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A THREE PROCESSES EFFECTS MODEL BASED ON THE MEANING OF INFORMATION

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ABSTRACT

Development starts with a new idea. One fundamental process for life is information, and this makes it the focal point of this new concept of operations and domains related to force transformation and societal changes.

The term *information* is interpreted as sensory impressions providing meaningful perceptions. Three fundamental sensing, decision, and behavioural processes are derived from the interpretation. The processes can be identified and distinguished for analysis including time and content dependence studies. Together they form a concept of a model which may be useful for analysis of effects of civil and military operations.

Basically information has three states: physical, symbol, and perceptual states [1]. They are fundamental for classification of domains, operations, and effects. A domain concept portraying the world is derived consisting of a concrete and an abstract domain, and a symbol domain where concrete and abstract characteristics are transformed into symbols common for communication.

The three processes model for effects based analysis complies with tenets of today's force transformation. The model is applicable to complex structures. It is compared with multisensor data fusion processes [1], the Boyd's OODA loop [2], the intelligence cycle, and the three domains used in EBO [3]. Common ideas are justified.

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1. INTRODUCTION

In the work by Miller [4], living systems are by definition open, self-organizing systems that have the special characteristics of life and interact with their environment. Interaction takes place by means of information and material-energy exchanges. Living systems can maintain their state as long as they are open, and can take in from the environment the inputs of information and material-energy they need. The interaction with the environment, and the essence of life, is process. Regardless of complexity of living systems – ranging from the single cell to supranational organizations – they each depend on the same essential processes.

Key points in this basic theory are the following: *living systems* are viewed *regardless of complexity*, living systems are *open*, open systems *interact* with environment *by processes*, one fundamental process for life is *information*.

The following concept of the three processes effects model is based on key points of this theory, starting with an examination of the term *information*, which is central for considerations in this paper. Key processes are identified, key states of information essential for living systems are identified, three basic domains portraying the world are derived, and the end state objective of terminating conflicts is discussed.

2. BASIC INFORMATION ELEMENTS

The meaning of the word “*information*” is a matter of discussion. Although “*information*” is a very common word, it may be perceived in several ways and is applied in different contexts. In the following some basic aspects of the meaning of information are discussed.

2.1 Meaningful perceptions

One interpretation based on living systems is that information received basically is the result of a process (with feedbacks) starting with stimulus, leading to sensory impressions, interpretation, association with previous perceptions, and finally to perception of the meaning of the stimulus.

The following short, broad explanation of information is proposed in this paper:

Information is interpretable sensory impressions providing meaningful perceptions.

The main facts are:

- Creation of information requires meaningful expressions
- Information must be able to be sensed
- Impressions must be meaningful – information must be understood in the receiver’s sense; without any meaning – no information
- Information received is the result of a perceptual process
- Information may be interpreted and perceived in different ways by different receivers and thus result in different meanings
- Information is a prerequisite to initiate behaviour and thus fundamental in all processes supporting life [4]

In addition to this the following conclusions can be drawn (including the case when the producer of information only conveys the information to himself):

- Information contents must be conveyed
- Information depends on communication
- There is no information if there is no receiver of information

People use technical sensors in order to cover a wider range of the world around. The sensors add various aspects of physical conditions not normally detected by the five human senses. This is of special importance in command and control business. Output from the technical sensors lead to sensory impressions by human beings.

The process described of acquiring information is a simple and coarse model without sophisticated and deep behavioural science of processes in the mind. It may be more adequate to speak about functions than of processes. It is known that signals in the brain can form complicated feedback loops, and that different opinions exist about the labelling of brain functions. However, the limited model is considered sufficient for a general comprehensive view.

Fig. 1 illustrates the basic meaning of information. Information received depends on stimulus, which can lead to sensory impressions, interpretation, and perception of meaning. The process of human beings receiving information is a process “in formation” in the brain of what has been sensed. Information received begins with sensory impressions (which in general can be received by living organisms and by technical devices). After decoding, interpretation, and association with previous experience the impressions perceived can lead to a meaning. This is information.

Fig. 1 also makes a comparison with three fundamental processes. Information received incorporates a sensing process and a perceptual process leading to a meaning (without illustration of feedback loops). The perceptual process is called the decision process. The decision process may be divided into different parts. One is the decision of the meaning resulting from what is sensed. The next is the decision if the information shall be useful and memorized and lead to a new perceptual state, or if it shall be discarded. Then there is a decision if some kind of behaviour and physical action shall follow, which then will be planned.

The decision process can be of conscious or subconscious nature. The decision process can initiate a behavioural process. Behaviour is the consequence of information and external to the basic meaning of information. Behaviour can be sensed, which in turn can lead to information. An other possibility is that the decision process results in inaction; observable only in a context where some action is expected. The arrow to the very right leads to production of new information, shown by the arrow to the very left.

Sensing of stimuli (by human senses as well as technical sensors) takes place in the concrete physical world. Sensory impressions and the decision process take place in the mind and cannot be accessed. However, behaviour which may result produces stimuli in the concrete physical world and is thus accessible.

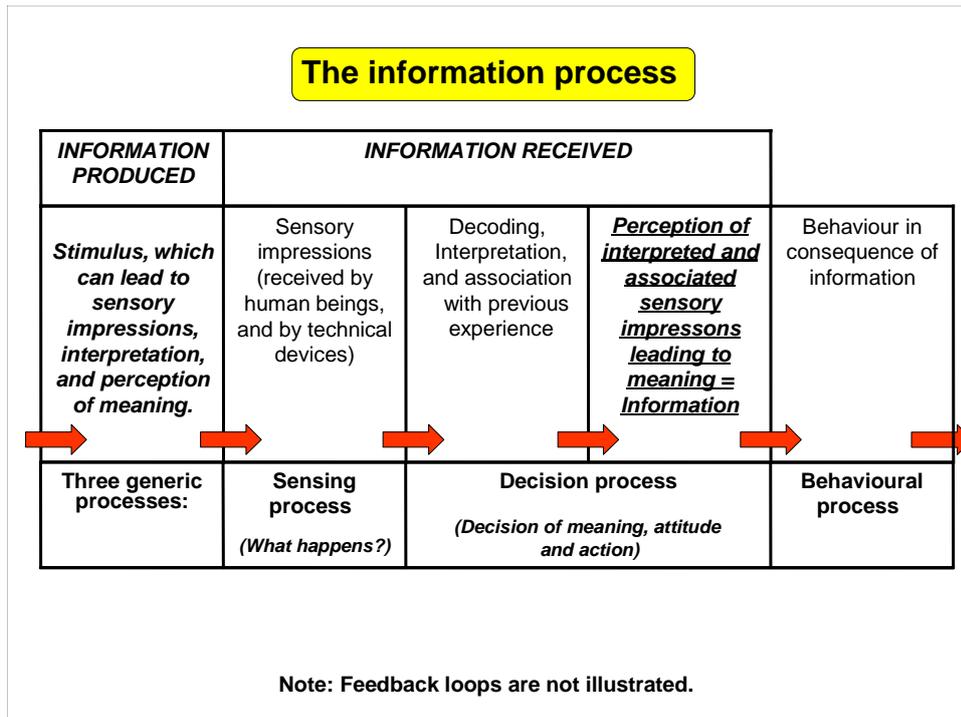


Fig. 1. Basic meaning of information and comparison with three fundamental processes.

2.2 Three states of information

Information explained as interpretable sensory impressions providing meaningful perceptions has three states of information [1]:

- *Physical states of information*
- *Symbol states of information*
- *Perceptual states of information*

Strictly speaking all states of information are physical states. Symbols can only be found in the physical world. Perceptions emanate from physical signals in the brain, although they cannot be accurately measured and interpreted. In the classification of the three states of information physical states are states of information which are not received as symbols or perceptions. The sensing of physical and symbol states activates perceptions from within the mind. As will be further mentioned, both physical states and symbol states are difficult to completely separate from perceptual states. The three states overlap one another.

2.2.1 Physical states

The physical state of information is the estimation of physical objects and actions in the physical world. All kinds of physical objects, actions and events in the physical world represent physical states of information. Examples of physical states are type of object, activity state, location, waveform, relation and role.

Human sensory impressions of the concrete physical world come from the five senses: seeing, hearing, feeling, smelling, and tasting. Anyone of these can basically stimulate reception of physical information. Technical sensors can be designed to identify physical states of objects.

2.2.2 Symbol states

The symbol state of information is the set of symbol representation like text and sounds in a language, and pictures. Human beings communicate using spoken and written words, and

pictures. This is a process of encoding thoughts into symbols useful for communication and decoding. Symbols are e.g. signs, data, letters, words in different languages and dialects. This state of representation of information is the symbol, informational¹, or language state of information. The symbol state of information is expressed by physical marks and sounds and is thus sensed in the physical world. A person's symbol state is the set of representations of symbols accessible to him. That is the symbols and languages he understands and uses for encoding and decoding in communication with the world around. The symbols are useful for encoding and decoding of thoughts, and form information products (e.g. documents, books, speeches).

Language is a systematic means of communicating ideas or feelings by the use of conventionalized signs, sounds, gestures, or marks having understood meanings. It may also be a formal system of signs and symbols (e.g. for use in programming a computer) together with rules for their use [5]. Such a system is useful when people design machines using a machine language for communication.

A symbol is something that stands for or suggests something else by reason of relationship, association, convention, or accidental resemblance [5]. Among symbols are also financial, ethnical, religious, national, and political symbols, as well as models and simulations. Symbols are catalysts changing and shaping physical and perceptual states.

2.2.3 Perceptual states

The perceptual state of information originates from within the mind and is the mind's estimate of the world state. Information can only be communicated in the physical world. However, with the reception of physical and symbol states of information stimuli is activated from within the mind of previous perceptions. This contribution is the perceptual state of information. The contribution is in the form of e.g. associated priorities, opinion, will, morale, plans and goals. The perceptual state of information is derived from the person's perceptual state, which includes aggregations of estimations of physical, symbol, and perceptual states and their interrelationships of what he has experienced previously in the world around [1]. A person's perceptual state is his bulk memory and mental images of estimates of perceived entities and their interrelationships and impacts on his plans and goals. The perceptual states are individually connected aspects of information based on personal life experience processes.

Perceptual states influence physical and symbol states of information, and physical and symbol states influence perceptual states. Physical, symbol, and perceptual states of information are indicated in Fig. 2. This shows a person's perceptual filter, and the interaction of a person's states of information with states of information in his environment, which is the physical world around.

We cannot read other people's thoughts, and this makes it difficult to find out more than parts of other people's perceptual states. These states are vital in effects-based analysis, as the end state objective in conflicts is to change an adversary's perceptual state.

The human brain has a genetic heritage and acquires languages, cultural and ethnical traditions, experience, creates new information and knowledge and omits some of the previous perceptions in lifelong processes. This results in each and every human brain having

¹ The term *informational state of information* is used by Hall et al. [1]. *Informational dimension* is used in [14]. The similarity of *information* and *informational* might lead to misunderstandings. The term symbol gives an explanation of the meaning, and may more easily be translated into different languages.

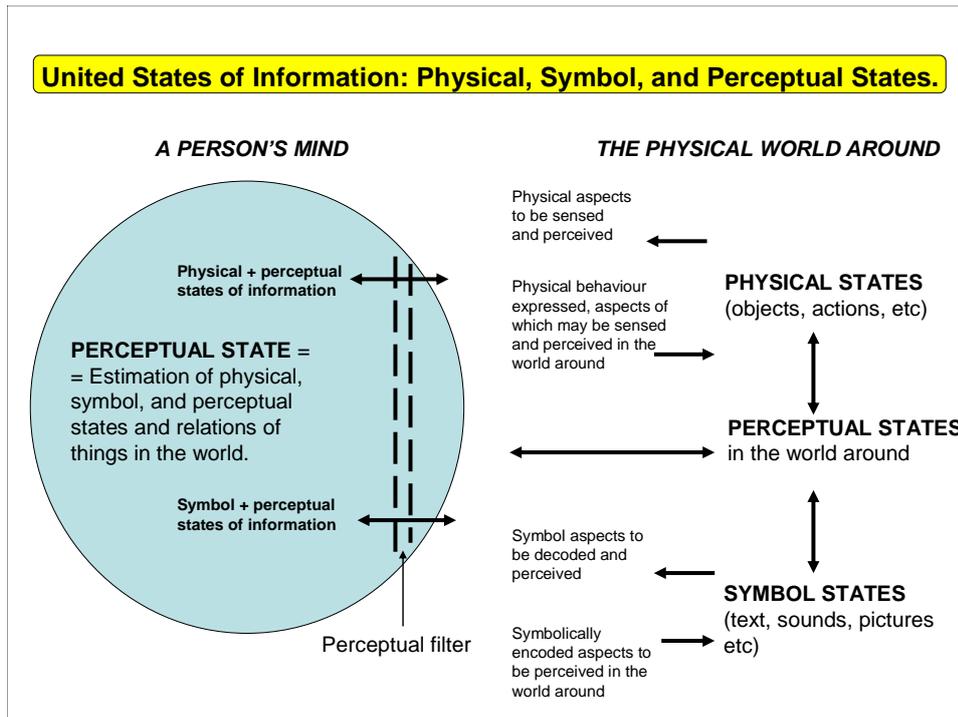


Fig. 2. Physical, symbol, and perceptual states of information

a unique perceptual state. The state is dynamically changing depending on combinations of sensory impressions and the development of refined estimates of perceived entities, referenced and associated with previous perceptions and insights.

In comparison with a computer, the human perceptual state is an aggregation of material memorized in the mind, together forming a large data base². The memory influences every human physical impression and expression. In consequence all physical and symbol states of information are influenced and combined with perceptual states of information derived from a person's perceptual state. The three states appear as united states of information.

Perception is the mental interpretation and integration of physical sensations produced by stimuli from the external world. Perceptions are building blocks in the construction of knowledge. Consciousness consists of loud knowledge (what we know that we know), and loud ignorance (what we know that we don't know). The subconscious is silent knowledge (what we don't know that we know), and the unconscious is silent ignorance (what we don't know that we don't know).

To give an example of the three states of information, a car is a physical object, which may be recognized as a car if the object seen is known from previous experience and associations. This is physical information about the type of object. There may be printed or spoken data available about the size and power of the car. This is the symbol part of information about the car. Then there is the observer's own opinion of the car in relation to his previous perceptual state, including attitudes and goals. The car might be nice looking or too expensive and this is an example of perceptual information.

² This is schematically illustrated in the upper part of Fig. 8.

2.3 The distinction between information products and information processes

Producing information is a process, and includes perceptions made by the producer. The information product unites symbol states and information perceptual states of the producer. When the information product is received, it is processed through the perceptual filter of the receiver and “coloured” accordingly. The information thus received unites information symbol states and perceptual states of both the producer and the receiver. It may be hard to separate the three states of information to any extent.

Information products may be accessed but not other people’s information, as the process the product goes through in people’s minds includes their perceptual states and thoughts. The importance of these facts varies depending on types of information products and information, but is a vital distinction between information products and information processes. Both information products and information processes are normally named “information”, which can contribute to indistinctness, can lead to misunderstandings, and in severe cases can be fatal.

Information can be viewed as a refinement process with a number of information products sophistication levels from signs and data to available products of knowledge and wisdom. This is indicated in Fig. 3.

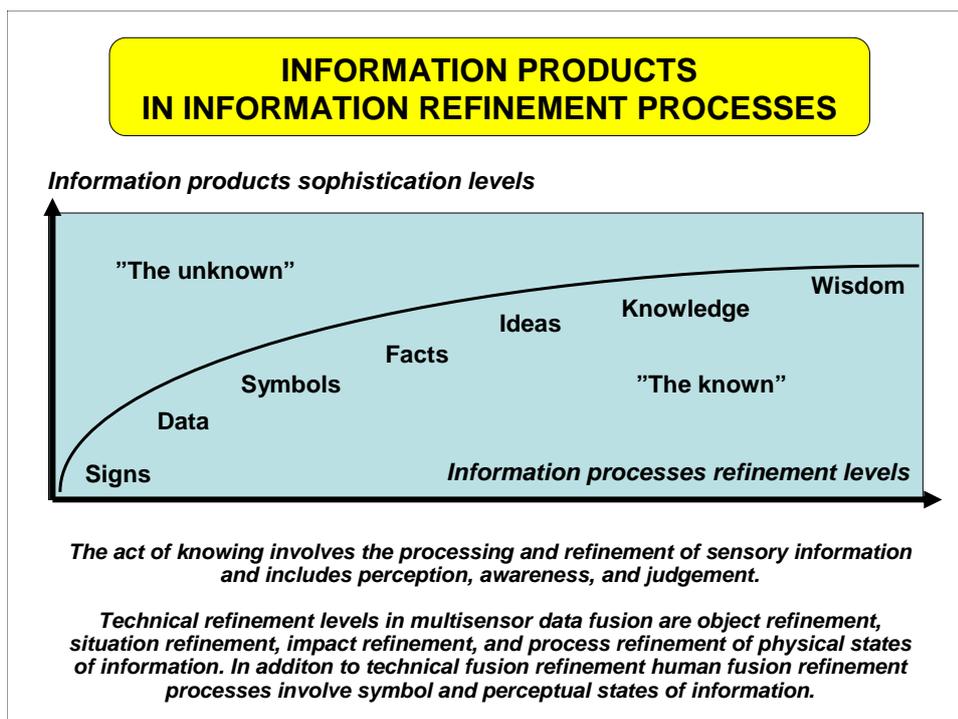


Fig. 3. Sophistication levels of information products as a function of information processes refinement levels.

In human cognition processes the act or process of knowing involves the processing of sensory information and includes perception, awareness, and judgement [5]. In technical multisensor data fusion the refinement of physical states of information comprises four levels: object refinement, situation refinement, impact refinement, and process refinement [1]. These technical fusion levels represent a functional model, not a process model. The information flow in data fusion must not strictly proceed from one level to the next. A continuous process is only possible under certain circumstances. Both technical and human processes may

include feedbacks and interacting judgements. This is also true for processes in the human mind.

In Waltz [6] data has been described as measurements and observations, information as data placed in context, indexed and organized, and knowledge as information understood and explained. Waltz distinguishes between these levels, and uses the general term information when referring to information in all its forms.

Meaningful human perceptions are needed in order to relate and organize data. In special cases this mental process is programmed to be handled by technical information systems.

In addition to technical fusion refinement of physical states of information (such as combining multiple reports of a target from different technical sensors) human fusion refinement processes involve fusing symbol and perceptual states of information. Symbol state refers to the data (symbols) available about the particular observation being made. Perceptual state refers to the observed object's own estimate of the world state.

To give an example, an observation of a military target – or any other target for that matter – can include people and various means used by the people. It may be of interest to find out about the target's physical state, e.g. type of object, location, and activity. Secondly it may be of interest to find out about the target's symbol or informational state, e.g. data available about the target, the target's communication relationships in a network of targets, specification about the target's sensing capability, and the target's information about the world around. Thirdly it may be of interest to find out about the target's perceptual state, e.g. goals, priorities, plans, rules of engagement, and the target's perceived estimation of the world around, based on the target's own situational awareness. All three states are of importance when analyzing effects.

3. CLASSIFICATIONS BASED ON INFORMATION

Many thoughts about classification of information are heading in the same direction. In the handbook of multisensor data fusion by Hall et al. [1] the three physical, informational, and perceptual states of information are described. (Informational and symbol state have the same meaning.) In the new US Joint Pub 3-13 on Information Operations [14] the information environment is described to consist of physical, informational, and cognitive dimensions. To some extent the informational dimension resembles the symbol states of information. The informational dimension is more adequate than the information domain described in the three domains used in NCW and EBO (e.g. ref [3]). Waltz [6] presents an operational model of information warfare with three levels: physical level, information structure level, and perceptual level, where the information structure level applies to the Open System Interconnection (OSI) architecture model.

The three physical, symbol, and perceptual states of information taken together may portray everything. This implies that all characteristics in the world may be represented by the three states. As an example, human beings' physical states correspond to their individual physical capabilities, the symbol states correspond to their individual available symbol representations for communication, and the perceptual states to their individual perceptual capabilities of the mind.

3.1 A new concept of three basic domains

Based on the classification of information and the semiotic³ distinction between physical, mental, and symbol objects a new broad concept of three basic domains portraying the world is derived. The concept allows for dynamic interaction between the three domains. According to the new concept the world consists of three basic domains (Fig. 4):

- *The concrete domain*
- *The abstract domain*
- *The symbol domain*

The nature of the domain structure is general and a stable foundation for applications. The domain structure covers not only warfare, but any business and any societal transformation and conflict and any kind of interaction in the world.

Napoleon Bonaparte has said: “There are but two powers in the world, the sword and the mind. In the long run the sword is always beaten by the mind.” The sword stands for the concrete domain, and the mind for the abstract domain. Symbols are catalysts charging and shaping the powers of the sword and the mind.

Strictly speaking the world only consists of concrete states. All kinds of symbols, signs, and behaviour can be detected in the physical world. The mind can be characterized by physical signals in the brain, although they cannot be accurately measured and interpreted. Thus, in the classification of the three domains, the concrete domain is restricted to consist of physical states, which are not symbols, or states in the mind.

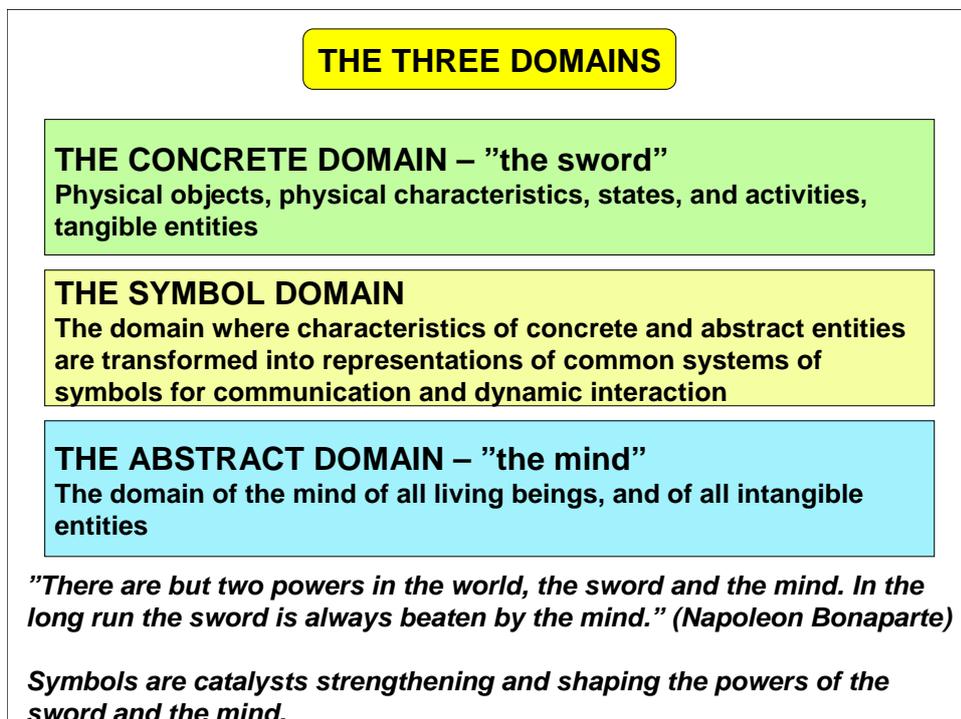


Fig. 4. Three basic domains constituting the world.

³ Semiotics is the study of human communication, especially the relationship between words and the objects or concepts they represent.

The concrete domain is the domain of physical objects, their physical characteristics, states, and activities. The domain consists of tangible entities, which can be sensed, and which are subject to physical laws. Symbols, and states in the mind, are not included.

The abstract domain is the domain of the mind of all living beings, and of all intangible entities. The mind consists of thoughts, feelings, perceptions, cognition, judgement, knowledge, intuition, morale, will, and other intangible characteristics. They cannot be directly sensed. The abstract domain is the antithesis of the concrete domain. The term abstract domain is more general than the term cognitive domain, which does not include all areas of interest in analysis of conflicts and societal transformation.

The symbol domain is where characteristics of concrete and abstract entities are transformed into representations of common systems of symbols which then may be sensed and *communicated* in the concrete domain. It is where pictures, written and spoken languages, data, and signs are conveyed. The symbol domain is the communication link of symbolism between minds in the abstract domain. The symbol domain is also the link of symbolism, which mediates between physical and mental objects and allows for interaction between the abstract and concrete domains. The symbols cover all sectors of society, such as the financial sector (symbols for money and physical effort), the ethnical and religious sectors (e.g. symbols for religion), the national and political sectors (symbols for nations and political parties), and models and simulations.

Thoughts in the abstract domain, and physical characteristics in the concrete domain, are transformed into symbols representing the thoughts and the physical characteristics. By physical carriers (e.g. paper, sound) the symbols are reachable in the concrete physical domain, and may be interpreted and perceived as information in the abstract (mental) domain. There would be no life on earth without interactions offered by the symbol domain.

Symbols can be of any kind, and in any kind of medium. The formation of powerful networks for information sharing and collaboration leverages activities. Communication flows are the keys to life and to all human activities and thus of ultimate importance. The symbol domain represents languages, and languages and expressions for communication play a vital role in conflict solving, and in any process aimed at mutual understanding, and should always be ahead of physical actions.

The concrete, symbol, and abstract domains resemble the Swedish Defence Doctrine describing warfare capability [12]. According to the doctrine warfare capability is built on Physical Factors (resembles the concrete domain), Conceptual Factors (resembles the symbol domain), and Moral Factors (resembles the abstract domain). There is a possibility to widen the scope of the doctrine accordingly and rename the three parts to incorporate other concrete, symbol, and abstract factors not mentioned specifically.

3.2 Domains in The Network Era

Much has been written about domains in connection with Network Centric Warfare (NCW), Effects Based Operations (EBO), and similar concepts. In a report on NCW [7], and later in a US Department of Defense Report to Congress (and in many other documents) three domains are described:

- *The Physical Domain*
- *The Information Domain*
- *The Cognitive Domain*

Warfare takes place simultaneously in and among the three domains. In some documents an additional Social Domain is introduced in order to point at collaborative decisions in NCW. The cognitive domain is from the attackers point of view designated to achieve a cognitive advantage, similar to information superiority.

The physical, information, and cognitive domains are on the whole similar to the classification of the three physical, symbol, and perceptual states of information, if the information domain is regarded as a symbol domain. The perception of what the symbols represent is a process which is part of the cognitive domain. The physical aspects of information (physical media carrying documents, sounds, and all other symbols) belong to the physical domain.

Creation of information is said to be part of the information domain [7], but the creation requires cognitive processes in the cognitive domain. Cognition covers different processes in the brain, and is the act of knowing that involves the processing of sensory information and includes perception, awareness, and judgement. The term “information domain” becomes misleading if “information” is regarded to consist of both physical, symbol, and perceptual states. One solution is to change the name of the information domain and rename it the symbol domain. An other solution is to clearly describe the limitations of what the information domain consists of.

The new concept of three basic domains is wider than the physical, information, and cognitive domains, and is considered more basic and applicable to both civil and military activities (such as have been discussed in EBO concepts), as the new concept covers all areas of interest in society.

The Swedish Defence uses the term “information arena”. Similarly to the US DoD term “information domain”, the information arena is an arena with three dimensions or three levels covering both the concrete, symbol, and abstract domains. Harmonization of Swedish terminology, doctrines, and concepts facilitating analysis of operations, targets, and effects is recommended.

3.3 Actions and operations

Physical (hard) operations are exertions of military physical power aimed at physical targets. Information Operations in the physical domain protects or attacks technical means for information and communication.

Symbol operations are *indirect* actions in support of physical and perceptual operations in order to strengthen and shape “the powers of the sword and the mind”. Symbol operations are planning and production of means and weapons for physical and perceptual operations using languages, pictures, signs, and other symbols. Symbol operations are performed both by civil and military actors.

Information Operations operate in the symbol domain for protection and assurance of symbols and symbol flows, or for attacking symbols, their meanings, and symbol flows in different ways such as exchanging symbols and flows, or insertion, disruption, and destruction of symbols and flows. Symbol operations use symbol power and symbol ammunition by analogy with firepower and fire ammunition aiming at influencing perceptions, directly or through physical means.

Perceptual (soft) actions and operations are exertion of civil and military mental power to reinforce or influence perceptions, opinions, and other ways of thinking. In a broad context and view, perceptual operations happen most of the time in political, economic, ethnical, and other sectors of society. Information Operations in the abstract domain are psychological operations aimed at psychological effects.

Just as physical, symbol, and perceptual states of information are overlapping, physical, symbol and perceptual operations and effects are overlapping. The ultimate target in all conflicts is human beings and their perceptions, will, and behaviour. Physical and symbol operations are only operations on the road towards influencing the perceptions and behaviour of human beings.

Information Operations can comprise all kinds of sectors in society, e.g. diplomatic, political, economical and financial, social, military, and ethnical. The physical, symbol, and perceptual types of Information Operations are applicable to all critical infrastructure sectors such as energy, information, distribution, banking and finance, and vital services. When the types of Information Operations are viewed as generic types of operations they may be applicable to all areas of interest (e.g. diplomatic, informational, military, economic, social, infrastructure areas).

4. THE MODEL OF THREE FUNDAMENTAL PROCESSES, AND EFFECTS BASED ANALYSIS

4.1 *The three fundamental processes*

The basic meaning of information is associated with the three fundamental processes:

- *The sensing process*
- *The decision process*
- *The behavioural process*

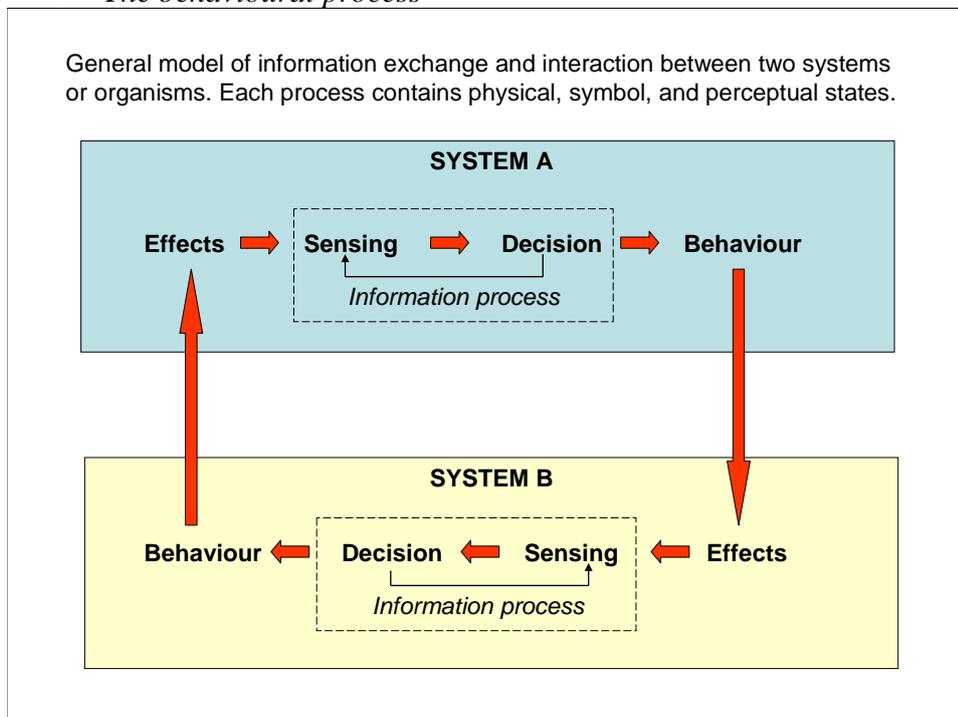


Fig. 5. Schematic illustration of the sensing, decision, and behavioural processes and interaction between two living systems or organisms.

The sensing, decision, and behavioural processes are illustrated in Fig. 5 for two interacting living systems or organisms, where the behaviour/action of system A leads to effects on system B, and its behaviour/action interacts and leads to effects on system A. There are similarities with the two fundamental processes for life – information exchange processes, and material energy exchange processes.

The sensing, decision, and behavioural processes, as well as the behavioural effects in the world around, have physical, symbol, and perceptual states. The states are interdependent and overlapping and have variable significance in different phases of the processes. Effects based analysis involves studies of all three states and interrelations. The perceptual state becomes of vital importance when the end state objective is change of perceptual state. (See the example of a military target given at the end of 2.3.)

The three processes model is considered technically rational and does not claim to comply in depth with behavioural science. A generalized model of hard and soft dynamic interaction between two systems is visualized in Fig. 6. The upper part of the figure illustrates the concrete domain, and the lower part the abstract domain. In between is the symbol domain for communication and interaction of information products. Sensors in the concrete domain and information products in the symbol domain lead to sensory impressions and sensing processes in the abstract domain. This result in decision processes, incorporating understanding of what has been sensed and possibly action plans to follow as information products. This can lead to behavioural processes in the concrete domain affecting the environment and sensing, decision, and behavioural hardware effects on interacting systems. Further sensing and decision processes in the abstract domain may follow. The end state of behaviour is associated with the will and is mutual understanding and acceptance of conditions.

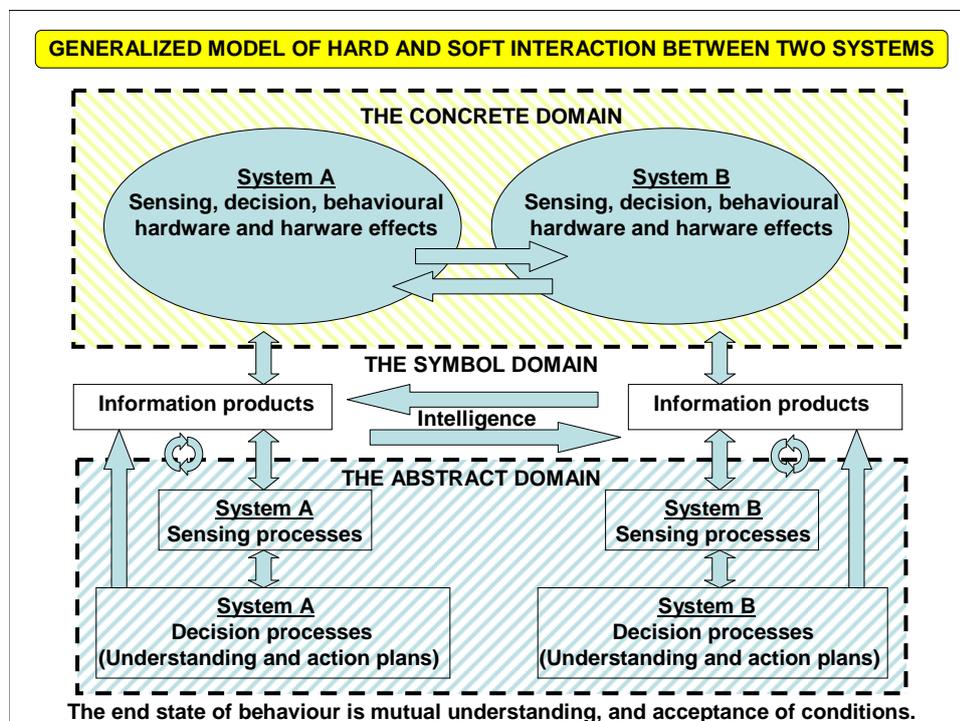


Fig. 6. Generalized model of hard and soft interaction between two systems.

The dynamic processes may be characterized by speed and power. However, behavioural processes can have very different time constants in different soft and hard parts of a conflict.

Whereas military physical operations are striving towards high speed in order to incapacitate the adversary's sensing, decision, and behavioural processes or functions, other operations such as diplomatic, informational, political, social, economic, and infrastructural must be given time to allow for sufficient adversary response. New forms of conflicts or "Fourth Generation Warfare" is thought to last for decades and include an adversary's long term defence of ideas. The adversary seeks to undermine and change way of thinking and leadership, also using several of the target's means against him. Different means to meet this must be allowed enough time.

The model is applicable to dynamic interaction in general, and not only to civil and military conflicts. Specialised functions may be added to represent special applications. In a paper by B. Brehmer [13] the Dynamic OODA Loop (or DOODA Loop) is presented for designing Command and Control support. A set of functions are illustrated, and may be inserted in the three processes model. Sensors, military activity, friction, effects, and mission completed will be represented on the concrete domain. Sense making and planning will be represented on the abstract domain. Mission, information collection, command concept, and decision/order will be represented on the symbol domain. Internal dynamic interactions and loops may be illustrated.

In Effects Based Operations, or in any kind of operation, the most important influences are of human nature, and associated with the three processes. Fundamentally information triggers brain activities, which in turn controls behaviour. Shaping the behaviour is the goal of Effects Based Operations (EBO) [3]. System behaviour is also mentioned in the United States Joint Forces Command (USJFCOM) working definition of EBO [8]. A prerequisite for information controlling the brain, leading to behaviour, is the sensing process; the start of the chain of the three processes. Sensing results in decision of what has been sensed, and the decision creates attitudes, which may result in behaviour. The sensing, decision, and behavioural processes are easily identified, understandable, and distinguishable for analysis purposes. This is why they are thought to form a concept of a model which may be useful in effects based analysis in the realm of the whole society.

In the tenets of Network Centric Operations (NCO) information is central linking process, organization, people, and technology. As an example, see Forsythe [9]. This is expected to create a robustly networked force, information sharing, quality of information, situational awareness, collaboration, self-synchronization, speed of command, and increased mission effectiveness. In Effects Based Operations a key enabler is the Collaborative Information Environment (CIE) [8]. The CIE is a virtual aggregation of individuals, organizations, systems, infrastructure, and processes to create and share data, information, and knowledge needed to plan, execute, and assess joint force operations. In System-of-Systems Analysis (SoSA) [10], an important sub-process of Operational Net Assessment (ONA), the adversary is analyzed as a system of systems. Leverage points are identified by which to influence capabilities, perceptions, decision making, and behaviour – key factors in SoSA, and in the three fundamental processes.

Organizations or nations can be regarded as organisms with the same fundamental characteristics as human beings with their three physical, symbol, and perceptual states. An organism is a system of systems, characterized by complex structures of interdependent and subordinate elements, whose relations and properties are largely determined by their function in the whole. The three states are applicable, and the main objective in a conflict is shaping or changing the perceptual state of the organism.

4.2 End state objective: Change of perceptual state

According to one broad definition of Effects-Based Operations, EBO are coordinated sets of actions directed at shaping the behaviour of friends, neutrals, and foes in peace, crisis, and war [3]. The desirable effect is human behaviour. Behaviour is anything that a human does involving action and response to stimulation. In other words, shaping the behaviour is changing the state of a human being.

The most desirable change of state is a desirable change of an adversary's opinion or mind in a conflict. This is a change of his perceptual state. Operations leading to effects changing the physical state or the symbol state are only effects on the road to the main effect.

The perceptual state influences cognition. The perceptual state forms opinions, and opinion is not the same as knowledge. In a conflict the major desired effect is to change the adversary's perceptual state according to one's will, not necessarily to try to change his cognition as a whole.

In a conflict it is important to try to investigate the adversary's perceptual state, including what the adversary thinks of his opponent. In order to do so, it is necessary to start by making a survey of what is accessible to the adversary of physical states, and of symbol states. Based on this, the next stage is to estimate how he estimates these states, in other words to estimate his perceptual state. This can only be done by observing his behaviour in the physical world, when he reacts to various sensed impressions. It is difficult to find out more than fragments of a human mind, and it is even harder to investigate the main perceptual state of an organization or a nation viewed as an organism. However, lack of investigations and assessments of this kind leads to misjudgements and wrong decisions, which may be very costly.

Each actor in a conflict has a designated set of processes. The three consecutive fundamental processes involve the important time factor, which determines the act-react situation and the leading actor. In the very basic case the processes follow a straight line. In reality all processes have more or less complicated feedbacks. In complex situations several processes appear concurrently, depending on one another, and on feedbacks. However, when analysing complex cases the three fundamental processes are building blocks.

The time aspect is vital for each of the three processes. As the sensing process continues with time, situational awareness normally builds up. However, based on situational awareness decision to act and action or behaviour must be executed in time to capture and hold the lead and force the adversary to react, eventually forcing the adversary to system collapse.

Information and situational awareness lead is of major importance in order to lead in a conflict, and is the condition for decision and action or behavioural lead. In the example in Fig. 7 the blue force succeeds to build up enough situational awareness sooner than the red force and the blue force decides to act before the red force acts. The blue force starts next operation before the red force has a chance to decide and to act. This results in the red force's system collapse. The figure also indicates the important trade-off between just enough information building up situational awareness and just in time decisions and actions.

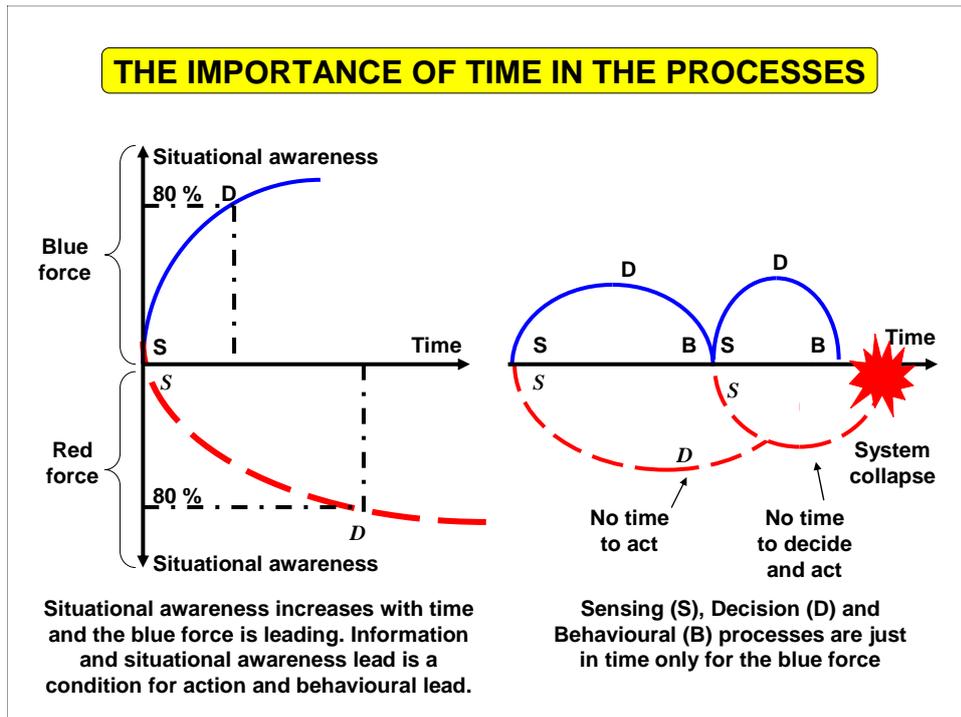


Fig. 7. Situational awareness lead and operational sequences in order to take control over an adversary.

5. SIMILARITIES BETWEEN CONCEPTS

The three processes model is compared with the revised JDL⁴ multisensor data fusion model [1], Boyd's OODA loop [2], and the intelligence cycle. Similarities justify the main idea of the three fundamental processes. Attempts are also made to compare with applications of the three domains used in analysis of EBO [3], and with different networks in the Network Era.

The upper part of Fig. 8 is a sketch of an organism with resemblance to the revised JDL multisensor data fusion model. The organism's interactions with the world around are shown. Stimuli from fractions of physical, symbol, and perceptual states in the world around are input to the human/organism "bus line" connecting different functions – such as decode, interpret, associate, combine, perceive, decide, encode – in the decision process. As a consequence of the stimuli, the organism may have three states of behaviour interacting with the world around. There may be behavioural change in the world around due to the behaviour of the organism.

⁴ JDL = U.S. Joint Directors of Laboratories

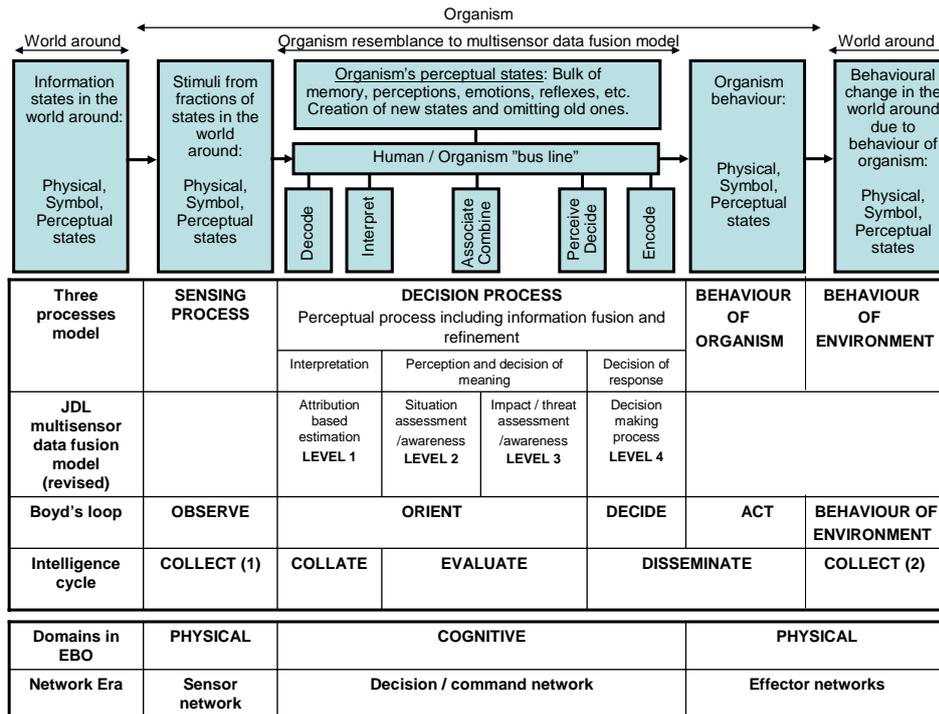


Fig 8. Similarities between the three processes model, the revised JDL multisensor data fusion model, Boyd's OODA loop, and the intelligence cycle. Points of similarity with the three domains in EBO, and with networks in the Network Era.

5.1 The revised JDL multisensor data fusion model

The decision process in the three processes model is compared with the four levels of the data fusion model. Data fusion is defined as the process of combining data or information to estimate or predict entity states [1]. This can be regarded in the broadest sense. In a general sense the fusion process is applicable to both people and machines in order to decide what is being sensed. The multisensor data fusion model has been developed for technical applications but may be compared with how people acquire information.

Technical sensors can deliver data to be analysed. Sophisticated information processing systems exist which can fuse sensory information. In military applications there may be data from radar, sonar, electronic intelligence, communication traffic, and infrared observations. Refined estimates of objects, relations and situations may be achieved through association, correlation, and combination of data in processes leading to higher level inferences.

The sensing process in the three processes model is external to the revised JDL data fusion model. The revised JDL model describes sources, of which there are sensors, documents, people, data stores etc. of local, distributed, and external kind. The revised JDL data fusion domain differentiates between four processing levels [1] relating to the refinement of "objects" (level 1, attribution based estimation), "situations" (level 2, situation assessment/awareness), "impacts or threats" (level 3, impact assessment), and "process refinement" (level 4, decision making process). The four levels constituting the data fusion domain cover the decision process of the three processes model.

The multisensor data fusion model uses physical information. People viewed as information systems additionally use symbol and perceptual information when fusing sensory impressions.

The human decision process includes decoding, interpretation and association with previous experience based on bulk of memory, perception and decision of meaning, and decision of response.

5.2 The OODA loop

Boyd's OODA loop Observe, Orient, Decide, and Act covers the whole three processes model. Observe is the sensing process. Orient covers interpretation, association and perception and makes use of new information compared to previous experience, genetic heritage, and cultural traditions in analysis and synthesis. New thoughts are created, no longer useful old ones omitted. Based on understanding of the situation decision about a course of action is taken. Both the orient and decide phases cover a number of steps of thinking including feedbacks which all together are labelled decision process in the three processes model. The act phase of the Boyd loop is called behavioural process in the three processes model.

5.3 The Intelligence Cycle

In the intelligence cycle "collect" is compared to the sensing process. "Collate" is compared to the first phase of interpretation and association in the decision process. "Evaluate" is part of the decision process, and compares to situation assessment and impact or threat assessment in the JDL model. "Disseminate" is the final part of the intelligence decision process and also covers behavioural processes.

5.4 The three domains in EBO

The three physical, information, and cognitive domains [7] are not completely commensurable with the three processes model. One problem is that the three states of information are present in all three processes. However, there are similarities. The sensing process occurs in the physical domain. The physical domain is where objects are found and events and actions appear. This also compares to behaviour in the behavioural process and to action in Boyd's loop.

In an example given by Smith [3] the decision processes are taking place within the cognitive domain and include prior knowledge, mental models, understanding of situation, sense making, judgement and decisions on which planning, directives, and action follows. The processes from data, information, decision, planning, and action form a loop, which is visualised by Smith [3].

5.5 Networks in the Network Era

The three fundamental processes model resembles three important types of networks in the Network Era: The Sensor, Decision, and Effector Networks [11]. The sensor network combines sensing processes providing commanders in a decision or command network with information for decisions of physical actions, and engaging physical effectors in an effector network. This resembles the sensing, decision, and behavioural processes.

Networking engages chains of events, which are speeded up by simultaneously passing information to all relevant actors. The chains of events follow the processes of sensing, decision, and action (or behaviour). Situational awareness depends on fusing and assessing sensor and intelligence information in networks. The information is used in decision networks resulting in commanding the armed forces to act with speed and optimal resources.

6. CONCLUSIONS (WITH REFERENCES TO THE CHAPTERS)

Information is central in all processes supporting life. (1)

Information is interpretable sensory impressions providing meaningful perceptions. (2.1)

Information has three states: physical, symbol, and perceptual states. (2.2)

There is a distinction between information and information products. Information is a process of information products, involving the receiver's perception. (2.3)

Three basic domains portraying the world and all kinds of conflicts and interactions are derived from the states of information: The concrete domain, the symbol domain, and the abstract domain. (3.1)

The symbol domain is where characteristics of concrete and abstract entities are transformed into representations of common systems of symbols for communication. (3.1)

The three domains in EBO and NCW portraying warfare can be misleading. The information domain used in EBO and NCW is a symbol domain if information is interpretable sensory impressions providing meaningful perceptions. Creation of information incorporates cognition processes. The same comments apply for the term information arena. (3.2)

The new concept of three basic domains is wider than the physical, information, and cognitive domains, and is considered more applicable to Effects-Based Thinking as it covers all areas of interest in society. (3.2)

The basic meaning of information is associated with three fundamental processes: sensing, decision, and behavioural processes. (4.1)

The sensing, decision, and behavioural processes, as well as the behavioural effects in the world around have physical, symbol, and perceptual states. (4.1)

The information states, the basic domains, and the three fundamental processes comply with tenets in the Network Era and with Effects-Based Thinking, and are believed to be useful in effects based analysis in the realm of the whole society. (4.1)

A desirable end effect in a conflict is a change of behavioural state, and change of the perceptual state is the prime objective. (4.2)

The three fundamental processes comply as concept with Boyd's OODA loop, with the revised JDL multisensor data fusion model and with the intelligence cycle. (5)

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