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English summary

The report presents the accumulated experience, obtained methodology and associated recommendations gained through FFI project P1200 (Analysis of Maritime Operations) and P1337 (Analysis of Maritime Operations and Exercises).

The Royal Norwegian Navy's (RNoN) increased attention to the analysis of operations and exercises, relates to the high complexity of new vessels and weapon systems, and an aspiration to optimise these exercises and operations accordingly. An essential part of P1200, and now P1337, is therefore to conduct analyses on a tactical level, whose outcome materialises in solutions and recommendations – also described as "Lessons Identified" turned into "Lessons Learned".

The concept of analysis includes, in this report, all accompanying activities, and two main approaches are both being used in our project: Inductive and deductive analysis. The inductive approach is more exploratory in nature, and is used when unforeseen, yet interesting, events occur, and where finding potential patterns and relations are needed to explore a new field. Deductive analysis is used when a strong hypothesis can be made ahead, and therefore where thorough preparations can be made accordingly. The project strives to work within the deductive approach as much as possible, albeit would naturally not shy away from inductively analysing new and unexplored events when they occur. After having contributed to several exercises, we have seen some reoccurring analysis fields, and for those we have been able to develop analysis objectives deductively. The methodology has been divided into three main phases:

1. Preparation of the analysis
2. At the event
3. Post event analysis.

For the first phase – the preparation of the analysis – we describe our team, the planning of the analyses, the definition of analysis objectives (AOs), the collection of data, and the general analysis plan. For the second phase – at the event – we describe the two different hats we wear as observers during an exercise; the hat for 'in theatre' observation and the one for data collection. For the last phase – the post event analysis – we describe how we reconstruct and visualise interesting events that take place, which tools are being used (specifically the analysis program Fram – a tool that enables a reconstruction and visualisation of events from the exercise), the post event analysis process, and finally the reporting and presentation of results to RNoN. A substantial amount of knowledge and experience has been accumulated in analysing maritime operations. Altogether, the project has gained crucial insight into the analysis of maritime multi-platform operations on a tactical level. This includes all the different aspects of data collection, analysis methodology and tactics, in addition to documentation and visualisation. Data collection and data analysis is demanding when it comes to data support utilities and data expertise. The RNoN now can benefit from the analysis capabilities at FFI in improving the identification of lessons from exercises. The project has experienced that a close cooperation between the analysis groups respectively at FFI and KNM T/TAS, when it comes to the reconstruction of events after exercises and the identification of lessons, is crucial to the outcome of the analysis.

Samandrag

Rapporten presenterar samla erfaringsmengd, innarbeida metode og tilhøyrande anbefalingar tileigna gjennom FFI-prosjekt P1200 (Analyse av Maritime Operasjonar) and P1337 (Analyse av Maritime Operasjonar og Øvingar).

Sjøforsvarets auka merksemd rundt øvingar/operasjonar og analyser av desse, har sitt opphav i mellom anna kompleksiteten til nye farty og våpensystem, kombinert med ein ambisjon om å kunne optimalisera øvingane tilsvarande. Ei avgjerande hensikt med P1200, og no P1337, er difor gjennomføring av analyser på eit taktisk nivå, og resultata medfører løysingar og anbefalingar – også skildra som «Lessons Identified» gjort om til «Lessons Learned».

Begrepet analyse famnar i denne rapporten om alle aktivitetar knytta til dette, og to hovudtilnærmingar vert nytta: Induktiv og deduktiv analyse. Den induktive tilnærminga er meir utforskande i sin natur, og nyttast når interessante og uforutsette hendingar oppstår, og ein freistar å finna mønster og samanhengjar i ukjend terreng. Deduktiv analyse vert nytta når gode hypotesar og teoriar kan opparbeidast i forkant, og førebuingar kan gjerast deretter. Prosjektet nyttar deduktiv analyse der mogleg, men unnlatar ikkje å analysera induktivt uutforska hendingar som oppstår. Etter å ha vore involvert i ein heil del øvingar, ser me også at enkelte emne går att, og har slik kunna utarbeida detaljerte analysemål deduktivt. Metodologien er delt i tre fasar:

1. Førebuing av analysen
2. Under øvinga
3. Etteranalyse

For den fyrste fasen, i førebuinga av analysen, skildrar me analysegruppa, sjølve planleggjinga av analysen, nedteikning av analysemål, datainnhenting og den overordna analyseplanen. For fase nummer to, under sjølve øvinga, skildrast dei to ulike rollene observatørar innehar under ei øving: Rolla som reine observatørar til hendingane som utspelar seg, samt rolla som datainnsamlarar. For den siste fasen, etteranalysen, skildrar rapporten korleis rekonstruksjon og visualisering av interessante hendingar føregår etter ei øving, kva for verkty som nyttast (spesielt skildrast analyseverktyet Fram – eit dataprogram som rekonstruerer og visualiserer hendingar frå øvinga), etteranalyseprosessen i sin heilskap, samt rapportering og presentasjon av resultata for Sjøforsvaret.

Ei betydeleg mengd kunnskap og erfaring er opparbeida i prosjektet gjennom analyser av maritime operasjonar. Samla sett har prosjektet opparbeida avgjerande innsikt i analyse av maritime multi-plattformoperasjonar på taktisk nivå. Dette omfattar ulike aspekt av datainnsamling, analysemetodikk og taktikk, i tillegg til dokumentasjon og visualisering. Spesielt er datainnsamling og -analyse krevjande i høve til datastøtteverkty og –kompetanse. Forsvaret kan no dra nytte av FFIs erfaring her for å få auka utbytte av øvingar. Prosjektet har erfart at eit nært samarbeid mellom analysegruppa på FFI og på KNMT/TAS, i samband med rekonstruksjon etter øvingar og identifikasjon av erfaringar, er avgjerande for ein god analyse.

Contents

1 Introduction

FFI was tasked by The Royal Norwegian Navy (RNoN) to give leverage to the effort of analyses of maritime exercises and operations, and in 2011 FFIs project 1200 ('Analysis of Maritime Operations') (AMO) was established. The continuation of this project was thereafter P1337 ('Analysis of Maritime Operations and Exercises'). This report is published by the latter (project 1337), and describes the methodology and the practical implementation of the different activities. These activities range from planning and data acquisition to analysis and documentation.

The report is intended to serve three main objectives: Firstly, to document the need for analysis of exercises – extensive data studies and lessons identification (LI[1]). Secondly, to emphasise to our stakeholders how we recommend solving our tasks together, and thirdly, to share our methodology with other nations that holds experience within similar analyses, to facilitate information exchange and possible collaborations.

For several decades, FFI has performed analysis on low level data – typically on radar and sonar systems – as a part of the RNoN's technical and operational evaluation of new vessels. These analyses have provided much technical insight into the Navy's systems, and several analysis tools have been developed as an integral part of the work. In 2010, this technical and analytical knowledge was decided reused at a tactical level through FFIs projects 1200 and 1337.

The RNoN has during the last years acquired the new Fridtjof Nansen-class frigates, the new Skjold-class corvettes and the new Anti-Surface Missile system, Naval Strike Missile (NSM). The Fridtjof Nansen- and the Skjold-class have completed operational evaluation, and the vessels have also lately been equipped with the NSM system. There are now several motivations for increased focus on in depth analysis of the exercise:

- The new platforms and weapon systems are more complex than earlier systems. This requires more structured exercises in order to utilise the new capabilities. In particular will the long range NSM missile, which allow third party targeting, require new procedures and perhaps also new communication abilities within target data acquisition and battle space management.
- Optimisation of multi-platform operations, involving the new vessel classes requires systematic analysis of the exercises.
- In general, the development and evaluation of network based and joint capacities will enhance the need for extensive data collection from a number of participating units and a corresponding lessons learned analysis.

[1] The LI is a mature observation with a determined root cause of the observed issue and recommended remedial actions (list of actions necessary for improvement) and action body (organization tasked to implement the remedial actions), which has been developed and proposed to the appropriate authority [1]. LI become Lessons Learned (LL) when the LIs are implemented.

Analysis methodologies, tools and methods for data collection, regression and visualisation are needed in order to increase the output from the type of exercise operations discussed above. FFI thus developed such capabilities in early stages of the project, and these are now used to facilitate the different analysis activities.

The primary use of the analyses is to improve operations on a tactical level through improvement of doctrines and tactical procedures. In addition, the analysis may reveal possible technical problems related to platforms and systems that might obstruct their intentional use, in addition to challenges connected to the use itself. Analysis of larger exercises may even reveal capability gaps that might influence future defence planning and capability development.

Historically, military organisations were early on to actively use analysis to support decisions and help improve their effectiveness. Analysis for this reason is referred to as Operations Research or Operational Analysis (OA) [2]. The NATO body, Joint Analysis and Lessons Learned Centre, has structured different methods related to operational analysis on a general basis. Their recommendations on methodology are described in the publication of the Joint Analysis Handbook [2]. This handbook has been an important guideline for our approach.

This report is structured into three phases: before, during and after the exercise. Chapter 3 – 'Analysis Preparation' – describes the activities prior to the exercise, where the analysis is planned and prepared. During the exercises FFI participates as observers, and more about this can be found in chapter 4 – 'At the Event'. After the operation, FFI delivers several analysis products where the extent of detail differs. This is described in chapter 5 – 'Post Event Analysis'. Chapter 6 – 'Experience and Recommendations' – includes experience from the analytic activity related to analysing maritime operations in this project at FFI. But, first, the theoretical background for our methods is described in chapter 2.

During project P1200's and P1337's existence, an extensive accumulated body of work has been published, mostly classified. A large amount of similar work, albeit not on a tactical level, has naturally been conducted through numerous analyses also during previous projects, especially in connection with the use of analysis tools developed specifically for those needs. Presentations are also an important tool in the correspondence between FFI and the RNoN, and they are continuously being held, most notably during the exercise's PXD, HWU and the semi-annual meetings of the Project Advisory Group, but also during numerous other necessary meetings.

2 Theoretical framework of the analysis

The official definition of *analysis* in NATO [2] is:

"The study of a whole by examining its parts and their interactions."

This definition is originally from [3], and is used for this report. Other definitions exist, such as the definition found in [4]. Chapter 2.1 gives our understanding of the term analysis, and chapter 2.2 describes analysis objectives frequently considered in our analysis.

2.1 Phases of the analysis

Analysis is used as a generic term comprising the whole field of post event analytical activities, including:

1) Reconstruction and visualisation.
2) The study of a whole by examining its parts and its interactions (definition of analysis from [3]).
3) Concluding and recommending.
4) Presentation and reporting of results.

The principle courses of action are the following: After the reconstruction of events, we break down the whole and study the different parts of the event. These parts are studied in detail, and causal relations between the parts are investigated. We then describe relevant parts of the event as accurately as possible at a required level of detail, and give reasoned conclusions to what happened and why. The last part of the analysis activity is to report and present the conclusions and recommendations that the outcome of the analysis constitutes of, together with presenting essential action bodies (a list of actions for improvement). This last part is in short generating the LIs.

The role and reason for conducting an analysis can generally be illustrated through the learning cycle, shown in Figure 2.1.

Figure 2.1 The role of analysis in the overall cycle of exercises is shown schematically.

In the step ‘Plan next exercise’, the actors involved in the process try to implement as many LIs as possible while outlining fields to train and therefore to analyse next. The project aims within our means to adjust the data collection plan as accurately as possible.

The next step ‘Exercises’ is where everything we have planned, together with KNMT, is being executed. Analysts participate as observers, checking also that data are recorded correctly.

The ‘Hot wash up’ (HWU) step is a day set aside partly to discuss observations made during the exercise, and where a reconstruction of events is being presented by analysts from KNMT and FFI to the exercise participants.

The ‘Analysis’ step is where the real deep dive into the analysis begins. At this point, through the reconstructions and HWU, we have a good platform to indicate the direction of our analysis.

The ‘Review findings’ step is where our findings and recommendations are being discussed with appropriate personnel responsible for their implementation – that is, to make sure LI turns into lessons learned (LLs) and to reassure the quality of our findings.

FFI assist when necessary during the process of the last step ‘Update tactical publications’. These updates are ideally being implemented before the next exercise begins and the cycle repeats itself with a content that is up to date.

2.2 Analysis fields

Normally, one operates with eight main analysis topics, and with the commonly used term DOTMLPF-I, they are [2]: Doctrine, Organisation, Training, Materiel, Leadership, Personnel, Facilities and Interoperability. Since the DOTMLPF-I-system is more or less all-encompassing, not all topics are dealt with for each exercise. Especially, the topics of doctrines and training are common. The project has mainly performed analyses that fall within the field of anti-surface warfare (ASuW), but also anti-air warfare (AAW) and anti-submarine warfare (ASW) have been dealt with. Analysis topics we often encounter are:

- Common Operational Picture (COP)
    - The use of Target Reporting Units (TRUs)
    - Assessment of conflicting issues in target area related to missile engagements
    - Collateral damage
    - Conflicts with man-made infrastructure (bridges, power lines, tall buildings etc.) related to missile trajectories
- Command and Control
- Airspace control
- Use of weapons
    - Missile engagement statistics

The ‘Command and Control’ part inlcudes i.e. distribution of urgent information, levels of decision making, etc.

From the topics listed above we are able to construct predetermined analysis objectives in a deductive manner (see chapter 3 for further information about the two main approaches to analysis – deductive and inductive).

2.3 Analysis team

FFI operates with a more or less permanent analysis team, consisting of analysts and software experts/developers. In addition to this, the project co-operates with analysts at the RNoN, acting as Subject Matter Experts (SME).

The FFI team generally has 2-4 people directly involved in the analyses, and from the RNoN there are about the same amount of personnel. FFI scientists and engineers perform analysis activities for an extended period of 2-3 months, whereas officers from the RNoN are involved in a more concentrated period of time before, during and after the exercise.

3 Analysis preparation

In this chapter the research is viewed in a theoretical perspective by presenting some of the theoretical background coupled with our implementation.

By definitions in general analysis, we often refer to the two broad methods of reasoning as the *deductive* and *inductive* approaches [5]. Deductive reasoning works from the more general to the more specific, and the method is illustrated as a 'top-down' approach in Figure 3.1. Inductive reasoning works the other way, moving from more specific observations to broader generalisations and theories. Our method for analysis includes both of these approaches, illustrated in Figure 3.1.

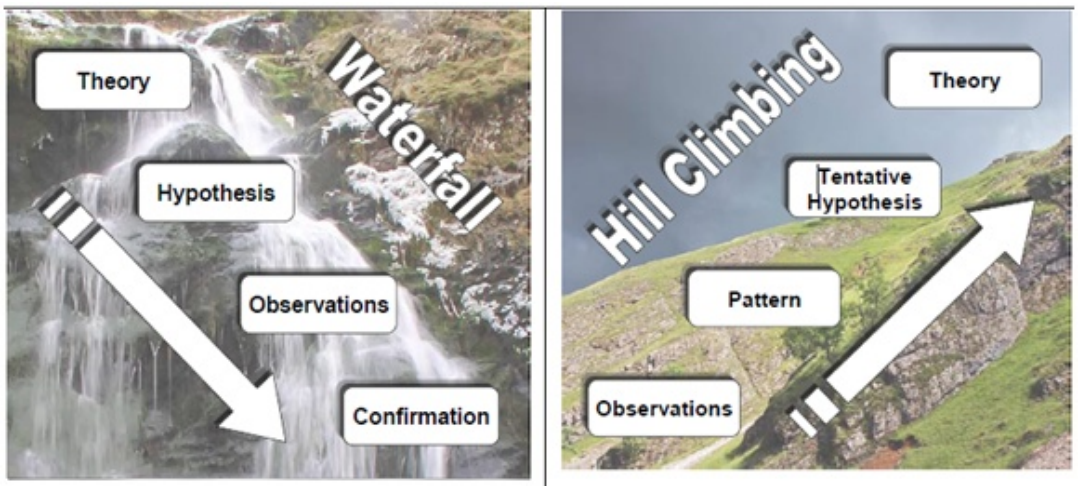

Figure 3.1 Different approaches to analysis: Deductive reasoning (left) and inductive reasoning (right)[1].

In the deductive approach the theory can both come from earlier observations, or we can have well founded theories from related topics in tactical operations. These topics can be general, or they can be found publications developed specifically by the RNoN; 'training lists' including a number of issues the RNoN aims to train during exercises. We have special focus on certain fields for our analyses, as mentioned in chapter 2.2. Two important terms here are 'joint operations' and 'execution and development of tactics'. Within these fields we have to consider everything that will influence this performance. The focus for each exercise can consequently be fields where the RNoN wants to develop or practice tactics, or fields where contribution to joint operations should be investigated further through analyses. The intentions here are clear, but the analysis objectives may not be, and these therefore have to be set up and structured each time.

We would for instance have a theory that the Recognised Maritime Picture (RMP) is important for the achievement in joint operations. A simple example of a basic hypothesis[2] can be seen concerning the analysis of the construction of the RMP for units involved in an exercise. Here, we

[2] A hypothesis is a specific statement of prediction. It describes in concrete terms (rather than theoretical) what you expect will happen in your study [5].

have a null hypothesis H_0, and further also an alternative hypothesis H_1. We hope to support the latter, and therefore must thoroughly test the first:

H_0: The construction of RMP for all units involved in the exercise is not satisfactory
H_1: The construction of RMP for all units involved in the exercise is satisfactory.

From the basic hypothesis, we then start to build the Analysis Objectives (AO). An AO is a clear, demonstrable and achievable tasking that identifies the outcome of an analysis [2], [4]. It will have a tangible output. To test our null hypothesis through answering the AOs, we mainly collect data, supported by observations. After analysing these data, we must not be able to confirm the null hypothesis if we are to give support to our alternative hypothesis. This means that if we don't find a substantial amount of irregularities in the RMP from the recorded data, we find that the RMP is likely to have been satisfactory during the event, even though some irregularities might still potentially have occurred within uncollected data.

During FLOTEX 2011, the RMP was analysed for ASuW, and evaluated in time and space through AOs developed for the exercise in advance. Through reconstruction afterwards, we could see that the rate of updates was satisfying with regard to defined friendly units, but more incomplete for simulated enemy units. The reason for this difference was also found in the analysis.

To build a sufficient RMP is a central part of all exercises and the AOs for the RMP can be used repeatedly. This gives us the possibility to study developments over time.

In the inductive approach we use the observations to sort out interesting or questionable events and by this our analysis is based on what happened during the exercise. The observations are therefore the starting point for our analysis. The observations raise questions and we make hypothesis from them. We then analyse further to answer these questions, and by that give support, or not, to our hypothesis. In a way we can say that the observations generate AO's. A deductive analysis is more exploratory in nature, and we aim for the initial and inductive analyses to lead to deductive when all branches and related topics are completely mapped out.

Inductive analysis has been conducted throughout both projects (P1200 and P1337), and examples of this can for instance be found in our ongoing analysis of the RMP (Recognised Maritime Picture), where occasional unexpected observations has been done, which again has required further testing to disclose whether this was a general pattern or a one-time occurrence in the picture compilations process.

We can use both approaches within the same exercise, but concerning different subjects. Both approaches end with conclusions, consequences and recommendations (LIs). All these LIs will be included in a final analysis report. When the LIs are implemented they become Lessons Learned. FFI is not responsible for the implementations of LIs; we only propose actions to solve issues described in LIs in the RNoN, who is responsible for taking the LIs further.

3.1.1 Pros and cons with the two different approaches to analysis

The approach of deductive reasoning gives us the advantage of a targeted data collection. The disadvantage is that we can lose interesting topics, since we then are tied to specific analysis objectives. Deductive reasoning also demands that FFI and the tactic centre in the RNoN have a possibility of influencing the planning of exercises, so that the relevant theories can be explored.

The inductive approach requires an extended data collection plan in order to get a wide data log. This approach can also be time consuming in searching for relevant topics. The advantage is that we have a wide approach to the analysis and that we are not limited to a small number of topics.

FFI has experienced that the inductive approach is a very suitable type of analysis in our situation. FFI only assists the RNoN in the analyses, and is not responsible for initiating and conducting the exercises. There is little room for the analysis team to fully apply a deductive approach, in the sense that we cannot tailor the exercise only to test AOs set by us in advance. However, after having conducted many analyses, we see certain recurring topics, as mentioned in chapter 2.2, and for these fields we have pre-developed AOs that can be used in the analysis of most exercises. The inductive approach, on the other hand, has a broad range of usage, where we seek to retrieve significant events in the aftermath of the exercise – events that highlight operational challenges.

3.2 Analysis planning

To conduct analyses of high quality, there are some premises that must be fulfilled [2]:

i. Good interaction with the exercise planners
ii. A detailed and understandable data collection plan
iii. A possibility to observe parts of the exercise
iv. A tactical play, where information between the parts is not shared

Exercises within the RNoN are planned partially based on separately produced documents – ‘training lists’ – containing lists of factors in need of more practising. These lists are used as important input for the exercise planners. In larger exercises, one or more of the serials are free play periods, which FFIs analysts often focus their attention towards, and these free play serials can be based on such mentioned lists of necessary training. The relations between ‘training lists’ and the exercise plans themselves are shown in figure 3.3.

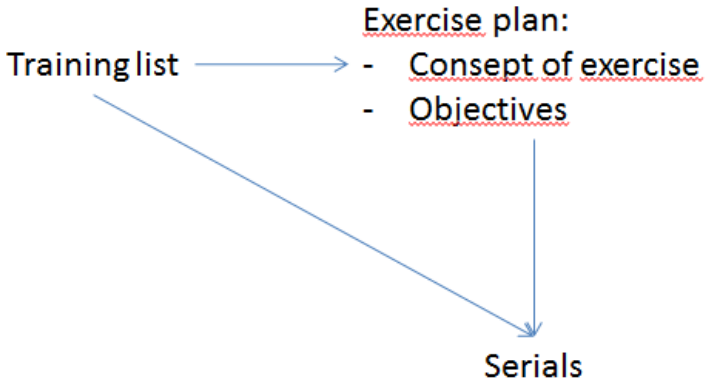

Figure 3.2 The relations between training lists, the exercise plans and the serials within the exercises are shown here.

Analysts from the RNoN and FFI usually participate at the exercise planning conferences, to inform about the analysis and to facilitate data collection.

3.3 Analysis objectives

The overall Analysis Requirement (AR) [2] is:

"How can the RNoN improve their performance in joint operations?"

Within this AR we have to consider factors that will influence this performance. New systems have been implemented in recent years, where the most important ones are the Nansen Class frigates, the Skjold Class corvettes, and the new Naval Strike Missile. It is important therefore to optimise the use of these new systems, and herein enters operational analysis. It is evident that the RMP is important for the achievement in joint operations, so we have AOs within this category for all three warfare areas: ASW, ASuW and AAW. The RMP is a central part of all exercises and the AOs for the RMP can be used repeatedly. This gives us the possibility to study developments over time. The AOs concerning the RMP for ASuW are shown in table 3.1.

Name	Analysis Objective (with levels)
AO 1.2	How good is NorTG's COP for ASuW?
AO 1.2.1	How up-to-date is NorTG's COP for ASuW?
AO 1.2.1.1	How up-to-date is ComNorTG's COP for ASuW?
AO 1.2.1.1.1	In regard to an escort operation?
AO 1.2.2.1	How up-to-date is other units' RMP for AAW?
AO 1.2.2.1.1	In regard to an escort operation?
AO 1.2.2	How complete is NorTG's COP for ASuW?
AO 1.2.2.1	How complete is ComNorTG's COP for ASuW?
AO 1.2.2.1.1	In regard to an escort operation?
AO 1.2.2.2	How complete is other units' RMP for AAW?
AO 1.2.2.2.1	In regard to an escort operation?
AO 1.2.3	How accurate is NorTG's COP for ASuW?
AO 1.2.3.1	How accurate is ComNorTG's RMP for ASuW?
AO 1.2.3.1.1	In regard to an escort operation?
AO 1.2.3.2	How accurate is other unit's RMP for ASuW?
AO 1.2.3.2.1	In regard to the escort operation?

Table 3.1 Analysis Objectives regarding the analysis of Recognised Maritime Picture for ASuW shown in the table can be used repeatedly, meaning that they differ very little or nothing from exercise to exercise. We also have AOs for AAW and ASW regarding the analysis of Recognised Ground Picture (RGP) and Recognised Air Picture, which together with the AOs for the RMP constitute the AOs for the COP.

We have special focus on certain fields for our analyses. Two important terms here are 'joint operations' and 'execution and development of tactics'. The focus for each exercise can consequently be fields where the RNoN wants to develop or practice tactics, or fields where contribution to joint operations should be investigated further through analyses. The intentions here are clear, but the analysis objectives may not be, and these therefore have to be set up and structured each time. During 'Fellesoperativ Arena IV' (FOA-IV – formerly known as FLOTEX 2013), an NSM engagement was to be set up, and for this we developed a list of analysis objectives. A selection of these concerning target data is given in table 3.2.

Name	Analysis Objective (with levels)
AO 3	How good is NorTG's NSM engagement?
AO 3.1	Are the target data good enough? An evaluation of utilised sensor considering:
AO 3.1.1	The accuracy of target data
AO 3.1.1.1	Could something have been done to improve this?
AO 3.1.2	The source's reliability
AO 3.1.2.1	Could something have been done to improve this?
AO 3.1.3	The source's survivability
AO 3.1.3.1	Could something have been done to improve this?
AO 3.1.4	The rate of updates
AO 3.1.4.1	Could something have been done to improve this?

Table 3.2 A selection of analysis objectives from FOA-IV regarding an NSM engagement is given in the table. The selection concerns the target data.

In addition to this, we generate other ARs, or more often AOs, adapted to specific exercises. These are based on exercise goals (see description of 'training lists' in section 3.2). FFI draft one or more proposed AOs, and these AOs are further examined and possibly refined by personnel responsible for exercise planning at the tactics centre in the RNoN – personnel with expertise in both warfare and analysis. In addition, the AOs are sent to ComNorTG, who are responsible for planning the exercise. In this way, they can give feedback or, at least, be familiar with the objectives for analysis.

The ARs and AOs are generated from hypotheses that we want to test, and questions we want to answer. We review the AOs with regard to Doctrine, Organisation, Training, Materiel, Leadership, Personnel, Facilities and Interoperability (DOTMLPF-I) [2], not to miss important aspects. In some cases, the AOs are general down to a certain level, and specific for the exercise in question at the lowest level. In this way the AOs can be reused in other exercises. For every exercise it is therefore useful to revisit the DOTMLPF-I categorisation system as a memo to see if additional questions should be asked.

After the AO refinement, we gather and read information about relevant tactics and we define a data collection plan for the exercise which makes answering these AOs possible.

As described in Section 2.3, we have experienced that both the inductive and the deductive approach apply well in our analyses. The deductive approach is used for analysing recurring topics like the picture compilation process and analysis of NSM engagements.

3.4 Data collection plan

The data collection plan varies very little between each exercise. Examples of data collected by the project are:

- Global Positioning System (GPS) – both handheld and from embedded systems on board
- Tracks from combat management systems (CMS)
- Signals from Military Message Handling System (MMHS)
- Tactical Data Link (TDL)
- Video from Frame Grabber from several operator screens
- FORMEX 101 (see 6Vedlegg A for structure)
- Chat-logs
- Automatic Identification System (AIS) data
- First Impression Reports (FIR)

We place mobile GPS receivers on as many vessels as possible, as to be able to compare tracks with 'correct' positions afterwards (GPS positions). This allows us to verify the accuracy of the picture compilation.

Chat-logs and FORMEX 101 are used as additional information to understand what happened when and why.

Frame Grabber is a video tool that enables data streaming from relevant operators' consoles. This gives us the ability to see exactly what kind of information the operators had access to, and also to see their center of attention.

First impression reports from the exercises are written by the crew on each unit. These reports are shown to be very useful when trying to identify important observations during the exercise.

Tracks from warfare systems are widely used in analysing the quality of the COP during the exercise. AIS-data can also be valuable in this regard.

We develop specific data collection plans for each unit involved in the exercise. These plans also describe how data should be collected after the exercise has ended.

3.5 Analysis plan

The analysis plan captures the AOs, the time periods for analyses, which data to collect and where to collect them, and finally the analysis team manning - including their location and deployment during the exercise. This plan also includes information about when and where to hold the Post Exercise Discussions (PXD) and reconstruction before HWU.

The exercise plans and orders are relevant in this context. One of the Annexes of these plans is generally called 'Analysis and Evaluation' and contains typically these topics:

- Participating analysis and evaluation bodies
- Analysis/evaluation objectives
- Execution of analysis/evaluation
- Coordinating instructions

FFI sets up a schedule to make sure that representatives from FFI participate in the exercise on all important units during analysis periods. Data collection plans have a certain distribution, and the project manager also sets up a schedule for this, displaying when and to whom the data collection plans are to be handed out before the exercise starts. FFI also makes an additional and more detailed plan to be used by those involved in the data collection and transportation.

4 At the event

During exercises, the analysis team is involved in two activities: observation and data recording. These activities are described in section 4.1 and 4.2. The time period for observation and data recording can range from one day and up to two weeks. It depends on the dimensions of the exercise.

4.1 Manual in-theatre observation

The members of the analysis team participating as observers, are reporting observations and thoughts throughout the exercise. A well-known phenomenon in analysis and research in general

is that all observation changes the subject. The mode of observation is therefore ‘observer as participant’, meaning that the observer participates in the event solely with the purpose of making observations and where the intention of the observer is known [2]. To familiarise other participants with the intention of observing is important, as this contributes to demystifying the observer’s presence and reducing the influence of the observation to a minimum.

In addition to making observations and taking notes, the observer has the important task of ensuring that all data logging has been turned on and are functioning properly. The observer can also discuss the writing of FORMEX 101 (6Vedlegg A) with the crew, to ensure that the members of the crew understand what is important to write down to facilitate a good analysis.

The observations are unstructured: the observer attends the operation as a witness to what is going on, taking notes and providing insights into the processes that are taking place [2]. Key data are time of observation and description of events, but also other information that can give insight. The collection of data is structured in such a way that the observers make their notes guided by a predefined format.

The observation period is intensive, with little room for review of on-going work, other than making sure that the right data are logged. In order to make more room for the observation itself, there is little contact between the observers and other members of the analysis team. On the other hand, a collective review of the observations is conducted afterwards to synchronise each observer’s notes, and to ensure improvements and optimisations before the next exercise.

4.2 Data recording

Data are continuously and automatically recorded during the analysis period on several data networks. The observers make sure that the right data are logged, and that they are recorded in a format which is manageable for the computer engineers during the post event analysis (see chapter 5).

To relieve the workload for the observers, frame grabbers are used to record screen videos on some of the operators’ consoles.

5 Post event analysis

Post event analyses are divided into different stages with associated deliverables. For all stages we reconstruct and visualise what happened during the exercise. We make the post event analyses in collaboration between subject matter experts, analysts and software developers. The first phase has a particular emphasis on reconstruction and visualisation, and this process is described in section 5.1. Section 5.2 describes the post event analysis in general, whereas section 5.3 deals with the reporting of results and findings.

5.1 Reconstruction and visualisation

FFI, together with the RNoN, reconstructs and visualises the exercise as soon as the data from the exercise is collected. The amount of time required for the initial reconstruction differs from event to event depending on the amount of data collected.

For larger exercises it is often preferred to use more effort (and time) in reconstruction, and in addition to this, we often include a preliminary analysis before the results are presented to the exercise participants during an exercise review. This potentially contributes to better feedback to the analysis team from the exercise participants, and improves the succeeding in-depth analysis.

Reconstruction and visualisation helps answering questions about *what* actually happened in the battle space. To investigate *why* things happened, we use additional information found in observer notes, FORMEX 101 (6Vedlegg A) and in the message traffic. Section 5.1.1 describes a computer tool developed by FFI primarily to be used for reconstruction and visualisation.

5.1.1 Fram – the analysis tool for reconstruction and visualisation

FFI has developed a software tool for reconstruction and visualisation of the exercises. This tool is named Fram, and it is a module in the geographic map tool Maria [7]. The analysis tool also has a timeline view of the exercise.

The analysis tool is able to show recorded data altogether, such as tracks from the CMS, GPS tracks and TDL tracks. It also presents data from RMP, which includes AIS data. This gives us a possibility to see how the units have moved around the battle space, and allow comparing GPS tracks with reported positions. The time controller in Fram gives us a possibility to play back at different speeds suitable for the situation. E.g. can the whole analysis period be shown at a HWU with high speed playback.

Figure 5.1 shows a screen shot from Fram. At the right hand side of the screen, there is a map showing positions and tracks. The data are filtered, and the tracks occupy different colours depending on filter criterias. On the left hand side of the screen we can see the time controller and observation data for the selected track. It also shows the display filter.

Fram gives the option of displaying all the data relating to each observation. In addition to the analysis tool we can use information from observers' notes and FORMEX 101.

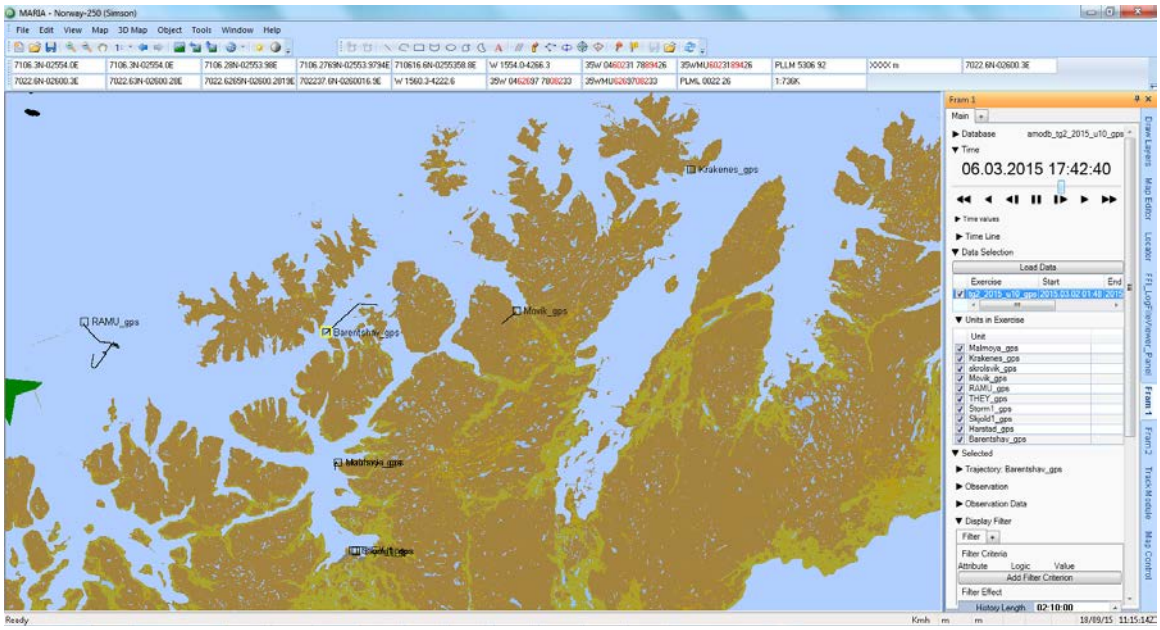

Figure 5.1 The figure shows a screen shot from the analysis tool Fram. The tool gives the opportunity to choose different colours for different tracks (red, blue and green, etc.) set by filter criteria shown on the right hand side. On the same side the time controller and other functions are also shown.

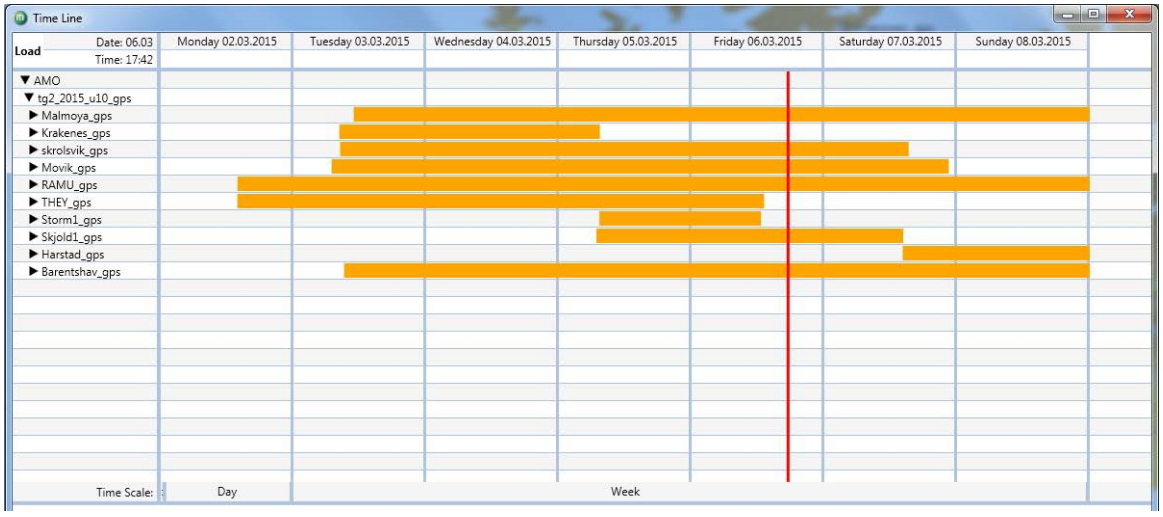

Figure 5.2 The figure shows the timeline view in the analysis tool Fram. The red vertical line represents the time chosen. Yellow lines show for which time period we have logged data from a specific unit.

5.2 In-depth analysis

After the reconstruction and visualisation of the exercise, the analysis team has a PXD after the event, where important episodes during the analysis period are identified. The episodes are then being listed by priority, and the ones with highest priority are presented at HWU.

All of the episodes are further studied and analysed in cooperation with SME. Together, we suggest recommendations (LI) with the purpose of giving feed back to the personnel involved in the exercise. If actions are taken to solve problems or to ensure that successes are repeated, Lessons Identified can become Lessons Learned already at this early stage. The same process is used in NATO [1].

FFI then continue with further analysis of a few important episodes identified in the PXD, but at a more detailed level, and we investigate these using the pyramid principle shown in Figure 5.3. The theses can derive from findings from the PXD chosen to be investigated further.

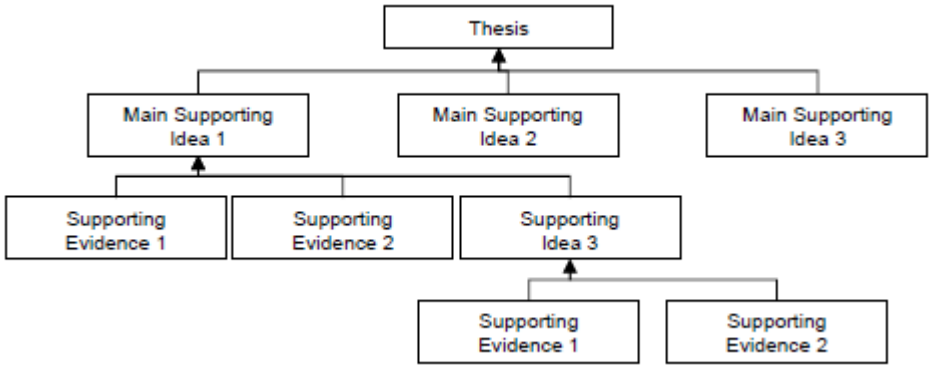

Figure 5.3 The pyramid principle[2]. This is a more detailed form of figure 3.1, which described respectively the deductive and inductive reasoning. Here, an inductive analysis would start with the bottom two boxes of the figure – supporting evidence 1 and 2 – and work towards a thesis – the top box. A deductive analysis would do the opposite – start with a theory and use an experiment to confirm or reject it.

In addition to analysing interesting episodes from the exercise using the inductive approach, we attempt to answer the AOs for the exercise through deductive analysis.

5.3 Reporting

Reporting the analysis results is challenging, and it is important to find the correct perspective for the recommendations. From [1] we find:
"The key to worthwhile post-event reporting is ensuring that the final product is focused on giving guidance to the next event's planners, not the previous event's players for review. This focus will help to ensure that mistakes are not repeated and best practice is institutionalised. Without this focus, post-event products tend to be shelved and do not become part of the knowledge base of the next rotation of actors in the exercise or operation" [1].

5.3.1 Analysis report

The analysis and the corresponding reports documenting the results have been arranged somewhat differently from earlier exercises in 2010 and up until now. The earlier analysis reports

present the selected episodes sequentially, with illustrations from the reconstruction through the analysis tool Fram. Each episode is analysed, and possible causes for interesting events described.

In later reports, a small number of defined AOs (ref. section 2.2) determine the structure of the analysis. Here, these AOs are assessed by means of episodes underpinning them. Through this approach, challenging fields are in focus and not the chronological sequence of episodes that might, or might not contribute to clarifying important issues.

Before distribution of the final report, a draft report is circulated to SMEs for commenting and quality assessment.

5.4 Presentation of results

The analysis results, including consequences and recommendations, are presented to exercise participants and other relevant personnel before the finalisation and distribution of the report. In this way they have a possibility to modify and adjust our findings and conclusions. In addition, the participants have the opportunity to learn more when they can get direct feedback on their tactical decisions. The amount of time necessary from the exercise ends to the results are being presented is about 1–3 months.

6 Experiences and recommendations

FFI has supported the RNoN on technical analysis and evaluation on combat systems for several decades. This low level experience has been, during the last five years, extended to analysis on a tactical level through the FFI project P1200, and later the succeeding project P1337. FFI has extensive experience in exercise analysis, and this has been valuable in naval multi-platform analysis on a tactical level. This includes experience in various aspects of data collection, methodology, tactics, documentation and visualisation that the RNoN can benefit from in levering the extraction of lessons learned from exercises.

Two different analysis methods are applied – the deductive and inductive approach. In our case, the deductive reasoning starts with a hypothesis and uses the results from an exercise to verify whether the hypothesis is true or not. Inductive reasoning works the other way. The exercise results are used to search for patterns that might indicate specific problems and how they can be explained. The project has experienced that inductive reasoning is more often applicable than deductive. The reason for this is perhaps that the exercise serials analysed often are free play periods, and more seldom tailored to specific exercise objectives mapped to hypotheses.

Data acquisition during exercises, and in particular for inductive analysis is demanding through the large number of data sources in different places, the various formats and the different information content (see section 3.5) that are to be recorded for extended periods of time (up to several weeks). This requires an extensive data collection plan. Further, the retrieving of data and the in-depth information extraction as part of the analysis requires powerful data inspection and visualisation tools in addition to computer expertise. E.g. analysing seconds of a missile

engagement and at the same time checking positions and actions for all involved and surrounding actors (firing unit, friendly and hostile vessels, command centres, civilians, etc.) requires powerful software. Simulation tools have been applied typically to study weapon-usage – analyses that do not occur during exercises. This has proved useful in detailing observations from exercises, and also in exploring alternative actions and consequences through 'what if' analyses.

FFI has experienced that a close cooperation between analysts at FFI and subject matter experts from the RNoN, in planning analysis objectives and in the reconstruction of the exercise course of events, has proven to be of vital importance – both to the understanding of what happened at the exercise, and to the identification of lessons to be learned.

During the last ten years, several new platforms and systems have been implemented in the force structure. The most significant ones are Fridtjof Nansen-class frigates, Skjold-class corvettes and NSM. These systems contain high-level technology, and the operational effects are not only emerging from each platform solely, but also at the tactical level *between* platforms. The operational effect stemming from NSM is a good example of the latter. To be able to learn from experience, also on this important tactical level, KNMT and FFI have analysed several exercises together during the last five years. This report documents the methods applied.

Bibliography

[1] Joint Analysis and Lessons Learned Centre, *The NATO Lessons Learned Handbook*, 2nd ed. 2011.

[2] Joint Analysis and Lessons Learned Centre, *Joint Analysis Handbook*, 3rd ed. 2007.

[3] "AAP-6 NATO Glossary of terms and definiton of military significance for use in NATO (English and French)", 2011.

[4] "Maritime Analysis Handbook", NATO UNCLASSIFIED, Jan. 2000.

[5] W. M. K. Trochim, *Research methods knowledge base*, 2006.

[7] "www.teleplanglobe.com", 2010.

Acronyms

AAW	Anti-air Warfare
AIS	Automatic Identification System
AMO	Analysis of Maritime Operations
AO	Analysis Objective
AR	Analysis Requirement
ASW	Anti-submarine Warfare
ASuW	Anti-surface Warfare
CMS	Combat Management System
ComNorTG	Command NorTG
COP	Common Operational Picture
DOTMLPF-I	Doctrine, Organisation, Training, Materiel, Leadership, Personnel, Facilities and Interoperability
GPS	Global Positioning System
HWU	Hot Wash Up
JAH	Joint Analysis Handbook
KNMT/TAS	KNM Tordenskjold/Tactic Centre
LI	Lessons Identified
LL	Lessons Learned
MMHS	Military Message Handling System
MPC	Main Planning Conference
NorTG	Norwegian Task Group
NSM	Naval Strike Missile
PXD	Post Exercise Discussions
RMP	Recognised Maritime Picture
RNoN	Royal Norwegian Navy
TDL	Tactical Data Link
SME	Subject Matter Expert

Appendix A Formex 101

ORIGINATOR:				**FORMEX 101**			
EXERCISE:				**CHRONOLOGICAL NARRATIVE OF EVENTS**			
SHEET		DATE		MONTH		YEAR	
ENTER ZULU TIMES ONLY							
TIME	CHRONOLOGICAL NARRATIVE			COMMAND DECISIONS AND REASONS			

INSTRUCTIONS FOR THE USE OF FORMEX 101

1. The purpose of this FORMEX is to provide a cohesive picture of the events that occurred. All items of tactical interest should be noted, with times entered alongside. To enable the development of events to be interpreted correctly after the exercise, it is important that reasons for decisions are recorded.

2. On ships, this FORMEX is normally kept in the Operations Room/CIC. Large units, e.g. aircraft carriers, may submit several FORMEXs 101 from individual sections (e.g. Operations Room, CIC, TSC, Bridge etc.).

3. Items recorded are to include, but need not be limited to:
   a. Inputs.
      (1) Orders received and special duties assigned, eg changes of operational control, SAU/SAG, threat warnings, changes to orders.

      (2) Information received, including detection of suspected hostile contacts (bearing/range), emergency signals, intruders, identification of contacts.

      (3) Occurrences affecting operations, e.g. breakdowns, weather, visual sightings, out of action times, experience of degrading radar jamming, loss of communication, streaming of towed devices, RAS, logistic problems.
   b. Decision Processes.
      (1) Command appreciation of any change of the situation, statements of policy and intention.

      (2) Contact classification and/or confidence level.
   c. Outputs.
      (1) Information/Orders given to other units or commands.

      (2) Amplifying contact information which resulted in action by own unit.
      (3) Action taken, indicating:

         -extent to which orders were carried out

         -method and tactics used

         -times of attachment or detachment

      (4) Results achieved.

4. This record is to be signed by the officer in command