Mapping a response: Using satellite images to aid humanitarian action

Matt Thomas with
Alice Obrecht

CASE STUDY

HIF humanitarian innovation fund

ALNAP

The **Humanitarian Innovation Fund (HIF)** supports organisations and individuals to identify, nurture, and share innovative and scalable solutions to the challenges facing effective humanitarian assistance. The HIF is a programme managed by ELRHA. **www.humanitarianinnovation.org**

ALNAP is a unique system-wide network dedicated to improving humanitarian performance through increased learning and accountability. **www.alnap.org**

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Front and back cover photo: Satellite image of Tacloban, Philippines from HOT's beta version of OpenAerialMap.org. Credit: beta.openaerialmap.org

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HIF-ALNAP case studies on successful innovation

This study is one in a series of 15 case studies, undertaken by ALNAP in partnership with ELRHA's Humanitarian Innovation Fund (HIF), exploring the dynamics of successful innovation processes in humanitarian action. They examine what good practice in humanitarian innovation looks like, what approaches and tools organisations have used to innovate in the humanitarian system, what the barriers to innovation are for individual organisations, and how they can be overcome.

About the case studies

Case study subjects are selected from a pool of recipients of grants from the HIF. The HIF awards grants of between £20,000 and £150,000 to support the recognition, invention, development, implementation and diffusion stages of the innovation process. The HIF selects grantees on the basis of a variety of criteria designed to achieve a robust representation of the range of activity in humanitarian innovation.

The case study subjects are chosen to reflect innovation practice in the humanitarian system. They cover information communication technology (ICT) innovations and non-ICT innovations, and they offer a balance between innovations that have reached a diffusion stage and those that have not. They also reflect the wide geographic range of the areas where innovations are being trialled and implemented. (For more information on the methodology and criteria used to select case study subjects, see the forthcoming 'Synthesis report' for the case study series).

About HIF-ALNAP research on successful innovation in humanitarian action

These case studies are part of a broader research partnership between ALNAP and Enhancing Learning and Research for Humanitarian Assistance (ELRHA) that seeks to define and understand what successful innovation looks like in the humanitarian sector. The ultimate aim of this research is to improve humanitarian actors' understanding of how to undertake and support innovative programming in practice. This research partnership builds on ALNAP's long-running work on innovation in the humanitarian system, beginning with its 2009 study, Innovations in International Humanitarian Action, and draws on the experience of the HIF grantees, which offer a realistic picture of how innovation actually happens in humanitarian settings.

Innovation is a relatively new area of work in humanitarian action, yet it is one that has seen exponential growth in terms of research, funding and activity at both policy and programming levels. While the knowledge base around innovation in the humanitarian sector is increasing, there remain a number of key questions for humanitarian organisations that may be seeking to initiate or expand their innovation capacity. The HIF-ALNAP research has focused on three of these:

Primary research questions

What does successful humanitarian innovation look like?

What are the practices organisations can adopt to innovate successfully for humanitarian purposes?

Secondary research question

What are the barriers to innovation in the sector and how can they be mitigated?

The case studies will be used to produce a synthesis document that addresses these three questions. The outputs of this research are aimed at humanitarian organisations interested in using innovative practices to improve their performance, as well as organisations outside the humanitarian sector, such as academic institutions or private companies, seeking to engage in innovation in humanitarian action.

1. About this case study

Organisation	Humanitarian OpenStreetMap Team
Partners	Development Seed; Azavea
Project	OpenAerialMap

Grant	Start date	Grant period	Total HIF budget	Location
Development	1 March 2014	17 months	£119,159	Global

Humanitarian OpenStreetMap Team (HOT), established in 2010, is a non-profit organisation that creates and provides maps to support humanitarian organisations in their response to conflict or natural disasters. They do this through collecting data, coordinating the design and development of OpenStreetMap (OSM) tools and documentation, teaching data quality assurance and collaborating with data imagery providers.

Today, aerial imagery is available from a variety of sources, including traditional satellites, nano satellites, manned and unmanned aircrafts, balloons and kites. This imagery can benefit humanitarian organisations in their response to disasters, but it is often difficult to share and access the data acquired efficiently, given the lack of a centralised digital index and an inability to turn imagery into useful maps for humanitarian response. Previously, the process of developing maps from imagery was painstakingly slow and it required a great deal of time from highly technically skilled individuals to patch different formatted images together.

The need for a system that enabled sharing of imagery and a centralised index for searching, as well as a process for translating images into useful maps, was first identified back in 2006 by graduates of San Diego State University as they sought to map imagery taken by drones. In order to address this challenge, experts in crisis mapping began to gather and discuss possible solutions to the identified need. HOT began to coordinate this community following its establishment in 2010.

HOT gathered a network of interested crisis mappers around the development of Open Aerial Mapping (OAM), an open source set of tools that would provide functions for hosting, uploading, sharing, searching, filtering, displaying, downloading and using imagery data. These discussions and additional face-to-face meetings with image providers generated a clear plan for the development of OAM. Software developers Development Seed and Azavea were commissioned to develop the final solution.

OAM consists of three main components: a database of aerial images, called a 'catalogue'; the functionality to search for images, called the 'browser'; and the underpinning 'server'. These enable humanitarian actors to search for, gather and utilise imagery swiftly. It also enables those who capture imagery to more easily share it with humanitarian responders to generate maps. The HOT OAM project has enabled significant learning around the challenges and technical approaches to improving the sharing and availability of aerial imagery. It also appears to offer an improvement over prior practice with regard to the sourcing of relevant map imagery for use in humanitarian response. At the time of completing this case study, the OAM had only just launched, therefore it is too soon to determine its contribution to a more timely and relevant humanitarian response or assess how successful the project has been in inspiring wide adoption.

The case study is based on a review of project literature and 12 interviews with project staff, partner staff, advisors and wider stakeholders across the humanitarian sector over two months in 2015.

2. The Problem

Up-to-date imagery is very helpful in providing a clear overview of the emergency situation in the aftermath of a disaster.[1] Humanitarian responders use it for many purposes, including using images to assess the boundaries of an affected area following natural disasters to indicate the extent of the damage and the impact on infrastructure.

Imagery can also support the logistical orchestration of relief operations, including estimating numbers of affected people; tracking cases for transmittable disease in epidemics; tracking displacement; identifying hazards; locating water sources, suitable areas for food drops and safe roads for transporting goods and staff; and pinpointing terrain that is suitable for radio communication.

Geographic information derived from imagery can provide a solid foundation for the efficient planning and distribution of aid in a response.[2]/[3] But unfortunately time is often lost in locating, accessing and collecting aerial imagery, limiting the effectiveness and speed of the response.[4]

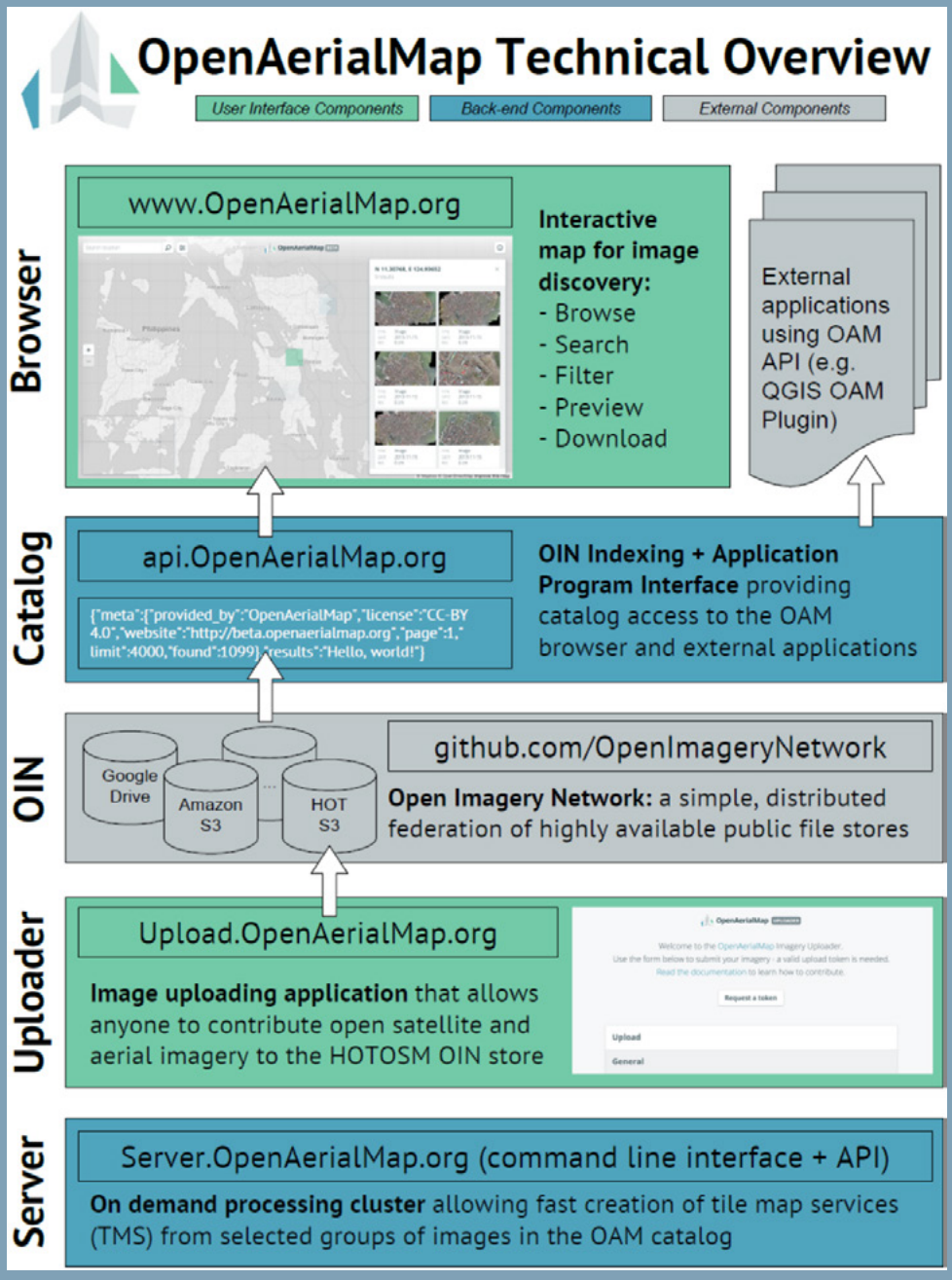
Aerial imagery is becoming increasingly available with the rise in unmanned aerial vehicle (UAV) use and cheaper satellites. The imagery is then stored on the servers of those capturing the images, which means after a disaster it is difficult to determine what imagery is available and how to access it.

Following the 2010 earthquake in Haiti, there was a flood of freely available imagery from satellite companies, organisations and individuals with UAVs. It was the first time imagery had been available in this volume and at this speed. Much of this imagery was provided in a raw format.[5] This required a substantial effort, mostly by volunteers on donated servers, to make the imagery available to the response community in a suitable format. Similarly, after Typhoon Haiyan hit the Philippines in November 2013, a great deal of imagery was made available from a variety of sources in many formats. However, there was still no digital index to see what imagery was available; nor was there a place where those who had imagery could share it easily with others.

The cost of addressing this problem was too great in 2006, when Cristiano Giovando and his colleagues first identified it. However, a significant increase in the availability of open imagery,

advancements in computer intelligence and improved data storage capabilities mean a solution is now far cheaper and therefore attainable. Previous attempts, such as the OAM prototype developed by Schuyler Erle and Chris Schmidt – members of the crisis mapper community: a community of experts, practitioners, policy-makers, technologists, researchers, journalists, scholars, hackers and skilled volunteers engaged at the intersection of humanitarian crises, technology development, crowd-sourcing and crisis-mapping – in 2010, have failed to produce a long-term solution because of issues related to the scalability of hosting data and licensing.

Figure 1: OAM Technical Overview



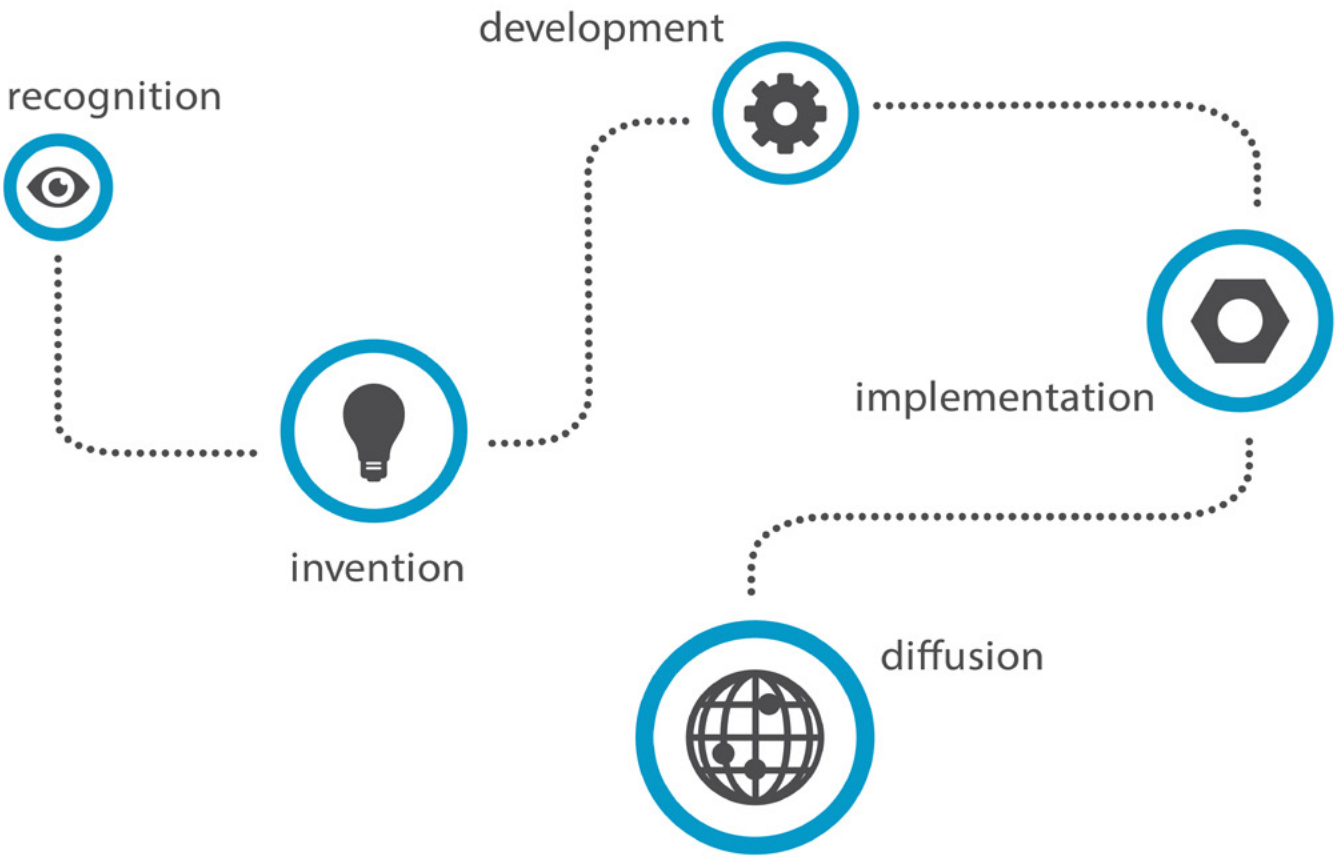
3. The innovation process

The stages through which successful innovations progress are often unpredictable and dynamic in nature, but there are often similarities. It is therefore useful to understand this innovation process when trying to capture why particular innovations succeed or fail.

There are various models to describe the innovation process, but HIF uses a model based on five stages:

- **Recognition** of a specific problem, challenge or opportunity to be seized
- **Invention** of a creative solution or novel idea that addresses a problem or seizes an opportunity
- **Development** of the innovation by creating practical, actionable plans and guidelines
- **Implementation** of the innovation to produce tangible examples of change, testing it to see how it compares with existing solutions
- **Diffusion** of successful innovations – taking them to scale and promoting their wider adoption

These five steps provide a useful archetype for the innovation process and are used in the HIF case study methodology. But they come with the caveat that innovation is complex and non-linear, and that identifying deviations from this model is just as important as (and possibly more so than) confirming the applicability of the model itself. The HIF-ALNAP case studies will seek to map in greater detail the chronology of these stages and how they overlap and interact for each HIF grantee.



3.1 Recognition

The concept of OAM has existed since 2006. The need was initially identified by Cristiano Giovando and Mikel Maron when they were graduates at San Diego State University. Giovando and Maron were both members of the OSM community, an online platform for 'enthusiast mappers, GIS professionals, engineers running the OSM servers, humanitarians mapping disaster-affected areas, and many more'[6] who use the platform to share mapping data and discuss problems and ideas. In 2006, Giovando and Maron were working on a NASA-funded project at the university, using UAV technology to capture images of migration patterns across the US/Mexico border. While undertaking the work, they were presented with the problem of finding existing imagery, sharing between multiple servers where the imagery had been stored, and sorting all of the available imagery in order to rapidly analyse changes in migration patterns. In addition to this, they also identified the more technical challenge of translating the images into usable maps. Giovando and Maron discussed these challenges with other crisis mappers and found that these issues were also starting to be identified by others, such as Schuyler Erle and Kate Chapman.

The digital humanitarian community, and particularly the smaller crisis mapper community, meets regularly at conferences and is in constant communication through open source forums. Discussions started to focus around the potential technical solutions needed to provide a platform that would link the providers of imagery with the humanitarian users of imagery. It was at this time that the idea of democratisation of digital cartography was born, leading to the democratised remote-sharing approach, encouraging the early ideas around OAM.[7]

Crisis mappers have been involved in humanitarian responses for over a decade and as such have significant first-hand experience of the challenges and needs when seeking to use imagery in such scenarios. During this time, large-scale disasters such as the 2007 wildfires in San Diego and the 2010 Haiti earthquake provided scenarios that could clearly demonstrate the merits of OAM and the requirement for it to both digital crisis mappers and the broader humanitarian community.[8]

The Haiti earthquake in 2010 was a key event identifying and further highlighting a number of needs associated with the vast amount of imagery available:

- The need for one centralised digital index where all imagery can be uploaded and retrieved;
- The need for the imagery to be archived so the same process of identifying and gathering imagery does not have to be repeated after each disaster;
- The need to process the imagery from its raw form into one that can be easily used by responders and the wider global humanitarian community.

Following the earthquake, members of the crisis mapper community explored how best to promote, support and advocate the creation, maintenance, use, distribution and availability of free, geographically referenced data to facilitate and provide humanitarian aid and permit faster and more efficient means to relieve poverty and foster economic development. As a result of these discussions, Kate Chapman, Schuler Erle and Mikel Maron established the Humanitarian OpenAerialMap Team (HOT), as a non-profit organisation that creates and provides maps to support humanitarian organisations in their

response to political or natural disasters. It does this through collecting data, coordinating the design and development of OSM tools and documentation, teaching data quality assurance and collaborating with data imagery providers.[10]

Anyone can take part in HOT, with volunteer members primarily undertaking the work. Members who demonstrate commitment to the HOT mission are given a vote and are responsible for voting on the election of directors and additional voting members, and other matters affecting HOT.[11] There are currently 86 voting members; these are seen as the HOT core team. HOT seeks to mobilise an open community of crisis mappers to deliver the work it undertakes.

As HOT continued to lead thinking around these issues, the response to Typhoon Haiyan demonstrated further examples of the need. Dale Kunce, Senior Geo-spatial Engineer at the American Red Cross, stated following Typhoon Haiyan that 'during the first few hours of the response the need for a centralised imagery data warehouse became very apparent. Many providers and government agencies received competing and overlapping requests that hampered their ability to push imagery out in support of the humanitarian response.'[12]

A key element of the recognition phase entailed HOT ensuring the scope of the project was not solely restricted to the users of imagery (the humanitarian response sector), but also addressed the challenges facing the suppliers – the organisations that collect imagery.[13] This ensured there was a strong definition of the technical problems concerning image-sharing, and a good understanding of the user's needs for those who provide images as well as those who use them. The involvement of both groups enabled more comprehensive input into the needs assessment as well as the resulting design process.[14]

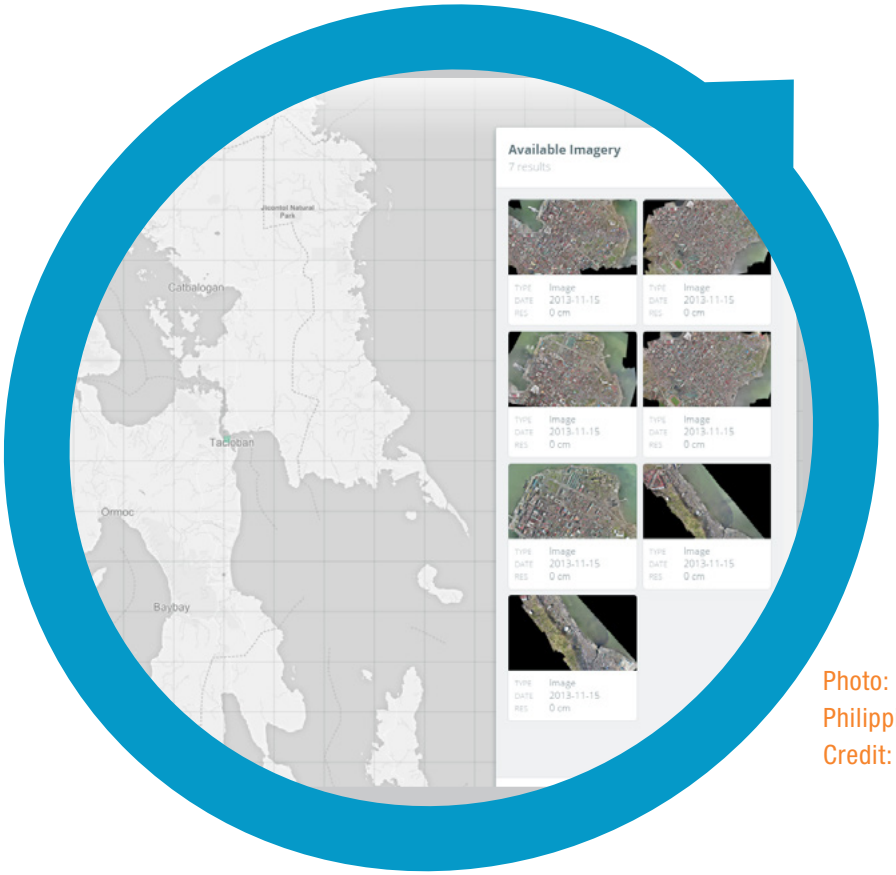


Photo: Screenshot of Open Arial Map:over the Philippines with imagery collected of Tacloban. Credit: beta.openaerialmap.org

3.2 Invention

While the concept of OAM is not a new one (it is available within the commercial market), HOT's OAM project is innovative in terms of its scale: a system that will eventually provide imagery of the whole world and is freely accessible to anyone, anywhere.

An important success factor within this innovation process is the universal access provided through the open source project approach. This has enabled a community of interested experts (members of HOT, other crisis mappers around the world, members of humanitarian organisations with an interest in imagery mapping, individuals engaged in capturing imagery through UAVs and satellites) to have access to the invention and development of OAM. These voices[15] helped clarify user need, as well as contributing to the invention, which ensured a more thoroughly considered design that caters for the whole imagery mapping community.[16]

In 2010, Schuyler Erle and Chris Schmidt worked on a very early prototype[17] of OAM and produced a solution with limited functionality. This failed to produce a long-term solution for a number of reasons, including issues related to the scalability of hosting data, the cost of server space and licensing.

> 'Once recognition has taken place, invention [new ideas bringing improvements or completely new features] continues until the very end, running alongside all other phases'
>
> Cristiano Giovando

Early explorations into OAM, by individuals such as Cristiano Giovando and Schuyler Erle, concluded that the costs were prohibitive and the technology was not sufficiently advanced to develop a sustainable solution. However, all the lessons had been captured and were therefore available to HOT as they sought to develop a workable solution, as Mikel Maron states:

> **'Everything has been done openly, even the previous incarnations, such as the Schuyler Erle/Chris Schmidt prototype, were all on GitHub […] so learning could take place and future iterations could be built on the existing knowledge of what works and what doesn't.'**

The concept of OAM became an ongoing topic of conversation among the broader community of crisis mappers until 2013. Individuals such as Schuyler Erle, Kate Chapman, Rob Emanuele, Mikel Maron and Cristiano Giovando kept the conversations happening at various conferences and ad hoc crisis mapper gatherings,[18] which helped further shape the invention of OAM. However, without a clear lead and a lack of dedicated funding, the concept did not progress rapidly. This changed when HOT began to facilitate discussions around OAM in 2013. This was achieved through regular communication via mailing lists and through the gathering of interested crisis mappers into a community of contributing individuals focused on the invention and development of OAM. HOT used the open source platform GitHub and the chat functionality of Gitter to facilitate this.

In 2013, HOT applied to HIF for funding to develop OAM. Kate Chapman, Executive Director at the time, and Heather Leson, President of the Board, worked together on the application, after Leson had identified HIF as an interesting funding opportunity.[19] HIF awarded HOT the grant for developing OAM in March 2014, at which point OAM became a project driven by HOT.

At the end of 2014, HOT hosted a gathering of interested image mappers in Washington, DC, to establish broad parameters for the OAM project, clarifying the overarching invention. As part of this, HOT recognised the need to recruit an individual to manage the project, provide focus for the multiple contributors and ensure OAM was successfully developed. This was a key factor in the success of the project.

3.3 Development

Software innovations such as OAM are continually being developed and improved, and as such are cyclical in their progression through the different innovation phases. Having established a broad invention, an initial burst of development is required to create a functioning prototype in line with the original plan, at which point development and implementation exist side by side and feedback is regularly provided. Again, a unique aspect of software development is that, as soon as it is developed, the software is 'live', becoming instantly implementable and open to feedback. The cycle of invention-development-implementation-feedback continues for as long as improvements can be made.[20]

The large grant from the HIF enabled HOT to manage the development process and pay highly experienced software developers, who would otherwise be asked to dedicate whatever available time they had on a volunteer basis. The software development for OAM is a complicated technical process, requiring expert input and extensive time to focus exclusively on the problem. The funding from HIF also enabled Cristiano Giovando to lead the development of OAM, and he did this by drawing on the expertise of different technically skilled groups.

HOT is an organisation that coordinates the community rather than being the entity that carries out the development work itself. HOT uses an iterative community-based approach placing a strong emphasis on the community ownership of the project. This is achieved through conducting all work openly and engaging the network of interested crisis mappers at every juncture, allowing space for input and seeking feedback on progress.

Giovando initially focused his energies on gathering interested crisis mappers into a group of contributing individuals focused on the invention and development of OAM. This group was primarily made up of members of HOT from around the world, other interested crisis mappers, members of humanitarian organisations with an interest in imagery mapping and individuals engaged in capturing imagery through UAVs and satellites. Even so, it was an open group that anyone could join. All communication was conducted openly and transparently on GitHub and Gitter, ensuring the potential for wider learning. Conversations about the development of OAM were constant, but, to bring structure to this, Giovando coordinated weekly meetings on Gitter that interested individuals could join to discuss and implement the latest developments.

At the same time, Giovando met face to face with various imagery providers[21] to gather their insights on the challenges they confronted when seeking to share the imagery they had captured. Giovando fed this information into the ongoing discussions around design and development.

One early outcome of the ongoing discussions over GitHub and Gitter was the clarity of definition of high-level requirements for the three core OAM components. HOT had foreseen that the

completion of these elements of OAM required dedicated time from highly skilled technical experts, and in March 2015 an open tender was released for the development of the OAM browser and catalogue.

The architecture of OAM has two main components:

1. Nodes of the Open Imagery Network (OIN), which provide hosting and access to open imagery;
2. The application stack, which provides the user with the possibility to search, visualise and upload open imagery from/to OIN nodes.

The application stack is in turn divided into three main components:

1. The OAM Browser – a web interface to submit, search, access and download available imagery;
2. The OAM Catalogue – a readily accessible index of information about imagery that is hosted elsewhere and how to access it through a web API;
3. The OAM Server – a map engine instance to create a tiled map service (e.g. TMS) and save it to a specific highly available online storage site (e.g. Amazon S3 bucket).[22]

Development Seed[23] was commissioned to develop both the browser and the catalogue and Azavea, with support from Stamen, to develop the server.

Giovando continued to facilitate and lead the ongoing input over GitHub and Gitter, as well as chairing the aforementioned weekly meetings. Alongside this, Giovando met weekly with both of the key development partners (Development Seed and Azavea) to discuss progress and give feedback on the initial design.

In May 2015, HOT hosted a summit in Washington, DC where they finalised the design of OAM, including significant adjustments to the overall architecture, by introducing the OIN, which underpins OAM. With this final design, the development partners now had the parameters for the detailed development of each component. The development work shifted to the development partners and the wider OAM community of crisis mappers took on the role of giving feedback.

Throughout the development process, Giovando continued to meet with each of the development partners on a weekly basis and remained in communication with them on a daily basis over GitHub and Gitter.

Development Seed, Azavea and Stamen all employed an agile project management approach, incorporating scrum methodology. This involves setting immediate goals and small teams undertaking short development sprints for one to two weeks. At the conclusion of a sprint, demonstrations and feedback are given and goals are revised for the next sprint. Mikel Maron states that:

> **'Agile project management allows for quick changes, encouraging innovation and responding swiftly. It avoids going down blind alleys and not meeting the needs. It's also recognition that developing software is really hard. Where you think you're going may not be where you end up. This approach is in a way a demonstration of a little bit of humility in that process.'[24]**

The browser and catalogue were completed in August 2015 and the server, following a change of format, was completed in October 2015 after Azavea and Stamen agreed to complete it with a no cost extension. The problem with the server was to do with the choice of technology for the main component of the system, called Amazon's Simple Workflow Service (SWF). SWF functions as a type of task coordinator, helping developers build, run and scale background jobs that have parallel or sequential steps. Unfortunately, SWF did not perform as expected and an alternative route, of which there are a number, had to be selected. The delay was unfortunate, but has not impacted the completed product.

3.4 Implementation

There have been limited activities within this phase because of the relative infancy of the completed OAM architecture and the fact that it has not yet been exposed to a large-scale emergency response. The HIF grant funded the development of OAM, and HOT is in the process of securing further funding from other donors for the ongoing implementation and diffusion of the innovation. Significant funding is required to fully code the catalogue and scale the operation.[25]

The OAM Beta[26] product went live in May 2015, and all three core components of OAM were complete and functioning by October 2015. The OAM community has been using each component as it goes live, and constantly providing feedback for further development and improvement.

3.5 Diffusion

At the time of writing, diffusion has yet to occur, given that the final versions of the software are going online at the close of 2015. However, HOT is employing a number of strategies to encourage the wider adoption of OAM.

Both HOT and Development Seed have written blogs throughout the process, informing the general public of their development. The open source data on GitHub and Gitter is available to all and current statistics drawn from the openaerialmap.org site confirm 5,591[27] people have accessed the information since May 2015. In addition, HOT has communicated updates through the OAM mailing list,[28] delivered presentations at the HOT summit in May 2015 and continues to respond to numerous email enquiries from humanitarian organisations and crisis mappers interested in OAM.[30] HOT and Development Seed plan to attend other conferences in order to share lessons learnt from the project and inform a wider audience regarding the innovation. Finally, HOT has commissioned Ithaca (Information Technology for Humanitarian Assistance, Cooperation and Action) to conduct research and develop a detailed white paper on OAM to demonstrate the benefits of the system and provide practical guidance on its functionality to the technical, humanitarian and academic communities.

Cristiano Giovando identified that he would have liked someone with more social media skills to take on responsibility for outreach. He felt this would have strengthened this element and enhanced diffusion of the project.[31]

One area of concern, which may hamper the ongoing diffusion and wider adoption of OAM, is that funding for the project manager role has come to an end, leaving the ongoing development activities without an individual to lead

and steer the work. HOT will continue to provide administration support, and Cristiano Giovando hopes to steer it from a volunteer position, continuing to facilitate the discussions over GitHub and Gitter, but there will be significant reliance on volunteers from the wider community around OAM, in a similar way to the ongoing development of OSM.

There was a risk that engaging the suppliers of imagery would have taken the focus of OAM away from humanitarian response, given that their scope extends beyond the humanitarian community. However, the engagement of additional voices helped highlight improved methods for supporting a humanitarian response. The primary result of engaging with this wider audience was the identification of challenges surrounding the coordination of image file stores, the requirement of very large server storage space and the ability of image capturers to create image files in a format useful for humanitarian response. This led to the creation of the OIN – a system that supports a federated network of file stores, which enables anyone to contribute imagery. Being open source meant that whatever was built was available for any kind of application beyond humanitarian purposes.

In broader sector-wide discussions surrounding this technology, concerns have been raised around privacy and the security of having open imagery available to all.[32] In response to this, Cristiano Giovando states:

> **'We are aware of privacy concerns, and have ideas on how to address them (e.g. reducing resolution when requested), but have not implemented any strategy yet. It's on the agenda for the next phase. In terms of security, at this point the responsibility is still with the uploader/provider. A system of checks and community review will eventually guarantee some security control of published imagery.'**

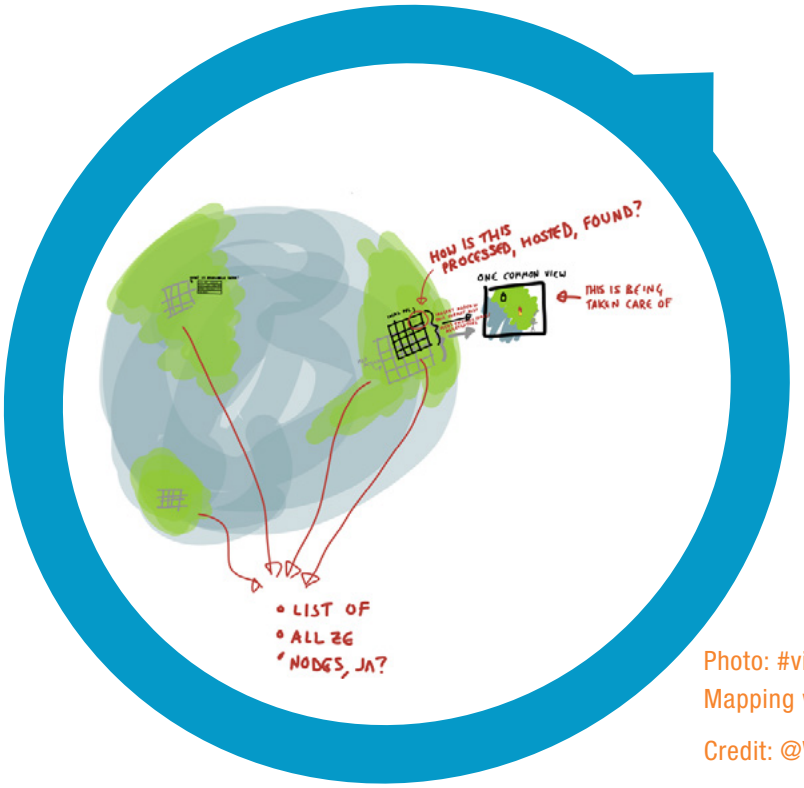


Photo: #visthink drawing of how Open Aerial Mapping works.

Credit: @Willowbløø/Viz.Bløøcyb.org

4. Was this a successful innovation process?

Inherent in all innovation processes is some degree of failure. This presents a challenge to understanding what contributes to a good innovation process: even successful processes will experience difficult pilots or setbacks in design or diffusion. The HIF-ALNAP research on innovation processes therefore distinguishes between a good innovation – an output of an innovation process that leads to measurable gains in effectiveness, quality and efficiency – and a good innovation process. This research defines a successful innovation process through three criteria:

Table 1: Criteria of success for innovation processes

Increased learning and evidence	There is new knowledge generated or an enhanced evidence base around the problem the innovation is intended to address, or around the performance of the innovation itself.
Improved solution	The innovation offers a measurable, comparative improvement in effectiveness, quality, or efficiency over current approaches to the problem addressed by the innovation.
Adoption	The innovation is taken to scale and used by others to improve humanitarian performance.

Through the research process for the case studies, ALNAP and HIF are also seeking to understand how HIF grantees define success in their work, in order to identify unexpected or unacknowledged benefits from engaging in innovation.

The research team used evidence collected for this case study to assess the success of the OAM innovation process against the above three criteria.

Overall, this process was successful in increasing evidence and learning. At the time of writing, the OAM platform had recently gone live and it was therefore too early to determine if the process had led to a fully improved solution or wider adoption. However, early pilot participants and potential users were positive about OAM's potential to fill an important gap in the use of maps for humanitarian purposes, by providing a one-stop shop for imagery. Specific findings were as follows.

Increased learning and evidence

Learning has been both captured and disseminated throughout this project. Those participating in the development of OAM have learnt a significant amount in terms of both the implications of sharing open imagery and the technical challenges surrounding the development of the code.[33] All of the learning has been captured and disseminated through the open source community on GitHub[34] and Gitter,[35] through the OAM mailing list[36] and through regular blogs from both HOT and its partner Development Seed. Consolidated learning has also been captured in a white paper on the findings of the OAM project, produced by Ithaca.[37] HOT has shown itself to be flexible, and the agile development approach has enabled it to incorporate learning into the design and amend plans

accordingly. It is yet to be seen, however, whether the increased evidence and learning have been passed onto the humanitarian community or if they will be kept within the confines of the more technical crisis-mapping community.

Improved solution

According to key informants in the humanitarian sector and the crisis-mapping community, OAM provides humanitarian organisations with an improved solution to one of the central challenges faced when seeking to discover, share and use imagery in a timely manner. One information management officer at UNOCHA believes OAM fills a large gap and meets a number of the current challenges surrounding access to and sharing of imagery in humanitarian response, believing it to increase efficiency and reduce duplication of effort in searching for imagery in multiple locations. During the recent response to Typhoon Haiyan, UNOCHA was able to recommend the Philippine government to place its aerial imagery in OAM and then direct humanitarian organisations to this accessible centralised catalogue, enabling more timely access to imagery.[38]

An interview with a British Red Cross (BRC) GIS analyst and data visualiser[39] confirmed OAM addresses a key part of the problem by creating an easily accessible repository and catalogue for imagery, enabling swifter identification and sharing.

However, in order to improve humanitarian response through the better use of mapping imagery, end users not only need access to imagery but also for this imagery to be analysed and structured in a way that makes it understandable and usable. Given that the initial proposal to the HIF was for the development of 'a full service for hosting and cataloguing imagery',[40] it would appear HOT has successfully developed these aspects and addressed the first component of this problem. However, both UNOCHA and the BRC highlighted that needs within the humanitarian community extend beyond this and as such the solution developed by HOT only partly meets the identified need. At this stage of OAM's development, there is still a requirement for highly technical individuals to help translate the raw image data into useful maps for humanitarian purposes.[41] With further funding, the community surrounding OAM seeks to further develop it and offer some analytical capacities directly online, addressing some of these challenges.[42]

Adoption

Given the relative infancy of OAM, it is hard to assess the degree of adoption and potential impact the innovation will have on the humanitarian community. However, early signs are promising. Those within the open community, who have closely followed the development of OAM, as well as many other potential end users within the humanitarian sector,[43] have expressed interest in using OAM as soon as the development phase is complete. Trialling has been restricted to those within the open community who have contributed to the development of OAM components. Wider implementation has not yet taken place, and a full trial within the context of an operational humanitarian response will not be possible until the next large-scale disaster. However, there is expectation and demand from the humanitarian community, with recent disaster responses such as Typhoon Haiyan and the Nepal earthquake highlighting the volume of imagery available and the need for a system like OAM to provide swift open access to it.

The development of a thriving open community around OAM, a core element of the ideological approach selected by HOT, has been a key factor in the successful completion of OAM and the potential success of the wider adoption of the innovation. This element has created a platform not only for contribution and feedback but also for sharing of learning and wider diffusion.

As alluded to already, there is not enough feedback on the implementation of OAM to accurately assess its adoption. Some diffusion activities have taken place and others are planned, but it is not possible to fully assess the success of this criterion at this juncture. One factor that has played a significant role up until this point has been the presence of a funded project manager to both lead and facilitate the project along its journey. Unfortunately, funding for this role finished in October 2015, raising questions about the ability of OAM to progress to successful diffusion.

The need to inform the broader humanitarian community of the existence and function of OAM is a key to successful adoption. Many of the technology-savvy members of the humanitarian community, including key bodies such as UNOCHA, are already aware of OAM and the potential improved solution it provides. However, for wide-scale adoption, it will be important to pass knowledge of OAM on to the whole sector. The lack of a paid project manager will likely hamper this process a little, but it is expected that wider adoption will take place through the work of the open community that surrounds OAM. These individuals are passionate and well networked and have links to the technical staff members of large humanitarian organisations. This cross-over will encourage diffusion. HOT has also targeted key humanitarian bodies, such as UNOCHA, in an endeavour to strengthen diffusion and wider adoption.

5. What are we learning about innovation?

Drawing on research from the humanitarian sector and beyond, including previous case study material, HIF has identified a range of factors generally held to be fundamental to successful innovation processes. An important part of the case study research lies in testing, through the experience of the HIF grantees, the extent to which these propositions hold true in humanitarian settings.

- **Managing relationships and setting common objectives**

  Innovation always involves multiple actors – partners, implementers and end users – all of whom can change over the different stages of an innovation process. Assigning specific time and resources to managing these relationships and ensuring common objectives across the different stakeholders of an innovation will contribute to a successful innovation process.

- **Dividing tasks and responsibilities**

  Given the complexity of many innovation processes, a clear division of tasks and responsibilities between individuals and organisational units is important for developing a successful innovation.

- **Resourcing an innovation**

  Working in innovation requires flexibility to deal with the unknown, and this is particularly so with an innovation in the humanitarian sector. Budgets and resource plans therefore need to be suitably flexible to accommodate several possible outcomes (e.g. the need for further trials) as well as likely deviations from the original plan.

- **Flexibility of process**

  At its heart, managing an innovation process is about creating space for flexibility. Processes featuring flexible timelines, feedback loops for adaptation during the piloting phase and individuals resourced to execute changes in response to emerging results will be more likely to succeed.

- **Assessing and monitoring risk**

  Innovation processes in humanitarian action need to have an appropriate relationship to risk. We expect processes will be more likely to produce improved solutions and achieve uptake when they include an assessment of the different risks that might have an impact on the effectiveness of the innovation, as well as a strategy or plan to monitor and adjust development in light of changes in these risks on an ongoing basis.

- **Drawing on existing practice**

  Knowledge of existing practice and experiences is expected to contribute to more effective innovations through a better understanding of past attempted solutions, an accurate initial understanding of the problem or opportunity addressed by the innovation and an awareness of potential users and their needs.

Findings for these six propositions are presented in the graphics on the next few pages.

Managing relationships and setting common objectives

How this factor worked in this case study

HOT recognised the importance of having a coordinator for the project and recruited Cristiano Giovando to manage the relationships with HIF and the partners as well as to develop a wider network of supporting contributors. HOT budgeted for regular travel for Cristiano Giovando to ensure regular face-to-face meetings with the development partners. HOT also invested in software to aid regular communication: weekly meetings on Gitter and tracking all communication through GitHub have ensured all parties are informed of progress and aware of the objectives.

Broad common objectives were established at the outset of development of OAM. In line with agile project management philosophy and to include community inputs as much as possible, HOT did not define a strict roadmap. The scrum methodology worked well in ensuring regular meetings, small working groups and quick feedback, all leading to shared common objectives. What was discussed and designed during the first three months shaped the work done from April until completion. Most of the milestones and roadmap tasks were managed through GitHub in each repository. The May sprint in Washington, DC, was a good time to sit together, validate that design and invent specific missing aspects, such as the creation of OIN.

Challenges

One challenge is the fact that the open community around OAM is disparate and there are many voices involved in the process of development. This presented a challenge to Cristiano Giovando, in terms of synthesising the useful contributions, steering the overall development of OAM and ensuring they continued to pursue the agreed-upon objectives.

How this factor related to the performance of the innovation process

The presence of Cristiano Giovando in the coordination role, managing relationships and ensuring common objectives, has been vitally important for the successful completion of the development of the innovation.[44] He ensured the multiple voices contributing to the project were heard while also keeping the project within the objectives.

Gitter and GitHub and the mailing list ensured learning was captured and new plans developed, actioned and tracked. They also served to ensure transparency and openness.

Dividing tasks and responsibilities

How this factor worked in this case study

The ToRs of key staff and MoUs of partner organisations clearly outline role and responsibility. This has been important in developing OAM quickly and to the desired standard. Without defined roles, development of OAM was slow. It required dedicated time and resources that were not available before the HIF funding was secured.

Software development experts were required to write the code for OAM and, as such, HOT released a tender for each of the three components of OAM and contracted the most suitable candidates for each. A MoU[45] was signed with each development partner and this, combined with regular communication over GitHub and Gitter, ensured the objectives were successfully achieved.

An agile project management approach was employed by each of the development partners. This steered them away from specific roles and responsibilities, focusing on the distribution of tasks through swift development sprints.

As stated in his ToR, one of the key responsibilities of Cristiano Giovando was outreach and the creation of a thriving open community around the OAM innovation. Although he recognised this was not one of his strengths, he implemented it very well and it became a key factor in the overall success of the innovation.

Challenges

Open source projects like the development of OAM run the risk of having input from a large number of voices, without one person taking responsibility to drive the process forward. The challenges connected with this were significantly reduced when Cristiano Giovando was employed. However, Cristiano's position is only funded until mid-October, meaning that there will be no specific individual funded to lead the project through implementation and diffusion.

Establishing the exact nature of the tasks in this project was a challenge. Attempting to distil the specific objectives from such a broad network of end users required a lot of discussion and the articulation of a realistic end goal from Cristiano Giovando. He managed this by keeping most communication and decision-making open and transparent, allowing for anyone's input and then steering when necessary in order to keep the project in line with the original goals and the roadmap.

Splitting up the components of OAM and distributing them between different developers risked creating three isolated, but workable, solutions that didn't mesh together. However, given the open source collaborating tools of GitHub and Gitter, this fear did not materialise.

Cristiano Giovando identified that he would have liked someone with more social media skills to take on the responsibility for outreach. He felt this would have strengthened this element and enhanced the diffusion of the project.[46]

How this factor related to the performance of the innovation process

The decision to divide the development tasks into three core components and distribute the development of these elements to experts has ensured the necessary focus on the individual components and the required expertise to develop a high-quality product.

It was important to clearly articulate tasks and responsibilities in the management of the development process and in the creation of the macro-level invention. However, when it came to the development of the solution, division of task and responsibility was less important, with the development partners employing the agile development process, which provides a more fluid approach to tasking.

With numerous contributors, it has been essential for the project manager and the development partners to have clear roles and responsibilities. The roadmap, combined with ToRs and MoUs, ensured the work was divided clearly, avoiding confusion, and distributed to those with the necessary expertise. Cristiano Giovando, Rob Emanuele and Nate Smith each took responsibility for addressing feedback and ensuring everything was documented on GitHub. This contributed to learning. The engagement with social media was also written into Cristiano's ToR and this ensured regular blogging that contributed to not only **learning and evidence** but also diffusion and in turn **adoption**.

Resourcing an innovation

How this factor worked in this case study

The funding received from HIF was for the development of OAM. Implementation and diffusion were not fully resourced. A more fully developed OAM would require significant funding beyond the scope of HIF.

The project has been heavily resourced in terms of expertise and participant engagement. The open source nature of the development ensured many people engaged in the design, development and implementation of the project.

Challenges

The funding was limited to developing a first prototype of OAM. Further funding would be required to further develop the innovation and enable sustainable implementation.

The budget was sufficient for the stated objectives but did not provide the flexibility needed for multiple iterations and feedback loops.

The limited funding meant the development needed to be rushed and it was only because experts such as Development Seed, Azavea and Stamen believed in the project and were willing to do the work for considerably less than market rate that the development even took place. However, the development phase was shorter than it would ideally have been, restricting the number of feedback loops (scrums) and iterations.[48]

How this factor related to the performance of the innovation process

It is too early to fully appreciate the contribution of this factor towards the success criterion.

The funding provided by HIF enabled HOT to develop OAM. It is unlikely OAM would have succeeded without the funding. The initial budget enabled the recruitment of Cristiano Giovando, who coordinated all organisational and OAM learning, ensured the project remained on track and gathered a vibrant community of experts around the innovation. The funding also enabled the commissioning of technical development experts who otherwise would not have had the time to commit to the project. This was a key factor in enhancing the technical quality of the final product.

There is now a functioning OAM browser, catalogue and server, fulfilling the original goal of the development grant from HIF. However it could be further developed to incorporate more tools or plug-ins. The architecture of OAM is solid and set for scaling, but it would benefit from even greater scalability (distributed caching, distributed tiling). Another potential improvement would be to make OAM work better on mobile devices and smaller screens. The usability of the browser could be improved for advanced filtering, and the imagery could one day be displayed in a seamless mosaic. If the funding and capacity were available then OAM has the potential to be Google Earth for humanitarians.

The limited funding has also limited the amount of time available to complete the development, relying on the generosity and passion of the developers to do the work for far below the market rate. The final OAM product is a significant improvement on the status quo, but with additional funding and resources it would have been an even better solution.

The funds were for development, but had there been more resourcing then HOT would have been able to undertake further development, implementation and diffusion activities, leading to wider adoption.

Flexibility of process

How this factor worked in this case study

The invention and development phases were purposefully long and detailed, allowing for considerable collaboration, feedback and testing of ideas from the open community. The development partners employed an agile software development approach as soon as a clear system architecture was agreed upon.

The agile development approach is flexible, responding to ever-changing needs. As such, the timelines were flexible. The weekly meetings on Gitter allowed for regular feedback and progress updates. Cristiano Giovando had responsibility to address actions presented at a programme level. Rob Emanuele and Nate Smith had responsibility to address the actions from feedback in Azavea and Development Seed, respectively.

The agile approach encourages swift testing of ideas leading to innovation. However, given the tight timeframe, the space for testing and feedback from the wider external group was limited. Despite the time pressures, weekly team meetings, and one-on-one meeting's with Cristiano Giovando, still took place, allowing for progress reports and feedback on the recent developments. HOT did manage to engage with end users in iteration feedback, ensuring those that understood the problems and the context had access to the development and could speak into the future iterations.[49]

Challenges

A key success factor was the time HOT dedicated to invention and early development scoping, but this then limited the actual development time available, reducing the space for feedback loops and resulting in the need for a NCE for Azavea and Stamen to complete the server component. As mentioned above, this was done at lower than the market rate because of the personal interest in the project for both Azavea and Stamen.

How this factor related to the performance of the innovation process

Within the constraints of the budget and time, HOT built a lot of flexibility in to its timeframe and processes, allowing for a wide range of contributors, significant feedback and iterations. The flexibility and time given to invention and development enabled HOT and the broader OAM community to create a high-quality solution that met the needs of not only the humanitarian organisations but also the image-capturing organisations.

The open source approach, with the use of GitHub and Gitter, gave interested individuals considerable access to the development of OAM, allowing them ongoing feedback opportunities. The open source approach allowed for a high level of input, feedback and learning, all of which was open and available for anyone to engage with.

The limited time available for the actual software development phase restricted the number of iterations and requests for feedback, thereby reducing the exposure to potential end users. This has potentially reduced target communities' awareness of the improved solution, which could hamper future adoption. Although there were sufficient iterations and flexibility, there can always be more within a software development innovation and as such the opportunities for additional learning were reduced.

Assessing and monitoring risk

How this factor worked in this case study

There was little initial risk assessment and planning other than the mandatory risk and assumptions section in the HIF application. However, the extended development phase undertaken encouraged a thorough exploration of the best technical approach, identifying issues and minimising the risk that an inappropriate solution was created.

The nature of open source projects also means multiple voices are included, leading to greater transparency and a wider group of people able to identify risks and offer solutions. The agile development approach, with its short development sprints and regular progress meetings, has meant risks are monitored closely and addressed swiftly.

Challenges

Neither HOT nor the development partners have undertaken a thorough risk assessment and there are no documents demonstrating mitigation plans.

In line with agile project management philosophy, and to include community inputs as much as possible, HOT did not define a detailed roadmap for development, leaving themselves open to more unforeseen risk.

How this factor related to the performance of the innovation process

This factor had limited impact on the success of the innovation. There was no specific risk assessment undertaken other than the initial risk and assumptions section of the HIF application. Despite this, the innovation has been a success and has met the challenges as they have arisen.

HOT has achieved this through having a long period of invention and development planning where it sought the input of a wide group of experts and gathered feedback from this experienced community on a weekly basis. In addition to this, the agile development methodology, with its short development sprints and regular progress meetings, allowed for quick assessment of progress and close monitoring of risks.

The nature of scrum methodology means issues are identified quickly, blind alleys are not followed for long and the small teams are constantly discussing progress. All of these factors, combined with the regular reviews and feedback, help identify risks when they arise and limit the advance of incorrect activities.

Drawing on existing practice

How this factor worked in this case study

OAM is built on the platform of previous endeavours and with the knowledge that comes from responding to disaster such as the Haiti earthquake, Typhoon Haiyan and the southern California wildfires of 2007. The need for OAM had been identified since 2006/07. HOT has also been able to draw lessons from a number of previous short-lived and unsuccessful iterations.[50]

HOT successfully established a thriving community of interested individuals and organisations around the innovation, incorporating experts in the field of crisis mapping and software development. Each member of the open community brought his or her own expertise and experience to the innovation development process, adding value and enabling better understanding of past attempts and helping provide solutions to current issues.

The three development partners – Development Seed, Azavea and Stamen – all bring years of relevant experience to the project having delivered similar open source software development projects previously. This ensured the necessary high technical quality of the OAM components.

Challenges

No challenges identified.

How this factor related to the performance of the innovation process

The wealth of expertise and experience within the OAM community has meant everyone involved has learnt something new. They have also ensured OAM is a better solution than previous prototypes by using their knowledge of the status quo within the sector and their understanding of past attempts, as well as their in-depth understanding of the latest technology and their experience of developing similar products.

Learning from previous attempts and having knowledge of existing practice ensured OAM was appropriate and met the identified need. OAM is therefore far more likely to be adopted by the wider sector.

6. Emerging lessons for best practice in innovation

- Engaging with end users at the recognition phase and opening the scope of the innovation out to encompass industry-/sector-wide voices supports the development of an appropriate solution.
- Coordination of a community of experts inputting into the innovation process helps better shape the invention and development of an innovation as well as encourage increased adoption.
- A long, detailed invention and development phase ensures learning and the design of an appropriate and improved solution.
- An individual point person managing the project, setting goals and coordinating the broader contributors is essential to keep the project on track and provide the impetus for a successful completion.
- An open source development process that tracks all activity online allows for greater contribution, feedback, learning and adoption. It also encourages greater transparency.

Endnotes

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Other case studies from HIF and ALNAP on innovation

Understanding the performance of emergency feeding programmes

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