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Original article

Requirements engineering as the foundation for the success of substantial shipbuilding projects

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INFORMATIONS

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ABSTRACT

The paper presents the general principles of requirements engineering with particular attention for the requirements specification presented on the example of an ambitious national program for the fleet expansion of the Polish Navy. The introduction outlines the origins of requirements engineering and its strong relationships with software engineering. It appears that most large IT projects usually struggle to meet the precisely formulated criteria of requirements engineering, which results in the tremendous waste of project resources. Next the concept of requirements and good practices in the preparation of requirements specifications is formulated. Later the example of the 15-year history of the Polish Gawron-class corvette, Project 621, is used to illustrate how systematic violations of the cardinal principles of requirements engineering and disregard for regulations can lead to major losses and consequently to suspending the whole project. An emergency solution was planned to conduct the thorough modification of the project so as to complete this very costly investment (about PLN 1 billion) and construct a much weaker patrol vessel – Ślązak, Project 621/M.

The main research thesis can be limited to the statement that amateur and improvised requirements specification in the case of a large shipbuilding project, which was mainly based on socio-political needs, leads directly to the collapse of the project and significant material losses accompanied by the painful embarrassment of state bodies on an international scale.

KEYWORDS

engineering, requirements, design, ship, deadlines, costs

Introduction

The notion of requirements engineering is formally derived from the IT sector (*Information Technology*) or, more precisely, it is related to the original computer software engineering whose professional applications date back to the end of the 60's of the 20th century. Both Software Engineering and its derivative Requirements Engineering belong to the praxeological tools of contemporary informatics developed to support and improve the increasing mass production of computer software, especially operating systems which successively grow in size, complexity and the number of functionalities. For the purpose of improving the efficiency and reliability of complex computer programmes, the already verified concepts and procedures originating from daily engineering practice were used. In this sense the general methodological foundations of engineering – the practical art of design, the implementation and usage of real products [Ficon 2010] – gave birth to a new category in engineering applications, i.e. software engineering [Gorski 2000] and later requirements engineering [Wiegers and Beatty 2014].

Engineering understood as the universal, practical art of constructing useful material (technical) and non-material (system) products is formally derived from classical military engineering which gave beginning to contemporary land engineering [Ficon 2010]. Currently engineering methods, technologies and standards are successfully used in nearly all scientific disciplines and the areas of economic and social life. In this sense, the approach based on the principles of pragmatic engineering stimulates the development of science and technology as well as the civilizational progress of contemporary societies. Such a practical engineering approach is a guarantee that final projects and products have the required functionality and usability, and they also meet the highest safety and reliability standards.

It is characteristic that in informatics unreliableness and the failure rate of complex computer software are quite high and this situation resulted in the necessity to make the process of software development more efficient thanks to the use already practically verified engineering tools and methods [Ficon 2007]. Software development practice showed that the implementation of software engineering standards and detailed methodologies only partly contributed to the improvement of the quality and usability of software products. This is why at the turn of the 80's/90's new engineering tools started to be used to develop the requirements engineering standards which, from the methodological perspective, precedes software engineering, and thus also organizes a wide spectrum of initial assumptions forming the basis of software development work. The main goal of professional software development is "creating good quality software in a timely manner and within the planned budget to meet the actual needs of a client" [Leffingwell and Widrig 2003]. The most important criterion are "the actual needs of a client" which directly refer to the specification of particular requirements which have to be satisfied by an ordered product.

The advanced methods of requirements engineering, which initially were developed for the needs of software engineering, have recently been applied in numerous areas outside the preferred IT sector, particularly in other engineering categories, such as land, mechanical, electrical, chemical, genetic and extreme engineering [Ficon 2010]. It occurred that in all engineering projects the problems related to defining and specifying a coherent set of initial assumptions, whose formal image is requirements specification being the base for the design and construction work at the later stages of the conducted engineering undertaking, were similar. The great social significance of the optimum solution for the problem of requirements specification as well as the necessity to undertake a scientific approach in the search for such a solution resulted in the creation of a separate category in requirements engineering which today encompasses all sectors of engineering and also other types of activity. One has to agree with the opinion that "…requirements engineering has a significant and direct influence on project objectives, the approach to its implementation and construction" [Chrabski and Zmitrowicz 2014]. Currently requirements engineering appears to be a universal research procedure supporting the design of any systems, applications, industrial and commercial products in various areas of social and economic reality.

1. Subject matter and attributes of requirements engineering

Initially requirements engineering was considered a subcategory of well-structured software engineering, while currently this approach seems to be significantly outdated because it is widely used mainly in all engineering projects and has become a certain standard, aside from risk analysis it is used in every complex project undertaking [Ficon and Krasnodebski 2009]. This thesis is confirmed by the requirements engineering definitions listed below:

– requirements engineering is a relatively new term coined to give a name to all actions related to the acquisition, documentation and maintenance of a set of requirements for a computer system [Boehm and Papaccio 1988],
– requirements engineering describes the requirements acquisition, documentation and maintenance scheme, and its implementation aims at the minimisation of possible negative consequences of the implementation of the whole undertaking [Wojciechowski 2012],
– requirements engineering is a process which allows to identify all limitations and requirements of the future system [Wojciechowski 2012],
– requirements engineering encompasses numerous tasks, starting with the definition of the sources of requirements and finishing with the analysis and specification of requirements for the purpose of ensuring quality control [Chrabski and Zmitrowicz 2014],
– requirements engineering is the process of defining, documenting and managing the requirements which should be met by software [Sommerville and Sawyer 1997].

In the context of the above definitions the word 'engineering' should be interpreted as a systematic and repetitive technique which ensures that requirements specification is complete, coherent and suitable for actual needs [Ficon 2010]. The perfect use of the rules of requirements engineering may significantly facilitate the achievement of goals, i.e. the delivery of high quality products to users in time and within the established budget, by the executive team.

The starting point for requirements engineering is usually a design and construction problem which determined a specific goal of an action and the need to find a solution. A signalled problem situation (related to design and construction) defines what needs to be achieved, at that moment without going into implementation, organisation, technology or technique related details. At this stage the focus is the identified need, usually a real and material one. The initially defined problem can be effectively solved using a certain engineering implementation, e.g. a professionally conducted project with its practical implementation. The final product (project, goods, services) must meet particular requirements, mainly functional ones included in requirements engineering which has a formalised form in engineering projects.

The scope of requirements engineering encompasses two principal stages: the preparation and development of detailed requirements and active management of these requirements [Chrabski and Zmitrowicz 2014]. The first stage of the preparation and development of detailed requirements comprises 4 sub-stages (Fig. 1):

– sourcing requirements on the basis of the set of actual needs introduced by the user to the developed system (product) as a result of direct consultations between the subcontractor and the user,
– analysis of specified requirements with regards to their significance so as to establish priorities and the urgency of implementation,
– detailed specification of principal requirements with their characteristics and the generation of documentation in the required form,
– requirements validation with regards to their completeness and coherence with e.g. the market and usage vision of the undertaking (product).

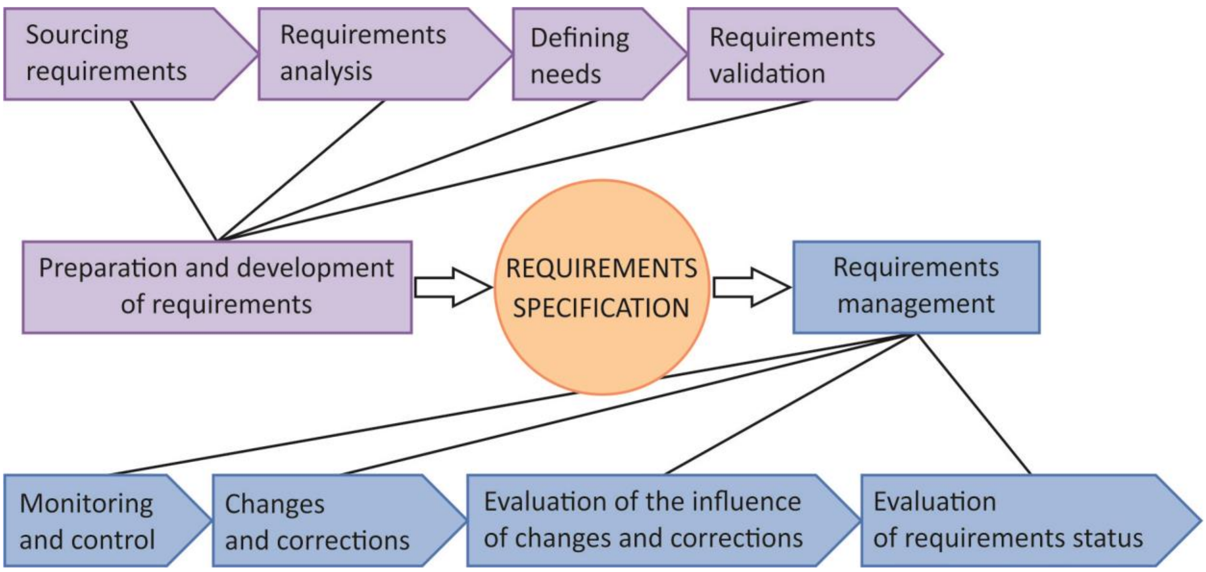

Fig. 1. Principal stages and sub-stages of requirements engineering

The positively completed stage of requirements preparation is the basis for the operational management of requirements at further stages of the implementation of a given undertaking (project, programme). At the stage of requirements management it is necessary to consecutively use the following procedures:

– monitoring and control of the implementation of particular requirements,
– introduction of changes ad corrections if need be,

– evaluation of the influence of changes and corrections on project implementation,
– evaluation of requirements status and the degree to which they are completed.

The stage of requirements management is very important for the quality and usefulness of the end product as well as its practical suitability to the needs of a given user. As is known, when it comes to prototype products, and each newly developed IT system or innovative engineering project, etc. is such a prototype, even the most precise requirements specification needs flexible management due to various exceptional ad hoc situations which may occur dynamically. It turns out that even the most perfectly prepared and developed requirements may need to be corrected due to, e.g. the introduction of new technologies, changes of priorities, time pressure, fierce competition, budget restrictions. According to the Standish Group the most common reasons for project failures are the continuous changes of requirements resulting from the changing client's goals, the lack of clearly defined organisation needs and plans as well as incomplete and incompetently defined requirements [www.standishgroup.com]. It is known that each complex, praxeological system has to be sensitive to the flexible compensation for various chance events and changing goals appearing at a specific moment in system implementation. This task should be consciously and rationally approached at the requirements management stage in complete symbiosis between the client and the contractor.

2. Notion and categories of requirements

IEEE (*Institute of Electrical and Electronics Engineers*) defines the key notion in requirements engineering, namely the 'requirements' as [*IEEE Standard*… 1990]:

– condition or possibility necessary for the user to solve a problem or achieve a particular goal,
– condition or possibility which must be embedded in a system or its component so as to meet the conditions of an agreement, standard or another formal document.

On the other hand, I. Sommerville and P. Sawyer define requirements as "…the specification of what should be implemented in a system, i.e. how the system should behave and what properties it should have" [Sommerville and Sawyer 1997]. In more general terms the above requirements can be considered the properties which are essential from the user's point of view. The collection of these properties can be extended in a random way and can also encompass very special, personalised categories which are significant from the perspective of a given user. The significance degree (value) of particular requirements is related to the subjective preference criteria used by a given user in their business, production, social or market strategy. B. Chrabski and K. Zmitrowicz observed that "…requirements not only determine the final product of an undertaking, but they can also clearly and directly impose certain implementation rules and project restrictions" [Chrabski and Zmitrowicz 2014].

Generally requirements can be divided into two basic groups encompassing: functional and non-functional requirements. The former specify the basic functions to be performed by the system to achieve a set goal. The performance of particular functionalities is a necessary condition to accomplish the system mission and satisfy its strategic needs. The latter do not have a direct influence on system functionality, however, they impose additional conditions and restrictions which should be met by the system. For instance, these conditions may refer to the particular reliability degree of system operation, the achievement of high quality indices, limitation of the use of resources, the use of a particular technology generation, green standards, etc. (Fig. 2).

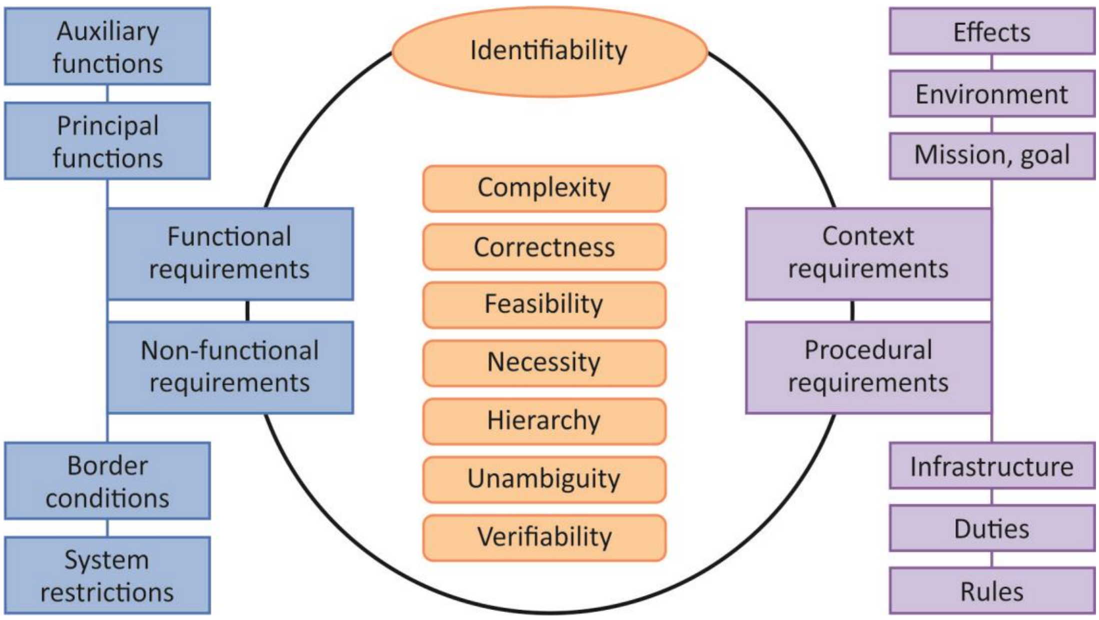

Fig. 2. Classification criteria and utilitarian features of requirements

A particular type of requirements is the "other" category which may encompass the so called Context and Business Requirements (Case Studies) as well as Procedural Requirements. The context requirements are formed at a general level and refer to the goal of a given undertaking set in its mission, e.g. market or technological one formulated by the client or end-user. The aim is providing a clear answer for a few key questions [Tabaszewski 2010]. Why does the user need this particular solution (system, product, service)? In what way will the introduction of a new application (technology) influence the functionality standards of a given company? What effects and benefits are expected by the user form the applied system? A good practice in this respect are various graphic schemes, roadmaps, milestones or scenarios which can outline the goals, tasks and visions of the implemented solution in a communicative way. The procedural requirements refer to user's duties resulting from system (product) implementation. An attractive way of presenting these duties is a graphic form, e.g. a roadmap with a suitable commentary.

All functional and non-functional, context and procedural requirements should be included in a special document *Requirements Specification* which is a binding document for all entities participating in a given undertaking, and first of all for the client and the contractor. To some extent it is also important to end-users, partners and subcontractors.

With reference to the form of *Requirements Specification* there are many ways and conventions of presentation in this respect and there is no one universal standard for all users and all developed applications. A specification prepared for a newly developed IT system is different from one made for a civil engineering project, a complex industrial installation or an innovative ship project. Depending on the type of undertaking the dominant provisions and conventions will be the ones suitable for programmers, designers, engineers, architects, entrepreneurs, financial specialists, managers, respectively.

It is very difficult to conduct an *ex ante* assessment of the level of details in the Requirements Specification and its substantial scope, volume, used notation, etc. It is advisable to make attachments and annexes to expand the knowledge on particular requirements. The editorial format of specification depends on the adopted form of communication between the contractor and the user and their mutual acceptance for particular cooperation forms. As it has already been signalled none Requirements Specification should be either completely unflexible or flexible because in extreme cases it is easy to provoke conflicts and misunderstandings between the client and the contractor. Such problems were especially serious in the above discussed the Polish Gawron-class corvette, Project 621. Certainly the flexibility level of the specification cannot jeopardise its completeness, coherence and its key role in the formulation of initial assumptions for a developed project. In no case should it be the reason for the destruction of the adopted concept of requirements specification or an excuse the change of budgetary or time resources [Mierzejewski n.d.].

In the primary sources there are certain already developed general guidelines for the construction of Requirements Specification especially in terms of the attributes of particular requirements [Wiegers and Beatty 2014]. For instance, in the case of IT projects there are the international standards of the development of *Software Requirements Specification* [*IEEE Recommended*… 1998]. Each requirement essential for the project should be described using a certain set of characteristics and possess such properties as: completeness, correctness, feasibility, necessity, priorities, unambiguity and verifiability. Simultaneously each requirement should be attributed an unambiguous identification symbol (descriptive label) which allows to establish its system position in the requirements set and in hierarchy according to a certain system of priorities. A very important characteristic of the specification is showing mutual connections between particular requirements and their influence on the progress of project implementation. A special square relationship matrix was proposed for this purpose, it has the same number of rows and columns as the number of specified requirements [Sommerville and Sawyer 1997]. At the intersection of two requirements, e.g. Wi × Wj there is an arbitrary symbol depicting, e.g. the degree of mutual correlation and interdependence between both requirements. Most frequently the used interdependence scales are individually selected to meet the needs of each project and the adopted cooperation rules between the client and the contractor.

3. Preparation rules of requirements specification

Most of software development methodologies locate the requirements specification stage at the very beginning of conceptual work preceding the other design and technology related stages. The classical creation scheme of a new engineering product, in particular software, encompasses 4 basic stages: design, manufacturing (constructing), implementation and exploitation [Tabaszewski 2010]. The initial basis of the whole undertaking is the specification of the actual requirements of the end-user for whom a given product is developed. This logic and order of events are binding not only in software and computer applications development sector, but also in all commercial, engineering and industrial, civil engineering, manufacturing and service projects, including business and managerial ones.

If the initial assumptions are not sufficiently precise and user expectations are not clearly defined, there is no guarantee that these expectations will be met and the usability of the implemented project (product) is decreased. The most important stage of each engineering (production) undertaking is its completeness and the full adequacy between initial assumptions and the final expectations and requirements of the client. The ordered final product must be tailored to the needs of the client. This is why these needs and requirements must be precisely and completely specified at the very beginning of the design process [Cempel 2008].

Commissioned project implementations should refer to the condition of meeting all quality and functionality criteria by defined by the end-user at the beginning. Otherwise it will be necessary to introduce various changes and modifications, which results in additional financial costs and other investments in time and materials, costs of guarantees and complaints, etc. Various modifications and changes resulting from discrepancies between initial assumptions and design requirements disorganise the planned product life cycle and decrease its usefulness. Too general or, what is worse, incorrect and usually also incompetent and incoherent requirements specification poses a threat to the success of the whole project, which disorganises the design and construction work and may incur additional costs. According to some estimates the correction of errors in requirements specification at the stage or project implementation may result in additional costs of about 30 to 70% of the planned budget [Wojciechowski 2012].

The problem of requirements can influence the quality of the final product in two ways [Tabaszewski 2010]. Firstly, requirements specification may be incomplete, incoherent and too general, which handicaps the client and the author of requirements. Secondly, correctly prepared requirements were not taken into consideration with due diligence at the design stage and the manufacturing of the final product, which handicaps the manufacturer (contractor). In both cases there is an urgent need to introduce the necessary changes in the design, construction and exploitation to prevent interferences in the product lifecycle although the consequences for particular entities participating in the undertaking may vary.

If the manufactured final product does not meet the expectations of the client, the value of such a product is decreased and it cannot be fully implemented and exploited before the necessary changes and corrections are made. This is why in engineering practice there is a trend to detect possible discrepancies and inaccuracies between the product and requirements specification as early as possible, at the initial stages of design and construction work because then the potential costs of the introduction of corrections is decreased [Pihowicz 2008]. The costs of repairing errors at the requirements specification stage grow exponentially with the stages at which they are detected. For the purpose of minimising these outlays, it is necessary to identify defects at the earliest stages of their occurrence. The earlier the discrepancies and inaccuracies between the product and requirements specification are diagnosed in design and construction processes, the smaller the consequences and costs of their elimination borne by all participants of the project.

4. Outline of requirements specification for Gawron-class Corvette, Project 621

An exceptionally educational example of a recklessly conducted process of developing requirements specification, also dominated by social and political considerations, characterised also by the lack of respect for the cardinal rules requirements engineering, is a well-known on a national scale case of an the ambitious programme of the modernisation of the Polish Navy fleet, the Polish Gawron-class corvette (Project 621pk.) conducted without any appropriate requirements engineering standards which has cost over PLN 1 billion in the last 15 years. The Gawron Programme concerned building a series of (7/5/2/1) modern corvettes in the Polish Navy Shipyard in Gdynia [Zagorski 2015].

Nowadays popular corvettes made for contemporary war fleets are designed as multitask ships which, regardless of their small size and displacement, are characterised by an extensive set of armament and deck equipment whose combat capability is increased thanks to automated command and combat assets management systems. The most important advantages of these vessels are [Solkiewicz 2012]:

- high maneuverability, high speed, seakeeping, tactical autonomy and multitasking,
- strong long-range cruise missile armament, the number of anti-ship missiles was comparable with their number on the frigate and destroyer class ships,
- possibility to strike in cooperation with other types of naval forces (aviation and naval missile units),
- multitasking allowing to strike waterborne, submarine, and air targets as well as stationary land objects,
- expeditionary capabilities (force projection) and possibility to eliminate asymmetrical threats in coastal regions.

Such vessels can perform tasks analogical or similar to the ones performed by much larger frigates or destroyers, and hence their action can cover over 80% of Task Areas according to AJP 3.1 (*Allied Joint Maritime Operations*).

The basic assumptions and tactical and technical data of the Polish multipurpose corvettes Gawron-type, Project 621 (as of 2001) were as follows (Fig. 3):

– MEKO A-100 licence granted by the Blohm und Voss shipyard in Hamburg.
– investor: Ministry of National Defence / Polish Navy
– contractor: Polish Navy Shipyard in Gdynia
– ship hull manufacturing technology: stealth.

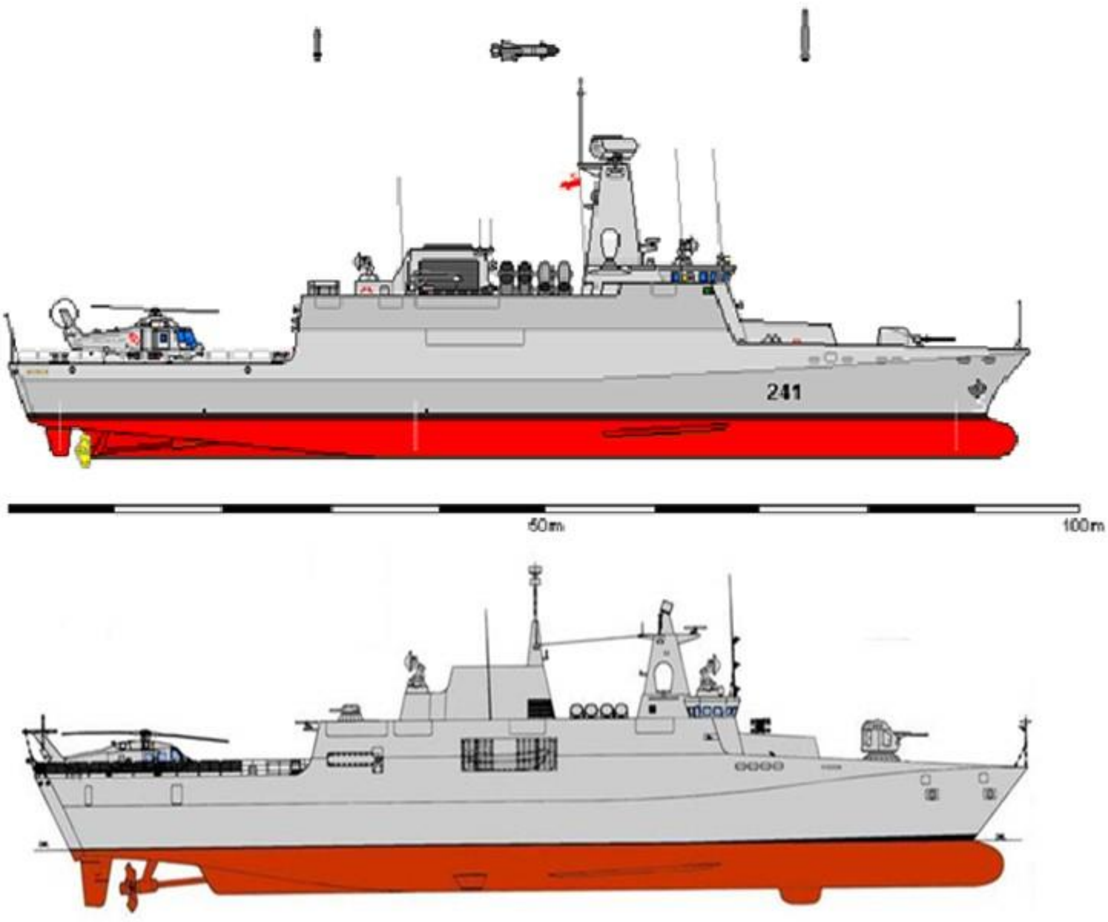

Fig. 3. Progressive changes in the requirements specification of Gawron, Project 621
Source: [https://www.google.pl/search?q=orp+%C5%9Bl%C4%85zak&biw=1536&bih=778&tbm=isch].

Tactical and technical data:

– Displacement: standard – 1690 ton, full – 2100 ton,
– Length: 95.2 m. Width: 13.3 m. Draught: 3.5 m,
– Drive – 2 compression-ignition engines, 1 gas turbine,
– Speed: max – 30 knots, optimum – 18 knots, economy – 13 knots,

– Maximum range: 4000-5500 Mm,
– Autonomy – 30 days,
– Crew: 74 crew members.

Planned armament:
– 1 cannon, OTO Melara 76 mm, mod. Compact,
– 4 missile launchers, Saab Bofors Dynamics AB, model: RBS Mk-3,
– 1 missile launcher, RAM Mk-31,
– 2 double torpedo launchers 324 mm, MU90 Impact,
– 1 VLS-8 missile launcher, See Sparrow Missile,
– 2 depth bomb launchers, Bofors ASW-610.

Equipment:
– Command and control system Thales UniMACS 3000,
– EHM (Equipment Health Monitoring),
– BDCS (Battle Damage Control System),
– ship-based helicopter ASW Kaman SH-2G Super Seasprite,
– engine room CODAG (Combined Diesel And Gas Turbine),
– gas turbine General Electric LM-2500, 26600 KM,
– 2 diesel engines MTU (Motoren und Turbinen Union).

Schedule of 621/1 Gawron project:
– beginning of construction – 2001,
– completion of construction – 2006,
– beginning of service – 2009,
– technical launch – 2011.

Planned costs of 621/1 Gawron:
– MEKO adaptation costs (Mehrzweck-Kombination) – PLN 20 m
– planned construction costs – about PLN 500 m,
– additional equipment costs – about PLN 300 m,
– construction costs borne so far – PLN 675.97 m,
– estimated final cost of the Polish Navy Ship Gawron – PLN 1,460 bn.

The planned number of ships in Project 621 – 7/5/2/1/0.

Planned exploitation period – up to 30 years.

The 15-year long history of this project has shown that the most critical and simultaneously key element in this specification was unplanned cost management or one should even say cost management based on wishful thinking as well as unstable and allegedly “flexible” implementation terms of the particular stages of the project and construction work. Additional perturbations were the consequence of no reliable managerial supervision over the schedule of project and construction work and mutual accusations of all involved parties of default on their general obligations. The engineering mode of the implementation of this large project was hindered by the lack of coordination by competent bodies – the owners of particular stages. For the purpose of saving anything from this bankruptcy estate of the project worth one billion PLN, the radical change of requirements specification was conducted, the project budget was reduced at the cost of its size and functionality [Kiewlicz 2013]. The currently made product (substitute) is nearly completely different form the ambitious initial assumptions and the real needs of the end-user.

5. Modification of requirements specification for ORP ŚLązak

In 2011 there was a sudden change of the requirements specification whose goal was the replacement of the Gawron type 621 corvette by Project 621/M – Ślązak which was a large offshore patrol vessel [Szczepanski 2014]. The direct reason for the change of the requirements specification of the corvette, Project 621, at the beginning of 2011 was the failure of the sales offer for the equipped hull of ORP Gawron for PLN 400 m on foreign markets. The modern hull with an engine room for a medium sided vessel turned out not to be interesting for any foreign parties. The hull of the corvette 621, equipped with the engine room, was used as the basis for Project 621/M – a patrol vessel with very limited tactical capabilities resulting from the radical reduction of the budget, which influenced the minimisation of the armament systems and combat equipment (Fig. 4).

Fig. 4. Visualisation of ORP Ślązak, Project 621/M
Source: [Dura 2014].

ORP Ślązak is a large patrol vessel with warfighting capability against close air targets (2-3 km) and water surface targets (4-5 km), used to protect sea transport routes and port areas and also against asymmetrical threats in sea basins. ORP Ślązak is particularly suitable to:

– detect and attack water surface targets using medium-calibre artillery weapons,
– detect and attack air targets using short-range artillery and missiles,
– attack smaller vessels and asymmetrical threats,
– patrol and protect port approach fairways,
– patrol sea transport routes,
– control sea sailing routes during military operations other than war,
– patrol cooperation in international teams,
– escort and protect commercial vessels,
– protect sea installations and infrastructure,
– combat piracy and sea terrorism,
– combat weapon and drug trafficking,
– counteract illegal immigration,
– cooperate with special forces to support their actions (transport, blasting, limited fire support).

Planned armament of ORP Ślązak

– 1 cannon, OTO Melara Super Rapid 76 mm,
– 2 MARLIN-WS 30 mm systems,
– 4 GROM man-portable air-defence systems,
– 4 machine guns, WKM-B 12.7 mm.

Planned equipment of ORP Ślązak:

– integrated command system Thales,
– naval combat management system ZSW Tacticos,
– SMART-S Mk2 radar to detect air targets,
– STING-EO Mk2 radar to detect water-surface and land targets,
– Electro-optical target tracker Mirador.

Planned schedule:

– technical launch of ORP Ślązak – December 16, 2014
– launching ORP Ślązak patrol vessel – July 2015
– planned beginning of service of ORP Ślązak – end of 2016.

Finally the real cost of the construction and equipment of ORP Ślązak is estimated to exceed PLN 1 billion. Ironically, it is already known that the final beginning of service deadline of ORP Ślązak, i.e. the end of 2016, for various reasons will not be met by the chief contractor the Polish Navy Shipyard in Gdynia [Dura 2016]. Possibly it will be necessary to wait for another modification of the constantly improvised requirements specification and the final return to the BAN (Biblical Noah's Arc) non-investment project.

Summary

The main reason for the failure of the ambitious Gawron Project 621 programme to build a series of modern ships for the Polish Navy was the fact that the elementary principles of requirements engineering were not observed, starting with the over-invested requirements specification, politicised rules of cooperation between the client and the contractor and finishing with uncontrollable costs and systematically broken all formal arrangements, especially time limits without any consequences. In effect this ambitious national programme of building a series of 7-5-2-1 621-type corvettes failed and the strongly restricted the patrol vessel ORP Ślązak project was a questionable rescue method which in terms of costs, over PLN 1 billion, and implementation time, 16 years, has had no precedence in the world history of shipbuilding [Szczepanski 2014].

The lack of knowledge and systematic ignoring the cardinal engineering rules, especially at the initial stage of requirements engineering by nearly all parties of this ambitious project was the main reason for national disgrace and a tremendous waste of financial means and public investments. In the case of Gawron, Project 621, requirements engineering was probably 'blurred', neglected or ignored as an art which did not fit the meanders of political sailing without a captain. However, it is commonly known that requirements engineering is an incredibly responsible and precise way of acting which consumes even 40% of resources in every project and it has a decisive influence on its success or failure [*Dlaczego inzynieria*… 2016]. This thesis is confirmed by methodically implemented projects which follow the principles of requirements engineering in shipyards in other countries.

Since 2001 the construction of about 20 ships under the MEKO license has been started, completed and the vessels have already started their service, 6 more ships are being completed. The Polish patrol vessel ORP Ślązak, which is still at the equipment fitting stage, will cost over PLN 1 billion and probably it will be the most expensive and the longest built patrol vessel in the world. For comparison large Holland-class type patrol vessels delivered to the Dutch navy forces by the Damen Shipyard in Romania and Holland (displacement – 3750 ton) cost about EUR 150 m each. On the other hand the cost of British River-class patrol vessels (displacement – about 2000 ton) was in the rage of GBP 150 m per piece. At the same time the construction of Holland-class vessels took 4 years, River-class vessels – from 4 to 5 years [Dura 2016]. At the beginning of the years 200 os, on the market of licensed military equipment the amount of EUR 250 m would allow Poland to buy a much more valuable Branderburg-class frigate which is the basic component of the German Navy and meets the high compatibility and interoperability standards of the NATO.

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Conflict of interests

The author declared no conflict of interests.

Author contributions

Author contributed to the interpretation of results and writing of the paper. Author read and approved the final manuscript.

Ethical statement

The research complies with all national and international ethical requirements.

ORCID

Krzysztof Ficon – The author declared that he has no ORCID ID's

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