SERVICES FOR AN EMERGENCY RESPONSE SYSTEM IN THE NETHERLANDS

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ABSTRACT:

During the crisis management, several organizations coordinate their emergency work based not only on well-defined policies and procedures (product of careful preparation) but also on the outcomes of the decision-making process. Decision-making is a highly complicated process in crisis situations. Good support in decision-making when disaster occurs is of critical importance to react accurately, fast and effectively. Good decision-making helps to control damage, save lives and resources, and reduce unwanted consequences of a crisis. Geospatial Data Infrastructure (GDI) is increasingly considered a critical aspect of decision-making in disaster management. This paper presents our concept for an appropriate GDI (open-standard generic platform) assisting in administration, analysis of data to predict development of a crisis event and accordingly advise for changes of plans.

1 INTRODUCTION

The first hours after a disaster happens are very chaotic and difficult but perhaps the most important for successful fighting the consequences, saving human lives and reducing damages in private and public properties. In these first hours, the good estimation of the current situation is of particular importance. A large number of questions (e.g. where is the emergency situation, how to get there, how many casualties, what kind of information do we have from there), are pending for answering.

Additionally to the unclear situation, many different actors (fire brigade, police, para medics, municipalities, etc.) with, sometimes, contradictory requirements are involved in managing the situation. Since many of the tasks they have to perform are rather different than their daily work routines, a good cooperation and collaboration between different teams is of critical importance.

There are numerous underlying obstacles that complicate an adequate crisis response (Borkulo et al 2005, Diehl and van der Heide 2005, Kevany 2005, Neuvel et al 2006, Ospina, 2006, Winter et al 2005):

- Lack of good communication between actors in crisis response. Different actors operate with particular systems as the exchanged information is not accessible for all participants in the crisis management.
- Diversity of systems in one sector. It is quite common practice to use various software in different regions or groups of regions. Realising this problem, for example, the Dutch police has already initiated a large project SHERPA aiming at standardisation of the geo-information provision of all the 25 police regions in the Netherlands.
- Lack of information about the 'information'. Often is unclear where certain information can be found and how reliable it is.
- Lack of appropriate platform (user interfaces) for data exchange. The interfaces usually serve tasks and activities of a specific unit (police, fire-fighters, etc.)
- Insufficient standardisation of processes and protocols, especially for data exchange.
- Difficulties in exchange and integration of various data. Resolution, accuracy, updateness are only few of the challenges.
- A variety of narrow specialised systems for only emergency situations.
- Management of information from the field (reports, images, video, etc.). Usually this information is stored as unstructured files, which is problematic for systemised analysis.
- Access to existing data is in general very slow.

New systems have to be developed that allow different rescue units to operate together in any critical situation. One of the main challenges is in the geospatial domain, i.e. definition of well-defined standardised services for discovery and exchange of information. Such services are closely related also to the development of Geospatial Data Infrastructure (GDI) at all levels (local, regional, national and international) for support of disaster management. Initiatives for GDIs are in progress at many levels all over the world, for example INSPIRE in Europe (www.ec-gis.org/inspire). Those have to be further enriched to be able to serve emergency sector. Large international projects, for example, ORCHESTRA (www.eu-orchestra.org), OASIS (www.oasis-fp6.org) and WIN (www.win-eu.org) are already reporting results of their research in this area.

Three aspects of a GDI are especially critical for the success of an emergency response system: generic services that would be available for all the actors (on the field and in the commando centre) in a disaster situation, management of dynamic information and appropriate interfaces for different end-users.

The services developed within this research have to be context-oriented with respect to the 19 types of disaster as specified in the Netherlands (Diehl and van der Heide, 2005). The user graphic interface should allow for both request of data and submitting (*insitu*) data to the system and will be built up on systems currently in use in the response sector.

Maintenance of dynamic data received from the field is still rather underestimated. In crisis response lot of information of different types is coming from individuals (camera images, voice, text reports, video, etc.) or from sensors (optical, thermal, infrared, etc.), which has to be properly organised and analysed. Most of the data are currently reported in text format via the telephone.

This paper will present first concepts and ideas for the development of GDI for disaster management. Next section presents the state-of-the-art in development of GDI. Section 3 discusses the services to be developed. Section 4 elaborates on graphic user interface used in the moment and demanded by the users. Section 5 concentrates on database and models appropriate for the management of *insitu* information. Last section concludes on expected added value of the developments. This research is a part of the project 'GDI for Disaster Management' (www.gdi4dm.nl) funded by the Dutch Research and Development Programme 'Space for geo-information'.

2 STATE OF THE ART IN GDI FOR EMERGENCY RESPONSE

GDI has been considered an important aspect of sharing data for years (Abrue et al 2000, Cattenstart and Scholten, 1999, Scholten et al 1999) Currently there are many international (Fabri and Weets 2005) and national initiatives for building GDI (INSPIRE, NEN, etc.). The reports for the EU member states show that a lot of progress is being made towards establishing European GDIs. There has also been progress toward a process of data harmonization as well as to common system and data models in disaster response and prevention (ORCHESTRA, OASIS, GMES). However, the large number of activities and projects funded by EU shows that the GDI is far from reality.

From a technical point of view most of the technology that is required for access and exchange of geospatial information is available as standards for implementation (e.g. OGC Web Services, SFS, GML), as concepts (e.g. OGC Abstract specifications for open distributed management of geographical imagery) or in process of development. It is worth mentioning that third phase of the OGC Web Services has been completed at the end of last year. Within these phase participants worked on several relevant topics for disaster response such as common architecture, sensor web enablement, Geo-decision support services (GeoDSS), Geo-Digital Right Management (GeoDRM) and Open Location services (OpenLS). Many extensions of existing standards are proposed for further discussions. For example the OGC OpenLS is extended toward indoor tracking (www.opengeospatial.org).

For the communication between the systems in this architecture, the use of web services and XML can be considered the state of the art. On the side of the clients, there is a great diversity ranging from rich clients based on web browsers over classic workstation applications to mainframes with terminals. These clients cover all the use cases for spatial data that so far exist and are based on highly heterogeneous programming and data models.

There are also many contributions from scientific projects. It should be mentioned many approaches for reaching semantic interoperability, search engines based on ontologies, security for agents and web services, as well as processing, indexing and serialization algorithms in the field of computer science. The topic of semantic interoperability is regarded as central and projects with strong industry integration like WIDE8 (IST 2001-34417) as well as those with a relation to metadata interoperability (like the INVISIP9 project, IST-2000-29640) are in progress.

3 GENERIC SERVICES

Our major objective within this project is to offer services that solve many of the obstacles that are now faced by emergency response systems. These services aim at improving communication between different actors involved in crises response. The services have part of an infrastructure that integrates and facilitates access to various information, existing data and data coming from the filed. It offers metadata – information about 'the information', exchange of data, etc. The focus will largely be on developing context-aware services.

Defining and implementing a GDI is traditionally done by creating application profiles, where the data model behind the data infrastructure is leading. Generic services based upon open standards can then be developed to make exchange of data possible. The major disadvantage of this approach is that development of the services can be complex and time consuming.

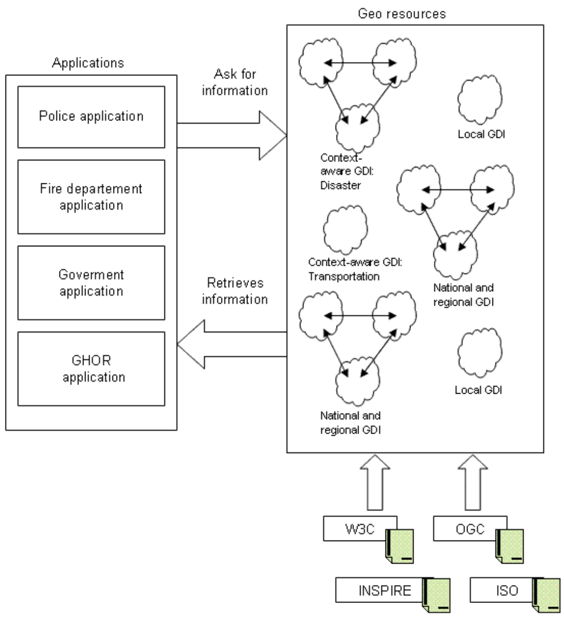

Figure 1: An overview of context-aware GDI for disaster management

A different approach is defining and implementing a GDI within the context it will be primarily used (Figure 1). For this project the context will be defined with respect to the 19 different disaster types. In this approach use scenarios within the current disaster type will prevail for the implementation of services within the GDI. Such services will only provide access to the data infrastructure that is relevant for the current disaster type. This approach will not only assure to maintain the focus within a certain context it will assure to application designers/architects to be able to use the defined and implemented services within their known specialization.

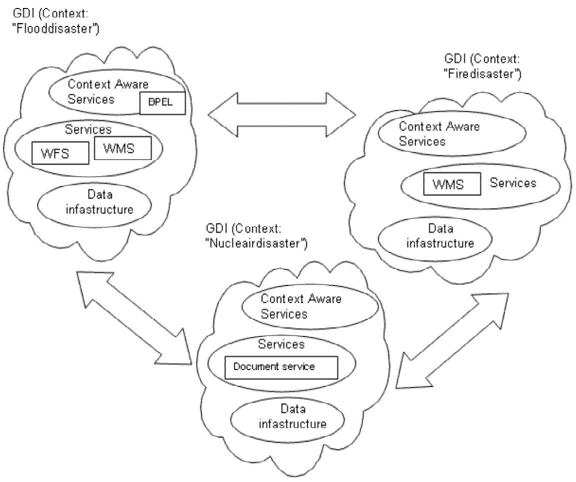

Figure 2: An example of GDI for the types of disasters: Flood disaster GDI, Fire disaster GDI and Nuclear disaster GDI

Within data driven (or syntax-aware) GDI's the application is directly communicating with the services which makes them very dependant and aware of the syntax being used by services or data infrastructures. In context driven GDI's high level functions within the active context will be exposed to the application making the dependency of the underlying services less relevant (Figure 2:). These functions will often consist of a series of calls to various services within the context-aware GDI. This approach is often referred as service chaining.

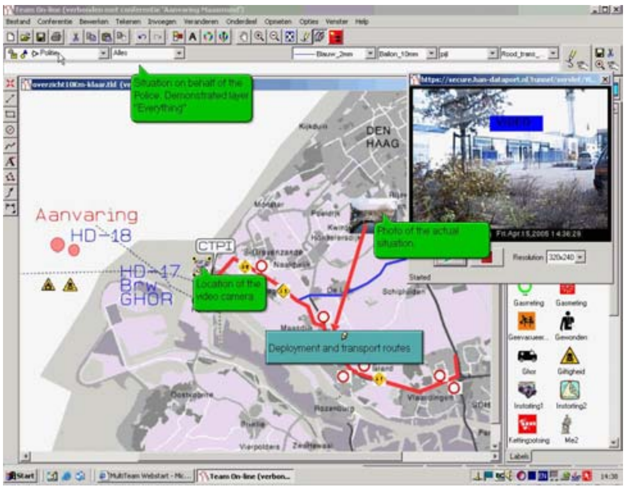

Figure 3: Graphic user interface of the system Mulltiteam

4 GRAPHIC USER INTERFACE

The design and development of appropriate Graphic User Interface (GUI) is yet another challenging task in disaster management. GUI is usually very specific with respect to particular user, type of device used and functionality to be offered. In disaster management these specifics are even more extreme, due to different user backgrounds, stress, time pressure, fatigue, etc. Therefore the interface has to be intuitive, easy for use and functional. This project will analyse and extend/modify the GUI of Multiteam (Figure 3 and Figure 4) (www.multiteam.info) and VNet (Figure 5).

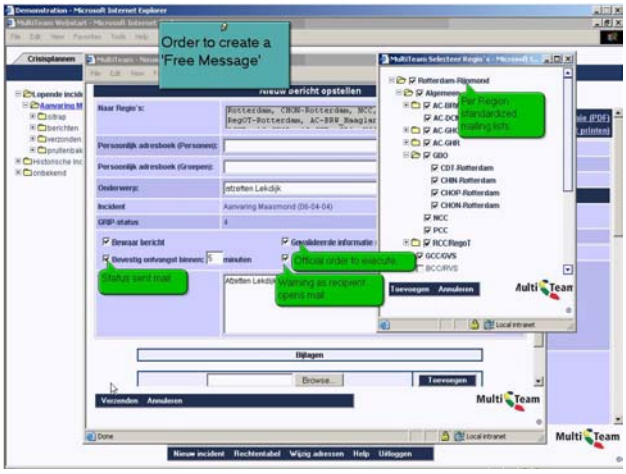

Figure 4: Interface for e-mail communication

In both systems the different responding agencies in the crisis response (Fire Service, Para medic, Police, municipalities, other special units) can access the system and give the location of their mobile-units (using special symbols) or mark important areas e.g. those not accessible to the Public. The user of the system can send e-mails and request different maps as a background. The systems differ slightly in their functionality and access to the information. While Multiteam has a quite large local database with information, the concept of VNET (Diehl and van der Heide 2005) is accessing distributed information (stored within the organisations responsible for their own service delivery). In both systems, however, (spatial) analyses are not available yet. The only existing functionalities are map overlay and visual inspection. Simulations (as discussed in flood risk management) are not available at the moment. In addition, compatible communication systems are being developed to improve communication during imminent floods.

Figure 5: Graphic user interface of VNet

The GUI interface in emergency response should be intuitive, and simple, yet providing the most appropriate information with respect to the user, the used device and the emergency of the situation. Furthermore the access to the data can be dependent on the location of the object, the process, the task and the particular organisation (Capelleveen 2005). It should be also remembered that the behaviour of people changes in critical situations. In this respect, different GUI interfaces will be developed for mobile users and decision-makers in commando centres.

3D display and tangible environments will be considered as well. Various groups are working already in providing 3D visualisation (Berlo et al 2005, Branco et al 2005, Bodum et al 2005, Kolbe at al 2005, Kwam and Lee 2004). It is well-known that 3D visualisation gives lot of advantages but puts big challenges to the developers of the system. For example, the 3D visualisation has to be very close to the real view. In contrast to maps, where a lot of symbols are used, 3D view should convey by realism and not by abstraction. Special techniques have to be used to focus attention to the most important information. For example, usage of a textured building amongst shaded ones. 3D models may be represented with plenty of details but in most of the cases this may lead to distraction. In this respect it is very important to keep the balance between important and fortuitous information (Zlatanova and Holweg, 2004).

3D representations and displays can be critical for indoor routing and navigation (Kwam and Lee 2004, Meijers at al 2005). Considering the complexity of modern buildings and the great numbers of people that can be inside buildings, it is often challenging to organise a quick evacuation. Very often serious problems such as huddle, trample, inaccessibility of exits, etc are observed. Despite al all the currently available means (alarm signals, evacuation plans, illuminated signs, etc.), three serious deficiencies are observed (Pu and Zlatanova, 2005): 1) lack of appropriate indoor geo-information about the structure and the available exits of the building, 2) lack of dynamic information about the current situation and 3) lack of flexible means for evacuation instructions Therefore we are going to investigate possibilities to employ interfaces that will dynamically evaluate the possible escape routes. The evacuation routes can be computed using network models (see next section) and the visualization 3D graphics or appropriate images (Figure 6) will be transferred to the client application.

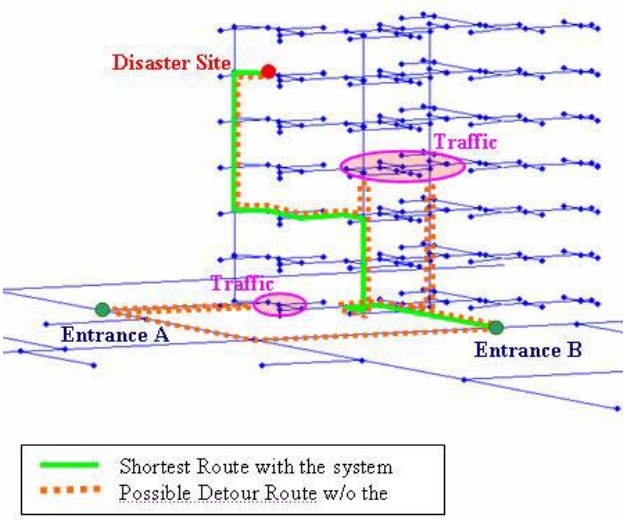

Figure 6: Navigation routes in a building (from Kwam and Lee, 2004)

Very often 3D models are not available, but still a sort of 3D effect can be obtained. Verbree et al 2004 have studied the applicability of panoramic images, a CycloMedia (www.cyclomedia.nl) full-colour images or Cyclorama's. The intention of CycloMedia is to cover the Netherlands with cycloramas to support all kinds of geo-information systems and services. All objects and locations are registered systematically from the public roads within cities, districts, etc. The cycloramas are recorded by a very special fisheye lens with a vertical view of 30 degrees below the horizon.

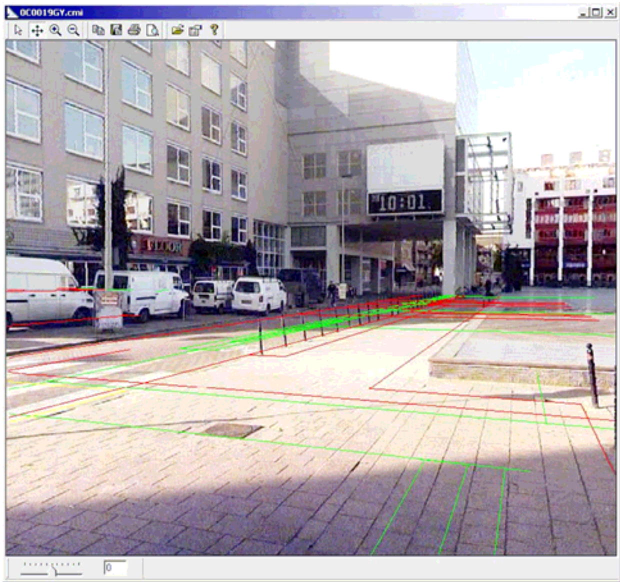

Figure 7: Cyclorama's, augmented with utility information (from Verbree et al, 2004)

Being geo-referenced, the images can be used for integration with various data. Actually, the cyclorama can function as the 'background layer' to display information labels, guiding directions, and position hotspots of other cycloramas in a given neighbourhood. The cycloramas can be integrated in any GIS system, as a clickable object either at the location where the image is taken from or at given addresses. By this, the user gets a far better impression of the surrounding objects and situation. Figure 7 illustrates a cyclorama image augmented with underground utility information. The cable data are taken from a 2D digital map and transformed in the projection of the image. Such an approach is readily applicable even for the restricted resources (screen, memory, bandwidth, etc.) of mobile devices. The image processing can be performed on a server and the augmented image can be streamed to any type of wireless devices.

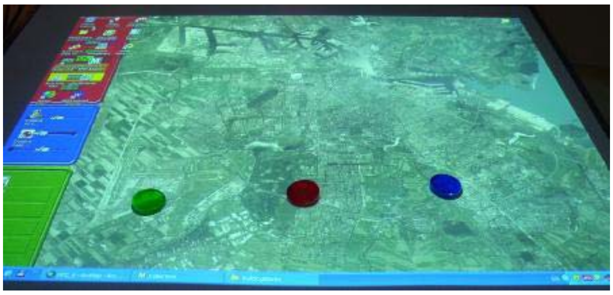

Figure 8: Geodan tangible user interface table (from Scotta et al, 2006)

This project will extensively explore new emerging tangible technologies. Such technologies provide realistic visualization, human-computer interaction, help in situational awareness, allow for cognitive mapping and collaborative decision making (Scotta et al 2006). Figure 8 illustrates the tangible table available at Geodan (www.geodan.nl), which will be used in the research.

5 MANAGEMENT OF INFORMATION

Last aspect to be developed in this project is data organisation of the *insitu* information. This information apparently has to be accordingly processed, maintained and further analysed. Numerous reasons can be mentioned in support of DBMS: reliable management of large data sets, multi-user control on shared data and crash recovery, automatic locks of single objects while using database transactions for updates, advanced database protocol mechanisms to prevent the loss of data, data security, data integrity and (standardized) operations that comfortably retrieve, insert and update data. Since many commercial and non-commercial DBMS offer support for spatial data types, it is now possible to manage any type of data in DBMS. Nowadays several commercial and non-commercial DBMSs are available with support for spatial data types: Ingres, Oracle, Informix, IBM DB2, MySQL, PostGIS. Some DBMSs (e.g. Oracle Spatial) even support several different spatial models (geometry, topology, network, LRS). The network model is quite appropriate for commutation of evacuation routes combined with 2D/3D visualisation since the geometry of the objects can be stored together with the nodes and links of the graph (Pu and Zlatanova 2005, Meijers et al 2005). Recent experiments and benchmarking have also clearly shown a significant progress in DBMS's performance (Oosterom et al., 2002).

A very critical question is the selection of the DBMS and more specifically a commercial DBMS or open source, freeware one. On the one hand, an open source, freeware DBMS (e.g. PostGIS) may have benefits in large area devastating disasters (similar to East Asia Tsunami or the hurricane Katrina) when existing infrastructure is destroyed and a commando centre has to be set up in few hours. Furthermore, fom a development point of view, open source software allows for seamless integration of new data types and functions. Current experiments with PostGIS have shown that a definition of new data types is quite straightforward.

On the other hand, many municipalities in the Netherlands have already commercial DBMSs such as Oracle Spatial. Oracle Spatial as mentioned above supports several spatial models for vector data as well as it provides management of raster data, multimedia, and mechanism for maintenance of history. All this functionality can be readily used for developing an appropriate spatio-temporal model for *insitu* data.

The next aspect to be considered is the support for data types, which have to be appropriate for information exchange in emergency. It is expected that besides various sensor information such as images (terrestrial, aerial), videos, laser-scan (also terrestrial and air- born), large amounts of textual data, audio, etc will have to be managed. Further investigations have to clarify the interpellation between those data as well as which of them have to be persistently organised in the DBMS. Currently, DBMSs support naturally only 2D spatial data types with their 3D coordinates. Though possible to organise even 3D objects (Zlatanova and Stoter 2006), some types of data (e.g. TIN, point-clouds) are not manageable with existing data types.

Another important aspect is time. As mentioned above most of these data are dynamic objects and therefore the temporal component is critical. Some DBMSs support the temporal aspect, but the spatial and temporal indexing is treated independently. Good spatial-temporal support needs an integrated approach, consisting of proper data types, operations and specific indexing (and clustering) structures (see also Laurini et al 2005).

Last but not least is a framework for describing multidimensional spatial relationships (or structures) for maintenance of multiple representations of objects (due to different resolution, dimension or time) is the third aspect to be considered in the development of the model. These relationships might appear critical for fast search and even generalisation (e.g. for mobile devices).

As a DBMS can be considered as a node in an information network, in which information from other sources (possible also DBMSs) have to be combined, processed and translated before presenting this to the user, formal semantics should be supported (up to a certain level within the DBMS). The lowest level, would be that the DBMS offers a formal semantic description of the schema of the data managed (so middleware translation servers can use this for further automatic translation). However, the next level of support of semantic translation is also conceivable: the DBMS does already perform a part of the translation (assuming the 'language' of the user is known). This may be more efficient as it avoids sending unnecessary data from the DBMS to the middleware, because now the DBMS knows what is relevant and how this should be combined and translated.

All the developments will consider the third dimension. If needed, 3D topologies (Oosterom et al 2002, Zlatanova et al 2004) at database level and corresponding operations will be investigated. 3D topology may be required to extend the spatial functionality with operations such as 3D routing, generalisation, and adaptation of different types of data, and consistent field update of data. Some of these functionalities have to be provided as a generic set of operations at a database level.

6 DISCUSSION

The standardised services developed within this project will facilitate the work of Emergency sector in a number of directions. We expect that the systems will allow for a better preparation to disaster management, because of the standardised operations able to be exercised in daily work.

It will be possible a better handling of the first period of an emergency, achieved by providing targeted information rapidly and by collecting relevant information from the filed that helps coordinating operations efficiently. This period, called the golden hour, will often determine the success of the entire operation, for instance as concerns the ability to save lives.

The integration of command-and-control with field operations will be significantly improved especially the coordination between forces, teams and organisations that participate in emergency management. The nature of the project is such that this impact will be achieved as concerns communication and data management.

The handling of emergency will also be improved, because information from multiple sources and databases will be possible to access in order to provide the emergency sector with all insights that can be realistically obtained in support of life saving and protection of material assets. This will prevent that vital data will not be usable simply because the data handling technical issues.

The visualisation of requested information will be improved with respect to the specific needs of the users and therefore provided in formats (e.g. images, vector, video) that are more compatible with the environmental conditions during the emergency.

This definitely will result in a better support to rescuers, based on information provision and coordination, which can on the one hand lead to faster and more effective operations and in the other hand ease the burden of stress on the operations theatre.

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