IDCP as Kernel Element for Force Level Recognized Maritime Picture Generation

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ABSTRACT

The Identification Data Combining Process (IDCP) is standardised in STANAG 4162. Edition 2 of the STANAG is promulgated and, e.g., implemented in NATO's ACCS (Air Command Control System). Currently Edition 3 together with Allied Identification Publication 01 is under ratification. The IDCP defines a standard for a real time process for identification and platform classification. The essential elements of the IDCP are a standardized process for the generation of ID results, standardized encoding and exchange of ID Source Information and the description of the generation and encoding of all operational and technical data that is necessary to use the process. IDCP can be regarded as hierarchical Bayesian Decision Network and provides a solid methodological foundation for identification. The IDCP can be integrated into a Coalition architecture in such a way that it guarantees the optimal force level use of identification information.

Keywords: Identification Data Combining Process, IDCP, STANAG 4162, force level function, Bayesian Network

1. INTRODUCTION

Interoperable Identification within multinational maritime forces is a key for the successful real-time processing of defence again agile threats like missiles. The paper describes why, where and how to use the IDCP according STANAG 4162 as an kernel element for the Force Level Recognized Maritime Picture Generation, i.e. how the IDCP can provide results which can directly be used by the subsequent processes, i.e. the Threat Evaluation and Weapon Assignment. Section 2 starts with a short explanation of the STANAG 4162 and the IDCP process. Section 3 describes the methodological foundation of the IDCP, i.e. its interpretation as hierarchical Bayesian Decision Network. Section 4 shows the possibilities to implement IDCP as force level function. Section 5 addresses the benefit using the IDCP.

2. IDCP – THE STANAG 4162

Before describing the application of the IDCP as Force level Function for identification, this chapter summarises the content of the STANAG 4162 and the essential properties of the IDCP.

2.1 Scope of STANAG 4162 and the Standard Related Documents

The current version of STANAG 4162 is the ratification draft of Edition 3 with its content elaborated in the Allied Identification Process Publication 01. Drafts of implementation guidance and user guidance (standard related documents SRD AIDPP-01.01 and SRD AIDPP-01.02. (See [1], [2], [3])) complement the STANAG 4162.

The AIDPP-01 provides a description of a standardized computer process for the automatic generation of an ID result, the IDCP. The IDCP is an automated data combining method which fuses identification data on detected objects from multiple and dissimilar sources and in all environments (land, air, maritime and space), providing ID Category recommendations to an operator responsible for identification. The operator can be located on a platform or at an operational site. The AIDPP-01 provides the required information to implement the IDCP such that it can be used for identification of objects in all environments using as many available sources as possible, and a maximum of interoperability with other host systems is guaranteed.

The AIDPP-01 provides a description and standardization of the data necessary for the IDCP. The AIDPP-01 defines the standards for the input to the IDCP, which is the so-called ID Source information. It prescribes how to convert and use all data, which are potentially usable for identification, so that IDCP can process the data. It is presented in the form of a systematic and hierarchical structuring of all possible ID Sources called the ID Source Taxonomy. For maritime

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applications, an exhaustive taxonomy of ID Sources is defined for the identification of air, surface and – with limitations – sub-surface tracks. STANAG 4162 standardizes the conditioning data, which is necessary to adapt the IDCP to a diversity of missions in various environments and operational conditions.

The AIDPP-01 provides a description of the required processes for data generation to supply the IDCP with the necessary input. The document describes the process for the generation of ID Source information and the process for the generation of the configuration data. It describes how this data can be derived from operational and technical knowledge and from data, which is not IDCP-specific (such as Air Tasking Orders, Order of Battle and geographical information).

The IDCP supports the use of both locally generated and remote ID Source information. The AIDPP-01 therefore also describes the information exchange requirements resulting from the requirement to be able to use remote information. It defines how to map the information to be exchanged (the ID Source Information) to message formats of available message transfer systems. The paper about IDCP in completed with two additional supplementary documents: The standard related document (**SRD) AIDPP-01.01 "Implementation Guidance (IG) for IDCP"** presents information to generate an implementation of the IDCP, which is in accordance with the objective of the STANAG. The **SRD AIDPP-01.02 "User Guidance (UG) for IDCP"** presents the information to the user to understand the IDCP application and how to use an implementation of the IDCP in accordance with the objective of the STANAG.

2.2 IDCP Process

The IDCP Process comprises the following steps:

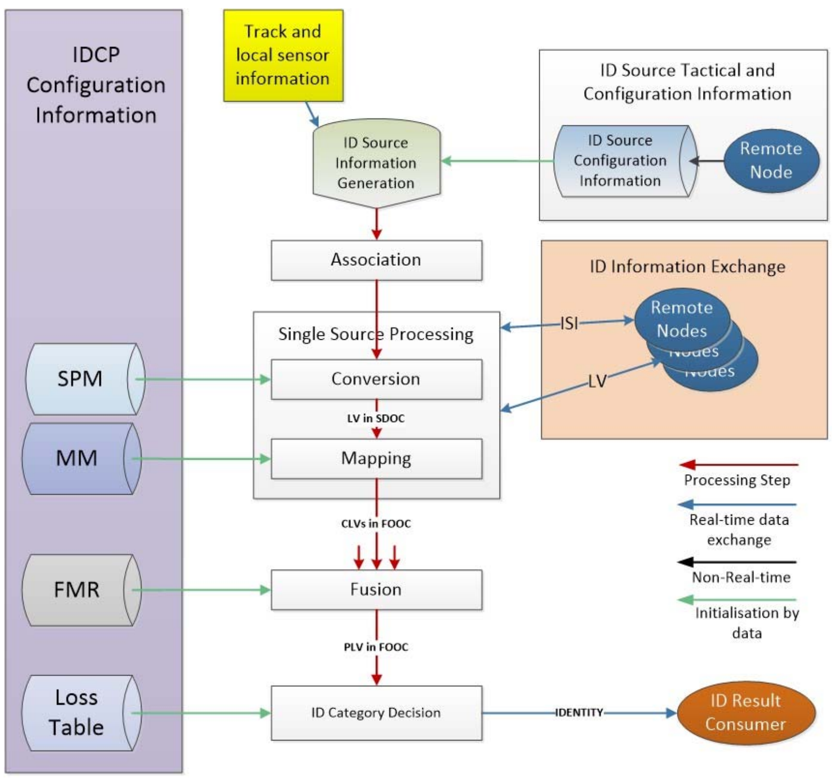

Figure 1: IDCP processing (according to [1])

2.2.1 The ID Source Information Generation

During this processing step, sensor information about a track is evaluated to generate information, which is relevant for identification. Usually this step is processed automatically. Host systems may also provide the functionality for operator interaction to check, change, delete and add ID Source Information. To be able to perform this step usually some tactical information is needed to configure the ID Source. Examples for ID Source information are Q&A-Mode 5 (it is checked whether a track answers to an IFF Mode 5 request); Movement and Procedural Routing (MPR)-Mission Plan (track trajectory is compared with an air volume to extract information whether or not it complies with a mission plan); IDBO (track origin is compared with an area surrounding an airfield).

2.2.2 Transmission / Reception of ID Source Information

During this processing step, the different entities, which are able to generate ID information, shall provide this information to the IDCP. STANAG 4162 Edition 3 contains the standard and the information exchange requirements for this ID source data exchange.

2.2.3 Kernel Processing

The kernel processing comprise three parts: The first step, "**conversion**", translates the ID Source Information into a standardized form (a so-called Source Likelihood Vector) which is defined for every source type in STANAG 4162. This format contains the mathematical representation of the discriminatory ability and quality of an ID source.

The **mapping** step converts the ID Source-specific result into tactical information (the so-called Output Object Class), e.g. the information that an aircraft has provided a valid IFF Mode 5 response will be used to derive that the track is a friendly military track (with very high probability).

After the mapping all information from the various ID Sources is available in the same form of tactical information and can be used by the **fusion step** to generate the result, e.g. the probabilities that the track is one of the objects "Own Force Military", "Own Civil", "Non Aligned Military", "Non Aligned Civil", "Enemy Forces Military" or "Enemy Civil". This result is the so-called Posterior Likelihood Vector (PLV).

2.2.4 "ID Category Selection"

The PLV is not the adequate result to be presented to an ID operator within the situational picture. Therefore, this step generates an Identity (Recommendation) in light of a risk assessment. In an air defence environment this is usually defined by the STANAG 1241 [6], resulting in an identity selected from the list FRIEND, ASSUMED FRIEND, NEUTRAL, SUSPECT, HOSTILE, UNKNOWN. This result will be presented to the ID operator by using the appropriate symbology as defined in APP-6. Additionally the IDCP can also be used to generate a recommendation for the platform class of the track.

2.3 Necessary Data for the IDCP

There are several different types of information, which must be considered for the IDCP as described in STANAG 4162 Edition 3. The first two types represent the technical and operational knowledge about the ID source, which are used in a specified host system, and the tactical environment of the current mission. They give the opportunity to adapt the IDCP to the technical specifics of the host system and to the operational requirements and conditions of the mission.

The first type is the IDCP Conditioning Information. This information is mostly static during a mission. It can be used to adapt the IDCP to changes in the mission environment (e.g. if the alert state changes from Crisis to war) a different Loss Table will normally be used. It includes

a) The knowledge about the discrimination capability and discrimination quality of the ID Sources. This information is represented by the so-called **Source Probability Matrix** (SPM). This information is used for the processing step "Conversion".

b) The operational knowledge about the interpretation of the ID Source Information. This information is represented by the so-called **Mapping Matrix** (MM). This information is used for the processing step "Mapping".

c) The a priori knowledge about the expectation concerning the distribution of the allegiance of the objects in a specific mission. This information is represented by the so-called **Force Mix Ratio** (FMR). This information is used in the "Fusion "step.

d) The knowledge and rules concerning the appropriate selection of an ID Category. This information is represented by the so-called **Risk Matrix**. This information is used for the process step "ID Category Selection"

The second type of information is necessary for the **configuration of ID sources**. It consists of the tactical information that is necessary to generate the appropriate ID Source information. The format of this data is not part of the IDCP STANAG. The **Track information** is fundamental for the complete ID process. All ID Source information and all intermediate IDCP processing results as well as the final ID result are associated to an appropriate track. Additionally track information is also the basis for the generation of several types of ID Source information, e.g. for the ID Sources of the type Movement Planning and Routing. The **ID Source Information** contains the information usable for identification, which was generated by an ID Source, either locally or remotely. This data must be associated to a track for it to be useful.

The exchange (transmission / reception) of the ID Source information guarantees that the generation of the ID Category recommendation is based on all ID Source information, which is available within an Identification Network. Normally this data must be exchanged in (near) real-time. The **recommendation for the ID Result** is the final information generated by the IDCP process. Usually, the ID result is provided as an ID Category and / or a platform class. If approved, the ID result will be used for the subsequent tactical processing steps (e.g. the threat assessment) and will be forwarded to other participants of the tactical network.

3. IDCP AS A HIERARCHICAL BAYESIAN DECISION NETWORK

The IDCP can be represented as a Bayesian hierarchical decision network with discrete nodes (see [4] for a more general Bayesian Network for Identification). The possible results of the fusion step – the OOC – defines the states of the top node. This node determines the probabilities of the states of the ID Sources (the likelihood vectors for the different source types) by applying appropriate Conditional Probability Tables (CPTs). The CPTs relating the OOC and the likelihood vector for the different ID Source Types are given by the mapping matrices. The standards for the description of the ID Source Types define the states of the ID Source Type nodes. The probability distribution of the states of these nodes determine the probability of the states of the ID Source nodes (i.e. the nodes representing the ID Source Information), the CPTs are given by the Source Probability Matrices. The standards for encoding of the ID Source Information define the states of the ID Source nodes. Finally, the Risk Matrix is applied for the calculation of the risk of possible decision (ID Category selections) by using a value and decision node.

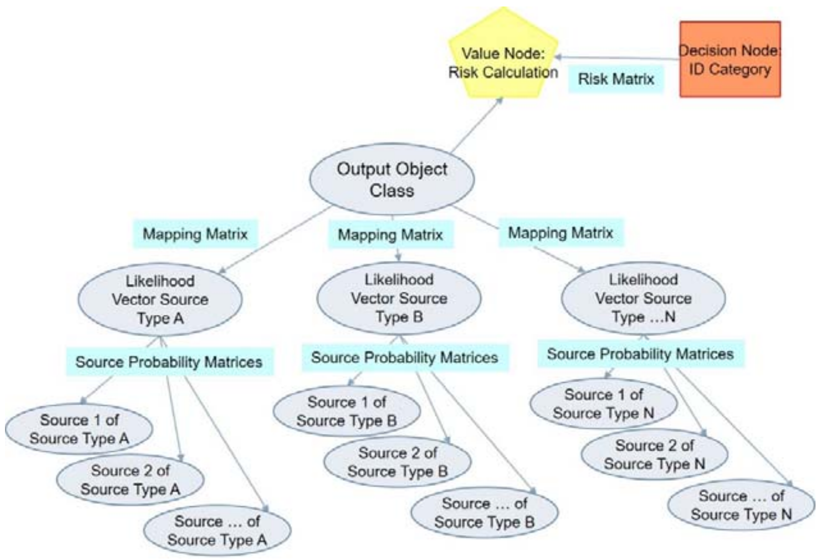

Figure 2: IDCP kernel processing as a hierarchical Bayesian Decision Network

4. IDCP IMPLEMENTATION AS FORCE LEVEL IDENTIFICATION FUNCTION

There is an high operational need to implement identification within a naval force in a way that the Identification is fully interoperable so that the ID results can be used within an automated processing. This is of special importance to enable naval forces to engage against threats like modern missiles, where the time to react is not sufficient for manual coordination of possibly contradictory ID results arising from incomplete availability of ID Source information and non-interoperable ID processing. STANAG 4162 defines the standardized data exchange of ID Source information. An IDCP implementation as force level function requires that all ID Source information is provided to the IDCP process(es) according to the STANAG which is (which are) used for the identification of tracks for specific environments. In [5] two basic architectural alternatives are described: The first is the implementation of IDCP as a function, which is not fully integrated in the Combat Direction System of the ships. In this case the IDCP is using the CDS specific ID Source information of the platforms, generates the standardized ID Source information, provides the information to the IDCP on other platforms. generates the ID Category Recommendation and provides it to the platform CDS. This is a solution for cases, where the integration of IDCP into an existing CDS might be too expensive. The second alternative is the implementation of an IDCP as CDS Identification component of the integration of newly implemented IDCP into the CDS. In this case, the IDCP within the CDS generates the ID Source information and provides it to the network and the CDS generates the ID result according to the STANAG for the application of the future processes.

Note that the experience with already available IDCP implementations shows that the implementation of the standardized fusion process is no great challenge. The effort to implement all ID Sources accurately is usually larger. Furthermore, there is a need for a tool (IDCP Conditioning Tool) for the generation of the necessary data for the IDCP by operational (educated) users, i.e. the source probability matrices, the mapping matrices and the risk matrix. This tool must additionally provide the functions to test the IDCP results applying a specific data set, e.g. for being sure that all mandatory ID rules are satisfied by the IDCP using this data set.

5. BENEFIT OF INTEROPERABLE IDCP IMPLEMENTATION

The IDCP is realized using a sound mathematical model, which enables the proper exploitation of all important technical and operational knowledge to its maximum extent. Therefore, the intermediate and the results are reliable, transparent and explainable. Under the assumption that the conditioning data set was generated correctly, the results will correspond to user expectations. The IDCP processing is based on an efficient algorithm based on Bayesian probability theory, which simplifies the implementation of an IDCP with full real-time capability. The IDCP can be implemented in a way that it is fully adaptable by definition and usage of appropriate Conditioning data sets. Therefore, it can be adapted without change of software, if there are changes in the technical equipment of host system e.g. due to future developments in technique, to different scenarios, and to different environmental conditions. The implementation and use of IDCP as force level identification process can guarantee that the recognized Picture of all force members coincides and that the recognized picture of them based on the use of all ID Source information available within the force.

6. CONCLUSION

This paper describes IDCP according to STANAG 4162 Edition 3, which is under ratification. IDCP is based on Bayesian probability theory and can be regarded as a hierarchical Bayesian Network. IDCP provides an approach for an implementation of an interoperable ID process, which can be used as force level identification process for naval forces. The successful application of the IDCP STANAG calls for its ratification and gradual implementation by a significant number of NATO members. On that condition, IDCP will improve the interoperability and quality of identification of NATO naval forces.

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