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"C2 and agility"

CICS: A Bachelor Degree for NEC-era Signals, IS, and C2 officers

Topic 7: C2 Approaches and Organization

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Abstract

The officers who will develop, use, maintain, manage, enhance, and exploit Network-Enabled Capabilities (NEC) for operational agility and effectiveness in five to 15 years time are now officer cadets and midshipmen at military academies and universities spread over the world. Few of their courses have caught up with the NEC-related changes that will drive the demands made on their students during their post-course career. In particular, computing and communications courses still emphasize information and communications technologies, while the emphasis in equivalent civilian occupations has shifted in the 21st century towards extracting operational/business benefits from these technologies.

At the Netherlands Defence Academy, our academic, three-year, bachelor-level course for officers in the Signals, Information Systems, and C2 branches is known as Communications-, Information-, and Command & control Systems (CICS). Over the past two years, CICS has been undergoing a fundamental review to meet the requirements of accreditation to European standards and of the new realities in the Netherlands Defence Doctrine. From around 2016 CICS officers will be required to operate at NATO NEC Maturity Level 4. The purpose of this paper is to describe the results of benchmarking CICS against the forecast needs of her graduates in the NEC era.

Keywords: Education, officer training, Command & Control (C2), Information and Communications Technologies (ICT), information systems, benchmarking

Introduction

Motivation

Personnel are central to Command & Control (C2) systems. US DoD Joint Publication 1-02 defines a C2 system as "the facilities, equipment, communications, procedures, and personnel essential to a commander for planning, directing, and controlling operations of assigned and attached forces pursuant to the missions assigned". The Netherlands Defence Doctrine (NDD, 2005) describes a C2 system as "a collection of different elements: doctrine, plans & procedures; a command structure; infrastructure (national and international headquarters, mobile operating centres, etc); technical systems (including computers, sensors, displays, communications equipment, radar); and personnel".

In the era of Network-Enabled Capabilities (NEC), military personnel will have to be adequately educated and trained to implement, operate, and maintain information-age C2 systems. The NEC community recognizes that the factors or Lines of Development (LODs) of Doctrine, Organization, Training & education, Materiel, Leadership, Personnel, Facilities, and Interoperability (DOTMLPFI) will co-evolve. However, the NEC literature does not yet indicate how a change in one LOD affects the others. This paper is intended to partly fill this gap in the literature by showing how an increase in NEC maturity level (NML) is likely to influence the evolution needed in the Training & education LOD.

The officers who, in five to fifteen years time, will exploit NEC for operational agility and effectiveness are now officer cadets and midshipmen at military academies and universities spread over the world. Their educators bear a heavy responsibility to ensure that their students receive a grounding in the academic knowledge and skills that they will need in the NEC era. This is difficult to do, because the design of academic courses is normally informed by past experience and by current insights in the appropriate scientific fields. By contrast, officer cadets and midshipmen must be given the knowledge and skills they will need to deploy and employ NEC up to fifteen years in the future. This involves forecasting their future needs, with the associated risk that these forecasts will turn out to have been wrong. Not surprisingly, few courses incorporate the NEC-related changes that will impact the future demands that will be made on their students.

This paper presents our thinking behind one of the bachelor-level courses at the Faculty of Military Sciences (FMS) of the Netherlands Defence Academy (NLDA). It makes contributions to two NEC audiences. For the general NEC community, the paper demonstrates how the intended evolution in NEC doctrine over the coming five to fifteen years is likely to affect another LOD, namely Training and education. For educators, the paper may suggest ways in which they could enhance their courses to meet the challenge of the NEC era.

Brief history of the NLDA

The NLDA was formed in November 2005 by bringing together a number of Dutch military institutions that were concerned with officer education from initial entry all the way through to serving at general rank. The NLDA's mission is:

- To train men and women to be professional and motivated officers who provide leadership in the dynamic Dutch Defence organization.
- To conduct academic research in military focus areas for the benefit of knowledge development, education, and policy advice.

Although the two parts of the NLDA's mission are closely linked, this paper concentrates on the first of these.

Up to November 2005 there were two Dutch military academies, each with a history and tradition of 175 years of officer education. The Koninklijke Militaire Academie[1] (KMA) gave military and academic education to Royal Netherlands Army (RNLA) and Royal Netherlands Air Force (RNLAF) officer cadets. The Koninklijk Instituut voor de Marine[2] (KIM) did the same for midshipmen in the Royal Netherlands Navy (RNLN) and Royal Netherlands Marines (RNLM). When the NLDA was formed, the FMS took on their responsibilities for academic education at its locations in Breda and Den Helder, The Netherlands. The KMA and KIM retain their responsibilities for the personal development and military education of officer cadets and midshipmen. There are plans to extend the FMS's bachelor-level academic education to masters level in about three years time, but this is beyond the scope of this paper.

NLDA's educational mission

A major driver for the NLDA's formation was the European-wide change in university education to a standard bachelor-master structure. This opens up the possibility of facilitating the international exchange of officers by providing them with accredited degrees. Most importantly, it meets the need for "thinking warriors" and "officer-scholars". In the FMS's educational vision (NLDA, 2008), a thinking warrior is an academically educated officer who is capable of making knowledge-intensive decisions under pressure. Academic thought processes enable the thinking warrior to develop original and effective responses to unexpected situations, even when under fire. An officer scholar is a thinking warrior who has developed to become a military researcher at PhD level. Lindley-French (2009) argues that smaller countries, such as The Netherlands, need proportionally more officer scholars.

The FMS is in the process of becoming accredited as an academic institution under European regulations. Accreditation is in four phases: accreditation of the institution, accreditation of her bachelor-level courses, accreditation of her research, and accreditation of the planned masters course. At the time of writing (March 2009), the FMS is awaiting formal confirmation of her successful accreditation as an institution, following a visitation in November 2008. The bachelor-level courses will be visited in 2009, with the research accreditation process beginning in 2010.

Scope of paper

This paper focuses on the FMS and the academic education of officers at bachelor level. Currently, the FMS offers full-time, three-year, bachelor-level courses in:

- Military Management Studies (MMS);
- War Studies (WaS);

[1] In English: the Royal Military Academy.
[2] In English: the Royal Institute for the Navy.

- Military Systems & Technology (MS&T);
- Communication-, Information-, and Command & control Systems (CICS); and
- Military Engineering (ME). ME is already accredited as a bachelor degree in construction and civil engineering under the auspices of the University of Twente (Enschede, Netherlands).

The first six months of all five courses is identical.

This paper centres on the CICS course. CICS was originally established in July 2002 to educate officers cadets from the Signals, Informatievoorziening[3] (IV), and Computer & Information Systems (CIS) branches of the Dutch Army and Air Force. More recently, the course has also been opened up to midshipmen from the Dutch Navy and Marines. As the course name suggests, it covers computing, communication, and their operational application to C2. Communication includes voice and data and both wired and wireless media.

Over the past two years, CICS has been undergoing a fundamental review in preparation for accreditation under European regulations. This review involved benchmarking CICS against the military "customer" requirements for the course, against the accreditation requirements, against generally-accepted curricula for bachelor degrees in the computing and communications disciplines (e.g. CC2005), and against similar degrees available from Dutch universities. An important part of the military customer requirements was the need for students to gain academic knowledge that they will need to operate in the NEC era. This paper describes only the benchmarking against NEC Maturity Level 4.

Purpose of paper

The purpose of this paper is to describe the results of benchmarking CICS against the NEC Maturity Level that CICS graduates will need in the NEC era, some ten to fifteen years from now. There are six sections. Following this introduction, Section 2 outlines the relevant aspects of the Netherlands Defence Doctrine. Section 3 looks at the roles of the Signals, IV, and CIS branches in the NEC context and how these differ between the services. Section 4 briefly describes the existing CICS course. Section 5 identifies the additional academic knowledge that CICS-educated officers will need from around 2016 onwards. Section 6 draws conclusions and makes recommendations.

[3] There is no exact English translation of this useful Dutch word. Informatievoorziening (IV) translates literally into "information measures", "information facilities", "information provision", or "information services", although "information systems" or "information management" capture the meaning more closely. IV covers the totality of information systems *and information* from technology through architecture up to business policy and governance. The terms most commonly used in English – Information Technology (IT) and Information and Communications Technology (ICT) – over-emphasize technology, and tempt users to overlook the business aspects. In military operations it is essential to get the right information to the right person at the right time. In principle, information consumers do not care whether this is achieved by means of computers or by using older technologies (e.g. paper maps, carrier pigeons, word-of-mouth), so long as their requirements (e.g. timeliness and accuracy) are met. From an academic viewpoint, the IV concept demands a focus on what is common across different technologies and applications, e.g. (business) process models, architectures, interfaces, logical data structures, standards, and protocols. In this paper I use "information systems" (IS) as my preferred English translation of "informatievoorziening".

Caveats

Several aspects of this paper are specific to The Netherlands. For example, Dutch defence doctrine partly reflects the politics, culture, geographical position and extent of The Netherlands. The organization of the Dutch military services – and that of the NLDA itself – may differ from the equivalents in other nations. By contrast, the accreditation requirements are common across Europe. NEC itself forces participants to adopt interoperable solutions, because it embraces joint, combined, and civil-military ways of working within NATO. This paper aims to present the thinking behind the CICS benchmarking process in such a way that educators in other countries can adapt it as necessary to their own circumstances.

Readers should note that this paper is based on the author's professional judgement, and should not be regarded as necessarily reflecting the views or policy of the FMS, of the NLDA, or of the Netherlands Ministry of Defence.

Netherlands Defence Doctrine

The operational demands on future officers in the NEC era will depend both on defence policy and on the future course of geo-political events. In The Netherlands, the starting point for defence policy is the 2005 Netherlands Defence Doctrine (NDD, 2005). For the purpose of the CICS review, we assume that the NDD incorporates an accurate view on the likely future course of geo-political events.

Main tasks of the armed forces

The three main tasks of the Netherlands armed forces are (NDD, 2005, p.37):

1. To protect the integrity of (Dutch) national and Allied territory, including the Netherlands Antilles and Aruba;
2. To promote stability and the international rule of law;
3. To support civil authorities in upholding the law and in providing disaster and humanitarian relief, both nationally and internationally.

NDD (2005) notes that the three tasks are starting to overlap. The resources needed for the first and second tasks are virtually identical (ibid., p.76-77). In recent years, the second task has gained in importance, with the size and organization of Dutch armed forces becoming more aligned with this task (ibid., p.38). Stability operations are usually conducted by NATO, the EU, or an ad-hoc coalition of nations. The importance of the third task has increased. In response to the terrorist threat, the links with the first two tasks have become stronger (ibid., p.39).

Recent trends

Modern military operations involve a mix of defence, diplomacy, and (overseas) development: the so-called "3D's". Recent trends include joint campaigns and multi-national (combined) operations (NDD, 2005, p.59-62). Joint campaigns are integrated operations involving at least two services under a single joint force commander. Combined operations integrate the armed forces of at least two nations. This increases the legitimacy of the operation, solidarity between the participants, and shares the burden and risk. Coalition partners may be NATO nations, but, as the Dutch

operations in Ethiopia, Eritrea, Iraq, and Afghanistan show, non-NATO nations may also participate. Success factors for cooperation include:

- Mutual respect for the ideas, culture, religion, and customs of other partners.
- Harmonious personal relations.
- Interoperability of C2 and communication systems.
- Allocation of tasks in keeping with each partner's capabilities and national guidelines.
- Mutual logistic support and management of assets.

Mental attitude required of officers

The military capability for conducting operations has three components (NDD, 2005, 50): conceptual, mental, and physical. The conceptual component comprises the basic principles of military operations, doctrine, and procedures. The mental component covers the motivation to perform the task, effective leadership, and organization. The physical component is the operational capacity of personnel, material, and equipment.

The Netherlands armed forces' doctrine stipulates the manoeuvre approach to combat operations (NDD, 2005, p.52-53). The aim is to break the opposing forces' cohesion and will to fight, rather than necessarily eliminating his combat power. Important features are momentum and tempo (speed of decision making and action), bringing about disruption and surprise. The opponent is forced to make decisions faster than he is actually able to cope with, so that he increasingly takes the wrong action or no action at all. Manoeuvre warfare requires from officers a mental attitude that allows for unexpected, rapid, and creative action to be combined with an unremitting determination to succeed (ibid., p.52). It involves taking calculated risks, because the opposing forces will not always react as expected.

In recent years, military operations by Western armed forces have been increasingly characterized by the ability to achieve well-defined effects using technologically advanced resources across great distances (NDD, 2005, p.58). The focus has shifted towards expeditionary land operations. Although events on land are largely influenced by events in the air or at sea, the decisive battle is fought on land. Each military operation is made-to-measure with high demands being placed on flexibility (ibid., p.59). The terrain, the coalition partners, the opposing forces, the attitude of local inhabitants, the desired effects, and the method of operation will differ in every case. The tempo is high, and circumstances can change rapidly during the operation. Again, a mental attitude that allows for unexpected, rapid, and creative action is at a premium.

In the Faculty's educational vision (NLDA, 2008) a thinking warrior is an academically educated officer who is capable of making knowledge-intensive decisions under pressure. Academic thought processes enable the thinking warrior to develop original and effective responses to unexpected situations. He/she has to be able to analyse problems, to develop solutions, to give leadership in implementing solutions, and to work together in continually-changing teams in the field, even when under fire. An academically educated officer:

- Is expert in his/her own field of knowledge;
- Can analyze, generalize, and reason;

- Actively seeks and employs "state-of-the-art" theory in analyzing problems and developing solutions;
- Is creative but critical in fulfilling missions; and
- Is reflective about his/her performance before, during, and after action.

Command & Control

The NDD (2005, p.51-52) lists seven essential operational capabilities (EOCs), of which two are directly relevant to the Signals, IV, and CIS branches:

- *EOC 2: Effective intelligence* aims to build up a picture of the operating environment by timely collection, processing, and dissemination of effective information.
- *EOC 5: Effective command, control, and communications* provide effective direction and control of units and staffs to achieve the set objectives. The NDD devotes its Chapter 5 to C2. Decision making follows Boyd's Observe-Orient-Decide-Act (OODA) loop (NDD, 2005, p.87).

The NDD (2005, p.62-64) identifies three new C2-related technological developments, as follows:

- *Information operations*. Without the right information, it is impossible to accomplish the operational task. The Dutch armed forces are faced with an increasing flow of information[4], both operationally and organizationally. More support is being provided by computerized information systems, which are now a vital part of C2 systems. Users require ready access to all relevant information and to the systems that provide that information. This demands a high level of reliability and availability of the information systems. Offensive information operations (a.k.a. cyber-warfare) combine C2 warfare with political, diplomatic, civil-military, and information activities to change the perception of the opposing forces. Defensive information operations protect friendly units and systems against similar activities by the opposing forces.
- *Effects-based operation (EBO)* is the integrated use of military and non-military instruments of power to achieve the grand-strategic political objectives. The focus is on the effects of actions, and not on the actions themselves or on the assets used to obtain those effects. Defence, diplomacy, and development ("3D") effects may be synchronised. The actual effects achieved are compared with those intended, and planning is adjusted as necessary. The emphasis is on minimizing the undesired effects of collateral damage and fratricide and on ensuring actions remain within the authorized rules of engagement.
- *Network-enabled capabilities (NEC)*. NATO defines NEC as "the Alliance's cognitive and technical ability to federate the various components of the operational environment from the strategic level down to the tactical level through a networking and information infrastructure". All units – particularly in joint, combined, and/or civil-military operations – must be linked to the network infrastructure to achieve the intended effects. Sensors, weapons, communications, and information systems must be interoperable. Electronic exchange of information speeds decision making and action, enhancing the tempo of operations. The technological steps needed to link all units to a

[4] The UK doctrine note on information management estimates an increase of 30% annually.

network are comparatively easy to take, given adequate funding. However, changes in technology bring with them associated changes in softer issues, such as procedures, personnel (recruitment and training), culture, and organization. In NATO, this is expressed in terms of the Doctrine, Organization, Training, Materiel, Leadership, Personnel, Facilities, and Interoperability (DOTMLPFI) factors or "lines of development". A change in any one line of development (LOD) causes changes in the others. Ideally, all LODs should evolve together. However, technological developments may lead the other LODs.

Signals, IV & CIS branches

Roles from network viewpoint

NLDA's Communications-, Information-, & Command & control Systems (CICS) course has been designed to meet the European regulations for the academic bachelor-level education of military officers from all armed services in the Signals[5], IV, and CIS branches, including the C2 specialization. Comparison with generally-accepted curricula in the computing field (e.g. CC2005) indicates that CICS should cover the Information Systems (IS) and Information Technology (IT) disciplines.

Officers in the Signals, IV, and CIS branches lead and manage activities that are intended directly or indirectly to support the operational C2 process. Fundamentally, C2 can be seen as a communication process, with information flowing between organizational entities at different locations. These entities form the nodes in the C2 network. Sensors and reconnaissance units report what they have observed to analysts. The analysts pass their assessments to the command team. Within the command team, the commander and his/her staff exchange information and knowledge in developing courses of action. Externally, they coordinate their plans with superiors, subordinates, and peers. Finally, the commander communicates his/her intent to the units and weapon systems that will execute the tasks they have been assigned. During execution, units and weapon systems report their progress back to the commander.

The Signals branch is responsible for ensuring that information flows in the communications network. In broad-brush terms, they are responsible for the arcs. In addition, they are responsible for information operations, specifically including signal intelligence and electronic warfare. Academically, their knowledge is rooted in communications sciences and technologies, ranging from electrical and electronic engineering (including the associated mathematics) to the configuration and operation of complete communications networks. In the NEC era, such networks have technical, cognitive, and social aspects.

At the nodes in the C2 network, information is processed. Sensors and reconnaissance units observe raw signals in the physical domain, converting them into symbolic information. Analysts assess the situation based on received sensory reports. The commander and his/her staff build up a picture of the situation based on the analysts' assessments, set their mission goals, develop plans of action, decide to pursue one of those plans, and prepare Operation Orders incorporating the commander's intent. The

[5] In Dutch: Verbindingsdienst (VBDD).

executive units and weapon systems turn the Operation Orders into action in the physical domain.

The IV branch is responsible for providing the means by which the right information is processed in the right way at the right node and at the right moment. In broad-brush terms, they are responsible for the nodes in the C2 network. Academically, their knowledge is rooted in the information processing sciences and technologies, ranging from organizational theory through business processes to technologies for automating, assisting, and managing information processing. In the NEC era, the information can take on cognitive (individual knowledge), social (shared knowledge), and technical (data) forms.

The CIS branch is responsible for the technical infrastructure – the hardware and software – underlying both information flows and information processing. Since computing and communications technologies are converging, their knowledge is rooted in ICT and in the sciences relating to the organization, management, and execution of the operation and maintenance of computing and communications infrastructure.

At Captain or Major rank, Signals, IV, and CIS officers may specialize in C2. They are given professional training in information management and the role of computing and communications in the sensory data reporting, situation assessment, planning, decision making, and direction processes. They learn how to play their role as a S6, N6, or A6 officer[6] in the command team. The CICS course must impart academic knowledge that will later be used as a starting point for this professional training.

Differences between services

There are differences in emphasis between the services. These differences stem from the characteristics of the environment within which they operate. The sensor and weapon systems of all services increasingly incorporate ICT, both for processing digital information and for automating the control loops within the system (e.g. target tracking). If the sensor or weapon system is manned, then ICT will also support the OODA loop, i.e. the internal C2 process, driving the human-computer interface. The extent of the internal C2 system differs according to the crew size. At one extreme, a modern air defence frigate with a crew of 150 personnel may well have five or six local area networks (LANs) onboard. At the other extreme, an individual dismounted soldier or the pilot of a single-seat fighter cannot attend to multiple networks or workstations. The army or air force equivalent to the five or six LANs wired into a navy ship takes the form of a wireless network linking a *platoon* of soldiers or the pilots in a *flight* or *squadron* of aircraft. Hence, what is within the province of the IV branch in the navy can fall in the army within the province of the Signals branch. This – together with the strong influence of terrain on communication links in ground operations – explains why the RNLA has a separate Signals branch, while the other services do not[7].

[6] Depending on which service they belong to.
[7] The Operations branch in the RNLN recognizes a Signals specialization, and there is a long-standing debate as to whether this should become a separate branch.

In navies and air forces, tactical C2 systems are integrated into the sensor and weapon systems, such as ships and aircraft. Computing and communications hardware and software for C2 purposes are typically supplied by the system integrator, i.e. the industrial company that supplies the ship or aircraft. By contrast, tactical C2 system used by armies and marines are largely external to their sensor and weapon systems. At most, one or two client terminals may be installed in (manned) sensor or weapon systems. An army or marines C2 system is very often a "weapon" system in its own right, typically being supplied separately from the sensory or weapon systems into which it is fitted. Moreover, the supplier may not be an industrial system integrator.

Modern C2 systems are increasingly based on Commercial Off-The-Shelf (COTS) products. In principle, military officers only need to support the operations and maintenance phase in the C2 system's lifecycle. The knowledge needed to design, engineer, and develop C2 systems resides largely in industry. A handful of officers needs basic computer hardware and software engineering knowledge to act as "smart buyers" of C2 systems.

The RNLN is unique in diverging from this principle. Water and especially the sea have a great influence on The Netherlands, stemming from the omnipresent risk of flooding, the country's position as a trading nation, and its maritime history. Hence, RNLN officers have always been intimately involved in the design, engineering, and construction of their own ships, more so than in other nations. This extends to the design, engineering, and development of the ships' C2 systems. A consequence is that, in addition to the "smart buyers", there is a cadre of RNLN officers who require extensive education in the design, engineering, and development of ICT hardware and software. The FMS meets this need by providing an ICT theme within her engineering bachelor-level MS&T course. In the rest of this paper, we consider only the educational needs of Signals, IV, and CIS officers and the operations and maintenance phase of the C2 system's lifecycle. These needs are met by the CICS course.

Existing CICS course

Officer profile

In July 2002, representatives of the Royal Netherlands Army and Royal Netherlands Air Force Signals, IV, and CIS branches determined that the professional profile of the military officer who completes the CICS course was to be as follows[8]:

- As commander, the [CICS-educated] officer decides on the application of CIS units during fighting, peacekeeping, and national operations. He/she is responsible for the planning, application, and maintenance of a reliable CIS network in support of the commander's and command staff's conduct of operations and administration. In particular, he/she may serve as officer is charge of the planning and establishment of Electronic Warfare units.
- As advisor, the [CICS-educated] officer is responsible for the planning and coordination of the application of Command & Control support systems, management information systems, and CIS networks so that these systems are optimized for the current and future IV-related requirements set by commanders and units.

[8] Author's translation of Part 1B (p.8), CICS Programmaboek, version OLM 2006/M1, March 2008.

- In peacetime, the [CICS-educated] officer is responsible as commander and advisor for making preparations for C2 and CIS support for possible operational deployments. In addition, he/she fulfils an important role in the development, selection, introduction, and maintenance of diverse (functional) information and communication systems and networks supporting the conduct of business within the armed services.
- The [CICS-educated] officer is capable of identifying and analysing the needs of commanders and staffs in the area of C2 and IV, and of covering those needs by coordinated application of ICT and CIS means in an effective and pragmatic way.

Since 2002 there have been a number of major changes:

- *Operational*. The Netherlands armed forces have gained experience in expeditionary operations in international coalitions in Iraq, Afghanistan, and off the coast of Somalia. This has put pressure on interoperability with other services' and nations' C2 networks.
- *Doctrinal*. The increasing involvement in counter-insurgency and anti-piracy operations has driven developments in joint doctrine. In 2005 this culminated with the publication of the joint Netherlands Defence Doctrine. Before that date, only single-service doctrine had been available.
- *Organizational*. The Netherlands armed forces have undergone a major reorganization between 2003 and 2005. The formation of the NLDA was itself part of this reorganization.
- *Technological*. The furious pace of technological development, especially in ICT, continues. In the 20th century, the emphasis was on industrial-age C2 and on technology-for-technology's-sake. Since the Y2K bug and the dotcom business failures, commercial organizations have learned that business considerations should drive technology, rather than the other way round. This lesson is now filtering into military organizations in the form of EBO, information-age C2, and NEC. In universities, bachelor courses in computer science (CS) have given ground to information systems (IS) bachelors[9].

These changes have triggered the need for a review of the military "customer" requirements. This review is in progress in parallel to the research reported here.

Competences

The set of competences that the student should have acquired on completing CICS was derived from the July 2002 officer profile. These competences are as follows[10]:

- The CICS-educated officer has:
    1. Knowledge of the current and future operational conduct of units in military operations.
    2. Insight into the C2 and business management processes during operations.
    3. Insight into the possibilities for applying information systems to business processes.

[9] Compare student and course numbers in (VSNU, 2002) and (QANU, 2007).
[10] Author's translation of Part 1C (p.12), CICS Programmaboek, version OLM 2006/M1, March 2008.

4. Knowledge of and insight into the capabilities and limitations of different information and communication technologies.
5. Knowledge of the theory of planning, establishment, and control of information, communication, and C2 support systems, and skill in applying this theory [to the operational situation].

- The CICS-educated officer is able to:
    6. Develop, configure, deploy, adjust, maintain, and secure an adequate and reliable CIS organization that provides timely and accurate information services on the basis of continually-changing information needs.
    7. Inventarize, analyse, assess, and evaluate actively the information needs of the commander and other users.
    8. Realize, combine, and synchronize diverse CIS systems to become a reliably-functioning network, as well as directing this process.
    9. Follow future technical developments in the ICT area, and to evaluate the consequences for current and possible future application to military operations.

These competences run the gamut from operations (competences 1 and 7), through organization and management (competences 2, 3, 5, and 6), to technology (competences 4, 8, and 9). They are consistent with the IS and IT disciplines in (CC2005).

Course structure and subjects

The CICS course is divided over three years. Each year is designed to impart a workload on the CICS student of 60 European Transfer Credit System (ECTS) "study-points". One ECTS is equivalent to 28 hours of study. The CICS subjects average five ECTS per subject. A bachelor project of 16 ECTS forms the course capstone.

The course is designed to become progressively more demanding over the three years, both in terms of scientific depth and in terms of the form in which knowledge is imparted. In the first year, a high proportion of the student's time is in the form of lectures. In the second year, the emphasis is on the study of textbooks, with guidance given as lectures and tutorials. In the third year, CICS students study key scientific papers in (for example) situation awareness, cybernetics, and human supervisory control. They are given assignments in which they have to search for, gather, assimilate, categorize, and review scientific information on (for example) the state-of-the-art in free-space optical wireless networks. Finally, they must propose and execute a nine-week bachelor project culminating in the writing and public defence of a dissertation. Recent bachelor dissertation subjects include:

- Identifying the operational concepts afforded by software defined radio;
- As a part of a larger PhD project, developing the communications plan for riverine operations in Africa;
- Evaluating suitable doctrinal countermeasures for fall-back when an ICT-based C2 system fails, depending on failure mode;
- Assessing the current NATO NEC Maturity Level of RNLA operations and proposing ways of increasing the NML; and

- Identifying the network structure of C2 networks in recent exercises and determining their corresponding vulnerability to enemy action.

Table 1. Structure of CICS course.

First year	Second year	Third year
Academic introduction (AI) Introduction to Operations 1 (IOP1) Introduction to WaS (IKW) Introduction to MMS (IBW) Introduction to MS&T (IMS) Introduction to Operations 2 (IOP2) Philosophy of science (WEF) Methods & techniques of research (MTO) Communication skills in Dutch (CVN) Communication skills in English (CVE)	Analogue communication techniques (ACT) Antennas, wave propagation, & Electronic Warfare (AGE) Sensor systems & data fusion (SDF) *Visual programming with Java (VIP)* Practical detachments (STG1 & 2) Digital transmission techniques (DTT) *Architectures of computer networks (ACN)* *Management & ICT: information strategy (MIT)* *Maintenance of information systems (BIS)* (Free choice, 4 subjects, 2nd part) *Operating systems (BSY)* Information security (IBV)	Information operations (IOP) *Project management (PM)* Network experience & theory (NET) *Object-oriented analysis (OAO)* Advanced communication systems (ACS) Mobile & satellite communications (MSC) (Free choice, 4 subjects, 3rd part) Command & Control systems (CVS) Military data-communication systems (MDS) Bachelor project (BPR)
Complex numbers (CWI) Fourier analysis (FFI) *Introduction to computer science (IIF)* *Databases (DBS)* (Free choice, 4 subjects, part 1) *Model-driven development (MDS)* *Communication technology (CCT)*		

Table 1 summarizes the structure of the CICS course by year. The first six months of the first year are common to all the FMS courses. This is devoted to introducing military operations, to imparting basic scientific skills, and to developing communication skills in Dutch and in English. In addition, students are given an introduction to the FMS's three largest courses: War Studies (WaS), Military Management Studies (MMS), and Military Systems & Technology (MS&T).

The Dutch abbreviations for each subject are shown in Table 1 in brackets after the subject's name. The subjects in italics are self-study modules bought in from the Open University Netherlands' (OU NL) BSc in Computer Science. FMS lecturers supplement the OU NL's self-study materials with (guest) lectures describing the application to military operations, providing the OU NL materials with a military "colouring".

Following the common introduction, the second half of CICS' first year covers the introductory subjects needed for the rest of the course, mostly in the form of OU NL modules. These include two mathematical subjects. Students need to have a grounding in complex numbers and Fourier analysis in order to understand subsequent subjects in tele-, radio-, satellite-, and mobile communications. Three OU NL modules provide an introduction to computing, data structures, and software development. One OU NL module introduces communication technology.

In the second year, OU NL modules and FMS subjects are almost equally balanced. A highlight of the second year is the two detachments that CICS students make to take part in military exercises. Academically, these detachments can be seen as practicals. The students are given assignments to complete that both further their study and solve some problem for their host unit. In one recent example, two students took part in the

annual Combined Endeavor exercise to test the interoperability of NATO nations' C2 systems.

In the third year, FMS subjects predominate. They emphasize more advanced, military-specific subjects, such as C2 software architectures, operational planning and decision-making processes, and emerging communications technologies for C2 systems. NET is a new subject under development to introduce the mathematical theory of and reported experience with computer, communications, cognitive, and social networks in network-enabled operations. The highlight of the third year is the final bachelor project.

The intake for CICS is no more than 15 students per year. Therefore, it is not cost-effective to offer minors. Instead, students are given a free choice of four subjects, spread over the three years. By default, the student can choose an additional four modules from the OU NL's BSc in Computer Science. However, FMS regulations allow CICS students to choose subjects from another FMS course or even from a bachelor-level course given by a civilian university.

Knowledge needed from 2016 onwards

NEC maturity levels

A maturity model provides a framework for defining or measuring the capabilities of an organization in a particular area. Based on Carnegie Mellon University's Capability Maturity Model (CMM) [11], NATO applied the concept of maturity to NEC. The resulting NEC Maturity Levels (NMLs) are developed by experts from NATO's C3 Agency and peer-reviewed by NATO Allied Command Transformation and the C2 Center of Excellence. The NMLs measure the capabilities of a military organization to work together with partners in joint, combined, and civil-military operations. As in CMM, there are five levels, with NML1 being the lowest and NML5 at the highest level. The five NMLs may be briefly described as follows:

- *NML1 (Standalone)*. Each organization acts independently of its partners in the pursuit of its individual intent. Partners operating in the same area may not be aware of one another. There is no way for them to avoid negative interactions. All NATO nations and forces currently exceed NML1.
- *NML2 (Deconflict)*. An NML2 organization does not yet display network-enabled capabilities. Partners operate independently, even though they share a common mission. To avoid interference with one another, partners accept constraints such as boundaries along temporal, spatial, or functional lines, or at particular organizational levels. Missions are executed in a pre-planned manner, with limited ability to change the mission in response to events. Command structures are hierarchical with little or no delegation of decision rights to lower levels. Across-hierarchy links are limited by incompatible C2 systems. Information flows in stove-pipes up and down the hierarchy.
- *NML3 (Coordinate)*. Organizations at NML3 are in transition to a network-enabled capability. They cooperate in operational planning, but execute their plans independently. They are capable of adaptive mission planning, but their command structures are still hierarchical. Partners are horizontally linked and vertically synchronized. Interaction between partners is supported by liaison

[11] See http://www.sei.cmu.edu/cmmi

- *NML4 (Collaborate)*. Organizations demonstrate collective development and execution of a shared common plan that establishes independent relationships. Multiple independent sensors are integrated at all levels into a joint common operational picture (COP). A unified infrastructure based on a single network allows the seamless sharing of data. Advanced horizontal and vertical interactive collaboration facilitates planning and execution. Major organizational and process changes are evident, with rich and continuous interactions between partners. The whole organization can readily adapt to any mission, rapidly planning and synchronizing to execute a common intent. Supporting technology includes semantic interoperability and integrated registry and discovery services. All user services are accessible through generic portals or workspaces.
- *NML5 (Coherent effects)*. At the highest level of maturity, coalition forces from many nations can rapidly plan and execute missions as if they were one homogeneous force. Complete situation awareness is possible through a proliferation of sensors and continuous interaction between partners. Information is transparently available regardless of location. Decision making is extremely fast and responses are agile.

NATO C3 Agency has defined a set of checklists for NMLs 2 to 4. The latest version (0.3) is from August 2008. The checklists detail the capabilities a unit must exhibit under each of the LODs at each NML. No checklist has been defined for NML1 (Standalone) because forces at this level are unable to take part in coalitions. The NML5 checklist has not yet been developed because it is currently difficult to envisage a coalition that is totally homogeneous. Present-day forces are likely to be at NML2 with some outlying capabilities at NML3.

NATO's C2 Center of Excellence (C2 CoE) has developed a set of questionnaires based on the NATO C3 Agency checklists to assess a military unit's NEC maturity level for each of the LODs. An NLDA-funded PhD student has been assisting the NATO C2 CoE on cultural and organizational issues (Van den Heuvel et al, forthcoming). At least three NATO Response Force (NRF) exercises have been assessed to date using the NATO C2 CoE questionnaires. The results show that, as expected, NRF components are between NML2 and NML3.

Netherlands' national NEC goals

The Netherlands NEC Action Plan (NAP, 2008) sets the goal for the Netherlands armed forces of reaching NML4 in 2016 in joint operations, in combined operations with their strategic partners, and in civil-military operations with the emergency services. This is within the five to 15 years time-scale for the CICS review. Therefore,

I use NML4 as the operational benchmark for what a CICS-educated officer will need to know.

The current NML must be assessed to determine what needs to be transformed to reach NML4. To date, the Netherlands armed forces' NML is unknown. A "null measurement" assessment will take place during a national joint exercise later this year. CICS students and lecturers are assisting the NATO C2 CoE in adapting the NRF questionnaires to the Dutch situation.

Knowledge needed for NML4

The scientific fields of knowledge that a CICS-educated officer will need to be familiar with have been identified by analysing NATO's detailed description of NML4 in terms of the DOTMLPFI factors. For example, the first sentence of the NML4 description reads as follows: "This level of maturity is characterized by continued transformational improvements especially in situation awareness and interoperability and adaptive planning and execution." The word "transformational" indicates change management, for which there is a substantial literature in organization and management theory. The phrase "continued … improvements" suggests the (software) process improvement literature. Situation awareness is a key specialization in psychology, well known in the area of C2; see Endsley (2000). "Interoperability" can be viewed in several ways, e.g. in terms of the semiotic levels (technical, syntactic, semantic, and pragmatic) or in terms of the seven ISO levels in telecommunications. The phrase "adaptive planning and execution" suggests the branch of Artificial Intelligence relating to the automated generation and execution of plans and schedules (Ghallab et al, 2004).

Table 2 shows how pieces of text extracted in this way from the NML4 description map to bodies of knowledge. These bodies of knowledge are in turn mapped to their scientific fields (T = technology, P = (cognitive) psychology, S = social sciences, O = organization & management), and to associated CICS subjects (where these exist).

Table 2. Mapping NML4 description to scientific fields & CICS subjects.

NML4 description	**Body of knowledge**	**Field(s)** (T, P, S, O)	**CICS subject**
Continued transformational improvements	Change management; process improvement	O	PM
In situation awareness	Situation awareness (e.g. Endsley, 2000)	P	CVS
Operational ... technical [and] ... advanced semantic interoperability ...	Interoperability (technical, syntactic, semantic, pragmatic)	T, (P), O	MDS
Adaptive planning and execution	Automated generation & execution of plans / schedules (e.g. Ghallab et al, 2004)	T, S	CVS
Collective development and execution of shared common plan	National, professional, & organizational culture relating to information sharing (Van den Heuvel et al, forthcoming) & cross-cultural competencies	P, S	-
Multiple independent sensors at all levels	Sensor technology, and sensor- & data fusion	T	SDF
Integrated into joint COP	Human factors & Human-Computer Interfaces	T, P	-
Common unified infrastructure based on a single [converged] network	Network theory (e.g. Newman, 2003)	T, S, O	NET
	Network infrastructure	T, O	NET
Seamless sharing of data	Data exchange	T	MDS
Large-scale advanced	Collaboration processes	S, O	-

horizontal and vertical interactive collaboration	Computer support for cooperative work; groupware	T, S	-
Transparent organization ... structure allows continuous dynamic interactions ... delegation of decision rights	Organizational structures & processes	O	GOO/CVS
Seamless sharing of data	Information sharing; knowledge sharing	(T), P, S, (O)	-
Shared situation awareness & understanding of intent	Shared situation awareness & understanding of intent	P, S	CVS
Readily adapt to any mission ... rapidly plan and synchronize execution	Organizational agility, adaptability	O	-
Integrated registry and discovery services ... user services ... C4I services	Service-oriented architectures, service composition, self-healing services, autonomic computing	T	MDS
Accessible through generic portals or workspaces	Portals and workspaces	T, S	-
"Need to share"	Security policy	T, S	IBV
Leaders foster interaction between partners	Trust	S	IBV, IOP
Multi-disciplinary knowledge	Information management (e.g. Bytheway (2004), UK and US doctrine notes)	O	DBS

Incorporating knowledge in CICS

Many of the bodies of knowledge identified by analysing the NML4 description relate to existing CICS subjects, as shown in Table 2. For example, change management and process improvement are clearly related to the Project Management subject. Such bodies of knowledge can be readily incorporated in CICS by refining the curriculum for these existing subjects.

By contrast, the analysis also shows that CICS currently lacks subjects that cover the bodies of knowledge on:

- National, organizational, and professional culture and cross-cultural competences;
- Human factors and Human-Computer Interfaces;
- Information sharing and collaboration processes;
- Portals and workspaces; and
- Organizational agility and adaptability.

Subjects covering these bodies of knowledge should be added to CICS. To make room for this new material, existing subjects will have to be examined critically, looking for outdated material that can be combined with other subjects or pruned completely.

Conclusions & Recommendations

Conclusions

This paper describes the results of benchmarking the Netherlands Defence Academy's bachelor-level Communication-, Information-, and Command & control Systems (CICS) course against the needs of future operations in the NEC era. The course is designed for officer cadets and midshipmen from the Signals, Information Systems, and C2 branches of all the Dutch military services. Benchmarking against NATO NEC Maturity Level 4 is an element of the military "customer" requirements, itself

part of the preparation of the course for accreditation under European regulations for university education.

The Netherlands Defence Doctrine identifies NEC as one of the key technological developments that will face the Dutch armed forces in the coming years. The Netherlands' ambition is to reach NML4 in joint operations, in combined operations with her strategic partners, and in civil-military operations with the emergency services in 2016. This is within the five to fifteen years timescale for CICS benchmarking.

Benchmarking has been based on the detailed description and LOD checklist for NML4 developed by the NATO C3 Agency. Analysis discloses the bodies of knowledge needed by future CICS officers. The majority of these bodies of knowledge can be matched to existing CICS subjects. This means that the design of these subjects will need to be refined. For example, CICS already includes a subject on Project Management, but the NML4 needs call for additional emphasis on change management (a.k.a. transformation) and process improvement.

We have identified five new subjects (culture and cross-cultural competencies, human factors and HCI, information sharing and collaboration processes, portals and workspaces, and organizational agility and adaptability) that have to be added to CICS. Existing subjects will need to be critically examined to make room in the curriculum for these new subjects.

The primary contribution of this paper is to suggest to educators at military academies ways in which they could enhance their courses to meet the challenges of educating the officer cadets and midshipmen that will have to make NEC a reality in five to fifteen years time. This paper also makes a contribution to the general NEC community in that it demonstrates how a change in one of the NEC LODs, namely Doctrine, is likely to affect another LOD, namely Training and education. This partly fills a gap in the NEC literature.

The main limitation of this paper is that several aspects of the bachelor-level CICS course described may be specific to The Netherlands. We have tried to present the thinking behind the CICS benchmarking process in such a way that educators in other countries can adapt it as necessary to their own circumstances.

Recommendations

We intend to perform further research in the following areas:

- Detailed analysis of the activities of officers in the Signals branch and in the IV and CIS branches should be done in their normal working environment to test the hypothesis that they employ academic knowledge from communications science and communications technology and from the IS and IT computing disciplines, respectively.
- The results of the benchmarking exercise documented in this paper must be harmonized with the results of benchmarking CICS against other military "customer" requirements obtained by interviewing senior military officers, against the European and Dutch government's accreditation requirements, against generally-accepted curricula for bachelor degrees in the computing and

- The new subjects should be designed in detail to dovetail into the CICS course.
- Existing CICS subjects should be examined critically to see whether they can be combined with other subjects or pruned to make room for the new subjects.
- A strong evaluation mechanism should be developed to check regularly that NEC doctrine evolves as forecast, and, if necessary, to adjust the CICS course content.

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