Development and evaluation of mission scenarios for a new telematic rescue assistance system

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ABSTRACT

To ensure the cost-effectiveness of a new telematic rescue assistance system, the Institute of Management Cybernetics (IfU) develops two mission scenarios. These scenarios illustrate a possible application of the system subject to social conditions in 2017. Additionally, for each of the two, an economic evaluation is made. The following paper deals with the approach adapted in developing the two mission scenarios and their evaluation. This process is carried through with the aid of the benefit orientated profitability evaluation (NOWS).

Keywords: scenario planning, profitability evaluation, telemedicine

1. INTRODUCTION

In Germany a diverging trend becomes noticeable, which exerts considerable pressure on rescue services. On the one hand, the demographic development and the resulting increase of the average age expectancy, causes an accession of assignments where emergency doctors are needed. On the other hand, the stagnating number of emergency doctors and the rising cost pressure make it difficult to hold up the quality of health care [1].
To counteract this trend an interdisciplinary consortium was created, which develops a new telematic rescue assistance system within the research project "Med-on-@ix". Its purpose is to support emergency medical services at the location of an emergency from a remote Competence Centre. This is achieved by the transfer of relevant medical data such as vital signs, auscultation and video material from the location of the emergency to the Competence Centre by a telematic support system [2]. Physicians in the Competence Centre are supported by software, which leads them through treatment algorithms.
During the development process, an economic evaluation is conducted to ensure the cost-effectiveness of the system [3].
However, due to the extensive economic and social consequences of the system, leading a profitability analysis turns out to be difficult. Furthermore, the time necessary until the system is ready to be successfully implemented is estimated at 10 years. Consequently, changes in the demographic situation in Germany as well as social and political trends which take place during that time frame, have to be factored into the analysis.
Therefore, the IfU develops two mission scenarios which allow a concrete illustration of the implementation of the system. These scenarios vary by regarding different variables during the next 10 years; social, technical or structural trends respectively.
Additionally, these scenarios are economically evaluated with the help of the benefit orientated profitability evaluation [4]. As traditional quantitative cost benefit analyses are not suitable in this case, this extended profitability analysis enables you to combine a quantitative cost benefit evaluation with an analysis of relevant qualitative variables. Hence soft facts of the rescue system such as social benefits and costs can also be quantified.

The paper is organized as follows: paragraph 2 gives an overview of the methodology and an approach description. Paragraph 3 deals with the development of the two mission scenarios based on the planning carried out by Geschka and von Reibnitz [5]. An overview of the two mission scenarios is also included. As follows, paragraph 4 describes the benefit orientated profitability evaluation and the results of the economic evaluation for each scenario. Finally, a conclusion and a perspective are given.

2. METHODOLOGY AND APPROACH DESCRIPTION

Due to the ambitious goals of the project and the manifold stakeholders, a systemic socio-cybernetic approach is the only feasible option [6]. Therefore, a holistic scenario technique combined with a sensitivity analysis based on Vester was chosen [7]. The advantage of such an approach is that all stakeholders are involved in the scenario planning, and interdependencies between the system variables can be identified and described. As a result, it becomes possible to identify the crucial scenario variables which define the system. All of the central variables have to be carefully considered in order to derive a realistic environmental setting for a successful implementation of the telematic emergency system by 2017. The two mission scenarios are based on the scenario planning by Geschka and von Reibnitz. Their definition of scenarios is as following: "Scenarios are the description of a future situation as well as the path, that leads to this situation." As the approach of Geschka and von Reibnitz describes the scenario planning for enterprises, their concept had to be modified to fit the requirements of the research project Med-on-@ix. This leads to mission creation scenarios in seven steps:

1. Structuring and definition of the field of study
2. Identification and structuring of the main spheres of influence (environmental analysis)
3. Identification of interdependencies (Sensitivity analysis)
4. Anticipation of the descriptor's future development
5. Clustering of predictions
6. Integration and analysis of perturbations
7. Describing the scenarios

The scenario creation has to pass through all seven steps. To assure an integrated approach, members with different scientific backgrounds were selected to create the two scenarios.

Vester's approach of analysing the interaction between variables, allows you to get an integrated view of the considered system as well as to identify the system's controllable variables. According to the implementation, it becomes significantly important to control the system by specifically influencing the controllable variables. Furthermore, you are able to anticipate critical changes of the system due to external effects.

In order to economically evaluate the two created scenarios, the NOWS-method was used. The abbreviation NOWS stands for use-orientated, cost-efficient evaluation, a method that has been developed at the Institute for Management Cybernetics. While conventional approaches limit themselves to quantifiable objects in terms of monetary data,(e.g. costs and revenues; the so-called hard factors), this method includes non-monetary objectives (the so-called soft factors) as well [8],[9]. Especially during the analysis of a system like Med-on-@ix, whose implementation has huge economic and social consequences, this integrated consideration is necessary. To achieve this aim, the NOWS-method is applied within seven steps (see fig. 1)

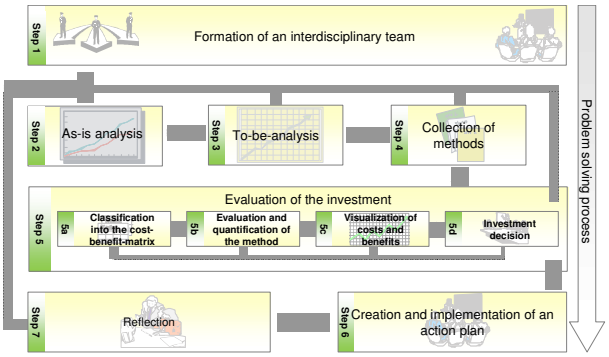

Figure 1: NOWS-Method

To ensure an evaluation which addresses different perspectives, it is necessary to form an interdisciplinary team (step 1). This had already happened during the preparation of the scenario-workshops, as different members of the research consortium had been chosen, leading to the cooperation of physicians, engineers and economists.

The second step, a complete as-is-analysis, had also already been done during the creation of the mission scenarios. Keeping in mind that NOWS had been originally developed to support enterprises when making investment decisions, steps three and four are not relevant for our evaluation.

At the beginning of any investment consideration, all relevant data has to be collected and classified according to the different types of benefits/costs. Therefore, both factors are distinguished as "direct, indirect and difficult to ascertain". The second classification reflects the probability of occurrence and contains the categories "high, medium or low". Afterwards each aspect can be put into a 3x3 matrix that shows both the probability of occurrence and the different type of cost/benefit. On the basis of that matrix all aspects are quantified. This leads to a second matrix that incorporates all quantified cost/benefit aspects. The variables are accumulated as to show the direct/high benefits first, along with the full costs. These will decrease later in the course of the juxtaposition.

This process enables the evaluation of costs and benefits at different risk levels. Consequently, in the beginning,

only secure benefits and full costs are compared (see fig. 2).

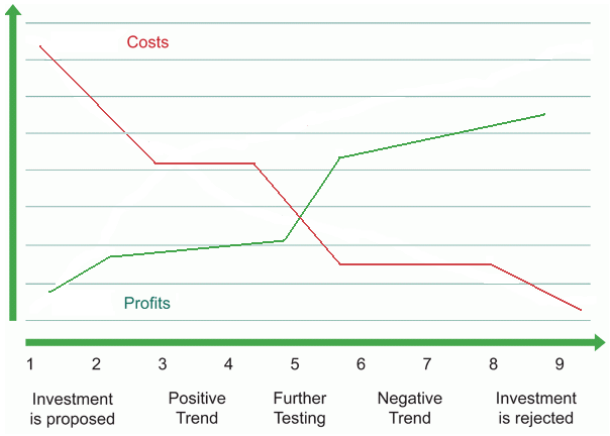

Figure 2: NOWS-Graph

The accumulated costs and benefits each form a curve. The effectiveness of an investment is determined by the intersection of the two curves. At this point the accumulated costs and benefits are equal. The further left the intersection point is located, the more profitable the investment turns out to be.

3. THE DEVELOPMENT OF TWO MISSION SCENARIOS

At first the field of study and its system boundaries were identified. The members decided, that the so called chain of survival, which starts with the emergency call and ends with the patient's check-in at the hospital, will be subject to this analysis. In order to do a valid and plausible anticipation later in time, the way how Med-on-@ix works and its characteristics had to be carefully described. Therefore, the main elements of the system, or variables, were identified. In this context 16 main variables, which describe the system and its environment, were found. These are:

- medical devices
- competence centre
- paramedics
- documentation systems
- operator
- public opinion
- network operator
- electronic insurance card
- health insurance funds
- hospitals
- law
- healthcare policy
- industry of medicine products
- organisations
- competitors
- communication device

Furthermore, the sensitivity analysis, which was developed by Frederic Vester [10], was used to identify the critical variables. As this analysis allows you to see the interdependencies of variables, it was considered very important preparatory work to step 5-the clustering of predictions..
The members of the workshop estimated the mutual influence of each pair of variables within a matrix of influence (fig. 3).

The effect of↓ on→	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	AS	P
1.Medical devices	X	1	2	2	1	1	1	0	1	2	1	0	2	1	1	1	17	306
2. Competence centre	1	X	3	2	2	2	1	1	2	2	1	1	1	2	2	1	24	624
3.Ambulance personnel	1	2	X	2	2	2	0	0	1	1	1	1	1	2	1	0	17	442
4. Documentation systems	1	2	3	X	1	1	0	1	1	2	1	1	1	1	1	1	18	378
5. Operator	1	2	2	2	X	2	1	1	2	2	1	1	1	1	1	2	22	550
6. Public Opinion	1	2	2	1	2	X	1	2	2	1	1	2	1	1	1	1	21	504
7. Network operator	1	2	1	1	1	1	X	0	1	0	1	1	1	1	1	2	15	135
8. Electronic health insurance card	1	2	1	2	1	2	0	X	2	2	1	2	2	1	1	0	20	340
9. Health insurance schemes	1	2	2	1	2	2	1	2	X	3	1	2	2	2	2	1	26	546
10. Hospitals	1	2	1	1	1	2	0	1	2	X	1	1	1	2	1	0	17	391
11. Law	2	3	3	2	3	2	2	3	2	2	X	2	2	2	2	1	33	462
12. Healthcare policy	1	2	2	1	2	3	1	3	2	3	2	X	2	2	2	0	28	504
13. Industry of medicine products	3	1	1	2	2	1	0	1	1	1	1	1	X	1	1	0	17	340
14. Organisations	1	1	2	1	1	1	0	1	1	1	1	2	1	X	1	0	15	300
15. Competitiors	1	1	1	1	2	1	1	0	1	1	0	1	1	1	X	2	15	300
16. Communication device	1	1	0	0	2	1	0	1	0	0	0	0	1	0	2	X	9	108
	18	26	26	21	25	24	9	17	21	23	14	18	20	20	20	12	PS	
	94	92	65	86	88	88	167	118	124	74	236	156	85	75	75	75	Qx100	

Figure 3: Matrix of influence

Here, variables which have an effect on other variables, are listed line by line, while those influenced by other variables, are listed column by column. By forming the line and column total (the active and passive sum), the identification of active or passive characters becomes possible. The result of this sensitivity analysis is shown in a graph, which illustrates the variables according to their character. Critical variables can be found in the upper right hand sector of the graph (fig. 4).

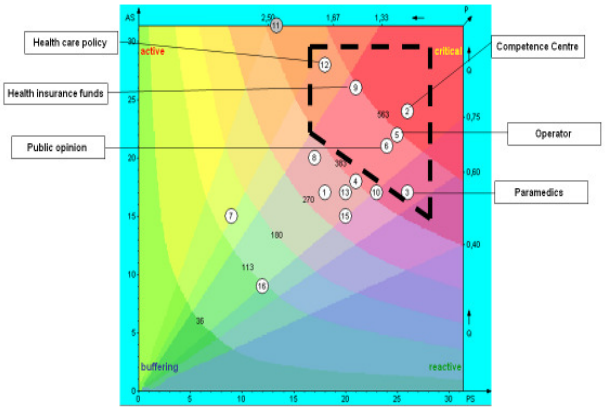

Figure 4: Role allocation

Critical in this context means that these variables have a strong effect on other variables while at the same time influenced enormously by others. These variables have to

be considered coercively during the description of the scenarios:

- health care policy (12)
- health insurance funds (9)
- public opinion (6)
- operator (5)
- Competence centre (2)
- paramedics (3)

Within this graph, the column total is shown on the x-axis, while the line total can be seen on the y-axis. Additionally, those variables which are estimated to be critical to the system, are marked within the black line.
Based on the sensitivity analysis, the future development of the variables was anticipated. Finally, the two mission scenarios were described after the bunching of predictions and the analysis of disturbances. Considering the time until the system is ready for serial production, the scenarios were supposed to describe the system subject to the conditions of 2017. Furthermore, the period under consideration for one scenario was one year.

Scenario I
Regionally operating Competence Centres
The Competence Centres are run communally by so called emergency medical service alliances. Their operating range includes several cities and districts. The size of a Competence Centre is limited to the availability of highly qualified medical specialists, who are able to work within the Competence Centre. These Competence Centres may vary in regard to crew, configuration and size and are able to be connected for the purpose of mutual support. Their focus is put on supervision and support of the emergency medical services.
The training of paramedics has to be modified to the increased responsibility, but there will not be a fundamental change in the concept of paramedic's training. The former system of emergency physicians, as it can be seen today in Germany will mainly be conserved. This leads to a diverging development: On the one hand the number of emergency doctor's missions decrease due to the implementation of the system, but on the other hand changes in Germany's demographic situation lead to an increased number of rescue operations.
Germany's health care policy is mainly influenced by questions of cost efficiency, which lead to a focus on rescue affairs within emergency medical services. Due to the fact, that the emergency medical services are still supported by public authorities there is no competitive situation. Furthermore health insurance funds offer just a basic care and request people increasingly to meet the costs of medical services as they are forced to put emphasize on cost reduction.
The people are skeptical of the system as they fear an impairment of the medical care due to the reduction of physicians caused by the system.
As cost pressure influences hospitals, they tend to be rather specialized and rationalized. Emergency medical services will no longer be integrated into hospitals, however documentation systems will integrate guidelines of emergency medical services. Furthermore the medical equipment will be more flexible due to a reduction of weight and a compact design.
The new electronic health insurance card forms the interface between hospitals and emergency medical services. Combined with the new hospital information system and new documentation systems the exchange of information is improved.
Additionally new medical equipment influences the rescue process in a positive way. New medical units possess standardized interfaces and intelligence. Communication devices are integrated into the medical equipment. The market of medical equipment is influenced increasingly by the consolidation of market participants and smaller firms are being bought.
Network operators keep on offering flat rates wide band connections even in rural areas.

Scenario II
Nationwide competence centre
The Competence Centre acts on a regional level, each federal state having a competence centre of their own. Headquarters are placed in contact with the competence centre; the incoming emergency call is checked in the control centre and, if required, transmitted to the competence centre. The control centre is staffed with employees who do not necessarily have medical backgrounds. However, it is imperative that the tele-emergency physician in the Competence Centre has the qualification needed for the field he practices in. Simple medical cases are taken over by the rescue assistants, but when the cases turn out to be more complex, emergency doctors from hospitals are sent onto location. The equipment in the Competence Centre and its maintenance is provided by the state, while the payment of wages is carried out by self-financed private firms. These costs in turn are covered by health insurance schemes.

The rescue crew stays at the incident location and is coordinated by the competence centres. This coordination results in high technical demand, so all communication taking place between the Competence Centre and the rescue personnel regarding the consultation is kept to basic, necessary knowledge.
Due to the preservation of the data by the competence centre, hospitals are better prepared for the admission of the patients.

Because the Competence Centre acts on a national level and the tasks of the rescue assistants expand, their qualifications must increase in accordance with regional standards. However, due to the high demands placed on these rescue personnel, the amount of voluntary work decreases, resulting in an increase of costs. Moreover, the level of training for the rescue personnel must rise in order to cope with the raised spectrum of the problems at hand, turning the paramedic profession into a more appealing option. The legislation becomes uniform across all regions, which leads to a tightening of the law. The responsibilities, as well as who makes the final decisions during an incident, are thus defined by law.

Due to standardized regulations, it becomes possible for a rescue paramedic to practice in several federal states without any addition qualifications. The decrease of cases where emergency doctors are required at the incident location results in having more on-call doctors working at the hospital.

The electronic health insurance card will not be introduced until 2017, consequently leading to loss of information and decreased speed in the rescue process. It will be necessary to build a database with all patient information in order to be able to access a patient's file from the competence centre.

The public fears deterioration of the health care system, reacting negatively to the system. The project could be attacked by politics and possibly even completely abolished by legislation. Incidents can be better analysed because of the system. This in turn would inevitably lead to improvements and process optimization. In this way public opinion can be influenced once again in a positive manner. A professional association of tele-emergency physicians was founded, which if necessary can come to influence politics and the public opinion.

The quality of the rescue service, in terms of equipment and medication, is uniform across all states, raising the flexibility of the rescue staff, simplifying remote delegation of the rescue team. In order to standardize the interfaces of the medical equipment, the medical products industry have reached an agreement with respect to common standards.

Most likely, extensive bandwidth coverage will not be possible, making this option only available in large metropolises.

4. EVALUATION OF THE MISSION SCENARIOS

According to the process described, benefit factors were collected at first. Then they were clustered and classified within the 3x3 matrix. In doing so the following benefit aspects were found:

- area-wide emergency service (direct, high)
- better network coverage (direct, high)
- better medical treatment in case of an emergency (direct, high)
- Increasing competence of paramedics (direct, medium)
- more efficient allocation of emergency physicians (direct, high)
- Improvement of medical equipment (indirect, high)
- Improvement of documentation systems (indirect, medium)
- Adaptation to regional requirements (indirect, medium)
- networking (indirect, low)
- more legal security for paramedics (hard to ascertain, low)
- satisfaction of the population (hard to ascertain, low)
- Improvement of the occupational image of paramedics (hard to ascertain, low)

Afterwards these aspects were quantified. The calculation of this quantification is illustrated as an example for the aspect "better medical treatment in case of an emergency":

First the total amount of all rescue missions, as well the missions carried through by emergency physicians in Germany during 2005, was estimated. 3,600,000 rescue missions and 1,800,000 missions for emergency physicians were accounted for during that time. With a number of no less than 300 districts in Germany, the number of rescue missions per district comes up to 12,000, 6000 of those being missions for emergency physicians. These numbers are factored with 1,25 due to demographic development. Keeping in mind that a competence centre covers 3 districts, the total amount of rescue missions per competence centre in the year 2017 is estimated at 45,000 (22,500 missions for emergency physicians). To quantify the benefit in regard to better medical treatment in case of an emergency, a cost reduction was estimated, by avoiding the transportation of people to hospitals who do not need it. It was estimated that 20% of the cases when people have been sent to hospitals by paramedics they were not even in need of it. Due to an amount of 45,000 rescue missions per competence centre, these cases number 9,000. As a rescue transport costs 200€ and a day of medical treatment in hospital 600€, the total reduction of costs amount to 7,2 million per year.

These calculations were continued for each benefit aspect, which lead to the total sum of 7,742,000€.

Thereupon, the same method was used to estimate the costs. In this context the following cost aspects were found:

- training costs
- personnel costs
- running costs
- maintenance and analysis of relevant data
- lobby and public relations
- costs due to networking

The quantification of one cost aspect is illustrated within an example as well. A special training concept lasting 2 weeks is used to train tele-physicians. Costs per day were estimated at 2000€. Consequently, the training costs of one tele-physicians amount to 20,000€. Due to the cost system for German physicians, the tele-physicians job is rated with the factor 4.8. Additionally, the fluctuation of tele-physicians working in one competence centre was estimated with a rate of change of 20%. This leads to a total sum of training costs of 170,280€. At the same time, a new three year training concept for paramedics is created. Based on a similar calculation, the costs for paramedic training amounted to 600,000€. All cost aspects lead to a total sum of 1,825,600€.
Within an analogue process, the benefits of the second scenario were quantified to 102,662,200€, while the costs amount to 16,584,000€.
All cost and benefit aspects were accumulated and juxtaposed by a computer based tool, which illustrates the results of our evaluation with the usage of a graph.
In both graphs the benefits overbalance the costs. At any risk level, the curve of the benefits runs above the curve of costs. Furthermore, both curves result in flat course lines as an aftermath of having found costs and benefits of only one type.

5. CONCLUSIONS

The approach proved to be suitable for such a complex system. However, as the project progresses, the scenarios have to be refined and adapted to the new circumstances as well as to changes in the social and economic situation. Further aspects which have possibly been ignored during the creation, will be added in the future. Therefore, a clear answer which scenario is economically more feasible cannot be given yet.

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