Annex C

The Role of Life Cycle Cost Analysis in Managing the Defense Enterprise

NATO RTO Systems Analysis and Studies Task Group-076*

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1.0 INTRODUCTION

1.1 Background

Confronted with expanding and evolving threats to our national security, which range from violent extremist groups equipped with roadside bombs to hostile nations with large standing armies of conscripted soldiers and weapons of mass destruction, the fundamental task of the North Atlantic Treaty Organization (NATO), members states therein, and Partnership for Peace (PfP) nations, in its bare essence, is to manage risk. With limited defense budgets throughout the Alliance, it's impossible for NATO, its members, and its allies to build, equip, maintain and deploy the forces required to meet all of its joint security challenges with perfect and complete confidence. The challenges, such as fighting the long war on terror, protecting our homelands and that of our allies, and preparing to fight and win a large-scale conventional campaign against a near-peer adversary, are simply too onerous. Instead, hard choices must be made amongst competing needs, with risks driven to an acceptable level.

In a national security environment, the business of risk management involves dimensions of difficulty which are often understood with little precision. As Admiral Mullen, Chairman of the United States' Joint Chiefs of Staff, observes "…we live on the cusp of a new era …plagued by uncertainty, change, and unrestricted warfare."[1]. To complicate matters, an entire set of threats to security must be identified and addressed not only today but several decades in advance given the time needed to nurture and harvest promising technologies that could yield a comparative military advantage and to develop, produce, and field major new weapons systems with required capabilities. The Joint Strike Fighter (JSF) aircraft, for example, took roughly ten years to design and develop, and will be in production through roughly 2035, with a service life of decades for each aircraft. By simple arithmetic, then, the JSF will offer a range of capabilities for deterring and defeating threats, but of uncertain and mutable nature, for much of the 21st century.

Threats, of course, can never be anticipated or understood perfectly. Hopefully, they can at least be bounded. John Maynard Keynes, in discussing investment decision of entrepreneurs, noted "…the extreme precariousness of the basis of knowledge on which our estimates of prospective yield have to be made."[2]. This observation on uncertainty often applies as well to assessments of threats, requirements, and capabilities in the national security domain. In defending our nations, however, the loss function for a wrong decision can be infinitely higher than for the private sector. Egregiously bad judgment on Bay Street[1] can lose a company but in national security it can end civilization.

To pile on difficulty, the defense environment is highly dynamic. Our enemies can and do react to any changes in our capabilities, and are quick to exploit weaknesses. This holds at the tactical level, with the evolution of improvised explosive devices in Iraq and Afghanistan but one example, as well as at the strategic, with potential adversaries now seeking to develop anti-satellite capabilities.

1.2 Study Objectives

Given this extraordinarily complex, high-stakes backdrop of strategic planning, capability development, and risk mitigation, the SAS-076 Task Group, under the authority of NATO's Research and Technology Organization, embarked upon an effort to capture national practices in managing the defense enterprise, with an emphasis on the role played by life-cycle cost analysis in the process. These templates were developed to ensure a common denominator of national responses:

[1] Bay Street, Toronto; the "Financial Capital" of Canada

- **Overview**
  Provides an overview of the basic systems or processes used in a nation in managing the defense enterprise;
- **Strategic Framework**
  Captures national practices in defining, managing, and implementing national security strategy;
- **Needs and Solutions**
  Defines the process for identifying military needs and developing and acquiring solutions;
- **Lexicon and Taxonomy**
  Captures national definitions of "defense capability" and defines methods that might be employed in grouping capabilities for the purpose of analysis; and
- **Role of Life-Cycle Cost Analysis**
  Captures the degree to which life-cycle cost analysis plays a role in planning, acquisition, and budgeting.

As a corollary, SAS-076 also examined a pilot effort in capability portfolio analysis (CPA) in the United States which investigated how costs, capabilities, and risks could be examined together in an attempt to engender more informed resource allocation decision making.

In both cases, for the templates and CPA, best practices were indentified by the SAS-076 Task Group. Recommendations are presented herein.

1.3 Scope

SAS-076's expertise lies in the discipline of defense cost analysis. That said, many members of the group have considerable expertise in defense planning. Therefore, within the overall context of managing the defense enterprise, the scope of this effort was limited by a desire to focus on cost-analysis issues.

Although responses from a larger sample of nations would have been desirable, the responses obtained were thought to be sufficient for generating good results, lessons learned, and best practices.

In summary, then, SAS-076 offers no recommendations on critical issues such as strategic planning, capability-based analyses, and on how best to acquire materiel solutions. Instead, the role played by cost analysis in these activities is noted.

2.0 MANAGEMENT OF THE DEFENSE ENTERPRISE

Figure 1 is a useful graphic for describing the management of the defense enterprise [3].

Figure 1: The strategic defense management loop

In NATO and PfP nations, political leaders at the highest level proffer national security guidance or objectives, usually in somewhat lofty, broad terms. Departments and ministries of defense translate this guidance into more concrete policy parameters for building and developing their military forces. In this context, requirements for many countries are defined in term of defense capabilities. This is the "gold standard" in NATO today. Many countries measure performance of acquisition programs, budgets, and military equipment and forces. Fewer, however, seem to measure performance at a strategic level, although the trend is in this direction.

3.0 CAPABILITY PORTFOLIO ANALYSIS

3.1 Background

Many countries within NATO are interested in exploring the methods, processes, and potential benefits of capability portfolio analysis to engender better decisions on the allocation of scarce defense resources. Our first step in SAS-076 was to develop a deeper understanding of the scope and substance of portfolio analysis. As a working hypothesis, we defined this discipline, in a national security context, as the art and science of allocating scarce resources to satisfy strategic requirements.

A literature review revealed that portfolio analysis in the private sector is characterized by

- Uncertain and changing information,
- Multiple goals and strategic considerations,
- Interdependence among projects, and
- Multiple decision-makers and locations [4].

Many of these attributes resonate strongly in the national security arena. Information, especially in wartime, is often uncertain and, at times, tragically unreliable[2]. And the business of defense is certainly dynamic. Threats change and induce changes in requirements and the value of existing defense assets. Further, most of the ships, aircraft, tanks, and helicopters in a nation's arsenal have multiple missions and capabilities, and are highly interdependent with other systems. And there's certainly no shortage of decision makers in a ministry or department of defense, or within NATO HQ.

We also learned that major goals of portfolio analysis typically include

- Maximizing value of individual projects,
- Balancing investments, and
- Adhering to strategy [4].

In the private sector, return on investment for a project is often computed as net present value of future earnings divided by investment dollars. In a defense environment, however, the appropriate computation might be future flows of military capability divided by life-cycle costs, with the numerator a much more amorphous concept than units of money. British defense analysts define military capability as

> "…the enduring ability to generate a desired operational outcome or effect, and is relative to the threat, physical environment, and contributions of coalition partners." [5]

Balance of a portfolio in the private sector is often assessed along the dimensions of research versus production, risk, product categories, and time horizon. These vectors hold in national defense, too. Each ministry of defense needs to balance funding for basic research, acquisition of new equipment, and support and operation of fielded forces. Short-run requirements such as better mine-resistant, ambush-protected vehicles must be balanced against investments in long-term capability, such as Joint Strike Fighter.

[2] See Ambush Alley: The Most Extraordinary Battle of the Iraq War, by British journalist Tim Pritchard, for a heart-rending example. On 23 March 2003 in Iraq, Clausewitz's "fog of war" quickly engulfed the 1st Battalion, 2nd U.S. Marines. Due to an unpredictable sequence of events on the battlefield, which rendered operational plans obsolete, Charlie Company was fired upon by U.S. Air Force A-10 Warthogs who had been mistakenly told there were no friendly forces around the northern bridge in Nasiriyah.

Finally, the Chief Executive Officers (CEOs) of best-practitioning firms want to ensure that projects are selected that adhere to the long-term goals of the company. Indeed, the estimation of a project's value sometimes includes an assessment of its strategic importance [4]. This "on-strategy" objective is equally fitting for defense.

3.2 International CPA Conference

After the literature review, our task group conducted a Capability Portfolio Analysis conference in Paris, France, in an effort to learn more about the application of the discipline in the international defense establishment. We found that many existing models and processes within NATO fall short of the ideal goal of addressing all strategic requirements and the capabilities and costs of all components of the portfolio, large and small alike.

One exception was the Strategy-to-Tasks Model (STAM) of United States Special Operations Command (USSOCOM), headquartered at MacDill Air Force Base in Florida. USSOCOM is the combatant command for the worldwide use of Special Forces such as Navy Seals and Delta Operators[3]. STAM identifies and weighs the importance of strategic requirements and operational and tactical tasks required to meet mission objectives. A board of directors assesses the military value of all assets in the context of these requirements and tasks. STAM does a good job of matching budget to strategy. And it uses impressive methodology in evaluating the warfighting value of assets in the USSOCOM portfolio. However, USSOCOM, unlike most ministries of defense within the Alliance, is not in the business of acquiring multi-billion dollar weapons systems since these are resourced through the Services in the U.S. DoD.

[3] See Inside Delta Force, Delacorte Press, 2002, Erik Haney, for a first-hand description of the skills and valor of 1st Special Forces Operational Detachment - Delta.

4.0 U.S. PILOT EFFORT IN PORTFOLIO ANALYSIS

4.1 Background

Applying theory to practice, the U.S. Department of the Navy (DON) several years ago launched a pilot program for building a construct to actually do capability portfolio analysis [6]. After considerable debate, the CPA team selected the defensive part of mine warfare, or mine countermeasures, as the subject of analysis. The offensive side, the deployment of mines, is of relatively low dollar value. The defensive side, on the other hand, was regarded as small enough to increase the probability of success of the effort yet large enough to maximize lessons learned.

To keep the pilot program within manageable scope, the team decided early on to restrict most of the work to the "materiel" component of the U.S.'s "DOTMLPF" solution space of "doctrine, organization, training, materiel, leadership and education, personnel, and facilities" used in defense planning and execution. Materiel assets are items such as weapons systems, equipment, supplies. For mine countermeasures these includes ships, helicopters, sonars, and marine mammals.

Non-materiel items such as doctrine, of course, can matter greatly, especially in war. Military historian Stephen Ambrose, for example, attributes the stiff resistance of the German army to the Allied invasion of France in 1944 to their superior doctrine and training in fighting in the hedgerows of Normandy[4]. More recently, the success of 2008 surge in Iraq can be attributed not only to an increase in troop strength but also to General Petraeus' doctrine of "securing the population" and, more particularly, to the use of "fusion cells" of intelligence, mapping, and forensic specialists, coupled with Joint Special Operations Command, to locate and target al-Qaeda operatives [8]. In a non-pilot effort, analyses of both materiel and non-materiel alternatives are essential.

In terms of costs, the pilot effort included materiel items and the personnel and training associated with operating and supporting them.

4.2 Mine Warfare

To understand some of the challenges faced by the Navy team in actually doing portfolio analysis, it's worthwhile to briefly describe the fundamentals of mine warfare.

4.2.1 Mission and Threat

The mission of mine warfare is to deploy mines against the enemy and to counter mines that the enemy might deploy against coalition forces.

The threat of enemy sea mines to our maritime forces is pervasive, international, and asymmetric. In addition to terrorist groups, more than 50 countries possess sea mines. They are designed, built, and sold on the international market from friends, second parties, and potential foes alike. Since the end of World War II, more U.S. Navy ships have been damaged or sunk by enemy sea mines than by enemy aircraft and missiles combined.

Adversaries can deploy mines in various depth regimes ranging from deep water to very-shallow water in the littoral, where threat is particularly acute due to the importance of coastal areas in expeditionary warfare and to the enemy's ability to easily, quickly, and cheaply exploit this regime.

[4]Facing an opponent with overwhelming air and materiel superiority, the Wehrmacht nevertheless managed to stymie Operation Overlord for a couple of months [7].

Types of mines include floating, moored, tethered, bottom, buried, rocket-propelled, remotely controlled, metallic, and stealthy.

In 1988, the USS Samuel B. Roberts hit an Iranian M-08 naval mine in the Persian Gulf while escorting Kuwaiti oil tankers during the Iran-Iraq war. The mine's explosion blew a 15-foot hole in the hull and ripped open the ship's engine room. The crew heroically fought flooding and flames and managed to prevent the ship from sinking [9].

She was repaired at Bath Iron Works in Maine at a cost of $90 million to the U.S. Navy. The price of the mine was $1,500.

While the Iranian mine was based on World War II technology, designers and developers of mines continue to take full advantage of commercial advances in electronics, wireless communication, and nanotechnology to make their products more stealthy and lethal than ever.

4.2.2 Portfolio

Figure 2 depicts the threat of sea mines to U.S. naval and coalition maritime forces, and the portfolio of current and planned countermeasures.

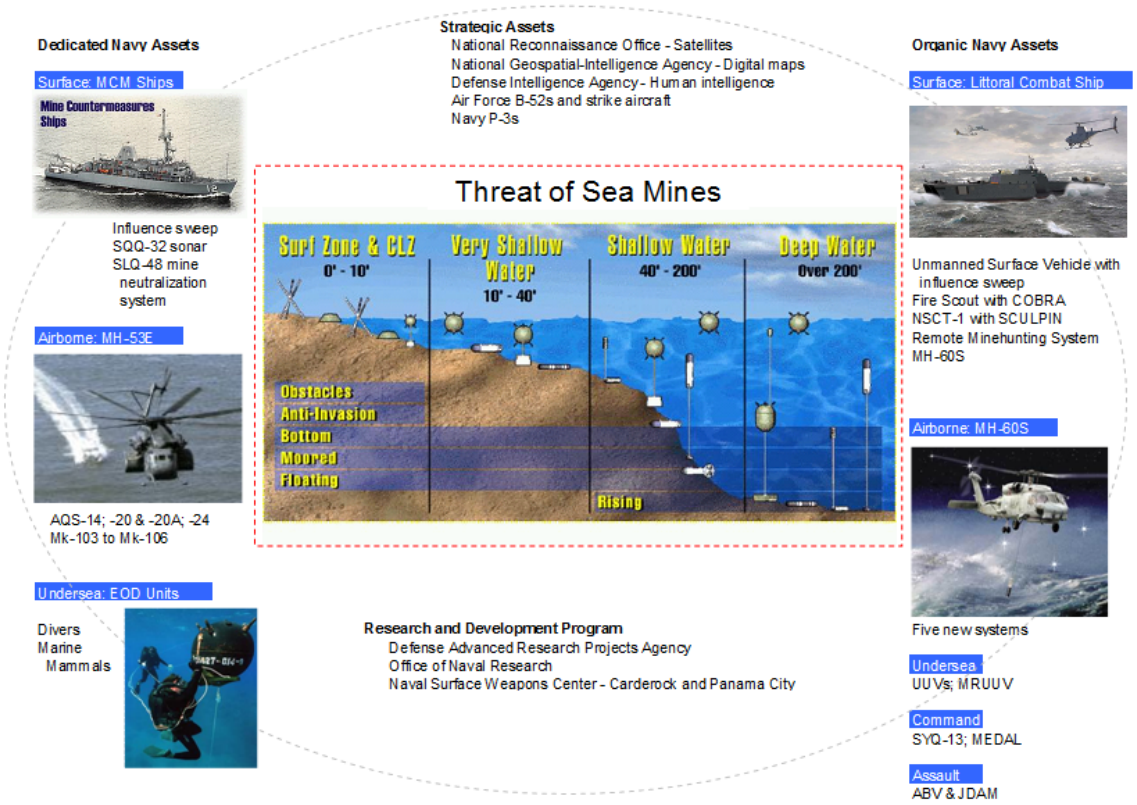

Figure 2: The threat of sea mines

Focusing first on threat, the diversity of depth regimes and the variety of mines within each pose a major challenge to our operating forces, and demand a variety of search and neutralization techniques. In mine warfare, there's no silver bullet or simple solution. One system does not do all. Instead, countering enemy sea

mines is regarded as one of the most complex and difficult realms of naval warfare. Multiple systems address the kill-chain steps of *search* (look for objects), *locate* (specify their position in the water, ocean bottom, or beach), *classify* (bin them into mine-like and not-mine-like categories), *identify* (determine which mine-like objects are, in fact, mines), and *neutralize* (render the mines harmless).

Focusing now on counter measures, at the heart of mine warfare is intelligence, surveillance, and reconnaissance. This is where many of our national, strategic assets play a role. These include the National Reconnaissance Office's constellations of polar-orbiting satellites with remote sensing capability; the National Geospatial Intelligence Agency's digital maps of the littoral; and the Defense Intelligence Agency's human, ashore assets which many analysts think will be increasingly important in the decades ahead.

At the operational level, the U.S. Navy uses dedicated and organic assets. The older, traditional dedicated systems are devoted fully or largely to mine warfare. The newer organic assets, on the other hand, travel with Carrier Strike Groups and attempt to meet the Navy's long-standing goal of removing the sailor from the minefield.

Dedicated assets are a triad of surface, airborne, and undersea systems. Included are 14 Avenger-class ships built in the 1980s and early 1990s of fiberglass-sheathed wooden hulls that enable them to operate within minefields. They deploy long cables astern charged with magnetic and acoustical signals that emulate those of our ships and submarines in an attempt to induce enemy sea mines into detonating. The vessels also deploy the tethered SQQ-32 sonar for mine detection and classification and the SLQ-48 for subsequent mine identification and neutralization.

The multi-mission MH-53E helicopter is the largest in DoD's arsenal. The Sea Dragon tows mine-hunting sonar such as the "Q-20" and the newly deployed "Q-20A" to find sea mines and mechanical, magnetic, and acoustic sweep gear to neutralize them.

The Explosive Ordnance Disposal units have the daunting mission of finding and disarming mines. Navy divers work closely with dolphins and sea lions who have a unique ability to find and neutralize mines nestled in the ocean sands.

Turning to the organic domain, the Littoral Combat Ship (LCS), along with its Fire Scout unmanned aerial vehicle[5], will be the U.S. Navy's mine countermeasure platform of the future. The USS Freedom, the first ship in the class, was delivered to the Navy in 2008. The multi-mission vessels will be configurable to perform mine, anti-submarine, and surface warfare missions. LCS will transport manned and unmanned mine countermeasure systems to the littoral, where they will be deployed, while the ship remains offshore and out of harm's way.

The MH-60S Knighthawk helicopter will deploy from the ship, and will carry a number of new mine countermeasure systems which have emerged from the science and technology community and are currently in development or testing.

These include the Airborne Mine Neutralization System and the Rapid Airborne Mine Clearance System which rapidly fires 30mm tungsten projectiles from a Gatling-type gun into the water to destroy enemy sea mines by sheer kinetic force.

Additional assets in the mine warfare portfolio include unmanned, undersea vehicles (UUVs), command and control systems, and assault systems for mine clearance in the surf zone and craft landing zone. Finally, the naval research community continues to develop new technologies for countering enemy sea mines, especially in the littoral.

The U.S. Navy pilot effort excluded the national, strategic assets from consideration. These are classified and devote but a small percentage of their time to mine warfare. This left 46 different systems plus a couple of classes of ships and helicopters to analyze in the portfolio of mine countermeasures.

[5] In its mine countermeasure mode, the Fire Scout will be used for a military task called "intelligence preparation of the battlefield."

4.3 Methodology

4.3.1 Assessing Capability – System Architecture

The naval task group, with strong representation from the mine warfare community, met monthly during much of 2005 to brainstorm ideas for assessing the military value of systems in the portfolio, both current and prospective, and large and small alike[6]. The task group recognized immediately the necessity of tying value to national security goals, set by higher authority. It wanted to avoid the error of operating like loose cannon on the decks of the Department of Defense.

The team received invaluable advice and support from professors and staff at the Naval War College in Newport, Rhode Island, on the business of scoring the importance of objectives. Following the lead of USSOCOM, the team developed a strategy-to-systems model for assessing the military value of systems in the portfolio.

As a backdrop to exercising the model, illustrated in Figure 3, the team first defined a master warfighting scenario. This was an amalgam of two separate scenarios, one for a major combat operation overseas and one for homeland defense, thus giving each of the assets in the mine countermeasure portfolio a chance to demonstrate its true capabilities. While unclassified, the master scenario nevertheless detailed factors such as bottom profile, tactical situation, mine threat, and dimensions and water depth of sea lines of communication.

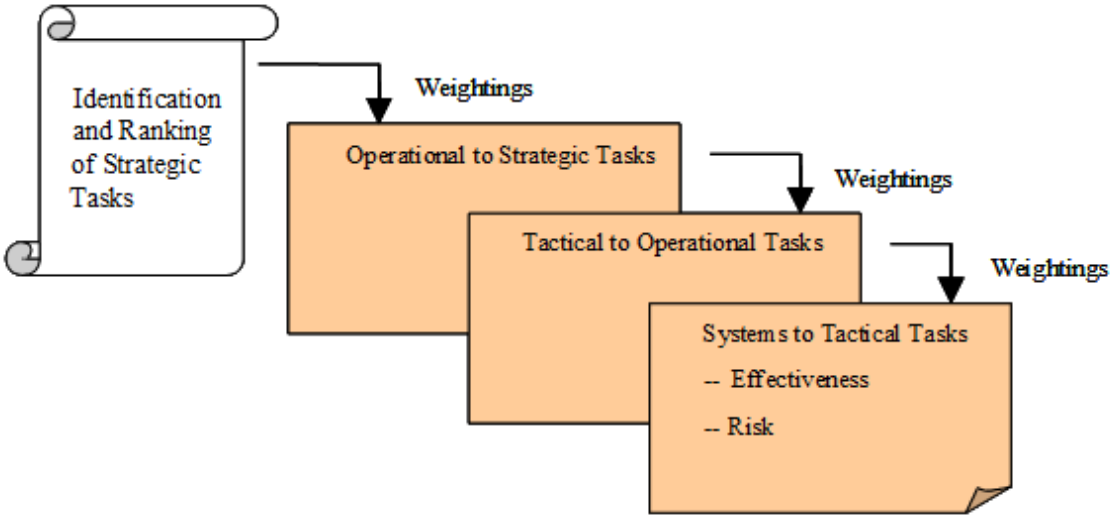

Figure 3: The master warfighting scenario

Next, the team identified and then scored the importance of five strategic tasks or requirements for mine countermeasures. These tasks were tied to National Defense Strategy and recent Presidential directives for increasing security in the maritime domain [10].

The team then defined six operational tasks and scored their importance in fulfilling the five strategic requirements. The team similarly defined 12 tactical tasks and related these to operational tasks. Finally, the team graded individual systems against tactical tasks.

[6]Task group members included representatives from Mine Warfare Command; Naval Surface Warfare Center Panama City; Naval Undersea Warfare Center; Naval War College (Warfare Analysis and Research and the Decision Support Center); Mine Warfare Program Office (PMS-495); the Chief of Naval Operations (Expeditionary Warfare and Mine Warfare); and the Office of Naval Research.

This linkage of strategy to tasks to systems was deliberate. In this sort of schema, those systems that score highest, *ceteris paribus*, are those that best respond to the strategic goals articulated by the President, the Secretary of Defense, and the Joint Chiefs of Staff.

4.3.2 Assessing Capability - Execution Details

The team conducted a scoring conference at the Decision Support Center at the U.S. Naval War College in December 2005. It employed a "Borda Count" technique to measure the rank order and relative importance of the five strategic tasks, shown in Table 1, while recognizing that no flawless procedure exists for doing so. As Arrow's Impossibility Theorem indicates, all techniques to rank-order preferences, other than using a dictator, will violate at least one commonly accepted measure of fairness [11].

Table 1: Scoring of strategic requirements

Strategic Requirements	Sample Score
Protect Operating Forces Against the Threat of Sea Mines for Power Projection Ashore	15
Defend U.S. Ports and Coastal Approaches Against Sea Mines	50
Maintain Mobility of Operational Forces in the Presence of Sea Mines	13
Collect, Analyze, and Share Intelligence Related to the Worldwide Threat of Sea Mines	10
Preserve Freedom of the Seas for Commercial Navigation in the Presence of Sea Mines	12

Each scorer was given a total of 100 points to distribute among the five requirements[7]. While the numbers here are fictitious, "Defend U.S. Ports …" did emerge as the top-rated priority in our scoring conference. This is perhaps not surprising upon noting that U.S. ports load and unload from ships an average of 71,000 containers daily [13] and that the value of commerce at the Port of Long Beach alone is $100 billion per year [14].

The team scored the importance of each of the six operational tasks in meeting *each* of the five strategic requirements using a template, shown in Figure 4, developed using a web-based decision analysis support tool[8].

After scoring the importance of tactical tasks in fulfilling operational tasks, the grouped the 46 individual mine countermeasure systems into these categories according to their basic function:

- Detection, localization, classification, and identification of sea mines
- Neutralization of sea mines
- Mine sweeping
- Assault

[7]This technique avoids the pitfall of cardinal ordering by measuring the amount by which one requirement is judged more important than another [12].

[8]The six operational tasks and the 12 tactical tasks (not displayed here) were based largely on a distillation of guidance provided in the "Universal Joint Task List" from the Joint Chiefs of Staff and from similar U.S. Navy guidance. The guidance lists military tasks or steps that need to be executed to accomplish a mission, such as countering enemy seas.

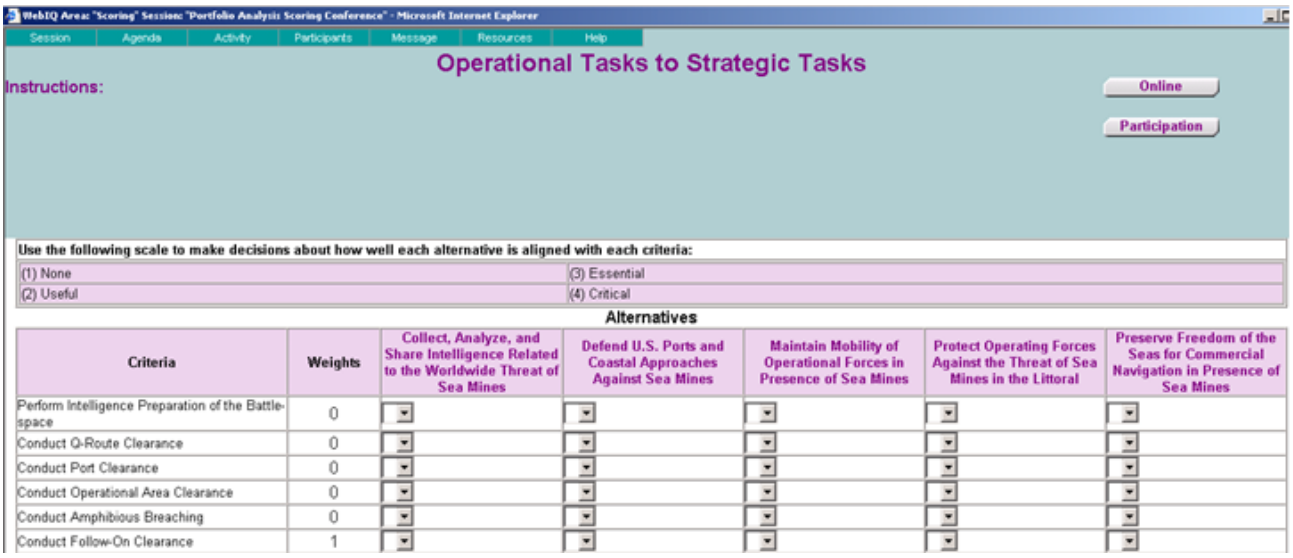

Figure 4: Sample scoring template

- Command and control.

The team then rated the *effectiveness* and *suitability* of each system, tackling one category of assets at a time, in executing tactical tasks. This was to keep the scoring manageable and to help insure consistency in evaluating systems with the same mission. *Effectiveness* was evaluated in terms of the overall ability of a system to accomplish its mission. *Suitability* was evaluated in terms of degree of reliability, maintainability, and interoperability of the asset in a warfighting environment.

Aggregate capability scores were tallied for each system using the cascading series of weights from the rankings of strategic, operational, and tactical tasks, applied to the numerical evaluations of effectiveness and suitability. The team converted raw scores into index numbers, using 1.0 as the mean or base value for the entire portfolio.

4.3.3 Estimating Risks

The team assessed risk according to a system's phase in its life cycle:

- **Science and technology projects**
  Risk of failing to meet design, research, and transition goals;

- **Acquisition programs**
  Degree of design, platform integration, and testing challenges;

- **Operational systems**
  Risk of failing to meet mission requirements.

In addition, the team developed risk weighting factors for each phase, running from high to low. An S&T project, for example, carries inherently greater risk than an operational system, *on average*, since it first needs to

achieve research goals and then pass through acquisition successfully before becoming a useful military asset. This is not to say that operational systems are without risk. Dolphins and sea lions, for example, are sometimes described as "capricious" in hunting for sea mines. When they want to work, they do a great job. Some days, however, they prefer to play.

4.3.4 Estimating Costs

Measuring military value and risk of 46 systems and four platforms was only half the work of the pilot program. Given the scarcity of resources allocated to national security in a pluralistic, free society, it was essential to scale capability by cost to provide a "value for money" metric, to use a favorite phrase of British defense planners. Team members believed strongly in the criticality of capturing the *total costs* of assets over their *service life* and not simply acquisition costs or costs in the year of the budget[9]. Depending upon where a system was in its life-cycle, this required estimates of development, production, and operating and support costs, as Figure 5 shows.

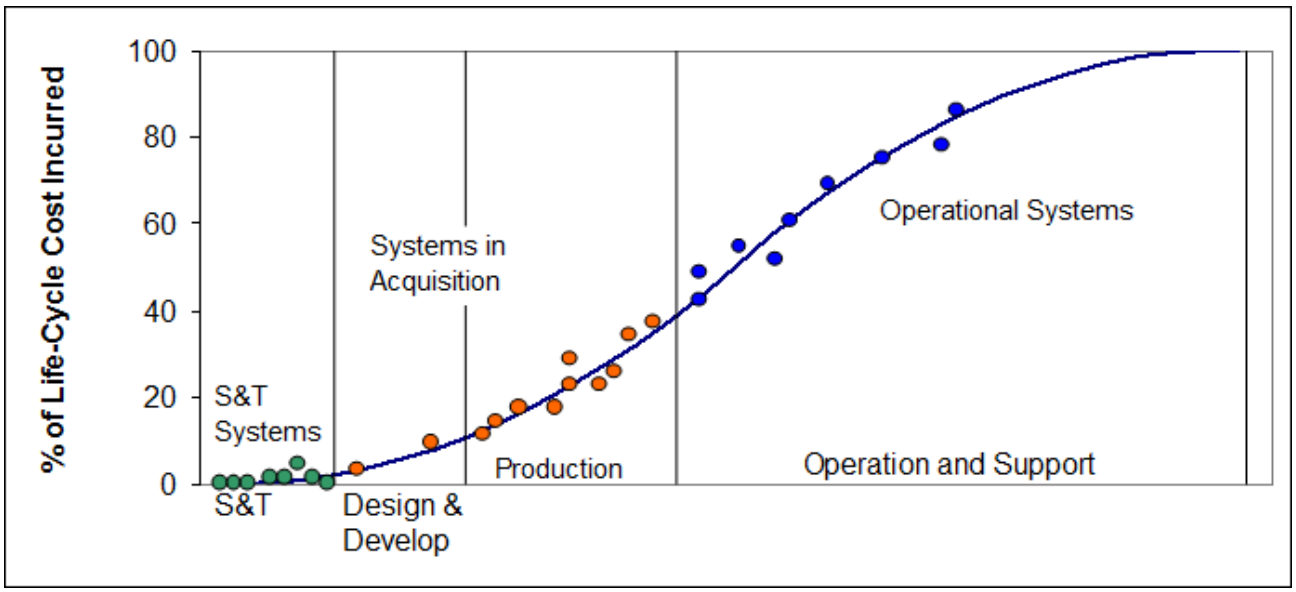

Figure 5: Life cycle of defense systems

The job of cost estimation in the mine countermeasure portfolio was made more difficult because of the numbers of relatively small, inexpensive systems involved. Many of these eluded the minimum dollar threshold for cost reporting in the U.S. DoD, and therefore required a variety of estimation techniques.

4.4 Findings

Combining assessments of military capability and life-cycle cost analysis for the mine countermeasure systems, the naval task group found risk-reward bubble diagrams particularly useful in displaying results. Figure 6 is

[9] In defense cost analysis, operating and support costs are usually estimated for ten years after initial operational capability (IOC) of a system, or the date of fielding. For mine countermeasure systems, this often required estimation of costs through 2020.

an example for the 16 systems in the detect-to-identify-sea-mines category. The size of each bubble represents resources to be expended, or estimated life-cycle costs, in 2006 constant dollars, scaled to a reference point of $100M. Costs include development, production, and operating and support, where applicable. Each accompanying number is an estimated return on investment (ROI), or military value divided by bubble size.

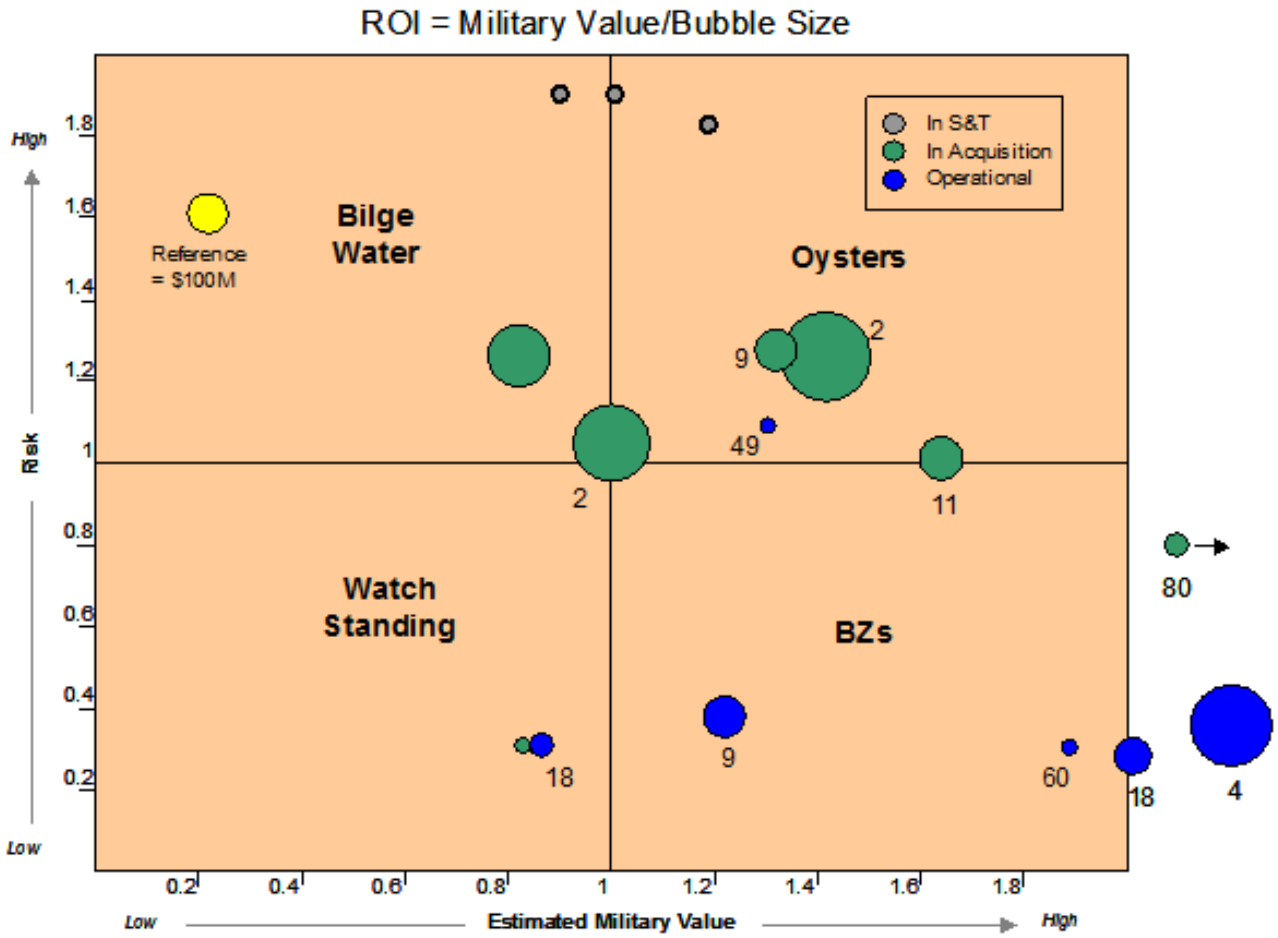

Figure 6: Detection, localization, classification, and identification of sea mines

The two axes intersect at coordinates (1.0, 1.0), the global portfolio average values for risk and reward – measured across all 46 systems.

The team labeled the four quadrants using nautical terminology. The BZs, or Bravo Zulus, meaning "Well Done", are the potential stars, the systems with high return and low risk. Moving in counter-clockwise direction, the Oysters are long-shot programs. These are often projects that could yield a high military return if technological breakthroughs are achieved. Moving along, every organization seems to have its share of bilge water, or at least one project or system of low value that's hard to kill. Finally, the watch standing systems are the no-brainers. These have a high likelihood of success but a low or moderate return. They often involve modifications, extensions, and fixes to older systems.

A couple of observations are readily apparent from the display. First, the detect-to-identify systems do very

well as a group. Roughly 2/3 of them fall to the right of the global mean. This is because of the numbers and importance of the tactical, operational, and strategic tasks they support. In mine warfare, it's all-important to find the mines in the first place regardless of mission. U.S. forces sometimes have the opportunity of going over or around sea mines, at least in the short run.

Second, there are profound differences in ROIs. An examination of the underlying data reveals that the deltas are driven mostly by differences in cost rather than effectiveness. The off-the-chart outlier with the ROI of 80, by the way, is a relatively inexpensive unmanned, underwater vehicle designed to engage enemy sea mines in the littoral. Principal decision makers might logically question the acquisition of the more expensive systems. This kind of insight is a potential payoff of portfolio analysis.

Balance in the portfolio can be assessed by evaluating the mix of S&T, acquisition, and operational systems, and their risks and returns, within and between categories of assets. Interestingly, to take one example, S&T projects represent roughly 10% of the total number of systems in the detect-to-identify category but 20% in the mine-sweeping category. But, as Figure 7 shows, sweeping systems perform poorly as a group because of the paucity of tasks they support. Decision makers might logically question if the percentage allocations shouldn't be reversed based on the criterion of relative worth.

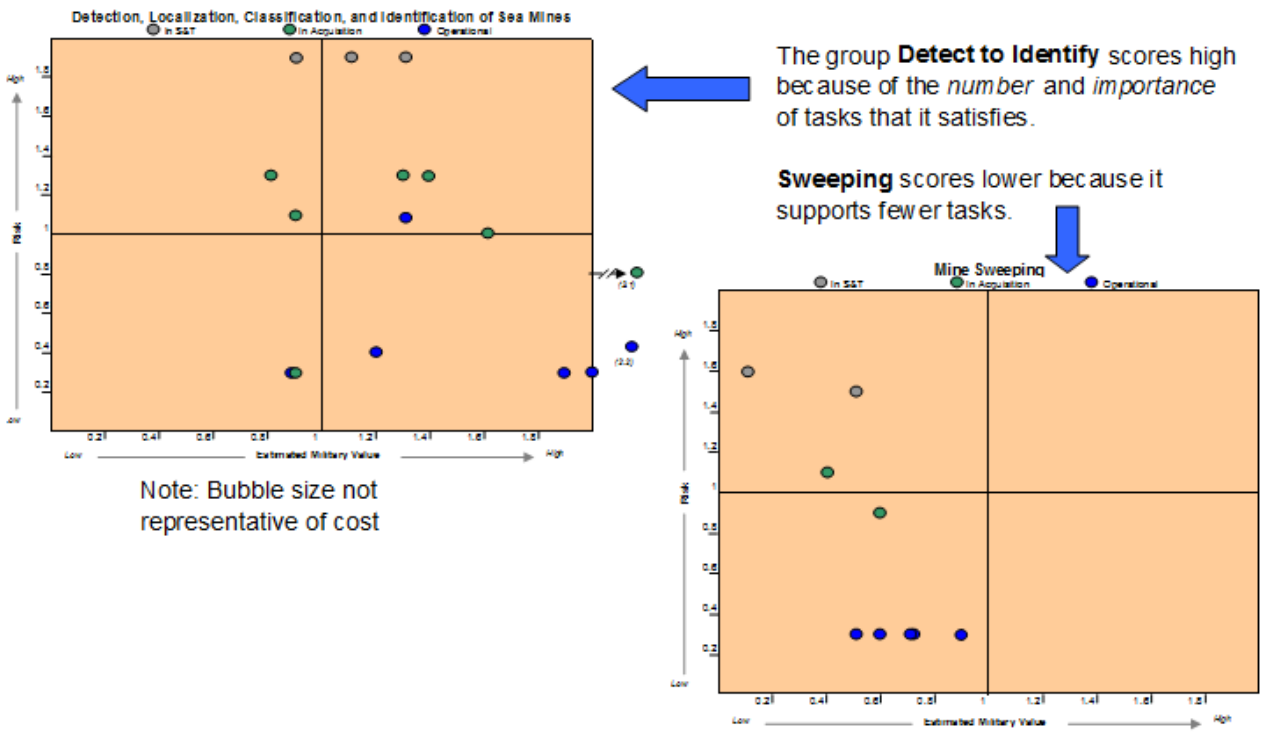

Figure 7: Analysis of detection, localization, classification, and identification of sea mines

Strategic fit is measured implicitly by the numerical military value of a system. The identification and ranking of strategic requirements is the lynchpin of the entire analysis. Weights assigned to strategic requirements cascade to supporting levels of tasks and systems. Any countermeasure asset that doesn't adequately support strategy is simply not going to score well. The lowest-rated system in Figure 7, for example, is an S&T project that appears "off-strategy", at least at first blush. Additional investigation seems warranted into the merits of the project.

In addition to assessing the capability of individual systems, the task group analyzed the military value of groups of interrelated systems. For example, as Figure 8 shows, a number of mine countermeasure systems are deployed from the legacy MH-53E helicopter and from the new MH-60S helicopter, with both labeled "platforms" in the display.

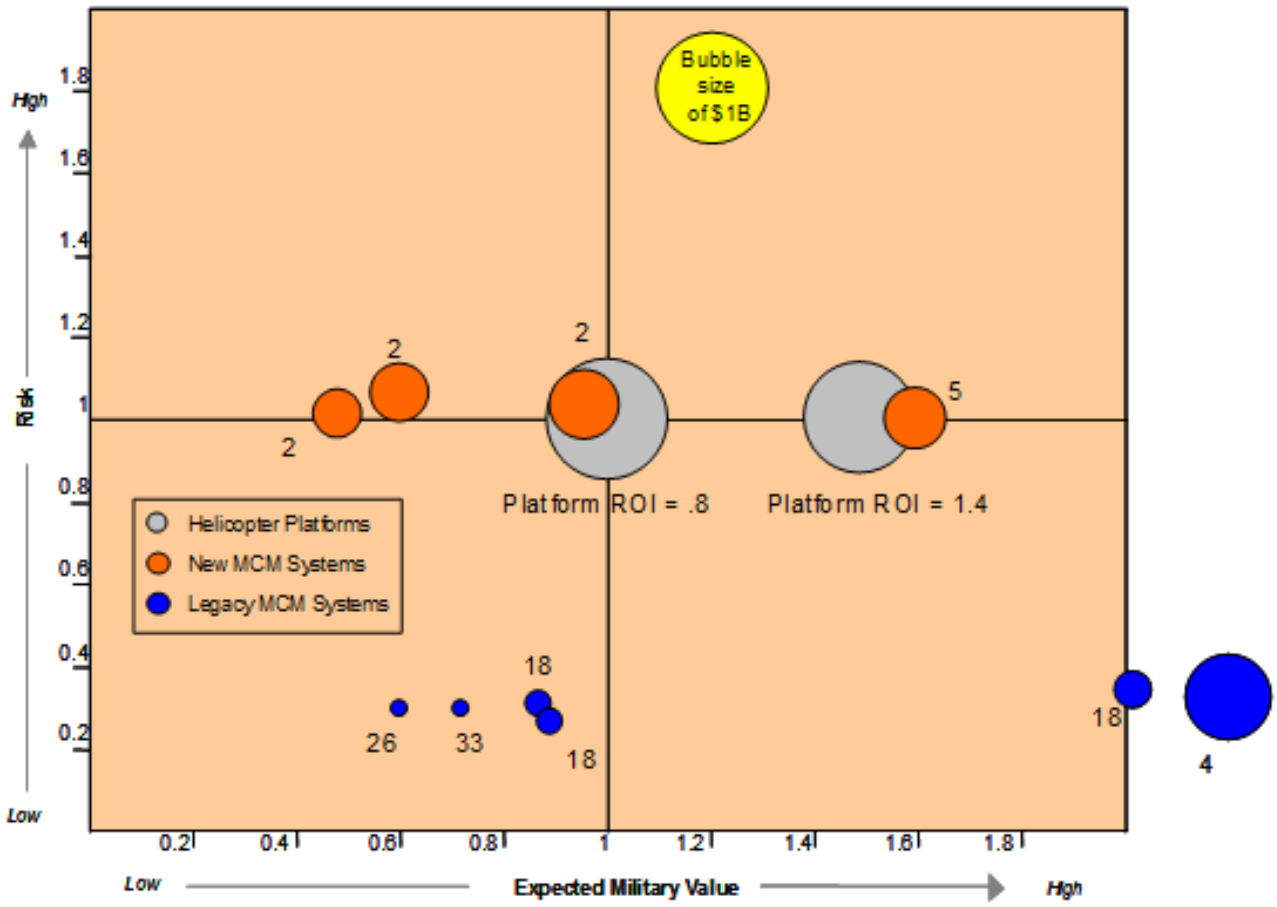

Figure 8: Analysis of groups of interrelated systems: MH-53E and MH-60S helicopters

One helicopter scores higher in capability than the other but their life-cycle costs are roughly the same. The MH-60S is a new system now beginning built. Interesting, its production costs are offset by operating and support costs which are much lower than the expensive-to-operate and aging MH-53E. In terms of the systems deployed from these platforms, the new MCM systems, or those carried by the new helicopter, do not show a marked advantage in capability over the older legacy systems. Indeed, a couple of advanced sonar systems carried by the legacy helicopter yielded the most military value in our pilot analysis.

4.5 SAS-076 Evaluation

The SAS-076 Task Group critically evaluated the U.S. pilot effort in capability portfolio analysis and offers these comments:

- The methodology of the pilot effort seems appropriate for complementing rather than duplicating existing decision-support systems and processes within the ministries of defense in NATO and PfP nations. The pilot's requirements-to-systems model, for example, does not identify capability gaps.
- The pilot effort does not adequately address the dimensions of capacity and time. Identifying the number of units required, for each kind of asset, is critical. Further, some units may be required before others, all have limited service lives, and threats are often highly dynamic and change over time.
- Use of scorers is probably inevitable; however, subjectivity should be minimized and known performance characteristics of equipment better utilized.
- Nevertheless, the pilot effort seems to demonstrate that portfolio analysis techniques can indeed be employed fruitfully in national defense. In short, the pilot effort in mine countermeasures should be regarded as a couple of steps in the right direction in providing senior defense leadership with a tool that measures the costs, capabilities, and risks of individual systems while linking them to national security requirements.

4.6 SAS-076 Recommendations

SAS-076 recognizes that no model is perfect. As the Dutch Econometrician Henri Theil once famously said, "models are to be used, but not believed." [15]. That is, models are parsimonious, plausible, and hopefully informative, but do not provide the ultimate truth. Nevertheless, SAS-076 makes these recommendations regarding future NATO efforts in the area of capability portfolio analysis:

- Include a menu of portfolios from which to choose,
- Include dimensions of capacity and time,
- Include estimates of life-cycle costs,
- Present joint solution space, and
- Minimize subjectivity in assessing military value.

On the first count, the current portfolio or program of record for mine countermeasures was merely one manifestation of reality. Other portfolios are imaginable. "High-tech", for example, would emphasize science and technology projects. A "coalition" portfolio, on the other hand, might include the assets from a NATO Alliance point of view, with many nations having a robust mine countermeasure capability[10]. This addresses another point, or the need to view joint solutions, not only among U.S. DoD components but internationally as well.

On the issue of subjectivity, a key metric in mine warfare is ocean coverage per unit of time. This value is known within fairly tight bounds for many countermeasure systems and can be used in follow-on analysis. However, some use of opinion is inevitable since warfare is both art and science. In short, we need "a nexus of academic rigor and operator experience".

[10]The Netherlands, for example, has a fleet of 10 mine warfare ships [16].

5.0 NATIONAL TEMPLATES

5.1 Overview

Completed templates or presentation slides were received from: Canada, Turkiye, United States, Sweden, Norway, Germany, and the Netherlands. Each, in one fashion or another, attempted to present details on:

- Overview of management of the defense enterprise;
- Strategic framework;
- Needs and solutions;
- Lexicon and taxonomy; and
- Role of life-cycle cost analysis.

5.2 Commonalities and Differences

The SAS-076 Task Group recognizes that every nation within the Alliance, and among PfP nations, has its own procedures and processes for establishing strategic guidance and objectives; for identifying military needs; and for developing and procuring solutions. The application of life-cycle cost analysis, captured in the fifth template, likely therefore differs among nations, too, according to the scope and complexity of its planning and acquisition processes. The SAS-076 Task Group identified the following commonalities and differences in national practices from the nations reporting.

5.3 Strategic Framework

Areas of Analysis

- Goal setting
- Global analysis
- National defense analysis
- Strategy formulation
- Testing the strategy

Summary

All nations in the sample state general goals or ambitions in a national security document. Some nations offer more detail than others. For example, some nations proffer ambitions in a worldwide context while others state goals in the context of specific scenarios. All nations have processes and products that translate high-level objectives into more concrete policy parameters needed to build military forces. Most nations in the sample and many others within NATO engage in capability-based planning.

Legend

	Yes
	Occasional/Not Concrete
	No
?	Response Unclear

	U.S.	NLD	CAN	SWE	NOR	TUR
Goal Setting						
Stated officially in a document	QDR	Policy View	National Security Strategy	Defense Policy Bill	Defense Policy Targets	Turkish National
Periodicity of publication (x years)	4	4	?	3	?	?
Presented by Ministry of Defense or equivalent	DoD	MoD	MoD	Government	MoD	MoD + General Staff of TAF
Global Analysis						
Described in an offical document		Policy View	National Security Strategy	Defense Policy Bill	?	Turkish National
Periodicity of global anlaysis publication (x years)	4	?	?	3	?	?
Looking ahead (Y) or Static (N)		Scenarios	?		?	?
Period considered for global trends analysis (x years)	20?	?	?		?	?
National Defense Analysis						
Described in an offical document		Policy View	Policy Recommendations	Defense Policy Bill	Strategic Analysis	TAF Operational Requirements
Periodicity of national defense anlaysis publication (x years)	4	4	?	3	3-4	2 (odd years)
Looking ahead (Y) or Static (N)		Scenarios	Policy Options	Mid-term	?	
Period considered for national defense trends analysis (x years)	20	?	?	?	?	2 (even years)
Integration of defense multinational cooperation	?		?	?		
Application of capability portfolio analysis			?	?	?	Occasionally
Strategy Formulation						
Described in an offical document		Defense Plan	First Defense Strategy	Defense Policy Bill	Strategic Defense	Strategy Target Plan
Periodicity of coverage (x years)	20?	10	?	3?	20	10
Describes possible scenarios & reasons for choice of strategy			?	?	?	Occasionally (MODSIM)
Includes considerations on multinational cooperation	?	?	?	?	?	Occasionally
Testing the Strategy	?	?	?	?	?	MODSIM

Figure 9: Summary of analysis of nations' responses with respect to strategic planning.

United States

National Security Strategy, signed by the President of the United States, provides top-level strategic direction and is required by law after a Presidential election. The Quadrennial Defense Review is mandated by law and requires DoD to undertake a comprehensive examination of its strategy and performance.

> *"The Secretary of Defense shall every four years ... conduct a comprehensive examination [the QDR] of the national defense strategy, force structure, force modernization plans, infrastructure, budget plan, and other elements of the defense program and policies of the United States with a view toward determining and expressing defense strategy of the United States and establishing a defense program for the next 20 years. Each such [QDR] shall be conducted in consultation with the Chairman of the Joint Chiefs of Staff."* [United States Code 10].

To date, QDRs have been conducted in 1997, 2001, and 2005, and 2009, and each of those reviews has resulted in substantial changes to defense strategy. The trend has been that the QDR report is the first document that details an incoming Administration's views on national defense, and it generally leads the production of other DoD strategic guidance. National Defense Strategy, signed by the Secretary of Defense, contains guidance on security challenges, key operational capabilities, and operational priorities. National Military Strategy, signed by the Chairman of the Joint Chiefs of Staff (CJCS), provides operational context to the Defense Strategy. Guidance for Employing the Force says how to employ the force in terms of operational plans, global force posture, and aims for security cooperation. Guidance for Developing the Force, on the other hand, contains program guidance; that is, what capabilities should be fielded and when. Both of these documents are

supported by more detailed implementing guidance.

Canada

The Government of Canada's national security strategy is typically outlined in several key policy documents, including Speeches from the Throne, major speeches by the Prime Minister, the annual Budget, statements by Ministers in Parliament, and Government announcements. While there is currently no updated overarching national security strategy document, Public Safety Canada (PS) is the federal department responsible for leading the development and implementation of Canada's national security strategy. PS works with five agencies, including the Canada Border Services Agency, the Canadian Security Intelligence Service, and the Royal Canadian Mounted Police, and unites them under a single portfolio and minister. The result is better integration among federal organizations dealing with national security, emergency management, law enforcement, corrections, crime prevention and borders. In addition to coordinating and supporting the efforts of federal organizations to ensure national security, PS also works with other levels of government, first responders, community groups, the private sector and other nations.

A key part of the Government's national security strategy is Canada's defense policy. When a new Government takes office, it will typically set out its defense policy objectives and its corresponding direction to the Department of National Defence and the Canadian Forces (DND/CF). The process for developing defense policy is flexible and varies, but always requires departmental and political involvement.

Canadian defense policy development and planning involves analyzing the national and international strategic environment, the defense and security needs of the country, and the Government's agenda, priorities, and fiscal context. From this, the required military capabilities are identified and policy options are formulated. Working with senior military leadership, the Assistant Deputy Minister (Policy) within DND/CF is responsible for developing policy options, and for coordinating with other departments and agencies (e.g. Department of Foreign Affairs and International Trade; Privy Council Office) to ensure government-wide policy coherence. Consultation with others external to the government may also occur, both with national groups (e.g. Parliamentary committees on defense and security; academia) and international actors (e.g. NATO; partner countries). Once the Deputy Minister and the Chief of the Defence Staff agree on the content of the proposals, policy options are discussed with the Minister of National Defence, who is then responsible for presenting recommendations to Cabinet and the Prime Minister.

The Canada First Defence Strategy sets a detailed road map for the modernization of the Canadian Forces. It puts forward clear roles and missions for the Canadian Forces, outlining a level of ambition that will enable the CF to maintain the ability to deliver excellence at home, be a strong and reliable partner in the defense of North America, and project leadership abroad by making meaningful contributions to operations overseas. Canada First Defence Strategy is the road map for the modernization of the Canadian Forces and is based on analysis of the risks and threats facing Canada in the years to come, as well as the government's vision for defense. The strategic decision-making process for defense acquisitions is called the Force Development (FD) process and the output is the Investment Plan providing detailed guidance on how and when to invest.

The Netherlands

The new Dutch national security planning consists of three new major components in addition to the existing planning mechanisms within the departments:

1. A new government-wide (meta-) foresight function, feeding
2. A national risk assessment which, in turn, forms the basis for

3. A strategic planning system for national security, based on government-wide capabilities-based planning.

Future Policy Survey

In order to develop an adequate conceptual foundation for decisions that will be necessary with respect to the future of the Armed Forces, the Netherlands government initiated the Future Policy Survey. The Survey makes a substantial and scientifically sound contribution to political and public perceptions about the future of the Armed Forces. The Future Policy Survey is an expression of the political will to do justice, now and in the future, to the requirement that the Armed Forces serve as a crucial safeguard against threats to the Netherlands and their society.

The Future Policy Survey project began on 1 March 2008 based on the plan of action approved by the Netherlands defence and on the terms of reference stated in the plan. Its assignment was: "To formulate, on the basis of expected long-term developments and possible scenarios and without constraints, policy options with regard to the future ambitions of the Netherlands defence effort, the appropriate composition and equipment of the armed forces, and the associated level of defence expenditure."(House of Representatives, 2008 31 243, No. 6). The Future Policy Survey makes a scientifically sound contribution to political and public perceptions about the future of the Armed Forces. Among other things The Future Policy Survey has resulted in the development of future scenarios that set out the main outlines of how the world may develop, and the consequences that those developments could bring in the coming two decades. The scenarios have been used as a touchstone for the development of policy options. The policy options have been used to determine the level of Dutch defense efforts over the long term. The results of the Future Policy View have been used as an input for the regular Policy, Planning and Budgeting (BPB–Dutch) procedure. The BPB-procedure contains a policy view and a defense plan. The policy view is the first decision-making document in a 4-year cycle of government and the document determines in outlines the ambition level and the composition and equipment of the armed forces. In the defense plan the policy view is elaborated in more detail and results in the required composition and equipment of the armed forces. The objectives are detailed in activities and required means. The defense plan contains proposals for the design of the organization. The defense plan has a horizon of 10 years, but it includes also topics with a longer timeline.

Norway

The Norwegian Ministry of Defence (NMoD) uses Strategic Defence Reviews (SDR) in the overall planning of the defence sector. In the SDR you conduct a comprehensive examination of the national defence strategy, force structure, infrastructure, budget plan, and other elements of the defence program and policies of Norway with a view toward determining and expressing a defence strategy and establishing a defence program for the next 20 years. SDRs have been conducted on several occasions, the last three in 2000, 2003, and 2007. Norway will continue using SDRs in the future, but will change to a more continuous long-term defense planning process. The scope of most of the studies will be narrower and conducted continuously, with a large review every forth year to sum up the development. Based on the SDR/ decisions in the Parliament, the NMoD develops a Long Term Development Plan (LTDP) where the main goal is to provide strategic guidance and to ensure and maintain a close link between long term planning and the ongoing implementation. Another purpose of the LTDP is to serve as a coherent long-term plan for organization, personnel, material and infrastructure. It gives the NMoD and the Armed Forces multi annual planning guidelines, which again provide a basis for annual planning. The LTDP has four important annexes:

- Structural Development Plan

- Long-term Material Plan
- Long-term Infrastructure Plan
- Long-term Personnel Plan

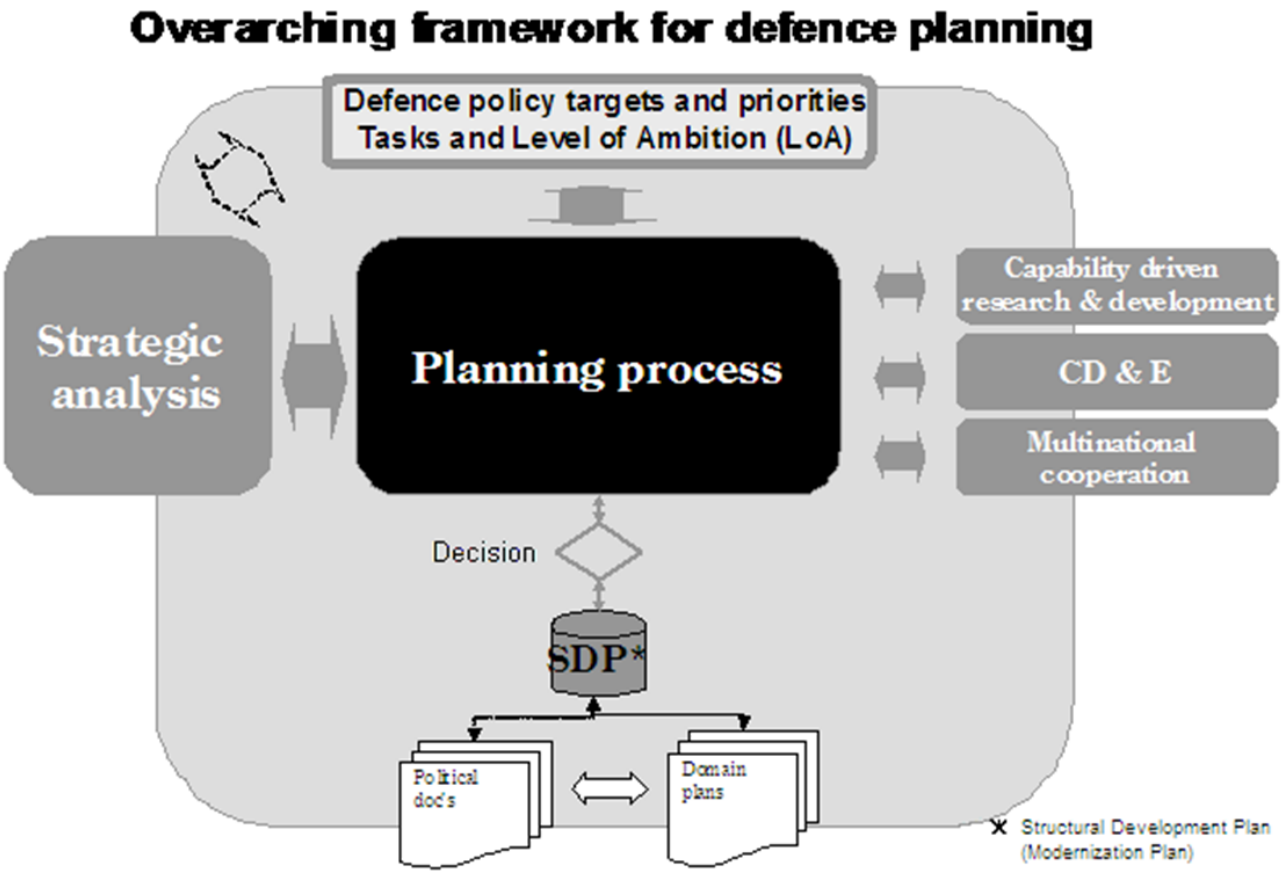

Figure 10: Norway's overall picture of the defence planning.

The model depicted in Figure 10 shows the overall picture of the defence planning and how factors from areas such as strategic analysis, defence policy targets and priorities give inputs and guidance to the planning process. Although it shows a clear distinction between the different areas, the reality is different. It is usually not easy to say where the borderline is between e.g. strategic analysis and the planning process. Furthermore the processes outside the "black box" are just as dependent of the planning process as vice versa.

Sweden

Approximately every third year the Government give directions regarding the Armed Forces in a Defence Policy Bill followed by a Parliamentary Decision. The Defence Policy Bill covers strategic analysis about development in the geographical vicinity, areas of interest for future operations and guidelines for the composition of the units

in the Armed Forces. The impact is mainly on the midterm defense planning. Capabilities are not used as a part of the strategic framework. With the same frequency as the Defence Policy Bill the Armed Forces presents the results of the long term planning.

Germany

In accordance with legal provisions, the equipment of the Bundeswehr must be geared towards its mission as defined by political decisions and the tasks derived there from. The economic use of resources demands the exclusive orientation to this mission. In order to be able to accomplish its mission, the Bundeswehr must have certain capabilities. Potential capability gaps—existing or arising—are identified by means of a capability analysis across all organizations and task areas. To close these capability gaps, potential solutions are to be investigated within all planning categories (organization, personnel, armaments, maintenance and operation, as well as infrastructure). Closing a capability gap in the planning category "armaments" (materiel solution) requires activities aimed at determining and meeting the demand. The implementation of these measures must not exceed the scope of resources available within the foreseeable future. Due to its high innovative speed, private industry sets the pace in technological development. Therefore, close cooperation between the Bundeswehr and industry is absolutely necessary in order to be able to maintain modern and efficient armed forces.

Turkiye

Goal settings and global analysis can be found in Turkish National Military Strategy which is signed by President of Republic, Prime Minister, Ministry of National Defense and General Stuff of Turkish Armed Forces (TAF). National Defense Analysis is described in TAF Operational Requirements Plan which is written by military only. This document is updated in every even year. The Strategic Target Plan includes the trends in national defense which sometimes has application of CPA according to technological development in the country and is updated in every odd year. Strategy formulation is defined in The Strategic Target Plan in the next decade with an update in 2 years time. If it includes scenarios which are also tested by MODSIM, 10 Year's Acquisition Plan document is also updated according to the results.

5.4 Needs and Solutions

Areas of analysis

- Needs and solutions
- Use of capability based planning
- Overview of the process
- Years and frequency of coverage
- Use of scenarios
- Responsibility

Legend

	Yes
	Occasional/Not Concrete
	No
?	Response Unclear

	CAN	GER	NOR	SWE	NLD	TUR	U.S.
Needs or Solutions							
Needs							
Solutions							
Capability Based							
Overview of the process							
Time							
Years covered	15+5	?	?	10	?	10	20+
Frequency	?	?	3-4	1	?	2	4
Use of scenarios		?			?		
Responsibility	MOD		NMoD	Armed Forces	Political decisions	Generel Staff Turkish Armed Forces	Joint Chief of Staff, Services; OSD

Figure 11: Summary of analysis of nations' responses with respect to defence needs and solutions.

Summary

Most of the sample nations describe their process to identify needs. They all use capabilities as a part of defense planning and execute a gap analysis. All nations seem to have alternative solutions that in different ways are prioritized before any decisions for future acquisition are made. Scenarios are for identifying needs or for describing strategic frameworks or both. This also means that some scenarios are not as detailed as others. The responsibility for working with needs and solutions differs between the nations. This is due to the different governmental organizations in each country.

United States

The U.S. employs a capabilities-based framework called the Joint Capabilities Integration and Development System (JCIDS) for identifying and analyzing needs and the Defense Acquisition System (DAS) for developing and acquiring materiel solutions, with the connection between the two processes shown in Figure 12.

Identification of Military Needs

JCIDS is the process by which DoD identifies, assesses, and prioritizes what capabilities the military requires to fulfill its mission. JCIDS is often referred to as the requirements generation process. The requirements identified through JCIDS can be addressed in a number of ways, including changes in doctrine, training, organization, or the acquisition of a new weapon system.

JCIDS was created in 2003 in an effort to fundamentally change the way the Department develops requirements. Before JCIDS, DoD used a threat-based approach to identify warfighter requirements based on who the adversary might be or where a war might be fought. With the advent of JCIDS, DoD shifted to a capabilities-based approach to identifying warfighter needs based on how an adversary might fight.

JCIDS is overseen by the Joint Requirements Oversight Council (JROC) and supports the Chairman of the Joint Chiefs of Staff, who is responsible for advising the Secretary of Defense on the priorities of military requirements in supporting the national military strategy. Within JCIDS, Functional Capability Boards (FCBs)

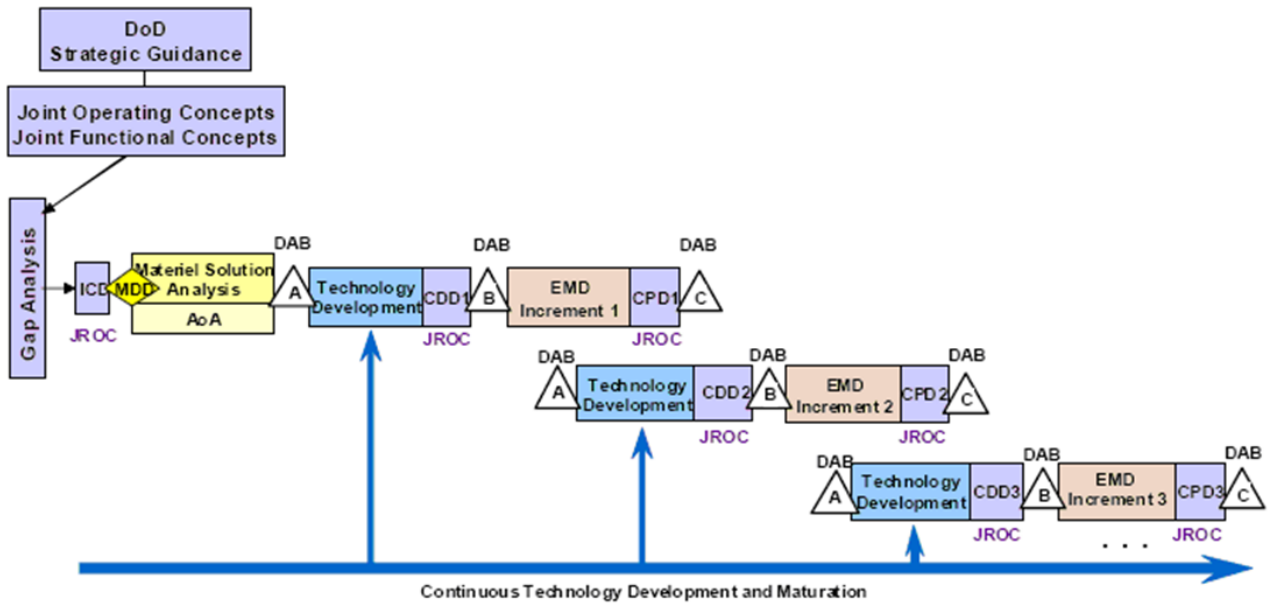

Figure 12: U.S. capabilities-based framework.

manage different capability area portfolios.[11] They are headed by a general or an admiral and made up of military and civilian representatives from the military services, Joint Staff, combatant commands, and the Office of the Secretary of Defense. The FCBs are intended to support the JROC by evaluating capability needs, recommending enhancements to capabilities integration, examining joint priorities, assessing program alternatives, and minimizing duplication of effort across the Department.

The JCIDS process requires the identification of gaps in military capabilities. Potential solutions for filling these gaps are identified and analyzed within DOTMLPF solution space.[12] The results of these analyses or capability-based assessments (CBAs) are formally submitted as initial capabilities documents, or ICDs. An ICD is a capability proposal by a military service, defense agency, combatant command, FCB, or other sponsor. ICDs are intended to document a specific capability gap or set of gaps that exist in joint warfighting functions and propose a prioritized list of various solutions to address the gaps. When a capability proposal is submitted, a Joint Staff "gatekeeper" conducts an initial review to determine what level of joint interest and review there should be and which FCB should take the lead. Capability proposals deemed to have a significant impact on joint warfighting, such as those involving potential major defense acquisition programs, are designated as "JROC interest" and must be validated or approved by the JROC.

The JROC may approve an ICD and recommend a non-materiel solution, such as a change to strategy or tactics. If the JROC approves the pursuit of a materiel solution[13] the program enters the Defense Acquisition System. Documentation developed during the JCIDS process is used throughout the acquisition process.

[11] The JROC charters eight FCBs to perform analyses: Command and Control; Battlespace Awareness; Force Application; Logistics; Protection; Force Support; Net Centric; and Building Partnerships.

[12] Doctrine, organization, training, materiel, leadership and education, personnel and facilities.

[13] A materiel solution is any item (including ships, tanks, self-propelled weapons, aircraft, etc., and related spares, repair parts, and support equipment, but excluding real property, installations, and utilities) necessary to equip, operate, maintain, and support military activities without distinction as to its application for administrative or combat purposes.

Development and Procurement of Materiel Solution

DoD purchases goods and services from contractors to develop and maintain the force, including related infrastructure. Any purchase of a good or service by DoD is defined as a procurement. In contrast, the term defense acquisition is a broader term that applies to more than just the purchase, or procurement, of an item or service. The acquisition process encompasses the design, engineering, construction, testing, deployment, sustainment, and disposal of weapons or related items. More formally, the Defense Acquisition System for designing and acquiring materiel solutions is

> *"... the management process by which the Department of Defense provides effective, affordable, and timely systems to the users, [and it] exists to manage the nationÕs investments in technologies, programs, and product support necessary to achieve the National Security Strategy and support the United States Armed Forces."*

As depicted in Figure 13, the Defense Acquisition System uses "milestones" to oversee and mange acquisition programs. Each milestone has specific requirements. A program must meet these requirements (statutory and regulatory) in order to proceed to the next phase in the acquisition process. The Milestone Decision Authority (MDA) is responsible for deciding whether a program meets the milestone criteria. Depending on the program, the MDA can be the Office of the Undersecretary of Defense (Acquisition, Technology, & Logistics) or an acquisition executive in a DoD component, such as a Military Department.

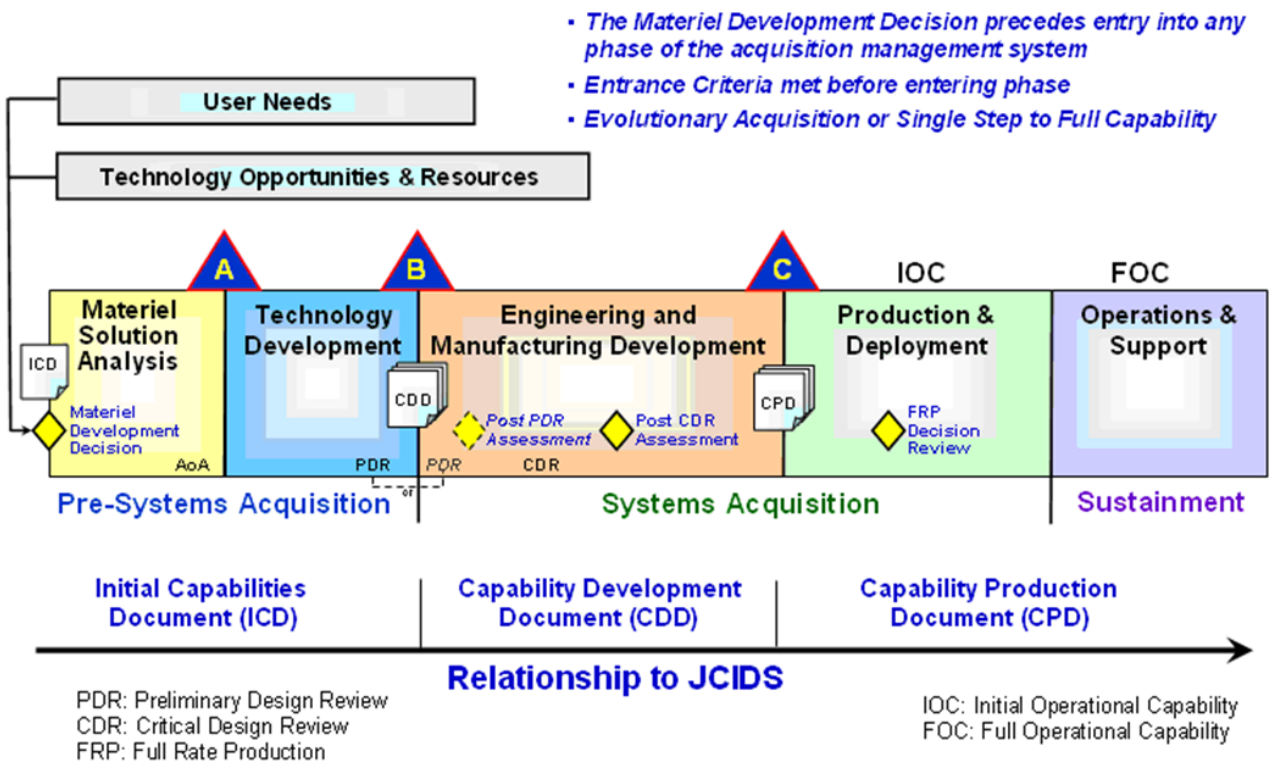

Figure 13: U.S. defense acquisition system milestones.

To enter the Defense Acquisition System, a program must pass a Materiel Development Decision (MDD) review, chaired by a Milestone Decision Authority. At the review, JROC recommendations are presented by the Joint Staff, and the relevant component presents the Initial Capabilities Document, which details the operational need for a materiel solution. During the Materiel Solution Analysis phase, an Analysis of Alternatives (AoA) is conducted and a Technology Development Strategy (TDS) is created. The Technology and Development phase is where a program determines what technologies are required to develop a materiel solution, and works to mature those technologies. This phase is also where competitive prototyping occurs. The Engineering and Manufacturing Development phase is where a system (or increment) is developed, full system integration occurs, and preparations are made for manufacturing, including developing manufacturing processes, designing for producibility, and managing cost. The Production and Deployment phase is where a system is produced and deployed. At Milestone C, the MDA authorizes the beginning of low-rate initial production (LRIP), which is intended to both prepare manufacturing and quality control processes for a higher rate of production and provide production representative articles for operational test and evaluation (OT&E). Upon completion of OT&E and demonstration of adequate control over manufacturing processes, and with the approval of the MDA, a program can go into full rate production. When enough systems are delivered and other pre-defined criteria are met, an Initial Operating Capability (IOC) can be attained, allowing for some degree of operations. Full Operational Capability (FOC) is achieved when the system is ready to operate as required. After development and production, a system enters the sustainment phase. Finally, programs are divided into acquisition categories (ACATs) based primarily on program value. Management and oversight of acquisition programs increases as the value of the program increases. The most significant DoD and Congressional oversight activities apply to major defense acquisition programs (MDAPs), which are categorized as ACAT Is.

Canada

Canada, in their template, has described a process focusing on needs, not how to develop solutions. The process is capability based. The strategic decision-making process for defense acquisitions is called the Force Development (FD) process and the output is the Investment Plan. The Investment Plan covers 15 years with the first 5 years in detail. The plan provides a rationale for new projects and funding provision of them.

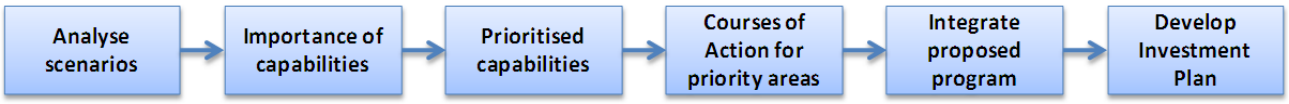

Figure 14: SAS-076's interpretation of Canada's force development process.

The process starts with development and analysis of scenarios that are representative for future missions. Starting with the scenarios it is possible to determine the relative importance of different capabilities and prioritize the capabilities for investment, sustainment or divestment. Courses of action for priority areas and selected preferred options are developed and proposed program changes are integrated with existing programs. Finally an integrated Departmental resource plan (Investment Plan) is developed. Multiple planning scenarios are used to determine likelihood of use and criticality of delivery of different capabilities. Environmental Chiefs of Staff, Chief of Force Development and Chief of Program work within the process.

The Netherlands

The Netherlands, in their template, has described a process focusing on solutions, not how to develop needs. Capabilities seem to be a part of the process although it is not described in what way they are used. The process used to identify and acquire the different solutions, i.e. different materiel, is called Defence Material Process (DMP). The DMP is divided into several phases: each phase is ended with a DMP-document.

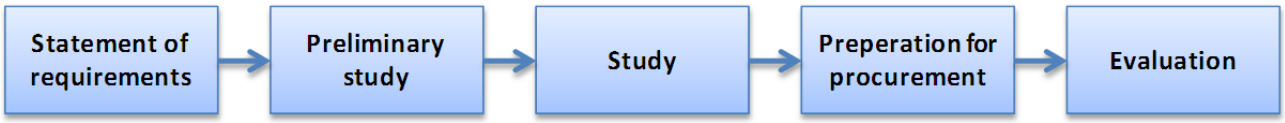

Figure 15: SAS-076's interpretation of Netherlands' defence material process.

DMP is the guideline for keeping the materiel management process on track and contains rules for realizing the requirement for materiel procurement. Financial claims are described. The preliminary study results in an initial selection of product alternatives, including a short list of most suitable alternatives. The Study phase should result in a validation or reassessment of qualitative & quantitative requirements, the detailed requirements and norms the product must comply with and used to compare and evaluate alternatives; an estimate of the life-cycle costs of each alternative product and the financial implications of the alternatives and, if necessary in a development process or a prototype trial, the outcome of the tenders. Preparation for procurement results in a choice of a particular product and the work includes validation or reassessment of requirements, results of development, specification of estimated project expenditure resulting, etc. The final phase, Evaluation, applies for projects exceeding Euro 250 million and is applied when a system has been in use for some time. The parliament is informed of the evaluation. The DMP provides for political decision making at important milestones and political and non-political steering throughout duration of project.

Norway

Norway, in their template, has described a process focusing on needs, not how to develop solutions. The process to identify military needs is capability based and called Capability Planning. The process maintains a link between defense- and security policy foundation, defense tasks and level of ambition, and main decisions concerning development of capabilities and how Defense Forces are structured. The Capability Planning starts with Task analysis related to tasks stated in parliamentary bill. A complete list of capabilities needed to solve imposed tasks is developed and then the level of ambition is stated. The Gap analysis identifies and analyzes the gap between the ability the structure has today and the defined capability need. A prioritizing is made based on probability, impact and economy. Finally the capability development plan is developed. The plan describes the gaps that are prioritized and in what way they will be closed.

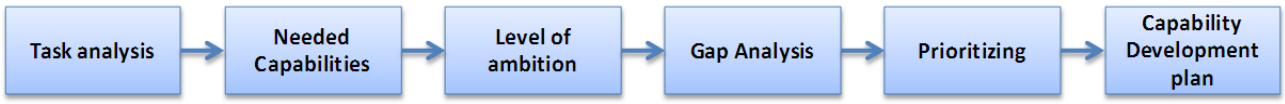

Figure 16: SAS-076's interpretation of Norway's capability planning process.

The Capability Development Plan is used to adjust the Structural Development Plan which is part of the Long Term Development Plan (LTDP). LTDP is a result of Strategic Defense Reviews which historically have been made every third or fourth year. Besides Capability Planning there is Structural Planning to maintain development of Defense Forces within defined lines of development and capability requirements and acquire capabilities through decisions on structural development and planned allocation of resources. Use of scenarios is not specified although they are used and their role in defense planning has been described earlier (example: conference in Paris). NMoD is responsible for the work with support from the Norwegian Defense Research Establishment (NDRE).

Sweden

Sweden, in their template, has described a process focusing on needs, not how to develop solutions. It is not explicit in the answer but capabilities are a part in the defense planning. But capabilities are not the only way to identify needs and a more capability based approach is discussed.

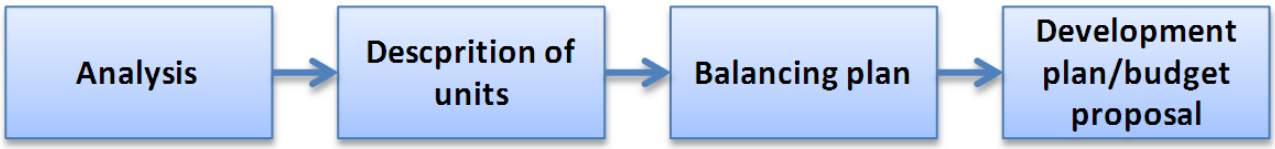

Figure 17: SAS-076's interpretation of Sweden's defence planning process.

The defence planning process starts with an analysis in order to describe the difference between the current plan and future needs. The difference between the plan and the identified future needs is the basis for the changes that needs to be done within the military units. The units are described considering for example number, quality and costs related to personnel, acquisition and exercises etc. All changes are prioritised. The development plan and the budget proposal must be funded, this is done by balancing the plan. When the plan is balanced it is possible to put together the development plan and the budget proposal. The development plan contains information about the number of military units, acquisition of new systems, a plan for ongoing and coming operations, and so on. The acquisition planning cycle starts from decisions taken in the development plan. The midterm defence planning covers the time frame up to ten years and it is normally revised once a year. The result of the defence planning is the Armed Forces' development plan and a budget proposal. The development plan describes in detail the Armed Forces for the first three years in the period and work as a guideline for the remaining years. Scenarios are used to prioritize capabilities. The Armed Forces are responsible for the process.

Germany

The information regarding the German process describes both needs and solutions but is focused on the solutions. The process is capability based. Potential capability gaps are identified by capability analysis across organizations and tasks. Potential solutions to close capability gaps can be identified not only by acquisition of new material but with a changed organization, infrastructure etc. Implementation of solutions must not exceed the scope of resources available. Customer Product Management (CPM) is the process used to determination and meeting the capabilities needed. The process is determined by principles of cost-effectiveness.

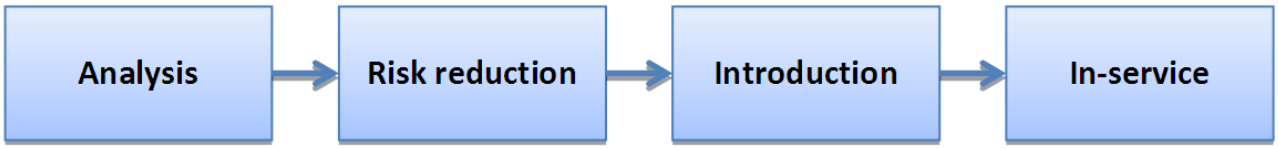

Figure 18: SAS-076's interpretation of Germany's customer product management process.

Determination and meeting of demands is divided into the phases analysis, risk reduction, introduction and in-service phase. During the analysis phase, the demand is determined and information to be able to select and implement the selected solution is gathered. Risk reduction means that all necessary steps is taken to ensure that risks relating to performance, time and cost aspects are reduced. During the introduction phase, development work will be rendered as part of a purchase—or manufacture- (construction-)—based contract and serves the purpose of adapting the solution to the requirements and preparing it for production. Development activities during the in-service phase serve to maintain initial operational capability. The Bundeswehr Chief of Staff determines required Bundeswehr capabilities, the Director General of Armaments and the IT Director are involved in the performance of the technical and economic assessment. The Chiefs of Staff of the armed services, the MOD Directors and the IT Director participate in the capability analysis. The Director General of Armaments, the IT Director and the Director of Defense Administration each assume ministerial responsibility for the provision of the appropriate products and services required to close capability gaps within their respective areas of responsibility.

Turkiye

"Scientific Decision Support" methods are used in the planning activities process in the fields of operations, force, personnel, logistics, intelligence and health as well as in the planning and programming of the capabilities and systems that the Armed Forces must have to ensure the defense and survivability of our country according to the current and future requirements. The process regarding the above-mentioned scientific decision support methods is basically composed of the following stages:

- Definition of the need for analysis/question,
- Collection and compilation of the required data,
- Making analyses through analytical models and simulation systems,
- Generation of decision alternatives and their presentation to the decision-making authority.

The outputs of needs & solutions analysis which is done by "Scientific Decision Support" are mentioned in "Strategic Target Plan" as the needs required and "10 Years' Acquisition Plan" as the solutions. Both documents cover next ten years with updates in each 2-year period and the responsibility of these documents is given to General Stuff of TAF.

5.5 Lexicon and Taxonomy

Most nations from the sample seem to define capability in terms of ability to achieve a desired outcome. Regarding components of the capabilities there seems to be a significant commonality. The result of the template shows that some nations use a much more extensive structure than others.

- Definition of a defense capability: Most nations seem to define capability in terms of ability to achieve a desired outcome.
  - **Turkiye:** Activities process in the fields of operations, force, personnel, logistics, intelligence and health as well as in the planning and programming of the capabilities and systems that the Armed Forces must have to ensure the defense and survivability of our country according to the current and future requirements.
  - **United Kingdom:** The enduring ability to generate a desired operational outcome or effect, and is relative to the threat, physical environment, and contributions of coalition partners.
  - **United States:** The ability to achieve a desired effect under specified standards and conditions through combinations of means and ways to execute a specified course of action.
  - **Canada:** Identical to definition used by the U.S.
  - **Norway:** The ability to complete a given task.
  - **Sweden:** Activities for which units have been acquisitioned and trained to reach a specific effect depending on scenario and ambition.
  - **The Netherlands:** The only definition used by The Netherlands relates to capability, and is taken from the NATO Bi-SC (Strategic Command) Agreed Capability Codes and Capability Statements dated 16 April 2008. It reflects operational capabilities which the armed forces, or a part thereof, should or can have.
- Components of capability: There seems to be significant commonality as shown here:
  - **Turkiye:** Doctrine, Training, Education, Leadership, Organization, Materiel, Personnel
  - **Canada:** Personnel, Research and Development, Infrastructure, Concepts and Doctrine, Information, and Equipment (PRICIE)
  - **United States:** Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, and Facilities (DOTMLPF)
  - **Norway:** Protection, Means of Action, ISTAR, C2, Mobility, Support
  - **Sweden:** There is no stipulated list of components of the capabilities. However they can be described in terms of *Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, and Facilities* or other similar expressions.
  - **The Netherlands:** DCTOMP(F): Doctrine, Command, Training & Education, Organisation, Materiel, Personnel and Finance
- Taxonomy: Some nations use a much more extensive structure than others.

– **United States:** Like capabilities are functionally grouped into Joint Capability Areas (JCAs) which cover 100% of DoD's budget and warfighting capability. Tier 1 JCAs are broken down into increasingly finer degrees of detail. Eventually, specific capabilities are linked to discrete warfighting tasks, such as neutralizing enemy sea mines in Very Shallow Water. Capabilities and associated tasks number in the thousands.

– **Canada:** The Canadian Capability Framework comprises five capability domains: Act, Shield, Sustain, Command and Sense. These are each expressed as a hierarchical tree of capabilities that cover all of the operational outputs of the Canadian Forces. The five domains break down to 336 discrete capabilities. A sixth domain, Generate, is identified as covering all of the non-operational capabilities of the Department of National Defense and the Canadian Forces (DND/CF), but has not yet been further developed.

– **Norway:** Broad capabilities are defined for each of the six major domains. Examples are Protection-Land-Heavy Machine Gun and Support-Joint-Medical Services.

– **Sweden:** The Swedish Armed Forces uses a model with Core Tasks, Defence Tasks and Defence Capabilities. The different tasks and capabilities are used to help the organisation to describe mission of the Armed Forces. An example of a Core Task is protecting the integrity of national territory, an example of a Defence Task is guarding maritime territory and finally an example of a Defence Capability is effect on sea targets. There are approximately 80 capabilities.

5.6 Role of Life-Cycle Cost Analysis in Defence Planning

Areas of analysis

The responses of each of the nations were analyzed with respect to the role of life-cycle cost analysis during three phases of defence planning and acquisition:

- Identification of needs;
- Programming and budgeting; and,
- Acquisition of materiel solutions.

For each of these phases, SAS-076 analyzed the nation's response in terms of:

- Requirement for LCC analysis;
- Performance of LCC analysis; and,
- Guidelines for LCC analysis.

Furthermore, when it was determined that LCC analysis is performed, SAS-076 analyzed whether the results of the LCC analysis were used by the nation for:

- Economic information;

- Prioritization;
- Affordability assessment; or,
- Analysis of alternatives.

Summary

Of the seven nations answering the template only one nation uses life-cycle costing both for identifying defense needs, for defense programming and budgeting and for acquisition of materiel solutions. The best commonality is identified in the field of acquisition of materiel solutions.

Figures 19 and 20 provide a high-level summary of the SAS-076 analysis. As indicated by the legend in Figure 19, colours are used to evaluate the degree of use and role played played by life-cycle cost analysis during the various stages of defence planning and acquisition. Green indicates that life-cycle cost analysis is usually performed and plays a role in decision making. Red indicates the opposite—life-cycle costing does not play a role. Yellow indicates that the use of life-cycle costing is occasional or the that the nation's response was not concrete. Question mark entries ("?") indicate that the nation's response was unclear or did not provide enough information to evaluate. Figure 20 illustrates the micro analysis which is then combined to obtain Figure 19.

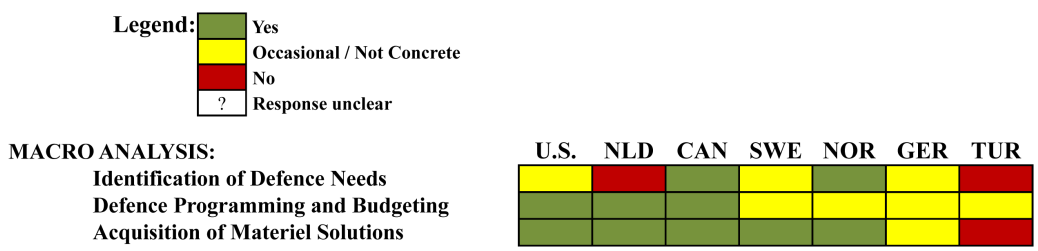

Figure 19: Macro analysis of role of life-cycle cost analysis in defence planning.

United States

The center of gravity of life-cycle cost analysis in the U.S. is in support of acquisition of materiel solutions. Little or no support is provided for strategic planning and only ad hoc support during the identification of defence needs. Guidance for this latter phase merely recommends the execution of affordability assessments. Life-cycle cost analysis supports budgeting more than programming. Due to recent statutory requirements, the U.S. defence budget now needs to reflect the acquisition cost estimates from each of the services. The acquisition of materiel solutions is heavily and extensively supported and informed by cost analyses which are required at milestones A,B,C, and full-rate production decision reviews. Over 1,000 government, in-house cost analysts provide this support.

Norway

Norway, one of the very few countries in the world with a national monetary surplus or negative national debt, sets the standard within NATO for use of life-cycle cost analysis early in the strategic planning process (identification of defence needs). This Norwegian penchant for sound fiscal constraint and avoidance of budget

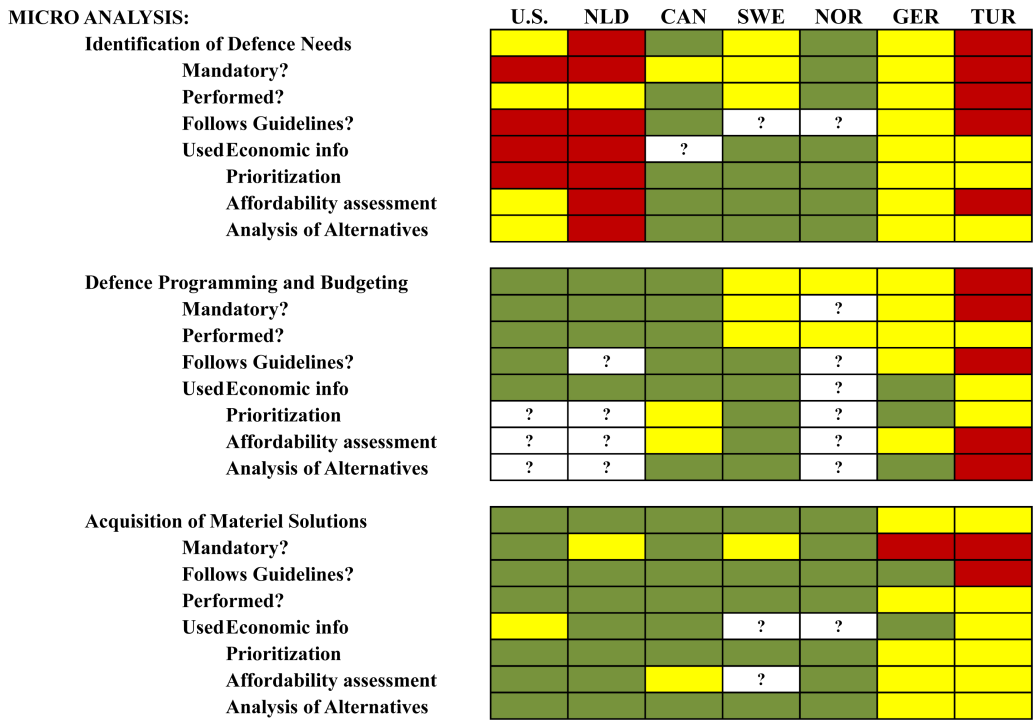

Figure 20: Micro analysis of role of life-cycle cost analysis in defence planning.

deficits helps ensure that national will matches national wallet. Norway believes that it's all-important to get the costs right the first time and simply not to develop, build, and deploy systems that are unaffordable. Along these same lines, life-cycle costs analysis extensively supports the acquisition of materiel solutions, either new developments or COTS procurements. Costs and capability tradeoffs are considered, as well as operating and support costs during the in-service phase of a program's life cycle.

Sweden

In Sweden, force-structure cost analyses is conducted during the long term strategic planning process. To direct the force structure planning process, the Swedish Ministry of Defence can give indicative levels for total future expenditures. The Swedish defence planning process analyzes the difference between the current and future needs. The difference between the two provides the basis for changes and the expenditures that these changes will induce are estimated. The sum of all suggested changes are then balanced against each other in the exercise called balancing the plan resulting in a new development plan. All changes are prioritised so it is possible to choose which changes to start with if there is not enough budget to do them all. There is an equipment acquisition strategy which stipulates that the equipment acquisition should be cost efficient from a LCC-perspective, and there is a directive stipulating how the LCC-estimates should be prepared.

The greatest percentage of resources in the cost community is devoted to support the defense acquisition system, but there are no mandatory directives in the field of cost estimation and analysis, only advisory and instructional policies. Further cost analysis support is provided for development and optimization of support systems, of the systems maintainability and reliability, of contractor source selection and earned value management.

The Netherlands

Netherlands is perhaps the only country in NATO that takes a "whole of government" (WoG) approach to national security planning. Strategic requirements and identification of needs and solutions cover the entire spectrum of national defence and civil concerns. Like the U.S., defence cost analysis supports acquisition of materiel solutions very extensively. This often involves make-or-buy decisions for weapon systems based on their estimated life-cycle costs. Furthermore cost and capability tradeoffs are commonplace. In the earlier stages of national planning, cost analysis employed far less frequently. For example, elements of risk (e.g., breach of dyke system or occurrence of a pandemic virus) are analyzed in terms of probability of occurrence and consequence. Cost, however, is not a dimension of the analysis at this early stage of planning.

Canada

As part of Canada's capability-based planning process, life-cycle costs are taken into consideration during the identification of defence needs phase of defence planning. At this early stage cost estimates rough order of magnitude calculations based on PRICIE cost breakdown models are employed. During the programming and budgeting phase—Canada's integration phase of its capability-base planning process—these rough order magnitude costs are considered during the decision process and used for prioritization of alternatives and further economic planning. Prioritization and analysis of alternatives is subjective. As with other NATO countries, the majority of Canada's life-cycle cost analysis is focused during the acquisition stages. The Canadian Department of National Defence must submit detailed cost estimates to the Treasury Board at various program stages (e.g., preliminary and effective project approval stages) in order to obtain funding approval. Comparative life-cycle cost models are employed by certain acquisition programs in order to evaluate industry proposals, however life-cycle costs are often appropriated less importance than the acquisition cost during tender selection. Canada's Department of National Defence does not have a dedicated cost analysis group. Acquisition program offices typically employ a small team of financial analysts who generate life-cycle cost estimates. Occasionally external consulting companies are contracted to generate primary and/or secondary acquisition cost estimates. Final program estimates are checked and validated internally, although the level of scrutiny or application of guidelines is unclear.

Turkiye

Turkiye, one of the countries within NATO which has a biggest defence budget according to the percentage of GDP (5-6%), surprisingly has no specific life-cycle cost analysis in the strategic planning process for acquiring the defence capability. The only use of the life-cycle costing in macro analysis is during defence programming and budget which is done occasionally. During identification of defence needs, the life-cycle costing is used only for economic input to make prioritization and sometimes for analysis of alternatives. In Turkiye, the mostly occasional use of life-cycle costing analysis is in the acquisition phase for economical prioritization of procurement alternatives. Despite the use of life-cycle costing analysis in acquisition, there is no requirement or obligation of industry to do life-cycle cost analysis as part of the tender solicitation from industry.

6.0 BEST PRACTICES AND RECOMMENDATIONS

Figure 21 indicates the likely current practice of NATO and PfP nations, with respect to the role of life-cycle cost analysis in defence planning, as culled by SAS-076 from national template surveys (based on responses of seven nations).

	Current Practice of NATO Nations			
MACRO ANALYSIS:	**Universal**	**Typical**	**Uncommon**	**Rare**
Identification of Defence Needs			✓	
Defence Programming and Budgeting		✓		
Acquisition of Materiel Solutions	✓			
MICRO ANALYSIS:				
Identification of Defence Needs			✓	
Mandatory?				✓
Performed?			✓	
Follows Guidelines?			✓	
Used Economic info			✓	
Prioritization		✓		
Affordability assessment		✓		
Analysis of Alternatives		✓		
Defence Programming and Budgeting		✓		
Mandatory?			✓	
Performed?		✓		
Follows Guidelines?		✓		
Used Economic info		✓		
Prioritization			✓	
Affordability assessment			✓	
Analysis of Alternatives			✓	
Acquisition of Materiel Solutions	✓			
Mandatory?		✓		
Follows Guidelines?	✓			
Performed?	✓			
Used Economic info		✓		
Prioritization	✓			
Affordability assessment		✓		
Analysis of Alternatives	✓			

Figure 21: Current practice of NATO nations with respect to the role of life-cycle cost analysis in defence planning.

Based on responses from seven countries, and through a process of vigorous discussion and even heated debate, SAS-076 identified the following best practices with respect to the role played be cost analysis in managing the defence enterprise.

1. **Engage Early-On:**
   In the long run, military power is a function of economic power. Spending imprudently in the short run on unaffordable "gold-plated" weapon systems will add to budget deficits and national debt in the long run. Use cost assessments to inform the strategic decision planning process on what a country can and cannot afford. Canada and Scandinavian countries seem the best practitioners on this score.

2. **Budget and Program to the Cost Estimate:**
   Independent cost estimates and cost assessments are valuable only to the degree they are used. A best practice is to generate an independent life-cycle cost estimate for every major weapon system acquisition program and to reflect this estimate in planning and budgeting systems. This is now a mandatory requirement in the United States Department of Defense for Acquisition Category I programs.

3. **Make Cost the Denominator in Needs and Solutions Analysis:**
   In identifying military needs and solutions, capability-based planning is the gold standard in NATO today. A plethora of techniques are used to assess military value of current and prospective assets including known performance characteristics as well as use of opinions culled from subject matter experts. All too often however, military value is estimated and interpreted without a complete and accurate view of life-cycle costs. A best practice is to compute a return on investment for defence assets defined as:

   $$\frac{\text{Military Value}}{\text{Life-Cycle Costs}}.$$

   It's important to note that risk and balance are other essential dimensions of a complete analysis.

4. **Move to the "Left" in Acquisition:**
   Many, if not all, countries extensively support the acquisition process at key decision points (e.g., "gates" in the United Kingdom, milestones in the United States). However, many cost analysts object to providing cost estimates early in acquisition when systems are only vaguely defined and exist only in design. However, paradoxically, this is when the cost estimates are of the most importance. After all, it is much easier to cancel a bad program that exists only in an analysis of alternatives than an actual program struggling with development or with enormous cost growth in production. Much more extensive cost-analysis support needs to be provided in early design phases. Rough order of magnitude estimates a this point in the life cycle will help empower informed decisions on the allocation of scarce defence assets.

5. **Optimize from an Alliance Perspective:**
   The United States, Canada, and most European nations are facing the dual dilemmas of aging populations, budget deficits and growing national debts that threaten stability. As a consequence, many nations are cutting defence expenditures. Defence spending as a percentage of Gross Domestic Product is approaching lows in contemporary times for many nations. Given pervasive threat to the security of NATO and its alliance members across the broad spectrum of conflict, optimization of military capability seems in order. Duplication of effort, such as several countries possessing extensive sea mine counter-measure capability, might be avoided. Individual Alliance members might develop expertise in a war-fighting domain that could be used to the benefit of the entire Alliance in times of conflict. Savings of hundreds of billions of Euros per annum might be achieved by managing from a NATO enterprise perspective.

6. **Present Decision Makers with Menu of Portfolios:**

Senior defense decision makers express a strong demand for a *menu* of acquisition *alternatives* from which to choose. Heretofore, inordinate attention has been devoted, at high levels, to the management of *individual* acquisition programs. Attention to acquisition details, at high levels, might be better delegated to subordinate authorities in each military department or acquisition community. Senior decision makers, instead, would focus on a complete *set* or *portfolio* of systems in any war fighting or mission area. The portfolio would include science and technology programs, current acquisition programs, and operational systems. Further, alternative portfolios could be defined. These might include:

- A status quo portfolio of currently programmed systems;
- An international portfolio which would leverage assets from a NATO-enterprise point of view; and
- A high-tech portfolio that would emphasize the development and funding of science and technology projects which might, in the long run, yield a competitive advantage on the battlefield.

A review of current and alternative portfolios would shift attention of senior decision makers to where it rightfully belongs, to addressing the fundamental, multiple needs of a ministry of defense, and *trade-off space*, in the face of an entire *spectrum of threats*.

7.0 REFERENCES

[1] Department of the Navy (U.S.), "*Sea Power for a New Era 2006: A Program Guide to the U.S. Navy*," 2006, http://nll.ahf.nmci.navy.mil/.

[2] Keynes, J. M., *The General Theory of Employment, Interest, and Money*, Macmillan Cambridge University Press, 1936, Chapter 12: The State of Long-term Expectation.

[3] Spiegeleire, S. D., "*"Closing the Loop"*," Presented to the Netherlands MoD, 24 March 2009, The Hague Center for Strategic Studies.

[4] R.G. Cooper, S. E. and Kleinschmidt, E., "Portfolio Management in New Product Development: Lessons from the Leaders – Part I," *Research-Technology Management*, September-October 1997, pp. 16–28.

[5] International Quality and Productivity Center (IQPC), "*Through Life Capability Management Conference*," London, June 2007.

[6] The Assistant Secretary of the Navy(Financial Management and Comptroller), "*Department of the Navy Portfolio Analysis*," 18 July 2005.

[7] Ambrose, S. E., *Citizen Soldiers*, Simon and Schuster, New York, 1997, Part 1, Chapter 2: Hedgerow Fighting.

[8] Warrick, J. and Wright, R., "U.S. Teams Weaken Insurgency in Iraq,," *The Washington Post*, 06 September 2008.

[9] Peniston, B., *No Higher Honor: Saving the USS Samuel B. Roberts in the Persian Gulf*, Naval Institute Press, 2006.

[10] National Security Presidential Directive 41, George W. Bush Administration, "*Maritime Security Policy*," 21 December 2004.

[11] Arrow, K. J., "*A Difficulty in the Concept of Social Welfare*," 1951, Ph.D. Dissertation, Columbia University.

[12] Downes-Martin, S. and Volpe, D., "*How to Use Rank Ordering for Comparison of Friendly COAs*," September 2005, United States Naval War College, Unpublished.

[13] U.S. Department of Transportation, "*America's Container Ports: Delivering the Goods*," March 2007, Bureau of Transportation Statistics.

[14] *World Trade Center Association: Los Angeles–Long Beach* in (http://www.wtca-lalb.org/resources/), accessed 26 May 2011.

[15] Theil, H., *Principles of Econometrics*, John Wiley and Sons, 1971.

[16] Commander G.A. van Marion, Royal Netherlands Navy, October 2008, Communication.