STO TECHNICAL REPORT

TR-SAS-129

Gamification of Cyber Defence and Resilience

(Ludification de la cyberdéfense et de la résilience)

Final report of SAS-129.

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The NATO Science and Technology Organization

Science & Technology (S&T) in the NATO context is defined as the selective and rigorous generation and application of state-of-the-art, validated knowledge for defence and security purposes. S&T activities embrace scientific research, technology development, transition, application and field-testing, experimentation and a range of related scientific activities that include systems engineering, operational research and analysis, synthesis, integration and validation of knowledge derived through the scientific method.

In NATO, S&T is addressed using different business models, namely a collaborative business model where NATO provides a forum where NATO Nations and partner Nations elect to use their national resources to define, conduct and promote cooperative research and information exchange, and secondly an in-house delivery business model where S&T activities are conducted in a NATO dedicated executive body, having its own personnel, capabilities and infrastructure.

The mission of the NATO Science & Technology Organization (STO) is to help position the Nations' and NATO's S&T investments as a strategic enabler of the knowledge and technology advantage for the defence and security posture of NATO Nations and partner Nations, by conducting and promoting S&T activities that augment and leverage the capabilities and programmes of the Alliance, of the NATO Nations and the partner Nations, in support of NATO's objectives, and contributing to NATO's ability to enable and influence security and defence related capability development and threat mitigation in NATO Nations and partner Nations, in accordance with NATO policies.

The total spectrum of this collaborative effort is addressed by six Technical Panels who manage a wide range of scientific research activities, a Group specialising in modelling and simulation, plus a Committee dedicated to supporting the information management needs of the organization.

- AVT Applied Vehicle Technology Panel
- HFM Human Factors and Medicine Panel
- IST Information Systems Technology Panel
- NMSG NATO Modelling and Simulation Group
- SAS System Analysis and Studies Panel
- SCI Systems Concepts and Integration Panel
- SET Sensors and Electronics Technology Panel

These Panels and Group are the power-house of the collaborative model and are made up of national representatives as well as recognised world-class scientists, engineers and information specialists. In addition to providing critical technical oversight, they also provide a communication link to military users and other NATO bodies.

The scientific and technological work is carried out by Technical Teams, created under one or more of these eight bodies, for specific research activities which have a defined duration. These research activities can take a variety of forms, including Task Groups, Workshops, Symposia, Specialists' Meetings, Lecture Series and Technical Courses.

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Gamification of Cyber Defence and Resilience
(STO-TR-SAS-129)

Executive Summary

The Wales Summit Declaration of 5 September 2014 provided the basis for establishing NATO SAS-129: "We are committed to developing further our national cyber defence capabilities, and we will enhance the cybersecurity of national networks upon which NATO depends for its core tasks, … We will improve the level of NATO's cyber defence education, training, and exercise activities" (NATO, 2014). Since the Wales Summit, NATO has issued a cyber pledge and designated cyberspace as the 5th domain during the 2016 Warsaw Summit (NATO, 2016a). For NATO, a serious cyber-attack could trigger Article 5 (Stoltenberg, 2019), and at the 2018 Brussels Summit (NATO, 2018a), NATO allies agreed to set up a new Cyberspace Operations Centre (NATO, 2019b, p. 17). The 2016 TAP predicted that "cyber threats and attacks will continue to increase in numbers, sophistication and the potential damage, and this activity will contribute to cyber defence resilience in modern NATO environments." (NATO STO, 2016). During their work, SAS-129 developed and tested various cyber security related game-based learning systems. The team gathered their collective expertise to put together a comprehensive guide to understanding, designing, developing, onboarding, and deploying game-based learning systems. This guide is targeted for experts who are focusing on game-based learning approaches for enhancing current defence and education training and education methods.

The guide starts with setting up the framework for understanding the theory of game-based learning. This section of the guide presents a classification and differentiates between methods that fall under the umbrella of game-based learning systems. This framework was designed with experts who focus on the doctrine, concept, and academic work relating to this subject. The following section provides a unified development methodology that is a project management tool, custom-developed to incorporate the agile development requirements of game development with the stricter norms of project management in the defence industry. The methodology covers project design, testing based on common development problems survey conducted by the team and, finally, deployment. The proposed methodology has been implemented by the team members during their own protype development efforts as part of the SAS-129 work and has been refined according to lessons learned. As the team saw game design as a separate process from game development, specific focus was placed on introducing Werbach's 6D Gamification Framework. This separate focus was justified because the team considers game design to be a mix of art, storytelling, mathematical and system design. While the development methodology introduced in the guide provides key information for fulfilling system requirements, the design framework helps the system to fulfil its game requirements.

Building on the SAS-129 team's own experience it was observed that designing and procuring game-based learning systems falls short of achieving a lasting move towards integration of this method into wider military training and education. To point at the key integration requirements, the guide also focused on roles and responsibilities required within the military education environment that would enable further integration of game-based learning systems into the wider educational framework. To provide guidance to smart buyers, SAS-129 gathered the critical "must ask" questions to evaluate or assess the validity of capability of a game-based learning system that can be readily acquired. The final section of the guide focuses on providing a taxonomy of Cyber Security related game-based approaches that SAS-129 either developed or examined during their study. This taxonomy was gathered to provide an overview to full spectrum of game-based learning methodologies application to cyber security training.

Ludification de la cyberdéfense et de la résilience
(STO-TR-SAS-129)

Synthèse

La déclaration du sommet du Pays de Galles du 5 septembre 2014 (OTAN, 2014) a constitué la base de la formation du SAS-129 de l'OTAN : « Nous sommes déterminés à développer plus avant nos capacités nationales de cyberdéfense, et nous renforcerons la cybersécurité des réseaux nationaux dont l'OTAN dépend pour mener à bien ses tâches fondamentales, [...] Nous accroîtrons le niveau des activités de formation et d'entraînement ainsi que des exercices en matière de cyberdéfense menés à l'OTAN » (OTAN, 2014). Depuis le sommet du Pays de Galles, l'OTAN a publié un plaidoyer en faveur de la cyberdéfense et désigné le cyberespace comme le cinquième domaine pendant le sommet de Varsovie 2016 (OTAN, 2016a). Pour l'OTAN, une grave cyberattaque pourrait déclencher l'application de l'article 5 (Stoltenberg, 2019) et pendant le sommet de Bruxelles (OTAN, 2018a), les alliés de l'OTAN ont convenu de mettre en place un nouveau Centre des opérations du cyberespace (OTAN, 2019b, p. 17). Le TAP 2016 prédisait : « le nombre, la sophistication et les dommages potentiels des cybermenaces et attaques continueront à augmenter et cette activité contribuera à la résilience de la cyberdéfense dans les environnements modernes de l'OTAN » (STO OTAN, 2016). Pendant ses travaux, le SAS-129 a développé et testé divers systèmes d'apprentissage basés sur le jeu et liés à la cybersécurité. L'équipe a réuni son expertise collective pour constituer un guide complet de compréhension, conception, développement, intégration et déploiement des systèmes d'apprentissage ludique. Ce guide s'adresse aux experts qui se concentrent sur les démarches d'apprentissage ludique pour améliorer la formation actuelle à la défense et à l'éducation, ainsi que les méthodes d'éducation.

Ce guide commence par mettre en place le cadre de compréhension de la théorie de l'apprentissage ludique. Cette partie du guide présente la classification et les différences entre les méthodes qui rentrent dans le cadre des systèmes d'apprentissage par le jeu. Ce cadre a été conçu avec des spécialistes qui se concentrent sur la doctrine, le concept et les travaux académiques à ce sujet. La partie suivante expose une méthodologie de développement unifiée qui est un outil de gestion de projet, élaboré sur mesure pour incorporer les exigences de développement agile du développement de jeux, avec des normes plus strictes de gestion de projet dans le secteur de la défense. Cette méthodologie couvre les étapes allant de la conception au déploiement, en passant par les essais basés sur l'étude des problèmes communs de développement, menée par l'équipe. La méthodologie proposée a été mise en œuvre par les membres de l'équipe pendant leurs propres travaux de mise au point d'un prototype, dans le cadre des travaux du SAS-129, et affinée à l'aide des enseignements retenus. Étant donné que l'équipe considérait la conception de jeux comme un processus distinct du développement de jeux, une attention particulière a été accordée à l'introduction du cadre de ludification 6D de Werbach. Cette attention se justifiait par le fait que l'équipe considérait la conception de jeux comme un mélange d'art, de narration, de mathématiques et de conception de système. Alors que la méthodologie de développement présentée dans le guide fournit des informations essentielles pour répondre aux besoins du système, le cadre de conception aide le système à satisfaire à ses exigences ludiques.

À partir de l'expérience du SAS-129, nous avons observé que la conception et la fourniture de systèmes d'apprentissage ludique ne parviennent pas à enclencher l'intégration de cette méthode dans l'entraînement et l'éducation militaires dans leur ensemble. Afin de désigner les exigences d'intégration essentielles, le présent guide s'est également focalisé sur les rôles et responsabilités nécessaires dans l'environnement de l'éducation militaire, qui permettraient d'intégrer davantage les systèmes d'apprentissage ludique dans

le cadre éducatif plus large. Dans le but de conseiller les acheteurs avisés, le SAS-129 a dressé une liste de « questions à poser » pour évaluer la validité de la capacité d'un système d'apprentissage ludique facile à acquérir. La partie finale du guide fournit une taxonomie des approches ludiques liées à la cybersûreté que le SAS-129 a soit élaborées, soit examinées. Cette taxonomie a été établie pour donner une vue d'ensemble de tout le spectre d'application des méthodologies d'apprentissage ludique à la formation à la cybersûreté.

GAMIFICATION OF CYBER DEFENCE AND RESILIENCE

1.0 INTRODUCTION

1.1 Background and Justification

The Wales Summit Declaration of 5 September 2014 provided the basis for establishing NATO SAS-129:

> We are committed to developing further our national cyber defence capabilities, and we will enhance the cybersecurity of national networks upon which NATO depends for its core tasks, in order to help make the Alliance resilient and fully protected. Close bilateral and multinational cooperation plays a key role in enhancing the cyber defence capabilities of the Alliance. ... Technological innovations and expertise from the private sector are crucial to enable NATO and Allies to achieve the Enhanced Cyber Defence Policy's objectives. We will improve the level of NATO's cyber defence education, training, and exercise activities (NATO, 2014).

Since the Wales Summit, NATO has issued a cyber pledge and designated cyberspace as the 5th domain during the 2016 Warsaw Summit (NATO, 2016a). For NATO, a serious cyber-attack could trigger Article 5 (Stoltenberg, 2019), and at the 2018 Brussels Summit (NATO, 2018a), NATO allies agreed to set up a new Cyberspace Operations Centre (NATO, 2019b, p. 17).

The 2016 TAP predicted that "cyber threats and attacks will continue to increase in numbers, sophistication and the potential damage, and this activity will contribute to cyber defence resilience in modern NATO environments" (NATO STO, 2016). This prediction turned out to be accurate; cyberspace is always active, and "NATO is a target three times over" (Omand, 2019, p. 17). Not only are the networks of the organisation targets, but also NATO members and soldiers' own mobile devices (Grove et al., 2017). Individual soldiers are particularly vulnerable targets (Kramper, 2017; Bay and Biteniece, 2019, pp. 7-18) and can be "catfished" (Lapowsky, 2019).

NATO SAS-129 developed this assessment further based on NATO expectations that the future theatre of war will be in mega-cities (Strategic Analysis Branch, 2017, p. 38), where the environment is rich with cyber assets. Therefore, NATO SAS-129 is developing the Multi-Domain Future Urban Wargame addressing these issues on the tactical and operational level. However, simple cyber hygiene efforts remain the foundation of cyber defence and resilience. NATO Secretary General Jens Stoltenberg summarised the cyber challenge as:

> Some of the biggest cyber-attacks have only been possible because of human error. Such as picking up an infected USB Drive placed in a car park, and plugging it into a computer. Or clicking on a bad link in a 'phishing' email. It is time we all woke up to the potential dangers of cyber threats. (NATO, 2018c)

The 2016 TAP recognised that although "many real-world solutions are available for training and education of cyber experts, there is a lack of training and education of cyber defence/resilience in general. Not many solutions are available for training and education of clients such as end-users, policymakers, and military decision-makers" (NATO STO, 2016). A significant number of publicly available games address the topic of cyber security. Merijke Coenraad, a doctoral candidate in the Technology, Learning, and Leadership program at the University of Maryland, College Park, playtested 181 mostly designed for young end-users (18.7% elementary school level, 29.3% middle school and 51.9% high school and above) and only a few of them have deep content (Coenraad et al., 2020, p. 22).

"Conventional methods for raising general awareness are often either costly or ineffective. Therefore, one of the possible solutions for training and education is developing Serious Games and Gamification applications." (NATO STO, 2016) Advertisements for professional Game-Based Learning (GBL) / serious

games solutions are built on the premise that PowerPoint presentations for teaching, training, and raising awareness are usually dull and ineffective (The Cyberwire, 2020). Humans are still the weakest link in any cyber defence (Spatz, 2017; Yan et al., 2018; Shalin Hai-Jew, 2019), and the low level of adoption of Multi-Factor Authentication (MFA) or two-Factor Authentication (2FA) is still a concern (Das et al., 2019). Compared with the required vaccination rate for measles and pertussis (92 – 96 %), rubella (84 – 88 %) and mumps (88 – 92 %) (Anderson and May, 1985, p. 324) we are far from herd immunity although the effect of increased general awareness can be see such in the case of increased adoption rate of 2FA from 2017 (28%) to 2019 (53%). Also, user awareness rose substantially from 44% to 77% (Engler, 2019, p. 3). However, opinions differ on the effectiveness on Two-Factor Authentication (Colnago et al., 2018; Covello, 2019). There are also different national attitudes concerning the implementation of 2FA for customers in the private sector. German companies, for instance, are much more reluctant to require 2FA for business transactions (t3n Redaktion, 2019) than U.S. companies (ThumbSignIn et al., 2019). At the end of the day, our societies are still highly vulnerable to attack.

The 2016 TAP assumed that Serious Games and Gamification could contribute to solving this problem. It also assumed that "games are available across platforms and can be designed in a way that it attracts the general audience" (NATO STO, 2016). For NATO as an organisation, it is essential to understand complex cyber resilience / defence / incident management scenarios. Based on the premise, "that Gamification techniques can be useful in training and education regarding different cyber defence/resilience scenarios in a joint and high-pressure environment," the TAP concluded that "Gamification provides opportunities to understand the possibilities inherent in cyber defence and train or educate people while they are having fun, contributing to the goals set forth by the Wales Summit" (NATO STO, 2016).

1.2   Objectives

SAS-129's main objective is to effectively enhance information security and cyber defence education and training through the use of serious gaming and gamification approaches. SAS-129 has gathered its efforts to achieve this main objective in three work packages. These are as follows:

- The definition of serious game and gamification, advantages and disadvantages, common problems during development, gamification characteristics, game mechanics and technologies, and defence applications will be examined.

- The big picture of cyber defence and resilience, classification of operations and decisions in cyber defence and resilience, and examples of cyber security training and education will be analysed in order to provide a baseline for the specification and prioritisation of cyber security subjects and user groups that can benefit from utilisation of gamification and serious game applications.

- Gamification and serious game methodology guidelines for cyber defence and resilience will be developed. Then one or more prototype demonstrations implementing this methodology will be developed.

NATO SAS-129 is supposed to submit a final technical report documenting findings on gamification, describing cyber defence and resilience baseline information, and game methodology guidelines with prototypes developed. This report is a contribution to the documented findings on gamification, game methodology guidelines and prototype development.

1.3   Research Process

SAS-129 has held 5 of the 6 meetings (Paris, Amersfoort, Tallinn, Hamburg and Ottawa) envisaged in its business plan, face-to-face. The last Ankara meeting was online. In this context, in the early stages of the research, monthly online meetings were also held.

SAS-129 has completed game development within the scope of the cyclical serious game development methodology developed in parallel with the research envisaged in the work packages specified in the objectives section. In the game development process, 11 iterations were carried out in different countries and in different institutions and organisations due to the methodology.

These iterations were completed in the following order:

- NATO ACT Urbanization Project, United Kingdom Defence Academy.

- Turkish Informatics Congress.

- German Command and Staff College.

- German Strategic Reconnaissance Command.

- Turkish General Staff Partnership for Peace Training Centre.

- Netherlands Land Warfare Centre.

- Turkish General Staff Partnership for Peace Training Centre.

- Cyber Wargame R&D Workshop, German Command and Staff College.

- NATO ORA Conference, Wargame Workshop, Canada.

- Turkish Air Forces Command, Cyber Defence Section.

- Turkish Land Forces Command, Training and Doctrine Command.

2.0 GAMES, GAMIFICATION, SERIOUS GAMES, WARGAMES, SIMULATION AND GAME-BASED LEARNING SPACE

2.1 Terminology

2.1.1 Games and Gaming, Play and Playing

The terms "gamification," "serious games," "wargaming," and "game-based learning" are all derived from the term "game" and the activity of "gaming." There are similarities between simulations and games. Both rely on a specific model that is exposed to time. Moreover, simulations can be used for gaming. However, the essence of a simulation is the representation of a complex reality to serve as a tool for understanding systems and events (Eng, 2020a). Fun is not included in simulations by design.

In English, there is a difference between play and game. In German, both terms translate into "Spiel," and the distinction is typically lost in translation. "Spiel" must be supplemented with a further description of the activity of "Spielen" as being either purposeless (playing) or purposeful (gaming). Gaming can be a targeted process (Merriam-Webster Dictionaries, 2020b). Games are activities and they have an explicit goal (Eng, 2020f).

Given the fact that a notion from Carl von Clausewitz's "On War" has been essential for this report and for the development of the CRCG prototype, the following paragraph will focus on how certain sentences in Clausewitz's work have been translated into English. "Wie durch seine objektive Natur, so wird der Krieg auch durch die subjektive zum Spiel": "War is a game, both objectively and subjectively" (Vom Kriege, Erstes Buch, Erstes Kapitel, 21 [On War, Book I, Chapter 1, p. 21] Clausewitz, 2019). "... und von allen Zweigen des menschlichen Tuns den Krieg dem Kartenspiel am nächsten stellt" (Clausewitz and Hahlweg, 1980, p. 207), for which there are several different English translations available. The revised version of Colonel J.J. Graham's 1874 translation (reprint 1909) translates the second quote mentioned above as follows: "... and makes War of all branches of human activity the most like a gambling game" (Clausewitz, 1909). This translation is still kept alive in the Project Gutenberg version, last updated in 2019

(Clausewitz, 2019). A direct online comparison of the German original text and Graham's translation is possible at clausewitzstudies.org (clausewitzstudies.org, 2020). On this website, however, the translation for "Kartenspiel" is game of cards. Specific attention was paid to these different translations, when developing the CRCG given its purpose and context as a card game, and also the relative proximity of their office, given that it is in the Clausewitz Garrison, onsite at BwCSC.

The standard English translation of "On War", according to The Clausewitz Homepage (Clausewitz.com, 2020), is the Princeton 1976 translation by Michal Howard and Peter Paret: "In the whole range of human activities, war most closely resembles a game of cards" (Clausewitz et al., 1976, p. 86). Any German native speaker will notice the profound difference between "Kartenspiel" and "Glücksspiel." The old translation gambling game is equivalent to "Glücksspiel." Gambling game is a generic term including games of cards and games of dice. "Kartenspiel" literally translates into game of cards. This understanding was central to the idea of designing the required prototype as a physical game of cards and not a digital game.

Philosophers from Berghahn and Schiller (Berghahn and Schiller, 2013) to Wittgenstein and Anscombe (Wittgenstein and Anscombe, 1968) have discussed the term "Spiel" and the cultural meaning of "Spielen." The German philosopher Wittgenstein did not consider a general definition of game possible (Wittgenstein and Anscombe, 1968, p. 3). However, the Canadian philosopher Bernard Suits (1967) described three core elements of playing a game. First, a game is goal-oriented and therefore requires a defined final state. Second, a game has a defined set of rules that limits activities and the use of resources. Third, players must voluntarily accept these rules (Suits, 1967, pp. 148-155). Johan Huizinga's "Homo Ludens – A Study of the Play Element in Culture" (1949) is another crucial work in understanding the nature of gaming. It describes the concept of a magic circle. A physical or virtual border separates the world of the game from the real world. A game is different from the real world and the rules of the game have a different meaning within the magic circle than the outside. The rules of the game are essential within the magic circle and players must be willing to follow them voluntarily (Huizinga, 2014, p. 23). The concept of the magic circle is still essential for contemporary gamification experts (Eng, 2020g).

Huizinga summarises the formal characteristics of a game as:

1) A free activity;

2) Outside "ordinary" life;

3) Being "not serious" but absorbing players utterly;

4) One or more clearly defined goals; and

5) Excitement and joy (Huizinga, 2014, 7-12).

However, the element of fun characterises the essence of any play (Huizinga, 2014, p. 3). In her book "Reality is Broken" Jane McGonigal describes "The Four Defining Traits of a Game" (McGonigal, 2011, p. 336):

1) A clear goal;

2) A set of rules that offers individual freedom and allows creativity;

3) Strong feedback; and

4) Voluntary participation and acceptance of goals, rules, and feedback.

Ralph Koster, on the other hand, focuses on the fun in his book "A Theory of Fun for Game Design" (Koster, 2014). For Koster "Games are puzzles to solve, ..." (Koster, 2014, p. 36) and therefore, "… games serve as very fundamental and powerful learning tools." (Koster, 2014, p. 37). As with Serious Games, gaming today is usually understood as digital gaming (Deeg, 2014, pp. 6-10) and Coenraad only examined digital games in her 2019 study on experiencing cyber security in games (Coenraad et al., 2020).

Figure 1 depicts the terms serious games, gamification, toys, and play into four quadrants along the *x*-axis from game-to-game elements and on the *y*-axis from playing to gaming.

However, these terms are not used with precision as can be seen with Lego® Serious Play®. Depending on the implementation of Lego® Serious Play®, it can be either gamification of education (Peabody and Noyes, 2017), serious gaming for management (Kristiansen and Rasmussen, 2014; Blair, 2018) or both (Lloyd Smith et al., 2016).
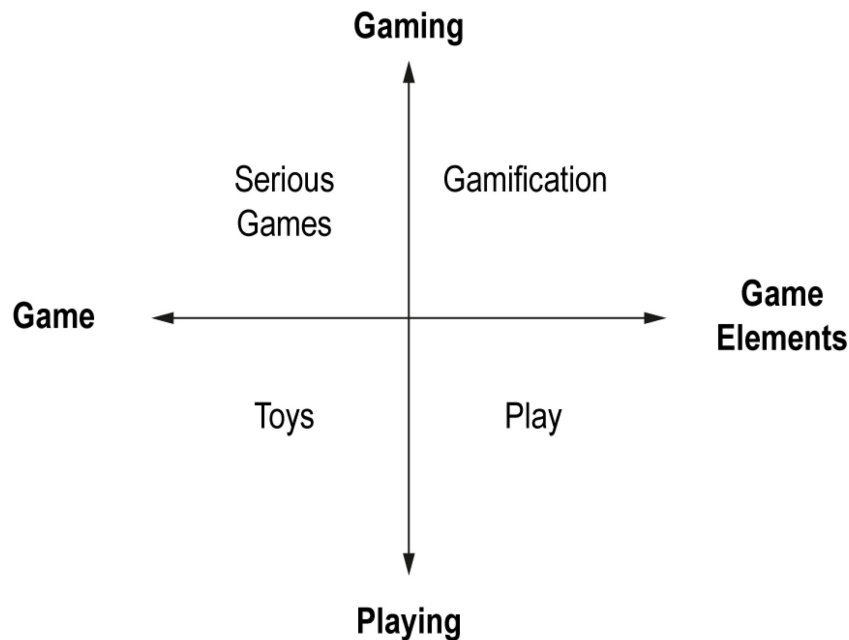
Figure 1: Gaming vs Playing (Langendah et al., 2016, p. 5).

2.1.2 Gamification

There are different definitions of gamification available, and there is no universally accepted scientific definition of the term (Sailer et al., 2017, p. 372). Gamification expert Andrzej Marczewski considered Sebastian Deterding's definition, "The use of game design elements in non-game contexts" (Deterding et al., 2011, p. 2) to be the most widely recognised one, and liked Kevin Werbach's 2014 definition, "The process of making activities more game-like" (Werbach, 2014, p. 266) the most (Marczewski, 2018, p. 107). However, Werbach also defined gamification as "The use of game elements and game design techniques in non-game contexts" (Werbach and Hunter, 2012, p. 318). In so doing, Werbach provides a process-oriented and an object-oriented definition. Marczewski provides a more user or player-centric definition: "The use of game design metaphors to create more game-like and engaging experiences" (Marczewski, 2018, p. 123).

According to Merriam-Webster, gamification is "the process of adding games or game-like elements to something (such as a task) so as to encourage participation" (Merriam-Webster Dictionaries, 2020a). Business sometimes uses this definition (Ballou, 2017). However, the common academic consensus regarding gamification is the exclusion of complete games. The exclusion of complete games separates gamification from serious games and game-based learning (Werbach, 2012a; Eng, 2020c). In many cases, however, the term gamification is often closely linked to marketing techniques as in this definition: gamification is "the application of typical elements of game playing (for example, point scoring, competition with others, rules of play) to other areas of activity, typically as an online marketing technique to encourage engagement with a product or service" (Lexico Dictionaries, 2020). As a result of this limited interpretation,

critics among game developers and academics refer to gamification often as pontification (Robertson, 2010), exploitation ware (Bogost, 2011, Bogost 2013) or pavlovication (Klabbers, 2018, p. 232) when using the term in a marketing context.

Some game developers avoid the term altogether (McGonigal, 2011, McGonigal, 2015). This controversy is sometimes lost in translation. McGonigal's book "SuperBetter: A Revolutionary Approach to Getting Stronger, Happier, Braver and More Resilient" was translated into German as "Gamify your Life: Durch Gamification glücklicher, gesünder und resilienter leben" and was advertised on the cover as the first book in German on gamification ("Das erste Buch zu Gamification auf Deutsch") (McGonigal, 2016).

Yu-Kai Chou offers the most comprehensive understanding of gamification: "Effective gamification is a combination of game design, game dynamics, behavioral economics, motivational psychology, UX/UI (User Experience and User Interface), neurobiology, technology platforms, as well as ROI-driving business implementations" (Chou, 2016a, p. 1). He also offers a differentiation into "Implicit Gamification" and "Explicit Gamification" (Chou, 2016a, p. 53). People are very aware of the fact that they are playing a game in explicit gamification because they are opting into playing a full game. Implicit gamification, on the other hand, creates a user experience, and people do not see themselves as players. Implicit gamification is "Human-Focused Design that utilizes game elements" (Chou, 2016a, p. 54).

The TAP defines gamification more broadly as "the use of game thinking and game mechanics in non-game contexts to engage users in solving problems and increase users' self-contributions." (NATO STO, 2016). Wikipedia used this definition in 2015 (Malokin, 2015). In 2010, there was a controversy among the Wikipedia community surrounding the question whether as to the term gamification qualified at all for Wikipedia as some critics called it a "recent marketing buzzword" (Bogost, 2013, p. 139). However, it has prevailed (Wikipedia, 2010) and the TAP definition is in line with the academic consensus and Chou's understanding of implicit gamification.

2.1.3   Wargaming

Hobbyists often use the term wargaming while industry professionals seem to prefer the spelling war gaming, separating the war from the game. War-gaming with a hyphen seems to be an acceptable compromise in both camps (Haggman, 2019, p. 36). The present report uses the term wargaming without disregarding the seriousness of war. Peter Perla, a distinguished expert in the wargaming community, defines a wargame as "a warfare model or simulation whose operation does not involve the activities of actual military forces, and whose sequence of events affects and is, in turn, affected by the decisions made by players representing the opposing sides" (Perla, 1990, p. 164). Philip Sabin defined recreational wargaming as "military simulation games" (Sabin, 2014, 359).

One of the most recent definitions of wargaming, provided by James "Pigeon" Fiedler, combines previous definitions. Wargaming is "a synthetic decision-making test under conditions of uncertainty against thinking opponents, which generates insights but not proven outcomes, engages multiple learning types, and builds team cohesion in a risk-free environment" (Fiedler, 2020).

NATO SAS-129 does not define wargaming, neither does NATO SAS-139 Research Task Group on NATO Analytical War Gaming. Depending on its purpose, wargaming could be either educational or analytical. This also depends on the usage of computers, as wargaming can be either manual (without computers) or computer-assisted (a full constructive simulation would be the purest form) (Development, Concepts and Doctrine Centre, 2017, pp. 1-19). The most earnest form of an analytical wargame is the courses of action analysis (CoA) which is a mandatory part of the United States Forces decision cycle (Duggan, 2005, p. 26; Headquarters, Department of the Army, 2019, pp. 2-18). The RAND corporation used a manual wargame, including six-sided dice (D6) to conceptualise NATO Enhanced Forward Presence at NATO's Eastern flank in the Baltics (Mueller, 2016, pp. 53-57; Shlapak and Johnson, 2016b, p. 12).

Wargaming has gained popularity again, and War On the Rocks and RAND have recently covered different aspects of wargaming, including its educational (Brynen, 2015; Bae, 2019; Fiedler, 2020; Buitta, 2019), analytical (Shlapak and Johnson, 2016b; Bartels, 2017; Pournelle, 2019; Lambert and Quinn, 2020) and manual dimensions (Shlapak and Johnson, 2016a; Mueller, 2016), as well as different topics like Artificial Intelligence (AI) (Schuety and Will, 2018; Jensen et al., 2018), future scenarios (Jensen, 2019; Lacy, 2019) and information (Paul et al., 2020).

There are several handbooks on wargaming available (Perla, 1990; Burns et al., 2015; Brashear et al., 2015); a very user-friendly approach to wargaming would be combining the 2017 British Ministry of Defence "Wargaming Handbook" (Development, Concepts and Doctrine Centre, 2017) and Gordon Longley Brown's "Successful Professional Wargames: A Practitioner's Handbook" (Longley Brown, 2019). The most recent comprehensive coverage of the topic is Matthew B. Caffrey's "On Wargaming: How Wargames Have Shaped History and How they May Shape the Future" (Caffrey, 2019).

The TAP does not mention the term wargaming. However, the report understands wargaming in general as suitable for explicit gamification. The report understands manual and educational wargaming as a subcategory of non-digital serious gaming, and analytical wargames as a form of simulation and serious games.

2.1.4   Game-Based Learning (GBL)

In private business, GBL is "training that uses game elements to teach a specific skill or achieve a specific learning outcome" (Findlay, 2016). Scholarly interpretations commonly imply the usage of complete games for educational purposes: "An educational game is defined as a game being designed and used for teaching and learning" (Al-Azawi et al., 2016, p. 132). These games used for GBL are sometimes seen as serious games (Noemí and Máximo, 2014, p. 230), implying that they are digital. GBL and gamification can be applied in parallel (Eng and Staats, 2020). This would be explicit gamification in combination with implicit gamification.

2.1.5   Conclusion on Terminology

Karl M. Knapp bypasses problems with the overlapping meaning of terms by combining the terms "games, gamification, and simulations," into the new term "Interactive Learning Event" or "ILE" (Kapp, 2014, p. 788). Thereby, the term ILE also reflects a specific focus on the topic of education.

Serious games are in the scope of NATO SAS-129. Educational and manual wargames are variations of (non-digital) serious games. However, the intended development of non-digital (war)games, for a serious purpose, to be used in an educational setting (as GBL) is a grey area somewhere in between the concepts mentioned before. The NATO SAS-129 approach does cover aspects of those concepts, but also explores fringes of terminology. Even though NATO SAS-129 uses the scholarly definition of gamification, which excludes complete games, it focuses on the development of a complete game (in particular the Multi-Domain Future Urban Wargame). It thus puts the main emphasis on serious games and explicit gamification (Figure 2).

The report suggests using the terms explicit gamification (thereby including complete games, educational and manual wargaming, serious games and GBL and excluding analytical wargames (specifically the CoA) and pure simulations) and implicit gamification. Therefore, the CRGC is a form of explicit gamification.
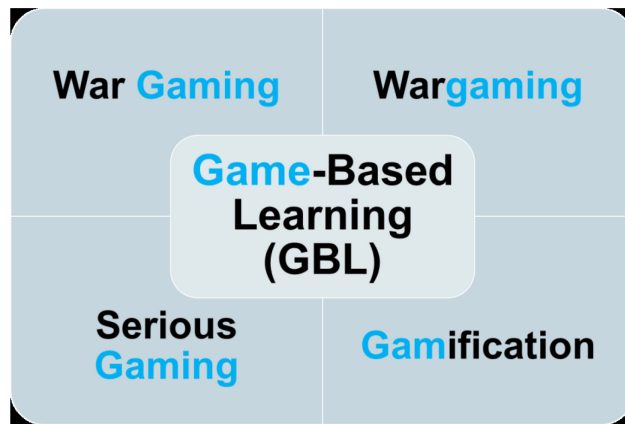
Figure 2: Terminology (Own Illustration).

2.2   Identifying the Difference Between Simulations and Game-Based Learning

The term simulation has been strongly associated with digital training tools. This creates a confusion separating simulation from non-simulation training software. When digital games and simulations are combined, we get the simulation games genre. Usually, simulation games do not have a specific winning scenario (Alvarez, et al., 2010). For example, in the simulation game "Flight Simulator" the user flies to different locations with different types of planes and tries to successfully land. However, the game does not have a levelling system or a specific winning scenario.

The key differentiating factor between serious games and simulations is as Roger Smith (Atkinson-Bonasio, 2009) states "In simulations users motivates themselves." Therefore, simulations seek to maximize the reality of the training and do not focus on increasing the motivation of the user. On the other hand, serious games' fidelity of the simulation is just another game mechanic. Thus, the game can bend the reality to increase the entertainment fact or to fit with the rest of the game flow. Serious games heavily rely on game elements to form the mechanics and the flow of the game. Section 3.0 discusses the difference between simulations and serious games with respect to game elements (Table 1).

Table 1: Differences Between Simulations and Serious Games.

	Serious Games	**Simulations**
Story	User does not need a background information to start the game.	Serious amount of background information is needed to understand the current situation.
In-Game User Camera	Provides a selection off isometric, 2D, platform, 3rd person view, orbital 3rd person, first and second person view cameras.	Main practices focus on first person and orbital cameras.
Environment Design	Various types and reality, only limitation is the imagination of the designer.	Developed around real-life scenarios. Usually limited with photorealistic environment designs and characters.
User Interface	Usually console or keyboard and mouse. Touch screen controlling and motion capture has been immerging interface methods in the recent years.	Realistic modelling of dummy control devices.

	Serious Games	**Simulations**
Rules	Rules govern the game. Mastery over rules leads to increase on the success.	Knowledge governs the simulation. Increase in knowledge leads to correct decisions in the simulation.
Linearity	Learning does not have to be linear.	Decision-making process moves linearly.
Changing Rules and Situations	In different levels or stages rules can change or new ones can be added. Gameplay style or difficulty can change.	Situations, variables, and environment can change with new scenario.
Feedback	Immediate feedback is enabled by points and levels. Failure comes in the form of not being able to continue playing.	In decision trees feedbacks can be delayed. Success or failure is determined by measuring the results.
Winning	Winning can be score gathered in the end of the game, reaching the final level, limited amount of replay or ranking the gamers' profile. Even though the winning scenario can be the same different types of winning conditions can mean infinite game play for repeating players.	Winning is defined as completing the main mission with limited decisions. Using the simulation, a second time becomes easier, but because the experience is similar, this helps.

3.0 SERIOUS GAME AND GAMIFICATION DEVELOPMENT METHODOLOGY

Unified Software Development Process (USDP) brings together best practices of software development together to produce a single process (Jacobson, Booch and Rumbaugh, 1999). Given this study is trying to achieve a similar goal of producing a single methodology for development of serious games, USDP was taken as an inspiration. Figure 3 depicts the proposed Unified Serious Game Development Methodology (USGDM).

3.1 USGDM Phases

The development cycle of the USGDM consists of four phases (Bennett, McRobb and Farmer, 2006) (Figure 4).

The *inception* phase focuses on analysing the scope and purpose of the project. This phase has two main iterations. It is suggested that these iterations be divided with the development of two versions of the playable prototypes and tests.

This kind of division enables the generation of the information necessary for establishing the *elaboration* phase. As it can be seen this phase places heavy emphasis on development and the need for training analysis, an emphasis that arises in response to the lessons learned from the survey, literature review and case studies. It is important to get the playable version as soon as possible given that it is the best way to capture key needs and requirements as well as deciding the limitation assumptions and system requirements. Furthermore, if it is determined that such training does not need a serious game or a different type of gameplay within this phase then a very critical-fail reason will be established from the very start of the project.
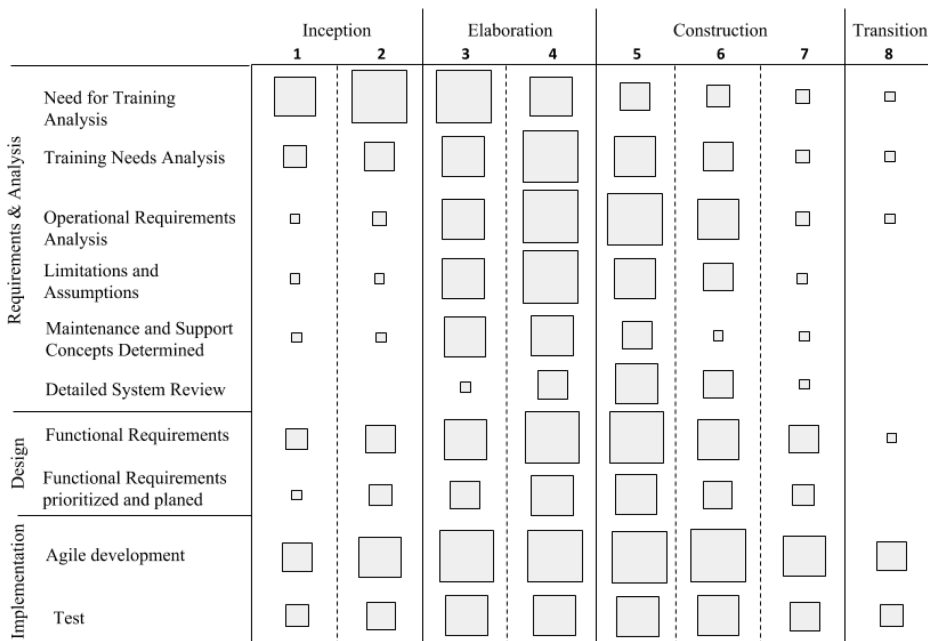
Figure 3: Unified Serious Game Development Methodology.
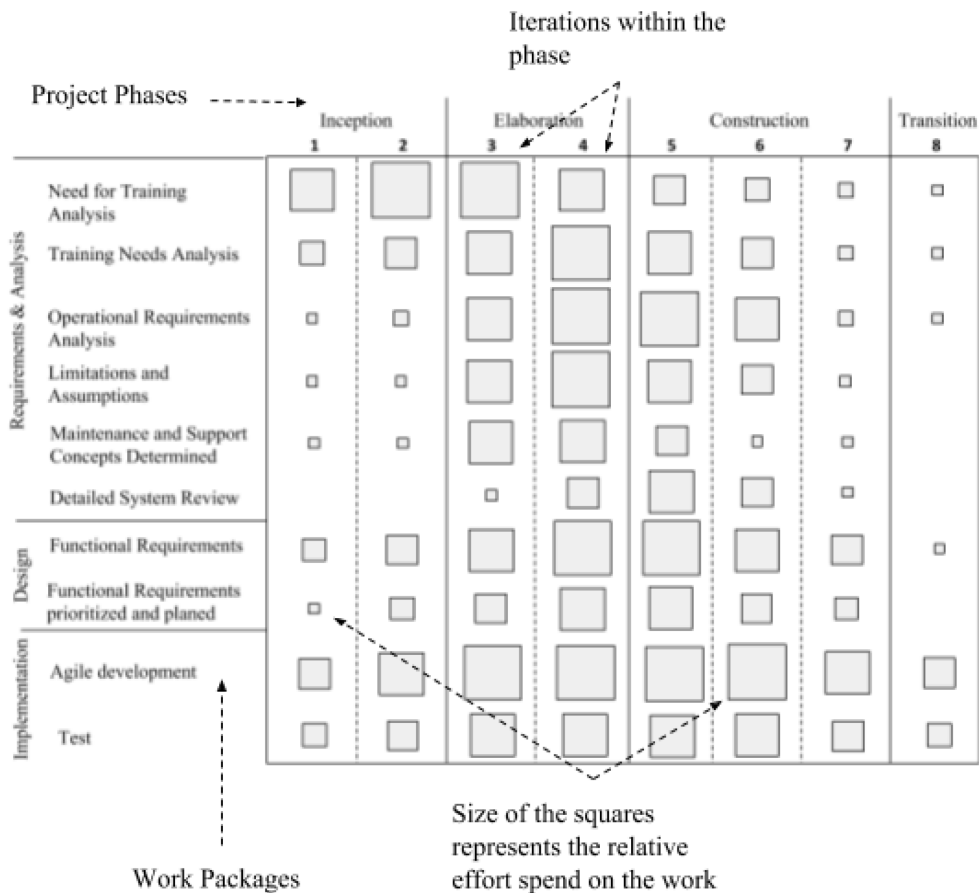
Figure 4: Unified Serious Game Development Methodology Break Down.

The *elaboration* phase captures and determines the structure of the system. This phase also consists of two main iterations. This phase has the heaviest workload. The first iteration starts with the design and testing key assumptions through prototype developments and testing. The second iteration sees a decrease in the need for training analysis. Towards this stage it should be more or less clear if the system is warranted and going forward in the right direction. This phase should end with the critical assumptions and vague points of design documented and functions tested through another prototype.

Construction is the phase where the game is actually developed. This phase includes three iterations. Given that digital games aim for entertainment while serious games have much more complex needs and recruitments especially the first two iterations of this phase give heavy emphasis on analysing and testing the system for verification and validation. It is believed that by distributing the validation and verification process in an iterative way across the development process it is possible to ensure avoiding critical pitfalls of common development problems of serious games.

Transition is the integration, installation and start of the in-operation support phase. The remaining active work packages focus on game balance, patching and adding new factions to keep the system alive and functioning. This phase ends with either by systems disposal as a legacy system or start of the entire USGDM to develop the release of an expansion pack or version two.

3.2   USGDM Work Packages

Work packages are divided into the three main tasks. Each phase contains sub-tasks that are designed to the unique needs of serious game development. Requirements and analysis phases consist of six sub-tasks. These tasks specifically focus on finding out the needs and requirements the stakeholders, operational environment, and most importantly self-justification of the serious game (Table 2). This phase concludes with the review sub-task to ensure the correct implementations of the work package.

Table 2: Sub-Task Questions.

Important questions should be asked during this sub-task.	Why am I teaching this subject?
	Who am I teaching this subject to?
	What am I teaching?
	How am I teaching?
	When and for how long will I be teaching this subject?
	What are the obstacles and facilitators to using SGs? (Ellotti, Francesco et al., 2010, pp. 22-35)

The next work package is the design task. This task consists of two sub-tasks; they focus on the functions of the serious game. Given the nature of the methodology these sub-tasks are not independent from the other work packages. In accordance with the system engineering approach, a detailed system review process also includes evaluation of system functions to determine the fulfilment rates of system needs and requirements. This work package concludes with concludes with function prioritisation and development plan.

The final package is the implementation task, which consists of two sub-tasks. This work package should be solely version-driven. The heaviest emphasis is given to the development of the systems. It is further suggested that an agile development approach should be taken. As detailed in previous sections, the process of game design and development is agile. Usually game developers avoid detailed – "mammoth" design documents and prefer developing by doing. Development starts with the most basic functions and graphics. Within cycles of development, it is played and extended with new factions and mechanics. The general concept of game design

is benchmarking a previous game in the same genre and adding unique selling points in a function-driven, iterative, and agile design process. Serious game development can be done in a similar way. The sprint cycle should start with ten days and could incrementally build up towards 3 – 4 weeks depending on the size of the project.

3.2.1 Special Consideration for Sub-Tasks

Before starting serious game development, it is essential to conduct a need for training analysis and identify the target audience and learning outcomes. As the project develops, this analysis is often reviewed and utilised. Collecting relevant educational literature on the subject also provides non-subject matter experts with a resource to visit back during the development phase.

The second aim of the sub-task is to conduct a feasibility analysis. This sub-task keeps asking the questions "Can this training be gamified?" and "Should this training be gamified?" Some educational content does not fit too well in a gaming scenario so it might not be cost effective. Although it can be argued that anything can be gamified, making everything into an entertaining game is not always a cost-efficient task. As the work package in process starts to produce playable content it is highly useful to involve the stakeholders by showing them concepts of the system – you are more likely to get useful feedback that way compared to providing oral or written explanations of the system.

An operational requirements analysis is used to examine and make decisions about technologies that will be used to develop the serious game. It is suggested that the design document be presented to development teams. Depending on the requirements, teams can decide and preferably test the relevant technology. In addition, during this sub-task, targeted platforms and the operational needs of the platform may be identified.

Depending on the size of the project and number of stakeholders it is suggested that during the detailed system review all the outputs from the previous phases should be collected in a single system design document and reviewed by all the stakeholders.

Moving from the initial analysis and during the requirement finalisation before the design phase, stakeholder involvement is critical, but most importantly subject matter experts and game designers should be involved and work together during this phase. Their involvement covers the validation process. Another important input to this phase is the lessons learned and feedback from the previous playable versions of the serious game.

Usually, the design phase includes the development of a game design document. There is no one standard for developing a design document. Most projects or companies have their own version of the design document. The size and detail of the document depends on the size of the project. Some agile independent game development teams completely avoid design documents and use story and character boards to design a game. For serious game development projects, we suggest producing a game design document for making it easier to track learning goals and game design elements. Table 3 shows suggested section titles for a design document.

Depending on the project and the preference of the team, a software development documentation can also be developed in this phase. This kind of document is definitely suggested for larger digital serious game projects with various software development teams.

While system functional requirements are finalised, prioritised, and planned according to the design document requirements, a list of system functions should be developed. It is useful to develop a project timeline in this phase, cross-referenced to the deadlines. In a case of inconsistency, decisions could be made with functional priorities. It is also useful to involve stakeholders in this stage. Any incorrect decision could lead to an unentertaining game or a serious game failing to fulfil educational goals. Once the functions are finalised, they should be analysed by the project team to make sure they are detailed enough, doable, and not duplicated.

Table 3: Serious Game Design Document Template Topics.

Serious Game Design Document Suggested Under USGDM
Summary of the game and properties of the game
Player characteristics – the preferences of the target audience
User experience (gameplay and rules)
Game mechanics
Control interfaces with relevant to game mechanics
Mission, quest, level design – rewards are included under section
Game elements and flow
Interaction rules between game elements
Story – if relevant the requirements for cut scenes and cinematic
If applicable – achievements and collectables
Menu and interface flow chart
Key performance indicators – game and educational data collection requirements
Graphic interface requirements
Sound and music requirements
Trainer module requirements

During the agile development and testing sub-tasks, the involvement of the subject matter experts and members of the target audience is highly suggested. Using the prototypes developed, functions should be compared with training needs, learning out comes, game and system requirements to make sure all requirements are met. Following the test and equipped with feedback, the development team should conduct a version review and plan for the next version.

3.3 USGDM Testing Methods

As mentioned previously, digital games are intertwined with software development. There are many studies and methodologies that solely focus on software testing. This section specifically focuses on methods for testing the quality of the serious game as well as the game component of the system. There could be and usually is a case where the serious game is developed according to the development methodology, yet the game is not fun, or it fails to achieve its educational goal. At that point, the developer team needs a method to tell them exactly what is going wrong. The section below argues for the use of a checklist derived from literature review and a common development problems survey as well as the Octalysis framework.

3.4 USGDM Specific Testing Methods

USGDM takes its core principles form system engineering, and its values form behavioural economics. The principles shape the process and the nature of the methodology, and its direct impact can be seen very clearly in its design. The values are not represented in the work packages or the phases. The values are there to remind the user of the USGDM that this methodology is a human-oriented one.

While using the USGDM, developers need to be aware that the key assumptions of behavioural economics are good source of guidance to achieving behavioural change and learning. In the end the single most important value of USGDM is that serious games are an effective tool for individual behavioural change.

The SAS-129 team conducted a survey among serious game developers from different parts of the world and subject areas. The results of the survey provide critical points to consider during testing to avoid similar development problems. Asking these questions between iterations will provide the opportunity to correct any unseen problem before the main release (Table 4).

Table 4: Common Serious Game Development Problems Survey Results.

Questions	Answers		
Do you experience problems identifying stakeholders?	64% – No	36% – Yes	0% – Other
Do you experience problems considering all the needs of stakeholders from research to marketing?	60% – Yes	40% – No	0% – Other
Is finding necessary development funds a problem?	71% – Yes	29% – No	0% – Other
How would you score the challenge of finding a balance education and entertainment?	47% – Challenging		
Are you able to find literature on extensive user tests that collect quantitative feedback from already implemented systems?	54% – Yes	20% – No	26% – Other
How difficult is to identify SG's learning outcomes	48% – Difficult		
Finding the graphic designer with necessary skills and expertise is challenging.	38% – Agree		
Finding necessary funds for a graphic designer is challenging.	49% – Agree		
Creating graphics for scenarios, levels, narratives, etc. is a major effort and consumes a large part of the budget.	59% – Agree		
How difficult is to design user experience to be "pleasantly frustrating" – Gameplay that is entertaining and challenging	71% – Challenging		
How difficult is to create an iterative collaboration environment consisting of various experts during the development phase?	54% – Difficult		
How challenging is to overcome time and space limitations for SG based education?	59% – Challenging		
How challenging is to develop a relevant back story to accompany the SG?	30% – Challenging		
Developing long, challenging, and complex serious games that are similar to games for entertainment.	53% – Challenging		
Finding modification options for existing game engines and collaborating with others.	26% – Challenging		
Capturing player expectations.	58% – Challenging		
Limitations of visual interactivity, immersion, and fidelity.	29% – Challenging		
Target demographics for serious games are often non-game players.	56% – True		
Making sure that the subject/content of the game is relevant to the training objective.	51% – Challenging		

Questions	Answers		
Designing for the whole context of use, including learning methods and domain specific constraints.	58% – Challenging		
Are you able to implement rapid prototyping?	79% – Yes	21% – No	0% – Other
Do you find measuring success of SG problematic?	64% – Yes	36% – No	0% – Other
Do you agree with the statement "Successful video games have always been characterised by high-quality 2D or, now ever more, 3D graphics?" (For Digital Serious Games).	43% – Yes	57% – No	0% – Other
How difficult do you find designing human-computer Interaction in Serious Game development? (For Digital Serious Games).	51% – Difficult		

3.5   USGDM Development Team Structure

NHL Stenden University has created a unique model for a serious game development team. This model distributes the project team's roles and responsibilities onto a system engineering v-model. There are six roles designed (Figure 5).
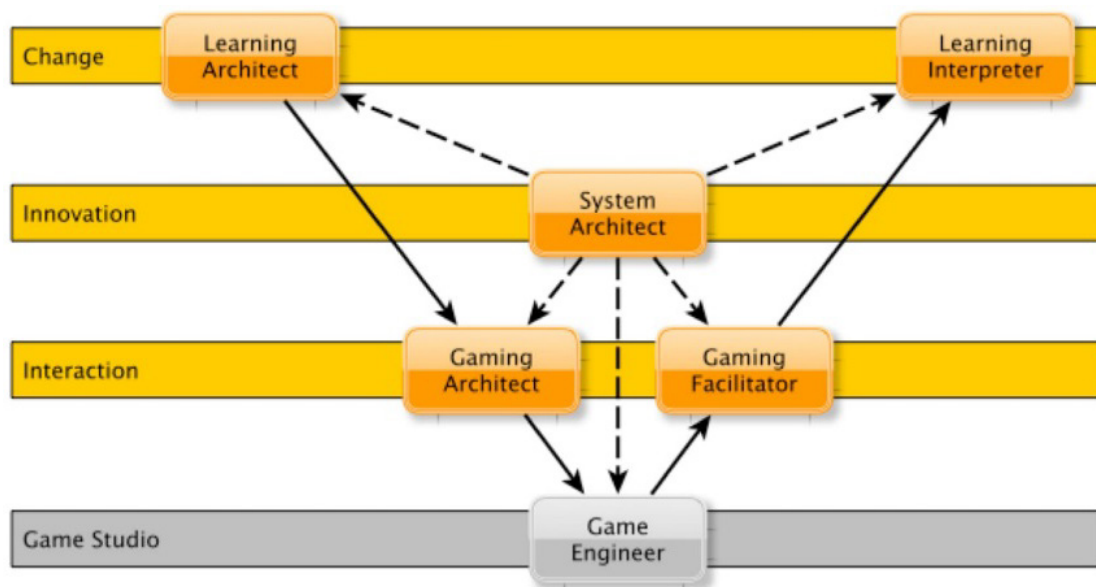

Figure 5: Serious Game Development Team Roles.

The Learning Architect works on developing learning goals and training/education design. The Game Architect translates learning goals and educational design into game design. The Game Engineer develops the game into a product or service. The Gaming Facilitator works as the presenter/trainer for the game once the game is in operation. The Learning Interpreter analyses the impact of the serious game and its effects on the individuals or the organisation. Finally, the System Architect's role is to oversee all the process and ensure the co-operation of the interdisciplinary roles and responsibilities. It is important to indicate that one person can fulfil all the roles illustrated above. Nevertheless, depending on the size and scope of the project it is possible to assign these roles to different members of a team.

The v-model was extended to fit the USGDM. The nature of the methodology is to bring together various stakeholders in an iterative way for developing a serious game. The six roles designed fit perfectly with the

knowledge and skill requirements of the USGDM. A combination of learning and game architecture brings forth the key requirement of serious games: the blending of education and gamification. Furthermore, by including a definition of the developer as game engineer the model enables game development expertise to be involved in serious game projects. Finally, by creating the two roles of gaming facilitator and learning interpreter, the model brings two key stakeholders and their expertise from the in-operation phase to the project from the beginning, thus enabling a future oriented design approach. Finally, USGDM takes its core principles from system engineering approach because of the multidisciplinary nature and complex stakeholder needs of serious games. As the model suggests, including a system architect would greatly increase the implementation success of the USGDM and coordination of the different roles need for the development process.

3.6 Werbach's 6D Gamification Framework: Define, Delineate, Describe, Devise, Do Not Forget the Fun, and Deploy

Werbach and Hunter have developed a gamification framework that has become known as 6D: Define Business Goals, Delineate Target Behaviours, Describe Your Players, Develop Activity Loops, Don't Forget the Fun and Deploy Tool. This framework provides a set of six steps in the design process. It also allows for a structured approach by methodologically and systematically working through the following set of exemplary questions (Werbach, 2012e):

Define Business Goals (determining organisational goals): why gamify? How should a company/ organisation promote employees or change their behaviour? If a gamified system behaves as intended, what specific positive results will the company/organisation achieve? This step is crucial because it provides the foundation for all other design thoughts (Werbach, 2012e).

Delineate Target Behaviours (determining the behaviour of the target group): what should the player do? Which metrics can be used to measure this? How does the behaviour shown by the player help the company/organisation achieve its goals?

Describe Your Players (description of the target group): who are the people participating in the gamification? What is their relationship with the developer? Are the players potential customers or employees of the company/organisation or part of another community? What characteristics (demographic characteristics such as age and gender; psychographic characteristics such as values and personality) do the players have? What sorts of game elements and other structures are likely to be effective for this population? Is a confrontational or cooperative system more suitable for the target group?

Development of activity loops (determining engagement loops): how are players motivated using engagement and progression loops? What types of feedback are offered to players to encourage them to take further action?

3.6.1 Application of Werbach's 6D Gamification Framework

Werbach's gamification framework provided inspiration for the game methodology guidelines developed by NATO SAS-129. Werbach's 6D was chosen because of simplicity. In the following sections, we examine Werbach's 6D framework according to the sequence of steps.

3.6.1.1 1. D: Define Business Objectives

Werbach asks a fundamental question in step 1: If a gamified system behaves as intended, what specific positive results will the company/organisation achieve? (Werbach, 2012e). A complete and in-depth analysis of NATO's business goals concerning the possibility for gamification is beyond the scope of this report. The report defines NATO's business objectives based on publicly available and unclassified source material. According to NATO's "Cyber Pledge" (NATO, 2016b), the report understands NATO's list of business objectives as the expressed goals and values in the Cyber Pledge:

- *... ensure the Alliance keeps pace with the fast evolving cyber threat landscape and that our nations will be capable of defending themselves in cyberspace ...*

- *... enhance the cyber defences of national infrastructures and networks, ... ensure that strong and resilient cyber defences enable the Alliance to fulfil its core tasks. ... work together to better protect our networks and thereby contribute to the success of Allied operations.*

- *... reinforcing resilience in the Euro-Atlantic region ... further NATO – EU cyber defence co-operation ... reaffirm the applicability of international law in cyberspace ... including the voluntary norms of responsible state behaviour and confidence-building measures in cyberspace ... recognise the value of NATO's partnerships with partner nations, industry and academia ...*

- *... emphasise NATO's role in facilitating co-operation on cyber defence including through multinational projects, education, training, and exercises and information exchange, in support of national cyber defence efforts. ... ensure that our Alliance is cyber aware, cyber trained, cyber secure and cyber enabled.*

- *... strengthen and enhance the cyber defences of national networks and infrastructures as a matter of priority. ... with the continuous adaptation of NATO's cyber defence capabilities, ..., this will reinforce the cyber defence and overall resilience of the Alliance.*

- *.... task an annual assessment based on agreed metrics, ... review progress at ... next summit.*

NATO's Cyber Pledge also provides a guideline for implementation with seven steps:

NATO will:

- *Develop the fullest range of capabilities to defend our national infrastructures and networks. This includes addressing cyber defence at the highest strategic level within our defence related organisations, further integrating cyber defence into operations and extending coverage to deployable networks.*

- *Allocate adequate resources nationally to strengthen our cyber defence capabilities.*

- *Reinforce the interaction amongst our respective national cyber defence stakeholders to deepen co-operation and the exchange of best practices.*

- *Improve our understanding of cyber threats, including the sharing of information and assessments.*

- *Enhance skills and awareness, among all defence stakeholders at national level, of fundamental cyber hygiene through to the most sophisticated and robust cyber defences.*

- *Foster cyber education, training and exercising of our forces, and enhance our educational institutions, to build trust and knowledge across the Alliance.*

- *Expedite implementation of agreed cyber defence commitments including for those national systems upon which NATO depends* (NATO, 2016b).

NATO supplements these goals with a factsheet on Cyber Defence (NATO Public Diplomacy Division (PDD) – Press and Media Section, 2016).

The following business goals were selected as particularly suitable for further investigation regarding gamification:

- *... enhance the cyber defences of national infrastructures and networks, ... ensure that strong and resilient cyber defences enable the Alliance to fulfil its core tasks. ... work together to better protect our networks and thereby contribute to the success of Allied operations.*

- *... emphasise NATO's role in facilitating co-operation on cyber defence including through multinational projects, education, training, and exercises and information exchange, in support of national cyber defence efforts. ... ensure that our Alliance is cyber aware, cyber trained, cyber secure and cyber enabled.*"

Concerning these goals, the following steps for implementation are relevant:

- Improve our understanding of cyber threats, including the sharing of information and assessments;

- Enhance skills and awareness, among all defence stakeholders at national level, of fundamental cyber hygiene through to the most sophisticated and robust cyber defences; and

- Foster cyber education, training and exercising of our forces, and enhance our educational institutions, to build trust and knowledge across the Alliance.

This selection puts a particular emphasis on training and education. Concerning training and education, NATO provides an educational reference document: "Cybersecurity. A Generic Reference Curriculum" (Partnership for Peace Consortium Emerging Security Challenges Working Group, 2016). In addition to the broad business goals and steps for implementation, this document specifies learning goals and learning outcomes.

NATO's Cyber Defence Awareness e-learning course (ADL 076 Cyber Defence Awareness) stood out as a suitable test case for gamification. NATO CCD COE developed the course, and the main purpose of the course is to provide awareness, basic knowledge, and familiarisation on the most important and relevant topics of the cyber defence and IT security areas. Furthermore, the course enhances the general user's awareness of cyber security risks and measures to mitigate those risks. The course provides an introduction to general cyber security to aid familiarisation with attacks, terminology and defensive techniques (NATO CCDCOE, 2019).

The goal of the course is in line with the identified business objectives, and the outline of the course provides further answers for the next steps. Furthermore, the course goals answer Werbach's question concerning the intended positive results.

This understanding leads to the research question: how can we develop a gamification prototype to increase cyber awareness and resilience? Furthermore, should this be explicit or implicit gamification or the combination of both? Explicit gamification was chosen for the development endeavour.

3.6.1.2 2. D: Delineate Target Behaviours

Werbach asks a few basic questions in step 2. What should the player do? Which metrics can be used to measure this? How does the behaviour shown by the player help the company/organisation achieve its goals? (Werbach, 2012e).

The objective of NATO's e-learning course is to enhance the general user's awareness of cyber security risks and measures to mitigate those risks. The learning objective is to provide a general introduction to cybersecurity, attack methods, terminology, defensive techniques, and an overview of the recent threat landscape (NATO CCDCOE, 2019). The learning objective focuses on cognitive learning outcomes. Therefore, the desired target behaviour from the designers' point of view would be high engagement with the content. However, to increase resilience, the performance of cyber hygiene would be the main desired action during gamification. The performance of cyber hygiene measures would be a perfect test case for gamification as it would turn an inconvenient activity into a fun activity, thereby increasing individual cyber resilience. Refer to the deconstruction of the CRCG for a detailed description of the desired action regarding the individual DMC. The focus regarding cyber hygiene of players would cover their own smartphones

(BYOD), thereby increasing their personal cyber resilience on the technical level. This behaviour could be measured by observation during gameplay. The development of further metrics beyond the current stage of the CRCG is for future development; for instance, the paper prototype could be transformed into a digital explicit gamification in the future. The shown player behaviour increases the cyber resilience of the player immediately during gameplay.

3.6.1.3   3. D: Describe Your Players

In this step, Werbach asks the simple question: Who are the players participating in the gamification? (Werbach, 2012e). According to the NATO e-learning course, the target audience is the average user within the NATO community, including all users of NATO networks (NATO CCDCOE, 2019).

Werbach provides a set of additional questions to guide the developer (as pointed out in Section 2.3.4):

- What is their relationship with the developer?
- Are the players potential customers or employees of the company/organisation or part of another community?
- What characteristics (demographic characteristics such as age and gender; psychographic characteristics such as values and personality) do the players have?
- What sorts of game elements and other structures are likely to be useful for this population?
- Is a confrontational or cooperative system more suitable for the target group?

The CRCG is the explicit gamification of the course content. Therefore, the target audience is, in principle, the same. However, the designer designed, developed, and improved upon the CRCG with students on-premises, usually in classrooms or workshop areas. Therefore, part of the target audience includes regular students attending the BwCSC and NAT DAT COE. Also, the designer played the CRCG at conferences and expositions with civilian visitors of all genders and age groups. This approach widens the audience beyond average users within the NATO community. However, any player needs to have sufficient English language skills to comprehend the rules and play the game. Given this broad spectrum within the target audience, a further distinction between particular DMC for particular target group did not seem necessary at this point. However, concerning the topic, a confrontational system seemed evident to the designer.

3.6.1.4   4. D: Devise Activity Cycles

Werbach provided the following questions as guidance for the developer (as pointed out in Section 2.3.4):

- How are players motivated using engagement and progression loops?
- What types of feedback are offered to players to encourage them to take further action?
- How does the feedback motivate the players?
- How can players progress/develop in the system/game?
- How does the system/game involve new players, and how does it stay refreshing for more experienced players?

3.6.1.5   5. D: Don't Forget the Fun

Werbach provided the following questions as guidance for the developer (as pointed out in Section 2.3.4):

- Is the gamified system fun?
- How would the system work without additional rewards?
- What aspects of the game could motivate players to participate without rewards?

The short answer to the first question is "yes." A system without rewards would work with addressing intrinsic motivation. Therefore, addressing mainly core drives 1 – 3. The answer to the third question requires the deconstruction of the game to identify this aspect.

Figure 6 lists all identified DMCs, core drives, player types, phase of the player's journey, and keys to fun regarding the deconstructed game parts. However, this is only a quantitative analysis. The real evaluation is only possible through playing the game. Fun is an emergent quality of gameplay and lies in the eye of the beholder (player). The detailed discussion of this analysis follows in Section 3.4.

Werbach's DMC							
Dynamics	**total**	**Mechanics**	**total**	**Components**	**total**	**Components**	**total**
Constraints	185	Challenges	20	Achievements	0	Points	97
Emotions	41	Chance	29	Avatars	0	Quests	0
Narrative	118	Competition	77	Badges	0	Social Networks	0
Progression	60	Feedback	140	Boss Fights	8	Teams	0
Relationships	3	Resource Acquisition	38	Collections	72	Virtual Goods	0
Bartle's Player Types	**total**	Rewards	75	Combat	84	**Player's Journey**	**total**
Killers	84	Transactions	98	Content Unlocking	63	Discovery	4
Achievers	91	Turns	18	Gifting	0	Onboarding	12
Explorers	106	Win States	25	Leaderboards	0	Scaffolding	175
Socializers	20	Cooperation	2	Levels	26	Endgame	9
Number	**total**	**Chou's Core Drives**		**Lazzaro's 4 Keys to Fun**			**total**
1	13	Epic Meaning & Calling		1. The Player: The Internal Experience Key			13
2	99	Development & Accomplishment					
3	100	Empowerment of Creativity & Feedback		2. Hard Fun: The Challenge and Strategy Key			136
4	93	Ownership & Possession					
5	32	Social Influence & Relatedness		3. Easy Fun: The Immersion Key			21
6	127	Scarcity & Impatience					
7	153	Unpredictability & Curiosity		4. Other Players: The Social Experience Key			18
8	97	Loss & Avoidance					
Quantity	0			non-existing			
0 -	39			very weak			
40	79			weak			
80	119			medium			
120	139			strong			
	>139			very strong			

Figure 6: Quantitative Assessment CRCG.

3.6.1.6 *6. D: Deploy the Appropriate Tools*

Werbach provided the following questions as guidance for the developer (as pointed out in Section 2.3.4):

- On which platforms should the game/system be provided (mainly PC, mobile devices, or other platforms)?
- Which game elements are used, and how will the players react to them (what experiences will they have)?
- What feedback, rewards and other reinforcements could the players receive?
- Are the design decisions linked meaningfully to other development steps?

Werbach suggested having a detailed prototype available for this final step. The analytical framework is also helpful in answering the last three questions in detail (see Sections 3.4 and 6.3 as a case study for a paper

prototype). The advanced paper prototype works very well in a seminar setting. However, a digital version may pose challenges for developers (see conclusion). Therefore, the developer needs to consider the first question quite early on.

4.0 WHAT TO DO BEFORE USING SERIOUS GAME AND GAMIFICATION IN TRAINING AND EDUCATION

Serious games and wargames are only successful insofar as they remain a relatively accurate representation of the situation being modelled, and deliver the desired insights, teachings, or information outputs to be relevant and useful. "The Craft of Wargaming" (Appleget, Burks, Cameron, 2020) argues that this accuracy should be enough to "keep the players focused" and the more important element is to address the objectives of training the rest of in accuracies has an high chance to be smoothed out by the power of suspension of disbelief, which implicitly means ignoring the inaccuracies in representation. Thus, the process of wargaming should include the collaboration between designer and player, and in many cases facilitator(s) (Figure 7).
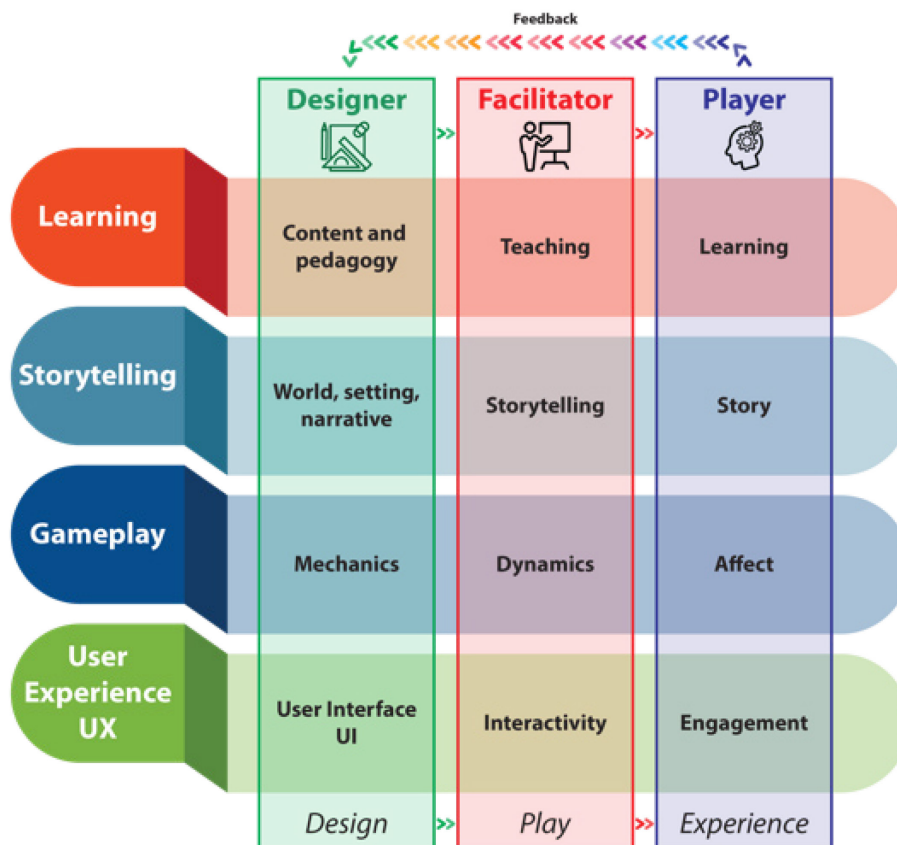

Figure 7: Serious Game Construction Worksheet.

When sufficiently complex, or large, a game may require facilitation, bridging the gap between design and player. This facilitation may take many forms. In the case of digital games, the facilitation is often automated, and the user interfaces with a screen, computer, and some control, whether a simulated cockpit, or keyboard to receive player input.

Often, however, this facilitation takes the form of a person or team that interprets player actions, guides the game in a timely and efficient manner, and restricts outcomes and inputs within the scope of reality and the scenario.

The particular skillset required of such a team or individual is quite particular and can be quite rare. At the centre of the most successful, efficient, and fruitful (and enjoyable) game experiences will be such a skilled person or team.

4.1 Serious Games Facilitation

Games facilitation is a specialised subset of facilitation and coaching that brings with it a particular set of obligations and expectations for a successful game run.

A serious games facilitator is often – due to budgetary constraints or availability on resources – tasked with accomplishing three disparate roles under the umbrella of facilitation:

- Facilitation.
- Adjudication.
- Subject Matter Expertise (SME).

While these roles can be accomplished by a single person, they should not be executed at exactly the same time (see Section 4.1.1). A single person may be asked to wear many hats but can only accomplish each role well by wearing one of these hats at a time (Figure 8).

Briefly, each of these roles can be defined as:

- **Facilitation:** engaging others toward a goal.
- **Adjudication:** umpiring specific a set of rules.
- **SME:** consulting on doctrine, and reasonableness of decisions as well as maintaining the setting.
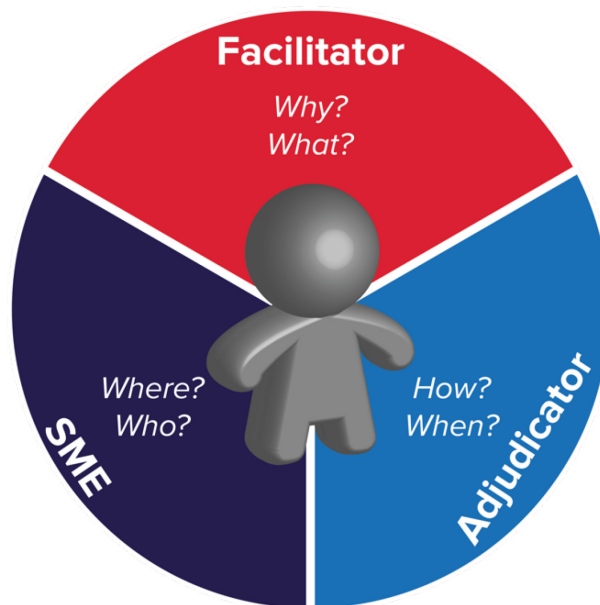
Figure 8: Roles of the Facilitator.

In the simplest of terms, a facilitator will guide the game along the *why* and *what* axes. Keeping the players focused on the purpose of the game, and what the exercise is seeking to accomplish.

An adjudicator will rule how player can achieve their goals, and when they can make moves and have effects.

The SME ensures that the player is virtually situated where the scenario takes place, and that actors behave appropriately and according to some convention that meshes with the reality of the situation. In short, the SME exists to ensure "magical" actions aren't taken, and game adjustments are made, when necessary, to reflect how things should occur in a real-world equivalent scenario.

4.1.1 Why Not at the Same Time?

The roles of Facilitator-SME-Adjudicator are quite often in harmony, but there will be cases when the domains of each blur, and a choice must be made how to proceed. Hence, it is important to separate the roles as much as possible within one's mindset. Imagine a scenario where a particular game-rule-related ruling might be in line with designer intent, but might bog down a game, and move entirely off topic. Few games are perfect, and a designer seeks to mitigate this circumstance as much as possible, but these matters do occur. So, how to make a choice? The only way is to effectively decide is to separate, logically, the roles and press forward in the manner that best serves the overall goals of the game, without bogging down the game in minutiae.

A bogged down game is engagement lost, and a game experience marred.

Separating the different mindsets required of the Facilitator-SME-Adjudicator triad serves to mitigate these circumstances, offering a possible solution as the cause-and-effect of each ruling is weighed against the exercise's goals.

4.1.2 Subject Matter Expert

The role of the SME is the most straightforward but can also be contentious, as "expertise" may be subjective, and there may be differing viewpoints.

The SME (or SME persona for an individual facilitator) should be well-versed in the topic at hand, and the platforms/systems used in the scenario. They will serve as the ultimate arbiter of the possible and provide on-the-fly adjustments for any non-player role's behaviour.

If one considers a kinetic Iraqi war scenario where the Daesh (ISIS) is engaged in direct and indirect warfare against coalition forces, the SME(s) should ideally be versed in the appropriate weapons systems and their effects, ISIS behaviour, desert warfare, weather, regional biases, tribal relationships, etc. Should a player proceed in a manner that is not within the real landscape of possibilities (ISIS allying with the Vatican, or other such fantastical happenstance), the SME must adjust the game to keep it in line with reality. Certainly, any real-world examples should be less off-the-wall, but it remains in the SME's domain to correct matters accordingly.

4.1.3 The Adjudicator

The adjudicator is the umpire. Game rules often need interpretation, and some situations are not so cut-and-dried as to be covered directly by one rule or set of rules. The adjudicator's presence acts as an authoritative figure on the rules as written, and rules as intended. The adjudicator will have final say on the degree of success or failure following a contentious move or action.

Needless to say, the adjudicator must be well-versed in the rules, and understand the ruleset as it was intended. Words matter, and rules may be misinterpreted if the written rules are not entirely clear. Imagine a scenario where a rule is written as: "the player shall move their token, then fire their main weapon." Does this mean a player must move before firing? What if this incurs a penalty? What if this moves them out of cover? Was this the designer's intention? Here the adjudicator will clarify, and rule on-the-spot to expedite the game, in conjunction with the overall goals of the game.

4.1.4 The Facilitator

The facilitator is the ultimate guide to the game. The facilitator controls pacing and drives the narrative forward towards the end goal. To be clear, the facilitator does not drive the narrative to a specific end result but engages the players, so they drive toward the overarching analytic or training goal of the game.

One can think of the facilitator as an orchestra conductor. The players are playing their part, but the conductor guides all in a harmonious performance. When that performance becomes disharmonious, the facilitator is also responsible for managing that conflict.

Put another way: the facilitator guides the experience.

4.1.5 The Experimental Game

Wargames are, ultimately, experiential games that create a virtual environment to mimic the real-life equivalent scenario. In a confluence of rules, roles, components, and players, the wargame seeks to engage in such a way that new information or insights emerge from the experience (Figure 9). Whether training or analytic endeavour, the goal of the wargame and its design and facilitation teams must be to exploit all aspects of the game to create the best possible experience, with real stresses, agency, decision making, and perceived effects.

In order to achieve this lofty goal, designer and facilitator collaborate to bring about a cognitive shift in the player. These effects are most easily achieved when an experience facilitator(s) engages with a strong design.
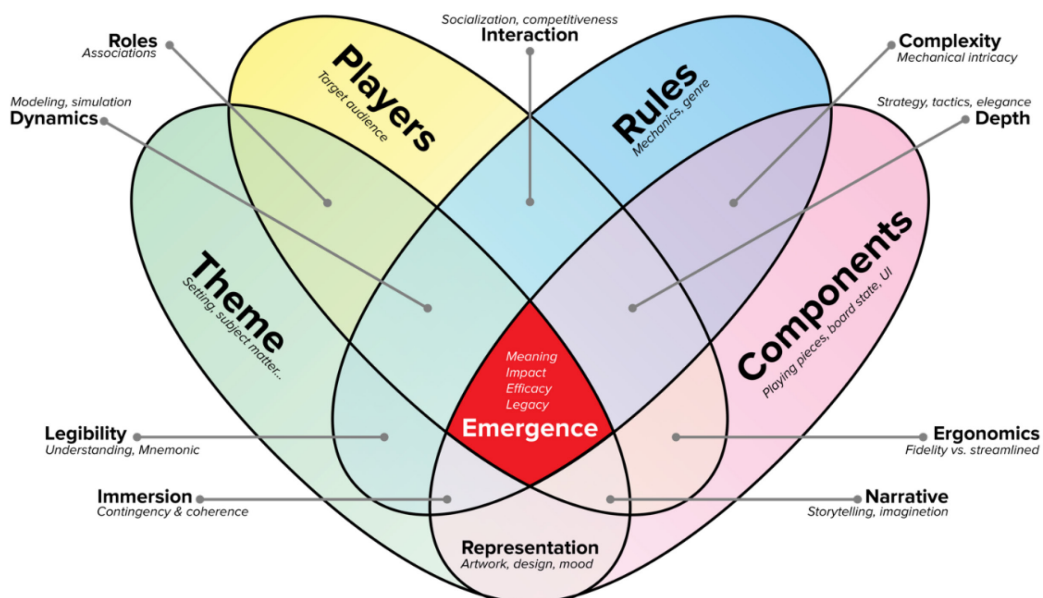
Figure 9: Interaction Between Themes, Players, Rules, Components and Representations.

The introduction to Section 4.1.5, above, discusses the schema for good game design. Here we will focus on the actual delivery of an experiential game, and the best practices of a facilitator (or facilitator team) in engaging players.

Here we combine all game components, theme, rules, and players to create an emergent experience to the benefit of the players, and the goal of the game. Games that effectively target this sweet spot convergence of all game elements create meaningful, impactful games that will not only be memorable and engaging but provide the richest information output or training experiences.

Much of the secret to achieving this ideal comes down to game management.

4.1.6   Ten Commandments of Game Management

Here the basic rules of game management and engagement are broken down into 10 (11) Commandments:

0. Thou shalt keep them engaged
1. Thou art always right
    a. But not always entirely right
    b. Be willing to make and own mistakes
2. Thou shalt endeavour to say yes
3. Thou shalt be passionate and animated
4. Thou shalt have a plan
    a. But do not depend on that plan
5. Thou shalt give players agency
    a. Never be prescriptive
    b. Let the players make their choices
6. Thou shalt use thy words wisely
    a. Encouragement is great
    b. What you say becomes a game rule
    c. Each ruling must be respected
7. Thou shalt be balanced in rulings
    a. Neutrality and consistency will keep player engaged
8. Thou shalt know thy players
    a. Know triggers, taboos
    b. Speak in their terms/language
9. Thou shalt steal ideas and example from other facilitators and adjudicators
10. Thou shalt keep the game moving.

4.1.6.1   *Thou Art Always Right*

A game calls for a certain suspension of disbelief. We're not actually engaging in a conflict in a hot zone in 2035, even if the game stresses and pressures may make some things feel real. In order to keep the players engaged and immersed they must count on the facilitator to keep things moving, and consistent. This means knowing the rules, ruling fairly, and consistently.

Often situations come up that are not covered by a specific rule or players will attempt something not specifically covered in the rules. Here the facilitator (adjudicator) will need to rule and stick to their ruling.

Sometimes a rule is missed or ruled incorrectly. The facilitator (adjudicator) must take the responsibility of being the final arbiter.

If ever a ruling is wrong and contrary to the rules, and this has had a detrimental effect on the game and its outcomes, the facilitator must own up to the error, fix it, and move on.

What a facilitator must never do is give up authority and be dictated to by players. It is one thing for the player to have agency, it is another thing entirely for a player to try to take over a game. A facilitator must maintain their authority over the game to ensure a smooth run.

4.1.6.2   *Thou Shalt Endeavour to Say Yes*

A facilitator should never say "You can't do that."

The game environment is one of experimentation and exploration, and players should be encouraged to keep thinking outside the box for novel solutions. Sometimes these solutions may be off-the-wall or be beyond the realm of the possible. A facilitator should guide the player back to a more realistic approach, while encouraging the novel thinking.

Most people's least favourite word is "No," and to hear "No" risks disengagement. There are many nuanced ways to say no without saying no outright. The facilitator's diplomacy will be put to the test, but this will make the game experience that much richer.

> Ways of saying no, without actually saying no:
>
> - That's a great idea, but beyond the scope of the game.
> - That's really novel, but the game limits us to these course of action.
> - I see what you're saying, let's discuss that after the game, but limit our in-game action to this.

4.1.6.3   *Thou Shalt Be Passionate and Animated*

Nothing ruins a game experience like a passive, monotone facilitator.

A facilitator usually needs to be the most energetic person in the room. The players will pick up on this energy and engage accordingly. Only rarely will a facilitator find a player who is more energised, engaged, and animated then they are. Thus, the facilitator sets the tone for the experience.

Certainly, when dealing with serious matters, one must temper eagerness, and portray the appropriate behaviours at all times, but engagement and energy needn't be in opposition to serious, sometimes dire scenarios.

Displaying passion and concern about the subject matter and investing in player involvement are tools the facilitator must master in order to get the most out of the players.

4.1.6.4   *Thou Shalt Have a Plan (but Not Overplan)*

"Plans are worthless, but planning is everything."

D. Eisenhower

A facilitator must be prepared. Know the rules, know the players as much as possible, know the audience, and the desired outputs. However, no game has ever gone to plan.

The details of the advance game plan will often be incorrect – players will often do the most unexpected and strangest things – but the planning process demands the good exploration of options and contingences. The knowledge gained during this probing is crucial to the selection of appropriate actions as future events unfold. This, of course must be balanced against available time and scale. It is possible to overplan. The best guideline is to plan to a comfort level with the material and prepare some solutions to anticipated contingencies.

Simply put: no game plan survives first contact with the players. However, having the plan in place, with contingencies, provides that level of comfort and preparation that will allow a facilitator to face most situations. Only the very best facilitators have the breadth of experience and skill to be uniquely improvisational and enter a game space unprepared.

4.1.6.5   *Thou Shalt Give Players Agency*

Player agency is simply the ability for a player to make free decisions based on the information at hand, and for these decisions to have a measurable effect on the dynamic game environment. Effectively this is the difference between a game and a puzzle. No matter a player's choice, a puzzle will always have the same outcome or small set of outcomes. A game's very make up is changed by a player's decisions, and the choices they make. Further the information they receive from the game and the manner in which they receive it can be changed.

4.1.6.6   *Thou Shalt Use Thy Words Wisely*

Everything the facilitators says, intentionally or not, becomes a game rule.

It is of great importance that facilitators pay very close attention to their words and rulings on grey areas of rules. Words matter, especially when describing a model to be used in a simulation game or wargame, as these words shape the reality of the game world. Precision and specificity matter.

Language should also be encouraging, and enthusiastic, keeping players engaged, and enabling an atmosphere of free expression, where the best novel ideas can spring forth.

4.1.6.7   *Thou Shalt Know Thy Players*

Whenever possible, a facilitator should have knowledge of the players, and even make up the teams/sides in a competitive wargame.

Knowing player and organisational mores and taboos is an important piece of engagement and keeping the focus on the game. One can imagine the shock of a player should a facilitator make a cultural faux pas. Trust, engagement, and immersion can be immediately and sometimes permanently lost.

Player teams can also be socially engineered to encourage (good natured) conflict, or by placing persons in power in a lower hierarchal position, giving them a different point of view. These powerful social tools and the lessons that can be gleaned from them are only possible if the facilitator has an understanding of the players.

4.1.6.8 *Thou Shalt Steal Ideas and Examples from Other Facilitators and Adjudicators: Steal but Steal Ethically*

An old idiom of game designers is to steal from other games and designers but give proper attribution and credit. This flows into the world of adjudication and facilitation. We have all been in the presence of great teachers, facilitators, and adjudicators. Until one develops a style of one's own: steal their style, their energy, and their pacing.

4.1.6.9 *Thou Shalt Keep the Game Moving*

A model is static, a simulation game is in constant motion.

A fundamental part of game engagement is constant movement. While a game may have quieter moments, there should always be something to do, or something going on.

4.1.7 Training

"How do you get to Carnegie Hall?"

"Practice."

Facilitation is a skill that can be taught through theory, but there is no substitute for hands-on experience. Games facilitation is no different, and likely even more dependent on practice.

We tend to facilitate on a daily basis: when dealing with colleagues, leading a meeting, delivering a presentation, even talking amongst colleagues. There is a natural social practice of facilitation or facilitation-like skills that takes place every day.

Games facilitation, however, is a skill not usually practised.

Hobby gamers practice this skill quite often and may be naturally fitted to the wargame facilitator role, but we need not limit ourselves to the narrow hobby game field. The skill of game facilitation can be taught and practised quite simply: through play.

The very best way to develop and hone game facilitation skills is to facilitate game play in low-stakes games, where the outcome is not being specifically measured. It is not that the skills are particularly hard to learn, but they are very particular, and mastery will take practice through play.

The very best experience one can have to develop facilitation skills is through gamemastery: that is running role-playing games. A Game Master (GM) runs open ended games within a specific Role-Playing Game (RPG) ruleset. Acting as director, adjudicator, conflict manager, and world-building SME, the GM puts into practice all the skills outlined above in a fictitious sandbox-like environment. Players have full agency to improvise and act out roles, and the GM must control the world, its environs, characters, "red team," challenges, combat, and helpful elements all within the chosen ruleset.

The most popular RPG, worldwide, is Dungeons and Dragons with a player base in the millions monthly. It would behove anyone serious about games facilitation to play and GM a few role-playing games to gain experience in the ebb and flow of the game and live the improvisational nature and quick-thinking necessary to keep a game in flow, and get the most out of the players, delivering them the most engaging experience.

After all, it is this engagement that drives the best serious games and wargames yielding the best outcomes.

5.0 WHAT TO DO BEFORE SERIOUS GAME AND GAMIFICATION ACQUISITION

During the acquisition phase for an off the shelf, custom made, or event based (workshop, seminar, etc.) game-based solution, testing the quality of the solution without full purchase and integration can be challenging. The Smart Buyer's Guide consists of key questions that need to be asked before purchase. The guide has been developed based on literature reviews, development methodologies and game assessment methods.

The guide does not specify which questions need to be asked and what are the right answers. The guide uses the questions to act as a checklist of critical considerations. Satisfactory answers will vary based on the size of the acquisition, the system and the context of the project, available testing opportunities and in the bottom line is up to the buyer to decide if the answer is satisfactory. However, it is important to note that, play testing is always the best method for quality assurance and will greatly improve the process of finding the answers provided below.

5.1 Design

- *Have suitable users been described?*

It is critical to assess whether designers of the proposed game-based learning product have spent enough time analysing their users. Details of who this product is designed for should be deemed satisfactory.

- *Have player expectations been captured in quantitative and measurable format?*

- *Have player expectations been processed as game adjustments?*

Player expectations have been found to be a challenging issue. The process of matching need to requirement to functional design minimises problems associated with this issue. Trying to trace function to need for any training solution will provide key insight into the design process of that product.

5.2 Digital Development Engine Selection

- *Does the Licence Agreement of the engine fulfil system and legal requirements?*

There are many digital game development engines (unity, unreal, etc.). Usually, their engines are free to use and only activate a licence agreement if the developed game if commercialised. Knowing the legal requirements and limitation before the engine selection could be critical in the long run.

- *Is the Cost of the engine within your budget?*

This is also part of the licence agreement decision.

- *Is there sufficient Documentation and Support available?*

Live support is fundamental in digital games. There is no improvisation available in many digital game systems, so if a part of the system goes down, the entire exercise will grind to a halt.

- *Is the Accessibility Learning Curve of the engine easy to master?*

While choosing most common engines be costly, not having the open-source community to support the development process can have hidden long-term costs.

- *Does the engine support the Platforms your system will operate on?*

One key aspect that can be usually overlooked is the deployment phase of the solution. Where this product will be implemented also carries critical importance. There can be solutions build or purchased that later on require additional IT investments to be used by the end user location.

- *Does the Audio-visual capability of the engine fulfil system requirements?*

- *Does the Fidelity capability of the engine fulfil system requirements?*

- *Does the Rendering capability of the engine fulfil system requirements?*

- *Does the Special Effects capability of the engine fulfil system requirements?*

- *Does the Shadows capability of the engine fulfil system requirements?*

- *Does the Lighting capability of the engine fulfil system requirements?*

- *Does the Texturing capability of the engine fulfil system requirements?*

- *Does the Animation Forward Kinematics capability of the engine fulfil system requirements?*

- *Does the Key frame Animation capability of the engine fulfil system requirements?*

- *Does the Skeletal Animation capability of the engine fulfil system requirements?*

- *Does the Morphing capability of the engine fulfil system requirements?*

- *Does the Animation Blending capability of the engine fulfil system requirements?*

- *Does the Scripting capability of the engine fulfil system requirements?*

- *Does the AI capability of the engine fulfil system requirements?*

- *Does the Composability Import/Export Content capability of the engine fulfil system requirements?*

- *Does the Networking Client Server / Peer-to-peer capability of the engine fulfil system requirements?*

Engine-provided functions need to be checked and double checked. Benchmark games, and key experts need to be identified, and an extensive reading effort needs to be conducted to ensure the engine can build the required game in all of the above-mentioned functional domains.

5.3   Content

- *Are the win and lose cases balanced?*

The word "balanced" has two critical meanings here. In player-vs-player kind of gamification/games, game balance is critical for fun and engagement. Both sides need to feel that they have equal chance of winning the game. However, for educational purposes the game can be designed to be "unbalanced." Kobayashi Maru from the famous Stark Trek franchise is a good example of this case.

Important to note that any serious game or wargame analysing or exploring real-world scenarios need not be balanced, and often shouldn't be balanced. The very nature and need for wargaming is to face unbalanced scenarios and determine the best path to victory, or an end goal.

- *Are the win conditions easy to understand?*

The learning curve needs to match the time the user can spend on the solution.

- *Are there in-game currencies or consumables embedded into core game mechanics?*

Such mechanics add to the gameplay, how they are embedded and if their addition to game has significant contribution to the game should be checked.

- *Is the game pleasantly frustrating?*

The game neither be too easy or too hard. There needs to be a challenge to the mastering of the game.

- *Are the game flow and variety of actions enough to reduce fatigue and boredom?*

Within the set play time game should have enough events and breaks to protect the user from over exhaustion and boredom.

- *Is the game long and challenging enough to keep the interest of the users alive?*

Sometimes short games designed for constraint time schedules are too short to be meaningful. Too easy games are also can fail to create enough of an entertaining and learning environment.

- *Is the game conflict balanced with strategic thinking?*

The challenge in the game needs to initiate a thinking effort. Sometimes games can have too many "bells and whistles" – though this is not bad for party games, it is always good that game-based learning tools initiate critical thinking processes.

- *Are the in-game mechanics easy to learn but hard to master?*

Learning how to play should be fairly easy and should not scare the user, however getting better at the game should require some effort and replay.

- *Are the in-game goals clear and easy to understand? Are there both short term goals and long-term ones?*

Goals and aims are the main motivators in the game, if the early goals are not balanced with long-term goals maintaining a steady game flow could be challenging.

- *Does the user feel emotional connection to the game world and/or to the main characters?*

The game world and game characters should make sense to the user, if the themes are too much of a foreign concept, the user will alienate from the game environment.

- *Does it have a tutorial level?*

- *Do your users find the tutorial educational and not boring?*

Usually beginner set-ups, scenarios, how to play use cases or tutorial levels are a really good way to curate a specific gaming experience that can teach the fundamental game mechanics. However, if this introduction is too long or too detailed users can get bored. Usually people like to play-learn, and this introduction level should enable this.

- *Is the storyline of the game in accordance with the learning content?*

Scenarios, stories, and flavour texts are key opportunities to set up the canon and the context of the game environment. Such set-ups can greatly contribute to the immersion.

5.4 Motivating the User

- *Is interaction between users creating social groups?*

Player vs. player environment directly plays to the competitive nature of the individual. People playing in the same side should come together while a rivalry should rise against the other side.

- *Do the game goals motivate the users?*

If the game's goals are too arbitrary, too hard to achieve or not enticing enough the user can ignore them, thus hindering a key mechanic of the game. All of the goals should be equally making sense to the user.

- *Is the system entertaining?*

Fun and entertaining are two different contexts. A refugee crisis gamified learning tools should not be fun, however time spent on it should be pleasant.

- *Does the system invoke intense and passionate involvement?*

If the users are observed to get passionate about the game, it is a good sign that game mechanics are working. Not all will be equally passionate nevertheless (healthy) passionate players on the same table can motivate the other users.

- *Do the game rules enforce structure of the system?*

Not everything should be ruled but rules should clearly set up the boundaries of the game. If key questions arise that are not clearly indicated in the rule book, should be covered. It is usually hard to understand this without few times play testing with different groups.

- *Is the game flow adaptive?*

Some users follow a fast strategy while other can prefer to build up. Game should be indifferent to both and enable both. Unless the speed of the game is part of the learning objective.

- *Does the winning provide ego gratification?*

If winning does not make any difference to the user, then a key mechanic of the game is missing. Either the game or its set-up and application methodology might be wrong. (Wrong people, wrong time, wrong place).

- *Does problem solving require creativity and use of gained new knowledge?*

For game-based learning tools, it is always best practice to tie up creative thinking problem solving and learning directly to the learning objectives.

- *Does the game's representation and story invoke emotion?*

The way the game is set up physically and mentally should invoke positive reactions from the users. If the game board, pins, and tools look cheap it can have a negative effect on the user. Reading a story that the user can relate, knows, and appreciate can increase user immersion to the learning environment.

5.5   Multimedia

- *Are the pictures, animations, sounds, and language used in the game suitable for the user?*

The design of the game and game elements should suit the lifestyle of the user and to the education environment.

- *Is the game interface attractive according to your target audience?*

During the testing phase the graphic interface design (software or tabletop) should attract attention of the user.

- *Do the graphics, animations, audio, and visual effects increase users' interest?*

Using effects for effects' sake can be confusing and frustrating. Effects should be a meaningful and balanced addition to the game.

- *Are the Avatar and character representations interesting or realistic in view of your target audience?*

Avatars, encounters, tokens, and pins should be interesting, artistic and/or realistic enough for the user to want it to use/remove/own it.

- *Does your environment promote immersion?*

Either the virtual or the training environment should promote immersion. The designed environment should cancel out enough attention to help user to feel connected to the game world.

- *Does the system provide playful feedback (visual and sounds effects or visual changes)?*

User inputs should change the game world/environment/board. Changes in the game should be visually represented and user should be able to clearly identify the new situation and/or change.

5.6   Interface Design and Structure

- *Are the graphics and control mechanics easy to understand and use?*

For both digital and board/card game designs, the game should be split into understandable parts, the more basic the better. Larger designs should have repeating patterns rather than more information crammed onto them.

- *Does the game include a help and hints function?*

Use cases, hints, and online communities (internet or intranet) are really good ways to help people learn and the game system to live. Some of these contents be available with the game material and some can be community driven.

5.7   Education

- *Is the information in the game accurate?*

Ensure that the game contains the right material and correct information.

- *Is the modelling of real life realistic or in accordance with the demanded system fidelity?*

There should be a clear fidelity recruitment when choosing a game-based learning solution and the selected product should match that level.

- *Does the learning material utilise real-life incidents or scenarios and is the user aware they are real-life or likely incidents?*

While it can be difficult to assess the quality of the information or the correctness, it can help to check if the game is utilising, and lessons learned from the real-life scenarios. Seeing the source material for the product's knowledge base can help answer key educational requirement questions.

- *Are the challenges in the game related to the learning materials?*

While game-based learning aims to entertain while educate, balancing game and education is also critical. Time is limited in a professional environment – ensure that the user is not jumping through any unnecessary hoops to reach the learning objective.

- *Is the order of the contents reasonable?*

Learning goals and knowledge acquisition should meaningfully build up, rather than an information dump on the user.

- *Is the important information presented clearly?*

The user should be able to clearly differentiate critical information that is directly connected to learning objectives.

- *Is the feedback provided in a timely manner?*

Feedback about the user's knowledge and learning opportunities should be provided to the user when they are most relevant.

- *Does the system provide a proper assessment of the user's skills/knowledge?*

The system should be able to clearly assess the user's knowledge and be able to determine if the learning objectives are met.

- *Can the system report user's status?*

The user should be given clear feedback on his/her learning process.

- *Can the learning process be analysed?*

The user's learning journey can benefit from milestone reporting to see how the user's learning curve develops throughout the educational process.

- *Does the after-action review process demonstrated change in behaviour, imparting of knowledge or skills, or the improvement of motor and cognitive capacities among the users?*

- *Is there before and after the training comparative knowledge measurement?*

During the testing period, observe effects of the game on the user. Specifically, note whether learning objectives are met.

- *Does the system make it clear that failure in the game reflects a serious mistake in reality?*

As part of immersion and good learning practice, it will help the user's learning process to match game failures to real-life lack of skill/knowledge.

6.0   TAXONOMY BASED CYBER DEFENCE GAMES

This section contains gamified training and serious games for different levels of cyber warfare collected or developed by the SAS-129 team.

Cyber Resilience Card Game	Awareness Level
https://gids-hamburg.de/workshop-multi-domain-future-cyber-wargaming/	
Status: The game is situated in the present. It is supposed to be updated to cover the most recent developments in cyber security. The status quo at the time of printing is 2016 – 2020.	
Summary of the Game: The CRCG is a 2 – 3 player game that could be facilitated but does not necessarily require a facilitator. The cognitive learning goals are knowledge about the most recent cybersecurity best practices against the most recent attack vectors. The behavioural learning goals are practising cyber hygiene during gameplay and therefore increase the individual resilience of the players.	
Target Audience: Any member of NATO (and their family members) who owns a mobile phone.	**Learning Outcomes:** Knowledge about the cybersecurity threat landscape, best practices and practised cyber hygiene.
Education/Training Method: Games-Based Learning (GBL) explicit Gamification.	**Gameplay Keywords:** Best Practices, Cyber Hygiene, APT
Purpose Keyword: Education, Resilience	**Game Platform:** Manual tabletop card game

Battlespace Next	Tactical Level
https://scholar.afit.edu/cgi/viewcontent.cgi?article=1812&context=facpub	
Status:	
Developed as part of Serious Games research thrust at Military graduate school.	
Summary of the Game:	
Battlespace Next: MDO is a card-based strategy game simulating modern peer-to-peer warfare. Engineered as a learning tool for military classrooms to engage students on the topic of Multi-Domain Operations (MDO). The game is a 2 – 4 player game featuring air, ground, cyber, maritime, Electronic Warfare (EW), and Information Operations (IO) capabilities. The goal if the game is to deploy and leverage forces to attack and outplay your opponent and ultimately destroy their Multi-Domain Operations Centre (MDOC).	

Target Audience:	Learning Outcomes:
Junior Officer	Recognise that both cyber and kinetic capabilities require a kill-chain and advanced planning; Match cyber defence capabilities to corresponding threats; Recognise the two levels on the Spectrum of Conflict (competition and conflict) and practice using appropriate assets within each; Develop and execute an MDO strategy in a complex and contested environment; Select and combine capabilities to anticipate, adapt, and respond to surprise and uncertainty in near-peer warfare.
Education/Training Method:	**Gameplay Keywords:**
Non-digital game	Collectable Card Game
Purpose Keyword:	**Game Platform:**
Multi-Domain Operations; Military Education and Training	Manual tabletop card game

Critical Energy Infrastructure Security Game	Technical Training Level

http://sisatem.com.tr/kategori/haberler/68585/enerji-sektoru-siber-kafe.html

Status:

The game was developed for Turkish Defence Industries and Cyber Cluster's Cyber Conference Event. Fifty IT specialist participated in the event.

Summary of the Game:

The participants were divided into teams and each table was assigned a facilitator. The teams were presented with an IT budget and set of IT capability cards. Each turn they were given an event card; cards were divided into global news cards, IT reports and cyber security event reports. Players were asked to react to these cards using their budget and capability cards. Depending on their right and wrong choices facilitators choose the next set of events cards. The game ended when the event cards ended. Both IT capabilities and successful cyber-attacks effected the company budget, and the teams were ranked based on the final budgets.

Target Audience:	Learning Outcomes:
IT and Cyber Security Experts	Effective IT Budget Management
	Reacting to global cyber security information
	Timely Cyber Incident Management

Education/Training Method:	Gameplay Keywords:
Players receive immediate feedback their actions through event cards. Cards contains detailed educational information.	Tabletop exercise, critical energy infrastructure, cyber event management

Purpose Keyword:	Game Platform:
Technical Expertise Training	Physical card driven board game

Lock Shields Exercise	Virtual Training and Cyber Range
https://ccdcoe.org/exercises/locked-shields/	
Status:	
This annual exercise, organised by NATO CCDCOE since 2010, enables cyber security experts to enhance their skills in defending national IT systems and critical infrastructure under real-time attacks. The focus is on realistic scenarios, cutting-edge technologies and simulating the entire complexity of a massive cyber incident, including strategic decision making, legal and communication aspects.	
Summary of the Game:	
The exercise is a Red Team vs. Blue Team event, where the latter are formed by member nations of CCDCOE. In 2021 there were 22 Blue Teams participating with an average 40 experts in each team. The Teams take on the role of national cyber-Rapid Reaction Teams that are deployed to assist a fictional country in handling a large-scale cyber incident with all its implications. The Exercise in 2021 involved about 5000 virtualised systems that were subject to more than 4000 attacks. The teams must be effective in reporting incidents, executing strategic decisions, and solving forensic, legal and media challenges. To keep up with technology developments, Locked Shields focuses on realistic scenarios and cutting-edge technologies, relevant networks and attack methods.	
Target Audience: IT and Cyber Security Experts	**Learning Outcomes:** Protecting unfamiliar specialised systems Writing good situation reports under serious time pressure Detecting and mitigating attacks in large and complex IT environments Team building and coordination
Education/Training Method: Involves regular business IT, critical infrastructure, and military systems Integrates technical and strategic decision-making exercise	**Gameplay Keywords:** Live-fire, real-time Red Team vs. Blue Team exercise More than 2000 cyber defence experts from nearly 30 nations
Purpose Keyword: Technical Expertise Training	**Game Platform:** Runs on Cyber Range, an innovative platform managed by the Foundation CR14

Archaria Multi-Domain Wargame	Operational Level
https://www.nato.int/cps/en/natohq/news_180639.htm	

Status:

SAS-129 has been working on developing a Multi-Domain Wargame that is a hybrid between conventional wargame, matrix gaming (argument games), and serious games. The purpose of this effort is to change the current military mindset towards more multi-domain approach and enable a motivational learning environment for non-technical personnel on the use of cyberspace in the near future operations.

Summary of the Game:

The wargame is played by two teams Red and Blue with four sub-groups, with approximately two persons each sub-group. The four sub-groups, representing Battalion Commander, Joint Staff, STRATCOM Office, and Cyber Command. Finally, the city is a green/white cell which is a non-playable character reacting to the team's activities. All of these groups need to coordinate their activities both before the conflict and during.

Target Audience:	Learning Outcomes:
Junior, Mid-Career Officers	What are the cyber assets in urban operations?
	What will be the cyber offence/defence tactics will look like in the near future?
	What will information assets look like in urban operations?
	What will be the information offence/defence tactics will look like in the near future?
	How will information and cyber warfare will assist kinetic effect in urban operations?

Education/Training Method:	Gameplay Keywords:
Learning is primarily through peer-to-peer discussion between players. Expert facilitation can help steer discussions	Multi-Domain, Mega-City, Near Future Urban Conflicts, Information Domain

Purpose Keyword:	Game Platform:
Education	Physical board game

The Great [Cyber] Game	Strategic Level
https://www.newstatesman.com/spotlight/2018/05/why-policymakers-are-playing-board-games-counter-cyber-threats	

Status:

The game was originally created as part of PhD research at Royal Holloway University of London. The purpose of the research was to analyse how a wargame could be used to generate cyber security learning opportunities for players. The first version of the game was made in 2015, with continual development in 2016 resulting in a stable version that was used during fieldwork in 2017 and 2018. The game was also part of the SAS-129 workshop in Hamburg in 2019.

Summary of the Game:

The game was inspired by the United Kingdom National Cyber Security Strategy. In the game there are 2 countries resembling the UK and a near-peer adversary, each with 5 playable actors: government, business, people, military/intelligence, and critical national infrastructure. Each of these actors is represented on a main game board, with linkages between them. Each actor is assigned unique, and conflicting, objectives. Gameplay revolves around resource management, with players spending resource to take actions including moving resources between actors, increasing the resilience of an actor, bidding on the black market, or launching attacks. Players do not have enough resources to do all actions and it is impossible for both teams to complete all objectives. There are two additional components: first, an illicit market containing offensive and defensive capabilities which are acquired through an auction mechanic; and second, a deck of randomly drawn event cards representing geopolitical realities. The game is turn-based with time limits on each team's turns. The game can be played with 2 – 10 players but works best with 6 – 8. A game session takes 2 hours including introduction and debrief.

Target Audience:	Learning Outcomes:
The game was designed for senior policy makers. In practice, the game works well as an introduction to cyber security for anyone who understands that cyber security is important but has not had a chance to meaningfully engage with core concepts and terminology.	• Actors in cyberspace and the relationships between them • Setting and achieving cyber strategy objectives • Managing limited resources • Dynamics of cyber-attack and defence • Geopolitical realities and landscapes • Visibility in and of cyberspace
Education/Training Method:	**Gameplay Keywords:**
Learning is primarily through peer-to-peer discussion between players. Expert facilitation can help steer discussions.	Strategy, resource management, attack, and defence
Purpose Keyword:	**Game Platform:**
Education	Physical board game

7.0 CONCLUSION

The keyword for the education of the new generation of military experts will be "engagement." One sided lecturing is not enough to capture the attention of the new generation of digital natives. Their entire lives have been shaped by the digital culture and they will only expect the same from their military education.

Rapid urbanisation has become a key trend, and the Mega-City seems to be the future ground for international conflicts. As all armies are small compared to a Mega-City of 10 million where only 1% of the population fosters ill content towards the arriving forces, conquering hearts and minds remains the battleground. Force structures of the future will rely on force multipliers of the combined effects of all five domains to tackle this environment against near-peer adversaries.

The information domain that includes cyber space, strategic communication, and the electromagnetic spectrum will be the main domain where all operations connect. Therefore, cyber security training and education cover a wide spectrum of target audiences. The delivery of mass awareness campaigns to a high level would be a strategic consideration for cyber deterrence in peace time.

This research task group set out to study the use of serious games and gamification for cyber security training. In it is earliest stages the group noticed that cyber security did not exist in an educational vacuum – any learning on the subject of cyber security, aside from technical training, needed a real-life element to it. Hence, the teams' efforts were divided into three main groups: awareness level training, expert technical training and Multi-Domain Operational Wargaming.

The group started with drawing the lines between concepts to better understand what constituted serious games, gamification, wargames, and simulations. The group settled on the term "interactive learning event" to cover all variations of game-based learning and made the key distinction between explicit and implicit gamification for understanding this environment.

The team analysed various design and development methodologies and chose unified serious game development methodology and Werbach's 6D Gamification Framework for the report, since being agile, iteration-based, and user-oriented were found to be the key elements of all methodologies and frameworks. Although there is no one clear method for creating an effective game-based learning experience, there are definite considerations that need to be taken into account and guidelines to follow. Not carefully thinking through the target audience's needs and requirements and tackling this process like a game development, leads to critical components of education or system operational requirements being left out. While designing and testing once creates half-finished good ideas, iterative testing that includes all the stages of development between cycles enables the flexibility to adjust the experience by including the collective creative thinking potential of all the participants: key assumptions are challenged at the same time as key balancing issues are addressed.

Though militaries are well adjusted to wargames, current computer technologies have helped wargames to evolve in a different way. While some countries keep the tabletop wargaming tradition alongside computer driven/assisted wargaming, many countries are opting for solely computerised wargames. While serious games and all other kinds of game-based learning systems are on the rise, key military structures are still not set up completely to enable the full and free dissemination of serious games within the military training environment. The SAS-129 team highlighted the importance of having facilitators, subject matter experts and adjudicators available within the military training system to help support game-based learning events and provide guidance on best practices for facilitating a game.

As use of game-based learning systems will become much more common, military organisations will rely on acquisition or funding development projects for of such systems. However, before going to the lengthy and costly term of defence acquisitions there are key questions the smart buyer can ask to ensure the system in

question will in fact solve the training problem it is meant to address. Though the group does not provide complete answers to these questions or details how these questions can be used, the team left this part to be adjusted to the smart buyer's unique case and provided the baseline critical questions that will highlight the key aspects of game-based learning systems.

Right after the beginning of SAS-129's work, the team set out the work on several prototypes as well as reach out to the expert networks to identify cyber security-related game-based learning systems to test and learn from. A catalogue and a taxonomy method were developed to analyse these games starting from awareness level to tactical, technical, simulation (emulation), operational and strategic level. These games were listed and analysed to showcase the wide applicability of game-based learning systems in all aspects of cyber security related training. These games utilise different explicit and implicit gamification and various fidelity levels.

Emerging hybrid and near-peer threats, combined with a Multi-Domain Operation focus on future military operations calls for cracking open high-tech defences against relentless, coordinated attacks from every domain of conflict: land, air, sea, space, cyberspace, as well as the electromagnetic spectrum and the information environment. Through rapid urbanisation new conflict areas will be mostly densely populated urban areas where the advanced adversary relies on the mega-cities as a force multiplier. All these changes raise questions about how NATO forces should be trained, organised, and equipped to comprehensively understand, execute, and sustain joint operations, and create desired effects across the multiple dimensions of increasingly complex and dynamic urban environments.

Game-based learning systems provide a relatively new emerging training and education field that supplies the new military organisations with a broad tool kit for tackling the growing need for engaging, interactive training and analysis learning events.

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Annex A – EVOLUTION OF THE CYBER RESILIENCE CARD GAME (CRCG)

The following is an excerpt from Thorsten Kodalle's Master Thesis titled "Gamification of Cyber Defence /Resilience" at the Bundeswehr Command and Staff College (BwCSC) in 2020.

This section covers the complete design and development process of the CRCG so far.

A.1   FIRST DESIGN IDEA

The first idea for a card-driven game was developed at the kick-off meeting of NATO SAS-129 12 – 14 June 2017. NATO SAS-129 examined, among other games (see Figure A-1), the COTS cyber card-driven game Android Netrunner developed by Richard Garfield (Garfield and Litzsinger, 2012).

Figure A-1: Games Under Review by NATO SAS-129 in June 2017.

Android Netrunner is an asymmetric two-player game that plays in a dystopian future about 300 years from now. It is entirely card-driven, without dice, a great tactical depth and was played in international competitions like Richard Garfield's "Magic: The Gathering" (Garfield, 1993). It was the first trading card game ever and remains prevalent today. Clausewitz compared card games and war. The author was intrigued by the idea to develop a cyber-related card-driven game prototype for the present.

A.2   IMITATION

To develop a cyber resilience card-driven game that would work for NATO, the author and his students aimed to identify the successful game mechanics, game principles and game elements from Android Netrunner. In principle, the author tried to reverse engineer the element of fun out of a highly acclaimed,

commercially successful card-driven game with a cyber-related topic and put it into his explicit gamification project. The imitation of successful features from other games is a common practice in the industry. In the context of game development, "imitation is a necessary part of innovation" (Katzenbach et al., 2016, p. 1). It is also an exercise in game thinking.

For this endeavour, the BwCSC acquired ten sets of Android Netrunner. The author asked the BSOC 3-2017 (17 students) to develop a current version of Android Netrunner that they would like to play.

The author assumed that gamification could target human-centric problems effectively, be it Tactics, Techniques, and Procedures (TTP) or just raising awareness for machine-centric problems (an affective learning goal). To select an appropriate mix of cyber security topics, the author analysed the content of NATO's Advanced Distance Learning (ADL) "Cyber Defence Awareness Course" (NATO CCDCOE, 2019) for guidance. As pointed out in the course information: "The main purpose of this course is to provide awareness, basic knowledge and familiarization on the most important and relevant topics of the Cyber Defence and IT Security area. Furthermore, the course enhances the general user's awareness of cybersecurity risks and measures to mitigate those risks. The course gives an introduction to general cybersecurity in order to aid familiarization with attacks, terminology and defensive techniques." (NATO CCDCOE, 2019) The estimated time to complete the course is 4.5 hours.

The main design idea was to gamify the course content with a game of cards. At the core of the game are sets of cards, based on best practices provided in the ADL course above and several supplementing card sets around diverse cyber threat-related topics like botnets (MIRAI and REAPER), Advanced Persistent Threats (APT) and cryptocurrencies. The main idea of increasing the individual cyber resilience of the player by implementing cyber hygiene practices on the player's mobile device in real-life actions (the main desired action) during gameplay emerged during the development process but was already present in the very first prototype. However, if effectively implemented, this would decrease the target surface of NATO considerably because all private mobile devices of NATO members are considered targets for cyberattacks.

Before imitation, there is playing. The first step for the author and the students was learning to play the game Android Netrunner. They had to embrace the fun of playing the game, the tactical depth, and develop an understanding about what makes playing the game fun. Based on observational data, the game was fun; indeed, the students played the game also in their free time (off-duty) for fun. This observation provides the insight that engaging content has the potential to drive students to act even after class. The author made the same observation in his seminar Gamification of Strategic Thinking, where students conducted red teaming, engaged in adversarial thinking, and posted their results late at night (at 10:30 p.a). However, one of the first insights while playing Android Netrunner was that learning to play a game with great tactical depth is time consuming. Students required approximately five hours of playtime to understand the game mechanics. The author concluded that the rules for explicit gamification needed to be simplified to make it viable in an educational institution with limited room for new ideas in an existing curriculum. Time constraints are a common problem in game design. Yuna Wong concluded, that if the sponsors of a wargame only want to implement it into a four hour time window, "that will cut out 98% of your options" (Wong, 2020, 42:13). Therefore, the author came up with a condensed and simplified version of the rules that were printed directly on the cards. However, even the simplified version provided a lot of complexity to new players.

A.3 FAST PROTOTYPING AND PLAYTESTING

The author designed, printed, and cut the playing cards for the very first prototype of the CRCG on the last weekend in October 2017. At the beginning of the next week, the author arrived with several sets of cards in the classroom. Then students engaged in playtesting. After playtesting, the author tasked the students to develop improvements for the prototype.

The first significant improvement was the creation of a game board by students in February 2018 (see Figure A-2, this is the most recent version of the game board). Players who are unfamiliar with card game concepts like Rummy are sometimes confused and have questions about where to put cards on the table. The game board provides visual clues and is in this sense also a scaffolding technique. There was also a specific demand by test players to write more detailed rules. During playtesting with different groups, the author encountered test players who had never played cards before. Before the first contact with this specific group of players, the author had not recognised the rule to shuffle the deck before playing as necessary.
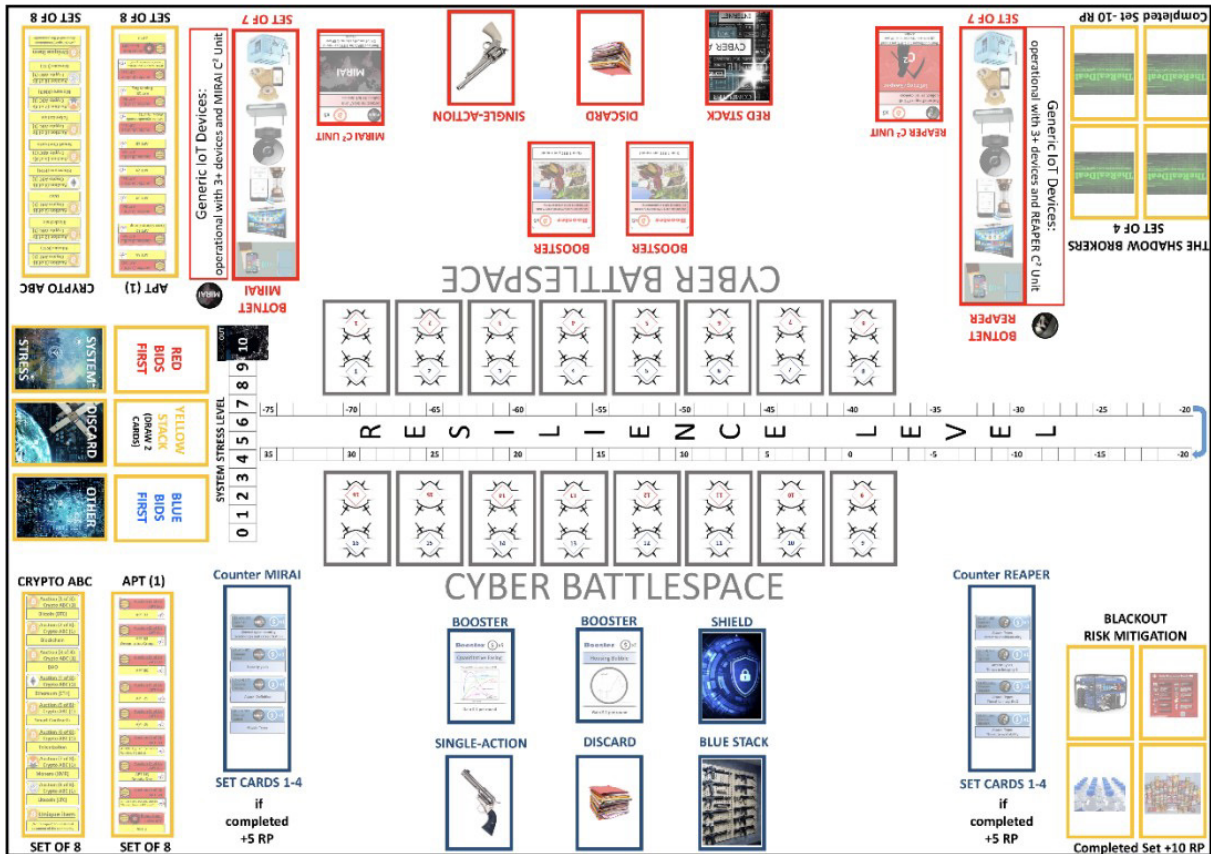
Figure A-2: CRCG Gameboard Version 7.

A.4 PROOF OF CONCEPT

The author observed gameplay, collected students' feedback and developed a survey (see Appendix 6.3) to proof or disproof the viability of the prototype. He also discussed the approach with experts in wargaming in general and in developing cyber wargames in particular.

From the author's point of view, performing cyber hygiene is not primarily an educational problem. It is a problem of attitude to engage in a perceived inconvenient activity. Raising awareness of risks and threats in cyberspace is essential. However, motivational core drives provide the foundation for effectively triggering the behaviour. Therefore, the author tested the persuasiveness of the CRCG. As a metric for evaluation, the author used Teresa de la Hera Conde-Pumpido's Conceptual Model for the Study of Persuasive Games (see Figure A-3) (de la Hera Conde-Pumpido, 2013). The author conducted a survey based on this concept and asked players how much they felt persuaded on the specific levels of signs, systems, and contexts (see Figure A-4) and about their perceived learning outcomes.
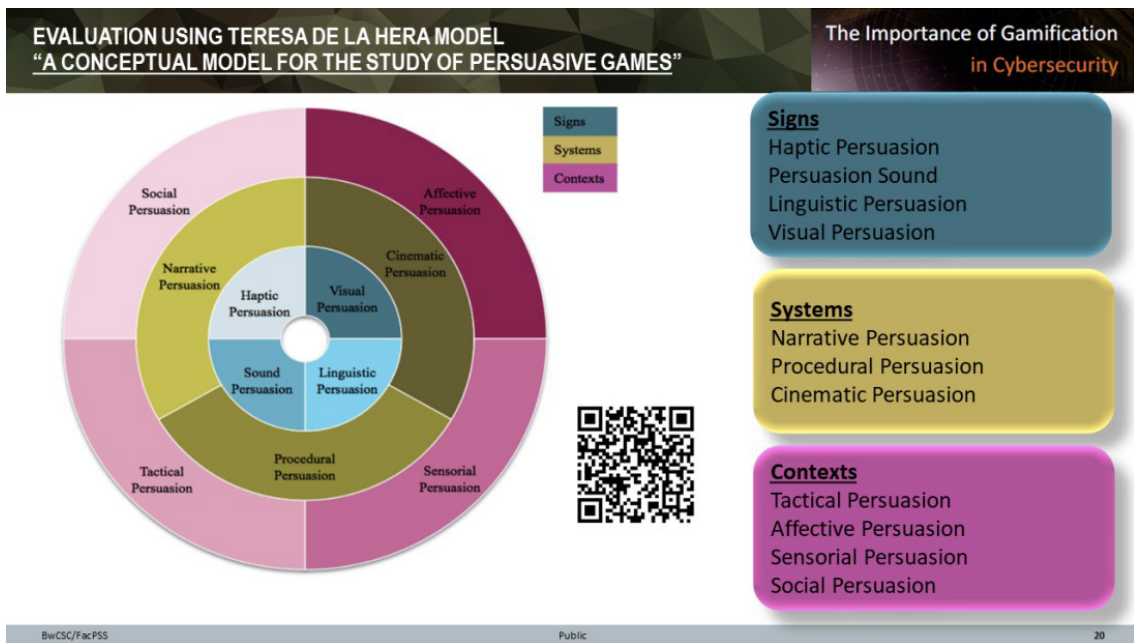
Figure A-3: A Conceptual Model for the Study of Persuasive Games.

Figure A-4: Evaluation of the CRCG by the Development Team in Comparison to Other Approaches.

The author surveyed the development team (15 students) and a control group (17 students) in the same BSOC class in 2017. The author tasked only the development team to compare the CRCG with the web-based training course "Cyber-Hygiene Check-Up" (Aufbaustab Cyber- und Informationsraum, 2016, p. 36) of the German Federal Ministry of Defence (FMoD), the French MoD board game "Cyber Strategia" (Ministère de la Défense et des Anciens combattants, 2016, p. 10) and the U.S. Post Naval Graduate School's Serious Game (digital) "CyberCIEGE" (Thompson and Irvine, 2011).

Also, the author played the advance prototype (including the gameboard) with 25 students at the 2018 "Terrorist Use of Cyberspace Course" at NATO DAT COE and surveyed the participants. The survey also included questions about the applicability of the CRCG to cover the topics of the NATO's 2016 "Cybersecurity A Generic Reference Curriculum" (Partnership for Peace Consortium Emerging Security Challenges Working Group, 2016).

The main findings of playtesting, observations, feedback, and survey proofed the viability of the prototype and the advanced prototype. The CRCG scored highest in comparison to the other applications from the development team's point of view (see Figure A-4). The control group evaluated the prototype even slightly better than the development team. The group of international students evaluated the advanced prototype slightly worse than the two German groups (see Figure A-5). However, the international students liked the CRCG most out of the entire NATO DAT COE one-week course. The author expected these results. After all, playing a game is usually more fun and engaging than listening to a PowerPoint presentation. From the author's point of view, this also proves the effectiveness of explicit gamification.
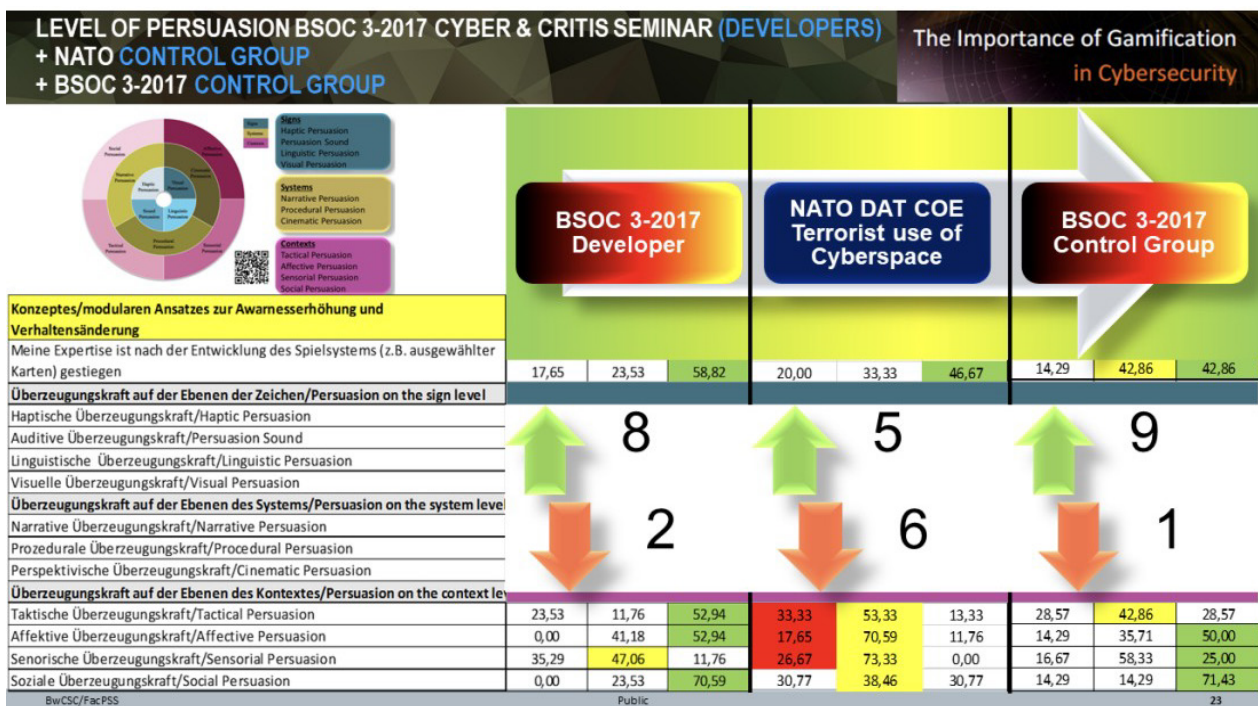
**Figure A-5: Evaluation Developer, NATO DAT COE Course and BSOC Control Group.**

All groups saw a high potential to apply the CRCG to the majority of the topics of the reference curriculum (see Figure A-6 for details). They were provided with 74 topics from the curriculum and evaluated 51 as suitable for the CRCG. From the author's point of view, this is proof of concept for addressing topics in cyber education with explicit gamification in general and advancing the CRCG in particular.

The author did observe the behaviour of players concerning the real-life action cards that required them to perform cyber hygiene. The most common player reaction was the tendency to assume the action without performing it. However, the game rewards only the performance of cyber hygiene, and the other players controlled this. The other players did consider non-performance as cheating. This field observation confirmed the consensus that cyber hygiene is just too inconvenient to perform in general and requires a strong incentive. However, within the magic circle of the CRCG, cyber hygiene became much more incentivised. The author observed that many players left the game with an MFA implemented on their

Amazon, Google and Facebook accounts, a downloaded password manager and a Google Authenticator. Furthermore, players downloaded the NINA App (BBK, 2020b), which is particularly useful in Germany because it alerts the user about catastrophic events (like weather incidents and industry accidents). As detection is a vital part of resilience, this also increases the resilience of the individual user in real life.
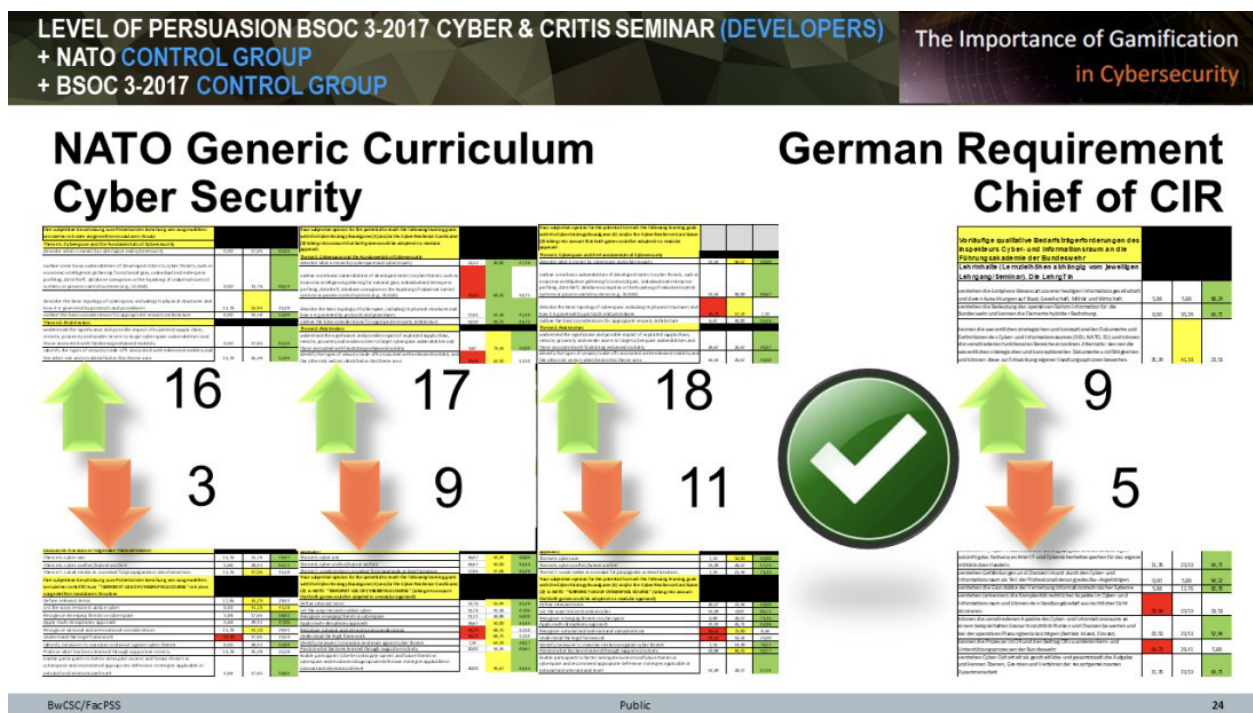
Figure A-6: Evaluation Applicability of the Concept of a CRCG to Other Topics in the Curriculum.

A.5 ITERATIONS

After proof of concept, the CRCG evolved in several iterations based on player feedback. It evolved in three main iterative steps during the BSOC 1-2018, 2-2018,1-2019 and the R&D NATO/GIDS workshop in June 2019. The February 2018 advanced prototype (BSOC 1-2018) included students' suggestions for content improvement (playing cards) and, in particular, the gameboard. Moreover, the CRCG was played again in 2018 and in 2019 at the NATO DAT COE in Ankara, played in three seminars at the BwCSC (in 2019 for the first time without the author but with a trained facilitator), presented at the ECCWS 2018, ICCWS 2019, again at the ECCWS 2020 and played and analysed at a workshop within the Bundeswehr Cyber Defence Community (Arbeitsgruppe Inforamtionssicherheit – AG InfoSec). The NATO/GIDS workshop in June 2019 provided the current status quo.

A.6 GIDS/NATO WORKSHOP JUNE 2019

In June 2019, NATO SAS-129 and GIDS hosted a Research and Development workshop to play three prototypes and improve upon them. The workshop provided valuable insights on Haggman's Cyber Strategy Wargame, the All Domain Future Urban Wargame (the focal point of NATO SAS-129) and the CRCG. Twenty-three attendees/facilitators attended the workshop. Among the attendees were members from academia (Bilkent University, University of New South Wales, Edith Cowan University, Swedish Defence Research Agency, Middle East Technical University); the defence community (German FMoD Department of Cyber and

Information Technology (BMVg CIT I 1), the German armed forces (Bataillon Elektronische Kampfführung 932 [EloKaBtl 932], Kommando Strategische Aufklärung [KSA], Kommando Cyber- und Informationsraum [KdoCIR], Landeskommando Niedersachsen [LKdo NI], Taktisches Luftwaffengeschwader 74 [TaktLwG 74]), and business (ETHOS-Investigations e.K., Terra Schwarz, Willis Towers). There were also additional attendees from the BwCSC Faculty of Land Forces, PSS Fac, Joint Ops/CyberInfoDS/JSES Fac, GIDS and NATO SAS-129.

The mix of military and civilian cybersecurity professionals in combination with possible end-users of these prototypes resulted in a high level of diversity. Attendees also had different levels of expertise in different cyber domains and on different cyber levels. The author and the other facilitators applied methods of design thinking and agile project management during the workshop and taped into new ideas.

One essential lesson learned from the workshop is this: team diversity provides new perspectives for developers, particularly perspectives the developers have not considered before. However, this insight is not unknown to game designers. Game designers recommend much playtesting and with diverse audiences. Moreover, to "listen carefully to what they tell you" (Phillies, 2014, p. 143). A blind playtest in the sense of no developer is participating and explaining the rules to the players is a crucial step in game development. Commercially highly successfully boardgames have been blind playtested over 1000 times (Stegmaier, 2015).

From the author's point of view, every new player can provide valuable insights. The level of expertise does not matter. A beginner can provide valuable feedback on playability and user experience. An intermediate can evaluate the concept of the game and game design. An expert can contribute to the content and balance game mechanics. Every player can provide feedback on the perceived fun. COTS wargames do not require any facilitation at all. However, professional wargames require skilled facilitation.

Consequently, a complex Multi-Domain Futur Urban Wargame and a Cyber Strategy Wargame also require facilitation. However, the CRCG is supposed to have no requirement for facilitation in the end. In this workshop, attendees identified a capability shortage for game distribution concerning the scalability of the CRCG. One feature of the CRCG is the high degree of adaptability and customisation by facilitators and participants who want to implement new content. Playing cards are provided by PowerPoint templates and are adaptable by anybody who can use PowerPoint. In the military community, staff officers usually do have the necessary PowerPoint skills. Therefore, the inclusion of a proposed set of new cards covering the topic of hack backs is no problem. However, the integration of new QR-codes for the cards is a time consuming endeavour. One workshop attendee developed an API QR Code Script for Excel that automated the process of card-generation after entering a hyperlink. Also, some rules were clarified, and additional tasks identified and put into the backlog of the Kanban board for future development.

Another essential lesson learned from the workshop is this: There is not one single game that fits all requirements. Depending on the target audience, the cyber domains and the cyber level, a developer needs to identify different problems and provide specific solutions. Particularly a game for education (like the Cyber Strategy Wargame or the CRCG) needs to emphasis simplicity to make abstract concepts understandable for non-experts (beginners). However, the target audience for performing the main desired action of cyber hygiene during gameplay should be as huge as possible to provide the most significant "vaccination" effect possible.

The CRCG, in the end, should not require any facilitation but should be able to be played out of the box. However, to prevent the CRCG from being just pointsification, a facilitator is still required. Andreas Haggman provided the primary insight to all wargaming in general, and in particular to this workshop, by quoting Peter Perla: "We may never know the right answers, but gaming can sometimes help us learn to ask the right questions." (Perla, 2012, p. 1195).

A.7   STATUS QUO

The CRCG is ready for implementation in a seminar setting and requires a trained facilitator and a timeframe of about two to three hours (including introduction and gameplay). The most recent updated edition of the CRCG, including rules and all additional visual aids for scaffolding, are available in the Dropbox folder. See Figure A-7 QR code for easy access or reference (Kodalle, 2020).

Figure A-7: QR Code Dropbox Folder CRCG.

The CRCG provides three customisable decks of playing cards (in the following cards) for three players: the Red deck (70 cards), the Blue deck (60 cards) and the Yellow deck (48 cards). It also provides a DIN A0 gameboard and in-game money (Bitcoin -BTC and Dollar $). The author intended the game for two to three players or a team Blue against a team Red. Team Yellow is optional. However, the facilitator should be prepared to play Yellow.

The duration of the game can be adapted from two to up to five hours, adjusting for available time. The game can also be the central part of a research, development, and education workshop of several days.

The primary desired action for the player is to perform cyber hygiene.

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Annex B – SQUAD LEVEL C-IED TRAINING AND AWARENESS SERIOUS GAME CASE STUDY

As the face of modern warfare changes, one of the biggest threats faced in asymmetric warfare are Improvised Explosive Devices (IED). With the increasing technological capabilities and introduction of new IED tactics it is becoming increasingly difficult to protect the personnel under IED threat. Counter IED effort can be gathered under three pillars: Defeat the device, attack the network, and train the force. Current solutions of training the force can be improved by the utilisation of serious games. Serious games can be the next step on military training due to the ever-increasing and ever-so-popular game technologies. With this in mind multiplayer counter IED (C-IED) serious game projects were started in the Turkish Military Academy, Science and Technology Institute. A concept prototype and a BETA version were developed (Figure B-1). Three dismounted infantry squads with previous IED training that have served in active duty and encountered IED attacks were invited to test the serious game. Teams' reactions were tested for the purpose of fidelity. In addition, a questionnaire was provided to the participants to measure the effectiveness of the training course. The following section will provide an example of a USGDM application from the C-IED serious game case study.

Figure B-1: A Screenshot from Introductory Video "Counter IED Training Serious Game."

B.1 INCEPTION PHASE

Improvised explosive devices are one of the biggest threats in modern warfare. IEDs are typically the main weapon choices in asymmetrical war theatres. IED related deaths increased in constant rate between 2001 and 2011 (Kotwal et al., 2011). After the introduction of three pillars of counter IED effort; "Attack the Network," "Defeat the Device," and "Train the Force" (Eisler, 2012, pp. 9-15). There has been a consistent decrease in the number of casualties in Afghanistan (Figure B-2).

A similar study was conducted as a terror pattern study for Turkey in Turkish Military Academy, Defence Sciences Institute. IED attack numbers and casualties have been constantly rising from 2010 to 2013. The IED threat in Turkey has reached its highest devastation in 2015. Asymmetrical warfare in the home front compels armed forces into the disadvantage of protecting everything (Blank, 2003). All the roads, countryside, mountains and urban areas are considered to be protected. When a threat is identified within the logic of domestic counter terrorism operation, immediate intervention is required. This causes arms race,

armed forces are constantly coming up with new methods, tactics and technologies to counter IEDs, while new IED deployment and trigger methods are being developed by the terrorists.
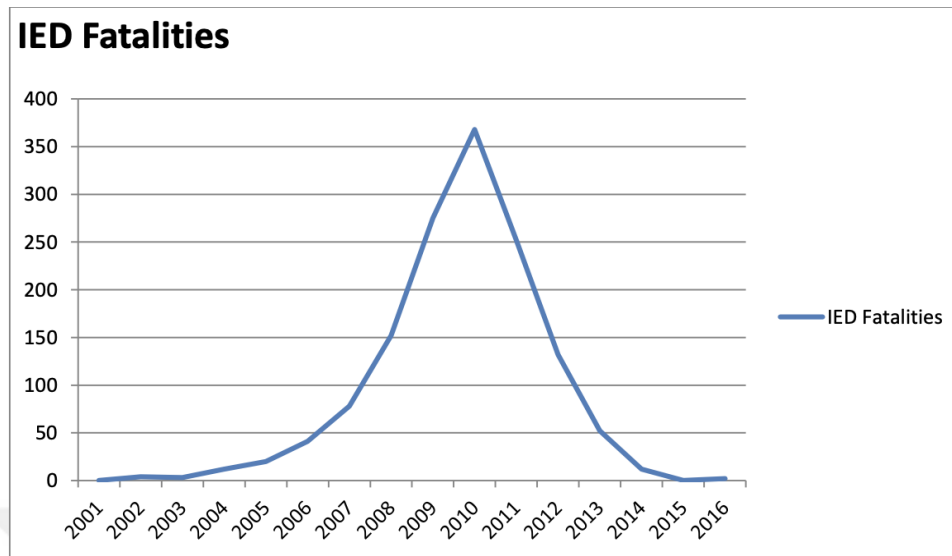
Figure B-2: U.S. IED Deaths in Afghanistan by Year.[1]

This struggle is creating a huge data flow on new tactics and countermeasures. This data could be used to gain an insight on future IED threats and possible preventive countermeasures. This data is vital for training the force and turning these lessons learned to permanent information that can be updated and carried to the battlefield in the minds of new officers. With this idea in mind, two master thesis studies were started under the Turkish Military Academy, Defence Sciences Institute with the task of completing the needed analysis and detailed design of the training system for countering IEDs in the form of a serious game. Though Serious Games are not widely used, they possess a certain potential. In its essence, serious games could be a key visualisation opportunity for years of IED experience (Kirkley et al., 2005).

The research done under the Defence Sciences Institute stated that key problems with developing a serious game are the gap of communication and mutual understanding of terms among armed forces, defence industry and game developers. During the development process, there are three parties involved: armed forces as customers, trainees as end users and IED experts as subject matter experts. Years of experience meant a long list of needs, and the development and usage restriction of the armed forces posed strong strains on the end product. Further, using game technologies for motivation and better learning opportunities has no strong framework to follow. Serious gaming has not been tried before in the Turkish Armed Forces for training and education purposes. Given said problems to consolidate all the parties involved, System Engineering (SE) was decided to be implemented during the development process. The game development processes were incorporated into serious game development and System Engineering. In this paper, the nature of this new method and lessons learned from the development and test of the prototype and a beta version will be discussed, as well as the serious game design document that has been developed during this study.

When faced with the questions "Can this training be gamified?" and "Should this training be gamified?" regarding counter IED training, we set out the discovered concepts of IED training within the Turkish Military. We found that current methods were based on educational videos – real and animated, real life training field and printed literature supported by visual contents. The common theme for all the training were

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[1] U.S. Fatalities in and Around Afghanistan, Support iCasualties, Retrieved on 08 August 2018, http://icasualties.org/oef/.

visual contents, this showed us the importance of such content. This was our first link to serious games. Furthermore, the real tactical environment of modern warfare is heavily replicated in digital games throughout the years. Finally, we found out that similar attempts for C-IED training using digital serious games have been made by different militaries. Literature review of these games pointed out that due to the inadequacy of artificial intelligence, multi-player systems were preferred to enable a realistic combat environment (Schneider et al., 2005, p. 6). Though, single player modes were utilised for teaching the fundamental principles of the training and core gameplay elements (Nieborg, 2004, p. 4). Most of the games were designed as first person shooter games and all the game elements such as uniforms, weapon models and environment were realistically modelled, including weather conditions. Teams were made up of 1 – 14 users, and separated into different roles like medics etc. (Schneider et al., 2005, pp. 6-15). Classic digital game combat dynamic of death players being cut out of the game became a problem for serious games; being cut out of the game meant being cut off from training. In order to solve this, other games allowed the user to respawn after a time penalty (Nieborg, 2004, p. 4). Combat bullet mechanics were also presented a problem, while bullets were not affected by gravity upon impact the damage they caused with respect to their impact point was based on numbers rather than psychical damage. As a mid-way solution after receiving a certain level of damage the character was modelled to become injured and required medical help before returning to game or dying from injuries if the help did not reach in time (Nieborg, 2004, p. 7). After reviewing the serious games while answering "Should this training be gamified" the games were shown to a focus group consisting of possible trainees. Their outright rejection of an unrealistic combat environment and strong belief on psychomotor skills cannot be training using keyboard and mouse compelled us to leave the combat dynamics out. Training goals for C-IED games where identified as; Experiencing realistic IED tactics, scenarios and adversity tactics. Systems were designed specifically to be easy to use, include various operational environments, use real geographical data to create the 3D environments and allow necessary tools for editing game scenarios. During this game the user plays the attackers role. The user can choose eight different roles; Leader, IED manufacturer, placer, observer, trigger-man, cameraman, financier. Through these roles user learns the phases of planning, situational awareness and defence, entrance to IED placement site, exit from the IES site, IED attack and cancelation of attack (Unrau et al., 2012, p. 19). In the end we were able to answer the question "Can this game be gamified" as yes. But we decided that further research was needed if the game should be gamified.

Following the decision to leave out the combat mechanics, it was decided to focus the serious game efforts on creating realistic environments, IED placement scenarios, and IED placement indicators. A concept prototype was decided to be developed. Unity game engine was decided as the development environment, this decision was made due development teams existing expertise to enable rapid prototyping. Unity asset store was utilised and a 3D environment graphic pack was acquired. Because realism was key the pack was not used as is, but rather Turkish Army elements such as forward operating bases (Üs Bölgeleri) were modelled into the environment. During this adjustment subject matter experts from the military were involved in the design. IED department of Turkish Land Forces were consulted for realistic IED placement scenarios with indicators that could give away the placement of the IEDs. A single player character was included in the game with human-like moving capabilities. At certain checkpoints voice recordings played containing orders for the user to follow giving information how to proceed with the game. An unseen IED was placed in the map; if a character came in contact with the IED an explosion animation was designed. It was also designed that the screen would blacken after the explosion. Though, there was no win scenario when nothing was added after an explosion prototype was criticised, so the development team felt the need to add a lose scenario.

The prototype was tested in the Turkish Military Academy, Defence Sciences Institute by subject matter experts. Environment was accepted as quite realistic and SME praised the high quality of the 3D environment (Figure B-3, Figure B-4). Adding in the Turkish elements was also warmly welcomed. It was also argued that scenarios should be extended to include dismounted small squat operation and motorised operation training manuals. It was also argued in addition to C-IED training the game should also include small squad training essentials, it was argued that without the right operational behaviour of small

squads C-IED training could not be achieved. SME experts also stated that given the operation environment the game should support multiplayer gameplay, with different representing small squad composure. Furthermore, it was added that different types of IEDs should be included in the scenarios. SME experts pointed out that most of the IEDs in the field were discovered through observation and a keen awareness for IED placements was a key for successful observations. Hence, it was noted that the number and variety of indicators needed to be increased. Trainer modules and after action review systems were also stated as future requirements.

It is very important to note that capturing the needs for functionality became much easier after SME were able to observe the prototype. Only after seeing the prototype's capabilities, it was made clear to the SME the nature of the serious game and from that point the game became a platform in their eyes hence it was much easier for them to describe the future capability needs.

(a)   (b)

(c)

Figure B-3: Original Picture (a); Game View (b) and (c).

(a)	**(b)**

Figure B-4: Game View of IED Detection Device (a) and Players Searching (b).

B.2   ELABORATION PHASE

Requirements were grouped into four main titles: C-IED training, performance and system operating conditions, trainer, and after action review module requirements.

In addition to lessons learned from the prototypes and SME interviews, C-IED training learning outcomes were derived from related Turkish Military Domestic Operations Manuals in addition Lessons Learned publications from Education & Doctrine School Command were utilised. From these documents training needs analysis were conducted and were listed. Sixteen main training subjects with 365 requirement objectives were identified (Appendix A). Recruitment analysis was conducted to make sure the recruitments were detailed enough, doable and not duplicated.

Target audience for the training was benchmarked from the current C-IED training. Usually, games have a very specific target audience. Usually, this audience is identified by their preferences of game type, age, platform they use and likings. As it can be seen from the previous sections if the target audience of the serious game denies or cannot use the serious game the system becomes useless. This presented a problem given the current Turkish Military C-IED training target a large training audience from officers to serving privates with diverse backgrounds of knowledge, experience and age. Furthermore, people who already played games were even lower. Finally, the common perception was that games were for fun and younger generations. The properties of the target audience presented the biggest challenge for using serious games for C-IED training. Prototype was the best place to observe the user-system dynamic and make the final decision on if this training should be a gamified question.

Less than 1 percent of the participants had played computer games before. Despite this fact after a brief introduction to control users had no problem controlling their charter as well as understanding the game mechanics. The debrief section and the discussions with the participants led to the following requirements regarding target audience; Controls always need to be simple. Number of control functions should be limited. First person shooter dynamics are considered more simulation-like. Movements, uniforms, in-game equipment and trains should be realistic. Serious games should not be framed as an alternative to real live training. In accordance with a military career the game missions should be challenging and have a level of frustration, good performance should be rewarded, and games should represent the hieratical structure of the military.

During identifying performance and system operating conditions it was evidently clear that military equipment and work environment attributes were presenting the main limitations. These limitations were gathered under 5 topics; Cost-efficiency, easy to set up and transport, a system that is already in the inventory, and being able to work outside the secure network infrastructure.

Trainer module requirements were mostly benchmarked from already existing similar systems. During the prototype testing it was possible to identify the unique needs of the system. Non-player observer camera was added to the system to mimic the trainer module during the prototype phase. This observer camera is also dubbed as the live presentation camera. C-IED trainer was given the control of this system and after asked what additional functions would be required.

After action review module requirements were divided into three subcategories, Main AAR database, Local AAR database and list of training data that will be logged. It was important to differentiate between local and main ARR modules. Military requirements were clear on using training within career development planning. At the same time this also contradicted with the requirement that the system needed work in local area network, be a modular system for transportation that was not be connected to the military or public network. An alternative system for creating training records for the HR career planning system was needed. Therefore, the main AAR module requirements were developed. The local system requirements were developed according to needs derived from the prototype and C-IED trainers that participated in the trials based on the needs for debriefing. Data that needed to be logged by the system was divided as qualitative or quantitative. The list was developed based on the learning outcomes. Collection of qualitative data that could not be tracked automatically by the system was integrated into the trainer module as ARR sub-module. Where the recorded training was evaluated by the trainer according to a checklist.

The prototype phase had given a clear idea of the type and genre of game best suited for the training. Benchmark research was conducted to determine the industry standard technologies used for development. It was analysed that the industry was either using commercial game engines such as Unity 3D, or Unreal or developing their own game engines. Self-developed game engines provide greater flexibility and security, usually trading off graphic quality and cost. Given the system requirement clearly stated that the system will be running parallel to secure network only in LAN. Therefore, security did not have high priority. In addition, development costs were preferred to be kept low. This leads to the decision of using off the shelf game engines. Other factors affecting development technologies were using virtual and augmented reality as well as movement capture technology. Expert interviews, trials and testing have shown that the self-theologies were not robust enough for military heavy duty use. Furthermore, though there was hype around using these theologies within the military. During the prototype phase it was discovered that SMEs and small squad operations members had a belief that physical skills that they require in the field cannot be thought over computer systems and stated that serious games were better suited for cognitive skill building. Further they mentioned technologies like motion capture, VR headset and augmented reality with their current status did not provide enough fidelity. Despite actually testing their claims, the design team decided not to utilise these technologies; it was argued that in adult training, accepting the benefit of the training by the user is as much valuable as the system being useful. Therefore, adding technologies that carried prejudices to an already alien serious game concept it was decided that the trade-off was not worth it. In addition, interviews with VR SME experts stated that using the VR headset for more than 15 minutes was not recommended. Given the average scenario length decided in the prototype phase was 45 minutes VR headsets were ruled out as a later option to be added to the system.

Operational environment constraints, requirements and development technologies that will be used give the necessary information to decide the targeted personal computer that the game system needs to run on. SME were consulted and benchmarking off the shelf game lowest setting hardware requirements helped the design team identify the minimum requirement for hardware requirements.

The most important decisions and limitations were documented to be referred throughout the development and testing phase. Most important decisions were; System will not try to replicate the real combat dynamics. System will focus on developing cognitive skills and will not focus on developing any physical skills. System will not include VR and augmented reality, but development will be made so to allow future integration for testing purposes. System will be limited to local use only. Average trainee of the system will be able to present at least the same level of knowledge as a trainee of the current C-IED training within the Turkish Military.

Designing a game from a functional point of view is a difficult task. Therefore, during this phase game design principles were adopted. Design document included following topics:

Table B-1: Topics Included in the Design Document.

C-IED Game Design Document (Subtopics are given in Appendix-B).	System Summary
	Game features
	Game elements
	Graphic needs including 3D animation needs
	Gameplay
	Game mechanics
	Interaction effects between all the game elements and mechanics
	Game control interface
	Game scenarios/levels
	In game data that will be recorded for AAR system

Also, after the completion of the design, quality control questions were applied to the design document. Preferably in smaller projects for some of the questions it is a good idea to produce concept prototypes and attest for answers. Another solution is to employ a ten-day development cycle to test key assumptions within the cycles.

As mentioned in the previous sections, designing the game in functional terms is not an efficient way. Therefore, while conducting the functional analysis internal analysis was conducted. For example, when analysing game mechanics, designed mechanics were accepted as individual functions and analysis were conducted accordingly. The same method was applied for every topic. Tracking the recruitments within the design document was crucial. Recruitment items were referenced as footnotes to design items. For example:

- Headlights of the vehicles will have adjustable beams – ref. requirement code: 4.4.1.16.33.

This method allowed for easily tracking recruitments over serious game functions. When the design document was completed functional analysis was conducted and documented as an annex to the design document. Explanations to high level system recruitments were given under this section. In addition, recruitments that were left out were mentioned in this section with explanations for why. During this phase the system was accepted as another off the shelf digital game and maintenance and support concepts were benchmarked from the industry. All the documentation output was combined in a single detailed design document and shared with all the stakeholders of the project. Partial or all stakeholder meetings were conducted for joint decision making. Revisions were collected, necessary changes were made, and the final version was released.

B.3   C-IED CASE STUDY CONCLUSION

Currently the C-IED project is in the beginning of the Construction Phase. The total duration of design so far has been over a year and produced two master theses. CIED project is a good example for mammoth design

for such projects it is vitally important to start with prototypes even before establishing the final design document. Findings from the prototypes become invaluable during the design process. In addition, the C-IED project had two prototypes before the design phase. A concept prototype was developed within 3 days using off the shelf game assets to test key assumptions during the preliminary feasibility analysis. Later, another prototype with more game mechanics and elements were developed. This prototype also included multiplayer infrastructure. Finally, adopting the ten-day build cycle was planned going into the development phase. Quality control questions including game quality measurements can be applied during these cycles by actually testing the system. It is critically important to note that every single phase always includes all the stakeholders. For example, from the beginning of the project including the first prototype military SMEs were part of the design and development process. Finally, the C-IED project was the first time USGDM was employed. Therefore, it was also a trial and error process for the methodology. Above section has focused on projecting the experience as is.

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Annex C – INTEGRATED LOGISTIC SUPPORT CARD GAME CASE STUDY

New threats are emerging requirements for defence armaments are also increasing. At the same time, many NATO countries are applying more and stricter defence budget controls. Integrated Logistic Support (ILS) is an effective method for determining the real cost of acquisition. Usually and depending on government structures, ILS requires a series of organisations working together to function. In some instances, the ILS concept can be completely foreign to a nation or partially implemented. In all cases, to increase cooperation, awareness, and dissemination of ILS workforce training is required. In order to achieve this Turkish MoD, Defence and Technology Training Centre (DTTC) started a two-day course on ILS targeted to the defence industry, government employees and military personnel. This gave rise to the opportunity to implement a gamified training for ILS. This section will discuss the design process and implementation of USGDM.

C.1 INCEPTION

The most important criterion in defence systems research projects is undoubtedly the fulfilment of the system design needs. It is important use cost efficiency analysis whilst alternative systems with same capability are selected. In addition to the purchase cost, system accumulates life cycle cost as long as they stay in the inventory. Furthermore, additional cost occurs during the system disposal phase. Integrated Logistics Support (ILS) lists all the criteria for the life cost supportability in a single framework. ILS has been adopted by the Turkish Military but there have been various problems executing ILS system. Due to this fact Turkish MoD, Defence and Technology Training Centre (DTTC) has been training various key stakeholders. This is where the main need for the training originated from.

Two main questions posed in this phase are "Can this training be gamified?" and "Should this training be gamified?" There has been an acquisition and defence system alternative choosing serious games in the past therefore it was clear this subject can be gamified. After talking with the instructors of the DTTC, it was analysed that current ILS training relied on computer assisted presentation and though the training was a two-day training most of the basic theoretical training could be given in a day. Rest of the training focused on demonstrating the practical application of the system. Trainers were looking for a hand-on solution for forty trainees. Therefore, gamification was accepted as a viable solution to test out.

Benchmark analysis showed card games were preferred for similar training. Training material was used to develop a basic prototype and hand crafted cards were made. Various game mechanics like player vs. player, deck control and turn based decision making were tested out. Finally, turn based decision making mechanics was decided due to the long list of learning outcomes that were expected from the game. Game relied on mathematics and attention to detail skills for core gameplay. Using the behavioural economics approach rather than designing the win scenario prototype was tested with loss ordinated design. Players were divided in two teams and competed with other groups in terms of scores. The highest score a team could achieve was 100 while wrong decisions were penalised in every turn resulting in the possibility of ending the game in minus 400 points. Finally, the first prototype was tested with the trainers from the DTTC, and it was decided to carry onto the next phase.

C.2 ELABORATION

Learning outcomes were derived from the class notes and joint analysis with the DTTC trainers. Graphics for card designs were also tested during the prototype phase therefore their requirements were also finalised in this stage. Target training audience was benchmarked form the C-IED project. Though considerations were made for operational needs, trainer modules and after action review only learning outcomes were documented, the rest of the recruitments were noted down as considerations.

Graphic design and printing were analysed as the two main development technologies needed for development. According to target audience requirements the card design quality had to be of a high standard. Therefore, a free software developed for card designs was utilised for card designs. A printing company was contacted to decide the printing method and prices (Figure C-1).

Figure C-1: Example Game Card Designs.

Time and place considerations were listed. Game setting and team arrangements were decided. Psychological facilities of DTTC, learning objectives and target group properties were the key constraints during this phase.

Most important assumption was that a loss oriented score competition dynamic would be motivating enough for the players. Furthermore, the game was limited to repeating the tasks set forth by the learning objectives rather than focusing on comprehensive ILS training. In addition, ILS Card Game's was limited to DTTC ILS workshop; there was no focus for developing a standalone game.

C.3 CONSTRUCTION

A flexible methodology was utilised in this phase by combining the three system requirements phase into a single phase. During the game design phase rather than developing a design document black board brainstorming method was used.

Table C-1: Construction Elements.

	Game elements
	Graphic needs
	Gameplay
Design Topics	Game mechanics
	Interaction effects between all the game elements and mechanics
	Game scenarios/levels
	ARR & Scoring Concepts

The development process became intertwined with the design process. Each turn had an effect on the following turn therefore a spreadsheet of calculation was developed to help the team track the effect of the changes on turns for the overall of the game. A Play-to-develop approach was taken to develop/design the game. Once the correct path of the game was designed testing was conducted to make sure incorrect way of playing would not result in a win case. Numbers and calculations were checked several times over. Finally, a trainer supervision checklist, score card and answer key were developed. Learning goals and mechanics that were duplicated were either changed or left out. Because the game was developed for a single DTTC workshop, no consideration to maintenance and support were given. Following, the DTTC trainer and design team played the game from start to finish and necessary corrections were made. Finally, cards were sent to be printed.

C.4 TRANSITION

The game was played by nine groups of five participants. For every three teams an assistant was assigned. They were tasked with teaching the game and answering questions as well as score keeping. At the end of the training a survey was conducted. From 16 questions 3 questions were about learning outcome, 6 of them were about the quality of the game and 7 questions were about the scenarios. Finally, the last question was an open ended question about evaluation of the training.

When the survey results were evaluated the majority of the participants found the training very educational. Other results indicated the game was found fun, short, and easy to learn and play. Furthermore, participants liked the card designs. Finally, on average the tasks were found easy. Open ended questions suggested that for further versions participants wanted longer and challenging scenarios and information packages about the game handed out beforehand. Currently, a new version of the card game that includes ILS considerations in contested and degraded environments is being developed using the lessons learned from the DTTC workshop.

C.5   ILS GAME CASE STUDY CONCLUSION

ILS Card Game was designed and developed within a week. No major documentation was developed and most importantly the design and development phases were intertwined in an iterative cycle. This case study is a critical example of how the USGDM can be implemented in agile development projects as well as mammoth design projects. The methodology helps ground the design and development process and helps to not overlook key considerations. Design and development aspects are for the greater part the same for big and small game projects while time and resource costs for each phase changes according to the size of the project. Therefore, supported by the case studies USGDM has the flexibility to work for different types of serious game and gamification projects.

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14. Abstract

Readers of this final report can expect to find a comprehensive guide to understanding, designing, developing, onboarding, and deploying game-based learning systems. The team gathered their collective expertise and their own lessons learned gained during their study developing and testing various game-based learning systems for cyber security. This guide is targeted to experts who are focusing on game-based learning approaches for enhancing current defence and education training and education methods. Critical distinctions are provided in the report for understanding and differentiating games, serious games, gamification, simulations, and wargames. The most common development problems and lessons learned from cyber security serious game projects are compiled within this report. Chosen design and development methodologies are discussed in depth for providing a quick guide to best practices to serious game development. These discussions were supported by case studies based on the SAS-129 team's own prototype development experience. The report also contains key information for experts looking for information on understanding the transformational needs of an organisation wishing to integrate game-based learning systems into its larger educational framework. Finally, the report includes a taxonomy of Cyber Security related game-based approaches that SAS-129 either developed or examined during its study. The taxonomy provides an overview of the full spectrum of game-based learning methodologies applicable to cyber security training.

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