DR 3.4: Shared Situation Awareness that Supports Resilience

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This deliverable describes the results in the TDS research and development in Year 4 of the TRADR project. The objective is a scenario response system for robot operations and information/team management in parallel.

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Executive Summary

Working together with robots in a response team for catastrophes requires special equipment. The operation of robots should be as simple as possible. The higher the level of autonomy the higher the level of usefulness. Instead of steering the robots the analysis of gathered information can be focused. Achieving this objective the WP 3 aims to develop a central system unit.

Role of Shared Situation Awareness in TRADR

The WP3 combines and integrates information and functionality through a central management system, the TDS. This is the new platform for the end users for their operation management.
It is a new situation. Robots, UGVs and UAVs, participate on rescue scenarios as team members and support the humans in doing the necessary jobs. They support by contributing to SA: taking videos for livestreams and photos for an overview and for 2D/3D maps, collecting data for an estimation of non-visible dangers like explosive atmospheres, radioactivity and more, depending on the available sensors. But in the same way as they scan the surrounding for the humans they do it also for themselves especially by recording LIDAR information. Based on that they create their own 3D virtual world and assess themselves in relation to that. UGVs are now able for exploring the environment automatically step by step and depending on the strategy most efficient. Alternatively and with the 3D maps as persistent background information they can be used for patrolling tasks alone or as a swarm with individual focus in execution. UAVs are still steered manually, because of the missed technology for an automatic collision avoidance and due to the regulations by law. But even without that the UAV delivers very fast an overview and details from an optimal position. It supports also the victim search as well as smoke and fire detection.

This rough list of robot functions gives an impression on the requirements for the TDS. On the one hand it must be possible to manage the robots, on the other it is important to manage the gathered information and to distribute them to the persons, who will need them. Over all the TDS is a management tool for all kind of operations from end user perspective.

Persistence

Persistence in WP3 is addressed by enabling end-users to interact with (relevant) information that is persistent within the TRADR system. In effect the TDS serves as a looking glass and filter into the TRADR databases, as to support persistent SA and allow tactical decisions to be made effectively. Thus, the TDS provides access into information retained over the course of multiple sorties.

Contribution to the TRADR scenarios and prototypes

Changing the test strategy to a realistic use, the TDS could demonstrate its use for end users.

1. Tasks, objectives, results

1.1. Planned work

The work in Year 3 was planned to address Milestone MS3.4: “A platform for sharing human-robot SA and adaptive human-robot communication”.

1.2. Addressing reviewers' comments

Reviewers’ recommendation: A contingency plan is needed in the short term to recover from the delay of the work.

The consortium implemented the plan shared with and endorsed by the reviewers after the Y3 review meeting. TNO has taken over the responsibility for the TDS development, TNO also engaged a suitable interface designer. The corresponding resources have been shifted from FDDo to TNO.

1.3. Actual work performed

Now at the end of the project it wass our endeavour to present a TDS which fits with the requirements and expectations of the end users. For this purpose two interview sessions were held parallel to the integration of functionality and independently of the TJEx/TEval so that an optimized TDS version could be used for the official tests. A group of six professional fire fighters evaluated during simulated scenarios the TDS regarding functionality, layout and quality of visualization for the information management. It turned out that the layout could be improved concerning clarity. Too many functions in the form of buttons overloaded the screen in the first impression. The map, the central situation report, was too small which reduced the situation awareness of the users. Together with a professional designer for user interfaces the layout was improved on a more structured basis. At the end the map could be presented larger. This is not to be underestimated with regard to the screen size of laptops or tablet PCs the typical tool for operations outside in the field. Other improvements led to a clear overview with only the really important functions and information at first sight, like the alerts (notifications), icons (placemarks) for marking operation relevant places in the map, layer list and so on. After the improvement the layout was accepted by the subjects. Further improvements concern the functionality. The handling of the TDS is now simplified. It is closer to the user's expectations and experience in other software products. For example the placing of icons can be done by a mouse klick everywhere on the map. The menu structure is concentrated on the right side of the window. It is the standard configuration of the TDS. With introduction of the modular design each user can optimize the layout to his needs. That means he can arrange the different menus like flying palettes and place them free as he needs to keep the overview and SA.

The new software developer integrated the bridge to connect the speech recognition to the TDS pushing forward the multimodal information input. The users can now set placemarks by spoken commands.

An example for the improvement of the quality of visualization is the renumbering of the alerts (notifications). The alerts obtain an agent based logical number in chronological order instead of cryptic names. That offers a real simplification in the information handling and communication.

Coming back to the challenge that the teamwork between humans and robots is a new situation. So far the TJEx and TEval were tests with predefined tasks focusing the different functionalities of the robots and the system in general thus the TDS. This procedure ensured that all functions were evaluated without exceptions and that the CIP (Continuous Improvement Process) was applied comprehensively. At the end of the project it was necessary to change the evaluation strategy. The key interest was now the application of the system in realistic exercises without any guidelines. Could the system meet the requirements and support the end users? To clarify this question a container was converted to an operation control center. Equipped with control units for robots and a team leader the management of the operation was organized and executed from here. Out of line-of-sight the operation of the robots was interesting because of a video delay problematic in the past and concerning the resilience of the system in general. It could be demonstrated despite of an existing small delay that the manual operation of the robots was fast and possible. Driving breaks couldn't be observed like in the past. In sum the operations could be managed satisfactorily.

The task management ontology has been added, and this resulted in two different GUIs for the TDS. The task manager and task editor. To allocate new tasks or edit existing ones, the team leader uses a task editor. A second GUI provides the team leader with a task manager interface to enable the team leader to track and monitor the progress of assigned tasks. Mission actors can track the progress of their tasks in the main display system which shows the task POI, description and status. The latter property is continuously updated by actors and agents throughout the execution process.

The actual work performed in WP3 Year 4 included the following:

- TDS interface design and communication (Section **1.3.1**)
- Interface for task allocation and management during TRADR missions (Section **1.3.2**)
- Interface for monitoring the workload of mission actors (Section **1.3.3**)
- Multimodal interaction with the TDS using speech (Section 1.3.4)

More details are provided in the next sections.

1.3.1. TDS interface design and implementation

First a quick scan of the user interface was performed by an user interaction designer, by using the TDS as it was during summer 2017, see Figure 1.Subsequently the user interaction designer gathered information about what the end users want and defined user stories. These two provided input for requirements and an interaction design. Next to the changes based on input from the interaction designer, input from end-users and partners were also implemented. Implementation also encompassed changes to ensure stability. For a more detailed overview see (Annex Overview 2.1).

Figure 1: TDS Summer 2017.

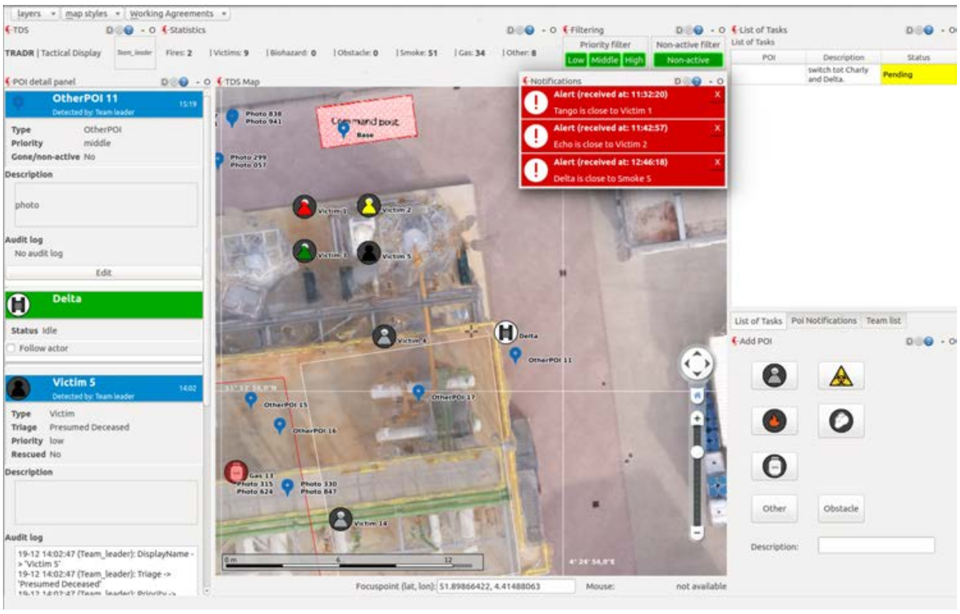


Figure 2: TDS after redesign and implementation.

1.3.2. Task Management Interface

To use and deploy the task management ontology discussed in Section 1.2.4 of document DR 5.5: Deliverable D5.4, two different GUIs have been designed. These GUIs integrate and provide support for task management in the search and rescue tactical display system (TDS). The latter is used for tracking the disaster area and has been developed to assist USAR teams in the TRADR project. It contains a map of the disaster site showing the location of actors and the detected POIs (victims, fires, chemical objects, etc.). It also provides support for assessing the disaster site situation and for gathering relevant information about it.

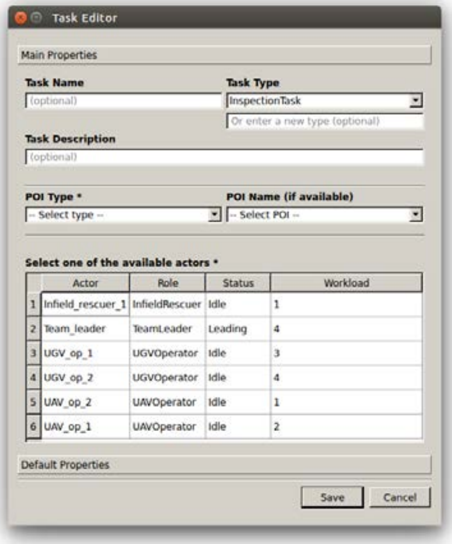
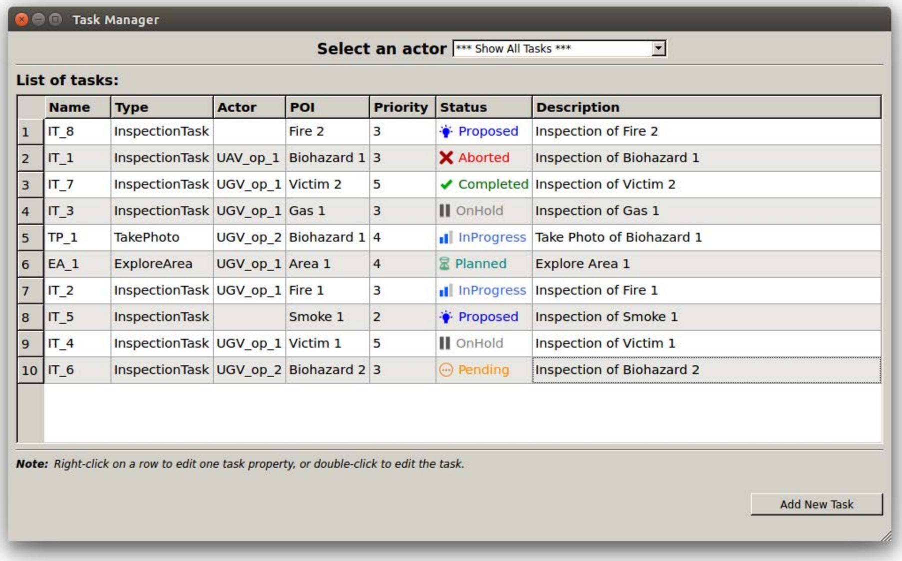


Figure 3: Task Editor for creating and editing mission tasks.

To allocate new tasks or edit existing ones, the team leader uses a task editor, as shown in Figure 3. In this GUI, the team leader defines the task properties including (1) a task type (inspection task, exploration task, etc.); (2) a description containing specific details or guidelines for the operators; (3) a POI which defines the task's objective; and (4) an actor from the list of available actors suggested by the system. Other optional fields can also be set, such as (1) a priority; (2) a status (pending, in progress, completed, etc.); (3) a list of required capabilities; (4) a required battery level; and (5) a required workload.



	Name	Type	Actor	POI	Priority	Status	Description
1	IT_8	InspectionTask		Fire 2	3	Proposed	Inspection of Fire 2
2	IT_1	InspectionTask	UAV_op_1	Biohazard 1	3	Aborted	Inspection of Biohazard 1
3	IT_7	InspectionTask	UGV_op_1	Victim 2	5	Completed	Inspection of Victim 2
4	IT_3	InspectionTask	UGV_op_1	Gas 1	3	OnHold	Inspection of Gas 1
5	TP_1	TakePhoto	UGV_op_2	Biohazard 1	4	InProgress	Take Photo of Biohazard 1
6	EA_1	ExploreArea	UGV_op_1	Area 1	4	Planned	Explore Area 1
7	IT_2	InspectionTask	UGV_op_1	Fire 1	3	InProgress	Inspection of Fire 1
8	IT_5	InspectionTask		Smoke 1	2	Proposed	Inspection of Smoke 1
9	IT_4	InspectionTask	UGV_op_1	Victim 1	5	OnHold	Inspection of Victim 1
10	IT_6	InspectionTask	UGV_op_2	Biohazard 2	3	Pending	Inspection of Biohazard 2

Figure 4: Task Manager for tracking and monitoring tasks.

A second GUI provides the team leader with a task manager interface Figure 4 which has been designed to enable the team leader to track and monitor the progress of assigned tasks. For each task, the GUI displays its type, description, assigned actor, priority and status, to provide the team leader with an overview of the execution progress. Mission actors can track the progress of their tasks in the main display system which shows the task POI, description and status. The latter property is continuously updated by actors and agents throughout the execution process.

For every new mission, the main ontology is initialized and loaded in a central repository (we use Stardog triple stores http://www.stardog.com} which provide support for querying, inferencing and manipulating the knowledge base stored in the repository based on the semantics defined by our ontology). To ensure this repository maintains an up-to-date state of a mission, we developed and use semantic modelers to continuously update the database with new knowledge acquired during a mission. These modelers map raw sensor data (e.g., point cloud, GPS coordinates, etc.) onto ontological concepts (POIs, locations, etc.) and store it in the repository.

The mapped data is then used to display and update meaningful information for monitoring the progress of a mission on TDS. It is also used to reason about the represented world and generate notifications related to the task being executed. The aim is to manipulate the gathered knowledge for (1) improving shared situation awareness; and (2) assisting the team leader in its job of assigning tasks by providing automated support through task proposals. For example, when a new POI is detected, the system will propose a new task so that the team leader allocates it to one of the available actors.

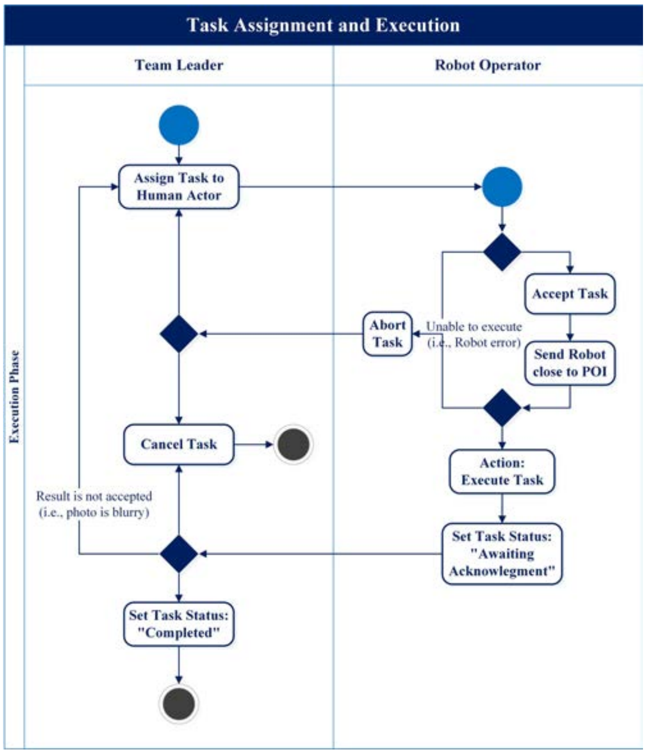


Figure 5: Activity diagram for assigning and executing mission tasks.

Throughout a mission, the team leader will continuously add new tasks or update existing ones (description, priority, etc.). The activity diagram in Figure 5 shows the workflow for assigning and executing a task. First, the team leader assigns a task to an actor. Then, the actor can accept it and start the execution or can abort it when facing technical issues (e.g., robot errors). When the task is executed, the actor sets its status to awaiting acknowledgment using the task manager. If the result is accepted, the team leader sets the task status to completed. Otherwise, it will be reassigned or canceled.

1.3.3. Interface for Monitoring Workload of Mission Actors

A workload GUI has been developed to monitor the actors workload during a TRADR mission. This GUI is integrated into TDS (Figure 2) to allow each actor manually enter their workload. As for the standalone application, illustrated in Figure 6, it is meant to be used by an external observer who is responsible for tracking the workload of the team throughout a TRADR mission. The team leader's workload is used as a trigger for working agreements in order to regulate the frequency of sending notifications and alerts during a mission. For example, when the team leader's workload is set to 5 (which means high), the system TDS will only display urgent notifications and alerts (i.e., if the POI priority is high). Whereas when the workload is low, the team leader will be notified more frequently, based on how they set the working agreements.

Figure 6: Workload GUI for monitoring actors workload using a scale from 1 (low) to 5 (high).

1.3.4. Multimodal Interaction with the TDS Using Speech

We continued the work from Year 3. Using the experience from TJex 2017 and additional input from the end users, we have analyzed the requirements on and usability of including speech-based dialog as an additional modality for interaction with the TDS. We extended the implementation of the frame-based dialogue manager and the Nuance.Mix models for speech processing. Speech-based dialogue has been integrated with the TDS, thus resulting in a multimodal system. Focus was on the operations related to victims and points of interest: adding new ones and displaying the existing ones. The multimodal TDS system was employed during the TRADR Evaluation Exercise 2017. The details are presented in the Annex 2.1.3.

2. Annexes

2.1.1. R. de Kok, B. van Woensel and N.J.J.M. Smets (2018), “Requirements and implementation TRADR TDS"

Bibliography: R. de Kok, B. van Woensel and N.J.J.M. Smets (2018), “Requirements and implementation TRADR TDS". Technical report

Abstract
This document lists the user interface requirements for the TRADR TDS (Tactical Display System) and the actual implementation. First a quick scan of the user interface was performed by an user interaction designer, by using the TDS as it was during summer 2017. Subsequently the user interaction designer gathered information about what the end users want and defined user stories. These two provided input for requirements and an interaction design. These were provided as input for the implementation.

Relation to WP This work contributes to T3.4 Sharing SA for human-robot teaming. Since the new design and implementation of the TDS supports shared SA better for the whole human-robot team.

Availability Restricted.

2.1.2. N. Smets, M. Neerincx and C. Jonker. “An Ontology of Team Situation Awareness for Support and Evaluation"

Bibliography: N. Smets, M. Neerincx and C. Jonker. “An Ontology of Team Situation Awareness for Support and Evaluation" (2018) Technical Report.

Abstract
We formulate an ontology with the concepts of SA, its effects and how to measure SA and use this as support before, during (real-time) and afterwards for evaluation purposes. We will illustrate how this is done by describing the process for small case studies in the USAR domain for human-robot teams. Such an ontology makes it possible to choose the correct level of SA in the design and evaluation process for human robot-teams. The ontology will be verified for internal consistency and validated by a focus group.

Relation to WP This work directly contributes to T3.4 Sharing SA for human-robot teaming.

Availability Restricted.

2.1.3. S. Sengupta and I. Kruijff-Korbayova. "Processing Multimodal Dialogue for Disaster Response Support"

Bibliography: S. Sengupta and I. Kruijff-Korbayova. "Processing Multimodal Dialogue for Disaster Response Support" (2018) Technical Report.

Abstract

In this paper we present an approach for processing multimodal dialogue in the context of human-robot teaming for disaster response. We have analyzed the requirements on and usability of a multimodal dialog system in the context where a human team works uses robots to assist situation assessment after large incidents, such as an industrial accident or an earthquake. We implemented a frame-based dialogue manager. For speech processing we have used the Nuance.Mix cloud services. The system was employed in a field trial with Dutch firefighters in the TRADR Evaluation Exercise 2017.

Relation to WP This work directly contributes to T3.4 Sharing SA for human-robot teaming.