Jaroslav Kapusniak

DSS model to support the fire equipment selection to fight the forest fires

Security Dimensions. International & National Studies nr 1 (11), 52-56

2014

SECURITY DIMENSIONS
INTERNATIONAL & NATIONAL STUDIES
NO. 11; 2014 (52-56)

DSS MODEL TO SUPPORT THE FIRE EQUIPMENT SELECTION TO FIGHT THE FOREST FIRES

Lt. Col. Jaroslav Kapusniak
Regional Directory of Fire and Rescue Corps in Žilina

ABSTRACT

In the paper we introduce a DSS model built in NetWeaver environment to help the fire fighters in process of selection fire equipment to be used for firefighting, in particular in mountainous regions. The model is composed of three general branches Ergonomics, Technical-operational parameters and natural conditions and Economics. Here we introduce more the Technical-operational parameters and natural condition branch. This one is composed of another three branches: Technical-operational parameters, Soil parameters and Opening-up of area.

ARTICLE INFO

Article history
Received: 29.04.2014 Accepted 13.07.2014

Keywords
GIS, DSS, fire-fighting equipment, technical – operational parameters, opening-up

INTRODUCTION

In the paper we introduce design of an optimization model to select suitable fire equipment. The model is based on multicriterial assessment of selected types of fire equipment, which is used to fight the forest fires in the mountainous regions of Slovakia.

INPUT DATA

The data on technical and performance parameters of evaluated fire-fighting equipment: technical documents, standards related to the minimal requirements which are defined to the individual types of fire-fighting equipment.

Geodata: National Forestry Centre in Zvolen: data from the forest management plan, digital forestry map (containing the forest roads, water bodies, stand outlines); Topography Institute of col. Jan Lipsky in Banska Bystrica: ortho photos, digital terrain model, data from the Central Spatial Database.

SOFTWARE ENVIRONMENT USED

Decision-making optimization model was built in a NetWeaver system, which is a development system for creating knowledge bases in space-related applications and forms a part of the EMDS spatial decision support system. It contains a core program for creating a knowledge base in the form of dependency networks and graphical interface for their design, editing and interactive assessment. The representation of knowledge in the system is based on object oriented dependency networks, with the application of fuzzy logic, under which it is possible to explain the phenomena.

Knowledge base system takes many forms, but the dominant type is currently used rule-based system. Knowledge representation

in a NetWeaver, is on the other hand based on object-oriented fuzzy logic networks (uncertainty principle), which offer several significant advantages over much more traditional representations that are based on the rules.

Compared to the rule –based knowledge bases, the knowledge bases in a NetWeaver are simpler in terms of their construction, testing, but mainly because the basic object-based representations make these knowledge bases modular. Modularity of knowledge bases in NetWeaver then gradually allows the designer to develop a comprehensive knowledge base from simpler in small, easy steps. This modularity also allows for interactive debugging of the knowledge base at any stage of development of the dependency network. Finally, the uncertainty principle (fuzzy logic) is a formal and complete number of representations of knowledge, which is less subjective approach to that used in rule –based systems and a lot more economical than bivalent rules.

Knowledge base generally refers to the very essence of knowledge on the problem area. The original meaning is a logical representation of the entities of interest of one of the problem areas and their relationship to others.

One of the assessment principles of the NetWeaver environment is "fuzzy logic" - the uncertainty principle. Uncertainty principle is a measure for the expression of the degree to which set representing the concept belong a test variable. Uncertainty values are expressed in the interval [0, 1]. The more the values are close to 1, the more they are approaching the truth, on the other hand, the more they are close to 0, they are thus closer to false.

The knowledge base in NetWeaver is built of:

- Dependency networks, which represent the areas of interest in the problem area;
- Links – to the data which are under assessment;
- Nodes, which specify logical (OR, AND, SOR, XOR) or mathematical (*, /, +, -, sin, ...) relationships between dependency networks and data links;
- Evaluated groups – those are optional and represent the selections of data and dependency networks.

The input of data to the knowledge base is performed through the data links, which are the basic components of the dependency networks. The NetWeaver supports two types of data links: simple and calculated.

Simple data links represent a value, which can be evaluated in accordance to a simple argument or membership fuzzy function specified for this data link. The result is true value of this data, which can be used directly in the knowledge database or for calculation of the calculated data links.

Calculated data link participates on the properties of the data links and networks.

DECISION MAKING MODEL DESCRIPTION

As mentioned above the decision making model was built in NetWeaver environment. It was built as dependency network composed of data and calculated links interconnected by logical relationship.

In the model, there are the individual types of fire equipment, used for fighting the fires, evaluated in the terms of 3 basic groups of factors: natural and technical – operational, economical and ergonomic (Fig. 1).

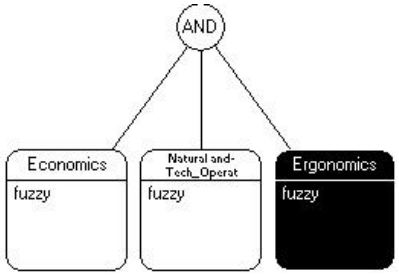

Fig. 1 Three basic groups of factors evaluated in the model

The selected types of fire equipment, which is suitable to be used to fight the forest fires in mountainous conditions of Slovakia, are divided to two basic groups: special forest fire-fighting equipment (vehicles) and firefighting equipment (vehicles) to be used to assign the shuttle and pumping extinguishing agent relay to the fire site.

Among the special forest firefighting equipment (vehicles), there were assigned: UNIMOG forest specials on the chassis of Mercedes Benz (Fig. 2), Praga V3S ARS, CAS 30 T 815-7 4x4.1. Into the assessment of this group of vehicles we also included the variant consisting of forest wheeled tractor (acronym LKT) + UNIMOG.

Fig. 2 UNIMOG special forest fire-fighting equipment

Among the vehicles specified to shuttle and pumping extinguishing agent relay, there were assigned [1, 2]: CAS 30 T 148, CAS 30 T 815-7 6x6, CAS 32 T 815 6x6 (Fig. 3), CAS 30 Iveco Trakker.

Fig. 3 CAS 32 T 815 6x6

In terms of natural and technical - operational parameters, the selection of an appropriate equipment for extinguishing forest fires is based on the parallel multicriteria assessment of natural factors groups (Fig. 4) represented by the subgroups of soil factors (condition and the type of soil and of these parameters resulting soil bearing capacity) and the area opening-up factors making for deployment of ground mobile fire-fighting equipment (fire suppression zone range [3] and accessibility of the territory, which is evaluated based on parameters such as slope gradient, expressed as the availability of terrain and the presence of obstacles such as rocks, cliffs and ravines).

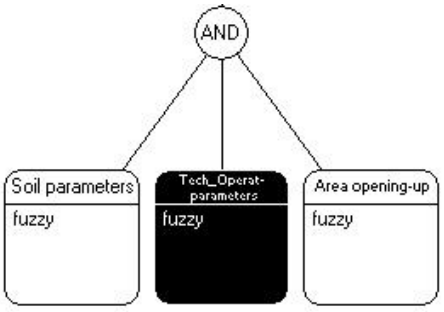

Fig. 4 Groups of factors evaluated in the view of natural and technical-operational factors

Technical - operational conditions are evaluated on the basis of selected critical parameters of fire-fighting equipment. Selecting and applying appropriate fire-fighting equipment is in the assessment of its technical parameters directly related to environmental parameters for which we analyse the suitability of selected type of fire-fighting equipment deployment. Among the assessed parameters belong, from vehicle chassis point of view, the Specific power [kW.t-1], Maximum drive speed [km.h-1], Ground clearance [mm], Approach and Departure angles [°], Gradability [°], Height of vehicle [m]. From the specialized superstructure parameters point of view: Water cistern capacity [l], Nominal water flow [l.min-1], Intake height [m]. As an important parameter (factor) involved in the assessment

the technical-operational parameters, the equipment of the fire fighting vehicles was considered.

In terms of assessing the economic suitability of the deployment of various types of fire-fighting equipment to extinguish forest fires, we focus on the following groups of factors: salaries and levies, depreciations, fuel, repairs and maintenance, materials costs.

From an ergonomic point of view, we focus on assessing the energy performance of each activity and the risk of injury.

As mentioned earlier the decision-making network is composed of data links representing particular evaluated factors interconnected with logical functions (AND - represents current rating of several factors defined = multicriteria decision making).

Selection of different types of fire-fighting equipment on the basis of individual factors assessment used in the decision-making, using the bottom (input data into decision-making) - top approach, is based on the continuous assessment of defined factors for which we have defined rule of selection based on fuzzy logic (uncertainty).

This means that any type of equipment is sequentially evaluated on the basis of the factors defined in the network (in the bottom-top approach, in the top of the network is situated the identified optimum variant - the principle of the pyramid), and on the basis of input values derived from the supporting data (e.g. results of analyses, GIS data, technical parameters, etc..). Those are in terms of the rules of fuzzy logic assessed with regard to pre-defined intervals to true (value 1) and false (value 0) values. To the assessment at a higher level, there comes only that equipment type which met the criteria set for the assessment at a lower level.

In the decision-making (analysis) process are simultaneously assessed all the defined types of fire-fighting equipment. On top of the assessment (end of the analysis), the resulting value of 1 have only those that are optimal and have met all the criteria at all levels.

The result of the evaluation (analysis) is not only the determination of the optimal variant, but in the database, which is the output of the decision making process are evaluated all the types of fire-fighting equipment, and each is assigned a suitability value in the interval 0-1. The closer is the resulting value is to the value 1, the more suitable is the type of fire-fighting equipment for deployment in the conditions of evaluated environment.

The database in addition to the results of the overall assessment (whole network of factors) also contains the results (suitability values in the range of 0-1) for each group of factors at individual levels as well as for the particular considered factors = comprehensive assessment results.

By linking the NetWeaver environment with EMDS environment we can obtain a tool for visualizing the results of the assessment in GIS environment and creating map outputs - spatial visualization of results.

CONCLUSIONS

To select the suitable fire-fighting equipment to fight the forest fires it requires knowing the terrain and natural conditions of the territory where it should be deployed as well as critical parameters of the equipment to be used. In the paper we introduced an approach to multicriteria and parallel assessment of individual type of fire-fighting equipment based on the natural, technical and operational parameters of technique used in the fire intervention territory (or also equipment that is available at home and world market to plan the supply of fire brigades with fire-fighting equipment suitable to the fire intervention territory conditions, taking into consideration also the type of emergency that is the most frequent in that area).

This approach is based on DSS tools application to enhance the decision making process of fire brigades commanders and operators of emergency operation centres in selection of type and number of fire-fighting equipment to localise and disposal of forest fires as soon as possible to avoid the development of fire to extensive fire.

REFERENCES

1. Landďák, M. Monoši, M., Kapusniak, J. (2011). *Doprava hasiacich látok k veľkým lesným požiarom. In: Hodnocení a zvládání přírodních a technologických rizik [elektronický zdroj]: mezinárodní konference mladých vědeckých pracovníků*, Ostrava, 24.-25. října 2011: sborník přednášek. Ostrava: VŠB - TU, 2011. ISBN 978-80-248-2486-4. S. 121-133.
2. Kapusniak, J., Monoši, M. (2012). *Výber vhodnej hasičskej techniky určenej na likvidáciu lesných požiarov v podmienkach SR*. In: *Požární ochrana 2012*: sborník přednášek XXI. ročníku mezinárodní konference: Ostrava, VŠB - TU, 5.-6. září 2012. Ostrava: Sdružení požárního a bezpečnostního inženýrství, 2012. ISBN 978-80-7385-115-6. S. 100-103.
3. Majlingová, A. (2012). *Opening-up of forests for fire extinguishing purposes*, "Croatian journal of forest engineering". - ISSN 1845-5719. - Vol. 33, issue 1 (2012), p. 159-168.

AUTHOR

Lt. Col. Jaroslav Kapusniak, He is a Director of the Regional Directory of Fire and Rescue Corps in Zilina. In his research activities he deals with management and optimization of forest fires suppression operations in particular.