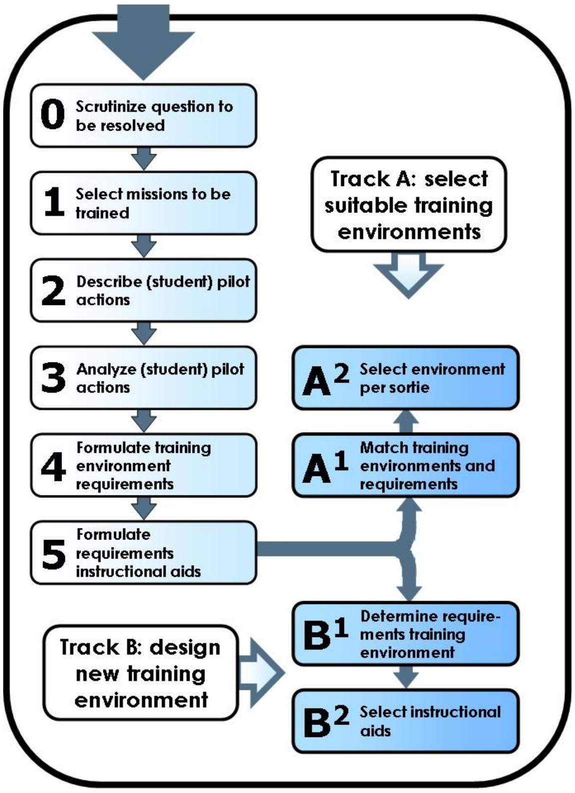
Nationaal Lucht- en Ruimtevaartlaboratorium

National Aerospace Laboratory NLR

Executive summary

The Selection of Realistic Training Environments for Tactical Aircrew Training



Method for the Selection of Learning Environments for Tactical Military Aircrew Training

Problem area
Recent developments in military training simulation technology enlarge the number of aircrew training solutions that can be deployed to reach desired tactical training outcomes. It is expected that despite current budget constraints, the importance of simulation as a training means for military training grows in the coming years. The spectrum of training devices for tactical training has grown rapidly. On the low end of the continuum desktop trainers are becoming more important for higher order (team) training tasks. On the high end of the spectrum –

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besides live training – Distributed Mission Training (DMT), Embedded Training (ET) and Live, Virtual, and Constructive (LVC) training are becoming realistic options for tactical team training. Given the increase of the number of training solutions for military tactical training, the question arises which mix of training environments are best suited to reach tactical training objectives?

Description of work

This paper presents a user-centered method for the selection of tactical training environments for the different weapon systems of the Royal Netherlands Air Force. The method supports tactical and weapons instructors, and squadron staff in the choice of training means for a specific training syllabus. Furthermore it provides a framework for specifiers and buyers to determine the specifications for the acquisition of training means. The method is based on the use case approach for designing software (Cockburn, 2001) and aligns with the competency-based aircrew training design approach as presented by Van der Pal and Abma (2009). The paper describes the underlying constraints and demands, and presents the seven-step method for the selection of realistic training environments for tactical aircrew training. The methodology will be illustrated with a process of specifying the needs for a multi-ship, multi-type helicopter simulation capability.

Results and conclusions

The result of the work is a five-step approach to training environment selection. After these five steps the method discriminates between two paths: 1. the selection of training environments for a given training program and 2. the acquisition of new training means. For each purpose two additional steps have been developed.

Applicability

The method presented in this paper can be used for the selection of training environments for tactical military aircrew training or the acquisition of new tactical training means, including instruction and debriefing tools.

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Abstract

Recent developments in military training simulation technology enlarge the number of aircrew training solutions that can be deployed to reach desired tactical training outcomes. It is expected that despite current budget constraints, the importance of simulation as a training means for military training grows in the coming years. The spectrum of training devices for tactical training has grown rapidly. On the low end of the continuum desktop trainers are becoming more important for higher order (team) training tasks. On the high end of the spectrum – besides live training – Distributed Mission Training (DMT), Embedded Training (ET) and Live, Virtual, and Constructive (LVC) training are becoming realistic options for tactical team training. Given the increase of the number of training solutions for military tactical training, the question arises which mix of training environments are best suited to reach tactical training objectives?

This paper presents a user-centered method for the selection of tactical training environments for the different weapon systems of the Royal Netherlands Air Force. The method supports tactical and weapons instructors, and squadron staff in the choice of training means for a specific training syllabus. Furthermore it provides a framework for specifiers and buyers to determine the specifications for the acquisition of training means. The method is based on the use case approach for designing software (Cockburn, 2001) and aligns with the competency-based aircrew training design approach as presented by Van der Pal and Abma (2009). The paper describes the underlying constraints and demands, and presents the seven-step method for the selection of realistic training environments for tactical aircrew training. The methodology will be illustrated with a process of specifying the needs for a multi-ship, multi-type helicopter simulation capability.

About the authors

In 1995, **Harmen Abma** (1971) received his Master's Degree in Educational Science and Technology from the University of Twente (Enschede, The Netherlands). After fulfilling his military service he started his career in 1996 as a training consultant for Postbank and later worked as a knowledge manager for ING Group's Economics Department. In 2001 he switched to the National Aerospace Laboratory NLR. In his current position of Senior R&D Manager he acted as the government support lead for F-35 pilot training program and is currently program manager for the research program 'Effective Training Solutions'.

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Contents

1 Introduction

In recent years, the possibilities for tactical aircrew training have rapidly expanded: the required infrastructure for Distributed Mission Operations (DMO) training is in place, Embedded Training Systems (ETS) are being implemented in the next generation aircraft and helicopters, Computer Generated Forces (CGFs) are gradually maturing and Live, Virtual, Constructive (LVC) training is finding its way from the research laboratories to the operational airbases. The next generation of synthetic training environments increasingly reflect the complexity of the operational mission environment in a realistic way and are therefore well-suited as a means for tactical aircrew training. As a result of these developments the role of live aircrew training may change, however, its importance does not alter.

The increased number of possible training environments for tactical training raises the question which combination of environments leads to the most effective training and highest operational performance? The answer to this question depends on a number of variables including the training platform, the training program and the experience level of the aircrew to be trained. Innovative training design methods aim to capture the complexity of the operational mission environment, identify aircrew competencies and use both to design competency-based training programs. It is envisioned that a user-centered training environment selection method that is based on a competency-based training design approach, helps to further increase training effectiveness. Most training design approaches, however, do not provide a method that assists in selecting the most suited training environments for a given training sortie. To complement the current aircrew training design approaches this paper aims to answer the following question:

> 'Which user-centered method supports the selection of training environments for tactical aircrew training?'

This leading question can be decomposed in the following four sub-questions:

1. Which are the existing methods for the selection of training media for complex learning tasks?
2. What are the constraints and demands for the development of a selection method for tactical training environments?
3. Given the identified constraints and demands, which method supports the selection of training environments for tactical aircrew training?
4. What are the first results from applying the method in practice?

Learning environment selection has two dimensions: 1. the selection of existing learning environments for a given training program and 2. the acquisition of new learning environments. This paper addresses both perspectives.

To answer the leading question this paper first addresses the framework that applies to aircrew training environment selection. Next, the subject of training media section in relation to training design is explored. Subsequently, the method is described, followed by the presentation of the results of the first application of the method for the feasibility study of a multi-ship, multi-type helicopter simulator for the Dutch Defense Helicopter Command (DHC). The paper concludes with a discussion on the presented method.

2 Defining the framework for the selection of training environments

The design of the training environment selection method that is presented in this paper has been conducted in a systematic fashion. This means that first the leading concepts used in this paper are defined and the scope is determined. Next, the objective and target audience are presented. Finally, demands and constraints that lay the foundation for this method are described.

2.1 Training Environments for Tactical Training

In this paper a distinction has been made between training platforms and training environments:

- Training platform
  Aircraft, helicopters, simulators or serious games that are used to enable student aircrew to master certain competencies.
- Training environment
  The training platform in interaction with a real or synthetic environment required to safely and effectively execute the training mission.

According to these definitions training environments incorporate training platforms. Training value is considered the result of the quality of the platform and the environment.

As the perspective for this method is tactical training, academic training environments like Computer-Based Training (CBT) and instructor lead class room training (in italics in the figure) are considered out of scope. Tactical training platforms and training environments can be arranged from simple to complex (see Figure 1). Simple environments are desktop trainers or serious games, while the more complex environments include Live, Virtual, Constructive multi-ship environments in combination with an advanced tactical flight range.

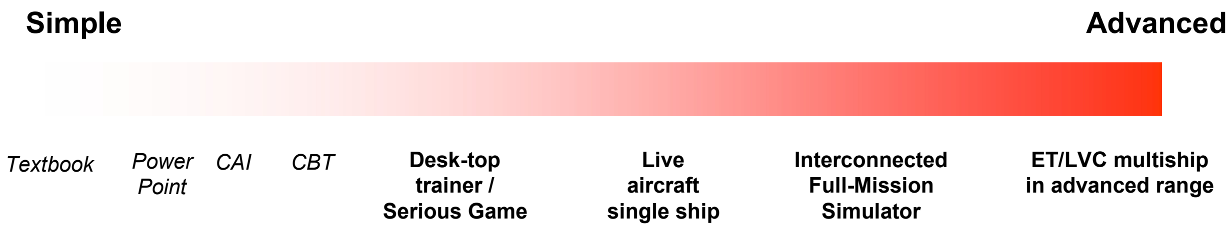

Figure 1 Continuum of Training Environments

2.2 Objective

The objective is to design and develop a user-centered method for the selection of tactical training environments for military aircrew training.

2.3 Audience

The method that is described in this paper primarily aims to support training designers, simulation experts and procurement staff in the selection of training environments for scheduled training sorties and the acquisition of new training media. Tactical and weapon instructor pilots, flight commanders and operations officers and squadron commanders are involved in the process as subject matter experts (SMEs). All actors play a part in the selection process. Their time is often scarce; therefore the method should be flexibly adaptable to the available number of resources and time.

2.4 Demands and constraints

The demands and constraints for the design of the selection method for tactical training environments that have been formulated state that the method shall:

- Reflect the inherent complexity and dynamics of aircrew training in a mission environment;
- Align with existing competency-based aircrew training approaches (e.g. Van der Pal & Abma, 2009);
- If possible, build upon existing selection methods for advanced training media;
- Support the target audience in the selection of training environments in a comprehensive way;
- Be scalable and adaptable to addressing different kinds of questions, including the acquisition of new training media and the selection of existing training environments;
- Provide insight in the amount of realism required for achieving the training objectives;

- Be applicable to the training environments for initial, recurrent and continuation training, and aircrew at different experience levels, ranging from student pilots to mission commanders;
- Comply with requirements concerning training devices as stipulated by the Netherlands Military Aviation Authorities.

3 Training media selection

Before the method is presented, this section reviews existing methods for the selection of advanced training media. Also recent perspectives on competency-based training design are reviewed, followed by the discussion of military aviation requirements for simulators.

3.1 Existing Methods for Training Media Selection

Many instructional design models have defined an explicit step or an activity that aims to select training media or delivery modes (Van der Pal et al., 2010). This step usually starts after designing of the training program and specifying of the concrete training tasks. However, there are only few instructional design models that provide a framework that guides the selection of advanced learning environments. The so-called GOLM-method[1] (Verstegen et al., 2000) is an exception to this rule. It offers a systematic approach to the development of a needs statement for the acquisition of advanced training systems. Even though the method was developed for the Royal Netherlands Army, there are a number of parallels with the method that is presented in this paper. First, the GOLM-method takes a mission perspective and explicitly uses operational scenarios as an information source to define the training need. Second, it acknowledges the importance of an existing training program as one of the pillars for the definition and selection of training environments. Third, the method incorporates a step to specify the needs for the facilities for instruction, feedback and assessment, based on a given training philosophy.

The GOLM-method, however, lacks specific guidance on how to gather information about the operational missions, the target audience and existing training programs to drive the selection process of advanced training systems. It acknowledges the importance of these sources of information, but it does not offer insight in the relationship between these different information elements and the motivation to select a specific training environment.

[1] GOLM: Geavanceerd OnderwijsLeerMiddel (Dutch), which can be translated as ‘Advanced Training System’.

The method presented in this paper aims to extend the view on training media selection and provide explicit guidance on the question of how to systematically translate the competency-based design parameters of a training syllabus to the selection of the training media to be used.

3.2 Training Design and Media Allocation

The preferred starting point of the selection of a rich and powerful training environment is a well-designed training program. In the past decade the instructional design models on the acquisition of complex skills in a dynamic environment have made a large stride (Van Merriënboer, 1997; Van Merriënboer & Kirschner, 2007). Earlier design models offered a fragmented vision on learning and instruction and did not provide a design framework that was able to handle task complexity adequately. Van der Pal and Abma (2009) constructed a domain specific competency-based training design approach for military aircrew training, based on Van Merriënboer's (1997) 'Four-component instructional design model' and the EuroTraining needs analysis (Van der Pal & Ligthart, 2003). Their approach aims to design training programs that steepen the student's learning curve and optimize his or her workload. The competency-based character of this method implies that it targets at the skills, knowledge and attitudes aircrew require to effectively execute an operational mission in a non-permissive environment. Important design parameters in this design approach are:

- Whole task training sorties
  - Based on realistic scenarios;
  - Taking place in a realistic environment;
  - Emphasizing specific aircrew competencies to be trained;
- Optimized (student) pilot cognitive load by
  - Setting complexity of operational conditions;
  - Offering part-task training;
  - Controlling instructor support levels;
- Academic training
  - To provide cognitive models and problem solving strategies needed to operate the aircraft or helicopter as a weapons system.

As student pilots progress through a tactical training program demands on the training environment evolve. Building cognitive, mental and psychomotor competencies required for future mission success demand an optimal mix of training environments. Variables in the operational mission environment determine the setting in which a crew has to execute its mission. Capturing these parameters allows training designers and squadron instruction staff to design high quality training scenarios. In turn these scenarios provide the basis for the selection and creation of an effective learning environment matching the performance level of the aircrew to be trained. Such a program reflects the operational environment – including the 'own ship' – in a realistic way, targets the competencies that need to be trained and provides the possibility to actively control student pilot cognitive load. This does not imply that the realism of the operational or wartime mission environment always needs to be reflected in a training environment. The objective is that the training environment offers a student pilot the opportunity to acquire the competencies that are subject to a certain training program. In other words, the realism of a training environment should allow the instructor and the student to achieve the training objectives.

The main anchor points for the selection of learning environments that are derived from the aircrew training design approach (Van der Pal & Abma, 2009) are presented in Table 1 below:

Table 1 Anchor Points for the Selection of Training Environments

Anchor points
1. The operational mission
2. The competencies to be acquired
3. Instructional support

The first anchor point for the definition and selection of a training environment is the operational mission. A mission can be described in terms of:

a. the characteristics of the target(s) or mission assignment;
b. the nature of other assets (blue forces and grey forces);
c. the characteristics of the threats (red forces);
d. the environment in which the mission takes place;
e. the characteristics of the 'own ship'

The competence of a pilot is determined by the ability to execute a task in a certain environment. Therefore the competencies to be trained in a training sortie are the second anchor point. This emphasizes the importance to align the training environment with the ability level of the student and offer them a challenge, yet preventing overload. Training effectiveness, however, is not solely the product of the training program and learning environment. Consequently, the third anchor point is instructional support, which refers to all activities an instructor may undertake to teach student pilots, observe their actions, intervene, provide feedback and assess performance.

3.3 Military Aviation Requirements for Simulators

Since 2005 the Netherlands have an independent Military Aviation Authority (MAA-NLD), which oversees the safe operations of military flight operations. Jansen and Koolstra (2010) converted the civil JAR-Flight Simulation Training Devices (FSTD) to the military equivalent: Military Aviation Requirements (MAR) – Flight Simulation Training Devices (FSTD). As civil and military operations differ considerably and military simulators are not always built against a specific standard, Jansen and Koolstra (2010) concluded that a different approach to simulator qualification was required. MAR-FSTD was developed to qualify training simulators for flight training and not for tactical training. The MAA-NLD designed a simulator qualification system that rates all major FSTD-features instead of rating the entire simulator and identifies the consequences of a rating for the different training tasks that can be performed on the simulator instead of the aircraft or helicopter.

The scope of the MAR-FSTD is complementary to the framework that is presented in this paper: MAR-FSTD focuses on flight training, while the scope of this paper is tactical training. As the military training squadrons use most simulators both for (recurrent) flight training and tactical training, in many cases MAR-FSTD provides the baseline for the selection of simulated training environments.

4 Method

This paragraph presents the method for the selection and specification of training environments for tactical aircrew training. The method is both suited for the selection of existing training environments as well as the identification of the requirements for the acquisition of new training environments (see Figure 2).

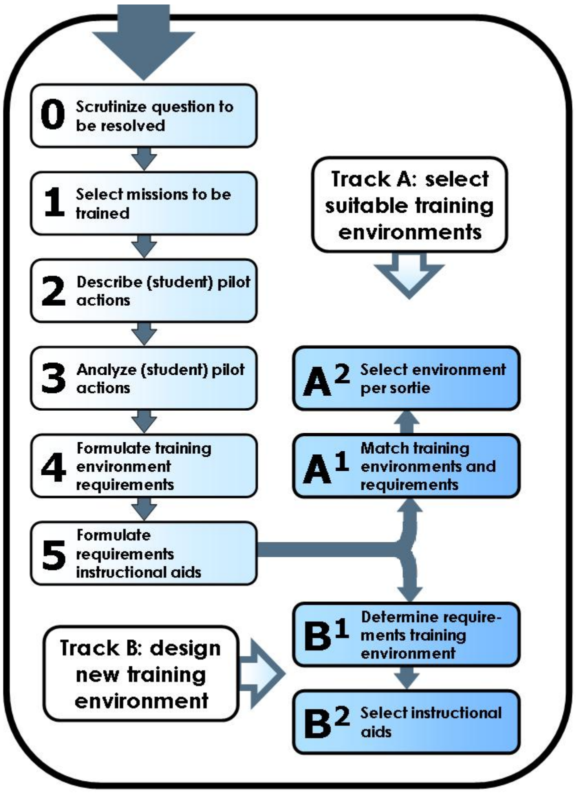

Figure 2 Overview of the Method

Step 0 to 5 are common for both purposes. Steps A1 and A2 focus on the deployment of existing training environments that are available at the home squadron or abroad. Steps B1 and B2 are designed to support the acquisition of a new training environment.

The method is presented as a linear approach. However, it should be emphasized that it has an iterative character, which makes it possible to go back to previous stages.

As stated earlier this method to the entire spectrum of training environments. It aims to identify which training means can be deployed to effectively train aircrew, ranging from desktop trainers/serious games, single ship live training to ET/LVC multi-ship operations in an advanced range.

4.1 Step 0 – Scrutinize question to be resolved

The method provides a systematic approach to the selection of training environments. Therefore, the objective of this initial step is to clearly describe the question to be answered or the problem to be resolved and determine the demands and constraints that apply. Typical questions that are addressed in this step are: what is the weapon platform to be considered? What is the target audience (student pilots, squadron pilots)? How many subject matter experts

(SMEs) are available and how much time can they spend on this project? Which other training devices are already in use? What are the experiences with these devices? Is there an existing training program? What are the experiences with the current training program and training environments? Is there a regulatory framework in place? What is the budget for the acquisition and for the life cycle costs?

During this initial step the question is also raised how the method itself should be tailored to deal with constraints, like the number of SMEs and the time available.

Output

- Project plan, which includes a proposition to adapt the method for this specific casus.

4.2 Step 1 – Select missions to be trained

After determining the leading question for the project and describing the demands and constraints, the first step of the method is to select the missions for which the training environments need to be utilized. Each platform has a list of missions. Due to time constraints focus may have to be given to the most demanding signature missions and partially incorporate other mission elements in this signature mission. For the composition of the AH-64 Apache backseat pilot competency profile (Abma et al., 2009), for instance, the deep attack mission was used as the signature mission.

Information may be reused from earlier training design projects in which a mission analysis has been performed. Other possible information sources to work with are Concepts of Operations (CONOPS) or the Tactical Operations Procedures (TOPs).

If the project team lacks recent experience with the missions and/or the platform, it is advised to observe the planning, execution and debriefing of a mission – preferably in a simulation environment – to get a clear picture of the operation.

Output

- List of missions;
- Signature missions and/or mission categories;
- Mission descriptions.

4.3 Step 2 – Describe student pilot actions

In this second step the mission descriptions are further analyzed and worked out into so-called use cases (Cockburn, 2001). Use cases are utilized in software development projects and systematically describe the interactions between a user and a system in natural language terms. Use case modeling offers an approach that can also be applied to describe and analyze the interaction between actors and other systems than software applications. In this method it is used to describe the interaction of the aircrew with the weapon system and the mission environment. The utilization of use cases helps to focus on the needs of the future users of the training environment by describing and – in step 3 – analyzing their actions.

The operational environment provides the baseline for the design of the training environment. Therefore, the starting point for the description of a use case for an aircrew training environment is the different operational mission scenarios that have been conceived in step 1. During this second step use cases are utilized to capture the interaction of experienced pilots with the aircraft and its environment. The objective is to gain insight in the design parameters of the training environment.

Cockburn (2001) defines twelve steps to describe a use case. The four use case steps that are covered in step 2 are:

1. List the user goals – e.g. the competencies pilots aim to learn using the training environment;
2. Describe the main success scenario – e.g. the way in which an experienced pilot would carry out the mission;
3. Describe a. stakeholders, b. preconditions and c. guarantees – e.g. a. pilots and instructional staff, b. the preceding training syllabus sortie and, for live training, the minimally required weather conditions and c. the training outcomes;
4. Extend complex use cases and combine sub-use cases.

Writing use cases is a time consuming activity. As use cases can be described at many different levels, the amount of detail should be carefully aligned with the project objectives. It is advised to initially formulate use cases at a global level and add more detail in later phases.

Output

- Worked out use cases for the selected missions.

4.4 Step 3 – Analyze student pilot actions

The objective of the third step is to analyze the use cases in terms of competencies to be trained, common student pilot mistakes and possible instructor interventions to help pilots to master the selected competencies.

First, the competencies that are addressed in each use case step should be listed. If there are multiple target groups involved in the training program, the competencies to be trained should be listed for each group individually. Next, instructors are asked what the mistakes student pilots often make and what problems they encounter when learning certain competencies. Competencies and problems provide triggers to formulate training environment requirements.

It is advised not only to focus on tactical competencies, as flight related skills may also be important for mission success. In addition to using workshop formats or group interviews, questionnaires may be used to gather information.

Output
- Overview of competencies to be trained and common learning difficulties per use case step.

4.5 Step 4 – Formulate training environment requirements
This fourth step aims to identify the required fidelity level of the training environment using the selected signature mission.

The characteristics of the training environment can be described in terms of a. the assets and threats, b. the environment and c. the 'own ship'. Additional categories may be added to this list. 'Assets and threats' include the size and nature of their own package, and the blue, red and grey forces required for the mission. The 'environment' refers to e.g. the geographical environment, the natural environment (terrain, weather, etc.) and the lighting conditions (sun, moon, stars, rest light). The 'own ship' refers to all relevant characteristics of the aircraft or helicopter. Especially for drawing up simulator requirements, the required fidelity level of hardware and software components of the 'own ship' is an important issue. For tactical training, a high fidelity replication of the 'own ship' is not always needed to provide sufficient realism to achieve the objectives for tactical training. The central question is what the required realism is of the different training environment components.

Again, the use cases described for the signature mission or missions are the starting point for this step. For each competency to be trained the minimal demands on the fidelity should be listed for the assets and threats, the environment and the 'own ship'.

When identifying the demands on the training environment, a distinction should be made in experience levels of the aircrew to be trained. The demands on the training environment for inexperienced F-16 wingmen, for example, differs form the training environment Flight Leads need to sharpen their skills.

If the demands for all competencies are identified, a list of functional requirements can be composed.

Output

- List of functional requirements for the training environment regarding assets, threats, environment and 'own ship'.

4.6 Step 5 – Formulate requirements on instructional aids

The objective of this fifth step is to identify the required instructional aids for tactical or weapons instructors. Selecting a suitable training environment alone does not guarantee effective training. The instructor fulfils a crucial role in enabling student pilots to learn and improve their performance. This applies both to live, virtual and blended training environments. Current training environments – live and virtual – offer the instructor a broad scale of support aids to give instruction, including Head Up Display (HUD) tapes, flight path analysis tools and weapon scoring sheets. The suitability of these aids for training depends on the experience of the aircrew to be trained and the possibilities to observe their behavior. Instructing experienced pilots in live single seat aircraft, for instance, provides little opportunity to directly observe a student pilot, while instructing pilots in a multi-crew simulator setting offers many possibilities to instruct the crew either from the Instructor Operating Station (IOS) or from the instruction seat. The question is which instructor aids are most suitable given the constraints of the training environment? As such, this step intends to identify the needs of the instructor as one of the main users of the training environment.

The anchor points for the selection of training aids are the instruction strategy, the student pilot characteristics, the mission and the competencies to be trained and the characteristics of the training environment. For each competency the cues an instructor prefers to use to assess student pilot's performance need to be identified. An example of the cues an instructor uses to assess the tactical decision making process in a multi-crew environment is listening to internal crew communication. For each of these cues suitable observation means can be selected, given the training environment. Internal in-flight communication in a two-pilot Apache AH-64, for example, can only be directly observed if the instructor is one of the crewmembers. If the instructor is on the ground or on board of another Apache in the package, the instructor needs to replay the communication during the debrief or the instructor should base his judgment on the mission outcomes and the pilot's self-assessment of the mission.

The Air Force Research Lab (AFRL) has conducted a significant amount of work to into the measurement of performance in an F-16 DMO environment (Carolan et al., 2003; Schreiber & Bennett, 2006). Data that is exchanged between the simulated entities on the DMO network is captured and used for performance assessment purposes. The AFRL toolset provides instructors a number of possibilities to give feedback on their performance at different levels. Measures of effectiveness, such as kill ratios, bombs on target, fratricides and mortalities, can be assessed in objective terms. Measures of performance that can be calculated on performance data are success in weapon engagement zone management, radar use, crank angles, notch mechanics and communication. Examples of competencies that need subjective assessment are situational awareness and tactical situation assessment (Carolan et al., 2003).

Depending on the instruction strategy, the available observation means, the competencies to be trained and the training environment possible instruction aids can be selected. The instruction strategy depends – amongst others – on the experience level of the aircrew, but also on the roles of the student and the instructor. Experienced pilots are debriefed in a different way than novices. To give both adequate feedback on their mission different observation tools are required. Especially when purchasing new training environments, implementing new missions or new weapon platforms this step can help instructors to align their instruction strategy with the possible observation means and instructional aids.

Output

- List of possible observation means and instructional aids per competency and mission category.

4.7 Step A1 – Match training environment and requirements (selection of existing learning environments)

The objective of this step is to select the most suitable learning environments for a specific mission category, using a generic Decision Support System (DSS). This step is targeted at the selection of existing learning environments.

The starting point for this step is a list of possible training environments that can be used to train aircrew for a certain mission. For instance for F-16 training for a certain mission the options could be live training at the Dutch North Sea ranges, live training in Nevada (US) or virtual training using a four ship simulator set. For each mission category the competencies to be trained have been identified in step 3. Based on the mission and the competency level of the pilots to be trained, the weighing criteria on the training environment are determined, expressed in terms of the assets and threats, mission environment and the 'own ship'. The following activity is to rate the suitability of the different options. Next, the costs per training hour are estimated. If all information is available, the total score per training environment is calculated to assess the suitability of all training environments.

This activity is time consuming. To save time it is advised to select the competencies and characteristics of the training environment that are most crucial for training the target group and rate the different learning environments on these items.

Output

- Top three of suitable learning environments per mission category.

4.8 Step A2 – Select training environment per sortie (selection of existing learning environments)

The goal of this step is to assign the most suitable training environment for a specific sortie in the training program. This step also applies to the selection of existing learning environments.

Again, the main drivers for the selection of a training environment are the mission to be trained, the competencies that are emphasized in a specific training sortie, the experience level and the role of the pilots to be trained. The demands on the training environment are copied from step A1 (assets and threats, environment and 'own ship'). In addition to these demands also the logistical constraints are taken into account. For instance, when travelling abroad the benefits of training at the local facilities or ranges should be maximized. It is possible that the logistical constraints lead to an adaptation to the training program. Next the most suitable training environment is determined per sortie based on the demands.

Output

- Carefully selected training environments for all training missions in the syllabus, taking into account logistical constraints and costs.

4.9 Step B1 – Determine functional and technical requirements (acquisition of a new training environment)

This step aims to draw up the functional and technical requirements for the acquisition of a new training environment.

All functional requirements on the training environment that are identified in step 4 for all training categories are added and organized, resulting in an exclusive set of requirements. In this step, simulator experts translate these user requirements into functional and technical requirements.

User requirements – written in the steps 0 and 1 – are statements, in a natural language or expressed in diagrams, of what services the training environment is expected to provide and the constraints under which it must operate. They should only specify the external behavior of the system, and should avoid system design characteristics. For example: pilots and Forward Air Controllers (FAC) shall be able to train together or Combined Air Operations (COMAO) training shall take place in association with Airborne Warning And Control System (AWACS) and Joint Surveillance and Target Attack Radar System (JSTARS) (from Air Tasking Order until debrief).

Functional requirements build upon user requirements and capture the intended behavior of the system. This behavior may be expressed as services, tasks, or functions the system is required to perform. Example: it shall be possible to connect the FAC trainer to the Mission Training Centre.

Technical requirements, in turn, are based on the functional requirements. They describe the characteristics, attributes, or distinguishing features, stated in terms of quantified performance requirements and design constraints, that a system element must have to meet the functional requirements. Examples are the requirements on the interconnection between the two simulators via HLA IEEE 1516-2000 or the bandwidth of the connection of minimally 1GB per second (TNO and NLR, 2007).

Output

- List of functional specifications per training environment;
- List of technical specifications for the training environment.

4.10 Step B2 – Select instructional aids (acquisition of a new training environment)

The purpose of this step is to select the most suitable instructional aids using a DSS.

The possible observation means and instructional aids are copied from step 5. For each competency the weighing criteria are determined and the importance of each of these criteria is fixed. Relevant criteria include effectiveness, stability, reliability, usage and process time and costs. Subsequently, the instructional aids are rated and the scores are calculated. This results in a substantiated list of suitable observation means and instructional aids.

Output

- Substantiated list of instructional aids per competency.

5 Validation

The method as presented in this paper was first used in a project to define a multi-ship, multi-type simulation training environment for relevant operational helicopter types of DHC (the so-called MSMT-project). These types include the CH-47 Chinook, the AH-64 Apache and the NH-90 Tactical NATO Frigate Helicopter (TNFH). The evaluation of the method has resulted in a number of suggestions for improvement. These suggestions have been analyzed and, if applicable, used to improve the method.

The primary conclusion of this first trial is that the method is quite extensive and needed to be adapted to match the available time and resources. The use of signature missions throughout the different steps to use the available time more efficiently originated from the MSMT-project. A practical advice was not only to use a workshop setting to gather information. When the global picture has been sorted out questionnaires can be used to fill in the details.
In step 3 – Analyze student pilot actions – it was found that identifying commonly made mistakes is not sufficient to analyze student pilot actions. The training environment needs to enable the problems aircrew encounter when executing a mission. Setting up the communication for a multi-ship mission and tuning the radios to the right frequencies in time is an example of a basic task that needs training. The method was adapted to broaden the horizon in this step and also ask for problems crew and instructors encounter.

In step 4 – Formulate training environment requirements – it appeared that instructors were often inclined to directly focus on detailed requirements that are important for the mission, instead of working from general to concrete. Examples of the details are the cues that SMEs use in a mission, like the direction of the wind that can be read from the smoke markers, muzzle flashes and fleeing civilians. The method describes to analyze the training environment requirements per mission and per competency, and differentiate between the cues that are important for aircrew at different experience levels. This analytical approach can also be used as a check after the SMEs have listed the requirements and check whether the key competencies are covered and the requirements of both novices and experts have been addressed.

In step 5 –Formulate requirements instructional aids – it appeared that SMEs often referred to their experience with a specific simulator to indicate which instructor aids they wish to have in the MSMT-simulator. In this step the focus should be on the cues instructors use to observe certain tactical competencies, given the training platform. It is envisioned that the analytical approach of first identifying the cues, then the observation means, followed by the instructor aids needs more explanation to go beyond user experiences to select the most effective aids.

As a result of the study the general outline of the model remained unchanged. As can be concluded from the above the content of the different steps as well as the working procedures have been refined after this first usage. The execution of the method proved to be time consuming. Therefore efficiency gains have been implemented in the method and the guidance materials provides suggestions to flexibly adapt the method to the project objective.

From this first trial it was concluded that the method is a promising instrument for the specification of tactical training environments, as was the objective of the MSMT-study. The student actions, as identified and analyzed in steps 2 and 3, provide a baseline to define training environment requirements. However, it is the users' responsibility to assure that the relevant tactical aspects are adequately tackled in these steps. The method itself does not automatically identify these tactical issues. The guidance material however provides instructions how to derive tactical requirements in the different steps of the method. Tooling that is be developed to support the execution method also provides support.

It is expected that future utilization of the method will lead to insights that will help to further develop the method and the corresponding toolset.

6 Conclusion

The method presented in this paper aims to offer a scalable and flexible approach that can be used to select available training environments for aircrew training or support the acquisition of new training environments. The method is aligned with the instructional design approach for aircrew training by Van der Pal and Abma (2009). As such, it builds upon the driving factors under a solid training design. It seeks to offer student pilots a cost-effective environment to sharpen their tactical competencies and help instructors and squadron staff to gain insight in the effectiveness of instructional aids and training environments.

The method will be expanded with a set of tools, including questionnaires and checklists. Moreover, a database will be designed and constructed to capture the acquired knowledge on the training environments for all flying weapon systems of the RNLAF, so this database can be used in future projects.

7 Discussion

The allocation of training environments for aircrew training is often based on instructor experience. For existing weapon systems and training environments instructors probably make a close to perfect decision on the training environment to select. However, if new aircraft or helicopters are introduced or new training means are to be acquired often existing instruction staff does not have practical expertise with these systems. In these cases a systematic approach to training environment selection helps to base the choices to be made on the missions, the instruction strategy, the competencies and the target audience to be trained.

The approach described in this paper has been built on a competency-based aircrew design strategy and gives the users – student pilots and instructors – a centralized position in the method. It is believed that a user-centered training environment selection method that has its roots in a competency-based training design approach can help to build better training environments and increase training effectiveness of military aircrew training.

The first application of the method has revealed that flexibility and scalability are crucial, as the different steps have proven to be quite time consuming. In the future this method will be tested and developed further to better match the training needs of the next generation military aircrew.

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