the research, we have collaborated with the firm's employees in order to obtain a preliminary architectural map of platform's functions and to identify the relevant dataset. Use cases mapped in the previous design phases were re-analysed by UML - data diagram to identify the internal/external repositories to connect with the ICT platform. Despite the presentation level could be very important and potentially impactful on the adoption of the system (OI platform), it is out of the scope of this paper.

4. RESULTS AND ANALYSIS

4.1 PLATFORM'S CONCEPTUAL DESIGN

The conceptualization of the platform functions has been obtained identifying and analysing use cases which may occur within the inbound OI process.

As explained before, after an in-depth analysis of the context, the conceptual design has gone through the following phases: conceptualization of functions, the preliminary design and the conceptual design of System/SW architecture. Here in the following we provide details regarding each phase.

a) <u>Conceptualization of functions</u>

The use cases have been inspired by the literature analysis and draw on the interviews with the business unit's employees. In so doing, they were circumstantiated and customized accordingly to the specific context through focus groups with company delegates.

At the end of this phase, twenty-five different use cases emerged. For sake of brevity, we exemplify here just a single use case (A.0 - i.e. user searching on patent DBs to identify potential partners). Yet, similar outcomes are available for all the use cases enabled by the platform functions.

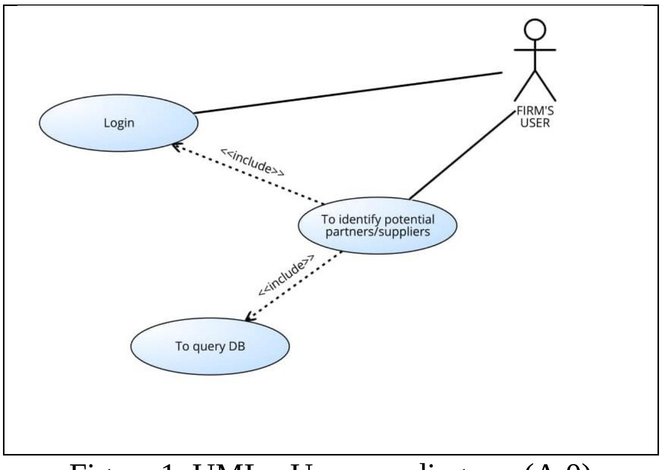

Figure 1. UML - Use case diagram (A.0)

The use case A.0 (Fig. 1) responds to the need of identifying a potential external source in order to acquire/co-develop a needed technology. The enterprise decides to carry out a patent analysis. Hence, it assesses the database search and identifies none, one or more potential partners/suppliers. Details are offered in the following table (Table 2)

Table 2. Details on Use case diagram (A.0)

To Identify Potential External Sources Which Could Provide The Technology Identified	
Actors	Firm's user
Pre-condition	This use case invokes use case A.1 (not showed here), and it is invoked by use case A.2 (not showed here) User must be registered
Main process flow	1. Include "Login" 2. Include "To query DB" 3. Firm's user analyses search results 4. Firm's user identifies potential partners/suppliers
Extensions	4. Firm's user does not identify suitable potential partners/suppliers 4.a to go back to step 2 OR 4.b to end the operation
Post-condition	Firm's user selects potential partners/suppliers

b) Preliminary design

Once the identification of the use cases was completed, we aggregated them considering both commonalities within each sub-process, and afterwards across the sub-processes. As an example, at a first level, we considered the type of data sources (formal or informal/internal or external) to be consulted for the identification of technologies and external knowledge sources.

Figure 2 shows the outcome from the first aggregation mechanism regarding the identification of technologies and external knowledge sources by means of formal sources. Also, a brief description of the search process from formal sources is provided hereafter.

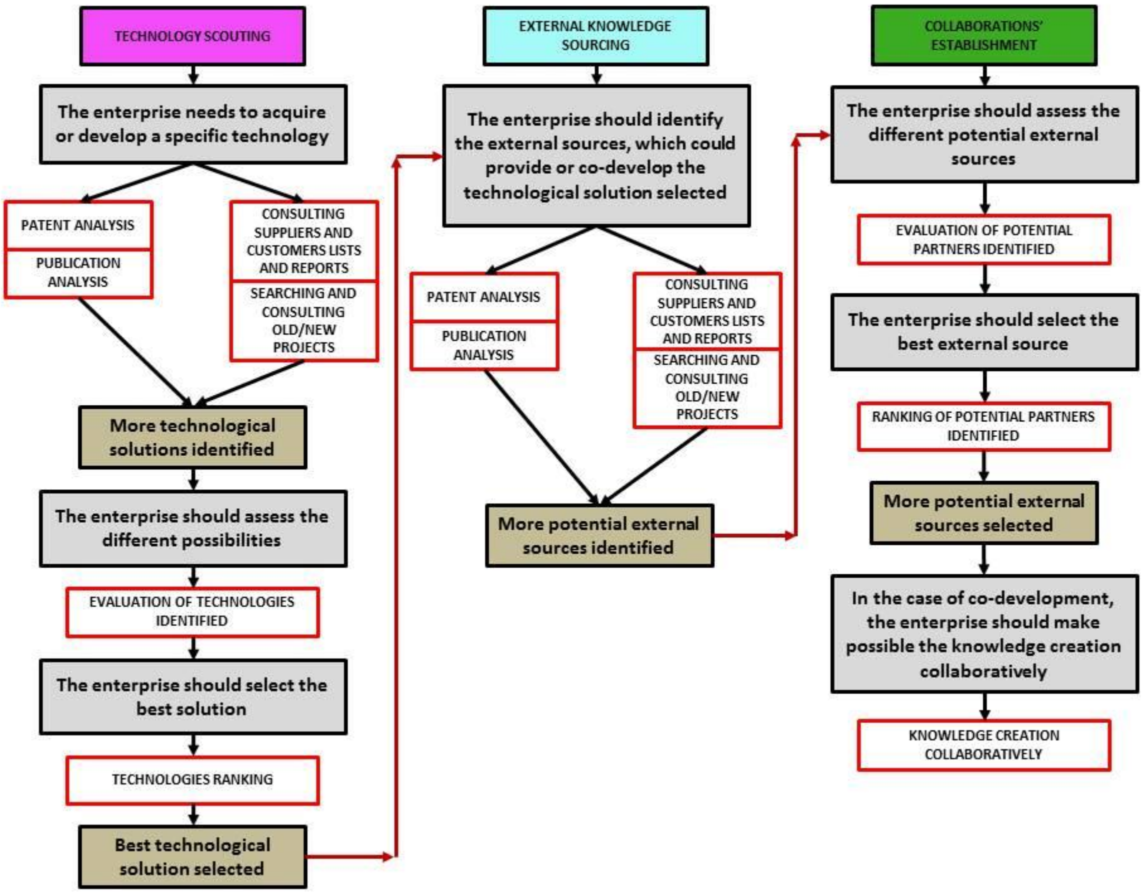

Figure 2. Aggregation regarding the identification of technologies and external knowledge sources by means of formal sources.

Aggregation 1. The firm needs to acquire or develop a specific technology. Possible technologies could be identified by means of external formal sources, such as patents or publications databases, for example carrying out a patent analysis and/or a publication analysis. Also, the enterprise could identify the technology by listening at partners, such as customers and suppliers, as well as looking at the internal formal sources, such as projects databases, or PDM/PLM databases. The search activities can be taken through looking at suppliers and customers lists and/or reports, or through the analysis of old and new projects. Depending on the specific case, none, one or more technological solutions could be available to the enterprise. If more potential technological solutions exist, the firm should assess the different possibilities in order to select the best one.

After that, the enterprise needs to identify the external sources, which could provide or co-develop the technological solution selected through the technology scouting. The identification of the potential external sources can be carried out leveraging on patent or publication analysis, i.e. searching co-developers and co-authors in patents and publications databases. After the identification of potential partners, the enterprise has to evaluate the different alternatives and select the most promising. In case of co-development with the external partners, tools supporting the process of collaboration and collaborative knowledge creation could be valuable.

A second aggregation of activities regards the identification of technologies and external knowledge sources by means of informal sources, and it is presented in the next picture (Fig. 3). Again, a brief description of the decisional context and the related search activities is reported soon after.

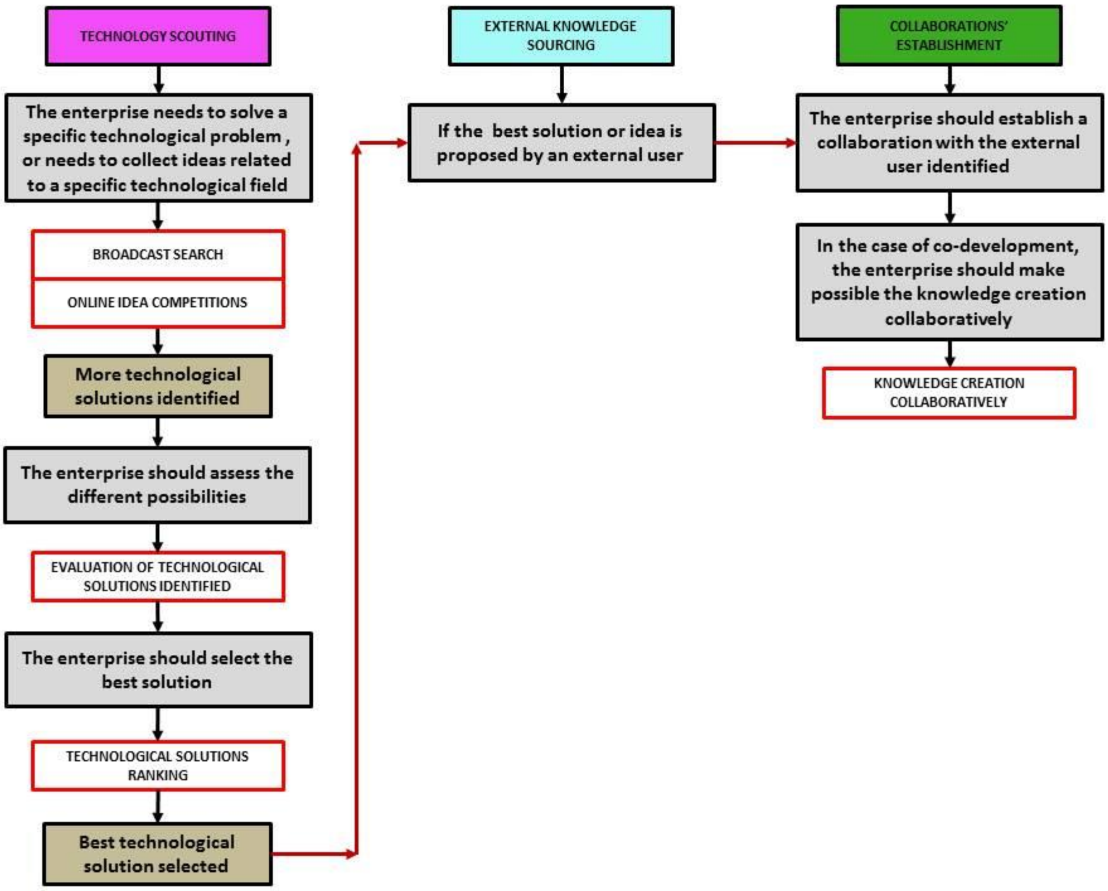

Figure 3. Aggregation regarding the identification of technologies and external knowledge sources by means of informal sources.

Aggregation 2. The firm aims at finding possible solutions to solve a specific technological problem. Solutions could be collected both inside or outside the company's boundaries by posting the problem online and gathering all the proposals. Results might comprise one or more feasible proposals, and the best one should be selected. When the best solution is proposed by an external partner, the firm is likely interested to deepen the contact with the proponent and possibly to establish a proficient collaboration. Alternatively, ideas could be collected by means of online idea competitions. Again, available results might comprise none, one or more feasible ideas, and the best one should be selected.

c) <u>Conceptual design of System/SW architecture</u>

Combining and aggregating the use cases analysed for Leonardo Defence Systems, we have finally elaborated a list of possible functions. A detailed description is given in section 4.2. They were organized in a synthetic map accordingly to the OI process phases and the different objectives of the functions.

The platform's conceptual design is showed in the figure below (Fig. 4). The purple, blue and green boxes represent the three sub-process of the inbound OI process; the grey boxes contain the different functions (in the red rectangles), as well as the objectives of each function. Finally, the external systems, such as for example databases (DB), which the OI platform should be connected are specified on the left.

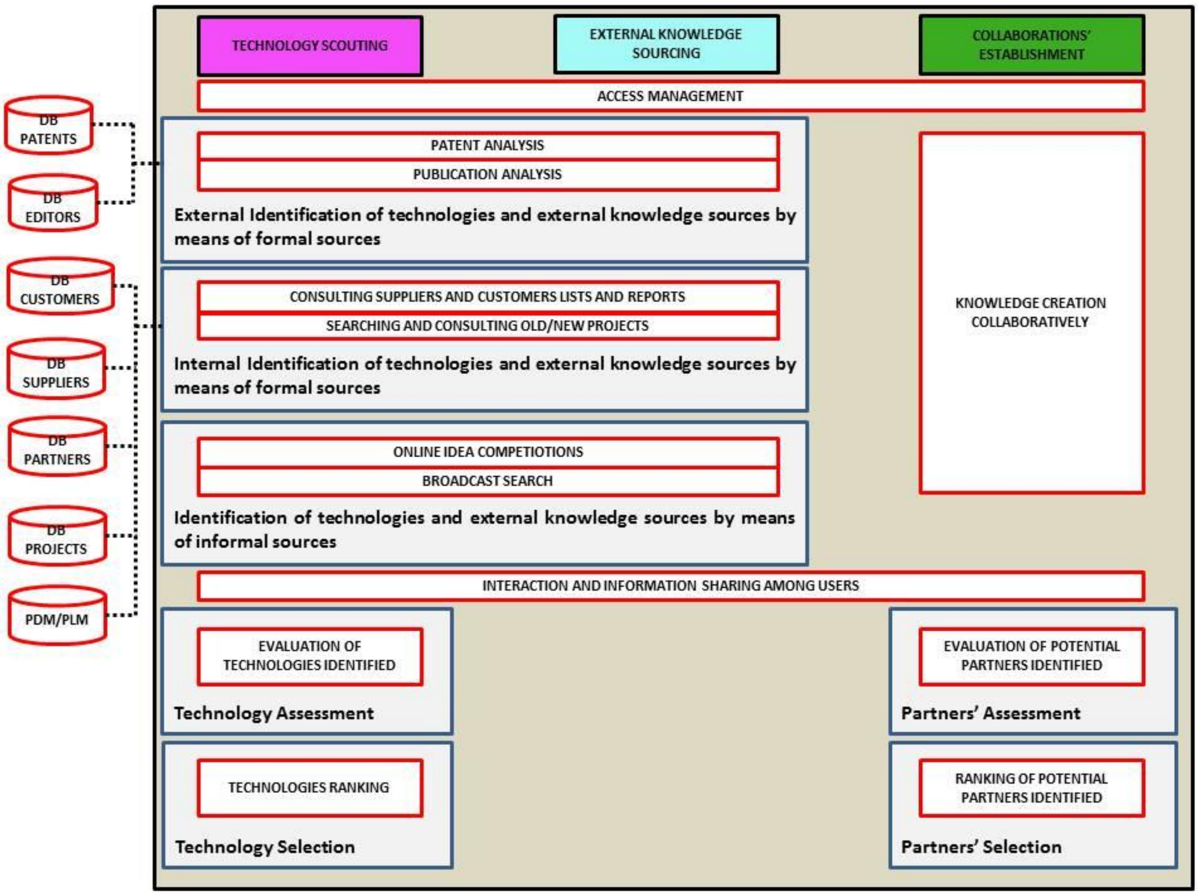

Figure 4. Platform's Conceptual Design.

4.2 DESCRIPTION OF FUNCTIONS

The conceptual model of the OI platform includes different kinds of functions. Hereinafter they will be shortly described. We can distinguish: (1) cross-cutting functions that aim to support all the OI sub-processes; and (2) more specialized modules that specifically support Technology Scouting, External Knowledge Sourcing activities and Collaboration Establishment sub-processes.

Furthermore, the functions are here grouped according to their main objectives, class and type of information source (i.e. internal or external sources; formal or informal): functions supporting the identification of technologies and external knowledge sources by means of (i) external and formal information sources, such as the Patent DB and the journal DB of the scientific Editors; (ii) internal and formal sources, such as referring to customers' and suppliers' list and reports or to new/old projects; (iii) informal sources both from internal and external actors, such as online idea competition and broadcast, or searching of solution to specific technology issues; (iv) functions supporting the technology assessment; (v) functions supporting the technology selection; (vi) functions supporting collaborative knowledge creation; (vii) functions supporting partner assessment; (viii) functions supporting partner selection; (ix) functions supporting interaction mechanisms among OI process participants; (x) functions supporting the identity and access management.

(i) Functions supporting the external identification of technologies and (external) knowledge sources by means of formal sources

This group of functions aims to identify externally both potential innovative technologies and external knowledge sources, which could provide the needed technologies. To achieve this goal, the functions look at the following formal and external information sources by: (i) patent analysis and (ii) publication analysis.

Patents (Jung and Ejermo, 2014) and publication data (Shibata et al., 2011) are widely used to map the emergence of technologies (Albino et al 2014) in the attempt to derive promising technology alternatives from blurred and various development directions of an emerging technology. Patents were one of the first forms of technical publication to be categorised with metadata. They were also among the first publications used by linguistic scientists to convert textual material into keywords, key concepts, and scientific themes. Because of the huge amount of information currently available in electronic repository, which derive by the increasing number of patents publications, as well as from scientific and technical articles, the platform responds to two main issues: how to identify the potential technologies responding to a specific company's need and then, to discover the right partners to acquire/obtain it; how to use patents and publications databases in order to identify the relevant technological trends and the most promising and influential external sources. Patent and publication analysis usually relies on the identification of specific contents within the documentation and extracting/aggregating this information on specific technological fields (as for example happens in Technological Roadmaps).

In order to identify specific contents, tagging systems, which assign keywords to any kind of electronic information or files, will be useful; furthermore, these keywords will support the identification of related content and their accumulation indicates trending areas. Also, content analysis tools can also offer a great support to the document exploration. In case of more complex contents-related elaborations, other searches utilities, as such as semantic search engines or more sophisticated machine-learning based search engine could also be useful.

These systems will improve search accuracy by understanding the searcher's intent and the contextual meaning of terms as they appear in the searchable data-space, whether on the web or within a closed system, to generate more relevant results. Semantic search tools can consider various issues including context of search, location, intent, variation of words, synonyms, generalized and specialized queries, concept matching and natural language queries to provide relevant search results. As a result, this evidence calls for an advanced semantic search engine which could be dedicated to specific modules or shared throughout the entire platform. As an addition, to extract and aggregate information on specific technological fields, for example, the newsreaders or similar reporting tools, including infographics and smart data visualization systems, could be useful. In fact, they are software applications that extract and aggregate information on predefined topics from a selection of sources. Finally, to carry out patent and publication analysis the connection interface with external databases, such as patents and publications databases, is necessary.

(ii) Functions supporting the internal identification of technologies and external knowledge sources by means of formal sources

This group of functions aims to internally identify both potential interesting/innovative technologies and external knowledge sources, which could provide or co-develop the technology or the components. The functions should include utilities for checking suppliers and customers lists, internal documentation or reports about supplies, searching and consulting old/new projects. To dynamically retrieve suppliers and customers lists and reports, and to search information on old/new projects, the connection with Customers, Suppliers, Partners, Projects and PDM/PLM databases should be guaranteed. Because of the vast amount of information available within the enterprise, which derives from the existence of different enterprise's units and the several competencies of the entire enterprise's employees, the platform has to respond to the following issues: how to identify the needed technologies and the right partners/suppliers in order to acquire/obtain them; how to use the information belonging to the databases to identify the needed technologies and the appropriate external sources of technologies. Tagging systems, newsreaders, or more complex search engines (semantic engines and machine learning tools) become useful to identify very specific information throughout the whole data system, developing new indexing and ontologies for data exploration, extracting and aggregating information about specific queries. To this purpose, Customers, Suppliers, Partners, Projects and PDM/PLM databases should be available, coherent, updated and possibly integrated.

(iii) Functions supporting the identification of technologies and external knowledge sources by means of internal and external informal sources

This group of functions aims to identify both potential innovative technologies or interesting solutions for open issues, and external knowledge sources, which could provide or co-develop the solution. With this aim the function retrieves informal data both internally and externally.

The conceptual model of the OI platform includes two most relevant approaches, and thus two submodules: the online idea competitions unit and broadcast searching unit.

Online idea competition system supports users to create a positive environment, in some case by setting context events where high potential participants are invited to participate in. This is in order to rapidly collect innovative ideas regarding new technologies or applications. Consequently, the system is also useful to identify potential partners or suppliers. The functional unit is similar to a crowdsourcing system for innovation projects and works in a competitive fashion, e.g. providing intrinsic or extrinsic incentives to participants. Also, it can be used with the aim to scan for relevant signals on change.

Broadcast searching unit instead aims to solve problems related to technology, exploiting ideas which are suggested online. Gathering this information, the function can also help to faster carry out the identification of potential external sources, for supply or co-development. Similarly to online idea competitions, they can also be used to collect signals on change in specific field. These types of searches can be carried out both inside and outside the enterprises boundaries. Often in fact, enterprises search outside possible solutions for some problems, ignoring the possibility to solve the problem “inside”, involving other Organizational Units and/or Project Teams which potentially implies lower costs. This function of the OI platform supports the publication of the issue on preselected communities and groups (both on the web and on the intra-net) and the management of the interaction with participants, and the information retrieval and analysis. By the way, it should also monitor participant activity and success in order to implement an effective system of incentives.

(iv) Functions supporting technology assessment

Once identified, the technology assessment unit aims to evaluate the potential interesting technologies or solutions/applications. Specifically, firms try to evaluate the extent to which technologies might respond to their needs and contribute to create value or to strengthen the firm position relative to competitors. As an addition, when managing their technologies, firms need to decide which of them should be developed internally and which from external partners; which technologies should be developed cooperatively, and which should be commercialized.

Several factors should theoretically be taken into account to accomplish that kind of decision. Moreover, evaluations usually occur along different directions of analysis and by numerous quali-quantitative criteria (objective and subjective ones). Sometimes they are contrasting and subject to trade-off. In very general terms, the technology assessment process consists of: appraising technological progress, and/or analysing socio-technical systems, and/or analysing the social impact of technology, and/or evaluating alternative technologies, and/or studying technological futures. Hence, it emerges the need to support users on the one hand to identify collaboratively an effective and shared set of criteria for drawing the final evaluation on technologies and, on the other, to enhance data collection by leveraging on both from formal and informal sources and combining their final evaluations. In this direction, possible instruments for data collection can include web forms, e-survey, e-mailing systems. Also, tools implementing Delphi method are useful to achieve the convergence of experts' judgments.

(v) Functions supporting technology selection

These functions can support decision makers in the selection of the best technology/ies among the options previously evaluated. This is finally useful to define guidelines for the future technological developments, to detect obsolete technologies, or to discover external technologies for monitoring or investing on. Therefore, this unit comprises multi-criteria-decision-aid methods and tools for the comparison and ranking of alternatives. Dealing with complex decision-making characterized by multiple, and often conflicting dimensions and criteria of analysis, objective and subjective judgments, structured and unstructured information sources, the Decision Support System relies on several well-grounded techniques as such as Analytic Hierarchy Process, Fuzzy Set Theory, Topsis and If-Topsis, Outranking Approaches such as PROMETHEE or ELECTRE, etc.

(vi) Functions supporting partners' assessment

This group of functions aims to assist the evaluation of the potential partners, which were previously identified for a possible relationship. Literature agrees in considering partners' evaluation as a very critical step for OI process to decide about their involvement along the different phases of the innovation funnel. Several perspectives of analysis are practicable. Despite this confirmation, literature does not give clear-cut indications on this topic (West and Bogers, 2013), particularly if intended as how to assess an effective partner selection (i.e. which criteria, approach, methodology, etc.). The assessment of partners, in fact, requires firstly the definition of relevant and suitable criteria (Aloini et al., 2016). Hence, data collection process has to be supported for defining aggregate measures starting from quantitative performance historical indicators and judgments of experts. Therefore, as in (iv) a tool suitable for aiding partners' assessment has been conceived firstly to correctly guide the formulation and choice of the evaluation criteria, then help users in historical data retrieval about past performance of partners coming from other experience, both looking at quantitative and qualitative measures. Finally, it has also to boost convergence of experts' judgment.

(vii) Functions supporting partners' selection

Similarly to the utilities at point (v), this group of functions aims to select the best partner or most valuable partners among those assessed before. The module drawn on the same Multi-Criteria-Aid methods and tools as in Functions supporting Technology selection.

(viii) Functions supporting collaborative knowledge creation

This group of functions aims to enable the collaborative knowledge creation among OI process participants. We mostly refer to wiki-like web pages that can easily be edited by anyone in the OI platform and used to create and share knowledge collaboratively into the OI network. Each user can add information, complete the previous entries or correct wrong information, resulting in up-to-date peer-reviewed information. Also, PDM/PLM systems could be used to foster the collaborative knowledge creation if available in a more open fashion to the NPD extended teams. Similar functions also facilitate collaborative co-design activities by an operational environment where users can work collaboratively on shared documents, as project reports, drawings, etc. Thus, an integrated document management system might be a valuable support to the collaboration process.

(ix) Functions supporting interaction mechanisms

This group of functions aims to rise interactions and information sharing among users through the different OI sub-processes. Sharing knowledge is believed one of the key interaction mechanisms that allow organisations to create value (Garcia-Perez and Ayres, 2010). Interactions and information sharing mechanisms are in fact necessary to carry out efficiently the technology scouting, the external knowledge sourcing and all the activities for collaboration establishment. Jeed (2008) argues that using Web 2.0 tools or social software inside organisations improves interaction, knowledge sharing and innovation (Garcia-Perez and Ayres, 2010). Online social and professional networks are tools where employees can interact, while leveraging their identity, roles and skills. Thus, such approach and architecture might be inherited with a more “closed” fashion to support users’ communication and collaboration within the OI platform. To further facilitate the communication and the information sharing within the inbound OI process other useful tools such as instant messaging, chat and similar systems could be adopted for disseminating information to predefined groups of users with common needs. With this aim, push mechanisms such as mailing list, RSS and similar systems can be used for retrieving specific information from both the OI intranet and the interned. Finally, forums, blogs and similar tools are used to regularly post new information, commentaries, graphical elements, and videos about the project activities since they are particularly suited to communicate information in fast-changing domains.

(x) Functions supporting the access management

Access Management aims to grant authorized users the right to use a platform service including the availability of information resources, while preventing access to non-authorized users. It essentially allows the platform master defining and executing policies defined in Information Security Management of the company. Thus, this function supports the creation and management of different user profiles, adding or revoking rights to users and application of privacy constraints for contents. The OI platform in fact deals with high sensible data/contents and potentially risky innovation projects. The complexity of managing an OI process in such an electronic environment increases with the number of internal/external participants, scale and type of the network, number of information sources, communications, etc. In addition, responding to privacy and rights concerns is critical to guarantee a reliable and safe use of the systems and to enhance effective platform introduction and adoption. Subsequently, the OI platform has to implement methods for controlling access to information resources, as for example a single secure sign-on setting user's right based on the role in the organization. Users have to be associated to roles, functional groups, and related rights. Also, information resources should be mapped into functional groups. This means that information about users, roles, functional groups, resources, and associations among them have to be stored, frequently updated and dynamically managed into the OI platform. Depending on information exchanged, the Access Management function has also to implement an Event Management system to monitor users' activity in to the platform systematically and finally detecting unfair or risky behaviours. To this aim it has also to deal with users' ubiquity and related issues.

5. DISCUSSION AND CONCLUSION

Information and communication technologies provide firms with unprecedented tools to support their Open Innovation Processes, in that they provide new enabling factors for generating, sharing, retrieving and storing data, information or knowledge that could dramatically impact how organizations manage their boundaries (Bogers et al., forthcoming). However, although Open innovation is deeply affected by ICT, many are the aspects and questions that ICT poses when used to support firms in managing knowledge coming from external partners (Awazu et al., 2009; Cui et al., 2015). One specific aspect that remains scarcely investigated in the extant literature on the topic is the role of ICT platforms in enabling the connectivity and collaboration between different actors. Therefore, this is felt in the scientific community as a compelling gap which should feed the next research agenda on OI (Bogers et al., forthcoming). Nevertheless, also firms are more and more interested in using ICT to support OI processes. For example, this is the case of Leonardo Defence Unit, a firm operating in the military sector, with whom we started two years ago a collaboration project in order to implement a platform which could support its inbound Open Innovation processes: although Leonardo Defence Unit has been so far rather closed, its strategy aiming at operating in the civilian market by means of dual-purpose technologies, and hence its necessity to manage a larger portfolio of technologies and types of knowledge, determined the necessity to make its boundaries more porous. Therefore, its managers felt it was necessary an ICT tool which could support them in managing the inbound OI process: this is the starting point of the research in which Leonardo Defence Unit asked for our intervention and specifically to develop a platform which could support its inbound OI process. Given that existing platforms such as Innocentive and NineSigma are focused on specific aspects and given that we could not find platforms reported in the literature which could support the whole OI inbound process, the project in Leonardo Defence Unit was challenging from two points of view: on the one hand, while covering the above scientific gap, it could add to the extant literature, and, on the other, it could help the firm to achieve its objectives supporting collaboration projects and connectivity with the external partners by means of a specifically designed platform. Also, the access to Leonardo

Defence Unit at the organization's invitation, gave us the possibility to fruitfully understand the organization.

The proposed conceptual design comprises different functions that support many of the needs that the literature addresses when investigating inbound OI. As an example, we refer to supporting the external identification of technologies and external knowledge sources by means of formal sources (such as patents and publications), allow the internal identification of technologies and external knowledge sources by means of formal sources (e.g. checking suppliers and customers lists, internal documentation or reports about supplies, searching and consulting old/new projects) or identify interesting technologies and external knowledge sources by means of internal and external informal sources (in order to retrieve informal data both internally and externally).

As anticipated, the conceptual design of the platform is relevant for both the scientific community and Leonardo Defence Unit specifically and practitioners in general, as well. More exactly, firstly, this manuscript can contribute to research by showing how ICT can support firms in their OI processes and, secondly, it can support firms aiming to create a positive environment that encourages people at leveraging existing technological capabilities outside the boundaries of the organization (Hung and Chou, 2013) or at capturing and benefiting from external sources of knowledge in order to enhance current technological developments (Huizing, 2011).

As regards the literature, the progress in understanding the role of platforms in facilitating the OI process and enabling the collaboration between different partners, required the merging of two literature streams – that of OI and that of ICT - that to our best knowledge remained so far parallel, without cross-cutting fertilization. Therefore, this article goes in the direction of opening two 'ivory' towers (innovation management and information system literature), in that each of them can lever on the other in order to flourish and give a relevant contribution to the scientific debate and practical relevant problems. Some streams in the literature regarding knowledge management already investigated the role of ICT in facilitating the KM process (Griffith ey al., 2003; Koh and kim, 20014; Alavi and leidner, 2001; Von Krogh, 2012) and therefore this specific stream has been very helpful for designing the OI platform, being the inbound open innovation process a knowledge intensive process. However, with respect to that literature, several are the steps ahead. Firstly, the literature aims at illustrating that a variety of IT tools may be drawn upon for support of different KM processes (creation, storage/retrieval, transfer, and application; Alavi and Leidner, 2001) in organizations, but, while largely adopting a general approach, has failed to hone in specific organizational processes. A plentiful of ICT tools is reported, but they are not integrated in a process view; therefore, this approach does not really help firms, in that a thorough understanding of how ICT can support the OI process is lacking. This article instead, analysing the outside-in OI process, provides examples of 'coherent' ICT tools, i.e. ICT tools that support the same process, with obvious implications in terms of guidance for managerial practice (see below). Secondly, and in continuation with what just stated, this platform supports the whole inbound OI process and not specific phases or even very restricted aspects of the process, so assuming a process-wide perspective. As stated above, this constitutes a step forward with respect to ICT platforms (Innocentive, NineSigma, Yet2come.com) and tools (Bretschneider et al., 2015) already reported in the literature, in that firms which conceive OI as a unique process which starts from the technology scouting and the selection of both the partners and the technologies to be (co)developed/acquired, up to the definition of the organizational modes for the acquisition, need platforms which build on conceptual designs like this described here. While assuming a process perspective, this article not only goes in the direction assumed by the literature on OI in these very last years (West and Bogers, 2013; Slowiski and Sagal, 2010), but also makes a step forward, by suggesting the necessity to avoid the provision of ICT tools properly suited only for specific phases: ICT tools indeed have to support firms in managing the assets that the firm found and got from external sources in order to achieve its wants (Slowiski and Sagal, 2010). Just as the OI process is not partitioned, also ICT tools should be thought as integrated in order to support the whole process.

Thirdly, the platform conceptual design includes not only traditional ICT tools, but also Web 2.0 technologies. Although the results are not generalizable, it is possible to provide an initial answer to that part of the literature which asks for digging in cross-industry differences (Von Krogh, 2012). Indeed, the platform originates from the need of the Technological Developments business unit of Leonardo Defence System, to catch or open up new opportunities in the civilian market by exploiting dual-purpose technologies. This is why the business unit did not reject the possibility to use social software (for instance wikis), which the business unit itself would have not allowed, had the platform to be conceived strictly for the industry in which historically it operated (military industry). Indeed, in this last case, the severe rules on secrecy would have imposed the business unit to ensure that strategic and classified information and knowledge are the focus of more traditional rather than social software-based implementations.

Fourthly, this article departs from that part of the academic research which, although theoretically ground-breaking, forgets to propose relevant results to the managerial readership and loses any opportunity of helping firms to understand and act in a world in which many environmental factors make the possibility to sustain a closed innovation model more and more difficult.

The above explanation of the scientific relevance paves the way to the managerial contribution. Specifically, as concerns Leonardo Defence Unit and practitioners in general, although defined only at the conceptual design level, this platform is a first step in the direction of helping the Defence Unit at opening its boundaries to the external environment. As a consequence, the platform, if put in place, could help Leonardo Defence Unit in overcoming some of those problems that many times prevented firms from being successful with open innovation initiatives (Huston and Sakkab, 2006; Sarker et al., 2012). This, on its turn, could make the investment in open innovation worth the risks (Chesbrough and Garman, 2009).

From a practical perspective, this article provides suggestions regarding ICT tools that support the outside-in OI process. This is fruitful not only for the investigated firm, but more in general, for other firms that, aiming at opening their innovation process, can find examples of ICT that do not refer to sundry organisational processes but to the inbound OI process, so avoiding dissipating attention on ICT tools which may be not proper for such a process. So far, this platform, although being a stimulating starting point, conveys the contextual situation in which it has been conceived: the Technological Developments business unit of Leonardo Defence System indeed needed a platform which could support the whole inbound OI process and that could reflect its own specificities. Firms approaching similar challenges can and should obviously contextualize the platforms to their own setting. This could be done at the level of both OI phases and tools. As regards the supported phases of the inbound OI process, practitioners should also consider that the conceptual design of this platform is modular and therefore firms can adapt the platform to its own specificities, adding or removing functions which are (not) judged useful. As regards tools, firms could conceive a different contribution from social software respect to more traditional tools, depending on the industry in which they work. For instance, the speed with which information and knowledge becomes obsolete could impose a greater reliance on web 2.0 technologies.

The research also presents some limitations, mostly due to the limited generalizability of findings and the nature of conceptual design which draws on the opportunities and needs of a single application settings. Also, results are mainly conceptual in nature and are still not implemented or validated. Future developments of this work should take into consideration to further advance the design process concerning the ICT platform to the detailed design phase and also to find ways and funding for its implementation and testing. Finally, we could also plan for an extension of the present study to other application contexts in order to enrich and also verify the conceptual proposal.

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