Building Systems Integration Capabilities: The Role of the Royal Netherlands Navy in Constructing and Innovating Warships, 1945-2024

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This paper examines how the Royal Netherlands Navy (RNLN) dealt with the restoration of a sizeable domestic industry capable of constructing and designing complex warships since the end of World War II. Given the relatively small size of the country and the high speed of naval technological change since 1945, the restoration was not self-evident, certainly not because of the ruined state of that industry. We argue that the development of systems integration capabilities played a key role in the restoration. By zooming in on the strategies of the Navy to support the development of systems integration capabilities we seek to understand how the Dutch naval sector developed since 1945. We show that the ability of the Navy to support the acquisition and maintenance of systems integration capabilities depended on both domestic and international political and commercial dynamics and that systems integration capabilities could also be lost.

Le présent article analyse les efforts déployés par la Marine royale néerlandaise pour restaurer une industrie nationale importante capable de concevoir et de construire des navires de guerre complexes depuis la fin de la Seconde Guerre mondiale. Compte tenu de la taille relativement petite du pays et de l'évolution rapide des changements technologiques navals depuis 1945, la restauration n'allait pas aller de soi, notamment parce que l'industrie avait été

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laissée en ruines. Nous soutenons que le développement des capacités d'intégration des systèmes a joué un rôle clé dans la restauration. En mettant l'accent sur les stratégies de la Marine visant à appuyer le développement des capacités d'intégration des systèmes, nous cherchons à comprendre comment le secteur naval néerlandais s'est développé depuis 1945. Nous indiquons que les habiletés de la Marine à favoriser l'acquisition et la maintenance des capacités d'intégration des systèmes dépendait de la dynamique politique et commerciale sur le plan national et international et que les capacités d'intégration des systèmes pouvaient également se perdre.

1. Introduction

After the end of World War II, the Dutch naval industry was in a state of despair. Most of the warships had been destroyed during the war. In addition, installations in Dutch sea ports and yards had been destroyed or dismantled by Nazi-Germany.[1] Rietschoten & Houwens, supplier of electrotechnical installations on ships, was partly destroyed by the German bombardment of Rotterdam in 1940.[2] Hazemeyer Signaalapparaten (HSA), supplier of fire control systems, was taken over and operated by the Germans since the beginning of the war but hit by allied bombardment in 1944. The equipment of Hazemeyer was taken away by the Germans. These companies recovered after the war, however, and became again main partners to the RNLN in naval shipbuilding.

The first questions to be answered then were what kind of fleet was required for which tasks, and to what extent should a domestic naval shipbuilding capability be rebuilt. To the Royal Netherlands Navy (RNLN) with its long tradition of operating an ocean going fleet to protect the Dutch overseas colonies (Indonesia, Surinam, and the Caribbean Islands), and the sea lanes that were of vital importance for the Netherlands as a trading nation, the answer was quite evident. The RNLN should have a full-fledged, modern blue water fleet. In view of the transformation of naval combat during World War II by aviation and sub-surface warfare, the RNLN wished to procure aircraft carriers, destroyers, submarines, and minesweepers, as well as cruisers, the traditional platform for distant ocean operations.[3] Other countries, notably the

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1 Naval Institute Press, *Conway's All the World's Fighting Ships, 1947-1995* (Annapolis, Maryland: Naval Institute Press, 1996).

2 See: Imtech, *1860-2010, De rijke geschiedenis van de Europese technische dienstverlener Imtech N.V.* (Gouda: Imtech N.V., 2010).

3 See Thomas C. Hone, "Replacing Battleships with Aircraft Carriers in the Pacific in World

United States and the United Kingdom, however, saw different future tasks for the RNLN and, in some cases, refused help in building up such a fleet.

The RNLN's desire to restore domestic shipbuilding capability was rooted in a long tradition of autonomy and autarky in designing, building, and maintaining its own warships.[4] Like the navies of other major maritime powers, the service wanted to construct warships according to its own specific requirements. In other words, the RNLN aimed at rebuilding a modern naval production and technological innovation system, in which the RNLN itself, as leading customer, could play a dominant role. This choice was not self-evident and other countries opted for a different approach. Norway, for example, acquired its submarines abroad, while (initially) building its frigates domestically.[5] Denmark first obtained its frigates from abroad (the UK) and started domestic building of these vessels only in 1960 but never did build its own submarines and abandoned this capability after 2004.[6] In promoting independent design and construction of a new fleet, the RNLN noted broader economic benefits: the resurrection of Dutch shipyards that were involved in building both commercial and naval vessels and were envisioned to play a prominent role in future shipbuilding in the world.[7]

In this paper we seek to understand how the Dutch naval sector recovered after 1945 and addressed the challenges of innovation and production capacity for complex warship technologies. To understand what has happened we combine a longitudinal approach with analytic concepts from innovation studies, in particular the concepts of Complex Product Systems and Systems of Innovation. Modern warships can be characterized as Complex Product Systems (CoPS) where systems integration is a key capability of firms and other actors involved in the production and innovation of such CoPS. The mechanisms in acquisition and maintenance of such capabilities then are important to identify in order to understand the evolution, or in our case the re-development, of a naval defence industry. In the case of defence industries, governments (ministries of defence) are involved both as purchaser and user of complex product systems which generates intricate dynamics. Zooming in on

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War II," *Naval War College Review* 66, no. 1 (2013); Robert L. O'Connell, *Sacred Vessels: The Cult of the Battleship and the Rise of the U.S. Navy* (Oxford: Oxford University Press, 1991); and Terry C. Pierce, *Warfighting and Disruptive Technologies. Disguising Innovation* (London: Frank Cass, 2004).

4 See Alan Lemmers, "The Pillars of Dutch Naval Shipbuiding after 1945," *The Northern Mariner/Le marin du nord* XXV, no. 3 (2015); and A.W.G. Oosterhout, "De Precaire Autonomie Van De Nederlandse Marinescheepsbouw" (PhD diss, University of Twente, 2001).

5 In the first decades of the twenty-first century, Norway started purchasing its new frigates from abroad, in this case from Spain.

6 MF Kluth, "Make or Buy? Explaining Diverging Frigate Procurement Approaches in Denmark and Norway," *Defense & Security Analysis* 38, no. 2 (2022).

7 Tweede Kamer, "Nota Inzake Defensiebeleid. Tk 1672 Nr. 11," (The Hague, 1950); "Rijksbegroting 1951. TK 1900 VIII a Nr.10" (1951).

the strategies of the navy with regard to systems integration capabilities offers us a window on major developments of the naval shipbuilding sector. We use the concepts of structure and functions from the innovation systems literature to describe and analyze the actions of the RNLN in order to understand how the Dutch naval shipbuilding sector developed since 1945.

In our empirical study we identified three main patterns in how the RNLN attempted to manage the development of systems integration capabilities: i) through formulating and legitimating requirements for complex warships; ii) by stimulating knowledge generation to develop specific systems integration capabilities; and iii) by supporting and orchestrating a naval production and innovation network consisting of companies, knowledge institutes and navy organizations. We show that the ability of the navy to effectively support the acquisition and maintenance of systems integration capabilities depended on both domestic and international political and commercial dynamics and, also, that carefully developed systems integration capabilities could once again be lost.

Our study contributes to new understandings on the evolution of defence industries and on studies of Complex Product Systems (industries). First, it shows the opportunities and limitations of armed forces such as the RNLN in shaping defence industries which tend to be understood as monopsonies. Second, it highlights how a specific set of technologies, such as systems integration of defence electronics, play a critical role in the evolution of defence industries. Third, our paper demonstrates that traditional conceptions of the pyramid of systems integration as well as the user-prime contractor model are not generally applicable, but that more sophisticated network forms apply.

We start our paper by introducing our analytical framework, including the concepts of Complex Product systems, and the structure and functions of Systems of Innovation. We use these concepts to describe and analyze developments in the Dutch naval shipbuilding industry. For our study, we made use of well-documented histories of the RNLN and naval technological change, as well as public records of the Ministry of Defence and the Dutch Parliament. We also collected reports from naval industry watchers and from academic literature on naval industry dynamics in order to put local developments in a broader perspective. We use these sources to map changes in the composition of the naval sector, as well as the acquisition, maintenance, or loss of systems integration capabilities. We then examine in detail how the actions and strategies of the RNLN related to these changes. We divide our narrative on developments in the sector into four periods which correspond with major changes in the acquisition of systems integration capabilities. We end with conclusions on how the RNLN attempted to influence the development of the Dutch naval shipbuilding sector and what this meant for the overall evolution of the sector.

2. Analytical Framework: Complex Product Systems and Systems of Innovation

Modern warships can be characterized as Complex Product Systems (CoPS). The notion of complex product systems as a category of products has its antecedents in literature on, among others, military systems, complexity of systems, and large technical systems.[8] CoPS are characterized by their relatively high cost, engineering intensity, elaborate product hierarchy, network structure, and system organization in order to perform a common objective. Scholars contend that CoPS industries constitute a specific category of economic activity. CoPS industries have distinct patterns of innovation and industrial organization compared to mass produced consumer goods.[9] In contrast to mass production industries CoPS industries are, for instance, highly regulated, have low-volume high-value products, include high involvement of users, and their industrial organization can be characterized by production networks rather than by large supply chain structures.[10] Firms supplying CoPS are often prime contractors or systems integrators who are responsible for managing large multi-actor projects including customers and suppliers of components and systems.[11]

The production of CoPS has a strong project-like character as the volume of products is typically low (batches of a few products up to single units). Projects consist of multi-actor alliances which may be disbanded after the end of the production process, or continued as we will show in our case study. The acquisition, design, development, and construction of CoPS like warships is notable for their lengthy and bureaucratic procurement cycles. Once in service, the vessels may be in use for often more than twenty-five years. However, during their in-service period, these warships may be upgraded once or twice by incorporating new technological innovations, while in the meantime a process starts for developing the next generation of these warships.

The elaborate product hierarchy and the variety of organizations involved in CoPS makes systems integration a key task that suppliers of CoPS need to perform. In a simplified schedule the end product may be represented by a "product pyramid," on top of which is the complex product system, under which are several layers of subsystems which in turn are built up from components

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[8] Michael Hobday, "Product Complexity, Innovation and Industrial Organization," *Research Policy* 26 (1998).

[9] Roger Miller et al., "Innovation in Complex Systems Industries: The Case of Flight Simulation," *Industrial and Corporate Change* 4, no. 2 (1995); Andrea Bonaccorsi, Fabio Pammolli, and Simone Tani, "The Changing Boundaries of System Companies," *International Business Review* 5, no. 6 (1996); and Andrea Bonaccorsi and Paola Giuri, "When Shakeout Doesn't Occur. The Evolution of the Turboprop Engine Industry," *Research Policy* 29 (2000).

[10] Hobday, "Product Complexity, Innovation and Industrial Organization."

[11] Andrew Davies and Michael Hobday, *The Business of Projects: Managing Innovation in Complex Products and Systems* (Cambridge: Cambridge University Press, 2005), 12.

that are assembled from parts depicted at the bottom layer. Likewise, again as a simplification, the variety of organizations involved in the production process may be represented by a "supplier pyramid." Here, users are put at the top of the pyramid because they formulate requirements and are often heavily involved in the design of the system architecture. Users often also stipulate which firms are to be involved further in the hierarchy and formulate guidelines on processes and schedules.[12] Prime contractors act as lead systems integrators in co-operation with suppliers and systems integrators of subsystems lower in the hierarchy. Prime contractors will attempt to influence choices and decisions of the customer. Other actors, such as governments and regulators, can also become closely involved, which heavily structures interactions between actors involved in the generation of CoPS. For instance, the international market for defense systems is both highly politicized and regulated through, for instance, export controls. The product/supplier hierarchy of a complex product system is illustrated in figure 1.

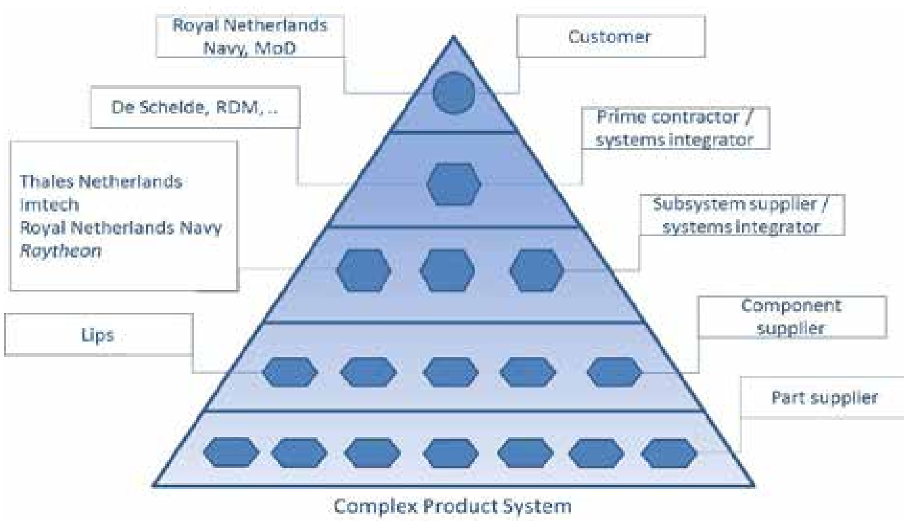

Figure 1: Complex Product Systems: systems integrators and examples from Dutch naval shipbuilding. (Adapted from A. Davies and M. Hobday 2005)

The scheme is a simplified one, because it suggests that the customer is only in contact with the prime contractor/system integrator. Though this might be the main interaction of the customer in the supply chain, it does not exclude direct interaction with lower-tier suppliers of specific subsystems or components lower in the supply chain.[13] Systems integration capabilities can

12 Michael Hobday, Andrew Davies, and Andrea Prencipe, "Systems Integration: A Core Capability of the Modern Corporation," *Industrial and Corporate Change* 14, no. 6 (2005).
13 Eugene Gholz, Andrew D. James, and Thomas H. Speller, "The Second Face of Systems

be located within specific organizations such as firms and their customers, but also distributed within networks. Networks of firms are particularly relevant for the production of CoPS.[14] In a production network, systems integration capabilities are distributed across the actors. The network as a whole offers the systems integration capabilities for a CoPS. In the case of warship building, it is not unusual that different groups of firms, who have major systems integration capabilities bid for the construction of new vessels.

The two – "production" and "supplier" – pyramids reflect what in the literature has been called the "two faces" of systems integration, one in system design, the other in the organization and management of networks of suppliers.[15] The first face is more hardware (and software) oriented, focusing on overall architecture, requirements, and performance of (sub)systems and components. In the second face, "systems integrators coordinate distributed capabilities and learning processes carried out by networks of specialized designers, equipment suppliers, and component manufacturers."

Users, as for instance the RNLN, are closely involved in the whole life cycle of CoPS, from research and development to maintenance. They can act as knowledgeable, smart buyers and may have system design skills of their own.[16] The innovation process is driven by user-producer interactions, among others because users redefine requirements, adding further complexity to products.[17] Other scholars have argued that customers such as the navy have also acted as systems integrators, and to a lesser degree still do so.[18] A similar argument has been made for the French Defence Agency (DGA) which for a long time had systems integration capabilities and played a key role in the design of defence programmes and in the French defence industry.[19] These studies offer empirical indications that the role of governmental actors, such as the armed forces, may extend beyond being a mere purchaser or user of CoPS and may also comprise their involvement in the "two faces" of systems integration.

The "second face" of systems integration, may also be interpreted as the

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Integration: An Empirical Analysis of Supply Chains to Complex Product Systems," *Research Policy* 47 (2018).

14 See also A. Prencipe, "Corporate Strategy and Systems Integration Capabilities," in *The Business of Systems Integration*, eds. A. Prencipe, A. Davies, and M. Hobday (Oxford: Oxford University Press, 2003).

15 Gholz et al., "The Second Face of Systems Integration."

16 Hobday, "Product Complexity, Innovation and Industrial Organization."

17 Ozgur Dedehayir, Tomi Nokelainen, and Saku J. Mäkinen, "Disruptive Innovations in Complex Product Systems Industries: A Case Study," *Journal of Engineering and Technology Management* 33 (2014).

18 See Eugene Gholz, "Systems Integration in the Us Defence Industry. Who Does It and Why Is It Important?," in *The Business of Systems Integration*.

19 N. Lazaric, V. Merindol, and S. Rochhia, "Changes in the French Defence Innovation System: New Roles and Capabilities for the Government Agency for Defence," *Industry and Innovation* 18, no. 5 (2011).

representation of a socio-technical network. A sociotechnical network may be defined as a set of actors (and their interactions) involved in the innovation, development, and production of a certain technological product or technology. Such networks may include a great variety of actors: (industrial) companies, research institutes, (potential) users (like the navy), but also political institutions, such as government departments (e.g. defence, economic affairs), parliament, and authorities issuing and overseeing specific regulations.

Studying the workings of such a network generally focuses on the interests (or tasks), the actions and interactions of the actors, as well as on the developments in the structure of the network because these are intertwined.[20] The variety of actors implies that they are not all involved in the network in the same way nor to the same degree. The perspective from which they perceive the function of the network may be different. They may also differ as to their "inclusion" in the network.[21] Some actors may have a low inclusion because they participate also in other networks (for instance, low tier suppliers). Others, like parliament, may have a low inclusion because of their position and role in which they have also to weigh different (political, societal) interests. Still, an actor with a low inclusion, like parliament, may, due to its role, have a decisive impact on processes of the network, for instance by withholding a required budget. Such an actor has been called a "critical actor." Finally, a special role is played by so called "dedicated network builders."[22] They have a special interest in cooperating with other actors and may therefore initiate the forming of an innovation or production network. The continuation of such a network often requires special efforts, on which the dedicated network builder also needs to work.

The fate of a network, its ups and downs, its expansion or shrinkage, and therefore the processes by and in the network, is not only the result of internal dynamics and factors of the network. External factors may also have their impact and may even be decisive.[23] In the case of defence industries, for instance, geopolitical dynamics will play a role in setting requirements for CoPS by the end-users, and the occurrence of an international financial crisis may have severe budgetary consequences. The network actors – particularly the dedicated network builders – must also deal with such external events.

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20 Jochen Markard and Bernhard Truffer, "Technological Innovation Systems and the Multi-Level Perspective: Towards an Integrated Framework," *Research Policy* 37 (2008).

21 W.E. Bijker, T.P. Hughes, and Trevor J. Pinch, *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (MA: MIT Press, 1987).

22 Boelie Elzen, Bert Enserink, and Wim A. Smit, "Socio-Technical Networks: How a Technology Studies Approach May Help to Solve Problems Related to Technical Change," *Social Studies of Science* 26 (1996).

23 See also Anna Bergek, Staffan Jacobsson, and Björn A. Sandén, "'Legitimation' and 'Development of Positive Externalities': Two Key Processes in the Formation Phase of Technological Innovation Systems," *Technology Analysis & Strategic Management* 20, no. 5 (2008).

Sociotechnical networks are embedded in a broader societal context. The Systems of Innovation approach takes such a broader context, including institutional and historical perspectives, into account.[24] We will therefore use such an approach as a heuristic for tracing and analyzing dynamics of a CoPS industry and by zooming in on how the navy attempts to shape the acquisition of systems integration capabilities. The Systems of Innovation approach is particularly suitable when discussing such complex issues as naval innovation which is characterised by its lengthy procurement cycles, historical precedents, and warships that may be in use for over twenty-five years.

In the case of defence innovation in general, and our naval case in particular, we suggest that the Technological System of Innovation (TSI) approach is a productive heuristic to analyze transformation dynamics.[25] A major advantage of applying the TSI approach is that it focuses on technologies and crosses national and sectoral boundaries,[26] which leaves it less susceptible to debates on national versus globalizing defence industries.[27] Still it is important to take into account national dynamics, considering the still generally national character of naval innovation and production. The national context helps to explain the divergence of requirements between navies of different countries that often has obstructed international standardization and hampered

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[24] Charles Edquist, ed. *Systems of Innovation:Technologies, Institutions and Organizations* (London: Pinter Publishers, 1997).

[25] Various systems of innovation approaches have been developed which emphasize either national, sectoral, regional, or technological perspectives. National: Bengt-Ake Lundvall, ed. *National Systems of Innovation: Toward a Theory of Innovation and Interactive Learning* (London: Pinter Publishers, 1992); Bengt-Ake Lundvall et al., "National Systems of Production, Innovation and Competence Building," *Research Policy* 31 (2002). Sectoral: Franco Malerba, "Sectoral Systems of Innovation and Production," *Research Policy* 31 (2002); Franco Malerba, ed., *Sectoral Systems of Innovation: Concepts, Issues and Analyses of Six Major Sectors in Europe* (Cambridge, New York: Cambridge University Press, 2004. Regional (Anna Lee Saxenian, *Regional Advantage: Culture and Competition in Silicon Valley and Route 128* (Cambridge, Mass.; London, England: Harvard University Press, 1999); Philip Cooke, Mikel Gomez Uranga, and Goio Etxebarria, "Regional Innovation Systems: Institutional and Organizational Dimensions," *Research Policy* 26 (1997). Technological: Bo Carlsson and Richard Stankiewicz, "On the Nature, Function and Composition of Technological Systems," *Journal of Evolutionary Economics* 1 (1991); Steffan Jacobsson and Anna Johnson, "The Diffusion of Renewable Energy Technology: An Analytical Framework and Key Issues for Research," *Energy Policy* 28 (2000)..

[26] M.P. Hekkert et al., "Functions of Innovation Systems: A New Approach for Analysing Technological Change," *Technological Forecasting & Social Change* 74 (2007).

[27] Judith Reppy, "Conceptualizing the Role of Defense Industries in National Systems of Innovation,"; John Lovering, "The Defense Industry as a Paradigmatic Case of Actually Existing Globalization," Andrew James, "The Place of the Uk Defense Industry in Its National Innovation System: Co-Evolution of National, Sectoral and Technological Systems," in *The Place of the Defense Industry in National Systems of Innovation*, ed. Judith Reppy (Ithaca, NY: Cornell University Peace Studies Program, 2000).

international collaboration in naval shipbuilding in Europe.[28] What happens within innovation systems, is captured by what has been called "functions of innovation systems"[29] or "activities."[30] For the purpose of this paper we will examine i) provision of knowledge inputs to the innovation system (research and development, competence building); ii) demand-side activities (formation of markets, articulation of requirements); and iii) provision of constituents for the system of innovation (creation of organizations, networking, institutions, support services, incubation activities, financing, consultancy services).[31] Moreover, actions and interactions within a network/system of innovation are co-shaped by institutions such as formal regulations, but also by informal codes of conduct, norms, and established practices with routinised (and legitimate) ways of behaviour – that is, all kinds of "rules of the game."[32]

In this study we conceptualize the Dutch naval shipbuilding industry, as a Naval Production and Technological Innovation System (NP&TIS) aiming at the creation of naval CoPS. We focus on the actions of the Royal Netherlands Navy as a player in this system, and as a key actor in the two faces of systems integration.

3. The Role of the RNLN and Technology in Dutch Naval Shipbuilding Developments Since 1945

The unique character of naval shipbuilding industries like those of the Netherlands with a centuries-long history is rooted in their autonomy in naval operations and domestic procurement. It is one of the reasons why naval shipbuilding industries have been strongly nationally oriented, in contrast to, for instance, the aerospace and defence electronics industries.

Innovation in naval shipbuilding in the Netherlands most often occurs in conjunction with new shipbuilding projects, most often through collaboration between the RNLN and, for example, the research institutes Netherlands Organisation for Applied Scientific Research (TNO) Defence Research and Maritime Research Institute Netherlands (MARIN) in projects to meet

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28 Wim A. Smit et al., "Naval Shipbuilding in Europe," in *The Restructuring of the European Defence Industry: Dynamics of Change*, ed. Claude Serfati (Luxembourg: Office for Official Publications of the European Communities, 2001).

29 Hekkert et al., "Functions of Innovation Systems"; and Anna Bergek et al., "Analyzing the Functional Dynamics of Technological Innovation Systems: A Scheme of Analysis," *Research Policy* 37 (2008).

30 Charles Edquist, "Design of Innovation Policy through Diagnostic Analysis: Identification of Systemic Problems (or Failures)," *Industrial and Corporate Change* 20, no. 6 (2011). Various lists of processes have been produced, which, by the way, demonstrate considerable overlap, see Bergek et al., "Analyzing the Functional Dynamics of Technological Innovation Systems: A Scheme of Analysis."

31 Edquist, "Design of Innovation Policy through Diagnostic Analysis."

32 Douglass C. North, *Institutions, Institutional Change and Economic Performance* (Cambridge, MA.: Cambridge University Press, 1990).

new military needs and requirements.[33] By definition there is considerable uncertainty, a basic feature of CoPS.[34] The required know-how is built up by and becomes located within the network of partners participating in the project.

In this section we will describe the transformation processes of the Royal Netherlands Navy's (RNLN) fleet and the related Dutch naval shipbuilding industry since World War II, zooming in on a number of critical events and episodes where outcomes might have been quite different for both the RNLN and the Dutch naval shipbuilding industry. We focus on the crucial role of systems integration, especially since the 1960s, in the design and construction of warships.

3.1 1945-1960s: Rebuilding Capabilities

The first two decades after the end of the war witnessed the rebuilding of the Dutch naval industry. The RNLN would take up an entrepreneurial role to realize its ambition for a new, modern fleet which was to be developed and produced domestically. During this period the foundation was laid for a modern Naval Production and Technological Innovation System (NP&TIS) in the Netherlands. Table 1 offers an overview of the main dynamics in this period.

Changes in structural components & systems integration	Role RNLN in key activities in the system	Supporting / limiting factors for strategies RNLN
Resurrection of yards, naval design bureau and supplying industries	+ Wish-list for new fleet, including aircraft carriers, cruisers, destroyers and submarines + Stimulating build-up of know-how for minesweepers and submarines + Support of the domestic shipbuilding industry a.o. by involving all main shipyards in naval shipbuilding + Financing and own designs of warships by RNLN + Stimulation of collaboration between firms and knowledge institutes	+ Successful legitimation of RNLN as blue water navy +/- US support limited to funds, no design knowledge + Entrepreneurial spirit RNLN + Political support

Table 1: Summary of main dynamics, 1945-1960.

[33] See Harry Webers, Eli Pernot, and Chris Peeters, *De Marine en Marinebouwcluster-Welvaartscreatie en innovatief vermogen. Stichting Nederland Maritiem Land* (Rotterdam, 2011).

[34] Luis Carral et al., "Evaluation of the Structural Complexity of Organisations and Products in Naval-Shipbuilding," *Ships and Offshore Structures* 16, no. 6 (2021).

3.1.2 Shaping the Demand-Side and Provisions of Constituents for the Rebuilding of a NP&TIS System

The RNLN was highly involved in the demand-side process of re-designing a potentially domestic naval shipbuilding system. To the RNLN with its centuries long tradition of operating an ocean going fleet the answer was quite evident. The RNLN should consist of a full-fledged and modern blue water fleet. This viewpoint, and the legitimacy to voice that perspective, is not surprising as the RNLN is an institutionalized phenomenon, integral to a long-standing merchant maritime tradition in the Netherlands. That tradition has provided the RNLN with a lot of public and political goodwill and support.[35] Nevertheless, the requirements posed by the RNLN for a balanced blue water fleet were to some extent controversial regarding both the type of warships and the feasibility of their domestic construction. They were also completely unrealistic in view of the limited financial resources of the Netherlands at the time.[36]

In the early 1950s, after several revisions, the RNLN succeeded in having its fleet wish list presented to the government as a commitment required by NATO.[37] Referring to NATO's expectations regarding a country's naval commitments was a legitimization strategy that the RNLN would often apply to have its wishes on fleet composition accepted by Parliament. The acceptance of this wish list was not sufficient to rebuild the navy as the nearly bankrupt Netherlands lacked the required resources. It required dedicated work obtaining international support for the emerging naval system. The Dutch government, for example, had to call upon the United States Mutual Defence Assistance Programme (MDAP) to acquire a sizable fleet of minesweepers. About half of these minesweepers were built at a number of relatively small Dutch yards, partly with financial support from the US.

3.1.3 Building Up Know-How and Design Capabilities

Next to the demand-side and supportive constituents such as financial

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[35] In official publications of the Ministry of Defence the order of treatment of the Military Forces is quite symbolic: first the Navy, then the Land Force, and finally the Air Force. The MoD's website mentions 8 January 1488 as the date of origin of the Dutch Navy, showing its centuries long tradition.

[36] The first fleet plan, in 1945 (Plan Termijtelen), for instance, envisioned three aircraft carriers, eight cruisers, and thirty-six destroyers. After several revisions, the final plan released in 1950 (Moorman-2), after the independence of Indonesia and the establishment of NATO in 1949, showed a fleet including one aircraft carrier, two cruisers, twelve destroyers, four submarines, and forty-eight minesweepers, see Oosterhout, "De Precaire Autonomie Van De Nederlandse Marinescheepsbouw."

[37] Oosterhout, "De Precaire Autonomie Van De Nederlandse Marinescheepsbouw"; and Sam Torres, *De Heropbouw Van De Koninklijke Marine, 1945-1951. Verklaringen Voor Het Succes Van De Nederlandse Marine* (Amsterdam: University of Amsterdam Library, 2016), 29-34.

resources, the generation of knowledge is key to a production and innovation system in the making. The RNLN was keenly aware of this and considered it important that the Dutch yards would build up know-how and experience, for instance for constructing wood and aluminium minesweepers, as was realized in the eighteen minesweepers of the Dokkum class.[38] In fact, the RNLN's policy was to develop knowledge of design and production of warships in close collaboration with industrial and knowledge institutes. In this way, the RNLN's decision to design and build various warships, despite US opposition, would support the build-up of the structural elements (i.e. the actors) of the naval production and innovation system.

Sittard, Dokum-class minesweeper. (Wikimedia Commons)

In the case of the RNLN's desired destroyers, the US and the United Kingdom refused support because they initially envisaged that the RNLN's task within NATO would be limited to coastal defence and mine sweeping.[39] An entrepreneurial RNLN decided to finance and design the twelve destroyers in cooperation with Nederlandse Verenigde Scheepsbouw Bureaus (NEVESBU), a joint design bureau established before the war by the main Dutch shipyards.[40] The construction of the destroyers and their equipment (except for weapon systems) was done in close cooperation with the Dutch naval industry. The hull design was tested by MARIN, while Hollandse Signaal Apparaten (HSA, now Thales NL) provided radar equipment and fire control. The Dutch aerospace

38 See Oosterhout, "De Precaire Autonomie Van De Nederlandse Marinescheepsbouw," 246.

39 C.M. Megens, "American Aid to Nato Allies in the 1950s, the Dutch Case" (University of Groningen, 1994), 476.

40 Lemmers, "The Pillars of Dutch Naval Shipbuilding after 1945"; Mila Davids and Hans Schippers, "Innovations in Dutch Shipbuilding in the First Half of the Twentieth Century," *Business History* 50 (2008).

research institute Nationaal Lucht- en Ruimtevaartlaboratorium (National Aerospace Laboratory, NLR, now Royal Netherlands Aerospace Center) was involved by testing the funnel design. The sonar equipment was developed by TNO-Defence Research in co-operation with HSA.[41] Rietschoten & Houwens (R&H – which later became part of the Imtech Holding) took care of the civil electro-technical installation, such as navigation and machine controls. The destroyers were built between 1951 and 1958 by the Dutch yards De Schelde, Rotterdamsche Droogdok Maatschappij (RDM), Wilton-Fijenoord, and Nederlandsche Dok en Scheepsbouw Maatschappij (NDSM). This close cooperation between the RNLN, prime contractors, and knowledge institutes reflect the basic composition and structure of the emerging domestic Naval Production and Technological Innovation System. The allies' refusal of assistance in acquiring destroyers implied, in the terminology of Thomas Hughes, a "reverse salient"[42] in the RNLN's intended fleet structure, which had to be remedied and thus actually helped to build up the innovation and production capacity of this NP&TIS.

The US also refused to support the construction of submarines.[43] Given WWII experiences, RNLN decided that the yards and navy had to innovate by designing and building a new type of submarine that had a capability

Friesland-class destroyer HNLMS *Groningen*, commissioned in 1956. (Wikimedia Commons)

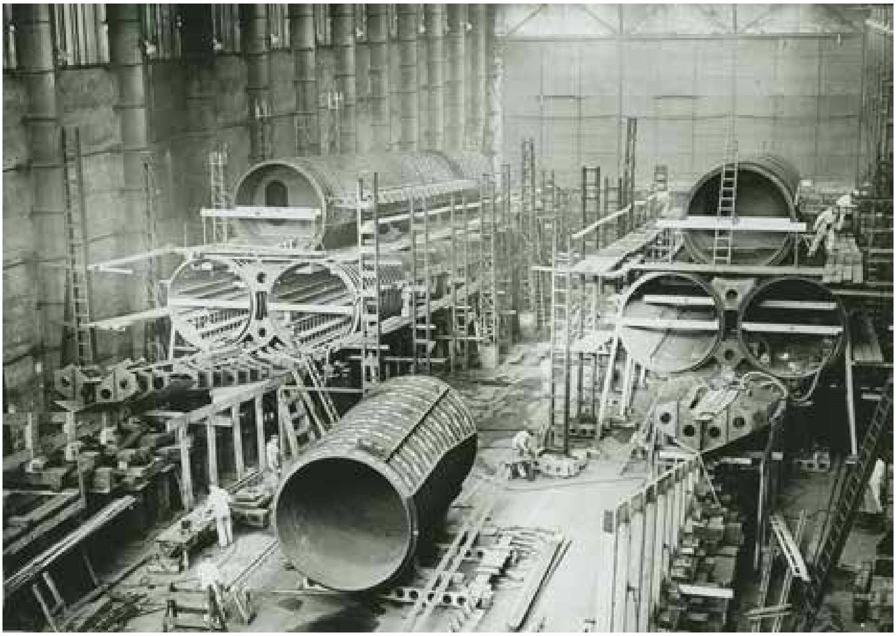
41 Oosterhout, "De Precaire Autonomie Van De Nederlandse Marinescheepsbouw," 295.

42 T.P. Hughes, "The Evolution of Large Technological Systems," in *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*, ed. W.E. Bijker, T.P. Hughes, and Trevor J. Pinch (MA: MIT Press, 1987).

43 Megens, "American Aid to Nato Allies in the 1950s, the Dutch Case," 92-94 and 163-165.

to dive deeper, go faster, and run submerged for extended periods of time, following the trend of the submarines Germany produced near the end of the war. A competition emerged between two different designs – one by the RNLN's own design department and the other, the so-called "three cylinder design" by design bureau NEVESBU which would eventually prevail.[44] As in the case of the destroyers, a close-knit network emerged between 1954 and 1960 from close co-operation between the RNLN and the Dutch Knowledge Institute TNO-Defence Research, which performed shockwave and vibration experiments, designed interfaces between sensors (sonar), weapons and users, designed climate control and so on. Sonar equipment was produced by the company van der Heem in close cooperation with TNO-Defence Research.[58] Hollandse Signaal Apparaten (HSA) became responsible for radar, fire control and electronic equipment. Two yards, RDM and Wilton-Fijenoord, each built two Dolfijn-class submarines (also known as three-cylinder submarines), which became operational between 1960 and 1966.

The policy of developing knowledge in order to be able to design and produce warships domestically was also – for a brief period – applied to procurement of an aircraft carrier.[58] As Dutch yards had neither the expertise nor capability to design and build aircraft carriers, the RNLN bought a small



Dolfijn-class submarines *Dolfijn* (left) and *Zeehond* (right) under construction in 1956. (Wikimedia Commons)

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[44] Oosterhout, "De Precaire Autonomie Van De Nederlandse Marinescheepsbouw," 122.

carrier (renamed as *Karel Doorman*) from the UK Royal Navy in 1948.[45] A three-year modernization of the carrier in the mid-1950s helped the RNLN in expanding its integration capabilities. The carrier became the centre of a submarine hunter-killer group.[46] In 1968, however, after a fire in the machine rooms, *Karel Doorman* was sold to Argentina. It implied the end of the Dutch carrier fleet and the loss of associated integration capabilities.

By the early 1960s a stable naval production and technological innovation system was in place, facilitated by the RNLN's instrumental role in establishing requirements and its knowledge development activities. The RNLN had forged a close-knit warship innovation and production network, containing the building blocks from the systems integration pyramid (see figure 1). The network consisted of four major shipyards (De Schelde, RDM, Wilton-Fijenoord and NDSM), prime contractors, like Rietschoten & Houwens (R&H) taking care of the civil electro-technical installations such as navigation and machine control, Hollandse Signaal Apparaten (HSA) responsible for radar, fire control and naval electronic equipment, the Knowledge Institutes TNO-Defence Research and MARIN (maritime research) and a number of suppliers of subsystems and components, Werkspoor, for instance, as a supplier of propulsion engines, and Lips, which supplied propellers. Within this network the RNLN played a central role, not only as the user but also as a "dedicated network builder" and main orchestrator of the network. The RNLN, itself possessing warship design capability, worked closely as a co-designer with the yards and other actors in the network. In other words, the RNLN played a central role in both of the "two faces" of systems integration.[47] Within this network a relationship of trust between the RNLN and other actors was created as a foundation for a stable NP&TIS.

3.2 1960s-1990s: Developing SEWACO Systems Integration Capabilities

From the 1960s onwards the incorporation of armament like guns, torpedoes, and depth bombs on naval vessels became more demanding with the advent of electronic and computer-controlled systems. The RNLN's vigorous response in the development of sensors, weapons, and communication systems (SEWACO) integration capabilities laid an important foundation for the ability of the sector to competitively produce and innovate advanced warships. An overview of dynamics in this period is in Table 2.

45 Oosterhout, "De Precaire Autonomie Van De Nederlandse Marinescheepsbouw," 117.
46 Naval Institute Press, *Conway's All the World's Fighting Ships, 1947-1995*, 271-272.
47 Gholz et al., "The Second Face of Systems Integration."

Changes in structural components & systems integration	Role RNLN in key activities in the system	Supporting / limiting factors for strategies RNLN
Accommodating the RNLN organization to systems integration Major mergers between yards Systems integration capabilities in SEWACO systems, frigates and submarines Stable network of suppliers and knowledge institutes, orchestrated by RNLN RNLN active in each of the two faces of systems integration Specialisation of yards on particular types of warships (frigates, submarines, minehunters/sweepers)	Stimulating knowledge creation submarines, advanced frigates, automation - sensors – weapons – communication systems Special requirements RNLN ships Spreading procurement across yards, adapting delivery schedules Development of in-house software department for systems integration	+/- Increasing dependence of yards on RNLN due to lack of export success, tough international competition on civil market + Suppliers of civil and defence electronic installations successful on export market + Ambitious RNLN +/- Cracks in political goodwill, cost overruns +/- Difficult international collaboration in naval shipbuilding projects

Table 2: Summary of dynamics 1960s-1990s.

3.2.2 Continuation of Demand Articulation and Close Collaboration in the System

In the 1960s and after, the RNLN continued its strategy of setting unique requirements, and close collaboration with the domestic companies and knowledge institutes in the NP&TIS, a practice which had become a "rule of the game." This is clear in the construction of new frigates fitted to carry and operate helicopters for anti-submarine warfare and other roles. Frigates with this aviation capability seemed to be a good alternative to a carrier-centered fleet which proved to be too expensive and ambitious for the Netherlands. The design of a first series of six Van Speijk-class frigates was derived from the British Leander-class frigate. However, a number of modifications were applied to meet special RNLN requirements and to bring equipment up to a new standard. The electrical installations, for instance, were of a wholly new Dutch design. Further, the bridge, personnel cabins, and machine room lay out

Van Speijk-class frigates *Van Nes* and *Van Galen* under construction in 1966. (Wikimedia Commons)

were built according to a Dutch design.[48] These frigates were constructed by the yards De Schelde and NDSM. Rietschoten & Houwens was again involved in building the civil electro-technical installations. Hollandse Signaal Apparaten again supplied radar and fire control systems, which had to be integrated with a British gun and British guided weapon systems.[49]

The RNLN also continued to develop expertise and systems integration capabilities for building submarines. Initially the RNLN, following the large US, UK, and Soviet navies, had the ambition to build nuclear propelled submarines. Attempts to get support from allied partners such as the US or France came to nothing. Still, the RNLN succeeded in having the need for a nuclear propelled submarine included in the Ministry of Defence White Papers of 1964 and 1968. As before, the RNLN and Ministry of Defence were able to convince Parliament by referring to NATO requirements.[50] The nuclear propelled submarine project would eventually (in 1974) be abandoned

48 Oosterhout, "De Precaire Autonomie Van De Nederlandse Marinescheepsbouw," 153-154.

49 S.G. Nooteboom, *Deugdelijke Schepen: Marinescheepsbouw 1945-1995* (Zaltbommel: Europese Bibliotheek, 2001), 56.

50 Ministry of Defence, "Defensienota 1964. Kamerstuk 7677-X, No. 1" (The Hague, 1964); "Defensienota 1968. Kamerstuk 9635, No. 1," (The Hague, 1968).

Zwaardvis, the lead submarine of its class. (Wikimedia Commons)

as being too complex and far too expensive.[51] However, the RNLN and its partners were successful in building diesel-electric ocean-going submarines. Testing and construction took about ten years, in part because much of the equipment had to be designed by Dutch companies as the US was not willing to share its equipment.[52] The first of the two Zwaardvis-class submarines were built by the yard RDM and became operational in 1971. They were considered the most modern and advanced diesel-electric submarines at the time.

The RNLN acted as a customer, shaping the demand side of the naval system by setting requirements, thereby inducing the generation of new knowledge and systems integration capabilities bcause much had to be developed by the Dutch sector itself. The RNLN also acted as an orchestrator of the tasks of various contractors and managed their relationships. The RNLN contracted for each type of large vessel at a minimum of two yards, thereby doubling the available expertise among yards for each of these warship categories. It became an informal "rule of the game." At the time these yards were also involved in merchant shipbuilding and, therefore, not fully dependent on naval contracts. The RNLN also reinforced the domestic naval technological

51 "Defensienota 1974. Kamerstuk 12994, No. 2" (The Hague, 1974).

52 Oosterhout, "De Precaire Autonomie Van De Nederlandse Marinescheepsbouw," 203-205.

capability by contracting the Dutch knowledge institutes TNO-Defence Research and MARIN, parties in the NP&TIS, for doing the required research and development. As the RNLN was the owner of the results, the knowledge institutes could not freely export their insights, making them highly dependent on the RNLN.[53] Given that the RNLN, through its own design department, was also involved in designing its warships, the navy actually played a central role in both of the "two faces" of systems integration. Important to note here is that the RNLN has also maintained direct relationships with a number of the suppliers of subsystems and/or parts, and not only with the prime contractors (e.g. Lips, Bosch Rexroth, Wärtsilä, Hertel). Thus, the positioning of the prime contractors and suppliers in relation to the RNLN, together with their mutual relations, may be represented rather by a network in a layered ring structure (see figure 2), with the RNLN in the centre, than by the hierarchical pyramid as often proposed for CoPS in the literature (see figure 1). As concerns the configuration of the network the RNLN showed a preference for longstanding collaboration, based on trust, with domestic partners in systems integration capabilities, like R&H for civil electro-technical installations and platform automation, and HSA (now Thales NL) for sensor and weapons integration. The same is true for collaboration with producers of components and subsystems, like propulsion engines, propellers and climate control. Again, this may be viewed as a "rule of the game" on which suppliers could rely, contributing to trust and assurances for companies.

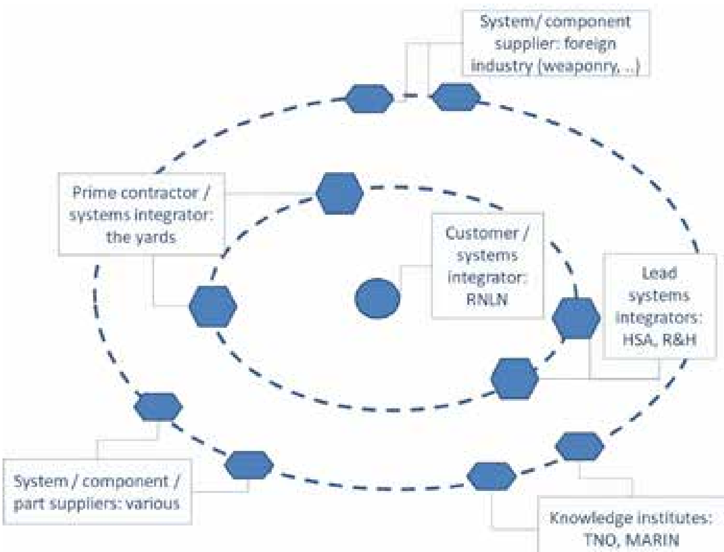

Figure 2. Systems integration configuration naval production and innovation system.

53 Ministry of Defence, "Defensie Industrie Strategie - Eindrapportage. Kamerstuk 31125 No. 1" (The Hague, 2007), 15.

3.2.3 Acquiring SEWACO Systems Integration Capabilities

The increased threat in the 1960s from air-launched and surface-to-surface guided missiles allowed very short reaction times for detection and defence, which could not be met by traditional procedures depending on human actions. Solutions came from developments in sensor and computer technologies.[54] Thus, the introduction of automation in SEWACO systems, with software for data processing from the sensors (radar, sonar) and for operating a ship's defensive weapons, became one of the major innovations in naval technology in the 1960s.[55]

The RNLN pro-actively responded by creating its own SEWACO systems integration organization. The Dutch also acted strategically with respect to its international partners. The RNLN wanted to co-operate with US and UK navies in developing such systems, while, at the same time, not becoming completely dependent on these navies for procurement. The Dutch found it necessary to have something to offer to act on equal footing when co-operating with other navies.[56] In 1967 the RNLN therefore decided to establish its own Centre for Automation of Weapon and Communication Systems (CAWCS, initially called CAS) for developing and maintenance of SEWACO software, in co-operation with the electronics and radar company HSA. The first application of an automated SEWACO system was on two Guided Weapons frigates which involved HSA's 3-D radar and the DAISY (Data Action Information System) software developed by HSA and the RNLN. The weapons were acquired, like before, from foreign companies, but the architecture and systems integration were entirely Dutch.[58]

The RNLN also adapted its internal organisation to the rise of systems integration. Departments of the RNLN responsible for electronics, weapons, and navigation, which until then almost never co-operated, now had to work closely together to install and maintain integrated sensor, weapon, and command systems.[57] To this end, the position of systems engineer was introduced, and system engineering would become a new speciality for the RNLN.[58]

Rather than merely relying on defence electronics equipment from the US or the UK, the Dutch Ministry of Defence opted for developing a domestic defence electronics industry for sensors and control systems.[59] This proved to be a successful and forward-looking initiative. The central role that defence electronics have come to play is evident from the fact that by around the year 2000 in major naval countries defence electronics companies rather than ship yards became prime contractors in naval shipbuilding, like BAE Systems in

54 Nooteboom, *Deugdelijke Schepen: Marinescheepsbouw 1945-1995*.
55 Nooteboom, *Deugdelijke Schepen: Marinescheepsbouw 1945-1995*, 103.
56 Nooteboom, *Deugdelijke Schepen: Marinescheepsbouw 1945-1995*, 121.
57 Nooteboom, *Deugdelijke Schepen: Marinescheepsbouw 1945-1995*, 58.
58 Nooteboom, *Deugdelijke Schepen: Marinescheepsbouw 1945-1995*, 104.
59 Naval Institute Press, Conway's All the World's Fighting Ships, 1947-1995, 269.

the UK, and Northrop Grumman Corporation and General Dynamics in the USA.[60] In the Netherlands, instead of a central concentration of naval systems integration capabilities by defence electronics companies as prime contractors, such capabilities were distributed over the main actors collaborating in the Dutch NP&TIS network, including the RNLN, Rietschoten & Houwens, Thales Netherlands, and the major naval shipbuilding yards.

The RNLN's fleet development program, including the required systems integration capabilities, was not without controversy. Since the early 1970s, some Dutch politicians have advocated for a redistribution and specialisation of naval tasks among NATO countries,[61] which included the end of the RNLN's submarine commitment.[62] The RNLN, supported by its NATO partners, strongly opposed such a policy.[63] It was successful. Parliament, although a "critical actor" whose consent is essential for naval programs, nevertheless has a low inclusion in the naval network because of its much broader agenda.

The RNLN pursued a novel submarine design to meet increased requirements in operating depth and thus hull strength, sound reduction, speed, automation and crew reduction, safety, advanced weapons, and SEWACO systems. The result was a highly complex design and construction project that started at the end of the 1970s, lasted some fifteen years, and had many cost overruns, partly brought about by changing requirements during the construction process.[64] The highly automated platform surveillance and operation system was of an entirely new concept. Given that no other navy deployed such far-reaching platform automation, no know-how or experience could be obtained from elsewhere. Main responsibilities were shared by the RNLN, the design bureau NEVESBU, the yard RDM, and Rietschoten & Houwens. The Dutch yard RDM was responsible for the hull and integration of the various systems. HSA supplied the fire control, command and communication systems as well as the SEWACO system for which the RNLN's own CAWCS supplied the software. R&H supplied the innovative electric and platform automation systems. The four Walrus-class submarines entered into service between 1990 and 1994.

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60 John Birkler et al., "Differences between Military and Commercial Shipbuilding: Implications for the United Kingdom's Ministry of Defence," in *RAND Corporation monograph series. Prepared for the United Kingdom's Ministry of Defence* (RAND, 2005), 53.

61 J.W.L. Brouwer and C.M. Megens, "Het Succesvolle Verzet Van De Koninklijke Marine Tegen Taakspecialisatie in De Navo," *Transaktie* 21, no. 1 (1992).

62 See Ministry of Defence, "Defensienota 1974. Kamerstuk 12994, No. 2"; and K. Colijn, "Laat De Marine Niet Meer Wereldwijd Opereren: Is Te Duur," *NRC newspaper*, 17 June 2021.

63 Tweede Kamer, "Stenografisch Verslag Van De Openbare Hoorzitting Van De Commissie Voor De Rijksuitgaven En De Vaste Commmissie Voor Defensie over Het Walrusproject. Kamerstuk 19221, No. 8," (The Hague, 1986), 3.

64 Algemene Rekenkamer, "Rapport Van De Algemene Rekenkamer Inzake Besluitvorming En Uitvoering Van Het Walrusproject. Kamerstuk 19221, No 2," (The Hague, 1985); Oosterhout, "De Precaire Autonomie Van De Nederlandse Marinescheepsbouw."

The Walrus-class submarine, *Zeeleeuw*, under construction at Rotterdam in 1987. (Wikimedia Commons)

3.2.4 Structural Changes in the Naval Shipbuilding Sector and Maintaining Systems Integration Capabilities in View of Exogenous Factors

The viability of the resurrected Dutch naval shipbuilding sector faced major exogenous pressures. Dutch yards were not very successful in the export market of warships. One reason for this lack of success is the highly politicized nature of the international naval market and the preference for long-standing supplier relationships.[65] Sizable naval countries protect their own naval industry by buying domestically, leaving no room for imports from other countries. In obtaining access to the remaining international naval market Dutch shipyards must compete with the main supplying countries, such as the UK, France, US, and Germany.[66] The Dutch naval exports were strongly dependent upon promotional activities by the Dutch government and the RNLN, where the navy plays the role of lead user or launching customer. As the RNLN has a clear interest in the financial health of the yards, it has on several occasions delayed its own procurement schedule to facilitate quick deliveries to foreign

[65] Ian Anthony, *The Naval Arms Trade* (Oxford: Oxford University Press, 1990).

[66] For instance, in 1984, after ten years of negotiations, perspectives for building S-Frigates for Portugal were nullified by a German offer. See also PricewaterhouseCoopers, *De Nederlandse Defensiegerelateerde Industrie (the Dutch Defence-Related Industry). Report for the Dutch Ministry of Economic Affairs* (1998), 51.

navies such as the export of frigates to Greece in 1981-1982 and minehunters to Indonesia in 1985.[67] At the same time, exports may be impeded by export control regulations, which prevented, for instance, the sale of submarines to South Africa and Taiwan.[68] In other words, constitutive processes in the system both supported (financial arrangements) and constrained (export regulations) innovation and production of warships. The privileged position of the RNLN on the demand-side of the system, resulting in the dedicated designs of the warships according to the need and requirements of the RNLN, also contributed to the lack of success on the export market. The specific requirements of the RNLN raised the price of the technologically advanced Dutch frigates and submarines, not affordable to emerging or less advanced naval countries. As a consequence, the yards became highly dependent on the RNLN.[69] By contrast, the lead systems integrators HSA and R&H, supported by the RNLN as a "launching customer"[70] were relatively more successful on the export market.[71]

An additional threat to the viability of the sector was that, since the early 1960s, European civil shipbuilding activities have faced heavy international competition from countries such as Japan and South Korea. This had also large effects on the viability of naval shipbuilding due to structure of the NP&TIS: naval and civil vessels were built in the same yards. Employment at Dutch shipyards, including those involved in naval shipbuilding, like De Schelde, RDM, and Wilton Fijenoord, decreased significantly.[72] Starting in 1966 the structure of the shipbuilding sector changed drastically through some mergers among the yards and the subsequent creation in 1971 of the mega-conglomerate Rijn Schelde Verolme (RSV) at the instigation of the Dutch government. Despite the one billion euros pumped into the consortium by the government, RSV went bankrupt and was dissolved in 1983.[73]

During this period the yards that were traditionally involved in both merchant and naval shipbuilding, such as De Schelde and RDM, had to increasingly specialise in naval shipbuilding in their struggle for survival. Through a dedicated policy of the RNLN and Dutch government to upkeep a strong and innovative domestic naval shipbuilding capability, naval orders were distributed across a few selected yards. The only shipbuilding activity within RSV that remained profitable was naval shipbuilding by the shipyards

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67 K. Colijn and P. Rusman, *Het Nederlandse Wapenexportbeleid 1963-1988* (Den Haag: Nijgh & Van Ditmar, 1989), 119.

68 Colijn and Rusman, *Het Nederlandse Wapenexportbeleid 1963-1988*, chapter 5.

69 The RNLN was more successful in selling its much lower priced, used warships to foreign countries.

70 B. van Elk, "Het Succes Van Imtech," *NIDV Magazine* (2010), 4.

71 Smit et al., "Naval Shipbuilding in Europe," 228.

72 Smit et al., "Naval Shipbuilding in Europe," 226.

73 Tweede Kamer, "Verslag Van De Enquêtecommissie Rijn-Schelde-Verolme (Rsv). Opkomst En Ondergang Van Rijn-Schelde-Verolme. Kamerstuk 17817, Nr. 16," (The Hague, 1984).

De Schelde, Wilton-Fijenoord, and RDM. To support these yards, the navy and defence ministry sometimes commissioned the building of new ships at an earlier time than originally planned.[74] After the break-up of RSV, the shipyards De Schelde and RDM, at the time both involved in building new vessels for the Dutch navy, were saved and acquired a privileged position regarding naval shipbuilding. De Schelde became the navy's partner for building frigates and RDM for submarines. The yard Van der Giessen-de Noord (not part of RSV) became the partner for minesweepers and mine hunters while continuing its merchant shipbuilding activities.

In summary, the naval shipbuilding sector and systems integration capabilities changed considerably during this period. The RNLN and the government played a major role in both innovating and sustaining the NP&TIS. Some shipyards vanished due to exogenous factors, while others were actively maintained by the RNLN and government, becoming more dependent on the navy for their future viability. The RNLN and HSA, working together, acquired capabilities in SEWACO (hardware and software) systems. R&H made a similar shift toward systems integration in civil electro-technical installations for warships, later on expanding its activities to the market for merchant ships. The domestic production and innovation strategy continued. The RNLN preferred contracting with its established partners when commissioning new, often a next, more advanced generation of warships, rather than applying open tender procedures. It was an accepted "rule of the game" based on mutual trust in a close-knit network.

3.3 1990s-2015: Reduction of Systems Integration Capabilities

The ending of the Cold War after 1989 would set in motion a series of changes in the structure of the naval production and innovation system. The RNLN would also adapt its strategy regarding innovation and producing warships. These developments contributed to a radical change in the capabilities for systems integration. Table 3 offers an overview of what happened during this time frame.

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74 This happened, for instance, with some S-frigates in the mid-1970s (De Schelde shipyard), some M-frigates in the mid-1980s (De Schelde) and the Walrus submarines (RDM shipyard). Moreover, the willingness of the RNLN, in 1980, to permit De Schelde shipyard to sell two S-frigates to Greece that were under construction, resulted in a loss of several hundred million Dutch guilders to the navy.

3.3.2 Changes in the Composition and Rules of the Game in the Dutch Naval Shipbuilding Sector

Changes in structural components & systems integration	Role RNLN in key activities in the system	Supporting / limiting factors for strategies RNLN
Globalization of firms Reduction in number of yards Loss of integration capability of submarines and mine combat vessels Reduced role of RNLN as designer of warships and orchestrator of networks Changing civilian-military relationships in shipbuilding	Less successful in legitimizing a sizable, modern fleet RNLN shifts from stimulating knowledge generation, co-design and co-maker to lead-user.	- 'Peace dividend' after end of Cold War (1991) - financial crisis (2008-2013) +/- reduction, but no loss of political goodwill +/- less dependency of firms on RNLN

Table 3. Summary of dynamics, 1990s-2015.

From the 1990s onwards a series of developments, largely exogenous to the Dutch naval system, occurred which would have a profound impact on its structure and way of working. A general tendency emerged with firms to concentrate on what was considered as their core business. Having in-house all kinds of secondary competences and tasks was considered too expensive and unnecessary, certainly in times of limited or decreasing naval budgets. Divisions were split off into new firms or taken over by other companies that, in turn, could further specialize and serve a broader (civil and international) market. This led to an extension of the value chain and number of actors involved in the production of warships and, by implication, also an extension of the scope of systems integration.

The increasing interaction with civil markets was also fuelled by procurement of components on the commercial market (COTS – commercial-off-the-shelf), whenever possible. Often this turned out to be cheaper than insisting on sometimes idiosyncratic military specifications ("milspecs") for the required components.[75] Moreover, in some sectors, like the Information and Communication Technology (ICT) sector, rapid innovations occurred in the civil domain resulting in a quick succession of new generations of technology

[75] Ministry of Defence, "Beleidsbrief Van Defensie Na De Kredietcrisis: Een Kleinere Krijgsmacht in Een Onrustige Wereld. Overzicht Van De Ombuigingen. Kamerstuk 32733, No. 1.," (The Hague, 2011); Ministry of Defence and Ministry of Economic Affairs, "Defensie Industrie Strategie Nota. Kamerstuk 31125, No. 92," (The Hague, 2013).

much faster than in the military domain.

Another change came from increasing globalization, including international mergers. Traditionally the RNLN had a close working relationship with domestic companies in acquiring (sub)systems, such as propulsion, sensors, and electrical systems, but several of these firms such as HSA, LIPS, and Stork Dieselmotoren were taken over by foreign, multi-national companies, with their headquarters outside the Netherlands. Often, however, a Dutch local branch was kept alive. This was already happening in the 1960s-1970s with the firm Rietschoten & Houwens which would become part of a large holding known as Imtech, the primary focus of which was the civil market.[76] The net effect of these developments was that the Dutch naval industry, like other defence industries, increasingly had to deal with actors working in civil-oriented markets.

The end of the Cold War and disbanding of the Warsaw Pact in 1991 was a further, important external development. "Peace dividend" became a buzzword in the West, including the Netherlands, highlighting the economic benefits of reduced defense spending.[77] In this period, the Dutch defense budget came under further pressure due to overall governmental budgetary challenges, including the international financial crisis between 2008 and 2013.[78] Discussions started about downsizing and restructuring the Dutch military forces, including cooperation with NATO partners to reduce commitments.[79] The RNLN succeeded in limiting the "damage" from shrinking budgets. The fleet, though gradually downsized in numbers of frigates and minehunters, kept its structure, and its main NATO task of defending the Atlantic and Mediterranean sea lanes. But plans for renewal of the fleet by next generations of frigates, submarines, and minehunters were sceptically received by Parliament, the "critical actor."[80] The relative autonomy long enjoyed by the RNLN in decision making on its requirements, already under parliamentary scrutiny since the dissolution of the RSV shipyard conglomerate in 1983, came under further pressure.

The Dutch Ministry of Defence no longer considered maintaining a

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[76] Imtech, 1*860-2010: De Rijke Geschiedenis Van De Europese Technische Dienstverlener Imtech N.V.* (Gouda: Imtech N.V., 2010).

[77] Tweede Kamer, "Prioriteitennota. Kamerstuk 22975, No. 2" (The Hague, 1993); R.M. de Ruiter, "Defensienota 1991: Het Belang Van Een Visie. De Krijgsmacht Neemt Afscheid Van De Koude Oorlog," *Militaire Spectator* 180, no. 2 (2011).

[78] Ministry of Defence, "Beleidsbrief Van Defensie Na De Kredietcrisis: Een Kleinere Krijgsmacht in Een Onrustige Wereld. Overzicht Van De Ombuigingen. Kamerstuk 32733, No. 1."

[79] Ministry of Defence, "Beleidsbrief Van Defensie Na De Kredietcrisis: Een Kleinere Krijgsmacht in Een Onrustige Wereld. Overzicht Van De Ombuigingen. Kamerstuk 32733, No. 1."

[80] Tweede Kamer, "Toekomst Van De Nederlandse Onderzeedienst. Kamerstuk 34225, No. 22," (The Hague, 2017); "Motie. Toekomst Van De Nederlandse Onderzeedienst. Kamerstuk 34225, No. 21" (The Hague, 2017); "Motie. Toekomst Van De Nederlandse Onderzeedienst. Kamerstuk 34225, No. 18" (The Hague, 2017).

domestic naval shipbuilding capacity as a key priority.[81] Moreover, in view of the overcapacity in Europe, the ministry mandated more international co-operation in shipbuilding.[82] This was a major deviation from the traditional "rule of the game" of support for the naval shipbuilding sector. Still, keeping up capabilities for design and development of integrated systems and automation was a key part of the Dutch defence industry strategy.[83]

As a result of the changes in the actor configuration in the NP&TIS and in the rules of the game, RNLN was less able to set the tone and orchestrate activity in the system. The RNLN had to adapt to the changing geo-political situation. This was evident in its changing fleet requirements but also in the ability of the RNLN to support continuing development of systems integration capabilities (see below). Since the demise of the Warsaw Pact and rise of asymmetric warfare threats such as terrorism and piracy, the need for large ocean-capable warships had been reduced. A letter to Parliament from the Ministry of Defence suggested there should be a shift from lengthy ocean-going tasks to expeditionary tasks and coastal operations.[84] As a consequence a substantial number of frigates were to be sold.[85] The actual tasks of the RNLN changed to some extent from blue water to brown water (coastal) operations, including amphibious tasks and humanitarian missions overseas with extensive hospital accommodations and medical services. To this end amphibious landing ships were added to the fleet.[86]

The increasing emphasis on coastal operations entailed a shift from frigates to smaller vessels. The RNLN, accordingly, sought to commission four "patrol vessels," but with the requirement they be capable of ocean-going operations. Interestingly, the "critical actor," Parliament, urged – with success – the Government procure these vessels to ensure continued employment and production capacity at the Damen Schelde yard, and with the intention the vessels could also serve as a platform for innovative technologies.[87] Thus, while

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81 "Vragen En Antwoorden Defensiebegroting Voor 2005. Kamerstuk 29800x, Nr. 15" (The Hague, 2004), 16-17.

82 "Vragen En Antwoorden Defensiebegroting Voor 2005. Kamerstuk 29800x, Nr. 15" (The Hague, 2004), 3.

83 Ministry of Defence and Ministry of Economic Affairs and Climate, "Defensie Industrie Strategie Nota," (The Hague, 2018).

84 Ministry of Defence, "Op Weg Naar Een Nieuw Evenwicht: De Krijgsmacht in De Komende Jaren. Kamerstuk 29200x, No. 4" (The Hague, 2003), 22.

85 Six M-frigates were sold to Belgium, Chile, and Peru between 2000 and 2010.

86 Ministry of Defence, "Op Weg Naar Een Nieuw Evenwicht: De Krijgsmacht in De Komende Jaren. Kamerstuk 29200x, No. 4."

87 Tweede Kamer, "Motie Voorgesteld Door De Leden Van Baalen, Kortenhorst, Bakker En Herben. Kamerstuk 29200-X, No. 32" (The Hague, 2003) ; Bert Minne, "Economische Gevolgen Van Korvettenaanschaf. Een Welvaartseconomische Analyse," in *CPB Document no. 68*, ed. Centraal Planbureau (Den Haag: SDU, 2004); Policy Research Corporation, "De Economische Effecten Van De Ontwikkeling En Bouw Van Korvetten in Nederland. In Opdracht Van De Stichting Nederland Maritiem Land," (Rotterdam, 2004).

it had become the MoD's policy not to sustain naval shipbuilding at all costs, there was still support for the sector. This was true for its systems integration capabilities, at least with respect to the surface combatants. The new patrol vessels had several innovative features requiring advanced systems integration capabilities. These features included an integrated sensor and communication systems suite, supplied by Thales Netherlands, and an advanced platform automation system supplied by Imtech which allowed for reduced manning.[88] The four ocean-going patrol vessels entered service in 2012 and 2013.

Holland-class ocean-going patrol vessel *Groningen*, which was laid down on 9 April 2010 and launched on 21 April 2011. (Wikimedia Commons)

3.3.3 Loss of Systems Integration Capabilities

While systems integration capabilities for frigates and OPVs were maintained, this was not the case for submarines. Building submarines was one of the sectors that ran into problems due to lack of naval orders in the 1990s. In the 1980s the costs of the advanced Walrus class by RDM substantially exceeded the initial budgets, partly the result of changing requirements during construction.[89] Parliament was not eager to fund a next generation of submarines in a time of shrinking defence budgets. When RDM ran into financial problems after having finished the Walrus class it could not be sustained by the RNLN and went bankrupt in 2004. This was the end of the systems integration capability for building new submarines in the Netherlands. Only the existing design knowhow and expertise on maintenance, located at the design and maintenance bureaus of the RNLN and NEVESBU, remained.[90] The close-knit network in the reduced sector remained, however. For the Life Extension Program for the Walrus class dedicated co-operation was established

88 M.C.W.M. Janssen, S.C. Horenberg, and F.G. Marx M., "Stand Van Zaken: Patrouilleschepen," *Marineblad* 2008.

89 Oosterhout, "De Precaire Autonomie Van De Nederlandse Marinescheepsbouw."

90 NEVESBU now presents itself as an independent maritime technology partner and platform integrator.

that included TNO-Defence Research, MARIN, Imtech Marine & Offshore, Thales-NL, and NEVESBU.

Another sector that ran into problems in the 1990s was minesweeping/hunting and mine countermeasures. The small sized yard Van der Giessen de Noord, which was active on both the naval and civil shipbuilding market, was specialized in building minesweepers/hunters and had built the RNLN's fifteen Tripartite-class Minehunters in the 1980s (in the RNLN, Tripartites are known as the Alkmaar class). The yard tried to retain its naval expertise during the early 1990s, while still hoping to receive the order for the so-called Troika minesweeper system, which had been postponed several times. The order did not materialize and in spite of having been taken over in 1997 by IHC-Caland, Van der Giessen de Noord had to close down in 2003. This meant the end of a systems integration capability for building advanced mine countermeasure systems.

Alkmaar-class minehunter HNLMS *Schiedam*. (Wikimedia Commons)

But this was not all. In the 1990s, De Schelde, the main yard for building the RNLN's frigates and other large naval surface vessels, ran into financial problems. One cause was heavy losses in the construction of an amphibious warship for the RNLN.[91] While still building four new Air Defence and Command (LCF) frigates, De Schelde, the last remaining Dutch naval yard, nearly went bankrupt. This would have been a disastrous blow to the Dutch

91 See "Zr.Ms. Rotterdam," *Marineschepen*, https://marineschepen.nl/schepen/rotterdam.html#bouw.

naval industry and its systems integration capabilities. Not surprisingly the RNLN did everything possible to preserve this yard and its expertise. Finally, in 2000, the yard was saved through a takeover by newcomer Damen Shipyards, with substantial financial support from the Dutch government – some 50 million Euros in loans and gifts as well as an order from the RNLN for two hydrographic survey vessels.[92]

With the entrance of Damen Shipyards, the structure of the naval production and innovation system (NP&TS) changed, in terms of actor composition and in the way naval business was conducted. The entrepreneurial Damen Shipyards, specializing in building small commercial ships, had entered the naval market in the 1980s by successfully building fast patrol and attack craft, mainly for the export market. With Damen, a different business culture made its entrance into Dutch naval shipbuilding. By contrast to the entirely naval, RNLN-oriented yard De Schelde, Damen had a strong commercial focus and was successfully exporting patrol vessels and corvettes. In particular, the vessels based on Damen's SIGMA concept, using a modular design which offers the user great flexibility at reduced costs, were less costly than RNLN's complex frigates. Damen was also actively looking for synergy between its naval and civil shipbuilding activities and cooperated with foreign yards (in Romania and Southeast Asia) to reduce construction costs. The net effect was that Damen was less dependent on the RNLN than the previous shipbuilders.

3.3.4 Shifting Role of the RNLN: From Co-Designer Towards Lead-User and Coordinator in Naval Systems Integration

Until about 2000, the RNLN employed four main strategies: i) legitimating a sizable and modern fleet countering sceptical actors (allied nations or the Dutch Parliament); ii) setting requirements and stimulating the provision of knowledge inputs to the system; iii) provision of supporting processes, such as financing yards and changing procurement schedules in order to prevent gaps in production of new warships; and iv) maintaining design capability for warships (including SEWACO software) and orchestrating a network of suppliers and integrators (that is, the "two faces" of systems integration). The limits of these strategies became clear around 2000, however, when the RNLN failed to save the systems integration capability for building next generation submarines and mine combat vessels. The RNLN's existing systems integration knowledge, though insufficient for building such vessels, would nevertheless be essential for midlife upgrades of the current submarines and minehunters to extend their in-service time. The RNLN preserved the capability for that purpose and in case future changes in policy should require construction of

[92] Tweede Kamer, "Brief Minister Van Defensie over Project Hydrografische Opnemingsvaartuigen. Kamerstuk 28000-X, No. 23" (The Hague, 2002).

these types.

The capabilities of the RNLN as systems integrator are clearly visible in the construction of a new supply ship (JSS) for the RNLN by prime contractor Damen Schelde Naval Shipbuilding. Thales Netherlands again became the main contractor for the sensor and communication suite. Working together, the RNLN was involved in the design of the vessel and, through the involvement of the RNLN's software house CAMS Force Vision, in the supply of the combat management system. The participation of CAMS was seen as a key strategy because a combat management system always needs to be integrated with the hardware (sensors, weapons, operating stations).[93]

3.4 2015 Onwards: A Renewed Future for Systems Integration Capabilities?

From 2015 onwards the international security environment changed which led to discussions on a renewal of the fleet and on the importance of systems integration capabilities within the defence sector in general. Successful export activities of Dutch lead systems integrators assured the continuation of these capabilities. For an overview of the dynamics, see table 4.

Changes in structural components & systems integration	Role RNLN in key activities in the system	Supporting / limiting factors for strategies RNLN
Systems integration capabilities maintained for surface warships and SEWACO International collaboration for building new submarines, but no substantial role in systems integration.	Successful legitimation renewal of the fleet Formulating requirements for surface warships and submarines.	+ changing security environment + increase defence budget + domestic defence industry policy

Table 4. Summary of dynamics, 2015-2024.

3.4.2 Changing Conditions for the Naval Industry

Around 2015 the international security situation deteriorated due to increasing tensions between NATO and Russia following the annexation of the Crimea, between the USA and Iran, as well as between the USA and China. New financing and defense industry policies opened up opportunities for strengthening the Dutch naval production and innovation system, in particular its systems integration capabilities. The budget of the Ministry of Defence

93 "Kamerstuk 25800, Nr. 23" (The Hague, 2009); "Kamerstuk 25800, Nr. 24" (The Hague, 2009).

RNLN fleet	1964 num.	1984 num.	2005 num.	2020 num.	in service between	Yards involved
Major Warships						
Aircraft carrier Karel Doorman	1				1948-1968	from UK Royal Navy upgraded 1955-1958 by Wilton Fijenoord
Cruisers: **De Zeven Provinciën** **De Ruyter**	2				1953-1975	RDM (1) Wilton Fijenoord (1)
Destroyers: **Holland Class (4)** **Friesland Class (6)**	12				1954-1982	De Schelde (4) NDSM (4) Wilton Fijenoord (2) RDM (2)
(Larger) Frigates	12				1945-1967	NDSM (1) Smit (1) Ex-UK (4) MDAP* (6)
Van Speyk Frigates		6			1967-1989	De Schelde (3) NDSM (3)
Guided Weapons (GW) Frigates		2			1975-2001	De Schelde
Standard (S) Frigates		10			1978-2003	De Schelde (8) Wilton Fijenoord (2)
Air defence (L) Frigates			2		1986-2005	De Schelde
Multi-purpose (M)Frigates			8	2	1988-2009 (six) 1993- (two)	De Schelde
Air defence and Command (LC) Frigates			4	4	2001-	Damen Schelde Naval Shipbuilding
Ocean Going Patrol Vessels(OPV)				4	2012-	Damen Schelde Naval Shipbuilding
Submarines **T-Class** **Guppy Class** **O24 & O27**	6				1945-1960s	borrowed from UK (2) borrowed from USA (2) RDM (2)

Three Cylinder Submarines		4			1960-1992	RDM (2) Wilton Fijenoord (2)
Zwaardvis class Submarines		2			1971-1994	RDM
Walrus class Submarines			4	4	1990-	RDM
Landing Platform Dock (LPD) Amphibious Transport Ship			1	2	1998-	De Schelde (1) Damen Schelde Naval Shipbuilding (1)
Joint logistic Support Ship (JSS)				1	2018-	Damen Schelde Naval Shipbuilding
Minesweepers/ hunters	64				1945-1960s /1980s	about half built in USA, other half in The Netherlands
Tripartite class Minehunters		7	15	6	1983-2009 (nine) 1986- (six)	Van der Giessen de Noord

Table 5. RNLN's major warships and the yards involved in building them. (*MDAP is the Mutual Defence Assistance Programme, a post-WWII program in which the US supplied European countries.)

was increased, in particular for improving the relatively poor situation of the material of the Dutch Defense Forces, including the RNLN. Thus, the needs and requirements of the RNLN's fleet and task were to be revised, once again. Interestingly, systems integration was explicitly mentioned in the new defense industry policy issued in 2018.[94] The new policy set out in this document allowed for domestic procurement of material. In particular, the policy aimed to maintain and strengthen the domestic naval shipbuilding sector, referring among others to Damen Schelde Naval Shipbuilding, MARIN, and Thales Netherlands. Platform design and integration capabilities, including SEWACO, should have a strong domestic base. Subsystems, like propulsion and energy systems of warships could be acquired from the market when fitting the RNLN's design and requirements of the ship. In supporting a strong domestic defence industry for the military forces, the RNLN should play a role as *launching* customer of innovations in naval vessels and domestically produced equipment. This policy fits well with the RNLN's philosophy on design, systems integration, and construction of its warships. Thus, the

94 Ministry of Defence and Ministry of Economic Affairs and Climate.

RNLN's plans for the future as formulated in the Defence White Paper of 2018 aimed at reinforcing its fleet not only for carrying out expeditionary tasks, but also (again) for anti-submarine warfare.[95] Table 5 is an overview of the fleet composition of the RNLN since 1945.[96]

3.4.3 Future Outlook: Maintaining and Partly Regaining Systems Integration Capabilities

The Dutch government's response to the changing international security environment has created opportunities to maintain systems integration capabilities. However, since the early 2000s there has been a shift in the traditional role of the RNLN as not only a user but also as designer of warships and as systems integrator, from smart developer to smart specifier or smart customer.[97] The exception is SEWACO systems for which the RNLN wants to remain a smart developer. This is evident in a number of acquisitions for the RNLN that are now under consideration.

Belgium and the Netherlands are now jointly procuring new Mine Combat Vessels and Anti-Submarine Warfare (ASW) Frigates. As the Dutch yards have lost their systems integration capability for advanced minehunters, the MCMs have to be acquired abroad. Belgium, as the leading country, has chosen the French Naval Group as prime contractor of the MCMs, which will design and construct the MCMs, including all systems integration.[98]

By contrast, in the joint acquisition of the four ASW Frigates, in which the Netherlands is leading, Damen Schelde Naval Shipbuilding and Thales Netherlands will be the prime contractors, working closely together with the RNLN on design and requirements, thereby avoiding the general European rule of open tendering by an appeal on article 346 of the Treaty on the Functioning of the European Union.[99] Thus the conditions for upkeeping and expanding systems integration capabilities within the naval production and innovation sector for large surface combatants remain favourable. The influence of the RNLN's contribution should be seen in context, however. Damen has also been contracted by the German government for the delivery of new frigates, in which Thales Netherlands also participates. Moreover, Thales Netherlands delivers systems and systems integration for new frigates for the United Kingdom. The export success of systems integrators makes them less dependent on the RNLN. The RNLN therefore has a less dominant role in

95 Ministry of Defence, "Defensienota" (The Hague, 2018).

96 A more complete survey can be found at https://www.orbat85.nl/order-of-battle/royal-navy/royal-navy.html#survey-ships; https://marineschepen.nl/schepen/marineschepen-nederland.html; and in Naval Institute Press, *Conway's All the World's Fighting Ships, 1947-1995*.

97 Ministry of Defence and Ministry of Economic Affairs and Climate.

98 See Ministry of Defence, "Internationale Militaire Samenwerking. Kamerstuk 3279, No. 29" (The Hague, 2019).

99 See Tweede Kamer, "Kamerstuk 27830, Nr. 307" (The Hague, 2020).

orchestrating the upkeep and development of systems integration capabilities than it had when firms were less successful in the export market.

The substantial increase of the Dutch defence budget after the 2022 Russian invasion of the Ukraine created financial room for continuing the RNLN's submarine task, which was then still under debate among Dutch defence experts.[100] Thus the acquisition process for the successor of the Walrus-class submarines could go on. The RNLN was actively influencing this process by shaping the demand-side of the production of the submarines.[101] Damen Schelde Naval Shipbuilding lobbied for a joint consortium with the Swedish submarine builder Saab-Kockums. In March 2024, however, the Dutch government awarded the design and construction of four new submarines to the French Naval Group and not to the consortium Saab-Damen.[102] The Naval Group had agreed to involve Dutch knowledge institutes and maritime companies, like Royal IHC and RH-Maritime, as subcontractors for developing and building parts and subsystems. By contrast, in the Saab-Damen consortium, Damen would, as a partner, become more involved in systems integration and construction of the submarines.[103] The governmental decision had to be approved by Parliament in its role as a "critical actor." Though a number of political parties preferred the Saab-Damen combination, believing that it would be more favourable to the Dutch (naval) industry, Parliament voted in support of the governmental decision.[104] It implies that the Dutch naval shipbuilding network will not re-acquire the systems integration capability that got lost through the bankruptcy of RDM in the 1990s. The long-term viability of such a capacity, however, would have been doubtful because of its dependency on future export orders in a highly competitive market.

4. Conclusions

According to the Ministry of Defence the origin of the Dutch Navy dates back to the fifteenth century. During the consecutive centuries it has protected the Dutch merchant fleet on a global scale and fought many naval wars. The

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100 "Motie. Toekomst Van De Nederlandse Onderzeedienst. Kamerstuk 34225, No. 18."; "Verslag Van Een Rondetafelgesprek over Defensie. Kamerstuk 34775-X, No. 68" (The Hague, 2018); and Colijn, "Laat De Marine Niet Meer Wereldwijd Opereren: Is Te Duur."

101 A lengthy negotiation process had started with four possible foreign candidates, in which *Damen Schelde Naval Shipbuilding* is the envisioned Dutch partner yard. These are the French Naval Group, the German ThyssenKrupp Marine Systems, the Swedish Saab Kockums, and the Spanish Navantia. See Tweede Kamer, "Kamerstuk 34225, Nr. 24" (The Hague, 2020b).

102 "Wat we nu weten over de nieuwe Nederlandse onderzeeboten," *Marineschepen*, 18 March 2024, https://marineschepen.nl/nieuws/Wat-we-nu-weten-over-de-nieuwe-Nederlandse-onderzeeboten-160324.html.

103 "Vervanging onderzeebootcapaciteit," *Tweede Kamer*, 3 June 2024, https://www.tweedekamer.nl/debat_en_vergadering/commissievergaderingen/details?id=2024A03222.

104 "Tweede Kamer, 82e vergadering Dinsdag 11 juni 2024," *Tweede Kamer*, https://www.tweedekamer.nl/kamerstukken/plenaire_verslagen/detail/2023-2024/82.

successful resurrection after World War II of the Royal Netherlands Navy and the naval shipbuilding sector cannot be separated from this historical perspective which has become part of the Netherlands' national identity.[105]

Our study found that the Royal Netherlands Navy employed various strategies to shape the re-development of its fleet and its main suppliers, together constituting a domestic naval shipbuilding industry capable of systems integration of the RNLN's complex warships. We identified three main strategies: 1) by formulating requirements for complex product systems that require advanced systems integration; 2) by stimulating the generation of knowledge which supported the development of systems integration capabilities; and 3) by supporting or contributing to what is called in the literature constituents for innovation, such as financing yards, adapting delivery schedules to continue workload and capacity at firms, and organizing its own systems integration capabilities.

We conclude that the RNLN was influential in shaping the Dutch naval shipbuilding sector through its role as a systems integrator, and by stimulating the development of systems capabilities in industry and research institutes. That said, we found that the RNLN could have a large influence on the sector: a) as long as the RNLN's claims were seen as legitimate and could count on

Artist impression of Anti-Submarine Warfare Frigates. (Ministerie van Defensie)

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[105] Such an identity emerges, for instance, from a canon of Dutch maritime history, composed by J. Korteweg in cooperation with the Maritime Museum Rotterdam. Korteweg, ed. *Maritieme Geschiedenis. De Canon Van Ons Maritiem Verleden in 50 Vensters* (Zutphen: Walburg Pers, 2009).

broad political support for an ocean-going navy, in particular from the "critical actor" Parliament; b) because of its own knowledge as designer and systems integrator; c) through its ambitious and entrepreneurial (and sometimes opportunistic) attitude; d) through the strong interdependencies between the Navy and the supplying firms and knowledge institutes; and e) by affordances generated in the external security environment, such as security threats and the willingness of foreign countries to collaborate.

Examining the actions and strategies of the RNLN to influence the development of systems integration capabilities has provided us "a window on the world" of Dutch naval shipbuilding and its restoration since 1945. How should we assess the re-development of the sector since 1945? First, whereas one might expect a strong hierarchical, government-driven mode in the restoration of the industry, given the complex product systems character and the defence character of the industry, our study rather revealed a network mode of dynamics, a mode where no single actor could fully control developments. In figure 2 we situated the RNLN as the spider in a network with a layered web structure where the navy, definitely in the post-war period, but increasingly less in the years after the ending of the Cold War, would take the role of a "dedicated network builder" orchestrating the composition of the network, as well as the actions and interactions within it. As mentioned, this does not mean that the RNLN was fully in control. Commercial success and failures, globalization, and changing geopolitical dynamics loosened or strengthened the ties between companies, knowledge institutes, and the RNLN. Systems integration capabilities for designing and building submarines got lost when the shipyard RDM went bankrupt by a combination of lack of orders from the RNLN and international customers for a next generation of submarines, and mismanagement. Similarly, systems integration capabilities for advanced mine combat vessels disappeared because of a lack of orders for a new counter-mine capability, followed by the bankruptcy of the specialized shipyard Van der Giessen de Noord.

Secondly, what became clear from our empirical study is that rebuilding both fleet and shipbuilding industry is not an unambiguous process, but marked by changing objectives and opportunities, like the evolution from an ocean-going navy with large combatants, to specialized medium-sized combatants consisting of frigates and submarines, to keeping up a sizeable fleet with new tasks, including amphibious warfare. This was not a straightforward story of demand and supply, as it became clear from our study that allied countries would not always supply the RNLN with the required ships. To a certain extent this forced the navy and the sector into domestic innovation and construction activities, as long as a favourable domestic political climate existed. In addition, technological change (see also below) and changes in military doctrine affected the preferred composition of fleet and industry.

Thirdly, and related to the previous two points, the re-development of the industry did not imply a reconstruction of all activities necessary to innovate and construct warships. We observed a pattern of specialization. The re-development focused on developing, maintaining, and expanding knowledge on warship design, and integration of sensor, weapon, and command systems, as well as integration of several electronic auxiliary systems. Restoration then was not solely or predominantly the rebuilding of yards, but rather the development and maintenance of systems integration engineering (which to some degree occurred at the yards). We suggest that the restoration of the shipbuilding industry thus had a specific focus and was partial, but effective in acquiring the ability to construct complex vessels domestically.

The development in close tandem of defence electronics and systems integration capabilities were especially important. Starting in the 1960s, with the emergence of electronic and computer controlled naval weapons systems, warships became really complex product systems (CoPS) and advanced Systems Integration capabilities became indispensable. The RNLN itself developed a capacity for the integration of sensors, weapons, and communication systems (SEWACO), both technically and organizationally, to be used in the construction of modern warships. By formulating the requirements for the new generations of naval vessels, the RNLN further stimulated the generation of systems integration capabilities by the above-mentioned prime contractors R&H and Thales. Systems Integration became also a core capability and an important business strategy of these companies.

Whereas in major naval countries defence electronics companies rather than shipyards were to become prime contractors in naval shipbuilding, implying a central concentration of naval systems integration capabilities at such companies, the situation in the Netherlands developed differently. Naval systems integration capabilities became distributed over the main actors collaborating in the Dutch NP&TIS network, including the RNLN, Rietschoten & Houwens, Thales Netherlands, and the major naval shipbuilding yards.

Considering the changing geo-political situation, the revival of shipbuilding and systems integration capabilities after World War II, and the RNLN's approach to fleet development in recent decades, we speculate that specific systems integration capabilities related to new technological capabilities and defence needs may be developed by the Dutch shipbuilding industry in the future. In view of the pressure for a more efficient European defence industry this may well happen through international collaboration. As before and after WWII, the acquisition and loss of systems integration and naval shipbuilding competences may have a cyclical nature. This holds particularly true when the historically developed legitimacy of a strong naval shipbuilding capacity remains in place and supports entrepreneurial customers and suppliers of complex product systems such as warships, like the current Dutch commitment for building surface warships domestically.

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