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Editorial

War Game; Strategic Decision Making for Battlefield

We are delighted to present a new issue. In this issue, two technical paper are reviewed. In the first article, Çolakoğlu has presented a technical paper about current and near term air defence, fire support and battle management C2 systems. In second technical paper Başaran evaluated C2 systems from platform centric to network centric according to new technologies.

In the first article, Özçelik have presented a research paper in order to determine the most appropriate special education and rehabilitation center, in terms of various criteria by using Fuzzy Analytic Hierarchy Process and MOORA. Baylan have handled facility layout as a tool for eco efficiency and clean production in second research paper.

I selected "war game" topic for this letter. Most of armies use war game as an educational or decision making process. I believe that staff officers should understand design and usage of war game in order to obtain useful results. Today war game have been depicted as a technique or tool, to support top-level strategic decision making process.

"War Games" have been described and taught as a technique, a tool, to support top-level "boardroom strategic activities (Rogers, 2014)

Let's have a quick look at the basic components of a war game first. Computers, 2D (or 3D) maps, war game software, players, war game halls and war game set of rules are components of typical war game (Albert et al, 2001). These components should precisely be used for the main goal. Every player should follow necessary rules in order to reach proposed stage of the planned operation. A player can create a specific event and explore what might have been if the player decides to do things differently.

Benefits of War game

At this very moment one should wonder importance of war game. Here we may mention outstanding benefits of it.

- First and most important benefit of war game is designing decision making process for strategy. It gives an opportunity to test the strategy (also military equipment's) in a robust and systematic way. If war game is well designed and the teams fully briefed, this can be realistic experience.

- The second benefit is the capacity of forecasting. Potential conflicts between countries or groups can be revealed applying to war game. War game can be adopted for commercial firms if resources and priorities are known.

- Another usage of war game is a test environment for detecting difficulties in the company's assumptions and market. It is possible to find out company's own capabilities according to their rivals.

- Non-Government Organizations (NGO) may use war game as a forecasting tool for prediction international relationships. War game can help to identify the strategic expectation on which the future decision making process depends (Dunnigan, 2005).

I think these benefits give perspective to expectations from war game. A sample framework for a war game process is given in Figure 1.

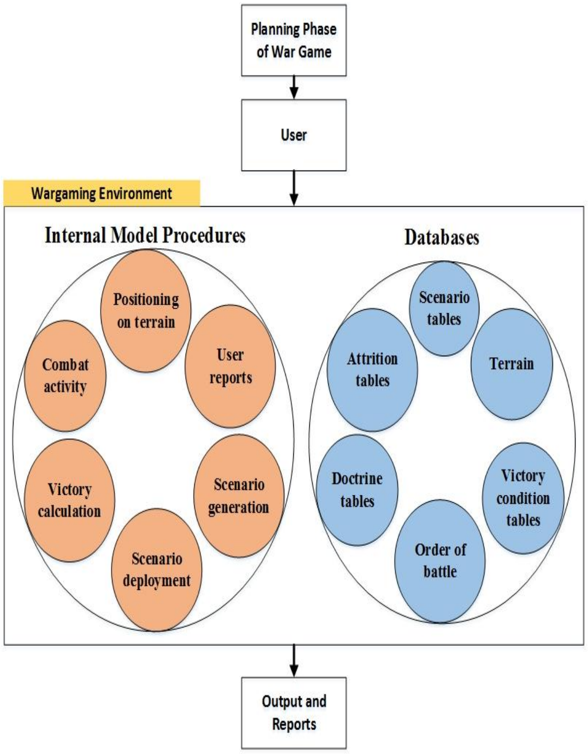

Fig 1. Main framework of a war game.

War game starts planning. Users, internal model procedures, databases, outputs and reports are components of a typical war game. Besides components, dimensions of war game needs to be understand by players. Perla et al (2004) defined six war game dimensions; time, space, forces, effects, information, command (Fig.2)

Types of war games

War game is not only based on computers. War game is an older issue than it is seen on the framework. There are some different manual war game types. For instance, chess is an earlier type of war game itself. The following list shows the primary types of war games (Dunnigani 2005).

- Manuel model with map.
- Manuel model without map.
- Spreadsheet combat model
- Cost/benefit model
- Expert system combat model
- Computer combat model with map
- Computer combat model without map
- Quick check list
- War game based on historical data

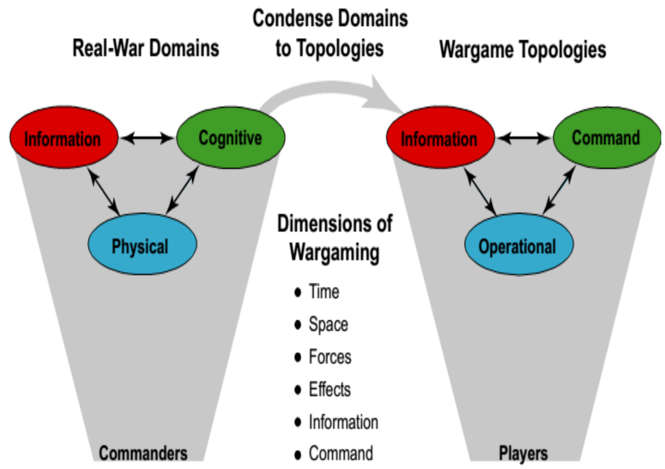

Fig 2. Dimensions of Wargaming, (Perla et al, 2004).

Most of the users joined in a war game miss the final remark. The educational purpose of war game is not only to increase the player's skills in combat tactics and strategy, but also to have him or her learn to find solutions appears during the game. In a combat environment, many surprising events occur that are not expected. User will be better equipped in finding solutions in real combat theater at the end of war game.

I tried to give a basic explanation about war game in this letter. I advise you to read Herman et al, 2009; Schwarz, 2013; Downes-Martin et al, 1992 and Caffrey, 2000, for detailed information about this topic.

Sincerely,

Kerim Goztepe, IE, Ph.D
Editor-in-Chief
Journal of Military and Information Science

References

Alberts, D. S., Garstka, J. J., Hayes, R. E., & Signori, D. A. (2001).Understanding information age warfare. Assistant Secretary Of Defense (C3i/Command Control Research Program) Washington DC.

Caffrey Jr, M. (2000). Toward a history-based doctrine for wargaming. Air and Space Power Journal Maxwell Afb Al.

Downes-Martin, S., Deutsch, S., & Abrett, G. (1992). Managing uncertainty in time-critical plan evaluation. International journal of man-machine studies, 36(2), 337-356.

Dunnigan, J., The Complete Wargames Handbook, 2005.

Herman, M., Frost, M., & Kurz, R. (2009). Wargaming for leaders: Strategic decision making from the battlefield to the boardroom. McGraw-Hill.

Perla, P. P., Markowitz, M. C., & Christopher, A. W. (2004). Transforming Naval Wargaming: A Framework for Operational-Level Wargaming.

Rogers, N. The Art of War Gaming, Medius Assosiates, www.medius-associates.com / wp-content/The-Art-of-Wargaming1.pdf, 06 May 2014.

Schwarz, J. O. (2013). Business wargaming for teaching strategy making. Futures, 51, 59-66.

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A Hybrid Moora-Fuzzy Algorithm For Special Education and Rehabilitation Center Selection

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Abstract- Special education and rehabilitation centers are established in order to train children and young people who need special education. The main goal of this study is to determine the most appropriate special education and rehabilitation center, in terms of various criteria by evaluating three different corporations which are active in Kayseri/Turkey. For that purpose, we apply Fuzzy Analytic Hierarchy Process and MOORA which are the methods of multi-criteria decision making. Education, compliance of ergonomic, compliance of corporation building, cost, public opinion and prestige and assessment of personnel are considered as the criteria. Firstly, these criteria are weighted by using Fuzzy Analytic Hierarchy Process, later MOORA method is used to choose the most appropriate corporation.

Keywords- Special Education and Rehabilitation Center; MOORA; Fuzzy Analytic Hierarchy Process; Multi Criteria Decision Making.

1. Introduction

Special Education and Rehabilitation Centers were established in order that individuals who can't adapt to living environment gain the skills that are necessary for self-reliance. This center is a school catering for students who have special educational needs due to severe learning difficulties, physical disabilities or behavioral problems. Special education alternatives in Turkey; Guidance and Research Centers, Special Classes in Regular Schools, Schools for Trainable Children, Primary Schools for Educable Children, Vocational Education Centers, Occupation Education Center, Residential Institutions, Private-special Schools, Private-Special Rehabilitation Centers, and University Affiliated Centers. (Cavkaytar, 2006). We have investigated private-special rehabilitation centers of those mentioned above. For that purpose, three different special education and rehabilitation centers have been evaluated in terms of various criteria. Then, we have applied MOORA (multi-objective optimization on the basis of ratio analysis) that is one of the methods of multi-criteria decision making. MOORA method is not used for the selection of special education and rehabilitation center in the literature. Firstly, the MOORA method was introduced by Willem Karel M. Brauers and Edmundas Kazimieras Zavadskas in 2006 (Brauers & Zavadskas, 2006). Although the MOORA is a newly proposed method; recently, it has been applied to solve many economic, managerial and construction problems.

Some studies in literature; Brauers and Zavadskas (2010, 2008) and Brauers and Ginevicius (2010, 2009) have proposed the use of MOORA method in economy.

Table 1. Comparative performance of some popular MODM methods

MODM method	Computational time	Simplicity	Mathematical calculations involved	Stability
MOORA	Very loss	Very simple	Minimum	Good
AHP	Very high	Very critical	Maximum	Poor
TOPSIS	Moderate	Moderately critical	Moderate	Medium
VIKOR	Less	Simple	Moderate	Medium
ELECTRE	High	Moderately critical	Moderate	Medium
PROMETHEE	High	Moderately critical	Moderate	Medium

Table 2. Criteria

Criteria	
C1. Education	
	C1.1. Awarding
	C1.2. Compliance with the curriculum
C2. Ergonomics	
	C2.1. Suitability of desks
	C2.2. Suitability of the use of the toilets for disabled
C3. Institution's Building	
C4. Cost	
C5. Image and Prestige	
C6. Assessment of Personnel	

Chakraborty (2010) uses the MOORA method to solve different decision making problems in the real-time manufacturing environment. Kracka et al., (2010) have ranked heating losses in a building by applying the MultiMOORA. The aim of his research is to create a technique for the selection of external walls and windows of buildings. In the mentioned field Brauers and Zavadskas (Brauers, Zavadskas 2009; Brauers *et al*. 2008) use the MOORA method for evaluating contractors in the facilities sector. The MOORA method has also been successfully used for determining the best alternative road design (Brauers et al. 2008a). Chakraborty (2011) has applied the MOORA method for decision making in manufacturing environment. Stanujkic et al., (2012) has studied multi-criteria approach to optimization using MOORA method and interval grey numbers. Krande & Chakraborty (2012) have applied the MOORA method for selection of materials. Brauers (2013) has planned the multi-objective seaport by MOORA decision making.

2. Methods & Application

In this study, the MOORA method is used for selection problems. Table 1 depicts the comparative performance of some of the most widely used MODM (Multi Objective Decision Making) methods with respect to their computational time, simplicity, mathematical calculations involved and stability (Ginevicious & Podvezko, 2008). In fact, these results can help us to explain why the MOORA method is chosen.

Three of Kayseri Special Education and Rehabilitation Centers are evaluated in terms of criteria. The aim in this study is to determine the most appropriate Special Education and Rehabilitation Center. The considered criteria are shown in Table 2. Based on expert opinion; the matrix of responses of different alternatives related to different objectives is created. That initial matrix is shown in Table 3

Table 3. Initial matrix

	C1.1	C1.2	C2.1	C2.2	C4	C3	C5	C6
	(max)	(max)	(max)	(max)	(min)	(max)	(max)	(max)
Parilti	3	7	2	2	1/8	4	5	5
Nida	4	6	2	4	1/8	4	6	7
Ilgim	2	8	2	3	1/9	5	5	6

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Table 4. Sum of squares & Square roots

	C1.1	C1.2	C2.1	C2.2	C4	C3	C5	C6
	(max)	(max)	(max)	(max)	(min)	(max)	(max)	(max)
Parilti	3	7	2	2	1/8	4	5	5
Nida	4	6	2	4	1/8	4	6	7
Ilgim	2	8	2	3	1/9	5	5	6
Sum of squares	**29**	**149**	**12**	**29**	**0,044**	**57**	**86**	**110**
Square roots	**5,39**	**12,21**	**3,46**	**5,39**	**0,21**	**7,55**	**9,27**	**10,49**

1.1. The Ratio System

In the ratio system, initial data of an alternative on an objective are internally normalized. Each response of an alternative on an objective is compared to a denominator which is a representative for all alternatives concerning that objective (Kracka et al, 2010). The denominator consists of the square root of the sum of squares of each alternative per objective (Van Delft and Nijkamp 1977) with: x_{ij} ; response of alternative *j* on objective *i*; *j* = 1, 2, …, m; m the number of alternatives; *i* = 1, 2, …, *n*; *n* is the number of objectives; x_{ij}^* ; a dimensionless number representing the normalized response of alternative *j* on objective *i* (Kracka et al, 2010).

$$x_{ij}^* = \frac{x_{ij}}{\sqrt{\sum_{j=1}^{m} x_{ij}^2}} \tag{1}$$

Firstly, Sum of Squares & Square Roots are determined and shown in Table 4. Then objectives divided by their square roots, normalized values obtained and shown in Table 5.

For optimization based on the Ratio system approach of MOORA method, normalized responses are added in case of maximization and subtracted in case of minimization, which can be expressed by the following formula (Stanujkic et al., 2012):

$$y_j^* = \sum_{i=1}^{g} x_{ij}^* - \sum_{i=g+1}^{i=n} x_{ij}^* \tag{2}$$

Table 5. Normalized values

	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
	(max)	(max)	(max)	(max)	(min)	(max)	(max)	(max)
Parilti	0,557	0,573	0,578	0,371	0,598	0,53	0,539	0,478
Nida	0,742	0,491	0,578	0,742	0,598	0,53	0,647	0,667
Ilgim	0,371	0,655	0,578	0,557	0,532	0,662	0,539	0,572

Table 6. Ordinal ranking of the ratio system

	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	Total	Rank
	(max)	(max)	(max)	(max)	(min)	(max)	(max)	(max)		
Parilti	0,557	0,573	0,578	0,371	0,598	0,530	0,539	0,478	**3,028**	**3**
Nida	0,742	0,491	0,578	0,742	0,598	0,530	0,647	0,667	**3,799**	**1**
Ilgim	0,371	0,655	0,578	0,557	0,532	0,662	0,539	0,572	**3,402**	**2**

with: x_{ij}^* as normalized response of alternative *j* on objective *i*; *i* = 1, 2, ..., *g* as the objectives to be maximized; *i* = *g* + 1, *g* + 2, ..., *n* as the objectives to be minimized; *j* = 1, 2, ..., *m* as the alternatives; and y_j^* as the overall ranking index of alternative *j*, $y_j^* \, E \in [-1, 1]$. An ordinal ranking of y_j shows the final preference. Thus, the best alternative has the highest y_j^* value, while the worst alternative has the lowest y_j^* value (Chakraborty, 2011). According to the results that are shown in Table 6, the best alternative is Nida.

1.2. Reference Point Approach

In the reference point approach, a maximal objective reference point is considered (Brauers & Zavadskas, 2009). The maximal objective reference point approach is more realistic and non-subjective as the coordinates (r_i), which are selected for the reference point, are realized in one of the candidate alternatives. Given the normalized values of the decision matrix, the deviation of a criterion value from the set reference point (r_i) can be obtained in the formula (3). In this approach, the performance index (P_i) measures this total deviation for all the considered beneficial and non-beneficial criteria for i_{th} alternative, which can be expressed as in the formula (4) (Karande &

Chakraborty, 2012). Reference values and the final table are shown in Table 7-8.

$$d_{ij} = \left| r_i - x_{ij}^* \right| \quad (3)$$

$$P_i = Min_{(i)} (\text{Max} \left| r_i x_{ij}^* \right|_{(j)}) \quad (4)$$

According to the reference point approach, still the most appropriate special education and rehabilitation center is Nida. Parilti and Ilgim have equal rank.

2.3. Significance Coefficient

In some cases, it is often observed that some attributes are more important than the others. In order to give more importance to an attribute, it could be multiplied with its corresponding weight (significance coefficient) (Brauers & Zavadskas, 2009) When those attribute significance coefficients are taken into consideration, Eq. 5 becomes as follows:

$$y_j^* = \sum_{i=1}^{g} w_i x_{ij}^* - \sum_{i=g+1}^{i=n} w_i x_{ij}^* \quad (5)$$

Table 7. Reference values

	x_1 (max)	x_2 (max)	x_3 (max)	x_4 (max)	x_5 (min)	x_6 (max)	x_7 (max)	x_8 (max)
r_i	0,742	0,655	0,578	0,742	0,598	0,662	0,647	0,667

Table 8. Ordinal ranking of reference point approach

	x_1 (max)	x_2 (max)	x_3 (max)	x_4 (max)	x_5 (min)	x_6 (max)	x_7 (max)	x_8 (max)	max	Rank
Parilti	0,185	0,082	0	**0,371**	0	0,132	0,108	0,189	**371**	**2-3**
Nida	0	**0,164**	0	0	0	0,132	0	0	**0,16**	**1**
Ilgim	**0,371**	0	0	0,185	0,066	0	0,108	0,095	**0,37**	**2-3**

where w_i is the weight of i_{th} attribute, which can be determined applying AHP (*analytic hierarchy process*) or entropy method. As the most effective way to include importance given to objectives into reference point approach of the MOORA method, we propose to adopt formula (3), after which adoption gets the following form (Stanujkic et al., 2012):

$$d_{ij} = w_i \left| r_i - x_{ij}^* \right| \quad (6)$$

3. Proposed Model

In this section, we applied to reference point approach using the significance coefficients. In this respect, FAHP (*fuzzy analytic hierarchy process*) is used for determination of significance coefficients of criteria.

The AHP has been widely used to solve MODM problems. However, due to the existence of vagueness and uncertainty in judgments, a crisp, pair-wise comparison with a classical AHP may be unable to accurately represent the decision-makers' ideas (Ayağ, 2005; Yazgan et.al; 2010). Even though the discrete scale of AHP has the advantages of simplicity and ease of use, it is not sufficient to take into account the uncertainty associated with the mapping of ones perception to a number. Therefore, fuzzy logic is also introduced into the pair-wise comparison to deal with the deficiency in the classical AHP, referred to as FAHP (Nooramin et al., 2012). FAHP is an efficient tool to handle the fuzziness of the data involved in deciding the preferences of different decision variables.

Table 9. Pairwise comparison matrix and fuzzy weights for sub-criteria related education & ergonomics

Pairwise comparison matrix and fuzzy weights for sub-criteria related education			
Criteria	C1.1	C1.2	**Fuzzy Weights**
C1.1	(1, 1, 1)	(1, 2, 4)	**(0.33, 0.67, 1.33)**
C1.2	(1/4, 1/2, 1/1	(1, 1, 1)	**(0.16, 0.33, 0.67)**
Pairwise comparison matrix and fuzzy weights for sub-criteria related ergonomics			
Criteria	C2.1	C2.2	**Fuzzy Weights**
C2.1	(1, 1, 1)	(1, 3, 5)	**(0.31, 0.75, 1.54)**
C2.2	(1/5, 1/3, 1)	(1, 1, 1)	**(0.14, 0.25, 0.69)**

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Table 11. Criteria & fuzzy significance coefficients

Global fuzzy significance coefficients for sub-factors		
	Criteria & fuzzy significance coefficients	Global fuzzy significance coefficients
C1 **(0.13, 0.29, 0.62)**	C1.1 **(0.33, 0.67, 1.33)**	**(0.04, 0.19, 0.82)**
	C1.2 **(0.16, 0.33, 0.67)**	**(0.02, 0.10, 0.42)**
C2 **(0.09, 0.21, 0.47)**	C2.1 **(0.31, 0.75, 1.54)**	**(0.03, 0.16, 0.72)**
	C2.2. **(0.14, 0.25, 0.69)**	**(0.01, 0.05, 0.32)**
	C3	**(0.03, 0.06, 0.14)**
	C4	**(0.04, 0.08, 0.20)**
	C5	**(0.11, 0.26, 0.59)**
	C6	**(0.05, 0.10, 0.24)**

The comparisons made by experts are represented in the form of Triangular Fuzzy Numbers (TFNs) to construct fuzzy pair-wise comparison matrices (Ghodsypour and O'Brien, 1998). In this respect; firstly, institutions are visited and points are given by making observations. Fuzzy triangular numbers that are developed by Prakash (2003) are considered and pairwise comparison matrices for criteria and sub-criteria created in Table 9-10. Then the obtained global fuzzy criteria significance coefficients are defuzzified and shown in Table (11-13, See Appendix A for Table 10). For the defuzzification, firstly lower and upper bound are determined for every factor at every α-cut value. (*Equation 7-8*). Later, combined lower (**$w_{i(lower)}$**) and upper bound values (**$w_{i(upper)}$**) are calculated for every factor (*Equation 9-10*) (Dagdeviren, 2007). Defuzzification for the first factor is mentioned in the below, the defuzzified weight of awarding factor is obtained as 0,278.

$$Lower\ Bound(\mathrm{LB}) = \alpha(\mathrm{m}_i - l_i) + l_i \tag{7}$$

$$Upper\ Bound(\mathrm{UB}) = u_i - \alpha(\mathrm{u}_i - m_i) \tag{8}$$

$$w_{i(lower)} = \frac{\sum_{i=1}^{l} \alpha_i (LB)_i}{\sum_{i=1}^{l} \alpha_i} \tag{9}$$

$$w_{i(upper)} = \frac{\sum_{i=1}^{l} \alpha_i (UB)_i}{\sum_{i=1}^{l} \alpha_i} \tag{10}$$

$$W_i^{'} = \lambda w_{i(lower)} + (1-\lambda) w_{i(upper)};\ \lambda \in [0,1] \tag{11}$$

In practical applications, λ=1; λ=0,5, and λ=0 are used to indicate that the decision maker involved has an optimistic, moderate, or pessimistic view, respectively. An optimistic decision maker is apt to prefer higher values of his/her fuzzy assessments, while a pessimistic decision maker tends to favor lower values (Deng, 1999). In this study; λ, is considered as 0,5. According to Eq (11); defuzzified significance coefficient is calculated for awarding factor. Since the sum of defuzzied significance coefficients is more than 1, weights are normalized. According to the results, the most appropriate special education and rehabilitation center is Nida, Parilti and Ilgim, respectively. The results are shown in Table 14.

Table 12. Defuzzification for the first criterion

Defuzzification for the first criterion (Awarding)									
α-cut	**0,1**	**0,2**	**0,3**	**0,4**	**0,5**	**0,6**	**0,7**	**0,8**	**0,9**
lower bound	0,055	0,07	0,085	0,1	0,115	0,13	0,145	0,16	0,175
upper bound	0,757	0,694	0,631	0,568	0,505	0,442	0,379	0,316	0,253

Table 13. Weights, defuzzified & normalized significance coefficients

Criteria	li	mi	ui	Com. Lower Bound	Com. Upper Bound	Coeff.	Nor. Coeff.
C1.1	0.04	0.19	0.82	0,135	0,421	**0,278**	**0,21**
C1.2	0.02	0.10	0.42	0,07	0,217	**0,144**	**0,109**
C2.1	0.03	0.16	0.72	0,112	0,365	**0,238**	**0,18**
C.2.2	0.01	0.05	0.32	0,035	0,149	**0,092**	**0,069**
C3	0.03	0.06	0.14	0,049	0,089	**0,069**	**0,052**
C4	0.04	0.08	0.20	0,065	0,124	**0,094**	**0,071**
C5	0.11	0.26	0.59	0,205	0,381	**0,293**	**0,221**
C6	0.05	0.10	0.24	0,081	0,151	**0,116**	**0,088**

Table 14. Ordinal ranking of reference point approach with significance coefficient

	x_1 (max)	x_2 (max)	x_3 (max)	x_4 (max)	x_5 (min)	x_6 (max)	x_7 (max)	x_8 (max)	MAX	Rank (MIN)
Normalized S.C.	**0,21000**	**0,10900**	**0,18000**	**0,06900**	**0,05200**	**0,07100**	**0,22100**	**0,08800**	-	-
Parilti	**0,03885**	0,00893	0,00000	0,02559	0,00343	0,00937	0,02386	0,01663	**0,03885**	2
Nida	0,00000	**0,01787**	0,00000	0,00000	0,00343	0,00937	0,00000	0,00000	**0,01787**	1
Ilgim	**0,07791**	0,00000	0,00000	0,01276	0,00000	0,00000	0,02386	0,00836	**0,07791**	3

3.1. Full-Multiplicative Form

Brauers and Zavadskas developed the following equation for the full multiplicative form of MOORA (MULTIMOORA) method to distinguish it from the mixed forms (Karande & Chakraborty, 2012; Brauers and Zavadskas, 2010; Brauers and Zavadskas, 2011).

$$U_i = \frac{A_i}{B_i} \qquad (13)$$

where $A_i = \prod_{j=1}^{g} x_{ij}^{*}$, $B_i = \prod_{j=g+1}^{n} x_{ij}^{*}$ and U_i is the degree of utility for i_{th} alternative. In Eq. (12), the criteria to be maximized (beneficial attributes) are taken as the numerator and the criteria to be minimized (non-beneficial attributes) are taken as denominator (Balezentis et al., 2010).

Brauers and Zavadskas suggested that if any of the x_{ij} value is 0, which signifies the absence of a particular criterion in the decision matrix, a foregoing filtering stage or withdrawal of that criterion from the decision matrix can be considered (Karande & Chakraborty, 2012; Brauers and Zavadskas, 2010; Brauers and Zavadskas, 2011). According to the multiplicative form method, Nida is also the best special education and rehabilitation center. The results are shown in Table 15 (See Appendix B).

3.2. MultiMOORA

MultiMOORA is the further sequence of the MOORA method and of the full multiplicative form of multiple-objectives. MultiMOORA was introduced by Brauers and Zavadskas for the first time at the beginning of 2010. MultiMOORA becomes the most robust system of multiple optimizations under condition of support from the ameliorated nominal group technique and Delphi (Brauers and Zavadskas 2010). In fact, MultiMOORA determines dominant alternative. The results are shown in Table 16.

Table 16. MutiMOORA ranking

	MOORA Ratio System	MOORA Reference Point Tchebycheff	MOORA Reference Point with Sig. Coef.	Full Multiplicative Form	MultiMOORA
Parilti	3	2 - 3	2	3	**3**
Nida	1	1	1	1	**1**
Ilgim	2	2 - 3	3	2	**2**

4. Conclusion

All calculation results show that the best alternative is Nida. According to MultiMOORA, the best center is Nida, the second center is Ilgim and the third center is Parilti. In this study it is shown that MOORA is an effective method for the selection of alternatives. The ranking of this case study is summarized in Fig 1.

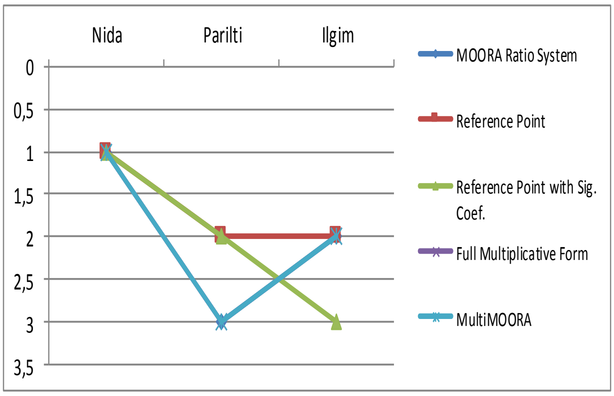

Fig 1. Ranking for all methods

The main advantage of these methods is that a simple ratio system is adopted to make the decision matrices dimensionless and comparable. The performance of these methods is also

Özçelik, G., Aydoğan, E.K., Gencer, C.. (2014). A Hybrid Moora-Fuzzy Algorithm For Special Education and Rehabilitation Center Selection , Journal of Military and Information Science, 2(3), 53-62.

comparable with other popular and widely used Multi-Criteria Decision Making methods. Thus, these methods can also be applied to the other decision-making scenario with any number of alternatives and criteria.

MOORA and MULTIMOORA optimization technique with discrete alternatives was used for ranking alternatives in the selection of the special education and rehabilitation center. In the future work, the case study will be analyzed using grey numbers. Moreover, the results will be compared results with other multi-criteria decision making methods.

References

Ayağ, Z. (2005). A fuzzy AHP-based simulation approach to concept evaluation in a NPD environment. IIE transactions, 37(9), 827-842.

Baležentis, A., Valkauskas, R., & Baležentis, T. (2010). Evaluating situation of Lithuania in the European Union: structural indicators and multimoora method.Technological and Economic Development of Economy, (4), 578-602.

Brauers, W. K. M.; Ginevicius, R., (2009). Robustness in regional development studies. The case of Lithuania, Journal of Business Economics and Management, 10(2), 121-140.

Brauers, W. M. K.; Ginevicius, R., (2010). The economy of the Belgian regions tested with MULTIMOORA, Journal of Business Economics and Management, 11(2), 173-209.

Brauers, W. K., & Zavadskas, E. K. (2006). The MOORA method and its application to privatization in a transition economy. Control and Cybernetics, 35, 445-469.

Brauers, W. K. M., Zavadskas, E. K., (2008). Multi-objective optimization in location theory with a simulation for a department store, Transformations in Business & Economics 7(3), 163-183.

Brauers, W. K. M.; Zavadskas, E. K.; Peldschus, F.; Turskis, Z. (2008a). Multi-objective decision-making for road design, Transport 23(3), 183-193.

Brauers, W. K. M.; Zavadskas, E. K.; Turskis, Z.; Vilutiene, T. (2008b). Multi-objective contractor's ranking by applying the MOORA method, Journal of Business Economics and Management 9(4), 245-255.

Brauers WKM., Zavadskas EK., (2009). Robustness of the multiobjective MOORA method with a test for the facilities sector. Technological and Economic Development of Economy: Baltic J on Sustainability, 15(2), 352-375.

Brauers, WKM., & Zavadskas EK., (2010). Project management by MULTIMOOORA as an instrument for transition economies. Technological and Economic Development of Economy, 16(1), 5-24.

Brauers WKM., Zavadskas EK., (2011). MULTIMOORA optimization used to decide on a bank loan to buy property. Technol Econ Dev Econ,17, 174-88.

Cavkaytar A., (2006). Teacher Traınıng On Specıal Educatıon In Turkey. The Turkish Online Journal of Educational Technology – TOJET July (2006) ISSN: 1303-6521, 5(3)

Chakraborty, S. (2010). Application of the MOORA method for decision making in manufacturing environment, The International Journal of Advanced Manufacturing Technology 54 (9-12), 1155-1166.

Dağdeviren, M., (2007). Personnel selection with fuzzy analytical hierarchy process and an application, J. Fac. Eng. Arch. Gazi Univ., 22(4), 791-799.

Deng, H., (1999) Multicriteria analysis with fuzzy pairwise comparison, International Journal of Approximate Reasoning, 21(3), 215-231.

Ghodsypour, S. H., & O'brien, C. (1998). A decision support system for supplier selection using an integrated analytic hierarchy process and linear programming. International journal of production economics, 56, 199-212.

Ginevičius R., Podvezko V., (2008) Multi-criteria graphical analytical evaluation of the financial state of construction enterprises. Baltic J on Sustainability 14, 452-461.

Karande P., Chakraborty S., (2012) Application of multi-objective optimization on the basis of ratio analysis (MOORA) method for materials selection. Materials and Design, 37, 317-324.

Kracka M., Brauers WKM., Zavadskas EK., (2010). Ranking Heating Losses in a Building by Applying the MULTIMOORA. ISSN 1392 – 2785 Inzinerine Ekonomika-Engineering Economics, 21(4), 352-359.

Nooramin, A. S., Kiani Moghadam, M., Moazen Jahromi, A. R., & Sayareh, J. (2012). Comparison of AHP and FAHP for selecting yard gantry cranes in marine container terminals. Journal of the Persian Gulf, 3(7), 59-70.

Prakash, T.N., (2003) Land Suitability Analysis for Agricultural Crops: A Fuzzy Multicriteria Decision Making Approach, MSc Thesis, ITC Institute.

Stanujkic D., Magdalinovic N.,Jovanovic R and Stojanovic S., (2012). An objective multi-criteria approach to optimization using MOORA method and interval grey numbers. Technological and Economic Development of Economy., 18(2), 331-363.

Van Delf, A., & Nijkamp, P. (1977), "Multi- criteria Analysis and Regional Decision- making", M.Nijhoff, Leiden, Nl.

Yazgan, H. R., Boran, S., & Goztepe, K. (2010). Selection of dispatching rules in FMS: ANP model based on BOCR with choquet integral. The International Journal of Advanced Manufacturing Technology, 49(5-8), 785-801.

APPENDIX A

Table 10. Pairwise comparison matrix and fuzzy weights for criteria

Pairwise comparison matrix and fuzzy weights for criteria						
Criteria	ED	ER	IB	CO	IP	AP
Education (ED)	(1, 1, 1)	(1, 2, 4)	(5, 7, 9)	(3, 5, 7)	(1/7, 1/5, 1/3)	(3, 5, 7)
Ergonomics (ER)	(1/4, 1/2, 1)	(1, 1, 1)	(1, 1, 1)	(3, 5, 7)	(1, 2, 4)	(1, 2, 4)
Institution's Building (IB)	(1/9, 1/7, 1/5)	(1, 1, 1)	(1, 1, 1)	(1/4, 1/2, 1)	(1/7, 1/5, 1/3)	(1/4, 1/2, 1)
Cost (CO)	(1/7, 1/5, 1/3)	(1/7, 1/5, 1/3)	(1, 2, 4)	(1, 1, 1)	(1, 2, 4)	(1/7, 1/5, 1/3)
Image and Prestige (IP)	(3, 5, 7)	(1/4, 1/2, 1)	(3, 5, 7)	(1/4, 1/2, 1)	(1, 1, 1)	(5, 7, 9)
Assessment of Personnel (AP)	(1/7, 1/5, 1/3)	(1/4, 1/2, 1)	(1, 2, 4)	(3, 5, 7)	(1/9, 1/7, 1/5)	(1, 1, 1)
Geometric mean of the 1th row: $\{(1×1×5×3×1/7×3)^{1/6},(1×2×7×5×1/5×5)^{1/6},(1×4×9×7x1/3×7)^{1/6}\}$=(1.36, 2.03, 2.89)						
Geometric mean of the 2nd row: $\{(1/4×1×1×3×1×1)^{1/6},(1/2×1×1×5×2×2)^{1/6},(1×1×1×7×4×4)^{1/6}\}$=(0.95, 1.47, 2.20)						
Geometric mean of the 3rd row: $\{(1/9×1×1×1/4×1/7×1/4)^{1/6},(1/7×1×1×1/2×1/5×1/2)^{1/6},(1/5×1×1×1×1/3×1)^{1/6}\}$=(0.31, 0.44, 0.64)						
Geometric mean of the 4th row: $\{(1/7×1/7×1×1×1×1/7)^{1/6},(1/5×1/5×2×1×2×1/5)^{1/6},(1/3×1/3×4×1×4×1/3)^{1/6}\}$=(0.38, 0.56, 0.92)						
Geometric mean of the 5th row: $\{(3×1/4×3×1/4×1×5)^{1/6},(5×1/2×5×1/2×1×7)^{1/6},(7×1×7×1×1×9)^{1/6}\}$=(1.19, 1.88, 2.76)						
Geometric mean of the 6 th row: $\{(1/7×1/4×1×3×1/9×1)^{1/6},(1/5×1/2×2×5×1/7×1)^{1/6},(1/3×1×4×7×1/5×1)^{1/6}\}$=(0.48, 0.72, 1.11)						
The sum of the fuzzy geometric averages: (4.67, 7.1, 10.52)						
The fuzzy weight of ED Factor: {(1.36/10.52, 2.03/7.1, 2.89/4.67)}=(0.13, 0.29, 0.62)						
The fuzzy weight of ER Factor: {(0.95/10.52, 1.47/7.1, 2.20/4.67)}= (0.09, 0.21, 0.47)						
The fuzzy weight of IB Factor: {(0.31/10.52, 0.44/7.1, 0.64/4.67)}=(0.03, 0.06, 0.14)						
The fuzzy weight of CO Factor: {(0.38/10.52, 0.56/7.1, 0.92/4.67)}=(0.04, 0.08, 0.20)						
The fuzzy weight of IP Factor: {(1.19/10.52, 1.88/7.1, 2.76/4.67)}=(0.11, 0.26, 0.59)						
The fuzzy weight of AP Factor: {(0.48/10.52, 0.72/7.1, 1.11/4.67)}= (0.05, 0.10, 0.24)						

APPENDIX B

Table 15. Ordinal ranking of multiplicative form

	x_1	x_2	2.1	x_3	3.1	x_4	4.1	x_5	5.1
	(max)	(max)	2.1=1*2	(max)	3.1=2.1*3	(max)	4.1=3.1*4	(min)	5.1=4.1:5
Parilti	3	7	21,0	2,0	42,0	2,0	84,0	1/8,0	**672,0**
Nida	4	6	24,0	2,0	48,0	4,0	192,0	1/8,0	**1536,0**
Ilgim	2	8	16,0	2,0	32,0	6,0	96,0	1/9,0	**864,0**

	x_6	6.1	x_7	7.1	x_8	8.1	Result
	(max)	6.1=5.1*6	(max)	7.1=6.1*7	(max)	8.1=7.1*8	
Parilti	4,0	2688,0	5,0	13440,0	5,0	67200,0	**3**
Nida	4,0	6144,0	6,0	36864,0	7,0	258048,0	**1**
Ilgim	5,0	4320,0	5,0	21600,0	6,0	129600,0	**2**

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Facility Layout: As a Tool for Clean Production and Eco Efficiency

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Abstract- Within the scope of sustainable development eco efficiency and cleaner production are new subjects for diminishing the industrial waste and increasing the productivity. They are broad topics. Eco efficiency philosophy aims decreasing usage amount of energy, water, raw materials during production cycle without decreasing quality of produced products. Because of less energy, water and raw material usage it provides environmental productivity (less pollution). Clean production, philosophically serves similar purpose. Clean production is minimizing the amount of waste on source of waste. It deals with eco design, good purification, and environmental friendly production processes. Diminishing amount of waste and pollution provides environmental productivity but also it provides economic productivity because of decreasing waste treatment cost. These subjects are generally linked with environmental sciences because they are about diminishing occurrence amount of waste and waste treatment. But also those subjects are related with productivity (industrial engineering). In this study, an industrial engineering subject which is Facility Layout is reviewed as a tool for eco efficiency and clean production.

Keywords- Facility layout, clean production, ecology, eco-efficiency

1. Introduction

By the beginning of the new millennium Sustainable Development gained more popularity. Amount of resources are diminishing. World population and their needs are increasing. For satisfying these demands, producers use more raw materials, more water and more energy. That causes more pollution. If this demand and supply cycle continues like this, it is going to be hard to satisfy demands of future generations. Besides that pollution of earth is going to be increased. Because of these reasons, some new philosophies and methods are developed to alleviate this big problem. Eco efficiency and clean production are few of them.

During production processes lots of activities are implemented. They can be physical reactions and chemical reactions. All these activities cause some wastes. Waste creation causes poor economic productivity and environmental productivity.

Waste is a material that we never want to produce. But we come across this problem in every step of product life cycle. At design stage of product design, materials that compose the products are determined. They should be designed as environment friendly (easy to recycle) for providing environmental productivity. This is about customer view. In fact, in this study it is dealt with production part of product life. Production process stage includes lots of activities which vary according to produced product. Every activity of production could create waste. Those wastes may come from residual raw materials, process water, using unnecessary amount of energy, much noise, dirty gas, unnecessary number of employees and equipment. As it can be imagined, this is also a productivity problem. Therefore these pollution problems are also related to industrial engineering subjects such as ergonomics, quality engineering and facility layout ect.. In this study we aim to draw the link between clean production and eco-efficiency with facility layout method by examining the general nature of these subjects

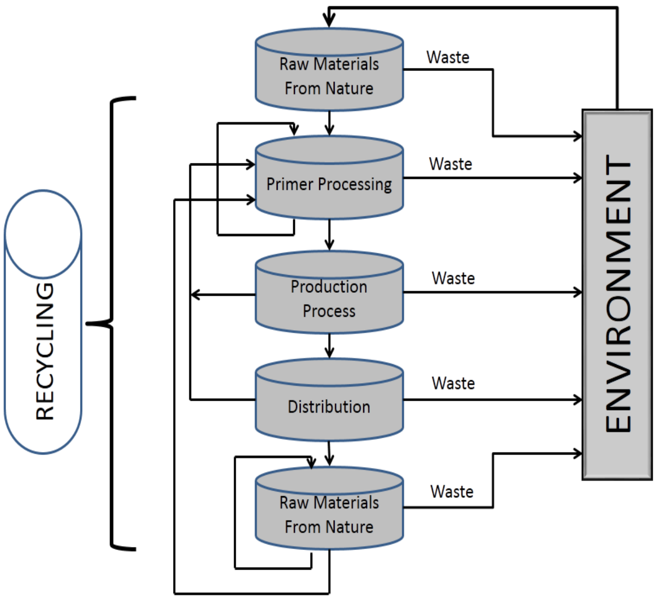

Figure 1. Relation between environment and supply chain (Tepe and Uludağ, 2002)

2. Literature Review

In literature review section, links between eco-efficiency, clean production and facility layout subjects were investigated. Clean production and eco- efficiency and clean production are subjects of sustainable development issue. That is why early and most of later studies about those subjects belong to environmental and chemical engineering researchers. However those subjects are broad topics. They involve lots of disciplines according to their particular cases. This research involves examination of clean production and eco-efficiency tools.

Research studies dealing with investigation of clean production methods were ordered chronologically. In 2003, a study in Norway focused on the intangible benefits and human factors derived from clean production projects, how the present clean production model could be improved and current ideas on how the clean production concept could be expanded to more directly address the needs of developing countries Improvements to the present clean production model should include means for ensuring sustainability of the local clean production center and its activities and financial mechanisms to facilitate affordable environmental investments. This study handled Clean production in a wide concept and tried to encourage the development of a "holistic view". It examined new job opportunities and how clean production concept integrated with foundations (Kjaerheim, 2003). Although this study examines new job opportunities and other trends which support clean production applications, it does not mention importance of plant layout in point of incensement of clean production performance. As it can be easily understood successful clean production projects provide profitability. A significant study was made that represents the link between clean production and profitability by examining 132 industrial pollution prevention projects (Cagno et al, 2003). Hierarchical pollution prevention 1990 U.S. is illustrated that was first defined in October 1990 U.S.

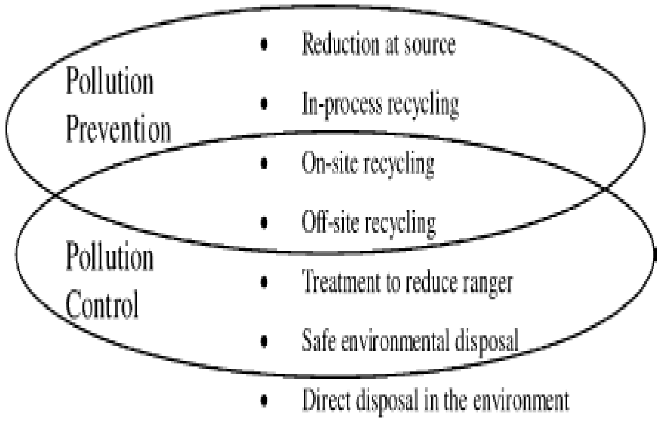

Figure 2. Evolution of the methodologies to design and manage eco-efficiency (Cagno et al, 2003).

In the view of our research we believe that examining reducing at source is more important than other methods. "Reducing at resource" philosophy has two components. One is reducing the amount of dangerous and contaminating substances which is used in production process and in the composition of waste. Second is reducing the variety of waste. Main techniques for "reduction at resource" are listed as below;

- ➢ improved operations in the factory;
- ➢ recycling of waste within the process;
- ➢ process modification;
- ➢ replacement of materials and products;

- separation of waste materials.

As it is seen plant layout design is not involved in the list (Cagno et al, 2003). At the conclusion part of study Cango and colleagues admit that clean production perception of companies change towards being a strategic issue. That intent is mostly because of cost reduction desire. Therewithal, it is observed that pollution prevention activities are still in the early stage, mainly based on pilot projects that are empirical and not completely integrated into the management processes.

Because clean production and eco-efficiency are multidisciplinary subjects, holistic view is very important. A generalized multi-objective process model is proposed that does modelling and optimization with environmental impacts and economic aspects simultaneously by Jia and others. A hybrid multi-objective evolutionary algorithm is used for solving the case of simple reaction system. In fact, main goal of this study is developing a decision support system for optimizing cleaner chemical production processes. Originality of this system is consideration of environmental impacts and economic aspects simultaneously. First, the chemical process was analyzed. Second, a generalized multi-objective mathematical model was developed for a process with environmental impacts and economics aspects (Jia et al, 2006). Model variables can be represented as below;

Table 1 Model parameters and variables (Jia et al, 2006)

Nomenclature	
e	energy matrix [kJ]
E	energy transformation matrix
f	objective function
F	flowrate [mol/h]
H	enthalpy matrix [kJ/kg]
ΔH	enthalpy change matrix [kJ/kg]
m	mass matrix [kg]
M	mass transformation matrix
m^*	environmental impact potentials
T	temperature [K]
w	weight matrix
x	conversion
X, Y, Z	components
Subscripts	
I	input
O	output
R	reactor
S	separator/recycle
P	product processing
V	energy recovery
A	energy processing
B	material processing
W	waste treatment

This model is developed to provide eco-efficiency for a chemical process plant. It only deals with process dynamics. Although it was proposed to consider both economic and environmental aspects in a holistic view, industrial engineering view (like plant layout or other quality improvement techniques) were not included in the model.

Another study which examines the link between clean production and productivity was made in China. Increasing of business performance is a good motivation factor for applying clean production and eco-efficiency projects but it should be analyzed properly. Zeng (2010) developed a model which represents the relationship between cleaner production and business performance was analyzed using Structure Equation Model (SEM). Zeng and others also impressed the financial view. High-cost and low-cost clean production activities were examined in Chinese manufacturing industry.

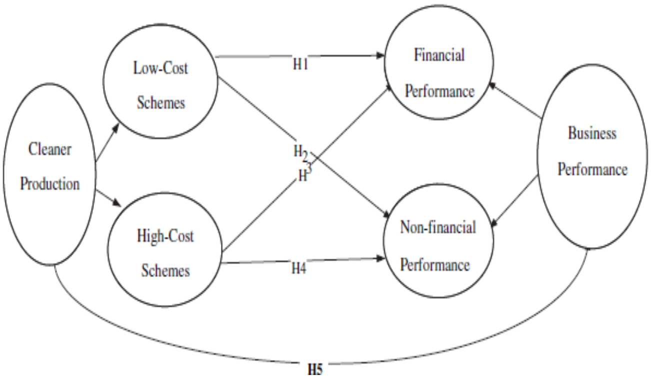

Figure 3. Relationship between cleaner production and business performance (Zeng et al, 2010).

One of the most important contribution of this study and which also related to our current study is the fact that cleaner production activities of low-cost scheme have a bigger contribution to financial performance, compared to non-financial performance. The reason is that the low-cost scheme cleaner production activities do not require significant financial input but may bring immediate financial benefits. So, as it is noticed that using energy efficient and clean technologies require significant financial investment but may not result in immediate economic benefits (Zeng et al, 2010). On the other hand some process redesign and employee training solutions provide more economic benefit than other high-cost techniques. Because facility layout is a low-cost productivity improvement method (which supports energy, raw material and time saving), it should be considered as a clean production technique. Indexes of clean production that study used was represented as below;

Table 2 Indexes of clean production (Zeng and others, 2010)

Evaluation index	Code	Index depiction
Low-cost scheme	CPL1	Improve employee environmental consciousness through training and evaluation
	CPL2	Improve working conditions to reduce waste
	CPL3	Strictly enforce rules on cleaner production
	CPL4	Enforce cleaner production as a long-term and continuous policy
	CPL5	Increase the recyclability of the products and components.
	CPL6	Possibilities of reducing the use of packaging are considered
High-cost scheme	CPH1	Possibilities of using energy efficient and clean technologies are considered
	CPH2	Possibilities of using renewable resources are considered when selecting raw materials and energy;
	CPH3	Increasing the durability of the products is considered;
	CPH4	Increase investment for environmental protection
	CPH5	Environmental issues are considered in the processes of production planning and technology innovation

Process monitoring and optimization are very important in terms of clean production and eco-efficiency. Klemeš (2012) made a research about recent cleaner production advances in process monitoring and optimization. Their study argues that decreasing CO_2 emission is a very important subject for clean production. On the other hand better product design, better process optimization, better monitoring, better training and management combined with improved governmental policies are effective tools for clean production.

SME's are very important economic and environmental actors in every country. Their environmental awareness is not as much as big companies. So they need encouragement. In Venezuela, a research was made which reviews public administration for encouragement tools and how they contribute to overcoming barriers to eco efficiency by offering external and internal incentives for SME. They assessed those tools based on criteria like: market influence, capability of the public administration for controlling results, tool costs, impact on public administration image, timespan to get results, etc. Finally they listed the public administration tools for eco-efficiency according to their suitability;

- Taxes
- Protection of Areas and Species
- Advertising of responsible consumption & eco-efficient products
- Subsidies
- Education in environment:
- Limit legislation
- Research in environment
- Legislation of BAT
- Green procurement policy
- Voluntary agreements
- Product panels
- Environmental Declarations (Fernández et al, 2013)

In this literature survey, eco-efficiency and clean production methods were researched comprehensively. Industrial engineering methods were not clearly considered by researchers. Facility layout subject has never mentioned either. In the following part eco-efficiency and clean production considerations will be defined briefly.

3. Eco-Efficiency and Clean Production Considerations

Within the scope of sustainable development environment and economic efficiency have begun to be considered together in order to encourage company owners. Eco-efficiency and clean production subjects are good examples for that because these production philosophies consider operational productivity and waste management. In the view of social and ecological responsibility governments and United Nations support applications of these methods by financing the projects and by training employees and engineers ect... Besides that those subjects are very important for company owners as they are closely linked by resource optimization. To define these methods and to have noticed the link between industrial engineering methods such as facility layout, it is listed some matters.

"There are ten core environmental considerations at the heart of eco-efficiency (Jung et al, 2001):

- using materials with less environmental impact
- using fewer materials overall in the manufacturing of products
- using fewer resources during the manufacturing process
- producing less pollution and waste
- reducing the environmental impacts from distributing products
- ensuring that products use fewer resources when they are used by end customers
- ensuring that products cause less waste and pollution when in use
- optimizing the function of products and ensuring most suitable service life
- making reuse and recycling easier
- reducing the environmental impact of disposal"

Second important stage of clean production and eco-efficiency is production of this eco-designed product suitable for environmental and economic productivity. A clean production process which is related to sustainable development should consider good waste management. Besides that it should consider energy and water usage optimization, quality engineering, inventory management, capacity management, supply chain management ect… That part of clean production and eco-efficiency process is closely related with industrial engineering subjects. Because productivity (using less raw material, energy, water and time without diminishing quality of product) yields cleaner production. Unfortunately industrial engineering techniques have not considered by clean production and eco-efficiency researchers. (In this study, we introduce an industrial engineering technique which is "Facility Layout".)

Third stage of clean production and eco-efficiency is waste management. As it was mentioned before we produce waste besides our products. Those wastes cause poor environmental and economic productivity. Waste treatment is the final task of clean production concept.

4. Facility Layout; As a Clean Production and Eco-efficiency Tool

In production plants, there are lots of resources (raw materials, water, energy, workers and also time) used for production. Their usage amount and style cause conflict most of time. After designing of product, production process is derived according to satisfy future demand. By keeping a certain capacity and certain quality of product; a production system is designed. Production engineers have to determine the amount of equipment, workers, energy, water and space needed for implementing production process. At that point facility layout techniques have benefits for solving this problem. "Manufacturing facility design is the organization of the company's physical facilities to promote the efficient use of company's resources such as people, equipment and energy" (Meyers and Stephens, 2005). This productivity improvement technique has some particular goals and most of them are related with clean production and eco-efficiency concepts. Facility layout goals are also related with eco-efficiency and clean production goals. In this part of paper, it is investigated. Facility layout projects provide firms those aspects shown below;

- Minimizing Unit and Project Cost: This means selecting most suitable equipment in order to minimize production cost. Number and skills of machinery and equipment have to be optimized according to capacity and total demand of product. That diminishes waste caused by machinery and equipment which provide eco-efficiency.
- Optimizing Quality: Quality is a very important concept for manufacturing. When designing the production plant, designing engineers consider quality characteristics of products. They choose the machines which are compatible with each other and have success at producing less variability. Increasing quality provides benefits in terms of eco-efficiency and clean production. Increasing quality by way of quality engineering causes reduction of variability of process outputs and decreases scrap and rework.
- Promoting Effective Use of People, Equipment, Space and Energy: This is the main reason for making a plant layout project. That is all about productivity. If a production plant is designed according to facility layout techniques, it needs less space, workforce and energy. Facility layout projects decorate inside of plant. It diminishes the total distance of raw materials and semi-products on the production line. So it requires less space and energy. Facility layout projects also consider ergonomics of working environment. They design the working environment with adjusting optimum noise, temperature and so on. Selecting suitable furniture style is also important for ergonomics. Those adjustments provide less pollution and efficiency.
- Providing better safety for working environment: Facility layout has to consider good safety because it affects employee motivation positively. Thus, they think that they are being cared about. Actually human resource is the most valuable resource. If employees are well motivated in a factory, quality of outputs increases.
- Providing high production flexibility: Some factories produce more than one product to get benefit of economies of scope or they need to increase production capacity suddenly. Facility layout design increases the success of those firms because they are supposed to be designed flexibly for sudden changes. Otherwise layout design could be unwieldy and that causes poor productivity and much pollution when capacity and product type need to be changed (Meyers and Stephens, 2005).

In fact, facility layout is part of operations management job. Operating a factory is a complicated job. First you need a proper market research to understand “What customer wants?”. After determining that an innovation or product redesign process start, products design process should be implemented with production process design simultaneously. That motion increases efficiency of production process. Capacity requirement of factory derives from future forecasts. Equipment selection is made in the light of this information. Finally, a last move is needed to increase production cost reduction and as it was mentioned in this study several times “minimizing the waste”. That is a good facility layout. To make proper facility layout information about product needs, process needs, capacity needs are supposed to be known. As a summary it could be said that Facility layout is part of a big job.

5. Conclusion

Clean production and eco-efficiency are new research areas of sustainable development. So, generally those subjects are approached in the concept of waste treatment and environment engineering. There are some national centers around the world. UNIDO (United Nations Industrial Development Organization) is the leader of this subject. They are trying to introduce importance of these subjects, giving financial support and training. This multidisciplinary research area is open for development either. Clean production and eco-efficiency projects are implemented by a multidisciplinary team. It includes environment engineer, process engineer, product engineer and definitely industrial engineer. Each expert has important responsibilities job for implementing the project. One of the vital jobs of industrial engineer is designing facility layout. In this paper, it is concluded the importance of facility layout concept in terms of clean production and eco-efficiency. Further studies should integrate other industrial engineering techniques to clean production and eco-efficiency.

References

Cagno, E., Trucco, P., & Tardini, L. (2003). Cleaner production and profitability: analysis of 134 industrial pollution prevention (P2) project reports. Journal of Cleaner Production, 13(6), 593-605.

Demirer, G., Cılız, N., Daylan, B., Baydar, G., Kara, H., Özçuhadar, T., Özsoy, G. (2011). Clean Production Sustainable Production and Consumption Publications - II. Ankara: Bölgesel Çevre Merkezi- REC Türkiye.

Erkut, H., & Murat Baskak. (2003). From Strategy to Application Facility Design (p. 428). İstanbul: İrfan Yayıncılık.

Fernández-Viñé, M. B., Gómez-Navarro, T., & Capuz-Rizo, S. F. (2013). Assessment of the public administration tools for the improvement of the eco-efficiency of Small and Medium Sized Enterprises. Journal of Cleaner Production, 47, 265–273.

Jia, X., Zhang, T., Wang, F., & Han, F. (2006). Multi-objective modeling and optimization for cleaner production processes. Journal of Cleaner Production, 14(2), 146–151.

Jung, E. J., Kim, J. S., & Rhee, S. K. (2001). The measurement of corporate environmental performance and its application to the analysis of efficiency in oil industry. Journal of Cleaner Production, 9(6), 551-563.

Kannegiesser, M., & Günther, H. O. (2014). Sustainable development of global supply chains-part 1: sustainability optimization framework. Flexible Services and Manufacturing Journal, 26(1-2), 24-47.

Kazmierczyk, P., Osuna, M. R. S., & Schwager-Quijano, P. (2002). Manual on the Development of Cleaner Production Policies Approaches and Instruments (p. 137). Vienna.

Kjaerheim, G. (2003). Cleaner production and sustainability. Journal of Cleaner Production, 13(4), 329-339.

Klemeš, J. J., Varbanov, P. S., & Huisingh, D. (2012). Recent cleaner production advances in process monitoring and optimization. Journal of Cleaner Production, 34, 1–8.

Knight, P., & Jenkins, J. O. (2009). Adopting and applying eco-design techniques: a practitioner's perspective. Journal of Cleaner Production, 17(5), 549-558.

Meyers, F., & Stephens, M. (2005). Manufacturing Facilities Design and Materials Handling. (S. Helba, Ed.) (Third Edit., p. 509). New Jersey.

Morrissey, A. J., & Browne, J. (2004). Waste management models and their application to sustainable waste management. Waste management, 24(3), 297-308.

Mörtberg, U., Haas, J., Zetterberg, A., Franklin, J. P., Jonsson, D., & Deal, B. (2013). Urban ecosystems and sustainable urban development analyzing and assessing interacting systems in the Stockholm region. Urban Ecosystems,16(4), 763-782.

Tepe, N., & Uludağ, S. (2002). Eco-Efficiency and Its Applications in SMEs, Endüstri ve Otomasyon Dergisi, 68, 6.

Zeng, S. X., Meng, X. H., Yin, H. T., Tam, C. M., & Sun, L. (2010). Impact of cleaner production on business performance. Journal of Cleaner Production, 18(10-11), 975–983.

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Technical Report

Tactical Command and Control Systems and Network Centric Warfare

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Abstract- One of the major requirements of a Command and Control (C2) system is to gather and distribute information. By bringing these systems under a network centric warfare architecture brings an integrated C2 system of systems. In this paper, information is given on current and near term air defence, fire support and battle management C2 systems. Capabilities for network centric warfare architecture are mentioned by applying of these capabilities to tactical C2 systems.

Keywords- Command and Control, Network Centric Warfare, Network Enabled Capability, Global Information Grid

1. Tactical Command and Control Systems

When we examine tactical command and control (C2) systems, we see that they basically send information gathered from various sensors and information sources to decision makers, which corresponds to tactical command centres in real life. After reviewing and analyzing this information, a course of action is decided and tasks are assigned to the relevant weapons and units accordingly. This cycle is typical for most C2 systems.

Tactical C2 systems can be classified according to their functional area, such as; Air Defence, Fire Support, Manoeuvre, Intelligence and Combat Support & Combat Service Support (Personnel and Logistics). Various C2 systems have been developed for these functional areas and are in use by the modern armies of the world.

Regarding the requirements of the Turkish Armed Forces, ASELSAN has developed and delivered functional areas as given below;

- Air Defence Systems
- Fire Support Systems
- Battlefield Management Systems

HERİKKS is the Air Defence C2 System, developed by ASELSAN and has been used by Turkish Armed Forces since 2001. The system is composed of an Air Defence Control and Coordination Centre at the Army Level and Corps and Brigade Level Air Defence Command and Control Centres operating at their respected levels. These Air Defence C2 centres have weapons and local and external sensors connected to them.

By using the sensor information received from local and external long range sensors, a combined and recognized air picture is formed and distributed to all relevant air defence units in at almost real time. Air picture is identified at Air Defence C2 Centres in coordination with the Air Force. Then, necessary course of action is taken by starting manual or automatic engagements to the appropriate weapon system. The engagement command is sent automatically to the weapon system. If the weapon is suitable, it is automatically cued to the related track.

A single integrated air picture (SIAP) is obtained through out the system by using sensor fusion algorithm. Low Level Air Picture Interface (LLAPI) is used to integrate with other allied country's air defence systems.

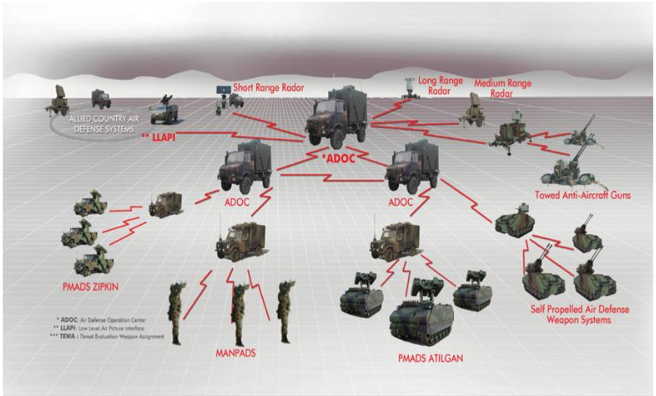

Fig. 1. HERİKKS

The system is also integrated with Turkish Land Forces Command Tactical Area C2 System and Air Forces Information System.

HERİKKS has been used by Turkish Naval Forces since 2008 for harbour air defence. The main difference between two applications is that the Naval version has C2 centre in a fixed site. In December 2008, ASELSAN was awarded a contract for HERİKKS, Phase 3, which was delivered and fielded in 2012. Work is in progress for the next HERİKKS upgrade, to be delivered in 2017-2018. It will include integration of new air defence weapon and sensor systems.

In the Fire Support functional area, ASELSAN has developed and delivered Tactical Fire Control System and Fire Support Automation System which is in use by Turkish Army since 2005.The system has units interconnected at corps, brigade, regiment and battalion levels. The system has a C2 centre at Corps Tactical Operation Centre – Fire Support Element. The target acquisition systems (Forward Observers, Fire Support Teams) provide target information to their Tactical Operation Centres. At the command centre, most suitable weapon for the designated target is calculated and fire mission is sent to this weapon system. The system makes ballistic calculations for the selected weapon system based on the selected ammunition and current weather conditions. The weapons are cued to the target accordingly.

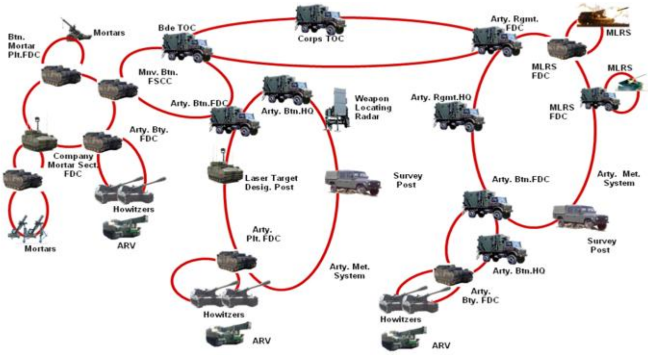

Fig. 2. Fire Support Automation System

For Battle Management, ASELSAN has developed Battle Management and Unit Tracking System (BATUR). BATUR is a C2 system that provides operational planning, situational awareness, common tactical picture, decision aids and functionalities to support the preparation with the mission supporting analysis tools, execution and after mission phases of operation for the contact units, multiplying the effectiveness of the maneuvers.

BATUR is designed to be fielded on mounted and dismounted maneuver forces including armored, mechanized infantry and infantry battalions, their combat support, combat service support, surveillance and reconnaissance units. BATUR provides seamless battle command. It increases the operational capabilities of the maneuver units from battalion level to the single platform/soldier level.

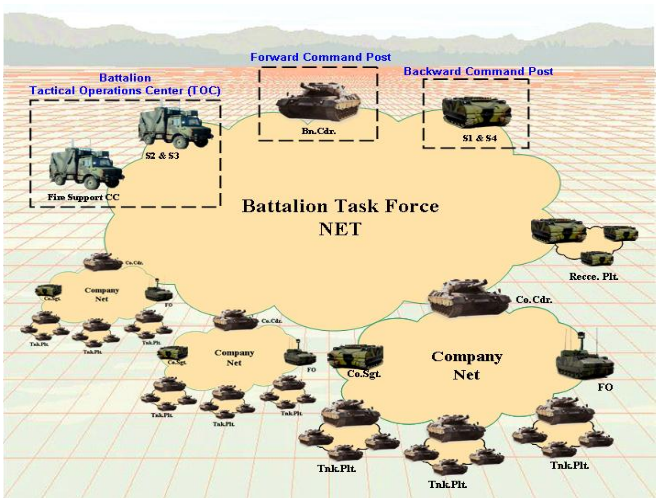

Fig. 3. ASELSAN BATUR

Another Tactical C2 system within the intelligence domain is the C2 of Electronic Warfare (EW) systems. Coordination between the electronic support measure (ESM) systems and electronic counter measure (ECM) systems is very critical in an EW operation. The signal intelligence (SIGINT) obtained from ESM systems (Communications Intelligence (COMINT) and Electronic Intelligence (ELINT)) are used by ECM systems to plan a successful electronic attack (EA) to the opponent systems.

Under C2 architecture, the ESM systems gather intelligence about the location and formation (Electronic Order of Battle (EOB)) of the enemy units, which is very valuable information for other friendly C2 systems around the area.

2. C2 Systems Common Capabilities and Simulation Capabilities

When we examine Air Defence, Fire Support and Battle Management Systems, C2 systems have common functions. These systems basically provide tools and services to increase situational awareness and help in decision making process. These tools and services are typically GIS capabilities, analysis functions, reporting capabilities, user authorization and authentication services and integrations with other C2 systems.

Depending on its characteristics and purpose, C2 systems can be mounted on sheltered vehicles, tanks, fixed sites or on a man worn system. These systems are also typically interconnected to the on board systems, such as fire control systems, vehicle systems, positioning systems.

Fig. 4. Shelter Mounted C2 System

The other important capability of C2 systems is the decision support algorithm. In a rapidly changing environment, it is critical to support the decision makers by analysing the situation and making recommendations about the course of action.

For Air Defence systems, Threat Evaluation and Weapon Assignment Algorithm (TEWA) is used for this purpose. The algorithm dynamically evaluates the current air picture, by taking into consideration parameters such as; type and location of available weapons and targets, effect of these weapons on these targets, status of the weapons. This function is very critical especially in a complex environment when there are lots of targets which cannot be handled manually. The system can make automatic engagements if necessary, or make recommendations for an engagement to a target.

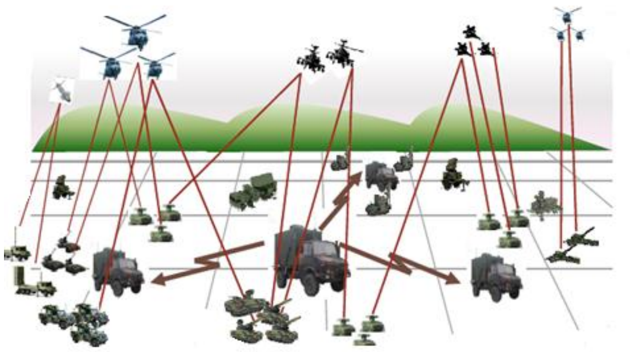

Fig. 5. Decision Support

A similar algorithm is also used in Fire Support systems. In a fire mission, a target list is formed with targets planned to be hit with a desired effect, or on call targets are analysed. The fire support decision algorithm analyses the fire mission and calculates the most suitable weapon system that will be effective on this target. In order to obtain the desired effect, munitions effectiveness algorithm calculates how many rounds should be fired on the target. After making ballistic calculations for that target, fire order is sent to the corresponding weapon.

After the deployment phase of the system, simulation capabilities are also critical both during the development phase and for training

System Effectiveness Analysis Laboratory (SEAL) is a current project that ASELSAN has invested on its establishment, in order to monitor efficiency of Air Defence Systems developed by ASELSAN. SEAL is aimed to be used for analyzing the effectiveness and determining possible improvements of these systems being produced by ASELSAN.

SEAL will serve as a simulation framework for distributed simulations along with its modeling and analysis capabilities.

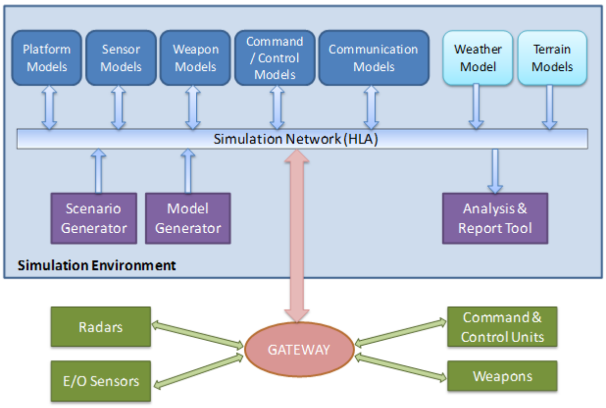

Fig. 6. SEAL Architecture

Another simulation infrastructure is the ASELSAN TEWA Analysis & Evaluation Tool (aselTAT) that is used to test a TEWA Algorithm with various scenarios and make interoperability tests for two GBAD systems running different TEWA Algorithms.

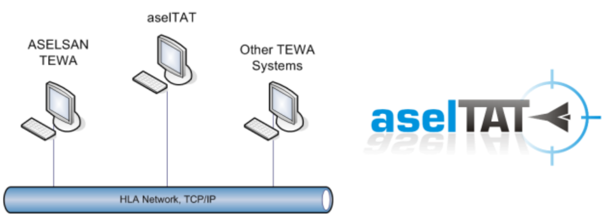

Fig. 7. aselTAT Architecture

The scenario generator provides a standard interface to the algorithms over an HLA network. It is possible to configure test architecture to test a single algorithm or two different algorithms that can either cooperate or operate independently.

3. Short Term C2 Systems

When we look at the systems that are going to be in service within five years, the following systems will be integrated under HERİKKS architecture:

- Low Altitude Air Defence Missile System (LALADMIS)
- Medium Altitude Air Defence Missile System (MALADMIS)
- 35mm Self Propelled Air Defence Gun System
- Fire Control Centre

HERİKKS is the overarching architecture (system of systems) for these Ground Based Air Defence (GBAD) systems.

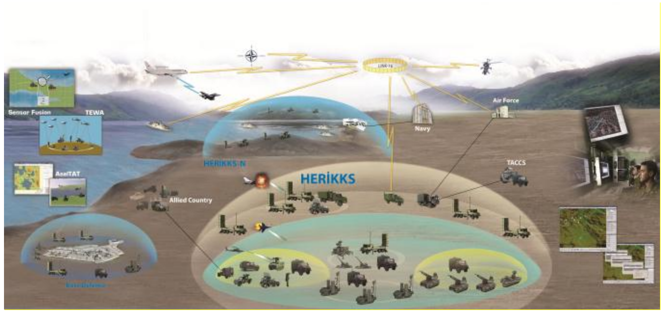

Fig. 8. Integrated Air Defence

Under the HERİKKS umbrella, GBAD systems with various capabilities starting from very low altitude up to medium altitude will be interconnected with interfaces to both Air Force assets and NATO systems, building up an integrated air defence system of systems. Link-16 tactical data link capability will be accomplished within the MALADMIS project, which will be the major communication infrastructure with other C2 systems.

Another system that is being developed as an R&D project is the soldier battle management C2 system. Depending on the configuration and mission requirements, following equipment could be mounted on the soldier for various C2 applications:

- Portable radio for voice and data communication
- Portable computer
- GPS

- Arm Display Unit
- Weapon Mounted IFF interrogator
- Various sensors to monitor health status, ammunition status, acoustic fire direction calculation
- Battery and solar charging panel
- Network module to interconnect the sensors and computer

By using acoustic sensors, soldiers can identify shooter direction when they are being fired. Using such sensors increase the situational awareness both for the soldier and other friendly units as the information is being shared. Soldier BMS C2 systems have applications related to all major functional domains, such as Air Defence, Fire Support, Intelligence. Some typical applications are Manpads units in Air Defence Systems, forward observers in Fire Support Systems, sniper detection systems for infantry units.

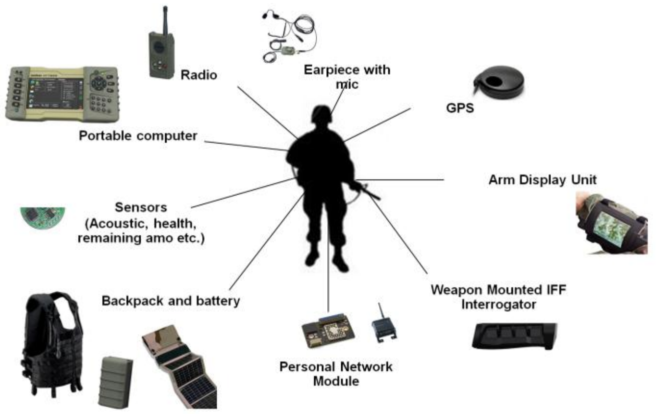

Fig. 9. Soldier BMS

4. Network Centric Warfare

Under the network centric warfare architecture (NCW), it is vital that these C2 systems operate in a synchronized manner. Within this architecture, a fire support system can receive target information from an Intelligence System, combat service support units could monitor the logistic status of the units and resupply in a short time, friendly unit and enemy unit locations can be shared among all friendly forces which could all be defined as a force multiplier for modern armies of the world.

Aselsan is working on establishing an integrated C2 system of systems.

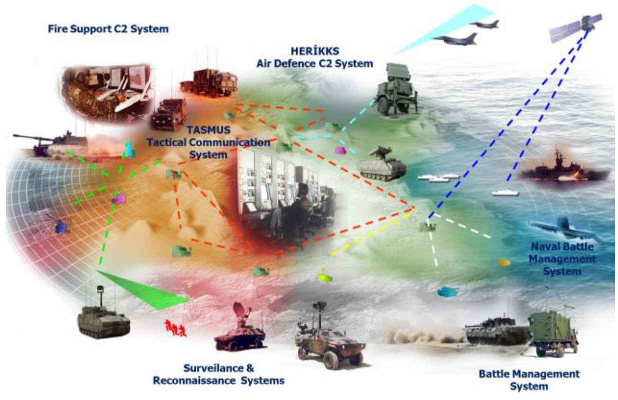

Fig. 10. Integrated Battle C2 Systems

The C2 systems work together as a single system, usually referred to as "systems of systems".(DoD, 2001). Systems of systems is defined as different mission specific systems come together and combine their resources and capabilities to form a more complicated system that has more functional capabilities and performance.

Today, system of systems approach is used not only in defence industry, but also in civil sectors such as transportation, health, space research. Integrating the domain specific C2 systems under a system of systems architecture enables a more effective C2 system. Communication systems supporting the network centric warfare architecture and services supporting the information exchange between C2 systems is vital for a successful C2 system. US Department of Defence (DoD) define these communication infrastructures and services as Global Information Grid (GIG).

Among the major capabilities of NCW is the ability to access information at any time and any location by all the present and future units in every echelon and share this information for faster and better decision making process.

It is criticized that the current C2 systems are ineffective in this manner. It is mentioned that the information exchange is done at specific nodes depending on the nature of the C2 systems and as more and more interfaces are available within those systems, it makes these systems more complicated and hard to manage. (Zenishek & Usechak, 2005) It is also mentioned that current systems do not support a dynamic architecture for new users and new systems that will be integrated, therefore new interfaces and new integration processes have to be implemented. (DoD, 2007)

By taking into consideration the objectives of Network Centric Warfare and experience from the C2 applications, NATO and US DoD foresee that the future data exchange technology for the applications in the battlefield should be based on Service Oriented Architectures (SOA). (DoD, 2007; Lund, 2007)

SOA is widely used in web based civil internet applications. It could be defined as a distributed architecture where separate software services built up a functional capability. In SOA, there are service/information providers, service/information users, and the interaction between these two parties form the bases of the SOA. One of the main advantages of SOA is that the services built up a functional capability of a system can run independently. This way, the user applications do not need to know where to request a service from beforehand, and the service provider applications can provide services to more than one user simultaneously. (ADatP-34, 2005)

NATO Interoperability Standards and Profiles (NISP, 2013), developed by the NATO Consultation, Command and Control (C3) Board, includes interoperability standards and profiles which are mandatory for use in NATO common funded Communications and Information Systems (CIS) to support C3 interoperability by assisting in the transition to the NATO Network Enabled Capability (NNEC). The standard points out short term and midterm standards. Emerging technologies are fading and become mandatory for a NNEC system. It is mentioned that information technology is undergoing a fundamental shift from platform-oriented computing to network-oriented computing. This shift from platform to network is what enables the more flexible and more dynamic network-oriented operation.

NATO SAS-085 study group made research on C2 requirements for 21st century military operations. The study points out that the military missions are large and complex, with extreme uncertainty and spectrum of challenges such as counter-insurgency, counter-terrorism, stabilization, reconstruction and support to multi-agency disaster relief. These missions are referred to as Complex Endeavours and require the participation and contributions of a large variety of military and non-military actors, a collective that SAS-085 refers to as a Complex Enterprise. The study points out that one of the key requirements for a C2 system is Agility. SAS-085 has developed a conceptual model of C2 Agility that captures the relevant variables and relationships. (Alberts et al., 2010) The study results of this group have been published as NATO NEC C2 Maturity Model (N2C2M2). (Mitchell et al, 2010).

Although SOA brings a lot of capabilities to NCW, there are also some drawbacks to this architecture. Applications are very much dependent on the services provided by other applications, which in turn brings development costs and processing power costs for the applications.(Perera, 2006; Zenishek & Usechak, 2005). In order to use SOA on mobile platforms, SOA messages need to be compressed. (Lund et al, 2007; Hafsøe et al, 2007) The applications also need to be optimized by taking the communication capabilities in the tactical field into consideration.

Despite these studies, using SOA effectively in the forward end tactical units is in very much related to the improvements on the communication capabilities of these units.(Lund, 2007) Looking at the current available technology, it is believed that in the short term, it will not be effective to use SOA for these units. One of the areas where SOA can be used effectively in tactical field is Tactical Command Posts and Headquarters. (Bieger, 2003; Ackerman, 2005) Command Centres at Brigade and upper levels usually have higher communication bandwidths which is an important infrastructure for using SOA services.

5. Conclusion

One of the main requirements of a C2 system is to acquire and distribute information. By bringing such systems in the tactical field forms an integrated C2 system of systems. These systems form an information sharing infrastructure based on NCW architecture. There have been many studies ongoing since NCW concept has been outlined. Some of these studies have been carried out under NATO study groups, of which their results have been published as reference models or standards. Using SOA on mobile platforms over tactical communication networks is currently being studied.

In the short term, it seems that using SOA at units above brigade level is more effective due to the availability of a higher bandwidth. The situational awareness for C2 systems will be increased in accordance with technology, starting from the single soldier up to the higher echelon command centres.

References

Ackerman, R.K. (2005). Defense Knowledge Management Hinges On Compatibility. Signal.

Alberts, D. S., Huber, R. K., & Moffat, J. (2010). NATO NEC C2 Maturity Model. Office of The Assistant Secretary of Defense, Washington Dc Command And Control Research Program (CCRP).

Allied Data Publication 34 (ADatP-34) (2005). NATO C3 Technical Architecture Volume 2 Architectural Descriptions and Models. Version 7.0.

Bieger, G. and Carpenter, J. (2003). Openwings A Service-Oriented Component Architecture for Self-Forming,Self-Healing, Network-Centric Systems. www.openwings.org/ download/ specs/ openwingswp.pdf

DoD (2001). Department of Defense Report to Congress, Network Centric Warfare, July 2001.

DoD CIO (2007). Department of Defense Global Information Grid Architectural Vision. Vision for a Net-Centric, Service-Oriented DoD Enterprise.

Hafsøe, T., Johnsen, F. T., Lund, K., & Eggen, A. (2007, June). Adapting Web services for limited bandwidth tactical networks. In 12th International Command and Control Research and Technology Symposium (ICCRTS), Newport, RI, USA.

Lund, K., Eggen, A., Hadzic, D., Hafsoe, T., & Johnsen, F. T. (2007). Using web services to realize service oriented architecture in military communication networks. Communications Magazine, IEEE, 45(10), 47-53.

Mitchell, D. W., Alberts, D. S., Bernier, F., Farrell, P. S., Pearce, P., Belanger, M & Henshaw, M. (2014). C2 Agility. NATO Research &Technology Organisation.

NATO Interoperability Standards and Profiles (NISP, 2013). Allied Data Publication 34(G).

Perera, D. (2006). Netcentric In a Snap The goal of netcentric warfare is to enable troops to adapt on the fly, but that means technology has to become plug-and-play. Government Executive-Washington Dc-, 38(9), 48.

Zenishek, S., & Usechak, D. (2005). Net Centric Warfare and Its Impact on System of Systems. Defense Acquisition Review Journal, 12, 217-232.

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Technical Report

A Short Review on Integrated C2 Systems

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Abstract- This report addresses the evolution of C2 systems from platform centric to network centric in the Information Age. It investigates the advantages of information distribution on a through different command grids to build a Force Multiplier. It addresses the standards, challenges and methods to overcome the limitations. Finally HAVELSAN C2 and supporting systems enabling Network Centric Operations are mentioned.

.**Keywords-** Integrated C2 Systems, Network Centric Warfare, NATO Network Enabled Capability, HAVELSAN.

1. Introduction

The level of information technology which has been reached today, has tremendous effects on our lives. Even small children at their first ages are developing motor capabilities and play games on tablet computers. In the following years of their childhood they enjoy playing online games in a networked environment, where game specific information is shared over internet among peers.

We exploit the benefits of the information age as it penetrates our daily lives. Even household appliances are operating in a networked environment nowadays, sharing information with other devices.

This evolution also affects the capability of C2 systems which are built for effective combination of sensors and weapons on those platforms.

In the late 90's, a new concept was introduced described as "translating an information advantage into a decisive war fighting advantage". Since the sharing of information is the core part of this new concept, the "Network" which enabled the data distribution became the central part of the system. The new concept was named as NCW (Network Centric Warfare) in USA (Alberts et al, 2000).

Eventually, NATO recognized that transformation of the military based upon Information Age principles was essential, and pursued a course of transformation denoted as NATO Network-Enabled Capability (NNEC) (Declaration, 2002). NATO adapted this concept by defining NNEC program to build a better Command and Co ntrol among allies, primarily for interoperability. The networking and information infrastructure (NII) is defined as the supporting foundation that enables collaboration and information sharing among users, and reduces the decision-cycle time. The infrastructure enables the connection of existing networks in an agile and seamless manner.

This leads to Information Superiority which is the ability of getting the right information to the right people at the right time. NATO defines information superiority as the operational advantage derived from the ability to collect, process, and disseminate an uninterrupted flow of information while exploiting or denying an adversary's ability to do the same.

The NNEC program provides various benefits to all levels of military and civilian actors. Some of these benefits are:

- Improved efficiency
- Drastic increase in interoperability among nations
- Improved and secure way of sharing information

- Better information quality
- Faster decisions and command.

Although NCW and NEC definitions are slightly different, both represent the intent of achieving enhanced military effects through the better use of information systems.

NCW/NEC is envisaged as the coherent integration of sensors, decision-makers, effectors and support capabilities to achieve a more flexible and responsive armed forces. In this vision, commanders will be better aware of the evolving military situation and will be able to react to events through voice and data communications.

It is a long-term transformation program which includes the communications, information systems, operational procedures and people.

2. Implementation Areas

Then, the structural or logical model for network-centric warfare has emerged. But there is a need of high-performance information grid which provides a backplane for computing and communications. This information grid enables the operational architectures of sensor grids and engagement grids. Sensor grids rapidly generate high levels of battlespace awareness and synchronize awareness with military operations. Engagement grids exploit this awareness and translate it into increased combat power.

Although building the key elements of these grids at strategic or operational level is a reachable goal, nevertheless there are still challenges at tactical level.

Several nations and organizations started developing standard architectures to improve interoperability between different nations and organizations.

NATO started developing an architecture framework abbreviated as NAF to assure interoperability at planning, programming, budgeting, acquisition, and Joint capabilities integration and system development process.

2.1. NATO Architecture Framework

The NAF is an Enterprise Architecture framework by the NATO which is derived from the DoDAF (USA Department of Defence Architecture Framework) Enterprise architecture and MoDAF (U.K. Ministry of Defence Architecture Framework)

NAF Goals from the point of Information Sharing:

- providing guidance for developing and describing NATO architectures
- Enabling a paradigm shift from human communication through mass amounts of written text to communication by standardized models of the real world
- Information Accessibility

Another work that NATO achieved is building an Network and Information Infrastructure for the Alliance's cognitive and technical ability to federate the various components of the operational environment, from the strategic level down to the tactical levels which is a formal definition of NATO Network Enabled Capability (NNEC)

2.1.1. NATO Network Enabled Capability

Briefly, NNEC can be considered as the ability to effectively federate capabilities in coalition operations, by addressing not only the networks and systems, but also the information to be shared, the process employed to handle it, and the policy and doctrine that allows sharing information and services.

The need for NNEC is intrinsic to all coalition operations. NNEC supports heterogeneous partners, with different capabilities and needs, to operate under a federate set of "rules" that provide interoperability from the technical to the cognitive domain.

2.1.2. NNEC Roadmap

In order to realize the net centric capabilities in a manner consistent with the development and implementation of the broad spectrum of NATO capabilities, the NNEC Feasibility Study is realized (NNEC FS, 2005).

In this study, it is suggested that design of a program management approach based on a description of NNEC Maturity Levels, to handle the complex development and integration necessary to realize NNEC across NATO.

The NNEC roadmap milestones as explained in (ACT ICT, 2009) were chosen based on operational capabilities required between 2009 and

2020. Each milestone is initially associated with a specific target date, as well as a long term goal made up of the specific milestone objectives.

- Milestone 1: Generalized Information Sharing

Milestone 1 aimed to "Achieve a Federation of NATO and Alliance Forces Capable of Sharing Information Services". The intent of this milestone is to improve both inter- organization and inter-agency (non-military government agencies, International Organizations) information sharing which result in limited federation of processes.

- Milestone 2: Federated Processes

The aim of milestone 2 is to "Achieve a Federation of NATO and Alliance Forces Capable of Federating Processes and Services in Addition to Information". This milestone concentrates on federating processes, both Alliance and national, as well as improving collaboration with the inter-agency.

- Milestone 3: Better Decision Support

The aim of milestone 3 is to "Achieve a Federation of NATO and Alliance Forces sharing a Majority of Services and Information". This milestone is characterized primarily by improvements in the supporting tools arena although additional improvements will also be realized in both information sharing and federation of processes.

Most of the systems will be interoperable enabling the seamless sharing of information across the functional areas. Command and Control capabilities will be more mobile and less dependent on location. Battle-space management and situational awareness will both be fused and capable of providing real-time pictures including force protection and logistics information. Logistics decision support tools will be shared or interoperable across all stakeholders. The initial role-dependent situational awareness capability will be introduced. This milestone will require a high degree of data/information fusion.

- Milestone 4: Continued Refinement increment

This milestone represents a state in which services shared and integrated, there exists dynamic integrated information access; high use of collaboration; and embedded reach-back with ad-hoc capability to extend or reconfigure on the fly. Future iterations of the Roadmap may include additional packages of milestones, providing the ability to concentrate on multiple threads of development within the same dataset.

Based on these roadmaps several C2 systems are developed and integrated with strategic and planning level. Existence of high capacity networks and SOA expedite this process

2.2. Integration of C2 Systems at Operational and Tactical Level

Based on the roadmaps, there is a wide range of applications at operational and tactical levels which includes management of sensors, weapons and communication systems.

2.2.1. Sensor Management within Battle Force

One application of NCW is Sensor Integration and Management at Multilevel Information Grids Common Operational (COP), Tactical (CTP) and Fire Control Picture (FCP) which are illustrated in Fig.1.

This concept is elaborated in (Johnson and Green, 2002) in detail. The COP consists of non-real-time tactical information used for mission planning and force management. The CTP consists of near-real-time tactical data and information used for cueing and managing BF resources. The FCP is the collection of real-time fire control quality data/measurements used to support weapons during launch and in-flight.

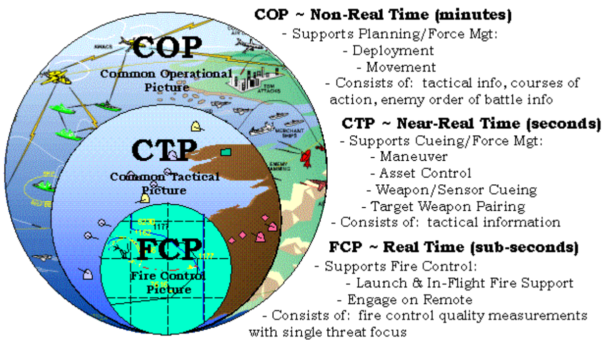

Fig. 1. Managing Resources in Battle Force

In this configuration all information is shared across BF platforms over a synchronized common database. Information superiority is achieved in the Naval Battle Force (BF) by establishing and maintaining shared and consistent battle space awareness across the BF in this concept. Information from all three categories are relevant to the effective and efficient management of BF resources as well as for addressing BF threats and operations.

The information superiority originates from taking full advantage of the capabilities of the distributed sensors and communication resources to best fulfil the dynamically changing needs of the distributed information users.

Utilizing resources in a platform-centric perspective, limits their utility to the BF at large. Additionally, both the sensors and communication links are constrained with physics-based bounds that limit their area of coverage and accuracy.

In order to achieve information superiority, the BF must ensure consistency between the three information grids. Thus, collapsing the information realms is both an enabler of resource management as well as a result of resource management.

An important enabler of network-centric sensor management is the automated control of data distribution throughout the BF. Major bandwidth constraints exist due to the physical limitations of the BF's communication devices. These limitations prevent the paradigm of wasteful transmission, or the sending and receiving of all data and information among the BF platforms or decisions nodes. To most effectively utilize the bandwidth, the BF must intelligently distribute data and information between decision nodes based on the needs of the BF information users, which dynamically change as the operations and missions unfold.

The BF's tactical information users consist of human operators and decision-makers as well as automated C4ISR, combat, and resource (i.e., sensor) management systems that have tactical roles. As missions change in priority and existence during the course of operations, the needs of such BF tactical information users change.

Automating the exchange of BF information to meet the dynamically changing user needs is a key factor in addressing this challenge. Since the timeframes required supporting the distribution of COP, CTP, and FCP are too fast and the amount of data and information is too large to permit a manual solution, the establishment of an intelligent data distribution capability relies on automation,

The intelligent data distribution concept is based on an automated, distributed link resource management system that places a smart processor at each decision node or participating platform. Each link manager should:

- determine the needs of the information-recipient users or decision nodes;
- keep track of what data and information is available;
- determine the feasibility of transmission
- send commands to other link managers within the BF to control and manage transmissions and transmission modes,
- transmit data and information as required.

A possible solution for managing links under such a paradigm would be to establish transmission modes such as one based on the three information grids (COP/CTP/ FCP). As platforms information needs change, the transmission modes change in response. For example, a platform in the middle of an engagement might invoke the "FCP" transmission mode that tailors the information update rate, bandwidth usage, and transmission direction on all remote links that can contribute to the engagement.

Once the Information Data Link between the platforms is established, the following goals can be reached.

- Effective Use of Limited Sensor Resources
- Effective Use of Limited Operator Resources
- Track Picture Advances
- Sensor Fusion and Synergism
- Situation Assessment Improvements
- Fire Control Support will be elaborated

A sample multisensory fusion application is depicted in Fig. 2. In this concept; track or plot information is collected from surveillance sensor of different platforms to build a coherent tracking and improve situation assessment.

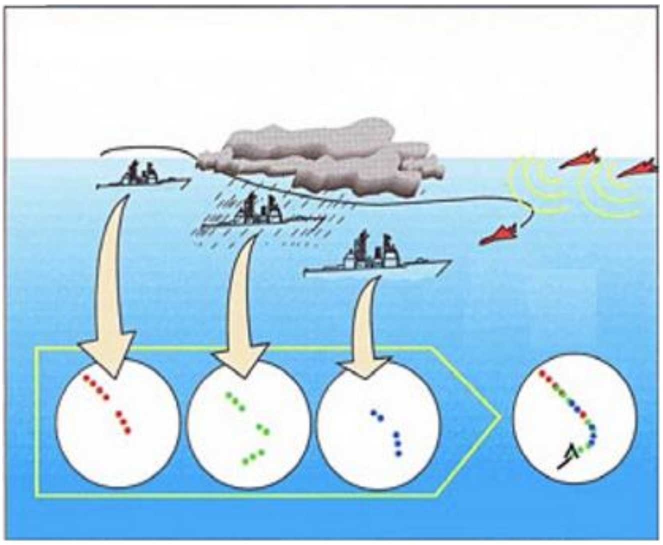

Fig. 2. Multi Platform Multi Sensor Fusion

Another example is presented in Fig.3 by managing sensors to improve precise tracking capability.

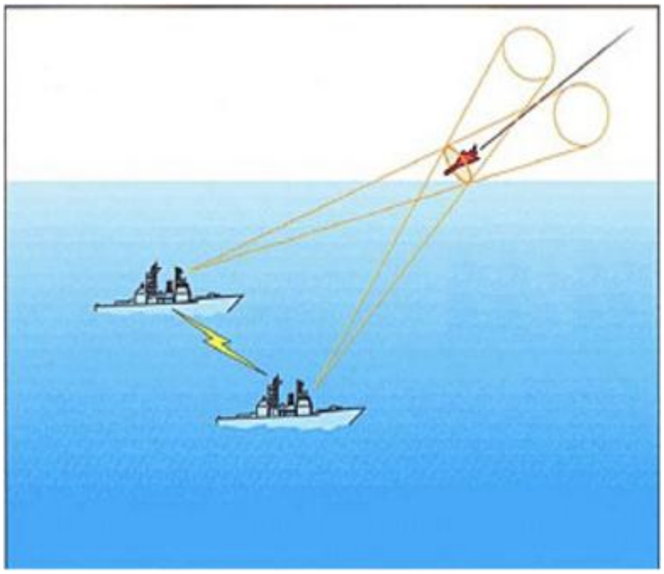

Fig. 3. Precise Tracking

2.2.2. Fire Control Integration

Another capability is optimizing the Fire power and effectiveness by the participation and coordination of multiple non-collocated warfare assets in tactical engagements. Possible integration approaches at fire control grids are analyzed in detail in (Young, 2005).

Integrated Fire Control (IFC) is the ability of a weapon system to develop fire control solutions from information provided by one or more non-organic sensor sources; conduct engagements based on these fire control solutions. IFC enables expansion of a weapon's battlespace to the effective kinematic range of the missiles and can remove dependency on range limits of the organic/dedicated sensor.

IFC relies on the ability of participating sensors, weapons, and C2 nodes to share target information in real-time and eliminate correlation errors so the engaging weapon system can utilize the information as if it was produced by its organic sensor(s).

Collaboration among distributed warfare resources to perform integrated engagements takes many forms. Distributed collaboration can consist of simply receiving a threat cue from a remote source to the sophisticated integration required to pass engagement control to a remote unit.

This section summarizes the major types of IFC capabilities from an operational perspective.

- Transfer threat information received from remote platform sensor to local tracker.
- Launch missile on remote sensor data without holding the track locally.
- Launch missile on remote sensor data while engagement calculation are also conducted by remote platform.
- Handing off the control of the in-flight missile to another unit to complete the intercept.
- Launch decision made by a remote unit.
- Preferred Shooter Determination.

Preferred Shooter Determination is a capability in which the optimum weapon from a group of warfare units is selected to intercept a threat target.

As stated in the sensor management part, information data link is also enabler of fire control network.

3. Challenges for Achieving NCW/NEC

Information sharing is a more challenging problem for distributed Naval Platforms when compared with the governmental organizations and land based units of the Armed forces, where information exchange media is better established and comparably more stable. This section outlines the naval problems that inhibits the achievement of cooperative resource management and network centric warfare in general. Mostly encountered

Başaran, C.. (2014). A Review on Integrated C2 Systems, Journal of Military and Information Science, 2(3), 77-83.

problems mentioned (Johnson and Green, 2002) are summarized below.

- The shift from platform-centric to network-centric has not completely taken place: network-centric concepts are not "designed-in" to systems.
- Current Naval systems are not designed from a network centric (multi-platform) point of view. Such network-centric design is necessarily a top down process starting with a design for Battle Force level and decomposing or allocating force-level requirements to the BF elements (or platforms/systems). The historical approach has focused on the design of each BF element individually and has attempted to achieve interoperability in an "after-the-fact" method by focusing on interfaces between the elements.
- The requirements for BF resource management are not specified from a BF-level perspective.
- The acquisition and program management practices prevent network-centric warfare. NAF, DODAF etc. type architecture framework and standards should be utilized.
- Legacy system constraints prevent an evolution to a network-centric systems.
- Existing sensor command and control mechanisms rely too heavily on manual participation. Involvement of automation and decision support systems should be considered.
- The legacy information architectures constrain cooperative BF resource management.

4. HAVELSAN Integrated C2 Solutions

Based on the NATO and National roadmap HAVELSAN has successfully developed various command and control based solutions for its national defense as well as friends and allies.

HAVELSAN positions itself as the Center of Excellence in command and control architectures and has proved its capability with its various field proven products.

Military Enterprise Information System has been the first and largest step of HAVELSAN's maturity and professionalism in the arena of Command & Control. This indigenous solution integrates many complex systems at strategic and operational level of military forces. This architecture is now in service with the Turkish and Pakistani Air Force.

As a tactical and joint command control solution, HAVELSAN has launched a new product called Defense out of Box (DOOB). This system solves from strategic to tactical C2 level problems and introduces an aspired solution for Joint Operational needs. It is a modular and scalable system that can be converted into any unit of the Armed Forces independent of its size.

HAVELSAN has developed several airborne command and control solutions in the past tailored for customer specific needs. Such an application was for the Turkish Maritime Patrol/Surveillance Aircraft program "MELTEM Project", where HAVELSAN has developed a unique airborne and ground mission system which can be adapted into any aircraft for patrol and surveillance purposes.

Turkish Airborne Early Warning Aircraft Program has further aggregated HAVELSAN's potency and capability to provide solutions to users of Early Warning capabilities throughout the world. Today HAVELSAN has the ability to transform different types of aircraft to special mission platforms.

Naval Command & Control Solutions

GENESIS is a world-wide acknowledged Combat Management System solution of HAVELSAN. It was first implemented on the Modernization of the Perry Class [ex-FFG] Frigates and has since been improved for the Turkish Corvette MILGEM, and the LST's.

HAVELSAN continues to invest in Network Centric Technologies. HAVELSAN will install its state-of-the-art solution Network Centric Combat Management system on the follow-up MILGEM and LPD platforms.

New features of the system include;

- Multi-Sensor Fusion,
- IP Based Network & Communication Infrastructure,
- Common Operation Control
- Display Technologies
- Multi-visual Data Processing Technologies, and Autonomous Systems.

HAVELSAN has been working on a solution for information exchange between different C2 systems and developed a Gateway called "Data Exchange Model", which facilitates the data exchange between different Command & Control Systems working with different software protocols. This introduces huge cost savings in systems modernization as it prevents expenditure on system upgrades for data transformation needs.

Finally as the enabler of seamless connection between geographically distributed naval units, HAVELSAN is developing prototype system called IP data link manager (DETTA).

5. Conclusion

Achieving net-enabled vision will require migration from the system-based implementation construct towards a shared services-based environment. Planning and executing the transition of C2 systems from the present-day client-server environment to a services-based, net-enabled enterprise is one of the major challenges we face today. Implementation planning involves identifying and prioritizing increments of C2 capabilities that are operationally meaningful, technically feasible, programmatically achievable, and fiscally affordable.

In the foreseeable future, these sources will be a mix of services and systems with the former gradually coming to predominate. C2 systems, platforms and facilities with reliable and robust access to a network will be the initial implementers of services, beginning the migration toward an SOE. However, some capabilities will remain to need traditional point-to-point information exchange solutions, particularly where required to support time critical sensor-to-shooter exchanges or disconnected, interrupted, and low bandwidth (DIL) operational environments.

References

Alberts, D. S., Garstka, J. J., & Stein, F. P. (2000). Network Centric Warfare: Developing and Leveraging Information Superiority. Assistant Secretary of Defense (C3i/Command Control Research Program) Washington Dc.

Declaration, P. S. NATO Press Release 127, 21 November 2002, Internet, accessed 12. 03. 2014.

Johnson, B.W., and Green J.M. (2002). Naval Network-Centric Sensor Resource Management. 7th International Command and Control Research and Technology Symposium.

Young, B.W. (2005). Future Integrated Fire Control. 10th International Command and Control Research and Technology Symposium.

ACT IS/NNEC Integrated Capability Team (October 2009), NATO Network-Centric Enabled Capability (NNEC) Introduction to the NNEC Roadmap Report

NC3A Program of Work (2005), Project Multinational NNEC Feasibility Study.

ACT IS/NNEC Integrated Capability Team (October 2009), NATO Network-Centric Enabled Capability (NNEC) Introduction to the NNEC Roadmap Report

www.act.nato.int/nnec, NATO Network Enabled Capability (NNEC), Internet, accessed 20. 01.

Command & Control Implementation Plan Version 1.0 (October 2009), U.S.A.Department of Defense.

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Book Review

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Military Risk Assessment:
From Conventional Warfare to Counter Insurgency Operations
By Chris W. JOHNSON
Glasgow, 2012

235 Pages

ISBN 978-0-85261-933-9

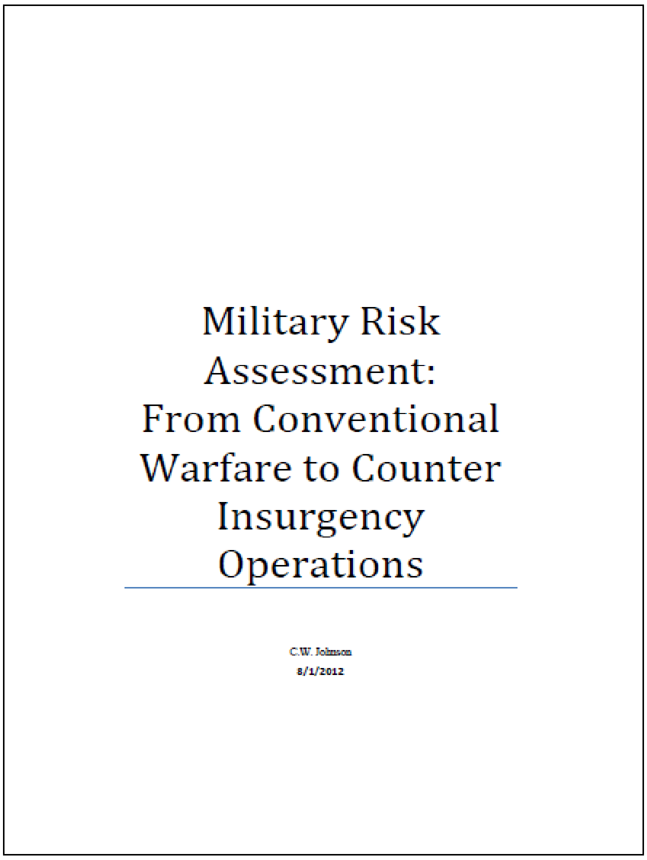
This book is written by Chris W. JOHNSON, a professor of Computing Science at the University of Glasgow, and published in 2012.

This book compares civilian and military risk assessment methods and advocates that civilian risk assessment methods often fail in military operations. Due to the high volume and complexity of military operations, as we all the diversity of threats encountered, civilian risk assessment methods were unable to respond adequately to the needs of modern warfare.

Professor Johnson argues that statistical data obtained by analyzing past accidents and incidents is useful and necessary for assessing possible future risks but insufficient. For example, monthly or annual average accident statistics may hide some incidents with potentially serious consequences or show them as low probability events.

Additionally, the author indicated that military staffs are making inadequate risk assessments while performing a given task in a limited period of time and are only focusing on the execution of tasks.

Johnson implies that fatigue caused by intense military action not only increase the likelihood of many hazards, but may also reduce the ability to assess the risks of these hazards. He claims that Night Vision Devices (NVDs), which are used to reduce the risk posed by fatigue, increase rather than decrease the level of fatigue because of sustained scanning. He argues that new operational risks can arise from the introduction of new technologies into



modern warfare. To support his thesis, he focuses on the loss of a rotary wing aircraft whose crews were using NVDs during brown-out conditions and the loss of helicopters and land-based vehicles to look at the use of innovative and disruptive technologies to mitigate military risk. He claims that with the use of Unmanned Air Vehicles (UAVs), conventional troops are exposed to more threats because they're forced to retrieve them from vulnerable crash sites.

Counter Improvised Explosive Device (IED) operations were also addressed in the book. Johnson says that in C-IED operations, it's very difficult to identify risks due to the constantly changing tactics of enemy forces. While some risks can be avoided or mitigated by taking precautionary measures, the civilian population may suffer as a result.

Taking into account the complex nature of military operations, the book assesses the differences between civilian and military risk assessment techniques. The hazards of modern warfare cannot be mitigated by using civilian risk assessment techniques. The limitations of civilian risk assessment techniques should be identified and developed to respond to the needs of modern warfare. In order to provide practical benefits, 'lessons learned' systems must be integrated into decision-making and planning processes.

Ultimately, the most significant contribution of this book has been to provide us a framework from which a second generation approach to risk assessment can be developed. This second generation approach can be specifically tailored for the changing demands of military organizations in order to more efficiently and holistically conduct full spectrum operations.

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Book Review

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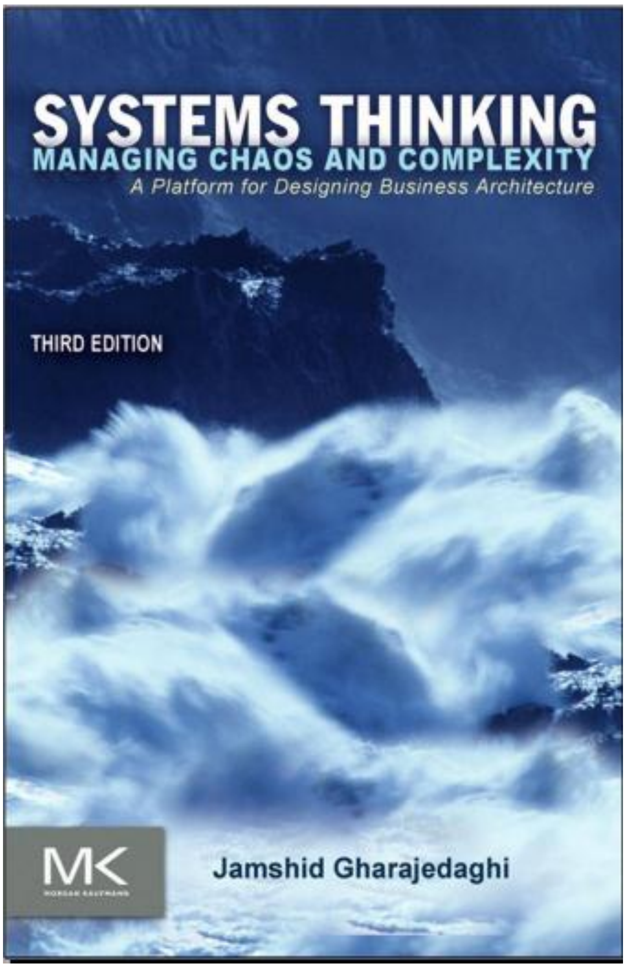
Systems Thinking
Managing Chaos and Complexity
A Platform for Designing Business Architecture
Third Edition
By Jamshid Gharajedaghi
Elsevier, 2011

351 Pages

ISBN: 978-0-12-385915-0

This book is the third edition of the Author's System Thinking and was first published in 1999 by Butterworth-Heinemann Title. This book is a direct result of the author's work with the systems methodology first introduced by the author's partner, Russell Ackoff, one of the founding fathers of systems thinking. Ackoff reported that it was the most comprehensive systems methodology he has seen.



This book is about to develop a working concept of systems theory and to deal operationally with systems methodology. It brings holistic approach to systems methodology. It deals with all dimensions of a system: structure, function and process. It is about a new mode of seeing, doing and being in the world; a way of thinking through chaos and complexity.

We see the world as increasingly more complex and chaotic because we use inadequate means to explain it. When we understand something, we no longer see it as chaotic or complex. Understanding a crisis, a problem or an environment including systems need a key to make changes leading to desired end state. With the system thinking and iterative design to holistic view dealt in this book, it will be easy to synthesize systems theory and interactive design, by providing an operational methodology for defining problems and designing solutions in an environment increasingly characterized by chaos and complexity.

This book has several parts including the synthesis of holistic thinking (iteration of structure, function and process), operational thinking (understanding chaos and complexity), sociocultural systems (movement toward a predefined order), the history of analysis and interactive design (redesigning the future and inventing ways to bring it about). With the chapters on self-organizing systems, Holistic, Operational, and Design thinking the Author simplifies the systems around us.

You will also enjoy the famous story of "identifying an elephant in the room" and the darkness story narrated by Molana Jalaledin Molavi (Rumi) with the eyes of holistic thinking.

I think this book can change your thinking paradigm. It combines system dynamics and systems design so beautifully that you understand easily. In my opinion what makes this book different from the others the way its operationally deals with the art of simplifying complexity, managing interdependency, and understanding choice using a different scheme called iterative design.