

Towards an impact evaluation framework for the collaborative information supply chain in humanitarian crisis response

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ABSTRACT

Emerging technologies provide opportunities for the humanitarian responders' community to enhance the effectiveness of their response to crisis situations. A part of this development can be contributed to a new type of information supply chains -driven by collaboration with digital, online communities- enabling organizations to make better informed decisions. However, how exactly and to what extent this collaboration impacts the decision making process is unknown. To improve these new information exchanges and the corresponding systems, an evaluation method is needed to assess the performance of these processes and systems. This paper builds on existing evaluation methods for information systems and design principles to propose such an impact evaluation framework. The proposed framework has been applied in a case study to demonstrate its potential to identify areas for further improvement in the (online) collaboration between information suppliers and users.

Keywords

Impact evaluation, systems development, information supply chain, requirement analysis, user participation

INTRODUCTION

In recent years new opportunities have arisen for humanitarian relief providers due to an ever more connected world and the technological advancements in the field of computer science and software engineering. These opportunities are described in the Disaster Relief 2.0 document:

“Powered by cloud-, crowd-, and SMS-based technologies, individuals can now engage in disaster response at an unprecedented level. Traditional relief organizations, volunteers, and affected communities alike can, when working together, provide, aggregate and analyze information that speeds, targets and improves humanitarian relief. This trend toward communications driven by and centered on people is challenging and changing the nature of humanitarian aid in emergencies.” (Harvard Humanitarian Initiative, 2011)

In response to the mentioned disaster relief 2.0 the Digital Humanitarian Network (DHN), a network of Volunteer & Technical Communities (V&TCs), has been formed. The DHN is a group of independent people and organizations from many different countries assisting the United Nations Office for the Coordination of Humanitarian Affairs (UN OCHA), other UN organizations and NGO's. The DHN focuses on providing information products to key-decision makers in crisis situations. The DHN aggregates information from a variety of sources, processes it and disseminates the information through a variety of information products (IP) using information systems (IS) setup and maintained by the DHN. One of the first deployments, LibyaCrisisMap.net - supported by volunteers from around the globe- was highly successful and encouraged UN OCHA to further investigate the possibilities of using the DHN to improve its (remote) information management support.

Impact analysis need

According to some decision makers, the DHN bodies have already made an important contribution in the efficiency of information gathering, processing and dispersal as demonstrated by the Libya Crisis Map and in the Haiti deployments (Clark et al., 2010; Liu et al., 2010; Margesson and Taft-Morales, 2010; Morrow et al., 2011; Munro, 2010). It is however important to the UN OCHA and other coordinating bodies to be able to determine and examine this impact in more detail for three reasons: (1) the results of an impact analysis (IA) can be used *externally* to demonstrate the effectiveness of the DHN and secure the needed resources for the DHN to continue their work; (2) the results from the IA can be used *internally* to evaluate products and systems delivered by the DHN and (3) due to the voluntary nature of the project, *providing feedback* to the participants and organizations

is important to increase their motivation to continue their efforts (McCurley and Lynch (1989). Therefore UN OCHA has formulated a Community of Interest to investigate the possibilities to determine the impact of the DHN deployments. This research is one of the results from this collaborative effort between UN OCHA, Tilburg University and the Harvard Humanitarian Initiative.

RESEARCH SETUP

Improving the response of the DHN requires a structured evaluation method. Taking the earlier mentioned reasons into consideration, the intended framework has a broader scope than existing frameworks: the focus would not merely be on the efficiency of information systems, but also the overall performance of the DHN and the value they bring to a variety of end-users of the supplied information products. Depicted in Figure 1 is the breakdown of the *impact structure* of the DHN in a crisis response.

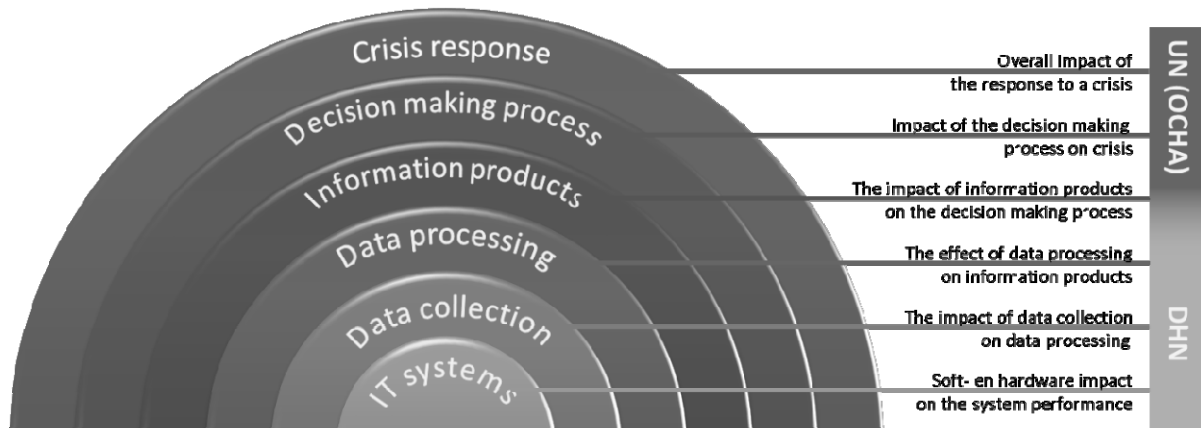


Figure 1. Impact levels

The diagram, drawn from the perspective of the DHN, shows that the impact consists of two major parts. The inner most part is concerned with the internal evaluation of the information systems and supply chain of the DHN. All of these processes impact their *parent level*, for example the quality of the provided software will positively affect the data collection and processing level. At a higher level the impact of the organized response to a crisis depends on the decision making process: mainly the quality of the decision being made. Which in turn is affected by the supplied information products. At some point in this information supply chain information products are handed over to entities outside the DHN. This point plays an important role in determining the impact of the DHN on the overall response to a crisis. This leaves two major parts that need to be considered by an evaluation framework. First the evaluation considers the *internal* efficiency of the information system and product delivery within the DHN, applying to the first levels of the impact structure. Next, the *external* impact of an information system, in this case the impact on decision makers, is considered: illustrated in the diagram above as the transition between the DHN and UN OCHA. This aspect of the impact evaluation will provide the DHN with the insight to determine the extent to which their supplied information products are used.

Research design

In order to determine this impact, a framework is needed to define and capture the impact. For this design we examined the principles of existing evaluation frameworks in general and for information systems and information products in particular. Next we consider how these design principles can be integrated with the specific requirements for an evaluation framework for the DHN, resulting in an evaluation framework design. Finally the framework is tested on a small scale using two case studies.

Cases

Using the framework, we analyzed a previous deployment of the DHN focusing on the in-field decision makers and coordinators using information products supplied by the DHN for their decisions and operations. These results will be contrasted with a non-volunteer based development of an information system for a humanitarian NGO. These outcomes will be reviewed in interviews in order to determine the accuracy of the framework. Although a case study approach will not provide sufficient results to reject or accept the framework as 'accurate' or 'useful', it will however demonstrate the frameworks' potential (Kaplan and Duchon 1988; Gable 1994).

RELATED WORK

For the design of the impact evaluation framework we look to the design of existing frameworks for information systems. In particular we look to different evaluation applications, their objectives and how these are designed. First, we can categorize the evaluation and impact assessment methods based on their application and purpose. Some methods aim specifically to measure the impact when a change has been made or a solution has been implemented, commonly known as *impact evaluation* methods (Rawlings and Rubio, 2005). These methods attribute intended and the unintended changes to a particular intervention, such as a project, program or policy (White, 2006). *Impact assessment* methods focus more on 'predicting' the impact (Roche, 1999), i.e. before the actual change or solution is implemented. These methods are closely related to the decision making process, as the methods are commonly applied prior to the actual intervention. Finally, *program evaluation methods* are used to analyze programs and in particular their effectiveness and efficiency. These evaluation methods are used to evaluate programs consisting of multiple projects.

Defining impact in system performance

Looking more closely to the focus of an evaluation, two main approaches exist: summative and formative evaluation (Bloom, 1971; Scriven, 1991; Worthen et al., 1997). *Summative evaluation* takes place at the end of a project or program. The focus of a summative evaluation is to determine to what extent certain objectives have been accomplished. *Formative evaluation* (Sadler, 1989; Scriven, 1967) has a stronger focus on the modification of the processes. This type of evaluation is used to rate or determine the effectiveness of the process used to teach or learn. In the summative approach the focus is more on whether or not certain (pre-determined) objectives have been achieved, the formative approach assesses the efficiency of the learning process.

Similar to these general evaluation approaches, in the context of information system evaluation two general views can be taken, each with its own focus. In the *goal-centered* view the performance of IT systems is evaluated using the objectives set for either the system itself or the organizational units using the system (Kriebei and Raviv, 1980). These objectives are used to develop criteria to assess to what extent the objectives have been achieved. In the *system-resource view*, the effectiveness is determined by the level in which a normative state is attained. In the system-resource view, rather than objectives, the viability of resource is considered to be a measure for effectiveness. Measured resources can be human (participation), technological (service levels) or financial (return on investment). The system-resource view considers that a system may fulfill other functions than the pre-determined, official or formalized objectives.

In both the goal-centered and the system-resource view the scope of the evaluation is not limited to the technical aspect of a system. The intended objectives when developing and implementing systems are rarely defined as a pure technical (IT) specification; however these can or should be a sub-objective. When evaluating systems the chosen approach will depend partly on the considered view. In practice, the two views should converge; for example, to explain the (lack of) success in achieving the objectives, the system-resources should be considered.

System objectives

In general, the primary objective of any system is to improve the ability of the organization to accomplish its strategic objectives. Evaluation methods rely on the definition of these objectives to determine how well the system is performing (Ginzberg, 1979; King, 1978; McLean and Soden, 1977). To classify these various objectives again two perspectives can be taken.

The *efficiency-oriented* perspective looks at the efficiency with which the system is provided to the user. In other words, the extent to which the development of a system is optimized (Norton and Rau, 1978). The objectives for the efficiency-oriented perspective can be stated in four levels: *systems, resource consumption, capability and investments* (see Table 1). The *effectiveness-oriented* perspective looks at the level at which the systems are used to accomplish the organizational objectives (Campbell, 1977; Molnar and Rogers, 2005; Quinn and Rohrbaugh, 1981). In other words: the extent to which a system is enabling the organization to achieve its goals. The objectives for this perspective can be categorized in three levels: *information & support, process & user performance* and *organizational performance*.

To accurately describe the impact of a system, the performance has to be considered in light of both the efficiency with which the system has been developed and the change in the effectiveness on the individual users and the organization. For example, if a system increases the organizational performance but requires a significant amount of resources to be developed, the overall impact may not be optimal. Hamilton and Chervany have created a classification to list and compare the different objectives and their scope found in system evaluation outlined in table 1 (Hamilton and Chervany, 1981).

Lower level objectives may have a limited scope, but have less interference from external influences and can

more accurately attribute the outcome of the measurements to the implemented change, while higher level objectives are used to assess the overall impact caused by the introduction of information systems and products.

System-efficiency				System-effectiveness			
Level	Objective	Measurement		Level	Objective	Measurement	
0	Systems	Technical compliance	Testing, use of standards, uptime				
		Design quality	User test, functional design, interface, requirements				
		Governance	Documentation, security, auditing.				
1	Resource consumption	Budget	Budget & expenses,	Information & support	Information quality	Data accuracy, scope, relevance, reliability	
		Schedule	Schedule and the actual completion.		Presentation form	Simplicity, graphical, availability, documentation	
		Participation	Involvement, existing resources used		Information quantity	Access to new or more data, more sources	
2	Capability	Available capacity	Productivity, response time, backlog	Process & user performance	Reduced processing	Automation of manual tasks, processing of data	
		Job satisfaction	Performance, percentage of sick leave		Decision making	Understanding of problem, confidence in decision	
3	Investments	Training	Training expenditures, staff investments.	Organizational performance	Financial	Sales revenue, profit contribution, ROI	
		Capital investments	Hardware investments, capital expenditures		Customer	Customer satisfaction, regulation compliance	
					Organization	Morale, image and reputation, advocacy	

Table 1 Levels, objectives & measurements for evaluating a management information system (Hamilton and Chervany, 1981)

IMPACT ANALYSIS FOR THE DHN

Taking the mentioned considerations into account, developing an evaluation framework includes the definition of the (1) objective, (2) scope, (3) measurements and (4) indicators. Using these properties we look at specific requirements of the evaluation framework for the collaborative information supply such as the DHN. We especially consider the specific measurements and indicators in relation to the introduced evaluation theory.

Objective

The reason for the interest in the development of an impact analysis method for DHN organizations is threefold: (1) demonstrate the effectiveness of the DHN aiding in securing resources and advocate the work of the DHN, (2) determine the most effective way to deploy the DHN and (3) provide feedback. Once the DHN has been deployed it is important to know how efficient and effective the response is and how this can be improved (Briceño and Gaarder, 2009; Fitz-Gibbon and Morris, 1987). This will allow UN OCHA and the DHN to adjust their efforts in order to maximize the impact of the action undertaken by the DHN (Rossi et al., 2004). Furthermore the results will also enable parties to extract lessons learned for future improvements (White, 2009).

Scope

A DHN deployment depends on requests received from either a coordinating body, such as UN OCHA, or decision makers from other agencies. These requests are collected, evaluated and put into action, resulting in the activation of the DHN. Figure 2 illustrates this process in more detail. This general process applies to a certain extent to every deployment, although its specific setup may differ between deployments.

In this generalized information flow several important exchange points are indicated. These handover moments exist between the coordinating organization, the DHN and the decision makers. Since the focus of this research is on the impact the information generation efforts have, these exchange points play an important role. Consider a supply chain where the output from one stage forms the input for the next: impact is then determined by the influence the work in one stage has on the success of the next (Gelderman, 1998). The final exchange point in this collaborative information supply chain is the transfer of information products from the DHN organization to the decision makers, illustrated in Figure 2 as the transfer from C to D. This exchange point is the main focus of this research as it determines to impact of the information products on the decision making process.

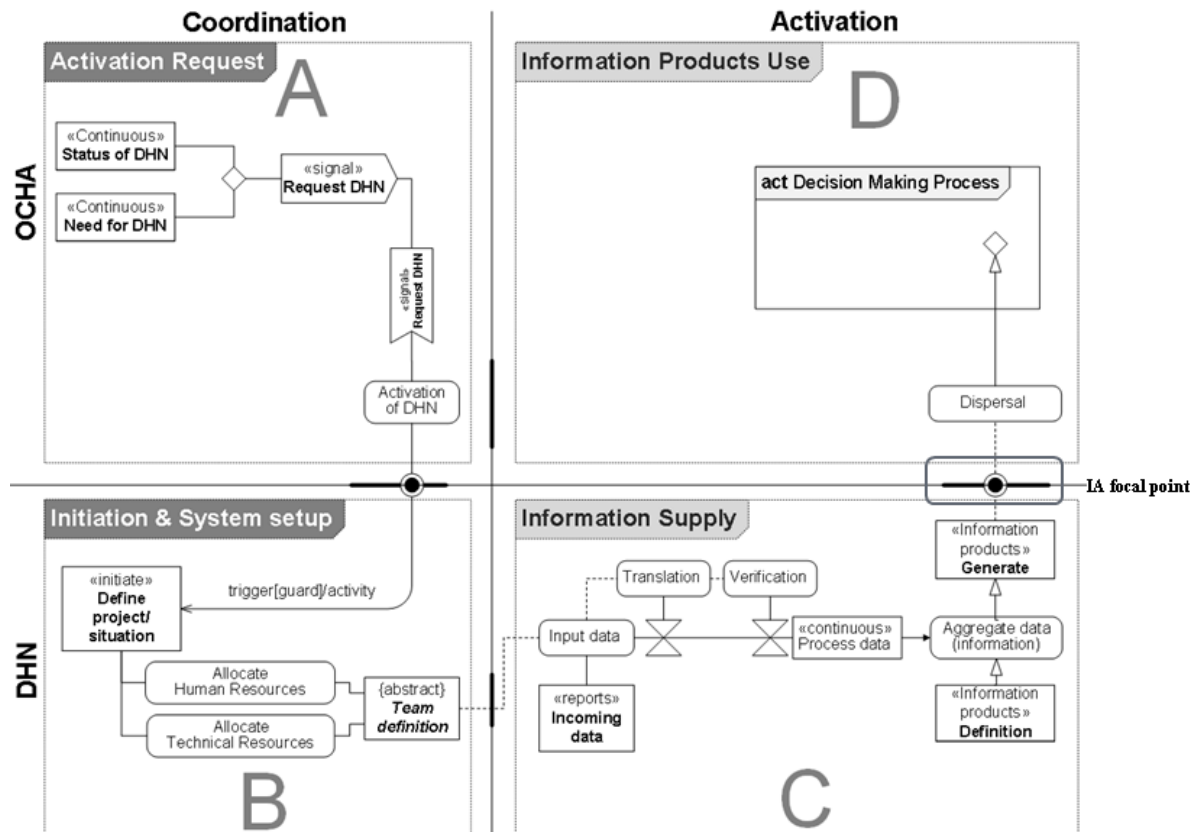


Figure 2 DHN coordination, activation and product delivery process

Measurement

Both sides of this exchange point have their own distinct dimensions for determining the impact of the information products. Considering the theoretical base of impact evaluation introduced earlier, this exchange can be described in terms of the *efficiency-oriented perspective* and the *effectiveness-oriented perspective*.

Efficiency-oriented levels				Effectiveness-oriented levels		
Level	Description	Application to DHN	Quadrant	Description	Application to DHN	Quadrant
0	Requirements definition	Received request project definition	A/B			
1	Use of resources needed	Team composition, tech. resources	B	Information Support & Providing information products		C/D
2	Resources capability	Team competences, specialties	B/C	Process user performance & Usage in decision making process		D
3	Resources investments	DHN knowledge and technical investment	C	Organizational performance & Impact on crisis response effectiveness		D

Table 2. Mapping efficiency and effectiveness levels to DHN process

The different levels correspond to the steps described in the process of DHN’s information product generation as shown in figure 2. The first steps, depicted in quadrant A, of this process focus on the project definition, similar to level 0 of the *efficiency-oriented perspective* of information system development depicted in table 2. The allocation of the resources (quadrant B) corresponds to Level 1 and the capability of the resources used to level 2. Finally the level the team invests in their knowledge and other resources can be considered part of level 3.

The use and effect of these products corresponds with the *effectiveness-oriented perspective*. Providing information and support on developed tools to (in-field) agencies, corresponds with Level 1. Increasing the effectiveness of the decision makers and processes using the supplied products can be classified as Level 2. The overall effectiveness of the decisions and the effectiveness of the response can be considered Level 3. In the scope of this research we consider the impact of the delivered products on the decision makers and the decision making process, reflected by level 2. The provided information itself and the included support are inherently a part of this as well. However the performance or quality of the decisions outcome is not considered. The final mapping of the measurements in the context of the DHN to the taxonomy of the impact analysis domain is depicted in Figure 3.

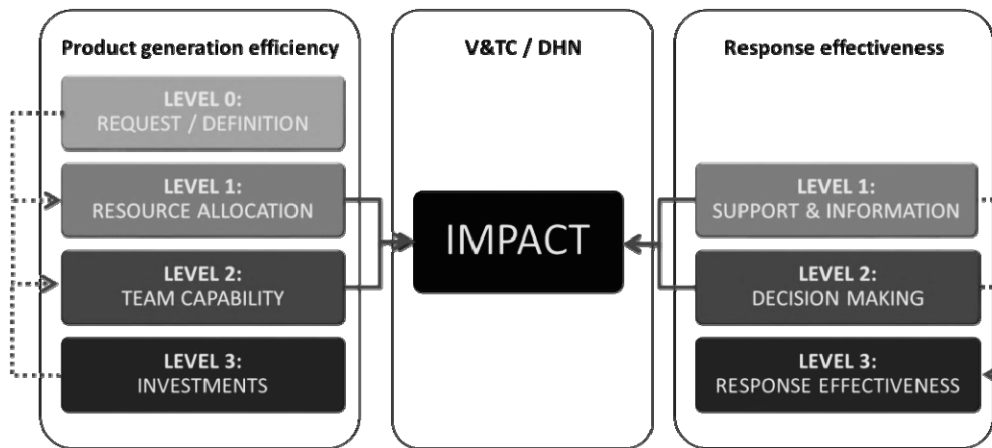


Figure 3. System measurement levels and impact relations

Indicators

The measurements used to evaluate the impact of the provided information products and systems, require translation to measurable indicators applied to the DHN field. Existing frameworks can aid in this translation process by providing indicators used in the industry. Indicators, used to assess *the development of information products and systems* can be derived from the *Post Installation Review* (Cooper, 1988). The provided indicators in this method match closely with the *Level 1: Resource allocation (consumption)* and *Level 2: decision making (performance and process)*. Additionally the *MIS Personnel Productivity measurement* (Myers et al., 1997) provides potential indicators that can be used to describe *Level 2: Team capability (production capability)*. Since the DHN is voluntary in nature, some of these indicators have a limited value, a different meaning or other significance. They do however provide an overview of variables to be used in evaluating the efforts of information product and system development (Ein-Dor and Segev, 1978; Pitt et al., 1995). Table 3 provides an overview of the used indicators in the design of the evaluation framework applied to the DHN situation.

The assessment of the *usage of the information products* consists of two sets of objectives in this research (Figure 3). The first set is concerned with the effectiveness of the information products themselves, which mainly includes the quality of the provided information products and their underlying systems. The second set of objectives considers the impact the products have on the performance of the users and their organization. These measures (Delone and McLean, 2002; Norton and Rau, 1978) are considered from the perspective of the user.

IS/IP development performance measure				IP usage performance measure			
Level	Objective	Measure	Applied to DHN	Level	Objective	Measure	Applied to DHN
1. Resources	System development	Facilities allocation	Availability of required (tech.) facilities	1. Information	System quality	Usability	Ease of use, matching needs
		Schedule compliance	Time required to setup required systems			System features	Customization of information products
		Requirements definition	The clarity of requested products			Availability	Ease to reach, uptime, access
	Operational resources	Data collection	Time/effort required to analyze data		Information quality	Understandability	Presentation of gathered information
		System maintenance	Time/effort required to maintain system			Consistency	Provided information is consistent
		Training support	Efforts for user assistance.			Importance	Relevance of provided information
2. Capabilities	Team capacity	Productivity rate	Level of DHN deployment	2. Decision making processes	Individual impact	Awareness / Recall	Better situational awareness
		Required man-hours	The total amount of hours used			Decision effectiveness	Enhanced effectiveness of job
	Operational capability	Throughput	Products delivered, users served		Individual productivity	Increased personal productivity	
		Utilization rate	Hours to product ratio		Organization impact	Awareness / Recall	Information products save resources
		Response time	Turn-around time on specific requests	Decision effectiveness		Increased effectiveness of operations	
				Organizational productivity	Improve outcomes of processes		

Table 3. Applied IS/IP development and usage performance measurements

Survey setup

To conduct the impact analysis, a survey consisting of two parts, is designed. The first part considers the efficiency-oriented perspective and is intended for the suppliers of the information products and systems. The second part focusses on the effectiveness-oriented perspective and on the users of the supplied products and systems. Both parts present several statements for each measurement defined in table 3 to the subjects. A likert-scale is used to capture the attitude of individuals towards the statements in regards to the systems and products of that particular case. The exact details of the survey, including the questions will be made available online. For the initial small scale test of the proposed evaluation framework 7 information suppliers and 12 information consumers completed the survey for the DHN deployment (Haiti), and 4 suppliers and 7 consumers for the NGO information system deployment.

Case studies

The design study of the impact evaluation and survey have been conducted in an in-field research in Port-au-Prince, Haiti. In the aftermath of the 2010 earthquake in Haiti, several DHN bodies have offered their services to assist decision makers. One of these DHN initiatives was based on the Ushahidi platform, facilitated and managed by volunteers this platform, enabled decision makers to enhance their situational awareness. (Liu et al., 2010; Munro, 2010). At the time of the research the (initial) emergency response to the earthquake disaster was over. However some decision makers remained in the country to support the ongoing humanitarian operations. These persons have been asked to participate in formulating the requirements of the impact analysis framework, test the survey and review the results in the post-survey interview.

NGOs use the supplied information products from official sources such as those supplied governmental or UN agencies, but also develop their own information systems. At the time of the research the humanitarian organizations active in Haiti are in transition from response/recovery operations to reconstruction focused projects. Due to this shift in the operations NGOs are transitioning from ad-hoc created spreadsheets to more structured and rigid information systems. The development and implementation of these systems and products is done for example by external consultants or by own (management) employees. Due to the opportunity to do field research in Haiti the scope has been extended to also include the provision of these information systems. Broadening the research allows additional validation of the results from the evaluation for DHN supplied systems against the 'normal' provision of information systems for non-governmental organizations, illustrating the difference in impact between these two cases.

RESULTS

In the section the results from the survey are presented and interpreted. The results for each level of both cases have been plotted in diagrams, illustrating the perceived differences between the deployments. These differences are further examined and interpreted in the conducted post-survey interviews with the participating subjects.

Information products supply

The combined survey results for the information supply (efficiency-oriented perspective) are depicted in figure 4. At the resource level (1), the facilities of the DHN deployment are valued high as the DHN community has the required technical facilities readily available or on standby, whereas in the NGO deployment the technical abilities and schedule compliance is valued lower as their systems are custom build. However the requirement analysis in this NGO deployment appears to be stronger. Both deployments provide quite some training, support and communication efforts. The DHN seems to mainly provide and receive this support through coordinating organizations. In the NGO deployment more direct interaction between the developers and users is established.

In the two deployments the team capacity was used in an equal optimal way, although the impact of longer deployments (time-wise) on the team should be considered. In both deployments the perceived usage of the supplied products corresponded with the development efforts, indicating that the work according to the development teams was worthwhile. The operational capability shows that the DHN outperforms the NGO deployment in most areas, especially in regards to the turnaround time between data-collection (input) and the release of information products.

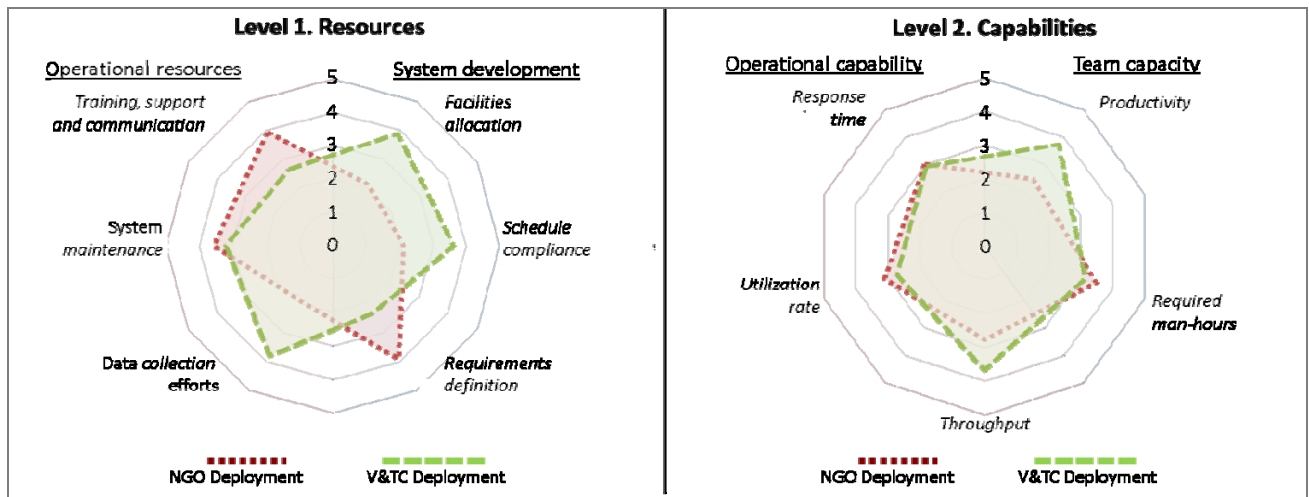


Figure 4 Information supply survey results

Information products usage

The survey results from information product usage (effectiveness-oriented perspective) are presented in figure 5. Users indicate that both systems at the very least do what they are supposed to do. Systems and products are accessible, current and available whenever users need them to be. Contrasted with the NGO deployment the DHN systems have a higher score when it comes to the availability, usability and especially features. In general, the information and information products provided by the DHN system have a high value for the individual users; they are consistent and understandable.

The results do however show an important difference in regards to the *capacity increase*. According to the surveyed users the information systems and products provided by the DHN have a strong individual impact, however the organizational impact shows room for further improvement. This is mainly reflected by the difference in capacity increase between the deployments, as shown in figure 5 – Level 2. Processes.

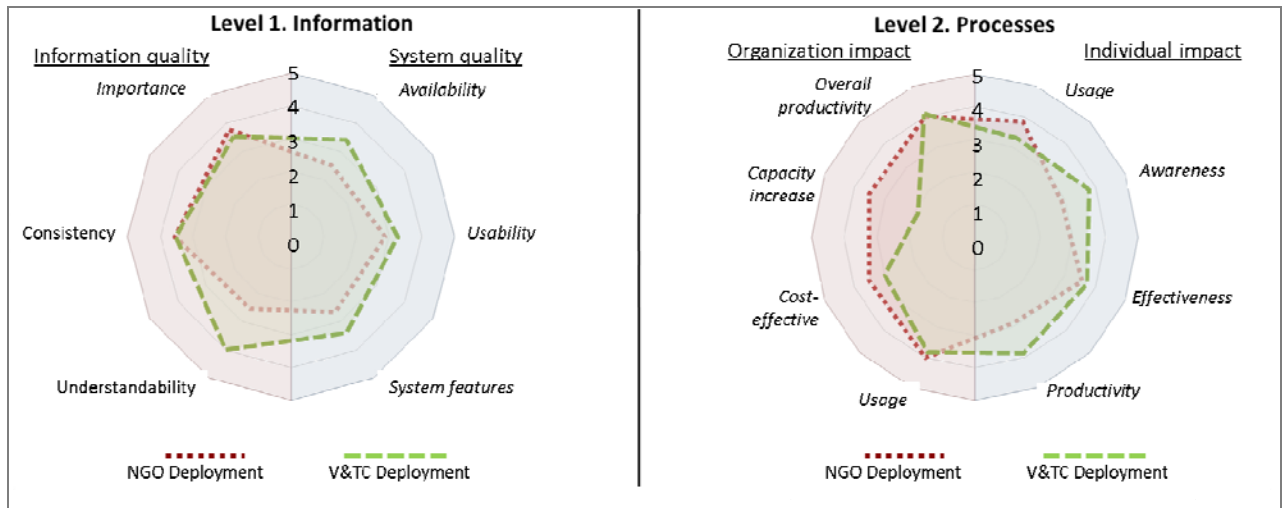


Figure 5 Information usage survey results

Post survey interviews

The DHN community consists mainly of experts in their respective field. They use the knowledge and experience from their professional life when working as a volunteer during a deployment. In some cases this even extends to the resources being used or available as confirmed by the survey results. Volunteers who supplied and maintained the information system already possess the necessary knowledge to use or maintain these systems or could easily acquire this knowledge. The technical resources (systems) required for the deployment were also either available or could easily be setup, partly due to the experience, skills or work-related opportunities.

One aspect stands out in the results of this evaluation: according to the survey results the requirements

engineering aspect of system development is 'under performing' relative to the other system development attributes. Participants confirmed in the interviews that compared to 'regular' system development projects users and their requirements are less clear and known in advance. Participants stated it was necessary to make assumptions based on either previous experience or the limited requirements information available. Furthermore the distance between the information product suppliers and users of these products impeded feedback loops.

Finally, considering the usage of the information products, the survey results indicate that the supplied information products are welcomed by individual users and help to increase the situational awareness. Although users may occasionally or even frequently rely on the products provided by the DHN, they are not embedded in the organizational structures of the organization and have a limited impact on the organizational capacity compared to the NGO deployment.

DISCUSSION

Although some similarities exist between both deployments, the survey and interview results have shown an important difference. The DHN can provide quick deployments, for example with a low turnaround time, where the development of an internal information system takes longer. Another, related, difference is the feedback loop from the users to the developers. Compared to the NGO deployment the DHN is less 'connected' with the end-users in terms of requirement analysis and requests, despite the shorter and more agile like development cycle. The NGO deployment may have a longer incubation time, but incorporates the users more in the development and support cycle.

More generally, the survey and the results thereof may have a limited value when evaluating the increase in quality of decisions based on DHN information products. It does however help to identify potential improvements to increase the efficiency and effectiveness, either during or after a deployment, of information products on the decision making process. In this case for example, coordinators could reconsider their role in the process: facilitating a feedback process between suppliers and users, reducing the information supply chain distance and increasing the effectiveness of the information supply chain (Markus and Keil, 1994). Furthermore, to increase the effectiveness, organizations could consider integrating the collaboration with the DHN in their operational routines.

CONCLUSION

The framework presented here is designed to determine and improve the impact of information products and systems in a collaborative information supply chain. In a collaborative information supply chain, such as the DHN, different parties most often physically separated, exchange information products. In such a situation a new evaluation approach is required that recognizes this separation, in both the evaluation itself as well as the application thereof. By integrating the efficiency and effectiveness evaluation perspectives and applying it to a collaborative information supply chain, the presented framework aims to establish a more comprehensive understanding on how information systems in a collaborative effort perform.

LIMITATIONS & FUTURE RESEARCH

As a key element of the DHN, the fact that volunteers from all over the world can help is something of which the impact in particular needs to be determined. The impact analysis could for example demonstrate that in certain cases, remote support can be less, equally or even more useful than local incentives. This aspect of the evaluation method could be defined by a categorical variable (remote, local, both etc.) and compared between various deployments. The results presented here are indicative and explorative and a follow up empirical study is needed to generalize the findings. This will lead, through an iterative process, to further refinements of the evaluation method and its application. Ideally these same methods could be applied to other information systems put into use during a crisis. It could prove useful for organizations to evaluate their information supply chain and identify points for further improvements. This emphasizes the need to include both the internal effectiveness evaluation and the external impact of the supplied information products.

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