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Performance Based Training

White Paper for RLNAF

DEPARTMENT: **Training, Simulation and Operator Performance**

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Introduction

The 5th generation Air Force must be deployed rapidly within a broad spectrum of military and humanitarian missions. To perform these missions, in a range of contexts, extensive training is essential. This is necessary to achieve and maintain the required level of proficiency. High standard training is expensive, while loss of proficiency is unacceptable. Loss of proficiency leads to unsuccessful missions, organisational inefficiency, and incidents or accidents. In other words, decreasing proficiency puts people at risk!

Problem statement

At the time of writing, RNLAF training strategy does not optimise the use of available training assets. Training is standardised per community, and each pilot receives approximately the same training. However, every pilot has an individual learning curve and his or her training must always reach the level of proficiency required for deployment in high threat scenarios (as per the RNLAF ambition statement). At present, instructor communities keep track of training in manual gradebooks and in their heads. This is however a subjective mechanism prone to individual instructor bias. Programmes do exist to standardise subjective gradings (e.g. in civil aviation: Evidence Based Training), but the digital era also provides us with tools to objectify tracking of training results and data analysis. This in turn makes it possible to provide each individual pilot with training most beneficial to their own personal learning or retention curve.

Implementing Evidence or Performance Based Training (PBT) is, however, not a plug and play solution. PBT makes for a far more complex future training environment and introduces many other challenges, such as cultural change and objective scoring. When introducing a new training concept and associated technologies, it is important to be aware of the capabilities and most importantly what impact they will have on the entire training environment. This, in turn, may well require an integrated system such as the ADL envisioned Learning EcoSystem.

Goal

Over the last decade, advances in technology such as artificial intelligence, data-science, learning analytics and the internet of things, are enabling implementation of new training strategies, such as PBT. The goal is to utilise the available training assets (flying hours, simulator hours, and individual man-hours) optimally to achieve the highest possible performance in the most efficient and effective manner, given the constraints present (e.g., financial, airspace, environmental rules). This results in readiness as defined by the organisation, and the highest possible level of personal performance.

Approach

A change trajectory utilising technological and data driven innovations, with such an enormous impact on the training environment will always be a long process. It will require a high level of integrated commitment to prevent frustration and dropout. There will be concerns from those working with the system about, among other things, loss of control, competence in dealing with the new system and about increase in work load. Trainees may also feel threatened by the amount of data being collected on their performance. All of which must be managed through involvement by all stakeholders and through specific measures such as a technical privacy solutions that ensure the pilot has access to all of their own data, while other stakeholders may only consult a relevant selection or aggregated level of the data.

In this document our definition and the end state of PBT are described, as well as a roadmap with a stepwise approach to setting up and working with PBT.

What is PBT?

Performance Based Training (PBT) is not necessarily new to the military pilot community as instructors apply a basic, intuitive version of this method almost every day. The instructor feeds a talented student more complicated problems in an earlier stage of training, whereas, for a struggling student, they will adjust the training to a slower pace with extra instruction. During a course or training cycle, instructors keep a mental picture of each pilot's individual progress. An instructor will always do their best to challenge an individual to their own respective limit, the end goal being as capable a community as possible.

PBT is a training approach that tailors training to the specific needs of the individual, taking the larger collective into account. This is done by measuring, tracking, analysing, and modelling each individual's performance (data) throughout their operational career. Performance related measures include objective task performance outcomes, quality of process measures, mental state (e.g., workload) and behavioural measures (e.g. point of gaze, communication). Analysing this data for training is often labelled 'Learning Analytics'. PBT can be applied to initial training (learning) or to refresher training (retention) and is most effective when used with a Competency Based Training framework.

Competency Based Training is a top-down approach for generating training programmes (syllabi) suitable for complex competency structure tasks and jobs. Competencies are identified and structured in a hierarchical competency & skills profile. With PBT, the training needs of each individual are fine-tuned and based upon individual performance (bottom-up fine tuning). This results in individual and flexible training programmes with PBT software keeping track of personal competences and skill development. Weak and strong areas are identified and learning curves or skill decay are monitored and predicted individually. This reveals individual training needs and then proposes differing exposure to training and types of training per individual. A personalised approach means that training takes the individual's training needs into account. It does not imply that training for all individuals can be planned perfectly according to each individual's needs, as training resources are scarce, certainly in aviation.

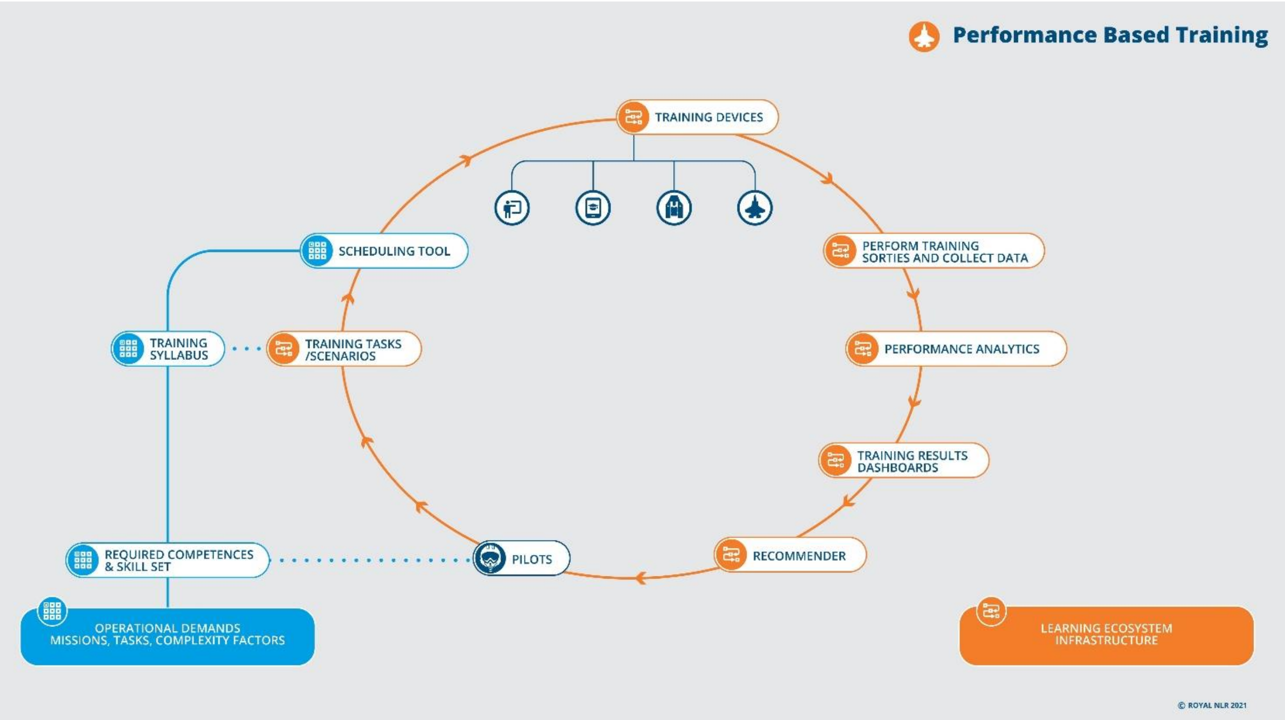
The Air Force Research Laboratory, AFRL, works with a similar framework and has redefined PBT as Proficiency Based Training. In our paper, the P may stand for Performance, Proficiency, or for Personalised. The three P's highlight different aspects of an otherwise similar concept.

This paper discusses the different elements involved in PBT regarding refresher / continuation training (CT). As an example, we will take the fighter community, however the PBT principles are valid for all pilot and other operational MoD communities. PBT may also be applied to qualification training, requiring similar principles, but worked out in a different way.

Elements of PBT

The infographic below contains the main elements of a PBT-cycle. Following the infographic, the end state of each of these elements is described in a way similar to a ConOps, using the fighter pilot community as an example. For each community, the PBT cycle starts with a generic training syllabus. The more cycles that have been completed, the more data collected, and thus the more personalised the system becomes.

A full PBT- cycle cannot, of course, be developed overnight and several steps are needed to reach this state. We therefore conclude with a basic roadmap to guide you towards a stepwise CD&E based implementation of full-scale PBT.



OPERATIONAL DEMANDS MISSIONS, TASKS, COMPLEXITY FACTORS

Operational demands, set out in the 'Aanwijzing Gereedheid Defensie (AGDEF – Designation Defence Readiness) are the starting point for Continuation Training. Combined with conditions (also known as complexity factors) such as level of threat, climate, and type of collaboration these operational demands impact the type and level of training required.

REQUIRED COMPETENCES & SKILL SET

A profile of the competencies and skills required for a combat ready fighter pilot, based on operational demands, must be identified. This profile should not only contain knowledge of procedures, tactics, weapons, systems, sensors, and opponents, but also competencies such as decision making, flexibility, planning, (de)briefing, aircraft handling and so on. The perfect fighter pilot would accomplish a maximum score on all aspects of this profile.

Over time the profile will change with new equipment and shifts in adversary capabilities. The system could suggest updates to the 'master profile' based on the data processed.

TRAINING SYLLABUS

A Continuation Training (CT) syllabus contains Techniques, Tactics, Procedures (TTP's) and all types of missions. The community uses the syllabus for flight training and a list of academic subjects, class sessions or e-learning modules. The CT-syllabus also contains a list of complexity factors such as GPS loss, weather, degraded systems, night, or changes to the battlefield that can be applied to training missions to increase complexity of the training. A competence and skillset template is placed alongside each mission (or training event) in the CT-syllabus marking exactly which competences and skills will be used/trained/challenged in the respective mission (or training event). These competencies and skills form the basis for good performance and are, alongside measurement of more technical skills, a way to evaluate and improve performance at a deeper level. If a TTP or mission is unsuccessful, an analysis of the underlying competency deficiency then forms the basis for further training (instead of merely a repetition of the TTP or mission). Underlying competencies must then be improved to assure flexible application of the competency, independent of a specific TTP or mission.

Within the CT syllabus, an individual optimum time period between exposures is set for each item. This is done to ensure that minimum exposure is required to regain proficiency.

PILOTS

For each individual within the community (in this example a squadron) a profile as mentioned above is maintained (in the database) with all skills and competencies scored according to their individual performance. Proficiency will decay over time, following the pilot's individual retention or skill decay rate.

The prediction of personal retention and skill decay rates may not be immediately possible at the start of an individual's career, but, given time, AI (machine learning) will be able to predict these more specifically. At the start of one's career, the system may therefore take the average decay rate of inexperienced members of the community (squadron, wing, base, or air force). These predictive models are however dynamic and will change over time with growing expertise and datasets.

TRAINING TASKS /SCENARIOS

In time, the standard CT syllabus construction and sequence of training missions (as described under 'Training Syllabus') may no longer suit the needs of the individual pilot. At that point, the syllabus functions merely as a training task database with associated scenarios that can be used for scheduling, to get the squadron as a whole and the individual pilots in the squadron to the highest achievable standard given the constraints (budget, flying hours, sim hours, man hours etc.). As training task sequences and schedules increasingly personalise, support systems to determine the optimal next training tasks and how this can be scheduled optimally considering all pilot needs, will be needed. Such support can be provided by a recommender and a scheduling tool (see below).

TRAINING DEVICES

Every community has several different training devices available to them, such as the aircraft itself, which may be combined with simulation (Embedded Training, LVC), Full Mission Simulators (stand alone or networked), VR and AR systems and/or e-learning. In the PBT system the most efficient and effective training device is selected for training the individual on the tasks/scenarios and competencies needed. These are then put to use in the most efficient way possible.

PERFORM TRAINING SORTIES AND COLLECT DATA

The PBT system must gather data for computerised statistical analysis. It must be fed with a substantive amount of data to perform at the desired level. The following data is needed from every refresher training:

- Training task information (e.g., training objectives, complexity level, instructor, training media, team composition)
- Context in which the training task took place (e.g., specific Complexity Factors (CFs), events, quality of teamwork)
- Training task performance information (e.g., order of pushed buttons, scanning patterns, response time, decision making, number of errors, errors corrected, accuracy)
- Personal physical information (e.g., physical, mental, and environmental conditions)
  The database will be classified as needed in order to protect individual data

Note 1: Most of this data is stored on the PMD for live missions and on servers for missions in the FMS.
Note 2: Apart from experiences in training, it is also important to collect data from e-learning events and operational missions, as this impacts the level of (tactical) proficiency and the need for training.

PERFORMANCE ANALYTICS

All of the information above is used to analyse performance (using techniques often referred to as Learning Analytics). This is carried out to support debriefing and, in the end, to define the level of a certain competence or skill as demonstrated by each individual. For correct analysis of the data the system needs coding of ‘correct’ or ‘optimum’ behavior for *smart agents* (AI based entities for threats, opponents, or own force elements) running against the same data. It can then recognise deviations from optimum behavior in a pilot’s actions (targeting plans, shot mechanics, weapon and sensor handling etc.). The system can then provide feedback to the individual pilot, the instructor, or flight lead. Based on these deviations and the end results the system can indicate the demonstrated proficiency level per individual for each competence or skill. The instructor or flight lead will review and, if necessary, correct the outcome and then feed the data back to the competence profile, updating the individual competence profile, retention interval and/or skill decay rate. This correction or fine-tuning is not limited to instructor or flight lead observations as self- and peer evaluation information should also play a major role in this process.

The core of PBT is the resulting data on individual retention and decay rates for tactics, (emergency) procedures, Missions, CF’s, and competencies, all compared to maximum retention intervals and/or absolute minimum proficiency levels

TRAINING RESULTS DASHBOARDS

Performance analytics not only provides results of interest to the individual pilot and the planner, but also provides an overview of readiness in a variety of ways. It may indicate the individual pilot’s readiness for particular missions (given the complexity levels required). It may also provide information on the percentage of a squadron that is ready for certain missions with certain complexity factors. Presentation of results is provided in a dashboard that can be tailored to the specific needs of the user. The individual pilot may wish to analyse a specific weakness while a base commander may need to check the predicted readiness levels of the squadrons three months from now. The dashboard will reflect those needs and provide easy access and a comprehensible overview of relevant data.

RECOMMENDER

The Recommender, a recommendation tool, will suggest mission types, complexity settings, training devices, airspace, and the best training scenarios given individual needs. This is based on the information feed to the recommender from the training results. This is the first step to ensuring the individual gets exactly the training they need at the right time.

SCHEDULING TOOL

A Scheduling tool supports the squadron planners (ops officers) in optimising the schedule given the recommended training for all pilots in a particular time frame. Optimisation relates to the pairing of pilots, selection of available airspace or simulation facilities, and planning in time. This implies maximising training value for the community as a whole. Unfortunately, this means that individual needs will not always be dealt with in the recommended way or time. The scheduling tool responds to the recommender (determined training needs), but can also keep track of upcoming currency needs or (regulated) maximum intervals between certain training events when suggesting a schedule to the planners.

It goes without saying that planners can overrule the system-generated schedule. It may, after all not be feasible to add all possible schedule-distorting parameters to the model. The scheduling tool will adapt automatically after each actual training event.

The tool can also help planning ahead with the required 'waves' of training and the size of these 'training waves' per training device in the upcoming weeks/months. This is done based on skill decay rates, availability, and mission types required to keep the squadron at the desired level of readiness (given the constraints of total flying hours, sim hours, man hours, available airspace, etc).

After deployment to low threat environments (with, for instance, little variety in mission exposure), pilots have maintained certain competencies and skills at a high level, but will show skill decay in others. The scheduling tool will be able to optimise training for these individuals to restore required levels of competence in the shortest amount of time and with the least effort. Note that experiences during operational missions, whether deployed or from the home base, will also be taken into account by the recommender to determine consequent training missions.

As a result of individualised skill decay and retention intervals one pilot can end up with more flying/sim/academics hours than another pilot. This is beneficial to the overall readiness level of a squadron or unit and should not be abused to lower the total cost (flying hours) of a combat ready squadron.

LEARNING ECOSYSTEM INFRASTRUCTURE

The learning ecosystem infrastructure is the ICT that forms the basis of the PBT cycle. It includes not only the technology and data solutions needed to carry out PBT, but also the interface between these systems enabling both integration and feedback. It includes among other things the training and simulation databases, dashboards, recommender and scheduling tools, and the interface between these different technologies. Note that definitions of learning ecosystems differ considerably. Some definitions restrict to technical components only, while other definitions include the training organisation and training concepts. What is important is that these three elements will need to be revised and aligned in order to be optimally effective.

Roadmap - heading for PBT

Full implementation of a cost effective PBT training concept will require modernisation of the training system. It is therefore quite ambitious, if not impossible, to realise this in one conversion step and within a short time frame. Firstly, data collection and learning analytics techniques are still under exploration. Secondly, this way of training involves cultural change, and changing communities' culture takes time. A cost-effective PBT capability that realises full and maximised readiness for all military pilots (and eventually all operational personnel) can be achieved by choosing an evolutionary (agile) development and deployment process, where major gains will be achieved with gradual improvements on the shorter term. Below you find an indicatory PBT implementation time frame. At the beginning of PBT, the levels of mastery, personal retention and skill decay are based on more subjective instructor or peer ratings and self-rating. Scheduling of training will be manually adapted towards individual training needs. In a later stage, with more data and more experience in learning analytics, objective measurements will be used in support of the subjective ratings (instructor, peer and self) and scheduling of training will become more automated. A roadmap and estimated timelines are described in the figure below.

Step1 **Establishing common strategy** (1 year)	Step 2 **Standardisation & Digitalisation** (1-2 years)	Step 3 **Learning analytics & automation** (2-12 years)	Step 4 **Expansion** **(12-15 years)**
Activities & Milestones • Establish initial PBT group • Formulate PBT strategy • Identify and cooperate with all relevant stakeholders (operators, IT, P&O etc.) • Support use cases for PBT related knowledge development in programmes L2118 and L2201 • Define impact on organisation once in use • Define use case for operational testing	**Activities & Milestones** With help of the selected use case: • Formulate core technical PBT framework • Define and test standards for Training Needs Analysis, training syllabus and 'subjective' assessment • Identify relevant personal dashboard information needs for the different users (training needs, combat readiness (CR)) • Develop an integrated digital format for training syllabus and assessment tool (compatible with FFI/NLR developments see step 3) • Develop personal dashboard (in support of training scheduling) • Implement	**Activities & Milestones** With help of the selected use case: • CD&E Learning analytics concerning individual training interval stipulation • Develop scheduling tool with automatic selection and booking of training device and airspace per pilot – This action can be combined with a future collaborative project with FFI (following a NLR-FFI feasibility study of 2021) • Integrate digital training syllabi with scheduling tool	**Activities & Milestones** • Fully implemented PBT for the selected use case • Expand PBT within other RNLAF operational units (may start earlier than year 12) • Expand PBT to other MoD operational units (may start earlier than year 12)
Result A well-founded PBT strategy and approach with the involvement of all relevant parties and stakeholders to manage implementation and organisational impact.	**Result** PBT working standards and tools (personal dashboard, integrated digital syllabus and assessment) based on subjective instructor/pilot/peer assessment data to provide insight in personal training needs and CR.	**Result** PBT working standards and tools (including automated scheduling) based on a combination of objective data and subjective data to provide insight in personal training needs and propose an optimised training schedule to secure CR.	**Result** PBT working standard, tools within RNLAF and MoD to support, optimise and align the training cycles and fine-tune large scale exercises to secure RNLAF and MoD CR.

Conclusion

The 5th generation Air Force strategy is pushing training to use modern technology and working towards optimising the use of available training assets. The training itself however, is still standardised per community and every pilot receives approximately the same training. This is in spite of the fact that every pilot has an individual learning curve and training needs. The concept of PBT ensures that they reach the level of proficiency required for deployment in high threat scenarios by taking the individual's learning curve and training needs into account.

Advances in technology over the last decade, such as artificial intelligence, data-science, learning analytics and the Internet of Things, are enabling implementation of new training strategies such as PBT. The goal is to have an optimal utilisation of available training assets (flying hours, simulator hours and individual man-hours) while achieving the highest possible performance in the most efficient and effective manner (given(monetary) constraints). PBT results in the highest level of both readiness (as defined by the organisation), and personal performance.