

How to evaluate mass casualty mission tactics using field exercises and computer simulation?

Sven Wirth, Johannes Sautter, Fraunhofer IAO • Friederike Schneider, German Red Cross • Maria Egly, AIT • Martin Scholl, cismet • Martin Sommer, Frank Jonat, Airbus DS

Keywords: mass casualty incidents, field exercises, modelling and simulation, mission tactics

1. Conduct field exercise

The context of use of the CRISMA reference application for Exercise-Support is an exercise setting of aid organisations or public authorities in Europe. Some tasks have to be sorted out before, during and after an exercise (run). This includes, for instance, the patient actors- and responder management before an exercise. The data capturing of certain aspects like (pre-) triage, care measures etc. during the exercise as well as the processing of this data after the exercise is very important for the next steps. The CRISMA application supports certain aspects of a field exercise for mass casualty incidents. These aspects can broadly be separated into three categories: preparation, capturing and debriefing.

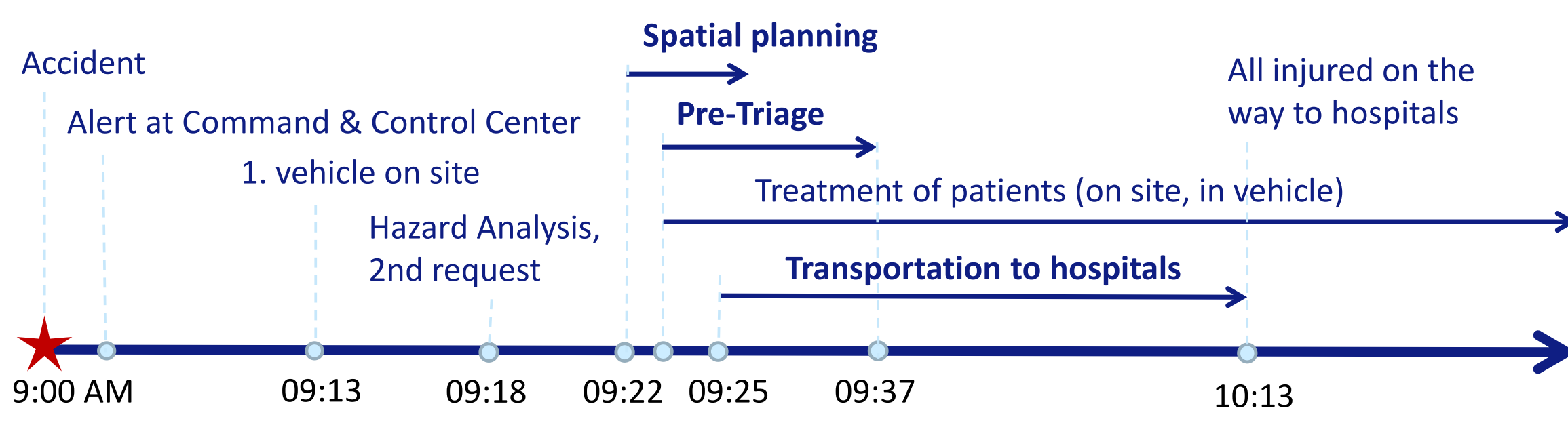


Figure 1: Mission timeline from a mass casualty exercise (bus accident on rural highway, 25 injured, Source: BRK Garmisch-Partenkirchen)

A typical mission timeline of a mass casualty field exercise is illustrated in Figure 1. Figure 2 illustrates the most relevant tasks to be done during an exercise day.

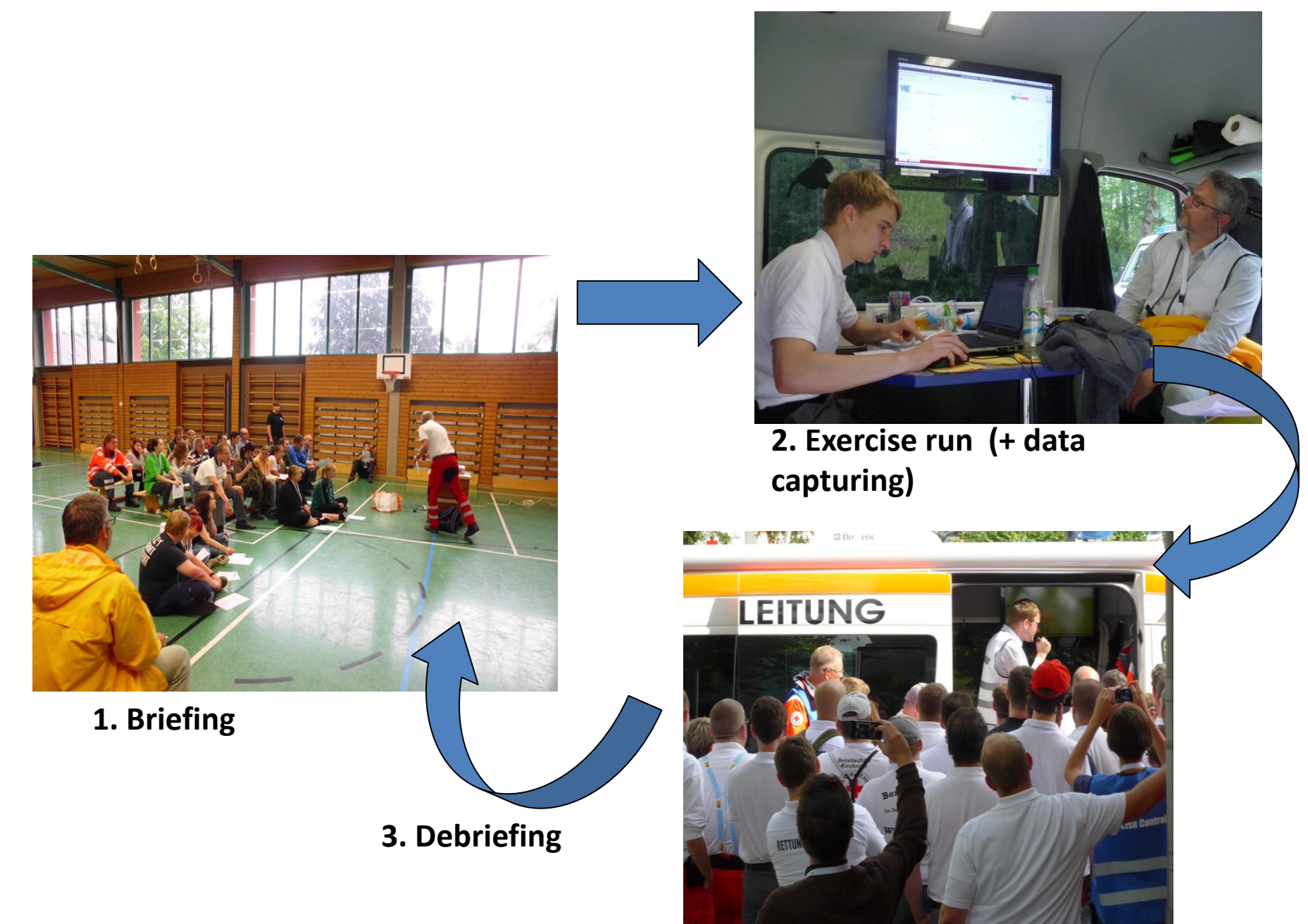


Figure 2: Patient Actor Briefing, Data Capturing and Responder Debriefing

2. Evaluate exercise using CRISMA tool and indicators

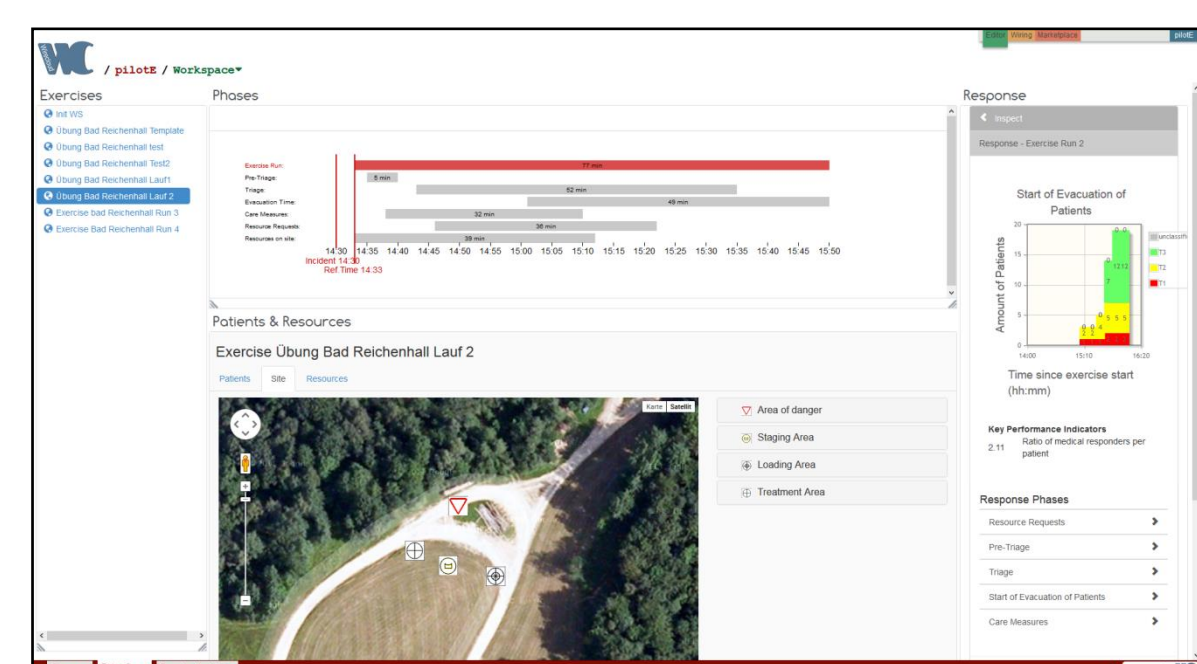


Figure 3: Debriefing View of the CRISMA Reference Application for Exercise-Support

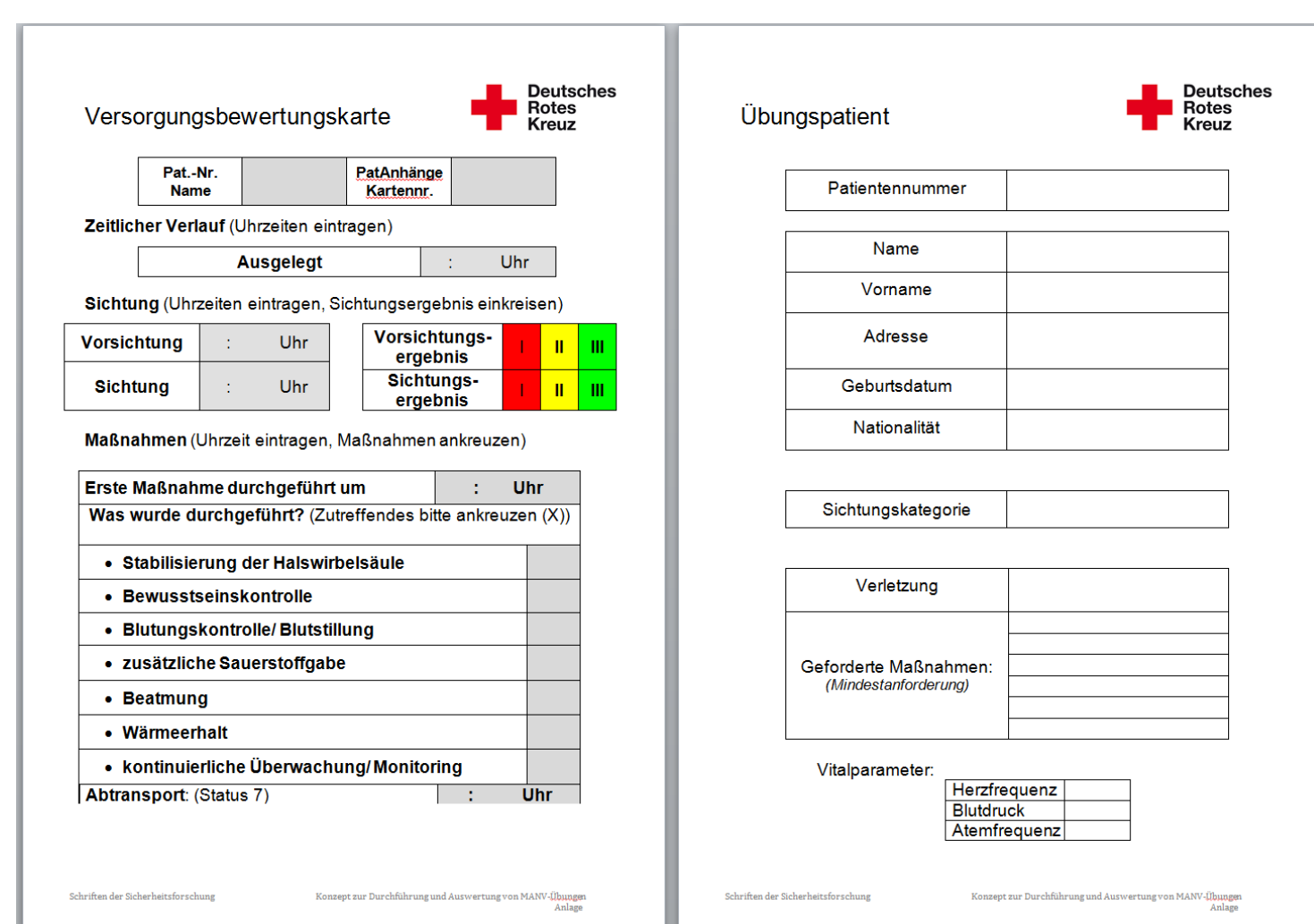


Figure 4: Evaluation sheet used by the patient actors

The patient actors use an evaluation sheet to capture data on times and care measures performed by the medical responders conducting the field training (see Figure 4). Field exercise control benefits from detailed quantitative evaluation data, which is enhanced by self-

assessment of the trainees as well by medical and mission experts feedback. Values of the red and blue marked indicators from the exercise runs shown in Table 1 are used as model parameters and for calibration of the model in the next step.

No	Category	Name	Deutsch	Start	End	Priority	BGL Exercise Run 1	BGL Exercise Run 2
1	Accomplishment	Time until last patient is transported to the hospital	Zeit bis letzter Patient zum Krankenhaus transportiert wird	Time of arrival of the first (medical) vehicle on scene Status 4 *	Last patient leaves the scene Status 7 *	1	76 min	77 min
2	Accomplishment	Time until red patients are away from the incident scene	Zeit bis alle rot-triagierten Patienten den Notfallort verlassen haben	Time of arrival of the first (medical) vehicle on scene	Last red patient leaves the scene	1	35 min	59 min
3a	Accomplishment	Ratio of medical responders per patient	Verhältnis von Einsatzkräften und Patienten insgesamt	Incident time	Last patient leaves the scene	1	1.6	2.1
3b	Accomplishment	Ratio of medical responders per patient per interval	Verhältnis von Einsatzkräften und Patienten pro Intervall	Incident time	Last patient leaves the scene	1	See tool	See tool
4a	Accomplishment	Time until all patients are pretriaged	Zeit bis alle Patienten vorgeschichtet wurden (nicht-ärztliche Vorsichtung)	Time of first triage (→ erste dokumentierte Sichtung in Mimenkarte)	All patients are pretriaged	2	6 min	7 min
4b	Accomplishment	Time until all patients are triaged	Zeit bis alle Patienten gesichtet wurden	Time of first triage (→ erste dokumentierte Sichtung in Mimenkarte)	All patients are triaged	2	72 min	63 min
5	Accomplishment	Number (+ kind) of vehicles involved	Anzahl der Rettungsmittel insgesamt	Incident time	Last patient leaves the scene status 7 *	2	10	10
6	Accomplishment	Percentage of correct supplied patients (basic care measures)	Prozent der korrekt versorgten Patienten (präklinische Maßnahmen)	Time of first basic measure (→ Beginn der ersten Maßnahme)	Last patient leaves the scene Status 7 *	3	28%	37%

Table 1: Besides qualitative expert feedback quantitative Indicators are used to evaluate the field exercises

3. Build and calibrate simulation tool using exercise data

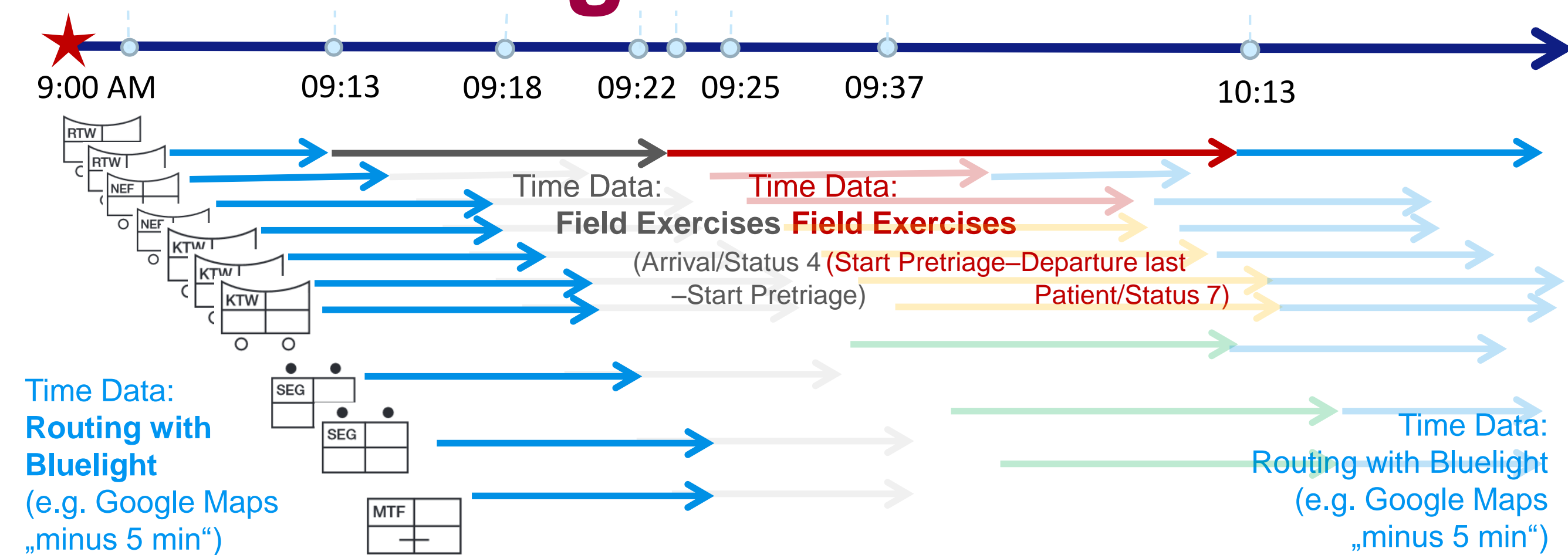


Figure 5: Several time slots of a mass casualty mission and respective data sources

After a data analysis that identified outliers, two model parameters could be derived from average time spans of two exercise runs in Bad Reichenhall (see Table 1, columns on the right):

- pretriage: 19.4 sec/patient
- triage: 188 sec/patient

Contact

Dr Anna-Mari Heikkilä, Project Coordinator
VTT Technical Research Centre of Finland
Tel: +358 20 722 3490, Email: crisma.coordinator@vtt.fi

The main simulation calibration process is running the model with similar inputs parameters as the inputs for the exercise runs were. Then the results of both are compared. If the results are satisfactory, the calibration is done; if not, some picked parameters must be adjusted in the direction of the mismatch.

No	Category	Short Name	Long name	Deutsch	Start (Values)	End	Priority	Exercise Indicator
1	Situation	Patients	Number of patients	Anzahl Patienten			1	–
2	Situation	Weather	Weather Conditions	Wetterverhältnisse	Values 1-5 (1 hot summer, 5 heavy winter)		2	–
3	Situation	Walking patients	Number of patients able to walk	Anzahl der Patienten, die gehen können			3	–
4	Tactics	Involved medical responders	Number of involved medical responders	Anzahl beteiligter medizinischer Einsatzkräfte			1	–
5	Tactics	Number of used tactical areas	Number of used tactical areas	Anzahl verwendeter Einsatzabschnitte			2	–
6	Tactics	Time until second resource request	Time until second resource request	Zeit bis zur Nachalarmierung	Incident time Status 0*	Second vehicle request is raised	2	–
7	Accomplishment	All patients got pretriaged	Time until Pretriage is done	Zeit bis Vorsichtung abgeschlossen ist	Incident time Status 0*	Last patient has been pretriaged	1	4a
8	Accomplishment	First red patient treated	Time until first red patient is treated	Zeit bis der erste rote Patient behandelt wird	Incident time Status 0*	First red patient is treated	1	–
9	Accomplishment	Last red patient treated	Time until last red patient is treated	Zeit bis der letzte rote Patient behandelt wurde	Incident time Status 0*	Last red patient is treated	1	–
10	Accomplishment	Last red patient evacuated	Time until red patients are away from the incident scene	Zeit bis alle rot-geschichteten Patienten den Notfallort verlassen haben	Incident time Status 0*	Last red patient is evacuated	1	1
11	Mission Accomplishment	Last red patients at hospital	Time until last red patient arrives at the hospital	Zeit bis letzter roter Patient im Krankenhaus eintrifft	Incident time Status 0*	Last red patient arrives at hospital Status 8 *	1	–
12	Accomplishment	–	Ratio of responder per patient	Verhältnis zwischen Einsatzkräften und Patienten	Incident time	Last patient arrives at hospital status 8 *	2	3a
13	Accomplishment	Loading Area built	Time until loading area set	Zeit bis RMHP eingerichtet	Incident time	Time until area BHP has been built.	2	–
14	Accomplishment	Staging Area built	Time until staging area set	Zeit bis Bereitstellungsraum eingerichtet	Incident time	Time until area BHP has been built.	2	–
15	Accomplishment	Treatment Area built	Time until treatment area built	Zeit bis BHP eingerichtet ist	Incident time	Time until area BHP has been built.	3	–
16	Accomplishment	Last patient at hospital	Time until last patient arrives at the hospital	Zeit bis letzter Patient im Krankenhaus eintrifft	Incident time Status 0*	Last patient arrives at hospital Status 8 *	3	–

Table 2: Indicators serve for evaluation of mass casualty missions (=simulations) by the simulation tool's user

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Keywords: mass casualty incidents, incident scene simulation, resource management, decision-support, mission tactics analysis

The diagram illustrates the Field Exercise process flow, centered around a large blue circle labeled "Field Exercise" which contains an icon of a group of people. The process is divided into two main phases: "Exercise-Support" (left) and "Planning" (right), separated by a vertical line. The "Exercise-Support" phase includes "Debriefing" (yellow oval) and "Capture exercise runs" (red oval). The "Planning" phase includes "Select region with specific capacities/availabilities" (blue oval), "Choose mission strategies and run simulation" (blue oval), "Identify best plan for Decider in specific region" (blue oval), and "Prepare exercises" (green oval). Arrows indicate a clockwise flow: from "Capture exercise runs" to "Debriefing", then to "Select region...", then to "Choose mission strategies...", then to "Identify best plan...", then to "Prepare exercises", and finally back to "Capture exercise runs".

Exercise-Support (Development August 2013-July 2014)

- Debriefing
- Capture exercise runs

Planning (Development since August 2014)

- Select region with specific capacities/availabilities
- Choose mission strategies and run simulation
- Identify best plan for Decider in specific region
- Prepare exercises

Field Exercise

Exercise Leader

Exercise Data Steward

Planner (MICEP/Command Center)

MC: medical incident commander
 (general, CDR, chief emergency physician, general LIA)

- Authorities and deciders that face tactical challenges in resource management are situated on a lower level (e.g. regional or municipality) and focus on short term decisions. In this simulation view the user is capable of trying different alternatives of managing available resources and take decisions regarding the allocation and deployment of equipment, vehicles and personnel.

Crisis Task Force Use: The CRISMA system may also be consulted as an evaluation tool in a command vehicle during real-life exercises or even when a real crisis is evolving. The command vehicle might be noisy with regular interruptions.

Decider on Tactical Level: situated one level above the operational level that carries out the orders given. Tactical deciders can make decisions which later result in such orders.

- E.g. Train Crash in Berlin with 213 injured**

- ## 4. Decide on mission tactics and run

E.g. Early vs. Late Request of SEG & KatS resources

Contact
Dr Anna-Mari Heikkilä, Project Coordinator
VTT Technical Research Centre of Finland
Tel: +358 20 722 3490, Email: crisma.coordinator@vtt.fi

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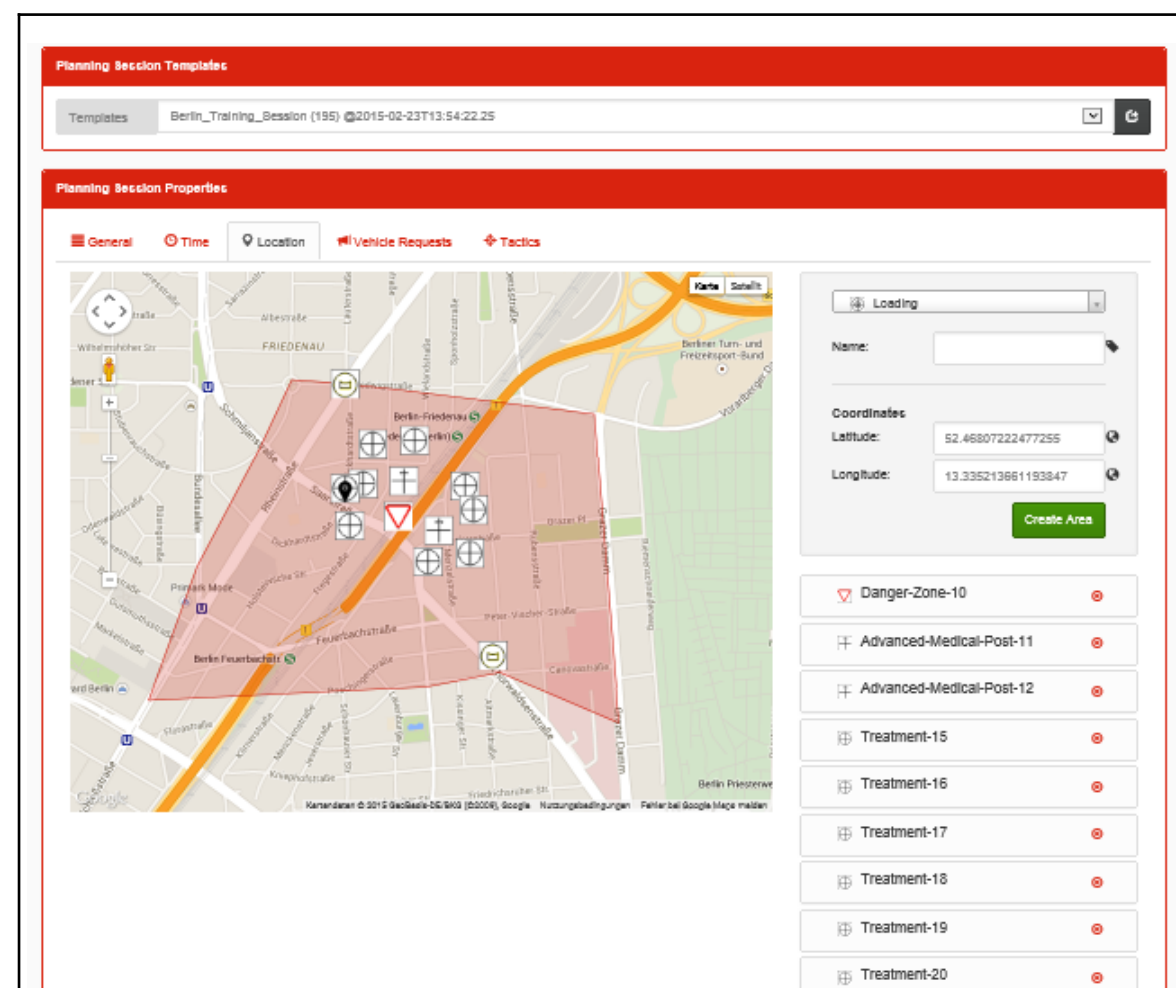


Which other tactics can be tested using the tool?

Sven Wirth, Johannes Sautter, Fraunhofer IAO • Friederike Schneider, German Red Cross • Maria Egly, AIT • Martin Scholl, cismet • Martin Sommer, Frank Jonat, Airbus D&S

Keywords: mass casualty incidents, incident scene simulation, resource management, mid-term decision support

1. Test use of tactical areas




Screen 1

Action: In order to elaborate mission tactics it is necessary to define tactical areas to be used for mission accomplishment. A user is capable of positioning the following area types:

- Danger Zone
- Advanced Medical Poster (PA)
- Loading Area (LZ/RMHP)
- Staging Area (BR)
- Treatment Area (BHP)

Output: According to defined areas the simulation tool assigns particular resources to these areas. E.g. the danger zone binds personnel for situation analysis. The advanced medical post binds personnel for leading the area as well as for treating patients. The Loading and Staging Area only binds personnel for leading. The Treatment area needs particular time, personnel and equipment for setup and patient treatment.



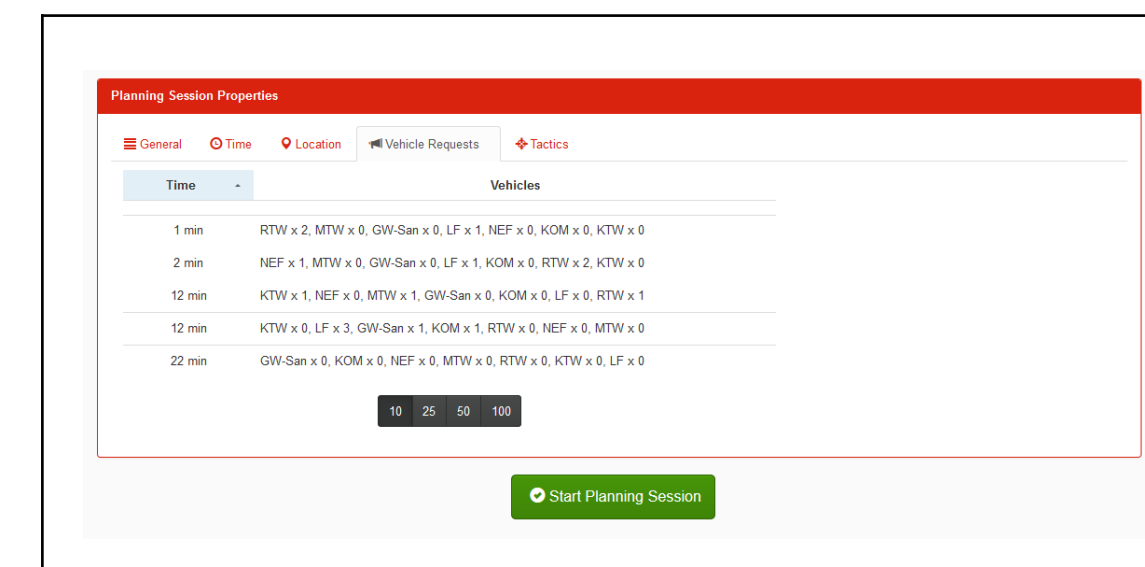
Screen 2

Output: The simulation result view shows a simulation run that used a Danger Zone, an Advanced Medical Post (PA) a Loading Area (RMHP) and a Staging Area (BR).

E.g. Train Crash in Berlin with 213 injured

- On the 10.04.2015 at 9:18 railway derailment at the stop Friedenau with 213 patients
- Railway derailment at a speed of 70 km/h
- The locomotive crashed into a bridge abutment
- The second and third wagon were perpendicular to the direction of travel and strong deformed just before a bridge

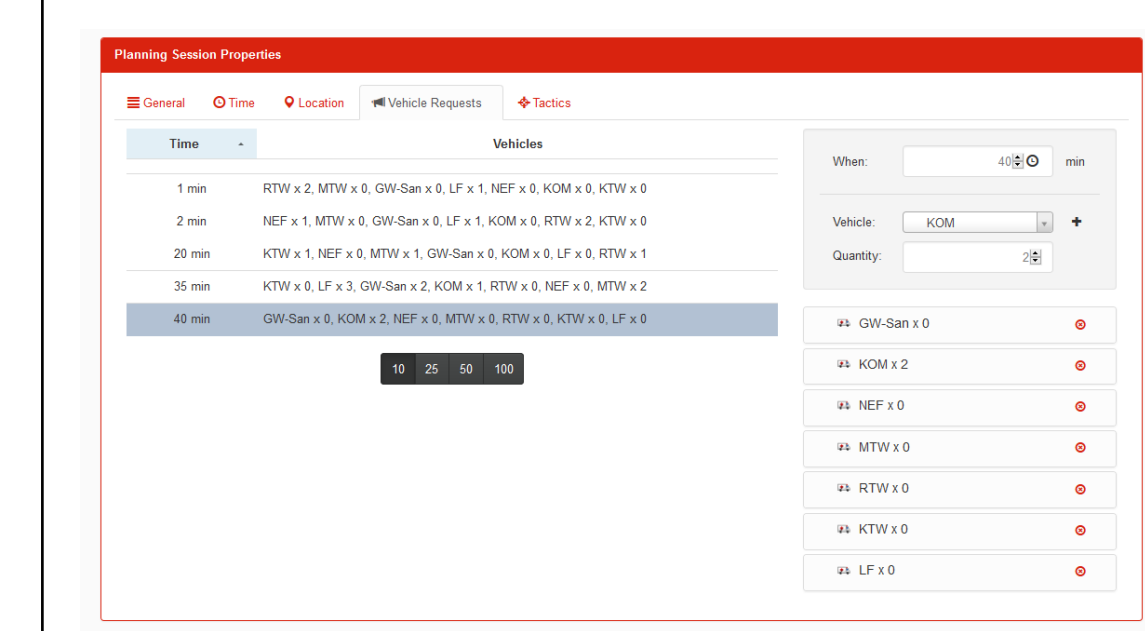
2. Change vehicles to alert



Screen 1 and Screen 2

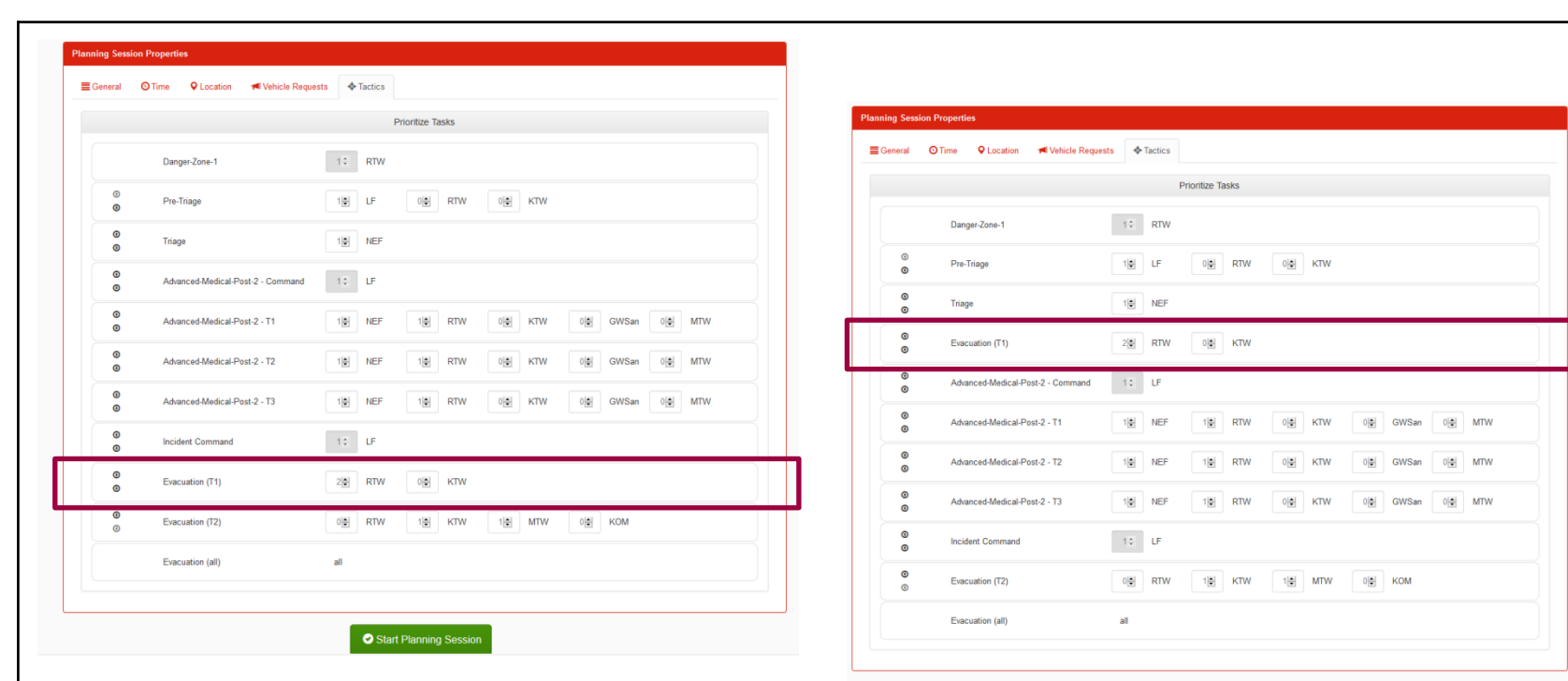
Screen 1 shows some initial resource requests as well as mission keywords from the order of alarm and action (AAO) of the particular region.

Action: A user is capable of changing times as well as number of vehicles to request. Now he or she changes the time of the 3th, 4th and 5th resource request and adds 2 additional GWSan, 2 MTW and 2 KOM.



Screen 2 shows the user interface after these changes.

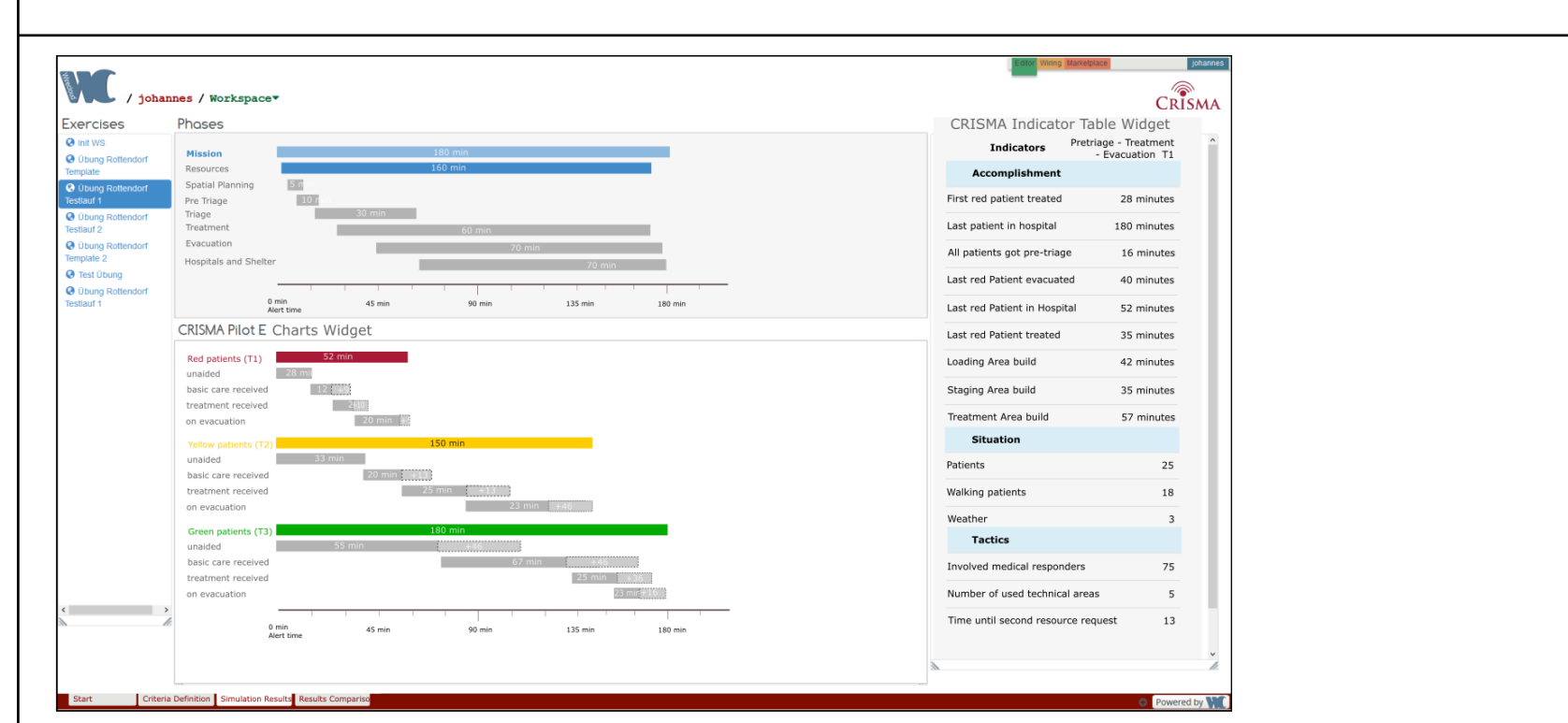
3. Adjust mission task priorities



Screen 1 and 2

Screen 1 shows an initial tactical tasks configuration that first foresees a situation analysis (Danger Zone), followed by Pretraiege and Triage. Further the four tasks of the Advanced Medical Post (PA) are listed as well as the incident command and the evacuation of red, yellow and green patients.

Action: The user now changes the priority of the tactical task "Evacuation (T1)" from priority 9 to priority 3.

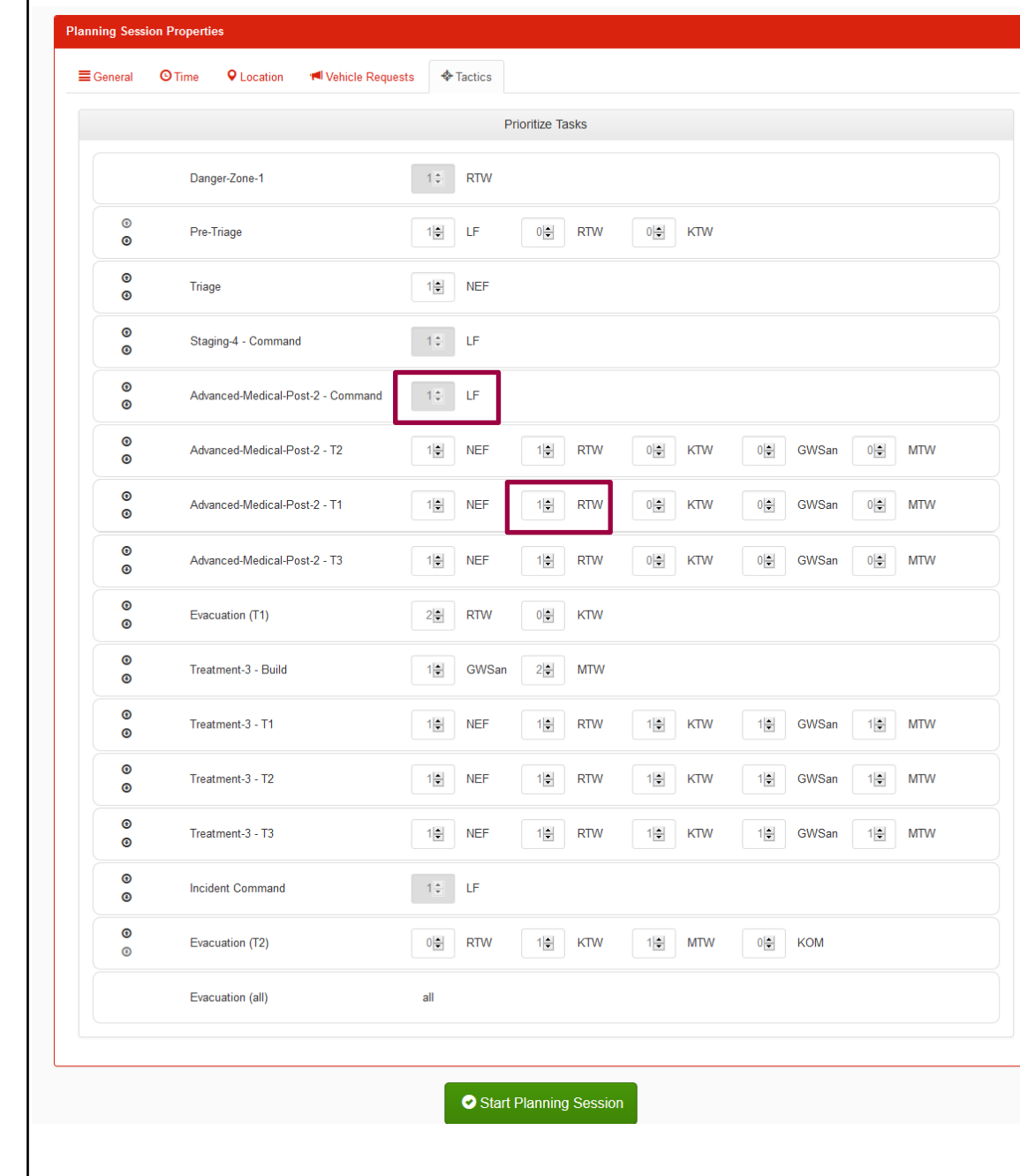


Screen 3

Output: the simulation results view for the chosen tactic illustrates an earlier evacuation of the red patients, while yellow and green patients remain longer on site.

E.g. Bus accident in Berlin with 25 injured

- Bus accident with 25 passengers at 18:25 in Berlin on the 10.04.2015
- Bus leaved the road with a speed of 70 km, tilted to the right and crashed into a tree
- Bus is in the front area strongly deformed and wedged in trees
- Suburban area, weather resistant at 6 degrees, light rain and calm




Screen 1

The Tactics tab shows a configuration with high prioritizes tasks of the leading of a Staging Area as well as the Command and Casic Care within an Advanced Medical Post (PA) (positions 4 to 8 in the priority list). The evacuation of red patients (T1) has further been set to a priority as the evacuation of other patients (last).

Action: In order to elaborate mission tactics for resource assignment to these tasks, a user is now capable of assigning reasonable vehicles to these tasks. Some vehicles per task type are preset. Some more vehicles of each type can be assigned. Important to know is that the user only should assign those resources he or she ordered previously on the resource request Tab.

5. Compare several simulation runs using multi criteria analysis



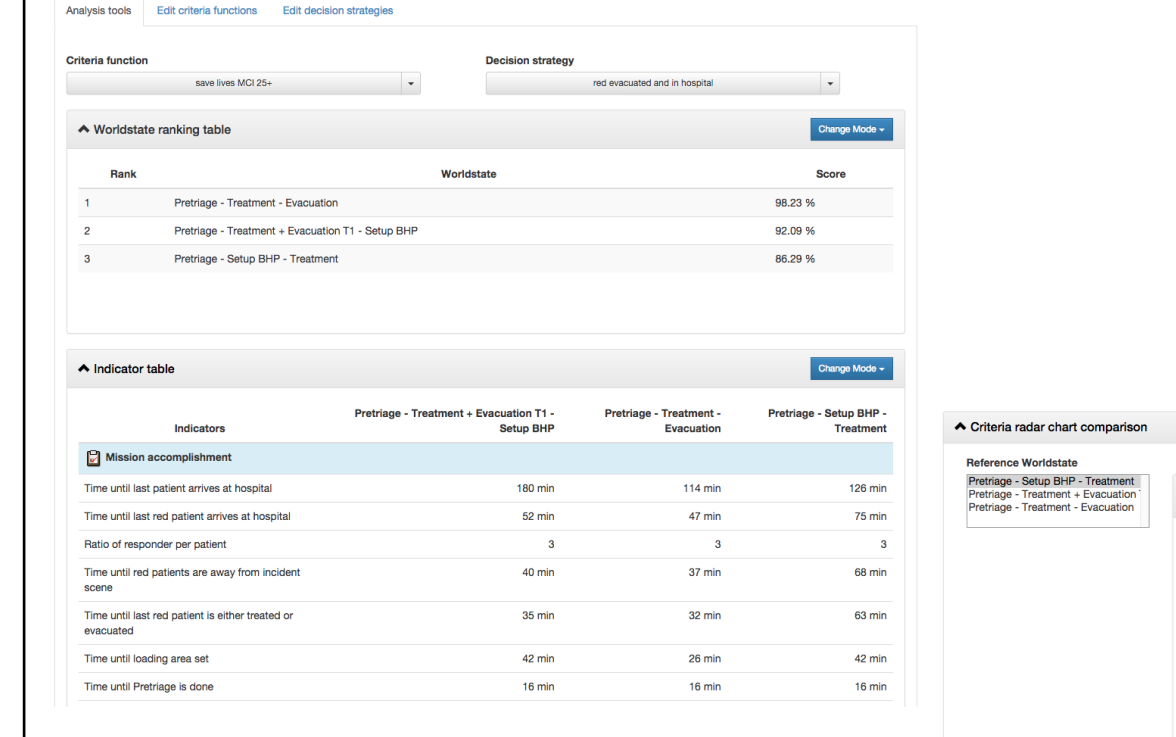
Screen 1 and 2

Action: For comparing several previously done simulation runs testing some mission tactics in a small mass casualty scenario of 25 injured, the user first defines a criteria function for scenarios around 25 injured (Screen 1, on the left) on the Decision-Support and Analysis Tab of the Resource Planning Application.

Output: The Criteria function widget allows to define a level of satisfaction for both "0% satisfaction" and "100% satisfaction" for each indicator and visualizes the definition.

Action: Second the user defines several decision functions that formulate decision strategies using the decision strategy widget.

Output: For each indicator the decision function widget shows the weight it is taken into account using the decision strategy.



Screen 3 and 4

Output: As soon as the user switches to the "Analysis tools" Tab a ranking of simulation runs regarding the selected decision function is showed. In the example showed in Screen 3 (left) the simulation run without treatment area (see 1.) got a score of 98 %, while two others that use treatment areas only got a 92% and 86% score. As shown in Screen 4 (below)also radar charts can be used to visualize the criteria-fulfilment of indicators.

6. Technical Implementation

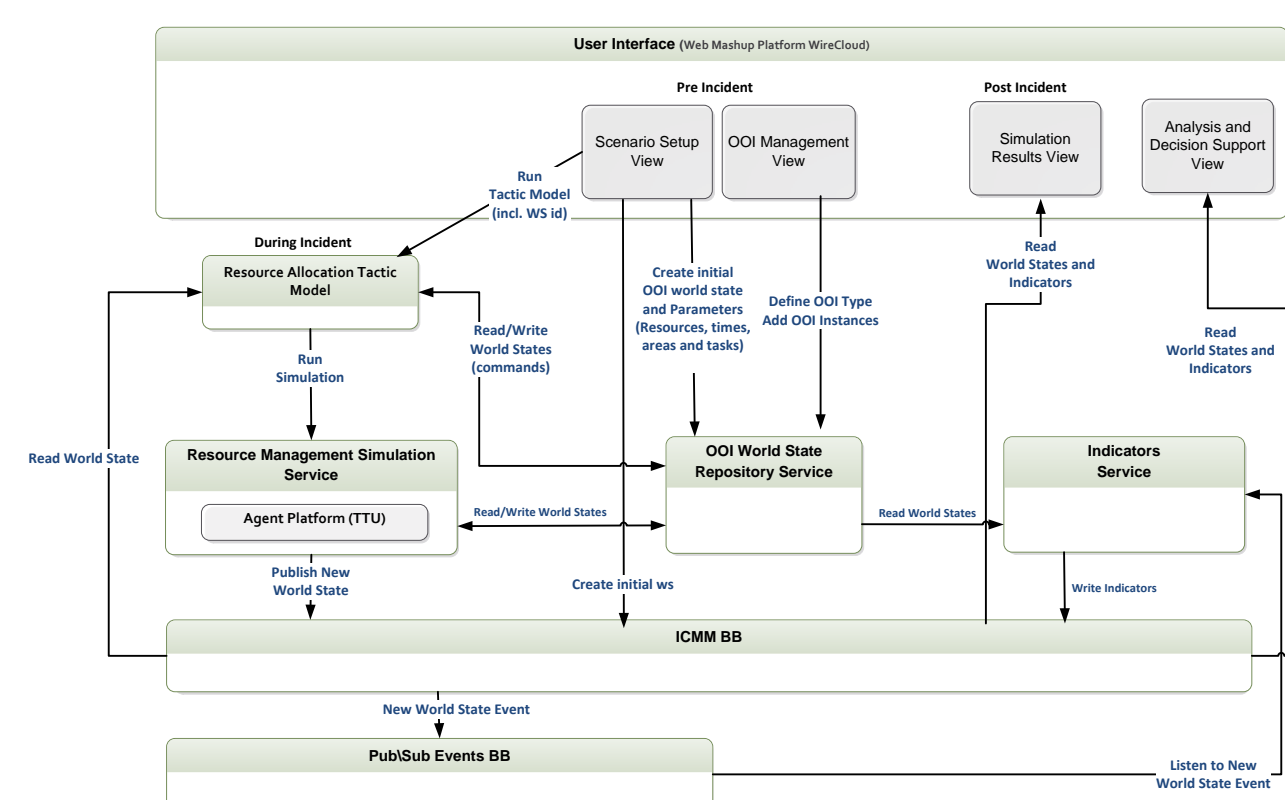


Figure 1: Implementation Architecture

The Resource Allocation Tactic (RAT) model replicates the decision making process of crisis managers in resource management planning applications. It allows us to test the planning scenarios with different mission tactics, e.g. "prioritize transport to hospital" or "prioritize treatment on the field". It realizes a second layer above the Ambulance Model in order to being capable of running simulations with predefined strategy settings.

The Resource planning application is conceptually based on the CRISMA Reference Application for Resource Management Training. However, the interactive view enabling the user to manipulate during a training session the model behavior is replaced by the RAT Model which undertakes the active part "during incident" from the user in the training case (see Figure 1).

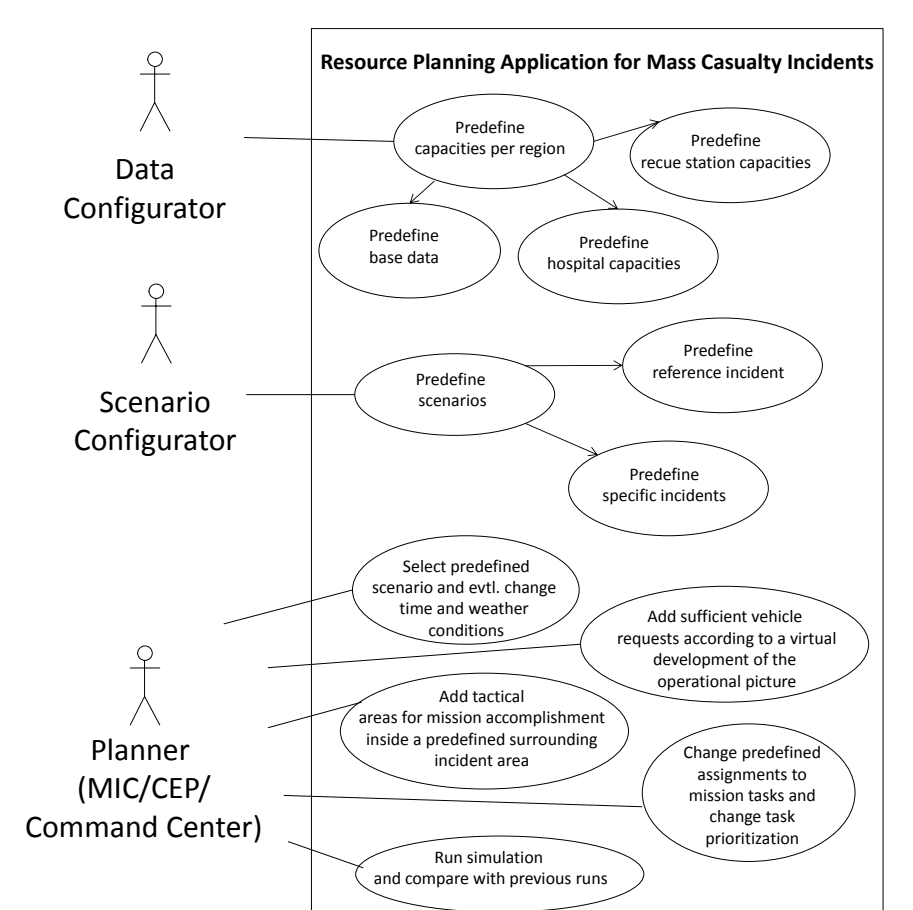


Figure 2: Use cases of the Resource Planning Application

Running	Running	Running	Running	Running
Vehicle Requested	Vehicle Requested	Vehicle Requested	Vehicle Requested	Vehicle Requested
Vehicle Requested 1	Vehicle Requested 2	Vehicle Requested 3	Vehicle Requested 4	Vehicle Requested 5
Vehicle Requested 6	Vehicle Requested 7	Vehicle Requested 8	Vehicle Requested 9	Vehicle Requested 10
Vehicle Requested 11	Vehicle Requested 12	Vehicle Requested 13	Vehicle Requested 14	Vehicle Requested 15
Vehicle Requested 16	Vehicle Requested 17	Vehicle Requested 18	Vehicle Requested 19	Vehicle Requested 20
Vehicle Requested 21	Vehicle Requested 22	Vehicle Requested 23	Vehicle Requested 24	Vehicle Requested 25
Vehicle Requested 26	Vehicle Requested 27	Vehicle Requested 28	Vehicle Requested 29	Vehicle Requested 30
Vehicle Requested 31	Vehicle Requested 32	Vehicle Requested 33	Vehicle Requested 34	Vehicle Requested 35
Vehicle Requested 36	Vehicle Requested 37	Vehicle Requested 38	Vehicle Requested 39	Vehicle Requested 40
Vehicle Requested 41	Vehicle Requested 42	Vehicle Requested 43	Vehicle Requested 44	Vehicle Requested 45
Vehicle Requested 46	Vehicle Requested 47	Vehicle Requested 48	Vehicle Requested 49	Vehicle Requested 50
Vehicle Requested 51	Vehicle Requested 52	Vehicle Requested 53	Vehicle Requested 54	Vehicle Requested 55
Vehicle Requested 56	Vehicle Requested 57	Vehicle Requested 58	Vehicle Requested 59	Vehicle Requested 60
Vehicle Requested 61	Vehicle Requested 62	Vehicle Requested 63	Vehicle Requested 64	Vehicle Requested 65
Vehicle Requested 66	Vehicle Requested 67	Vehicle Requested 68	Vehicle Requested 69	Vehicle Requested 70
Vehicle Requested 71	Vehicle Requested 72	Vehicle Requested 73	Vehicle Requested 74	Vehicle Requested 75
Vehicle Requested 76	Vehicle Requested 77	Vehicle Requested 78	Vehicle Requested 79	Vehicle Requested 80
Vehicle Requested 81	Vehicle Requested 82	Vehicle Requested 83	Vehicle Requested 84	Vehicle Requested 85
Vehicle Requested 86	Vehicle Requested 87	Vehicle Requested 88	Vehicle Requested 89	Vehicle Requested 90
Vehicle Requested 91	Vehicle Requested 92	Vehicle Requested 93	Vehicle Requested 94	Vehicle Requested 95
Vehicle Requested 96	Vehicle Requested 97	Vehicle Requested 98	Vehicle Requested 99	Vehicle Requested 100

Figure 3: RAT Model widget

Contact
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