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Hierarchic Assessment Tool (HAT) – a tool for monitoring status in campaign assessment

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English summary

This report describes an assessment tool developed through FFI project 1122, Analysis support to military operations. Campaign assessment is one of the main OA tasks in planning and execution of military operations. The tool aids the analysts by providing a way to store data, monitor campaign status and make illustrations to communicate this information. The tool is implemented as a macro in MS Excel, since this makes it highly available and easy to exchange.

One main idea behind the development of the tool was that it could be useful for the analysts from the Institute deployed to the Norwegian led PRT in Meymaneh in Afghanistan. In addition, the tool has been used by analysts participating in exercises. Military personnel have provided positive feedback at these exercises.

Sammendrag

Denne rapporten beskriver et verktøy utviklet i FFI-prosjekt 1122, Analysestøtte til militære operasjoner. ”Campaign assessment” er en av hovedoppgavene til operasjonsanalytikere som deltar i planlegging og gjennomføring av militære operasjoner. Verktøyet som beskrives kan brukes til å lagre data, overvåke operasjonens status og lage illustrasjoner for å fremstille denne informasjonen på en god måte. Verkøyet er implementert som en makro i MS Excel, siden dette gjør det lett tilgjengelig og å utveksle.

En av hovedårsakene til at verktøyet ble utviklet, var at det vil være nyttig for analytikere fra instituttet som deployeres til det norskledede PRT-et i Meymaneh i Afghanistan. I tillegg har verktøyet blitt brukt på øvelser i Norge. Militært personell har gitt gode og nyttige tilbakemeldinger på verktøyet gjennom disse øvelsene.

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1 Introduction

Through FFI project 1122, Analysis support to military operations (ANTILOPE), the Norwegian Defence Research Establishment (FFI) shall be able to provide deployable analysts to operations and exercises, both nationally and internationally. In addition to supporting operations directly through deployed analysts, the project shall maintain an operational analysis (OA) cell at the Institute in order to provide a reach back functionality to deployed analysts.

Among the variety of OA tasks which may emerge within military operations, several will be planned and prepared for, but it is not uncommon that tasks need to be solved ad hoc and in a spontaneous manner [1]. For both purposes, the development of relevant tools is extremely helpful.

The different phases of an operation – planning, deployment and execution – require different support and tools. Often, fast analyses are required, so tools should not be too complex, but intuitive and flexible. For this reason, in addition to the fact that it takes a long time to get approval of new software in operational command and control systems, Microsoft Excel is much used in OA support of military operations [1].

NATO System Analysis and Studies (SAS) 044 has provided an overview of necessary and suggested tools for use in military OA [2]. In its report, SAS-044 has also described the role of OA analysts in military operations.

1.1 Purpose of this report

Campaign assessment is one of the main OA tasks in the planning and execution of military operations. This report describes the purpose and area of application of a tool for use in campaign assessment, called Hierachic Assessment Tool (HAT). HAT is implemented as a macro in MS Excel. The report also contains a user guide for the tool.

One main idea behind the development of HAT was that it could be useful for the analysts from the institute deployed in the Norwegian lead Provincial Reconstruction Team (PRT) in Meymaneh in Afghanistan. The analyst who will be deployed from June 2010 will bring HAT with him. In addition, HAT is well suited for use in exercises.

1.2 Target groups

Target groups are anyone involved in campaign assessment or effect based approach to operations, deployed or deployable analysts and analysts in OA cells and reach back groups. Analysts involved in multi-criteria decision analysis may also find HAT useful.

2 Measurements in campaign assessment

2.1 Why campaign assessment?

Campaign monitoring and the assessment of overall campaign success are ”mission critical tasks that must be considered and integrated throughout all phases of an operation from pre-deployment to exit strategy” [3].

By analyzing the status of the operation, the question of whether we are doing the right things can hopefully be answered.

In operational planning, the desired end state is decomposed into objectives and goals. The relations between these decomposed elements are often illustrated through an operational design. This is explained further in Chapter 2.2. Overall progress and success can be assessed through measuring the effects of actions taken and the level of success achieved for the given objectives and goals.

Using a tool for storing effect measurements and calculating goal achievements has several advantages:

- Recording information in one place gives easy access to data and prevents unnecessary duplication of work
- Recording measurements at different points in time provides the ability to do trend analyses and follow development over time
- Through automated graphical illustrations like timelines, hierarchies and ”traffic light” status indicators, information can be presented in a fast and easy-to-follow manner

It should be mentioned that HAT can also be used in other domains, as an OA tool for solving m*ulti-criteria decision analysis problems.*

2.2 Terminology

Some of the relevant terms from campaign assessment are described below. This information is taken from [4]. Similar information can be found in [5], [6] and [7].

Assessment
The function that enables the measurement of progress and results of operations in a military context, and the subsequent development of conclusions and recommendations that support decision making.

Campaign
A set of military operations planned and conducted to achieve a strategic objective within a given time and geographical area, which normally involve maritime, land and air forces.

Decisive condition
A specified sustainable system state necessary for the successful achievement of an objective.

Decisive point
A point in space and time, identified during the planning process, where it is anticipated that the commander must make a decision concerning a specific course of action.

Effect
A change in the behavioral or physical state of a system or system elements that results from one or more actions, or other causes.

End state
The set of conditions that defines an acceptable concluding situation at the end of a strategic engagement.[1]

Line of operations
In a campaign or operation, a logical line linking effects and decisive conditions in time and purpose to an objective.

Measure of effectiveness
A metric used to measure a current system state. Measures of effectiveness (MOEs) are used to help determine whether we are ”doing the right things”.

Measure of performance
A criterion used to evaluate the accomplishment of force actions. Such measures may tell whether we are ”doing things right”.[2]

Objective
A clearly defined and attainable goal to be achieved by a campaign or operation that will contribute decisively to strategic outcome. Achieving these goals is necessary to reach the desired end state.

[1] There may exist desired end states in planning at all levels, not only at strategic level.

[2] A common mistake is to use MOPs as MOEs. MOPs are used for evaluation of own organization, while MOEs are used for evaluation of systems outside own organization. Finding MOEs that are quantifiable may often be difficult. MOPs are often easier to find/formulate and easier to quantify.

Operational design

The relations between the key elements described above can be illustrated through an operational design. This design is a plan, but is often also used during the operation to show status and results from the assessment. One way to illustrate the operational design is shown in Figure 2.1. This is taken from [4].

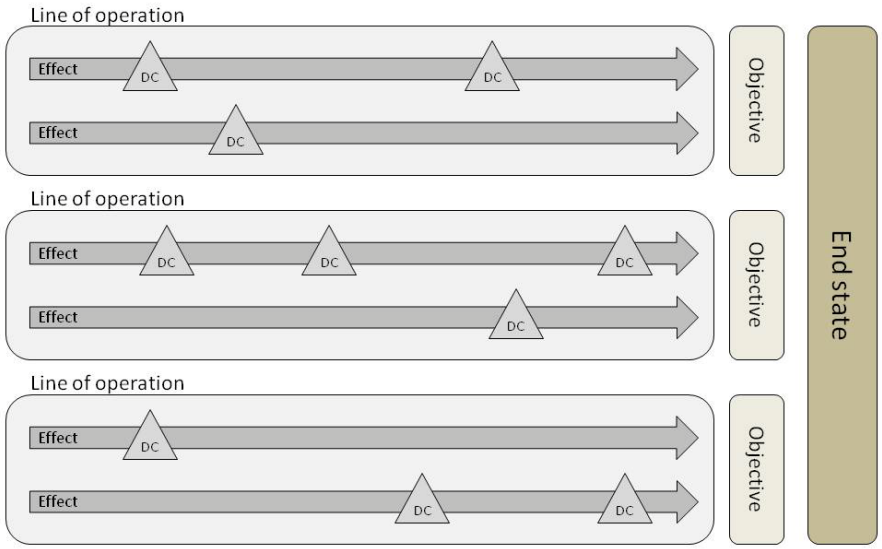

Figure 2.1 One possible structure for operational designs (DC = decisive condition)

2.3 Using HAT to keep track of campaign status

The primary function of HAT is to keep track of campaign status. There exist other tools which are used for the same purpose, e.g. a NATO campaign assessment tool which is developed for integration in the TOPFAS planning tool [8]. HAT is a stand-alone tool which can easily be exchanged through e.g. e-mail, which makes it highly available to anyone.

HAT can be used to create a hierarchy of elements, i.e. a tree of nodes connected together as ”parents” and ”children”. The purpose of this structure is to have the ability to calculate the value of a parent based on the values of its children.

In HAT, a tree may consist of a hierarchy of general elements, like effects, or it may consist of elements making up an operational design. In any case, values for every node in the tree are calculated in the following manner:

$$\sum_{\forall i} w_i v_i \tag{2.1}$$

where every i is a child of the parent node, v_i is the value of child node i and w_i is the weight of child node i.

The values of all leaf nodes, i.e. nodes without children, need to be set by the user, as well as the weights of all nodes in the tree, except from the top node. When all this is set, all values in the tree can be calculated automatically.

Leaf nodes are typically MOEs, i.e. quantifiable measures. It is common to specify which values are good (green), OK (yellow) and bad (red). This means that in HAT, the user has to set the thresholds values for each MOE indicating where its value is green, yellow and red. These ”traffic light” intervals are used to normalize the input value. The purpose of this is to be able to compare numbers with completely different denomination. For example, number of IEDs in an area cannot be compared directly with the number of people who trust the government, but a green value and a red value can be compared and can be used to calculate values further up in the tree.

When all leaf node values, weights and thresholds are set, the result of the calculation is a tree with traffic light status indicators on all nodes. In Chapter 4, examples of this are shown. Value updates and recalculations can be done easily, which makes this a good way to follow campaign status over time.

3 Development of HAT

HAT was created as a macro in MS Excel 2003. Excel was chosen for its availability and because it´s intuitive and easy to use, and because as a part of Excel a tool does not need further approval or integration with large operational C2 systems. In addition, analysts working in operation planning are often familiar with it. Data storage in Excel is also practical in this context, since the format makes the data highly reusable.

3.1 Validation and verification

Requirements for HAT were formulated by analysts who have worked with campaign assessment in ISAF operations in Afghanistan, in military exercises and in educational settings, and by the Reach back group at the FFI.

Verification
Verification is asking ”Is the product built right?”. Is it consistent, complete and correct? Verification of HAT means, for example:

- Findig bugs in the code
- Checking whether all calculations are performed correctly
- Checking whether ”traffic light” colors are set correctly in the calculation process
- Checking whether figures are drawn correctly in the automated drawing process

HAT has been verified through tests performed by the developer and by analysts/users. Verification is an iterative process, since testing by users often generate new whishes and requirements that have to be implemented and then verified again.

Validation
Validation is asking ”Is the right product built?”. Does it conform to user needs and intended uses? Validation of HAT means, for example:

- Does it contain all functionality wanted by the users?
- Does it represent a good way to measure campaign status?

Including end users in the requirement specification process has been a part of the validation of HAT. In addition, it has been validated through testing in several real military exercises where it has been used by an analyst in the OA cell and demonstrated for military staff. This has resulted in useful feedback and many wishes for further functionality, which as far as possible has been implemented in HAT. Military personnel were especially eager to have automated illustration/drawing functionality.

3.2 Strengths and weaknesses

The strengths of having a tool like HAT have already been described. To sum up, some of the most important of these are the possibility to store information, to see development over time and to illustrate campaign status graphically.

One of the weaknesses of HAT is a result of the way it has been developed. It has been an iterative process, starting in the small and through use and testing it has grown to be something much larger, and though more useful, this has to some extent been at the expense of smart and efficient code. Therefore, users or developers may find it frustrating to make changes to the code, if that should turn out to be necessary.

Another disadvantage for the user, is that the code reads data directly from the Excel sheets and it is therefore necessary that all data have been correctly typed in. If the user makes a mistake or puts some data in the wrong cell, this may destroy the structure of the tree, which will cause the program to fail.

A lesson learnt from development of this tool is to keep in mind from the start that the code needs to be easy to understand and easy to maintain for others than the developer.

4 How to use HAT

The purpose of HAT is to create a tree of elements or an operational design in order to monitor and assess the campaign. This process consists of the following steps:

1. Create the tree structure by adding nodes
2. Assign weights to all nodes
3. Assign status threshold values for each leaf node
4. Register the collected data and values of the leaf nodes
5. Calculate values in the tree based on the input data and weights
6. Create illustrations of the results

In this Chapter, each step will be demonstrated. The example chosen for the demonstration is a fictious effect hierarchy.

In HAT, step 1 and 2 can be done in two different ways – via the graphical user interface (GUI) or by making a list in Excel that is read and opened by the GUI.

When opening the Excel workbook, the Main menu of HAT automatically opens, see Figure 4.1. This gives the user three choices – create a new tree from scratch, read a new tree from a list in the Excel workbook or open a previously created tree.

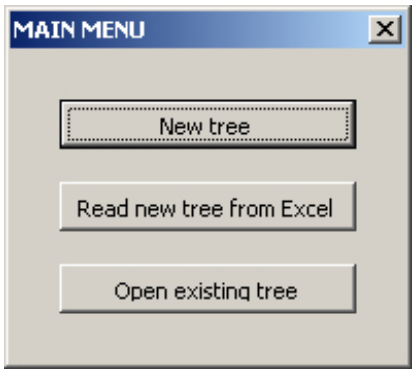

Figure 4.1 Main menu

4.1 New tree

When New tree is chosen, the Tree structure window opens (see Figure 4.2). This is where the tree will be created. To add a new node, write the title in the Title box and press Add to tree. There can only be one top node, so all other nodes have to be added as subnodes.

To add a sub node, double click the node that is the sub node´s parent. The title of this parent will show below the Title box, to indicate that nodes now will be added under this node.

When a node is assigned subnodes, it turns blue. This is to show that the subnodes haven´t been weighted yet.

To add MOEs to nodes, mark the node and press the Add MOE button to the right. A window shows up where information about the MOE can be entered (see Figure 4.3). When saved, the

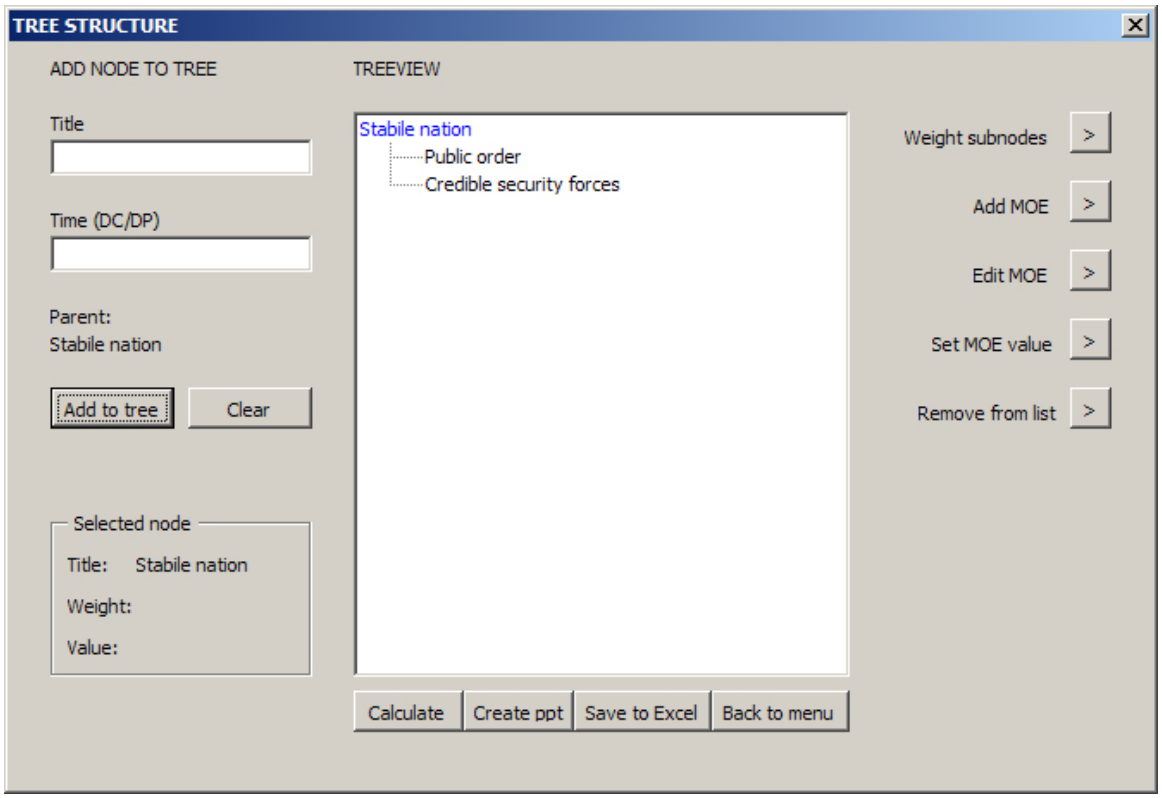

Figure 4.2 Add nodes to tree

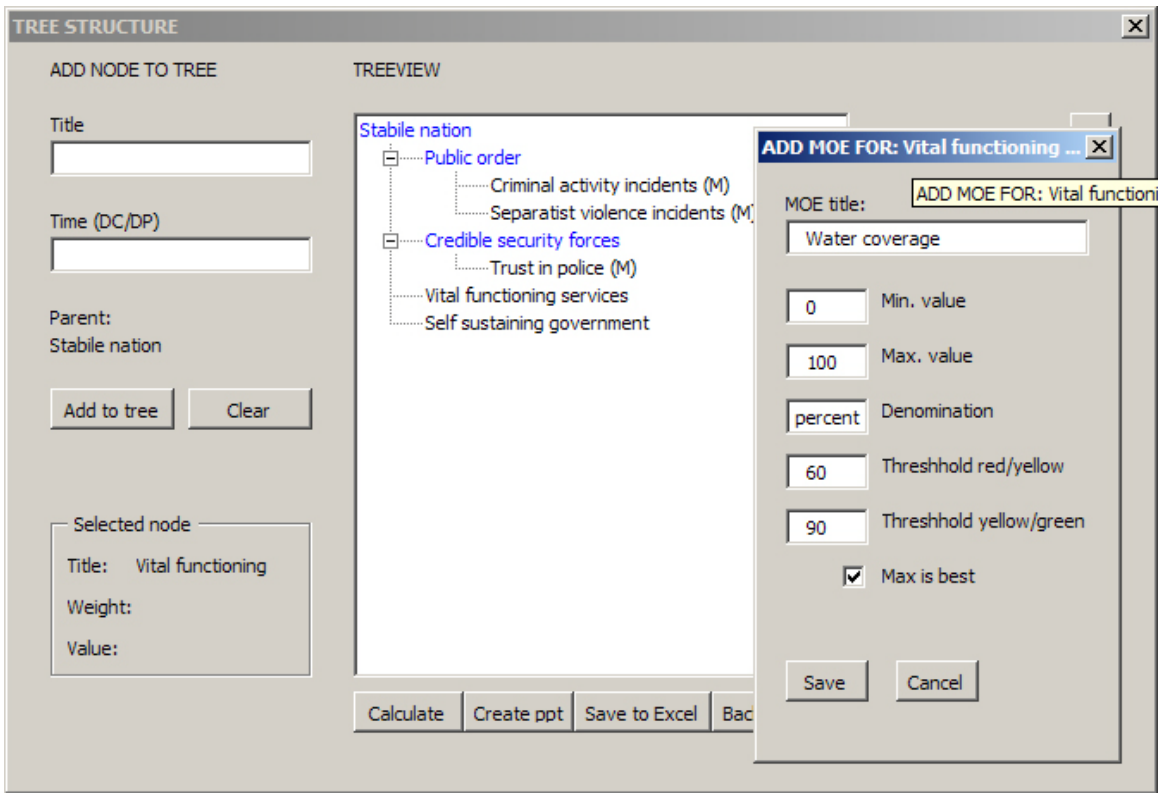

Figure 4.3 Add MOE´s to tree

MOE shows up in the tree marked with ”(M)” to separate it from other nodes. The following information has to be registered for the MOEs:

- Min. value: Sometimes there will, in theory, not exist a lower limit for a MOE´s value. In such cases, a sufficiently small number should be chosen
- Max. value: As for min. value, there may not exist an upper limit. In such cases, a sufficiently large number should be chosen
- Denomination
- Threshold red/yellow: Marks the limit between a red (bad) value and a yellow (OK) value
- Threshold yellow/green: Marks the limit between a yellow (OK) and a green (good) value
- Max is best: Indicates whether the maximum value or the minimum value is the best

To weight a node´s subnodes/MOEs, mark the node and press the Weight subnodes button. A window showing all subnodes/MOEs and their respective, adjustable weights is shown. Weights are given in percent (see Figure 4.4). By default, all subnodes have the same weight. Adjusting one weight will cause all other weights to change in the opposite direction. To lock a weight so it will not change when another weight is adjusted, mark the weight as shown in Figure 4.4 for the MOE Vital functioning services.

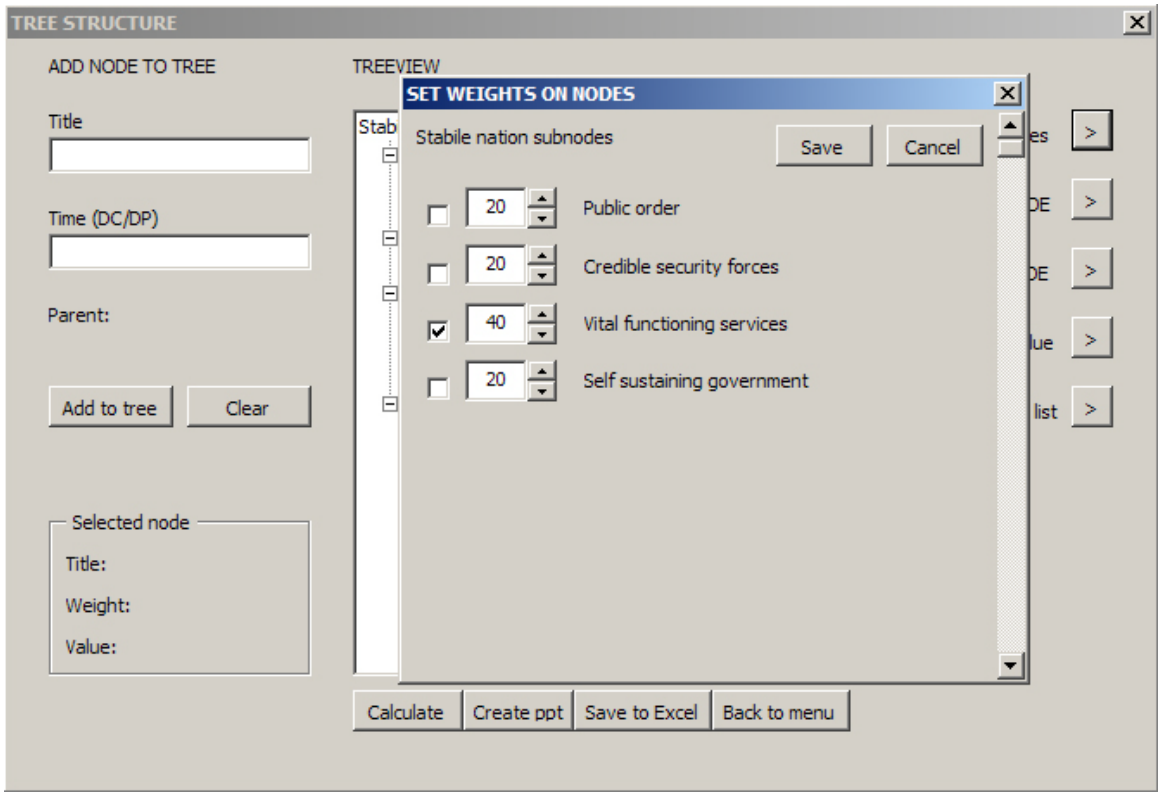

Figure 4.4 Add weights to subnodes

Building an operational design
If the tree is the basis of an operational design, it is important to remember that the tree can only contain the elements listed below, and that they must be sorted in levels in the tree following a certain order:

- End state: must be top node, must be present in tree
- Objectives: must be second level if present in tree
- Lines of operation: must be second or third level if present in tree
- Effects: must be third or fourth level if present in tree
- DC/DP: must be second level from the bottom, if present in tree
- MOEs: must be bottom level, must be present in tree

The order and levels of the elements listed above are only required if a figure of the operational design is to be generated automatically as a PowerPoint illustration.

DCs and DPs are often wrongly used interchangeably. To take this into account in HAT, both DC and DP are used as elements that are related to a point in time. In HAT, the operational design can contain DCs or DPs, but not both. The point in time can be filled in the field below the Title field. Time is given as percent of total operation duration.

4.2 Read new tree from Excel

To read a tree from Excel, information about nodes needs to be stored in an Excel sheet in a specific format. Figure 4.5 and Figure 4.6 show an example of this structure. In Figure 4.5 all nodes and MOEs are listed, with their respective parent nodes. The MOEs need additional information stored. This is illustrated in Figure 4.6.

Most columns represent parameters involved in the actual structure of the tree. These are marked with bold, non-italic column headers. Filling in values in these columns is mandatory. The parameters involved in calculation of the values in the tree are optional, which means that these can be left blank, but then they have to be stored later via the GUI. These columns are marked with italic headers.

The order of the node list is not important, with the exception that a child node cannot be listed higher up in the list than its parent. Also, all MOEs must be marked with ”(M)” for the program to understand that it is in fact a MOE.

	A	B	C
1	**Effect**	**Parent effect**	***Weight***
2			
3	Stabile nation		
4	Public order	Stabile nation	0.7
5	Credible security forces	Stabile nation	0.1
6	Vital functioning services	Stabile nation	0.1
7	Self sustaining government	Stabile nation	0.1
8	Criminal activity incidents (M)	Public order	0.6
9	Separatist violence incidents (M)	Public order	0.4
10	Water coverage (M)	Vital functionin	0.33
11	Electricity coverage (M)	Vital functionin	0.33
12	Medical coverage (M)	Vital functionin	0.33
13	Trust in police (M)	Credible securi	1
14	Trust in goverment (M)	Self sustaining	1
15			
16			

Figure 4.5 Tree input in Excel sheet

F	G	H	I	J	K	L	M	N	P
MOE	**MOE parent eff.**	**Min value**	**Max value**	**Denom.**	**Thresh RY**	**Thresh YG**	**Max is best**	***Value***	***Norm. value***
Criminal activity incidents (M	Public order	0	1000	incidents	350	50	FALSE	44	2
Separatist violence incidents	Public order	0	100	incidents	15	5	FALSE	4	3
Water coverage (M)	Vital functioning	0	100	percent	60	90	TRUE	67	2
Electricity coverage (M)	Vital functioning	0	100	percent	60	90	TRUE	89	2
Medical coverage (M)	Vital functioning	0	100	percent	60	90	TRUE	78	2
Trust in police (M)	Credible security	0	100	percent	40	70	TRUE	95	3
Trust in goverment (M)	Self sustaining g	0	100	percent	40	70	TRUE	0	1

Figure 4.6 MOE input in Excel sheet

4.3 Open existing tree from Excel

A tree that has been saved to Excel, can be opened later in the GUI. A tree can be saved from the GUI at any time, before or after weights and values have been assigned. If a tree is opened that is lacking weights or values, evidently these have to be added before the tree can be calculated.

4.4 Add data

MOE values are set by marking a MOE and pressing the ”Set MOE value” button to the right. To edit a value, mark a MOE and press the “Edit MOE” button. See Figure 4.7 for illustration.

4.5 Calculate tree

Input values from the user are normalized according to the threshold values in the following manner:

- Red = 3
- Yellow = 2
- Green = 1

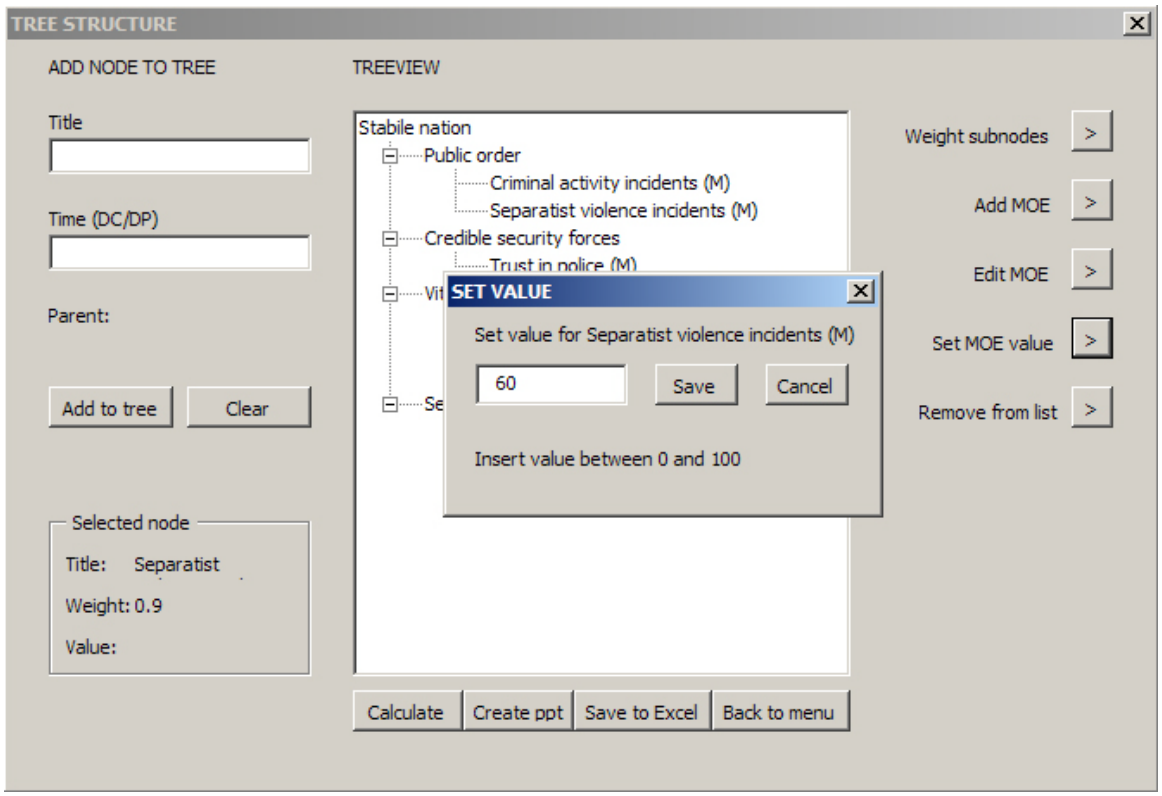

Figure 4.7 Set MOE value

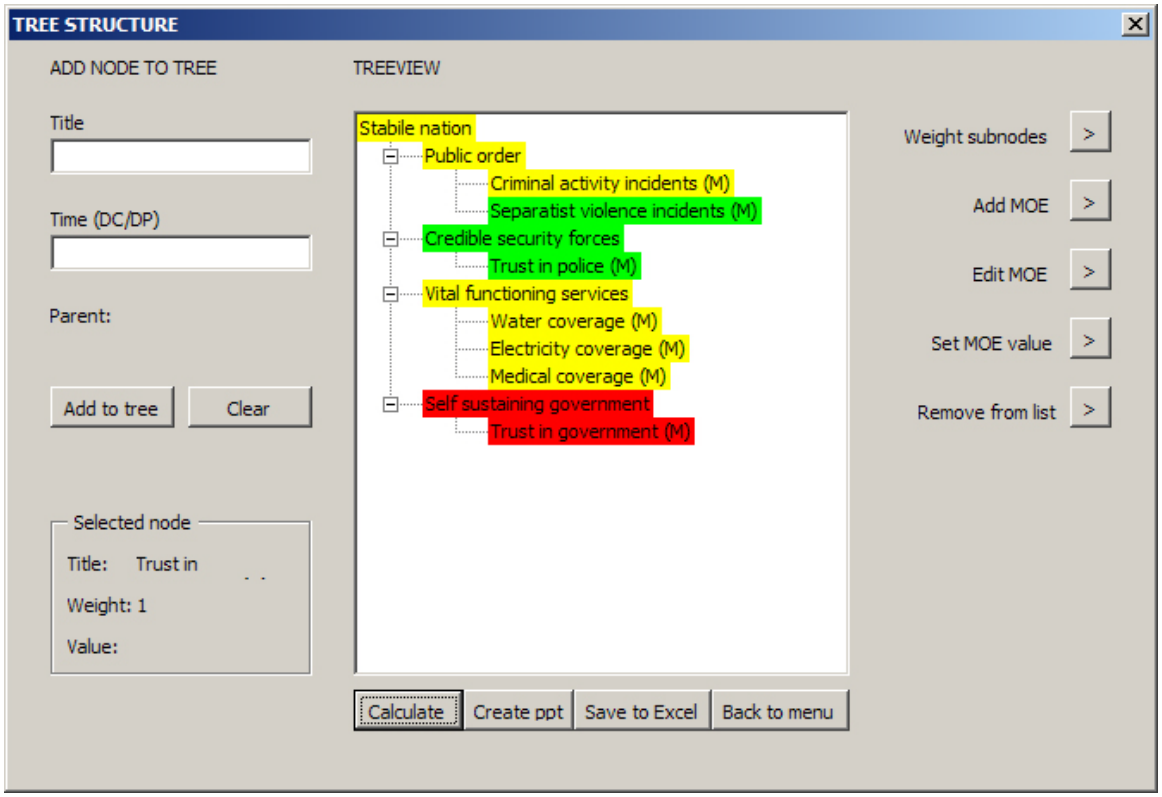

Figure 4.8 Calculated tree with status colors

A node´s calculated value is given by formula (2.1). When the user presses the Calculate button below the tree, every node value is calculated, and the corresponding colors show up in the tree. See Figure 4.8.

4.6 Save to Excel

The results of the calculation are saved to the Excel workbook in the sheet called Results. Note that if the tree should be opened at a later time, the tree needs to be saved in its own sheet, since the Results sheet is overwritten every time a new calculation is performed. This can be done by pushing the Save to Excel button. Then the user can choose a name for the tree/sheet. This makes it easy to save several measurements to the same tree, by opening it and saving it with a new name for every new measurement. This is useful for following campaign status over time.

4.7 Create PowerPoint file

Illustrations in PowerPoint can be created in two ways. As a general hierarchy or as an operational design.

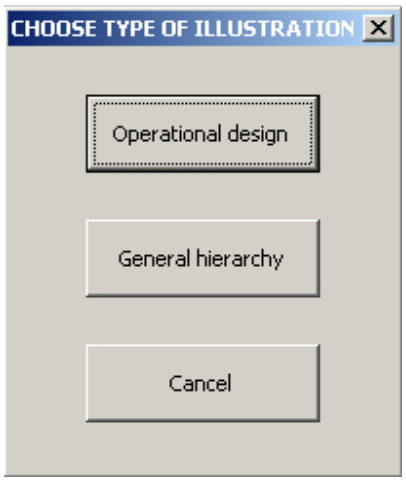

Figure 4.9 Choose which type of PowerPoint illustration to create

General hierarchy

The purpose of the general hierarchy figure is to illustrate the relations between elements and show their status. A node in the tree is clicked and when pressing the Create ppt-button, a hierarchic illustration of this node and its subnodes can be created. Figure 4.10 shows such an illustration for the top node ”Stabile nation”.

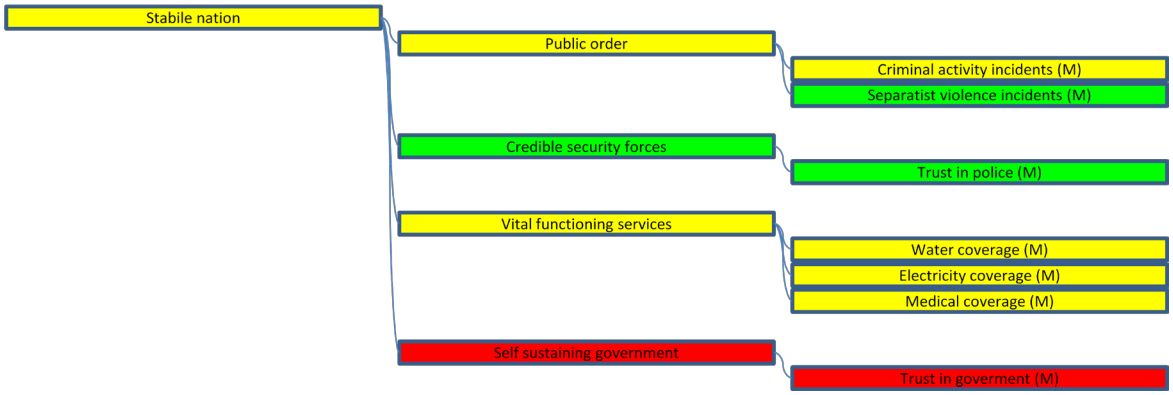

Figure 4.10 PowerPoint illustration of general hierarchy

Operational design

As explained earlier, not all elements from an operational design have to be present in the tree. Before making the illustration, the user must therefore specify which levels are present in the tree. In Figure 4.11, there are two columns of checkboxes. In the leftmost column, the user specifies which levels are present in the tree. In the rightmost column, the user specifies which levels to include in the figure. In Figure 4.11, End state, Lines of operation and DCs/DPs are ticked. Figure 4.12 shows the resulting PowerPoint illustration for a general example of an operational design.

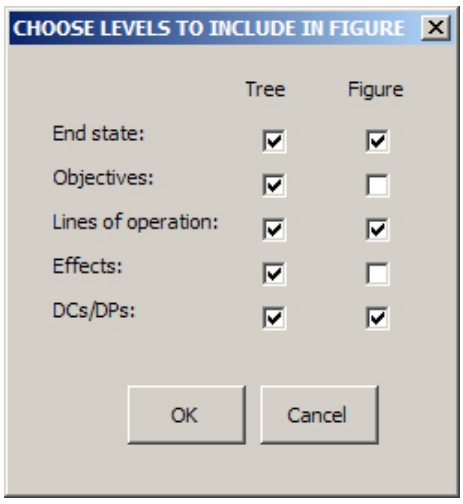

Figure 4.11 Choose which levels to include in the operational design figure

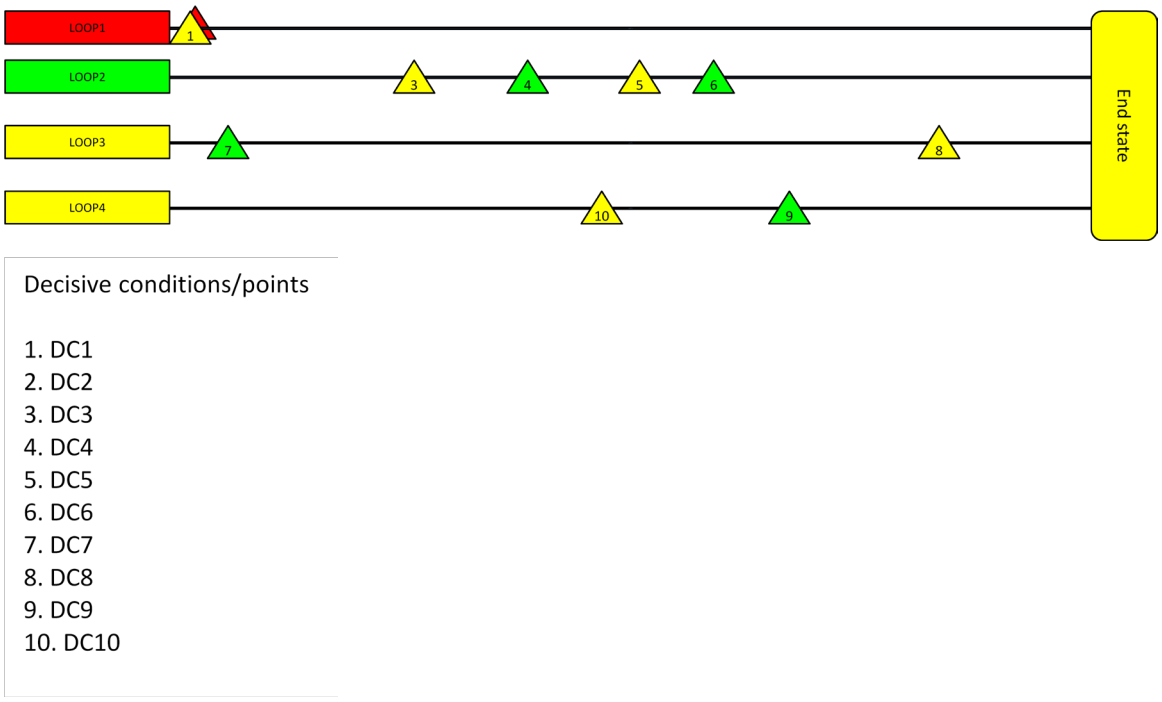

Figure 4.12 General example of an automatically generated operational design

5 Conclusion

Campaign assessment has become one of the main tasks for OA personnel in military operations. HAT aids the analysts by providing a way to store data, monitor campaign status and make illustrations to communicate this information.

5.1 Usability and usefulness

HAT has been used by analysts in exercises and seems to work as intended. Military personnel have provided positive feedback. There have been some wishes for extended functionality, especially concerning the automatic generation of illustrations. More flexibility has been requested on this point. This is further described in Chapter 5.2.

The intention is that HAT will be used in ISAF operations in Afghanistan in the course of 2010, by the analyst deployed to the Norwegian led PRT in Meymaneh. This will provide important information about the HAT´s usability in real operations.

As an Excel macro, HAT is available to anyone with MS Office installed, and the file is easy to exchange and move around.

5.2 Future development and improvements

More flexibility in HAT is an area of possible improvement. This is especially relevant in the following areas:

- The user should be able to control the use of status colors, i.e. be able to choose to use more than three colors and to use other colors
- The user should be able to choose what kind of geometric shapes to use in the illustrations
- The user should be able to specify levels in the operational design more freely. For example, elements of the same type could occur at different levels. One way to obtain this would be to let the user specify the type of a node when it is added to the tree

There are several issues related to the calculations in HAT and how results are analyzed:

- It should be considered whether a different set of rules should be adopted for finding status colors in parent nodes. For example, there could be requirements like “If at least one of a node´s children are red, the node itself has to be red” or “For a node to be green, at least 50% of its children have to be green”
- Resulting colors in the tree cannot be accepted as the whole and only truth. The results are meant to give an impression of current status, and are first and foremost a basis for further judgement. The analyst should carefully consider how the calculation framework influences results and colors. There are probably many ways to build this framework, some of which should be explored in further work
- A sensitivity analysis could provide useful information about how input and threshold values influence the results. Implementation of some kind of automated solution for doing such analyses should be considered in future work

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