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FORESIGHT OF AEROSPACE AND DEFENCE TECHNOLOGIES IN GREECE UP TO 2020

A project submitted to Middlesex University in partial fulfillment of the requirements for the degree of Doctor of Professional Studies

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THESIS CONTAINS CD/DVD

To Kallirroe,

with infinite love

and deep gratitude

for the marvellous 25 years

of our common life, so far…

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CONTENTS

ABSTRACT

Technology Foresight examines the future of the Greek economy and in particular what the contribution of science and technology is to this. Greek Technology Foresight started in October 2001 as a programme co-financed by the European Union and the target was to create a functional view after two decades.

The main purpose of this project is the identification of cost-effective Aerospace and Defence Technologies for Greece in the year 2020. Firstly, the capacity and capability of Greek industries and the research environment are examined in conjunction with the products demanded by Armed Forces. Secondly, comes the examination of all relevant factors (industry, university, government) which have a considerable contribution to research and innovation in order to promote networking and further institutional development.

Research was absolutely necessary to foresee and evaluate specific technologies within a frame of long-term development strategy for the various stakeholders. This research area is directly related to my managerial role as I have been in charge of this programme during its implementation.

The research methods employed are documentary evidence, interviews and the Delphi approach. Thus the data collected from a variety of sources ensure the qualitative character of the thesis. The main findings are that the outlined Aerospace and Defence technologies can play a decisive role in the three different scenarios for the future of the country and they are related to the outcomes of science and technology evolution.

The general conclusion is that taking into consideration Technology Foresight results defence procurement could be managed better which would result an efficient contribution to national economy, an improvement in intra-community transfer and several benefits from export opportunities of dual-use products.

1
INTRODUCTION

People in different historical periods and in different socio-economic systems shared at least one desire, which was to know their future in advance or even to influence it to their advantage. They used very different approaches and methods, from spiritual-religious ones to scientific investigations and various modes of planning. Therefore it might be claimed that the history of mankind can be written by analysing these different attitudes and approaches towards the future. Efforts have always been made to improve decision-making and public debate by thinking about longer-term trends and the long-term implications of short-term decisions.

In the beginning of nineteenth century, economists stated long arguments about the future of capitalist economies but when the industrial revolution became solid, social sciences tended to become fragmented and more focused on the short term. A lot of developments in social and technological forecasting and then in future studies happened before and after the Second World War. In the 30s many of the principles of trend extrapolation and social indicators were established and by the 1960s, methods of expert analysis such as Delphi and cross-impact together with the first computer simulation studies started to appear.

The so-called "future studies", although they faced some resistance from traditional disciplines, seemed more holistic than the usual forecasting exercises and they did not attempt to predict the future. They intended to connect together various driving forces, trends and contemporary factors in order to envisage alternative futures, and were strongly influenced by new issues such as environmental problems and modern technologies. The first influential proponents of these future studies were the military and other large corporations, which were interested in strategic analysis across a wide variety of problems.

Only in the late 1980s the term "Foresight" started to be used. The success of some foresight exercises pushed the relative term "Foresight" to be used for all kinds of activities and nowadays the "Technology Foresight" definition is internationally accepted. Our world is characterized by rapid changes, which cannot be stopped at national borders and new technologies will always have a growing role. The worldwide environment is also becoming more competitive and thus competitiveness depends on technological, organisational and social innovation. As a result no firm can survive this global competition without investing in emerging technologies and strategic research. which are often too risky or too expensive. Hence governments have to share this financial responsibility with industries and this assumption means the setting up of R&D priorities, resulting from a thorough strategic analysis. This comprehensive analysis depends on effective networking between business, academia and government. The essential tool towards this end is provided by Technology Foresight.

There are three aims in this dissertation. Firstly is to locate which are the future key technologies in Aerospace and Defence to be developed in country up to 2020. Secondly is to examine the influence of human factors integration into the design and realization of these high-technology systems. Thirdly is to study the role of the dual-use technologies applied in both military and civil products (See Chapter 6.1). These aims include the objectives of the project as stated in the Programme Planning Rationale/Module DPS 4521 (Tsolakidis, 2002). Among these objectives were:

- To propose commonality of utilised defence technologies in the three branches (Army, Navy, Air Force)
- To encourage the public and private services to adopt concerns over the environmental protection and energy conservation
- To diffuse findings of discussion within internal workshops in the public provoking social participation
- To investigate the need for new education trends and human resources management
- To identify crucial R&T requirements and examine how effective is the existing structure of defence research institutes.

The Chapter 2 of this dissertation gives the background for the Greek Technology Foresight programme including the methods used for its realization.

Chapter 3 reviews the literature presenting all type of Foresight approaches (national, regional, organisational) linking them with the international economy evolution.

Chapter 4 presents the Aerospace and Defence Industry in Greece examining its connections with European and national defence framework as well as the influence of technology transfer through Offset Benefits and other international cooperations.

Scenario planning is the topic of Charter 5 and explains how the three hypotheses of future worlds (optimistic, conservative and pessimistic) could influence the state strategy in Aerospace and Defence Technologies prioritisation.

Chapter 6 justifies how the quantitative and qualitative inductive research methods chosen are applied to achieve the aims of the project. Special analysis is given to the Delphi method which is the backbone of the Technology Foresight.

Future technologies are covered fully in Chapter 7 and it is the outcome of Technology Foresight as it was required by the sponsors who were the European Union and the General Secretariat of Research and Technology.

Chapter 8 focus on dual-use technologies serving both military and civil purposes which are very vital for the Greek economy and national resources proper use.

Human factors in Aerospace and Defence are presented in Chapter 9 and fill the gap in the design, development and operational use of high-technology systems.

The importance of Technology Foresight exercises worldwide imposed the existence of Chapter 10 where is attempted a comparison of Greek case with other Technology Foresight programmes. Significant results are drawn which could lead to better implementation of next generation Foresight efforts either in national or in regional modes.

Last but not least is Chapter 11 which refers to the general conclusions and recommendations. Here is also presented the leadership role of the researcher in the groups of Technology Foresight participants and how the collaborative activities have contributed to the project management.

Apart from the managerial requirement of this unique effort the researcher has proceeded further during the preparation of this dissertation. Additional research work was done in implementing a third round of Delphi method, in exploring the human factors interface and in approaching dual-use technologies mapping them accordingly. Another one output of research are critical technologies with wide applications besides the main ones refered in Chapter 7.

In spite of the weaknesses and shortcomings of this first generation Technology Foresight programme compared to other national exercises, it is our belief that this is an original contribution to the Greek economy and the beginning of a new culture creation for all stakeholders.

2
THE GREEK TECHNOLOGY FORESIGHT

2.1 Targets

The subject of the Greek Technology Foresight (TF) is the examination of the future of the Greek economy and especially the role of science, technology and research in shaping this future. As time horizons for this examination the years 2015 and 2021 have been set, while the target is to establish a framework of effective orientation which will assist the government in the preparation of long-term policy and enterprises for better strategy planning. Within the final aims of the project the foundation of a center for know-how absorption is also included and applications of TF in order to further continue this activity in country.

TF is not an exercise to forecast the future or a study for national development or any kind of strategic plan analysis but just a tool to define the critical factors, the drivers, the continuities/discontinuities as well as the opportunities/challenges of Greek society always related to the existing obstacles and taking into account that science, technology and innovation consist of one of the main feeders of economic and social evolution (TF Contract, 2001). The main research focus of this thesis is to locate specific Aerospace and Defence Technologies which will play a key role in Greek economy and development.

2.2 Characteristics

The three characteristics of the process in the Greek TF remain the specialization, the creativity and the interaction. The triangle in Figure 1 represents the process including the various methods and planning techniques for decision making. These characteristics are necessary for the successfulness of TF (Van der Meulen, 1999). First of all is specialization which connects the possible future with current technologies, then creativity which doubts the rooted constraints and interests, while lastly remains interaction to prepare a common vision for the future by combining the ideas and beliefs of individuals with estimations and anticipations in various domains. Lack of balance between these elements could offer poor final benefits because if specialization prevails then it will tend to reproduce itself or creativity alone will create only science fiction scenarios or the interaction without a certain target will be a simple loss of time. As it seems in Figure 1 the presented technologies inside the triangle can be advantageous only if such equilibrium exists (ibid).

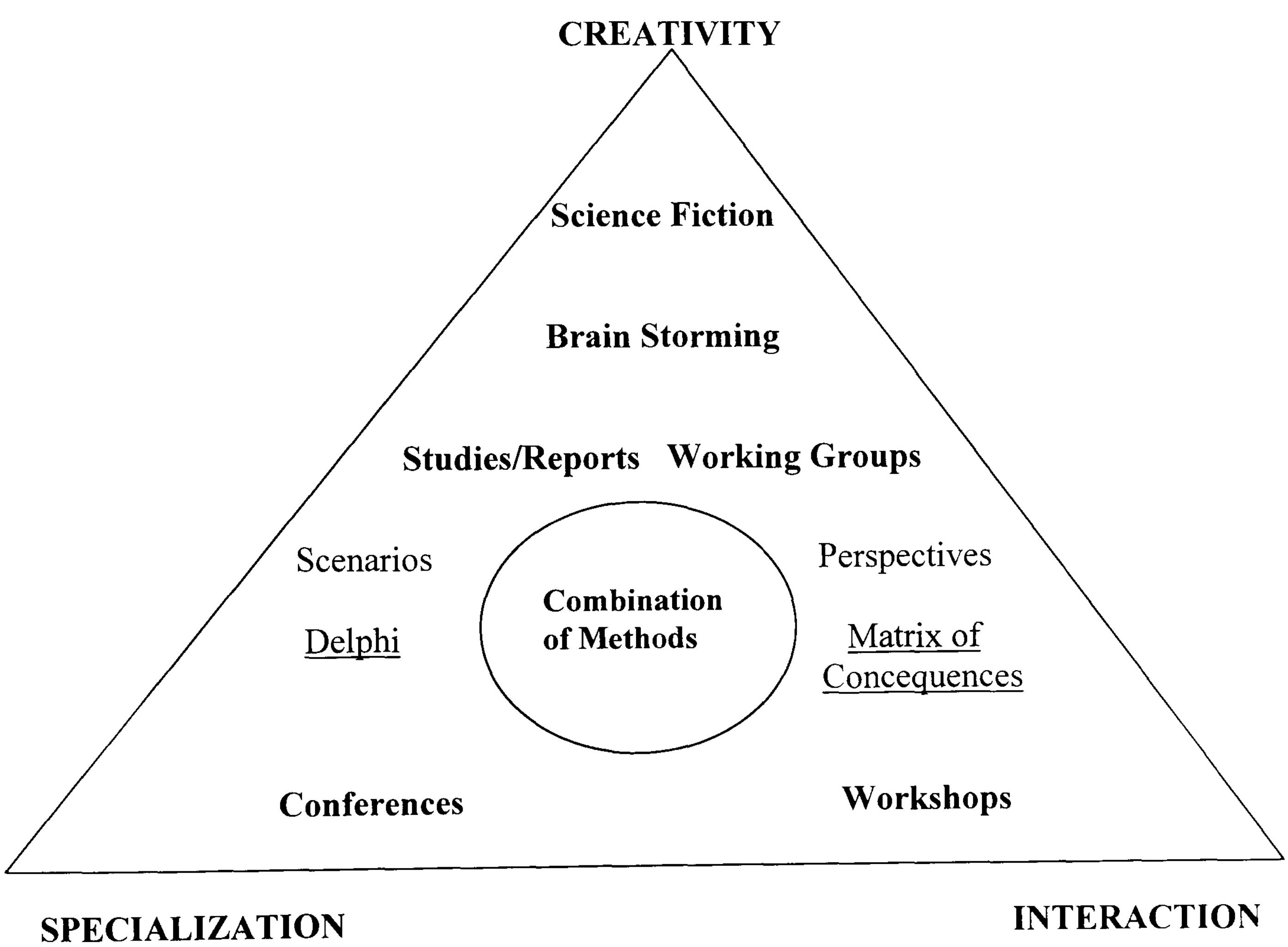

Figure 1. Balance of Specialization, Creativity and Interaction benefits TF results.

The TF programme is co-financed by the European Union and the Greek government while the contract was signed on October 19, 2001 between General Secretariat of Research and Technology (Ministry of Development) and a consortium consisted of the National Technical University, the Economic University of Athens, National School of Public Health and two private companies, Logotech and K-Net. The total budget reached 1.182.685 Euros and programme duration was originally 30 months. However, an extension of 15 months was awarded and the project was completed on March 21, 2005. Moreover the amount paid is 20 per cent less than the agreed contractually because of delivered material shortfalls according to the final evaluation of the newly elected government.

2.3 Methods

2.3.1 Working Groups and Horizontal Actions

The first Greek TF has used a combination of methods and has emphasized in an exchange of opinions, dialogues and interactive approach since it has not been limited only to technologies but also covered critical issues (i.e. Health) or vital branches (i.e. Tourism)[1].

The Working Groups undertook the responsibility for shaping the scenarios at the level of thematic domains. They consisted of entrepreneurs, academicians, researchers, representatives of professional bodies, governmental officials etc., according to the subject area of each group. The Working Group members selected a Chairman, who presided over the organised meetings and workshops[2]. The Rapporteur of the Working Group was the key-person for the function of the group and had the responsibility for preparing the essays and organising the workshops. The selection of

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[1] Actually, ten years ago, the General Secretariat for Research and Technology (GSRT) funded on initial effort of eleven TF exercises for corresponding different application fields. These independent experiences could be considered as the predecessors of the present TF which is the first real TF process in country since early ones lacked the element of interconnection and interaction which strongly characterises the current case.

[2] The WG Rapporteurs were appointed by the Steering Committee (with the GSRT's consent) and were responsible for preparing the essays.

Working Group members was done through an invitation of public interest issued by the General Secretariat of Research and Technology in cooperation with the Steering Committee.

In total the following eleven thematic Working Groups were formulated with between 10 to 15 members each

- Agricultural and Fishing Development
- Tourism – Civilization
- Energy
- Transportation
- Governance and e-government
- Industrial Production
- Environment
- Biotechnology
- Health and Quality of life
- Information, Communication and e-business
- New Materials

Each Working Group was assisted by another broader Support Group, which consisted of representatives coming from various agencies, social groups, professional unions and other prestigious personalities of the specific working environment. The first selection of the Support Group members was drawn from the list of individuals gathered after the first call of interest. These people have formed the first target group for the systematic communication and dispersion of ideas. They have been receiving on a continuous basis the results of the meetings, copies of the interim reports, newsletters, information bulletins and all documents produced by the Working Group. Additionally the Working Groups and the Support Groups were complemented by a broader team, the Groups of Commentators. These members were all those who had replied positively to the initial call of interest but practically they were not able to participate either in the respective Working Group or in the Support Group. Later on the Groups of Commentators have also joined every participant in the open discussion of partial TF analyses.

TF programme has also included five Horizontal Actions. These actions aimed in helping the Working Groups to develop their activities according to the international state-of-the-art in the fields of Society and TF, Human Resources Training and Development, Space and Regional Character, Innovation and Investments. The principal interface among the Working Groups, the Horizontal Actions and the Steering Committee was during the preparation of TF documents. As a first interface can be considered the Start Text which included guidelines and directives while the second interface was the Main Report which aimed in displaying all the significant terms and conditions for the evolution of sciences and technologies in Greece up to 2021[3]. The Figure 2 gives an idea of the interactions developed between involved parties (see page 18).

2.3.2 Scenarios Development

The creation of scenarios based on data elaboration, documentation exploration, public discussion and test of methods – was a tool to investigate the future (Chermack et al, 2001). Through scenarios the shaping of possible worlds is permitted where specific activities and social partners are defined. The basic assumption for this remains that only free creative imagination could catch this future environment for the year 2021 and the triptych of research/science/technology is simultaneously the field, the source and the variable which outline the picture of the 2021environment.

There are two basic known working modes to produce scenarios (Ringland, 1998). The former assumes an analytical approach and many studies together with a vast experience in forecasting and strategic analyses. The second is based on the building of a mosaic of events, which in any case are properly documented. The Greek effort was mainly established on the second pattern but there were some cases where the first pattern was used (i.e. scenarios for Energy and Materials). Scenarios are of a hybrid character composed of elements of scientific speech and narration because they are at the same time a discourse and a fiction (Aligica, 2005). Due to the TF programme complexity and broadness it was necessary to prepare scenarios at both a macro-level (the whole TF project) and at a micro-level (the thematic areas) (TF Synthesis Report, 2004).

[3] More information can be found in the TF project website (www.foresight-gsrt.gr)

At a macro-level, the Steering Committee prepared some scenarios initially which were further processed with the Chairmen of the twelve Working Groups and the responsible Coordinators of the five Horizontal Actions. This top-down technique has permitted scenarios to be presented, which were exposed to the criticism of Working Group members and other selected commentators. Then one particular day in January 2003 was devoted to the elaboration of scenarios. The results of this generalized bottom-up debate were analyzed and evaluated by the Steering Committee operating as the final arbitrator for the definite shape of the macro-scenarios. The international bibliography has also provided enough material to support the scenarios for Europe (OECD, 2001).

At a micro-level, the analysis focused on twelve thematic areas corresponding to different domains and technologies. At this level it was necessary to develop detailed and specialized micro-scenarios, which examined the strategic planning and policies for the development of science, technology and innovation for easy thematic domains. At the same time, these micro-scenarios control the possibility of macro-scenarios realization as well as probable alternative future works, based on progress in certain areas.

It must be noted here that scenarios create ideal situations, which are controlled principally by the completeness, the cohesion and the interconnectivity of their data. Above all they are logic constructions, allowing the location of topics, problems and chances, which must be given special attention and care. Scenarios do not describe nor they foresee future situations (Gregory and Duran, 2001). As a matter of fact, the future will be a special mixture of the scenarios, therefore this analysis of problems and challenges was considered one of the main feeding inputs during the preparation of micro-scenarios by the Working Groups in parallel with the four basic TF macro-scenarios.

2.4 Initial Plans Amendment

The initial declaration of TF project for the 11 thematic domains has been modified by the Steering Committee in some aspects, for example, the separation of Tourism from Civilization and the addition of a Special Working Group (May 2003) for Defence Technologies. The focus of this last group was broader in relation to the other Working Groups. Their aim was double; to register the trends and the perspectives of the local defence industry but also to examine its possible incorporation into the European defence conglomerate in parallel with the Greek participation into the common European Policy for Defence and Security.

For this reason the members of the Defence Technologies Working Group were originated from

a) Political Analysts and Economists who analyzed issues influencing the long-term planning of the country and
b) Engineers and Scientists of the public and private defence who were concentrated in describing the key-technologies and the micro-scenarios for the future of Greek defence industries.

This new Working Group has followed a different time frame but the respective report was delivered properly within the deadline set for the whole TF[4].

The same logic for researching new and more functional ways/schemes of work has driven the Steering Committee to restructure the Working Group of Governance and e-Government. The original complex character of the vague field of this group in conjunction with the permanent practical difficulties for most of the members forced the Steering Committee to replace the Chairman and the Rapporteur of this team, as well as to activate new members from the relative Support Group, thus achieving the early delivery of their final reports.

[4] The Steering Committee set some guidelines for the WG and SG members selection process, emphasizing the need to have representatives of different schools of thought in a given field, the balance between age groups, genders and those from the capital and other parts of the country. Although no rigorous statistical analysis has been conducted to describe the panels, yet it can be said safely that these guidelines were only partially respected by us.

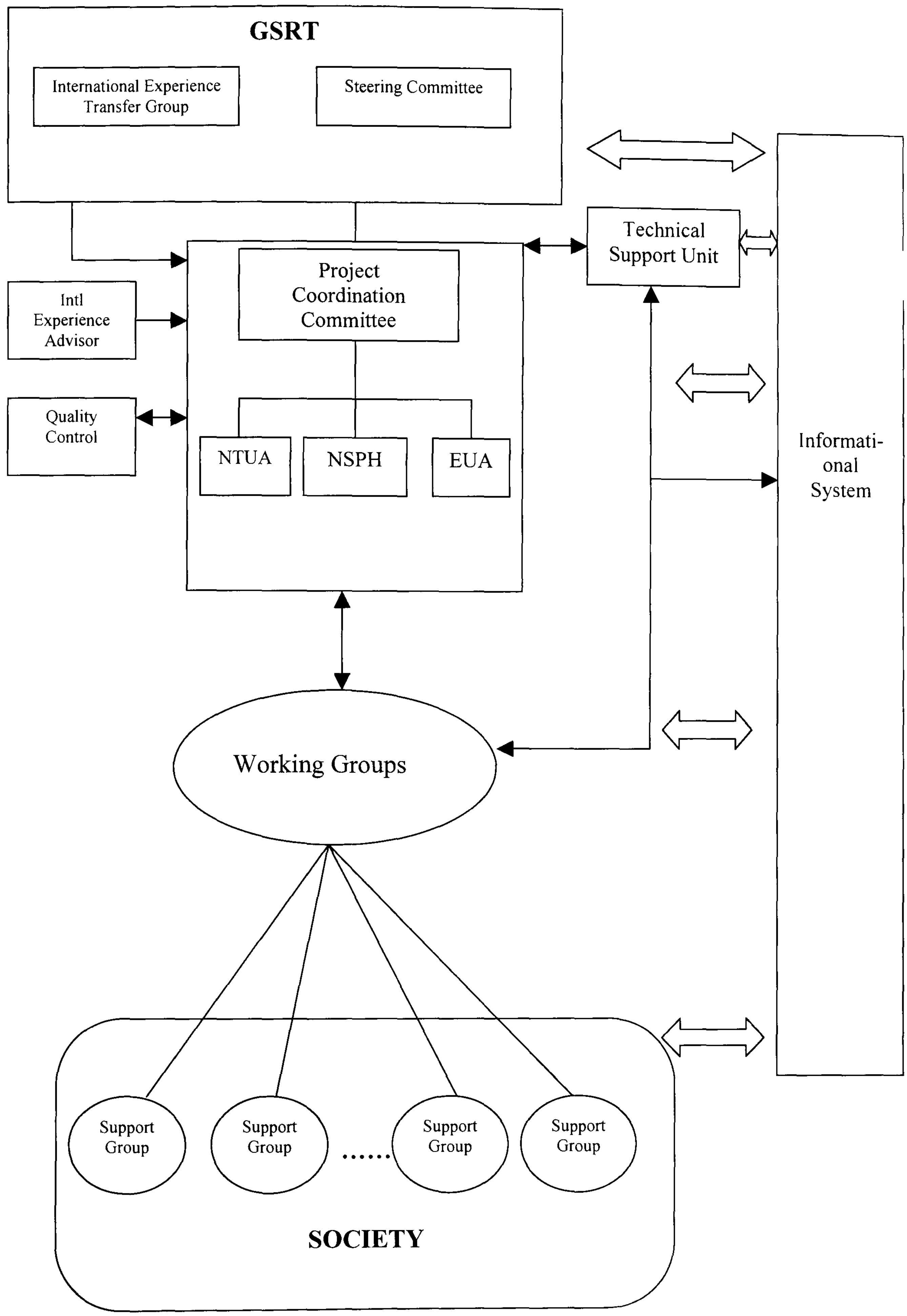

Figure 2. Interactions of groups involved in the Greek Technology Foresight process

The progress of the Working Groups in supporting the first working texts has shown the problem of homogeneity of these reports concerning their appearance and quality because they had to be equivalent and complementary to each other leading to the final modulation of a total synthetic document. This is the reason why a special conference was organized (June 2003) in order to present and discuss the interim results of all Working Groups and Horizontal Actions of TF. During this conference Dr.T.Kuwahara – Director of Japan's Science and Technology Foresight Center and of National Institute of Science and Technology Policy – has presented the Japanese experience on five consecutive TF programmes carried out over the last 30 years, which makes it the oldest in the world.

As a follow-up to this conference was the organization (end of July 2003) of an ad hoc meeting of all Chairmen and Rapporteurs. During this large meeting the Steering Committee commented on every first text, critising the structure and the format of these reports in order to assure a common appearance of the global Synthesis Report.

2.5 Technology Foresight Implementation

The dissemination and diffusion of TF results to the broader public were completed in a period of four months in five different Greek cities. Every such conference had a specific main discussion topic and invited lecturers to develop current issues of national or even international interest related to the thematic areas of TF. Naturally the results of the various Working Groups were also presented in connection with the Horizontal Actions.

This long effort started from Athens (November 19, 2004) presenting systems and policies for the global learning economy focusing on regional development of innovation and knowledge flows. Then we moved to Thessaloniki (December 13, 2004) covering the issue of governance in economy and society including human resources management and development. The third meeting was in Heraklion, Creta (February 17, 2005) under the title of sustainable development where biotechnology, renewable energy resources and touristic activities with respect to the environment were examined. Patras in Peloponnese (February 22, 2005) hosted the next public conference exploring the question of innovation support through the studies of potential foreign investments, boost of research opportunities of technology parks with as a main objective Greek competitivity in Europe and other continents. The fourth event occurred in the city of Volos, Thessalia (March 1, 2005) where the two Working Groups of Aerospace and Defence Technologies, Agricultural/ Fishing Development and Industrial Production have presented their findings. The subject of the conference was to find the challenges and chances for regional industrial and agricultural evolution. The final and closing meeting was again carried out in Athens (March 5, 2005) focusing on the science and technology policy of Greece in 2021, while in parallel the Working Groups of New Materials and Human Resources Development had the opportunity to disseminate the results of their reports.

Up to the end of March, 2005 the mobility of Greek TF was very dynamic. The Table 1 below summarizes some characteristic indicators presenting the interests shown.

- 780 Applications of Experts
- 250 Members of Working Groups
- 400 Members of Support Groups
- 220 Commentators
- 65 Meetings of Working Groups
- 25 Consultation Meetings
- 15 Additional Events (Conferences, Workshops, Fora etc.)
- 2200 Participants in Consultation Meetings
- 165 Experts participated in Panels
- 231.000 visits in TF web site
- 2.100 Pages of 19 Reports

Table 1. Indicators for the Greek Technology Foresight exercise

3
LITERATURE REVIEW

3.1 Introduction

Before attempting an analysis of the Foresight phenomenon it would be useful to identify its definition, which will help to follow the process of it and also to find its main elements.

A recent definition was given by the STRATA-ETAN Expert Group (EU/DG, 2001).

> *"An important tool in the development and management of future-oriented innovation systems, based within a wider context of future-oriented coordination activities in a society. It could be defined as a purposefully organized process bringing together expectations of diverse actors about possible development paths to formulate strategic views about the future that take into account broad social and economic developments."*

From similar sources (EU/FOREN, 2001) comes a rather complementary definition as:

> *"A systematic, participatory, future-intelligence-gathering and medium-long-term vision-building process aimed at present day decisions and mobilizing joint actions. Foresight arises from a convergence of trends underlying recent developments in the fields of policy analysis, strategic planning and future studies. It brings together key agents of change and various sources of knowledge in order to develop strategic vision and anticipatory intelligence".*

Moreover the stronger definition, according to the English dictionary. Foresight is:

"Regard or provision for the future".

More specifically there are definitions for Technology Foresight. Slaughter (1998) supports that TF in an organization is

"The ability to create and maintain a high-quality, coherent and functional forward view and to use the insights arising in organizationally useful ways, for example, to detect adverse conditions, guide policy, and share strategy and to explore new markets products and services."

Within the tradition of policy-making at governmental level Martin (1995) defines TF as:

"The process involved in systematically attempting to look into the longer-term future of science, technology, the economy and society with the aim of identifying the areas of strategic research and the emerging genetic technologies likely to yield the greatest economic and social benefits."

To interpret these definitions we should examine the wider scenario to which they belong. European Union member states have been following the "Lisbon Strategy" (established during the European council in Lisbon, March 23-24, 2000) for a common vision of the socio-economic development of Europe. The objective of this strategy is to render the European Union by 2010 *"the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion"* (FOREN, 2001). To achieve this, Foresight and policies for research and innovation are essential mechanisms within the broad context of political interventions on the socio-economic level.

In an organizational concept Foresight has been considered as the ability to foresee events before they happen, providing thus the capability to anticipate the future (D'Aveni, 1994). This has led to many forms of Foresight: national, regional and organizational, which will be examined later on.

Returning to the previous definitions some considerations can be drawn on which European approach to Foresight is based. Firstly. Foresight emerged from building on the past, thinking of the present and looking into the future. Therefore it attempts to predict the future not simply by extrapolating the past – like forecasting – but it tries to design an orientation by managing uncertainties and ambiguities. This implies that, in spite of casual events, people's role is the central point of efforts for the construction of their own future. Human action is not but a sum of actors such as power levels, requirements, perspectives and general interests, which inevitably drive the need for a strategic and parallel vision of the risks and problems together with opportunities. Finally, we are dealing with a holistic approach because there is a simultaneous interaction between not only technological but also social, economic, political and cultural parameters.

In the rest of this Chapter the concept of Foresight and its applications to national, regional and organizational context with the associated transverse characteristics and objectives will be presented. The comparison of Greek TF with other countries' Foresight exercises in Chapter 7 will present a practical application of this theoretical analysis.

3.2 Evolution of the international economy and Foresight

The transformations of economy. both in macro- and micro-level have been radical during the last 30 years whilst the activities of Foresight developed. The relatively stable national or international markets. based mainly on physical resources. have given their position to new dynamic and highly competitive local and global markets depending on intangible assets and principally on knowledge in processes of creation of value (Dunning, 1997). The transition from hierarchical to flexible capitalism has been encouraged by certain factors such as (Romano. 2002)

- Complexity and specialization of activities
- Interdependence of many markets

- Increasing rationalization and extension of actions of business units
- New organizational culture and behavior
- New institutions and enterprises forms
- Innovation-driven economy and amazing diffusion of information technology

As these were the characteristics of the macro-economy at the micro-economic level, the respective gradual passage from hierarchical organizational structures happened to network knowledge-based organizational forms. Actually, during the 1980s, the competition amongst companies was the important element in a market-oriented view. The next decade, the 1990s, was characterized from more knowledge than assets-based focus. Higher value of the intangible resources (know-how, skills, total quality management etc.) prevailed over tangible assets and analysis of sectors (Liu et al, 2002).

The knowledge-based economy emerged favoring the transition towards flexible production and inter-organizational co-evolution systems (Schwartz et al, 1999). It was unavoidable because innovation was connected with the introduction of digital technologies forming the information technology society based on network organizational structures. These type of structures are more suitable to the dynamism and complexity of the new competition strategy, influenced heavily by uncertainty and rapid changes.

All these changes have strongly influenced the evolution and application of Foresight. The concurrent "resources based" approach of business strategy model is the integration of entrepreneurship and strategic management that's why some analysts call it strategic entrepreneurship. In mathematical language, it is the transition from interpretative models of a Newtonian deterministic nature to new dynamic-non-linear models. These realistic models are open systems to the external environment hence unstable, troubled, irreversible and path-dependent (Cariola and Rolfo, 2004). Since the final state is unpredictable and as complex evolutionary systems tend to explore only possible futures that is the reason why Foresight is important in these cases.

The creation of Foresight (or sometimes insight) models was encouraged taking into account local and global aspects, rapid and continual changes as well non-linear approaches. Strategic thought shifted from objective to a more subjective view of reality and from linear cause-effect relationship (technology forecasting) to methods of influencing the emergent phenomenon (technology foresight). Thus decision-making processes are regulated by multi-parameter dynamic competitive context where other correlated objectives such as growth, development of knowledge, traditional local advantages and cultural characteristics co-exist (Banders, 1998).

3.3 Foresight Diffusion

In light of the above described economic evolution and theoretical aspects since the 1980s, governments have subsequently paid increasing attention to Foresight both at a national and at a regional level. So far, more than 30 countries have completed Foresight programmes of every kind with very encouraging results (Miles, 2003). These exercises aimed at identifying emerging trends, technologies or possible futures and their classification below as either regional, organizational or national explains why the expanding Foresight culture is considered as a new tool for strategic decision making.

3.3.1 Regional Foresight

Despite the domination of the globalized world, there is an increasing consensus that the regions are often the most significant place for the improvement of economic performance. This occurs through routines that are still connected with regional and local institutions and with socio-territorial contexts (Aydalot, 1998).

Regional Foresight exercises are a critical tool for local authorities to identify their strengths and potential as well as to prepare plans to build on these with the aid of scenarios. The success of Foresight projects depends heavily on the full involvement of the relevant actors (citizens, industries, authorities, educational units etc.). At regional level this is much more manageable because of the smaller numbers of people involved and also because they have more reference points in common. Physical proximity and local familiarity still play a major role, while global and international competitiveness depend more and more on development of regional strengths and particularities (STRATA-ETAN Report, 2002).

The recent turn in the regional dimension of development does not concern only an accumulation of economic activities but principally the communities of interests capable of expressing synergies and relations among different actors (Ohmae, 1995). The European Union, as a supra-national institution, among its policies has established the European Research Area (ERA) by reinforcing and widening European unity through co-ordination of initiatives in diverse regions and by strengthening regional development in all member states. By improving learning and collaboration on regional Foresight across the ERA, they contribute to the creation of a pool of knowledge on European Foresight activities, combining the potential of each region with a wide and competent network of institutions all over the European continent (Keenan and Uyarra, 2002). On the other hand, faced with competitive pressure from other countries (i.e. low labor costs) regional industries are trying to find an independent path where globalization cannot be avoided.

Regional Innovation System (RIS) – in comparison with National Innovation System (NIS) – are not many and nor they are powerful, so local authorities try to establish optimal conditions for their activation and the innovative transformation of respective districts (HLEG, 2002).

The problems and challenges in implementing regional Foresight are classified in three categories: conceptual, methodological and procedural. However the four significant experiences of regional Foresight in Europe, Lombardy (Italy), West Middlands (UK), Grand Lyon (France) and Catalonia (Spain) are considered satisfactory (Appendix 8). Greece has already prepared a regional Foresight in West Makedonia and now they issued the public bid for Ionian Islands.

3.3.2 Organizational Foresight

Organizations in their efforts to cope with the future they have been following the concept of organizational Foresight which shows three main characteristics.

Firstly is the key element of time (Blackman, 2004 and Brown, 1997) in the development of Foresight, which enables organizations to anticipate what will happen and prepare possible future scenarios. Secondly, Foresight is connected with the process of organizational learning (Havel, 1994, Hejden, 2004). In this case, managers play a pivotal role because they scan the environment by collecting relevant information from different sources (Cohen, 1990), which may include customers, competitors, suppliers and others. This scanning is either passive (Higgins,1987, Fiske.1991) or active (Argyris, 1996, Van Lehn, 1993). One confirms the existing situation with some adjustments and the other chooses to change activities by abandoning old ones (March, 1991). The whole procedure for the determination and implementation of their future actions – by using their cognitive schemata to interpret and evaluate the resulting probes of this research – enhances the process of organizational learning (Daft, 1994). Therefore Foresight seems to pivot around a cycle of environmental scanning, interpretation and consequent learning. The third characteristic of Foresight for business units is the directed process (Slaughter, 1996). Looking carefully for possible futures the firms' boundaries are broadened and through the methodical process they can avoid potential problems and crises before they occur, plan proactively by evaluating the implications of future events and strengthen their envision capabilities.

The modern strategy development (McMaster, 1996) is based on Foresight tools for prediction and planning. These tools include brainstorming, econometrical forecasting and worst-case scenarios against disasters (Mendonca et al, 2004). The methods of scenario planning is widely adopted in the industry either as exploratory (based on past and present trend) or anticipative (based on different visions of the future) (Godet and Roubelat, 1996).

Attention has been given recently to using Foresight in the product development and technology field. While traditional forecasting methods have been accused of being responsible for many failures of new technology products – since technology is not the only driver in the market (Carlson, 2004) – Technology Foresight is very much appreciated. The principal reason is its relation to the processes, which take into account the R&D department proposals for innovation and combine them with the users opinions (Anderson, 1997). Similarly a set of probing processes allow organizations to balance the rigidity of business plans and the real chaos of future trends because otherwise they will lose their focus in product development (Constanzo, 2004).

The significance of probes is well acknowledged (ibid) by innovation enterprises when they desire to highlight possible development avenues. Direct probes (hands-on experience) pertain to experimental procedures for new workers and data collection is realised through alliances with other firms and use of customers' opinions. Indirect probes are done through internal meetings complemented with the parallel employment of futurists groups.

However, the probing process is never an end goal but Foresight emerges continuously so companies' visions and strategies are developed or rejected through the perpetual probing and learning process (Andriopoulos and Gotsi, 2005).

3.3.3 National Foresight

The drivers for conducting Foresight activities by many nations seem very common. Japan, which started 30 years earlier, had applied the policy to move away from imported technologies trying to develop local capabilities. The same happened recently in Austria where innovative technologies developed in-country were considered more necessary. Germany, after unification, desired to find efficient ways to finance research programmes in their FUTUR Foresight because of the imposed budget constraints. Similar financial limitations drive the UK programme asking for better co-ordination of the national R & D efforts. Hungary and the Czesh Republic facing a transition to a market economy, have applied Foresight to study and experience new approaches to innovation policies. France has located 100 key technologies for framing expenses and has focused them on specific areas. Greece the youngest member of the Foresight Club completed its efforts to locate domains for development in the national Technology Foresight programme for better value of money three months ago (TF web site, 2005).

To sum up, the main target of national Foresight exercises appears to be the desire to establish a new policy tool for the future policy challenges. Keenan (2001) summarizes these challenges as follows

- Policymakers are putting science and technology (S&T) priorities in relation to restricted budgets and growing international competition

- The interest to create new networks and strengthen existing ones – particularly between the S &T base and business – has forced us to live in a "network society" and to innovate in a "network economy". Foresight helps in creating shared strategic visions because companies are required to manage interfaces with cooperators, regulators, customers and suppliers
- The arrival of the 21st century and the so-called "Millennium Effect" has favored futures-type studies since government seemed to be preparing for new opportunities
- Foresight exercises emphasizing on processes assisted in the emergence of a new more inclusive style of policy-making during the last decade of the past century. Moreover the public sector became less dominant and has permitted the wider engagement of business and civil society in decision making for policy matters.

These challenges tend to feed into the general objectives of Foresight exercises, which must have credibility, legitimacy and authority in order to be accepted by the target audience (Tamsin et al, 2001). Almost all national Foresight programmes include the three main specific objectives stated below.

The first objective is to provide guidelines for the prioritization of science, technology and innovation plans. Recommendations for industrial innovation according to in-country abilities must be coupled with future trends or forces whether these be market or S&T driven. The next objective is to mainly encourage business units to apply long-term strategic approaches and to flexibly respond to changes according to their SWOT (Strengths, Weaknesses, Opportunities and Threats). One instrument of Foresight for this is the preparation of possible scenarios. The third and last objective is to improve collaboration and strong partnerships for better-wired innovation schemes between the triple helix: government, business and science base.

Since most exercises are sponsored by science and technology ministries. Foresight objectives are primarily concerned with S&T issues. However it is not uncommon that the results of Foresight include non - S&T recommendations.

Every national Foresight programme can include specific objectives other than the above stated ones: for example Hungary view it as supporting their entrance to the European Union and Spain expected to be helped through Foresight to have better access to and presence across European research programmes and institutions. Alternatively Sweden and The Netherlands broadened the scope of their national projects by inserting more socially oriented objectives and the second round of the UK Foresight effort was more problem-oriented than market-driven (Keenan, 2001 and Rappert, 1999). The perception is that Foresight activities are widely accepted and appreciated and are becoming more sophisticated in their efforts to achieve better results for users.

4
AEROSPACE AND DEFENCE INDUSTRY

4.1 Globalization of Economy

The decade of 1990s was the critical period when Technology Foresight (TF) became widespread. Before 1990 some few efforts started in The United States, Germany and The United Kingdom while Japan and France have been engaging since 1970 and 1980 respectively. Around 1990 other countries followed: Netherlands, Australia, Austria and Hungary (NISTEP, 2001). The main drivers of change, which forced the interest in Technology Foresight, was competition, scientific competencies and the complexity and constraints on public budgets (Martin, 2003).

Starting from competition its seems that economic antagonism brought immense variations in labor cost which led companies to shift resources and production without difficulty from country to country in order to obtain corresponding advantages. The more industrialized countries however apply continuous innovations and use emerging technologies to enhance competitiveness. As long as investments are required for these efforts, they must share the financial responsibility with industries since the latter do not desire to undertake the whole risk. On the other hand, a number of social factors (unemployment, inequality, environmental sustainability) came to balance the continuous trend for higher productivity so Technology Foresight was considered the new policy tool to achieve this equilibrium (Georghiou, 2004).

Similarly another balance has been experienced in national budgets because of a considerable number of reasons. Amongst these there are the increasing costs of healthcare and social welfare due to an ageing population, the funds for education while the limitations for tax-raising and other regulations for EU member states constrain state income. Therefore the greater accountability for governmental spending imposes better justification of funds for research and technology where selectivity and priority remain key factors. Here again Technology Foresight can help substantially (ibid).

Complexity of systems is also inevitable, since coupling and interaction are growing among public and private responsibilities, local, national and global concerns as well as politics and cultures. Technologies either fused or not (Kodama, 1992) together with the various sources, which produce knowledge still form a synthetic group of issues adding to the general complexity. The approach to confront these interrelations is first of all to understand these systems then to create better collaboration schemes and finally to use flexible ways and links for effective outputs. Technology Foresight is a good way to prepare these internal and external operations.

Scientific and technological competencies are significant to make our lives better and creating skills necessary for every kind of cooperation and knowledge exchange. As skills inevitably became obsolete new ones arise and that is why written or oral knowledge must be transfered. This transfer is generally not easy and appropriate connections among people must be established; Technology Foresight again assures proper ways of communications (Menendez and Cabello, 2001).

4.2 European Defence

The Hellenic Government is aligned with the European Defence policy, which is moving towards the improvement of Europe's capability to react in periods of various crises, apart from those caused by terrorism.

Of course, first of all, Greek national military forces have a primary role to defend Greece against any external enemy. In addition to these national efforts and our participation to NATO, Greece must enhance EU Common Foreign and Security Policy (CFSP). According to this CFSP European nations can react to any kind of crises by supplying civilian and humanitarian assistance or even providing military support if needed[5].

[5] Article 223 of the 1957 Treaty of Rome excludes defence from EC's joint responsibilities ("Any Member State may take such measures as it considers necessary for the production of or trade in arms.

Up to now European states have depended heavily on the United States in dealing with crises around or sometimes within Europe. Hence there is a need to improve European military capabilities without any tendency to compete but to complement and strengthen NATO forces. These improvements either in the short or in the long term are connected to defence reviews, which must be conducted by European nations towards the deployment of modern and flexible Armed Forces.

The Maastricht Treaty came into force in November 1993 introducing amongst others the European Union's Common Foreign and Security Policy. This is a very important agreement aiming to protect common values and common interests by reinforcing EU security levels, safeguarding peace and global feelings of assurance through the promotion of international cooperation and democratic principles as they are defined by justice and respect for human rights and freedoms.

The same treaty also foresees "the eventual framing of a common defence policy, which might in time lead to a common defence". However the Western European Union (WEU), although existing for fifty years and been responsible for the implementations of ESDP decision for defence matters, is under suspension because it was proved ineffective, especially during crisis in Kosovo. The EU nations admitted that effective crisis management is based upon the combination of diplomatic, economic, civilian and military efforts. Therefore the military shortfalls of the EU will be covered by CFSP and this framework is continuously stressed during the various European Councils. Additionally, European nations, which are not part of the EU can be involved in European Defence as well as in other civilian aspects of crisis management. The management process remains a complex issue since the respective missions belong to a wide spectrum as they are described in Petersberg tasks below. The necessary coordination has to take also into account the national programmes of Member States and the NATO initiatives (Papantoniou, 2003).

The EU Headline Goal towards this purpose covers the deployment capability of 60,000 troops within two months and to sustain them up to one year accompanied by additional air and naval units. This force by no means could be characterized as a European Army or a Rapid Reaction Force. It is simply a pool of capabilities from

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munitions and war materials; such measures shall not adversely affect the conditions of competition in the common market regarding products which are not intended for specifically military purposes").

which necessary groups can be assembled quickly to confront particular operations always with the approval of national governments. These operations are defined in the following Petersberg Tasks:

> *"Humanitarian, rescue, peacekeeping and tasks of combat forces in crisis management including peacemaking. At one end of the spectrum an operation could be dealing with the evacuation of people from an area and providing security and assistance to humanitarian organizations in order to help restore order and to allow the relevant organizations to provide relief to refugees. The definition also covers "conflict prevention" where a force may help to prevent a potential conflict situation from escalating in order to create conditions where the conflict can be peacefully resolved. Finally, at the more military demanding end of the spectrum, an operation could help to resolve a crisis between two warring factions" (1999).*

It is meant that those units covering EU led missions must be in a high readiness and well-equipped with modern equipment meeting criteria of interoperability, sustainability and deployment ability. This multinational cooperation brings many benefits such as increased cost-effectiveness because of the resources pools between countries and enhanced overall military capability. Moreover smaller nations are allowed to contribute to large-scale operations, which could be sustained otherwise by individual countries.

This effort will also strengthen NATO by using the existing operational capabilities of the Alliance in varied circumstances, which remains the only organization for collective defence in Europe. The transparency between EU and NATO will have the additional advantage of avoiding duplication of capabilities and structures but on the contrary increases cost-effectiveness through the interoperability and complement of missions. The whole strategic direction is carried out by the Political and Security Council, assisted by EU Military Committee and EU Military Staff, which have the necessary expertise for the operations.

In conclusion, Common European defence pertains to the previously mentioned approaches to face prevention and management of conflicts wherever they arise. However military power is only one aspect of the overall subject of security and crisis management in the 21st century. The EU possesses other civilian means (such as sanctions, external assistance, trade control, migration policy measures and transnational justice rules) to exercise pressure whenever needed and in general uses these resources and skills before any military actions.

4.3 Hellenic Aerospace and Defence Industry

Many countries spend considerable resources on procurement, maintenance and training of their Armed Forces in order to deter a military engagement and, if necessary, be ready for a possible attack against them. Major wars have some characteristics like rareness, unpredictable timing and uncontrollable variability over time and geographical coordinates. Moreover opposing forces may use technologies and weapons quite different. Consequently it is not easy at all to calculate the benefits of national defence expenses of a particular country like Greece, especially in peacetime. The main governmental aim is to decrease defence expenditure and direct these funds to other urgent social needs; but without investing substantially during many years on defence you are not adequately prepared against any external threat.

Internationally, military production capability has had a slight reduction, therefore the respective export markets have become very competitive. Western Europe and the USA governments were obliged to intervene in the defence market and subsidize development costs, thus protecting their domestic manufacturers of military and paramilitary equipment. All these happened in spite of the necessary processes to do with the privatisation and consolidation of the defence industry leading to the creation of a few immense defence firms, which offer their products firstly in their national armies (Dundervill et al, 1999).

Although after the end of cold war the military budget fell dramatically, the Greek Armed Forces spend a lot of money (30% growth during the year 1989-2001) to protect themselves from any Turkish aggression. In general Greece's defence budget is classified as one of the highest in NATO and EU organisations. The fact that Greece is classified as the seventh larger importer of major conventional weapons worldwide is depressing (SIPRI, 2001)[6]. Thus, in view of the above mentioned there are efforts to reduce dependence on foreign monopolies by developing a local industrial complex of state or private companies. Currently this complex consists of 85 firms with an annual turnover of more than € 1.5 billion and employing around 17,000 people. Nevertheless the military equipment produced domestically covers only a certain part of national demands such as ammunition, ground vehicles, explosives, portable weapons and maintenance services for aircraft and helicopters. Hence technologically advanced weapon systems (submarines, airplanes, helicopters, airborne or surface missiles, radars armored vehicles etc.) are imported from western (USA, France, UK, Germany) or even eastern countries (Russia, Ukraine, Slovakia, Yugoslavia, Armenia) (Economicos Tachydromos, 1999).

Apart from the obvious target of strengthening the Greek Armed Forces one of the main aims was to improve the participation in terms of Greek added value to the local defence industry in the various procurement programs. In 1996, when the realization of the first Joint Medium Term Armament Programme (JMAP) started, the involvement of the Greek defence industry in the military purchases was around 4% of the total contracts value. Then JMAP aimed to improve this share to 15% and now the government promises a further increase to 40%. This is not feasible because of the relatively weak industrial infrastructure of the defence industries and the limited technological abilities (Bartzokas, 1992). The motive for this policy is threefold: to cover the strategic, the political and the economic aspects (Brauer, 2002) but the resulted 3.7% of Greek participation in this first JMAP proves that the set target was ambitious.

The effort for the development of indigenous arms production started in the mid-1970s. The only achievements of local industry before this period where the Greek Powder and Cartridge Company (PYRKAL) and the State Factory of Airplanes (KEA) which as a pre-Second World War establishment showed examples of manufacturing airplanes for the Air Force. Thus the original defence industry development programme included the following projects (Tsolakidis, 2002):

[6] Military appropriations are funded one year at a time; however, they are normally authorized several years (i.e. 5-year plan) with funding levels adjusted due to inflation of each year. It is also called a rolling defence budget since it includes purchases which are repeated if it is possible to be realised within this year.

(i) Hellenic Aerospace Industry (EAB) established (1975) as a major maintenance and overhaul facility for military aircraft and helicopters.

(ii) Hellenic Arms Industry (EBO) was set up (1977) for the licensed production of the Heckler & Koch light infantry weapons.

(iii) Hellenic Vehicles Industry (ELBO) was created in cooperation with the Austrian firm Steyr-Daimler-Punch (originally as STEYR Hellas) to manufacture the over structures of heavy army trucks.

(iv) Hellenic Electronics Industry (ELBHL) was later transformed to various private electronics industries (ELFON, NETCOM, INTRACOM etc.) trying to absorb the first demands for military radio and other digital communication equipment, optical and laser technology items (DID, 1995).

Currently, apart from the 85 defence firms originally mentioned there are 150 in fact which are members of the Hellenic Defence Industries Association but only the first group are involved in defence-related products on a more permanent base. According to the Hellenic Defence Industries Catalogue (HELDIC, 2004) published by Hellenic Defence Industries Association these companies are classified as follows:

(a) Aerospace Industry and Repair Sector: 7.7%

(b) Arms, Ammunition and Explosives Sector: 2.55%

(c) Military and Armoured Vehicles Sector: 5.1%

(d) Shipbuilding sector: 5.3%

(e) Electronics and Telecommunication: 16.6%

(f) Electrical Products and Electro-optics sector: 5.2%

(g) Command, Control and Communications sector: 2.55%

(h) Metal Works, Machining and Spare Parts sector: 35.9%

(i) Armouring, Passive Defence Products and Military Accessories sector: 9%

(j) Services, Software and Quality Control sector: 9%

(k) Unmanned Air Vehicles and Target Systems sector: 2,55%

By industrial sector all companies could be categorized in general as:

- Metal Products and structures: 37%

- Electrical and electronics equipment: 25.8%
- Transport equipment: 18.5%
- Machinery: 9.26%
- Rubber and plastics: 9.36%

The first observation of Greek defence companies shows that they are separated mainly in two large groups: public and private manufacturing firms. Here it must be mentioned that PYRKAL and EBO merged into Hellenic Defence Systems and Hellenic Shipyards as well as ELBO have been privatised recently. Although the state-owned companies are larger than the private ones they are not as profitable as the latter (Defendory Conference, 2004). The second observation has to do with the actual output of the defence industry in terms of technology. The products produced are of relatively low technology and are principally parts and subassemblies of larger weapon systems manufactured under joint venture or co-production agreements with major international manufacturers who had obligations to the Ministry of Defence with the Offset Benefits programmes (ibid). The ratio of net fixed assets versus the number of employees forms a basic technological intensity indicator, which can be applied in the case of Greek defence companies. Therefore it is found that four of the major producers (three public and one private) are among the 12 companies with the highest technological intensity in country. Consequently, as this indicator is strongly related to the production technology itself one could consider these firms as technological pushers for the whole defence industry (Kollias and Rafailidis, 2003). Again, the aim remains a high value added which could be achieved in several cases by firms utilizing low value assets as in information technology (IT) industry where intellectual capital outperforms physical capital.

When the Greek government decided that the country should participate in the global economic system in view of the parallel participation in the EU and European Monetary Unification (EMU) they had to follow a bifurcated way. First to be integrated into international trade and the respective financial streams and second to involve into the global technology and outcoming production. Radosevic (1999) maintains that the first dimension is not deep but the second dimension has the characteristics of real integration of a country into the worldwide economic system. Although the first way is very important, it is incoming and outcoming technological flows that play a pivotal role for Greek economic development and competitiveness. Towards this end, the industrial base of the country must be wider and to achieve this technologies should be imported which in turn have to be absorbed by local firms. Even though the aim of increased value added has not been reached yet, the competition of produced goods is based on prices. However a few manufacturers of electronics and telecommunications exist who are integrated in the international market supporting famous companies abroad with the totality of their production (Kollias and Rafailidis, 2003).

Coming back to the fact of the technological distance existed between the Greek defence industry and similar industries in main military equipment exporting countries, some issues can be perceived. First of all, Greece imports almost all-capital equipment required for production and secondly the pre-condition for future development is the collaboration in technological projects with foreign partners. The local partner must provide a minimum technological capability before entering into global production. This is often lacking as explained in the next sub-section presenting the Offset Benefits experience. Therefore technological advancement is a matter of conscious and continuous learning effort to go much further than technological frontiers. The concentration of forces and recourses needs to be done within the framework of a certain strategy which is expressed by the Technology Foresight programme.

Human resources remain the key factor for the recipient country of advanced technologies. There is no chance to manage offered know-how without the adequately educated and trained (both off-the-job and on-the-job) personnel ready to acquire, accumulate and improve the imported knowledge. This human capital exists either in country or abroad and the responsibility belongs to the governmental policy, which should plan the motivation and corresponding preparation of these individuals. In parallel this strategic could stop the brain drain outside Greece especially in western countries.

4.4 European Defence Industry

When talking about the European defence industry we mean the companies. which belong to the EU member states now numbering twenty-five[7]. Greece as a member state is directly influenced by EU policy and directives, therefore it is useful to examine the environment, which obeys the same rules. The EU defence industrials were obliged to operate in a different world under new political and economical conditions starting from 1985 and not only because of the Maastricht aims. All these had the effect on the stronger European countries of reviewing their defence policy, which brought changes to the structure of the military forces. The respective impact on defence budget was a 50% decrease (€205 billion in 1990 and €108 billion in 2003) (NDASP, 2004).

Apart from the new targets of the EU, the international markets also shrunk while the competition, especially from the USA, is aggressively supported directly by the governments. The European share internationally has fallen from 56% to 30% within the last fifteen years and keeps decreasing rapidly (Defence Analysis Institute, 2003).

In view of these facts, the EU has prepared a master plan of actions (ibid) towards the solutions of existing problems together with the assurances of conditions for further development of the defence industrial network. Among the various steps is the foundation of a common European market of military and paramilitary equipment accompanied by the avoidance of overlap in research and technology (R&T) policy among the nations of the old continent.

The European Commission also encourages mergers and acquisitions, which lead to the establishment of big business groups capable of competing with US rivalries. Privatization belongs to this new strategic plan in order to free companies from the asphyxia caused by governmental embracement. The common European policy in defence and security will improve the interdependence of EU countries in managing crises in different areas like internal or external conflicts, terrorism, cost effective support of Armed Forces, through interoperability and commonality, same orientation

[7] A defence industry and technology base is the combination of people institutions, technological know-how and facilities used to design, develop, manufacture and maintain the weapons and supporting defence equipment needed to meet national security objectives.

in R&T, better use of national resources, reduction of unemployment and other associated social benefits.

The autonomy and independence of EU defence is a vital factor for the above targets. Presently 30% of the defence material used in Europe is of US origin. The overlap of production lines is another serious point. For instance, only in EU 4 different programmes for battle tanks and 16 programmes for personnel armored carriers are maintained while in the USA the corresponding programme numbers are only 1 and 3 respectively. The rationality in effectively using the resources of all kinds also contains the approach of technologically innovative items for the development of dual type equipment, which are ready to perform – or after minor adaptation – for both types of uses, military or civil. Therefore, when military expenditute is constrained, the factories could shift to civil material production lines thus amortizing fluctuation of demands (Moran, 1990).

R&T in defence provides a substantial leverage for the modernization of weapon platforms applying less expensive innovative ideas through the incorporation of knowledge–intensive technologies. For this purpose the amount of € 9 billion allocated by EU for R&T programmes should increase drastically to shorten the gap existing between the € 35 billion in USA. A significant contribution to this aim could be a bigger part of budget for national R&T to be directed in defence related research. Again in the USA 55.3% of state budget for R&T is devoted to defence projects while France and the UK allow less than 30% for this purpose. Greece has anticipated through a common inter-ministerial decision the amount of 1% of all defence expenses to be directed for R&T but this has never been materialized (MoD and MoE, 2000).

4.5 Offset Benefits (OB)

Greece started the OB experience thirty years ago when the first Mirage F1CG airplanes were bought. The main effort has began in 1981 when the Defence Industry Directorate (DID) established a special office in the Ministry of Defence (MoD) where the first guidelines on OB were prepared. In parallel the Ministry of Economy (MoE) established a similar office to handle respective OB from the Air Traffic Control project. Afterwards (1985) MoE undertook the global responsibility for all OB covering every public procurement. The main reason behind this action was the idea to use OB as a leverage for development. From 1994 on, no OBs were asked for public procurement except for the MoD, which has been handling its own programmes since then (Tsolakidis, 2001). In Table 2 below some cumulative data are presented showing the importance of the OB

Total Contracts	:	167
Total Progammes	:	766
Value of Contracts	:	13.5 billion €
OB Credit Value	:	14.7 billion €
OB Nominal Value	:	3,210 billion €

Table 2. Offset Benefits Contracts (1996-2001)

The basic aims of Greek OB today are defined below (MoD Guidelines, 1996)

a. To support local defence industry–state and private– and to develop / support further the business opportunities which contribute directly or indirectly at the upgrading of the technological and industrial infrastructure of the country.

b. To strengthen Military Forces in an effective way through the supply of equipment and services where appropriate.

c. To decrease substantially the procurement cost of the defence material through the indirect return of the biggest part of the expenditures.

Eligible OB should fall in the next categories (ibid):

i. Purchase of Greek defence products or services and the award to a local firm of subcontracting work for manufacturing military items

ii. Production in-country of new, complete autonomous products as well as subassemblies and spare parts of weapon systems through transfer of technology together with personnel training or any technical support. The supplier could also participate financially in order to create an infrastructure specific for the material under consideration. It is necessary that the transaction also includes partial absorption of the new production by the supplier who should provide respective licences too for the Greek market.

iii. Direct investments to increase the capital of an industrial firm (either existing or under establishment). The condition here remains the investor to participate in the long-term financial activities of the said firm.

iv. Any grant of capital equipment to public defence industries.

v. Similarly, any grant of material or even services to the Armed Forces such as defence material, production and test equipment, information technology hardware and software or any other type being of high interest to the MoD.

4.5.1 MoD Guidelines

The guidelines set up by MoD for OB are briefly described just to form an idea of the procedure (Kantas, 2002). In general, a seller is responsible for signing an OB agreement with the buyer only when the total procurement contract value exceeds the equivalent of € 1.2 millions. Correspondingly, OB total volume should reach at least 60% of the foreign currency part of the procurement contract and it is obligatory to include subcontracting work or purchase of defence materials and/or production of new products reaching the minimum of 50% of OB total credit value. The formula, which defines OB is

$$\mathbf{C = n \times E},$$

where **C** is the OB credit value, **E** the procurement contract amount (including material prices, transportation/insurances, taxes (national and international) and license royalties) and **n** the credit coefficient according to the nature and the volume of the work, the technological level and the kind of the charge-free support provided (training, documentation, technology, technical support etc.).

The license must be valid in the Greek market for a period over 15 years while the foreign contractor undertakes the commitment of the partial absorption of the new production with a minimum credit value equal to 70% of all credit values accumulated sum for the technology / know-how transfer and the technical support / training.

Thus the total credit amount could be expressed as

$$\mathbf{C = n_1\, E_1 + n_2\, E_2 + n_3\, E_3 \;+ 4\, E_4 \;+ n_5\, E_5 + n_6\, E_6 + n_7\, E_7 + M,}$$

with n_i as the various coefficient ranging from 1 to 12 and more specifically

$1 < n_1 \leq 8,\ 1 < n_2 \leq 8,\ 1 < n_3 \leq 10,\ 1 < n_5 \leq 8,\ 1 < n_6 \leq 10,\ 1 < n_7 \leq 12$

E_i pertain the various costs which are:

E_1: the nominal cost of the technology / know-how transfer

E_2: the nominal cost of the charge-free technical support and training provided

E_3: the level of participation

E_4: the purchase value of new products

E_5: the amount of direct investment

E_6: the current value of the equipment offered to state-owned firms. In case of used equipment they subtract the amount corresponding to the depreciation during its use before

E_7: the market value of the materials or services granted to the Armed Forces

M: it covers all cost of surcharges (transport, insurance, taxes, installation costs etc.) of the items E_6 and E_7

The total implementation period for the OB realization is supposed to be the same period with the main procurement contract and, if needed, there can be awarded a grace period too. If part of the OB obligation has not been fulfilled at the end of the agreed implementation period of OB the supplier has to pay the amount equal to 10% of this OB unfulfilled part which amount is taken from the corresponding already deposited bank guarantee.

It is worthwhile to be mentioned here that OB proposal plays a significant role during the evaluation of the global competitive proposal as it comes out the formula of reflective value

$$\text{Reflective Value} = \frac{\text{Procurement Cost}}{(0.8) \times \text{Technical Evaluation Grading} + (0.2) \times \text{OB Evaluation Grading}}$$

The evaluation of OB policy so far is difficult because there is a lack of information concerning the implementation of these contracts because General Directorate of Armaments and its evolution the General Secretariat of MoD are neither an efficient organization nor can supply data since defence contracts are classified (Antonakis, 1996). In any case, there is an important transfer of technology and know-how to domestic producers and this investment will have future yields in the form of improved technological capability and increased productivity. Some examples of critical high technologies absorbed through OB are presented in Table 3 below.

1. CATIA CAD/CAM (Hellenic Aerospace Industry, Air Force University)
2. EUCLIDE CAD/CAM (Hellenic Arms Industry / Crete Technical University)
3. UHF Airborne Radio (Hellenic Aerospace Industry)
4. VHF Portable Radios (Intracom)
5. Wiring / Harnesses manufacturing and control technologies (ELFON)
6. Multiple layer printed circuit boards (Metelco)
7. Hot section aeroturbines parts technologies (HAI)
8. High accuracy technology for missiles (Olympic Tool)
9. High power aeroengines test stand (HAI)
10. Coproduction of airborne ammunition (PYRKAL)
11. Naval technologies for frigates and submarines (Hellenic Shipyards)
12. Electromagnetic Compatibility Anechoic chamber (ACT)
13. Metrology technologies (Space Hellas)
14. Spectrum of electro-optics items (THEON / ECON / HAI)
15. Material and Geostructure Mechanics (Penteli Institute)
16. Chemical treatment of metals (HAI)
17. Plasma uses (EBETAM / HAI)
18. Aluminium alloys thermal treatment through tribology (Nikolco)
19. Titanium, inox steel and light metals hardness tests (HAI)
20. High speed mechanical manufacturing (HAI / EBO)
21. Aeronautical technologies for manufacturing and maintenance (HAI)
22. Quality Control and Assurance Methods
23. High accuracy mechanical parts through CNC (HAI / Grammenos)

Table 3. New Technologies Transferred to Greek Industries through Offset Benefits

Analysis and Recommendations

The firms appearing in this list as recipients of the corresponding technologies were able to capitalize on OB because they had an intermediate technological distance with the foreign manufacturers. Thus they had the technological capability to assimilate the offered know-how and use it properly. The problem with OB is that the majority of Greek industries wanting to be involved in OB transaction are not able to materialize such technology transfers because they belong to a much lower technological level. Therefore foreign industries are practically forced to select non-complex forms of collaboration. Licensing is a simple form of know-how absorption, which helps in the acquisition of better technological qualities. On the other hand, this means accepting transferred technology by a certain supplier which should be cost-effective. Without well prepared personnel, adequate infrastructure and realistic prioritization the technological accumulation by the local partner is a waste of time and money even if the partner is willing and capable to offer the required knowledge (Rafailidis, 2003).

In conclusion OB has had a positive influence on Greek technological and scientific level and the executed transfer of all technologies is useful here and in other countries too. The national economy has also benefited by OB and within 20 years the number of private Greek enterprises involved in OB have increased by 500% (they started from 20 in 1983 and now exceed 100) officially recorded in Hellenic Defence Industries Catalogue (2004). Moreover there are about 2,000 smaller units, which are activated not exclusively in defence but according to main producers needs and they are registered in Hellenic Industrial Subcontractors Association.

Anyhow there has been a debate on various sides whether OB has contributed to defence procurement and the new government plans to bring some changes to OB procedures in the new law, which is under preparation. The recommendations below is an output from the general multiyear experience in OB as they were expressed during the last Defendory 2004 conference in Athens. The WG of the TF programme has taken these proposals seriously into account because they are directly linked with the transfer of Aerospace and Defence Technologies in Greece up to 2020.

- Formation of a new broader but stricter legislative framework instead of the unique pamphlet of guidelines

- OB minimum total volume should be 200% and not only 60%
- Credit coefficients of 1.5 value must be used in some cases as incentives to promote specific industrial products
- Faster procedures for OB crediting
- Shorter negotiation period for OB contracts
- Reduction of time for OB implementation. It is proposed to be the half of the main contract endurance. Additionally instead of imposed penalties if there are problems during OB implementation to extend the main contract payment schedule proportionally
- Flexibility in replacement of the initial programmes with other alternatives if required
- Intensive monitoring and control of contractual obligations: frequent visits, progress reports and total workload division in sub periods
- Encouragement to OB offering
  - New work positions
  - Quality of investments: high technology, long-term and viable programmes, high Greek added value, acceleration of economic and technological development, production of dual-use items
  - Strategic alliances with foreign big industries
- Cancellation of unprogrammed grants of materials or services to the Armed Forces. On the contrary, the grant should contain items from a list where special military equipment or infrastructure technologies should be prerecorded. In parallel to ensure their most effective exploitation and support without any surcharge of the initial procurement cost
- Coverage of OB positions with skillful, professional and authorized individuals who could fight bureaucratic phenomena.

4.5.2 Prioritization of Technologies with Wide Applications

The researcher has further located such technologies important for R&D in Aerospace and Defence[8]. The presented technologies – apart from those analysed in

[8] MoD for internal purposes distinguishes between Research and Development. In their terms, work is "development" if it is directly linked to a specific equipment project. It is "research" if it is of a more general nature, not related to the procurement of any specific item of equipment.

Chapter 7 – reflect the direct responses to the questionnaire and the followed discussions during the interviews.

They are additional technologies either generic or infratechnologies[9], which apply in many domains during systems development and should also be considered seriously. These are presented in the Table 4.

1. Platform and System Concept Studies
2. Requirement's Capture and Definition
3. Effectiveness and Performance Design
4. Digitization of the Battle Space
5. Systems Engineering and Integrated System Design
6. Safety Systems
7. Architectures
8. Information and Data Fusion Technology
9. Synthetic Environments Generation
10. Reliability and Maintainability of Systems
11. COTS Software Assessment
12. Data and Information Management Technology
13. Combined Operational Effectiveness and Investment Appraisals
14. Life Cycle Improvement
15. Cost Engineering
16. Concurrent Engineering
17. Skills Training Systems for Individuals and Teams
18. Human Information Processing
19. Test and Evaluation Facilities

Table 4: Technologies with Wide Applications

[9] As infratechnologies, we mean an instrumental basis of R&D including the scientific data necessary for the operation of measurement, test, control and trial, methods and research instruments, techniques and knowledge.

5
SCENARIO PLANNING

5.1 Theoretical Background

Organizational leaders are in a continuous search to understand the environments in which they operate. They have been using several methods – strategic planning, integrated strategic change, transorganizational development or open system planning – to achieve this (Mintzberg, 1994). One of the techniques towards this understanding is scenario planning, broadly admitted as quite effective for examining future uncertainties and investigating all types of assumption in various organizations (Schwartz, 1996).

This method consists of organising information and future possibilities into alternative visions for the future, especially useful to comprehend events that seem to contain a mixture of unrelated information. Scenario method can be extrapolative or normative depending on the starting point. The scenarios themselves must be internally consistent pictures of future possibilities and should be composed of a mixture of quantifiable and non-quantifiable components arranged as alternative logical string of events. Scenarios writing is particularly helpful in the decision making process. In fact, this method is useful in terms of lowering the level of uncertainties and raising the level of knowledge. Scenarios can be combined with other methods, such as workshops or Delphi questionnaires (Masini Barbieri, 1993)

In a world that changes rapidly and which seems very unpredictable, scenarios appear to be useful in preparing for an uncertain future and they are gaining credibility to improve performance in a dynamic environment by altering models of thinking and by testing decisions (Chermack et al, 2001). During the last 20 years the increasing demand for tools like scenario building has become reality and the various applicants are looking for difficult answers to questions about the prediction of the future and how to face any arising crisis[10]. One of the problems is that fast growing practice of scenario planning is not supported by adequate research and theory development so far.

Despite its achievements in the practical world of business and public policy, the scenario method has been of marginal interest in academia. The puzzling nature of scenarios may be one reason for this. They deal with the world of speculation and in the same time scenario analysis/building/ planning are indispensable for any social activities based upon choice and deliberation political, business or military (Fauconnier and Turner, 2002). However the epistemic function of scenarios can be seen in its definitions, both given by Schwartz (1998) as

> *"A tool for ordering one's perceptions about alternative future environments in which one's decisions might be played out"*
>
> or as
>
> *"A set of organized ways for us to dream effectively about our own future"*

Therefore scenarios either in the common sense understanding (as a habitual pre-decision procedure) or in the technical understanding (as modeling using interdisciplinary approaches) operate at the epistemic level as a thought experiment and at the cognitive level as conceptual blending (Aligica, 2005)[11]. Finally, the general method of Lynham (2002), the diamond model of Van de Ven (2004) and the classical 8-step theory building of Dubin (Fig.3) are some efforts to fill this theoretical gap.

In the Greek TF, the Working Group for Aerospace and Defence Technologies has built three scenarios which are presented below and intend to help policy makers to understand what is happening and why in order to make their own prediction. The scenarios are constructed in three phases (Cristensen and Raynor, 2003)

1) Description of the anticipated phenomena
2) Classification of these phenomena into categories and
3) When phenomena might occur what hypotheses could be formulated.

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[10] One has to remember that the Chinese write the word "crisis" using two ideograms: one means opportunity, the second means danger.

[11] The terms "visions" or "scenarios" are mostly used as interchangeable ones in the Foresight literature, although "scenarios" might well also have a narrower meaning: a "time-line" of actions and events leading to a specific end state.

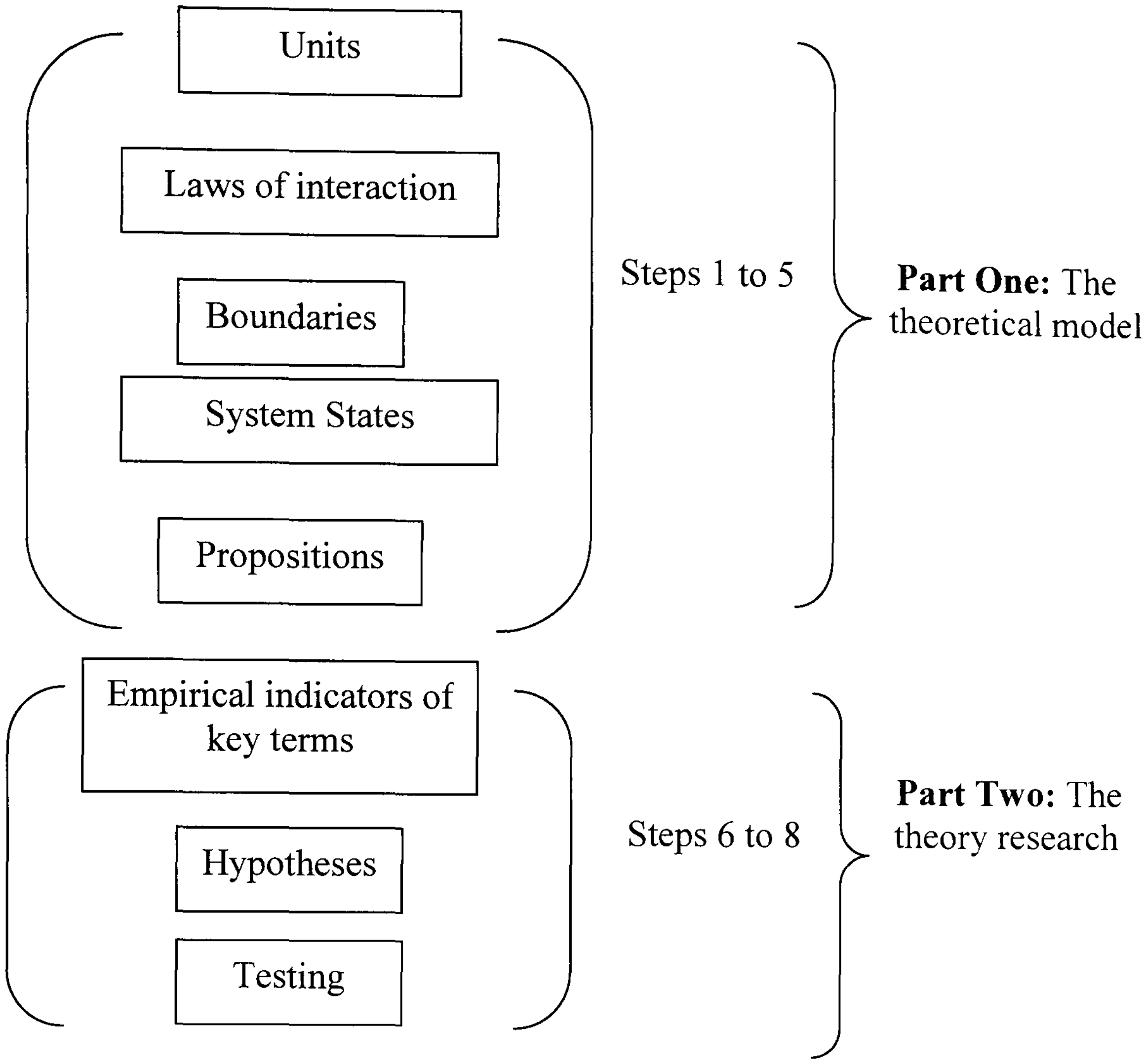

Fig.3 Eight-step theory building research methodology

Postma and Liebl (2003) propose three alternative ways for scenario design. These include recombinant scenarios, context scenarios and inconsistent scenarios. In this research a mixed model of the three has been followed. The reason is that firstly scenarios have been distinguished by different recombinations of trends, secondly there is a need to investigate the variation of the contexts to find out about their consequences and thirdly the recognition of cross-impacts and high-inconsistency can lead to a possible fact (Table 5).

The present scenario preparation is based upon the recognition by the Working Group as being important the general political and economic environment. The macro-analysis of this environment is necessary because this specific sector depends directly on the international political balance and the global economic reality. This frame includes, among others, European – American relations, emerging European military cooperation, the new NATO structure, asymmetric threats and modern security issues.

	Top-down approaches		Mixed approaches		Bottom-up approaches	
Exploratory approaches	(1)	Analysts define "what-if" scenarios	(2)	Analysts heavily structure group discussion or survey instruments to focus on a few predefined exploratory scenarios	(3)	Experts involved in free-form scenario workshop, or provide survey responses (e.g. conventional forecast Delphi) which are grouped by statistical methods to yield scenarios
Mixed approaches	(4)	Analysts define scenarios based on different theories/perspectives	(5)	Analysts define normative profiles, these are elaborated by experts	(6)	Experts grouped according to worldviews and expectations by statistical methods or discussion, and then elaborate scenarios as distinct groups
Normative approaches	(7)	Analysts define normative end-state scenarios	(8)	Analysts define normative scenarios, experts comment on them, identify key issues	(9)	Experts involved in free-form normative scenario workshop, or provide survey responses (e.g. goals, Delphi) which are grouped by statistical methods to yield scenarios

Table 5. Taxonomy of scenarios

Practically the three scenarios are developed according to the method of Bood (1997) and Ringland (1998) following 12 discrete steps (Table 6)

Step 1: Identify local issue or decision

Step 2: Key forces in the local environment

Step 3: Driving forces

Step 4: Rank by importance and uncertainty

Step 5: Select the scenario logics

Step 6: Fleshing out the scenarios

Step 7: Implications for strategy

Step 8: Selection of leading indicators and signposts

Step 9: Feed the scenarios back to those consulted

Step 10: Discuss the strategic options

Step 11: Agree the implementation plan

Step 12: Publicize the scenarios

Table 6. A representation of the process of scenario development.

5.2 The "ELYSIAN FIELDS" scenario

The structure of the global system is based on a cooperative model (monopolic or multipolic). International Governance, however, cannot be considered as a possible event. The influence and prestige of international institutions and the acceptance of Justice worldwide are not at a high level. Transatlantic relationships are smooth in general and there is an internal agreement for role distribution between the USA and the EU. The EU structure is very close to the model of federational Europe. Concerning the Central European Policy for Defence and Security in conjunction with the European Defence Industry there is an essential and fast progress towards a common European defence capability.

A clear improvement can be seen in reducing the economic gap between North and South, in tackling with the "Grey Zone" issues (overpopulation, religious extremism, immigration trends etc.) while confrontation of "Asymmetric Threats" (terrorism, organized crime, illegal refugees etc.) is successful. The management of global environmental problems has advanced smoothly while in the domain of energy there is a significant evolution after the exploitation of new, environmental friendly energy resources (independence from oil) which will have implications for international power correlations. Immigration is under control while it is beneficial for both sides.

Concerning the peripheral tensions, Balcans are characterized by problems related to their development and participation in the EU, while in Turkey there is a realization of changes, a complete democratisation, entry to EU and peaceful arrangement of problems with Greece (including the Cyprus issue). In the Middle East there is a final positive solution to the Palestinian problem, political stabilization and democracy in Iraq, democratic changes and economic development in most Arabic states is accompanied by a general transformation in the wider area. The consequences of this evolution for the Greek security are important. Greece feels secure within the framework of the EU and NATO. The population is increasing rather marginally while the various immigrants are gradually being integrated into local societies.

The Armed Forces have covered their needs after the planned reform to semi-professional and their participation in the European Forces. As basic missions, they maintain participation in peacekeeping operations and confront the so called "asymmetric threats". The Public Security services still need higher investment in personnel training and the necessary equipment to execute their objectives where the management crisis of disasters is also included.

As a result of such an international environment there will be a gradual decrease in Greek defence expenditure, reaching the average of EU member states. At the same time there will be a redesign of the defence budget towards high technology weapons acquisition and the formation of rapid intervention units for facing the modern threats. All this is done according to the extension of Central European Policy for Defence and Security and the corresponding Greek obligation to share in the common European defence budget. Given the aforementioned, Greek Defence Industry is anticipated to be organically incorporated into the workload distribution for the production of military equipment always after conforming with competitiveness and cost effectiveness criteria. This collaboration and interconnection, together with participation in common R&D programmes will drive the reallocation of defence industries leading to the creation of many small and flexible firms of high technological specialization in specific products and services. Consequently, this will force the traditional companies with only low levels of knowledge and invested capital to withdraw, leaving space for business units capable of operating as sole-source contractors. Moreover the secure environment allows for long-term planning (over 10 years) in science and technology, increasing financing opportunities of strategic research.

5.3 The "JANUS" scenario

The structure of the global system is based on a monopolic-despotic or a multipolic-conflicting model (China could figure as the main opponent of the USA). The influence and prestige of international institutions and the keeping of justice rules all over the world are relatively restricted. Transatlantic relations are rather disturbed. The EU hard-core structure is very close to the model of federal Europe, while the rest of the member states have the choice of a loose union (i.e. common market). The

Central European Policy for Defence and Security and the joint European Defence Industry are advancing at a slow pace.

The "Grey Zone" issues and economic gap between North and South remain static or slightly changing (either worsening or improving) while the "Asymmetric Threats" seem to be under a relative control but they stand as serious menaces. Most of the Earth's environmental problems are being managed smoothly but energy requirements are still dependent on oil and coal mining. Immigration waves provoke local problems and regional tensions.

Concerning the peripheral situation, the Balcans peninsula is quite stable without a parallel solution in existing problems. Although Turkey has achieved some reforms it is limited to a special relationship with the EU (not full participation) and the bilateral problems with Greece are still unsolved. The Palestinian problem has been adjusted together with political tranquillity in Iraq but the general periphery instability is maintained at high levels.

The implications of these events to Greek security are determinative. Greece is relatively secure within the framework of a looser EU or even in an Atlantic-sovereign situation. The population still moves in marginal increases and immigrants are only integrated in to Greek society occasionally or in accordance with the rules of the labour market.

The Armed Forces have completed their reform to semi-professional rapid intervention flexible small units force with a basic mission to defend against an aggressive neighbour (Turkey) and in parallel to participate in peace-keeping operations and confront the asymmetric threats to the European Army. The Public Security Forces tries to invest more heavily in training and in obtaining necessary equipment to perform their missions enlarged with crisis management issues.

The defence budget is expected to decrease more or less relatively to the spectrum mobility of the JANUS scenario in order to reach a better effectiveness of the allocated financial resources. Further, the defence industry will be obliged to make a partial or extensive reorganization where the only survivors will be the companies, which have made investments in knowledge and capital assets. The public sector has to support the rest of the enterprises according to their importance to Greek defence planning and the Greek economy otherwise they will be out of business. Essentially a shrinking of this industrial branch arrives, together with the emergence of the so-called "National Champions". These companies together with the other surviving firms will be awarded subcontracts of the main European or US weapon systems purchased by Greece since there will be a general positive trend in defence expenses. Promotion of technological cooperation means know-how transfer in a country based on the criteria of one-way directed influence (i.e. USA/EU towards Greece).

5.4 The "ARMAGEDON" Scenario

The structure of the global system is mostly chaotic either due to the loss of USA sovereign role or because this country is becoming isolated. The influence and prestige of international institutions and the presentation of worldwide justice rules are almost inexistent. A deep crack characterizes transatlantic relations while the EU presents a lack of coherence, facing a clear risk to dismandle. The EU hard-core structure is closer than ever to the model of federal Europe while the other nations cannot select anything but the loose union (i.e. common market chances). No progress appears to the Central European Policy for Defence and Security and the unification of European defence industrial entities.

There is neither control on the asymmetric threats nor on the "Grey Zone" issues while the economic gap between North and South deepens. More than one global environmental problems has escaped human control with serious local or international impacts and a shortage of energy resources is observed. Massive immigration displacements create serious problems and frustrations.

The Balkans return to the era of "explosive powder stock house" and in Turkey internal instability occurs: a reanimation of the Islamic and Kurdish movements, a failure to join EU resulting to an aggressive external policy and peripheral stress with Greece. In the Middle East the already long-term difficult issues cannot be handled any more and this transforms the area into an open field of clashes.

Consequently these events for Greece's security are very important. Greece feels unsafe within a split EU or in a North-South environment of generalized conflicts. Concerning the demographic case there is again a marginal population increase and simultaneously a blockage of the entrance of immigrants is applied which is accompanied by an effort to create minorities issues artificially.

To cover the requirements of Greek Armed Forces a return to a large-scale army of draftees is needed to increase the number of both officers and non-commissioned officers, focusing on the deterrence of external attacks and the confrontation of asymmetric threats. Security agencies have an upgraded role in order to face the modern menaces and the severe control of illegal immigrants. An upgrade of the crisis management mechanism must be effected the soonest possible.

The ARMAGEDON scenario proposes that the Armed Forces prepare heavily equipped rapid intervention brigades which will be capable of attacking diverse targets in parallel with the demonstration of their power (using ballistic or cruise missiles). The defence budget remains at present levels or ever higher in the case of extreme events or increased dangers. The ability to keep a high level of defence expenditure depends on the growth of the national economy. To improve the defence effectiveness of the invested amounts furthermore, the relative budget must be rationalized because it is not possible to increase expenditures due to public income limitations. Hence, there arises the requirement to improve the ratio of domestically produced to imported military systems in order to achieve an effective feedback mechanism from defence towards economy. For this purpose in-country research, technology and development (RTD) must be strengthened, the national defence industry should be partially autonomous (i.e. like Israel) taking into account Greece's revenues and existing technological level. The branch is concentrated around the big traditional factories, which compose the trunk of the defence industrial complex.

A development of synergies with other countries – outside of NATO – is realized at the same time and some small firms, usually the smaller ones, try to produce "dual use" equipment useful for both military and civil applications (Chapter 8). The technological priorities are diverted towards reverse engineering and the coverage of short-term needs. Besides all these, there is an orchestrated coverage effort to push exports for financial and external policy reasons too.

Some conclusions

The preparation of the three scenarios was based on the use of variables defined by the Working Group as catalytic for the defence industry and Armed Forces in Greece. Some of the factors, which have modulated the scenarios, are distinguished as more important than the others. Thus, the field of the competitiveness of the Greek Defence Industry and of the research, which is compulsory for the Research and Technology Policy, are linearly dependent on the perspectives of Central European Policy for Defence and Security and the evolution of a transatlantic relationship.

The Working Group in any case foresees a relative technological autonomy of the nation and the decrease of dependence upon foreign agents. The defficiencies in the defence industry and research (coming from low technological return, loss of opportunities to cooperate with foreign contractors, lack of official mapping of defence business units, reduced financing for research projects) could be amortized after close cooperation and coordination of the respective research directorates of the Ministry of Defence and the Ministry of Development.

General policy proposals include

- The creation of model programmes for Research and Technology development
- Generous financing of the scientific research and re-evaluation of defence budget targets
- The adaptation of educational and skills development priorities as well as best use of human resources especially on the interdisciplinary characters of critical technologies (as proposed in Chapter 8).

6
RESEARCH PROCESS AND METHODOLOGY

6.1 General Approach

Research process and methodology must be developed properly in order the links of research spiral to serve their aims as per Rudestan and Newton (2001) description. The aim of the research is to find out which are the future key technologies in Aerospace and Defence which should be developed up to 2020 in Greece. Moreover to investigate the role of human factors integration into the design and development of these high-technology systems. Also the interrelationship between military and civil technologies leading to the creation of the so-called dual-use technologies is examined because they are very critical for the national resources management (Appendix 6).

The approach used in this research is a multi method. Although the principal method is the Delphi technique in order to implement its process there were used additional methods which included documentation, interviews and questionnaires as they are presented in the following sub-chapters. The general strategy for doing this research is also a combination for fieldwork and deskwork because each complements the other. Moreover even though the form of this research is qualitative, certain characteristics of quantitative methodology could not be left out since the use of questionnaire as a research technique belongs to this research family. From the early phases of TF (Jantsch, 1967) certain quantitative and qualitative methods were accepted as the most suitable for this kind of research and the effort here was to follow this pattern in the preparation of questionnaire and scenario building. Amongst qualitative methods are included the application of intuitive thinking, exploratory and normative methods. Intuitive thinking includes brainstorming, utopian writing and science fiction which are more qualitative or artistic methods. For instance, brainstorming is a group method where a period of free thinking is used to articulate ideas. It can be an useful technique for expert committees and consultation management groups. Exploratory methods begin with the past and present as their starting point and more toward the future in a heuristic manner, often looking at all available possibilities. Normative methods start with the future by determining future goals and objectives, then work backwards to see if these can be achieved given the constraints, resources and technologies available. Quantitative methods can be divided into time series and causal methods. They can be applied when three conditions exist: information about the past is available, this information can be quantified in the form of numerical data, it can be assumed that some of the aspects of the past pattern will continue into the future. Examples of quantitative methods include trend extrapolation, substitution theory, systems dynamic simulation, econometric models etc.

6.2 The Delphi Method

6.2.1 Evolution of Delphi

The Delphi technique is a special featured survey method, which has taken its name after the Oracle at the ancient Greek site of Delphi where people used to go to get insights into the future. Delphi became internationally known during the 8th century BC, because of the oracular power of the priestess Pythia who sat on a tripod and falling into ecstasies made predictions about the future. Pythia was so famous among the Mediterranean people who believed in her views of the forthcoming events that no major decision was made without consulting the oracle of Delphi first.

The Delphi method was first used in the early years after World War II to foresee horse racing results in the UK. Then it was originally developed by RAND Corporation analysts under the auspices of the US Air Force projects in the beginning of 1950's. These projects had to do with the choice – from the enemy's point of view – of the optimal industrial targets in USA, by dropping an estimated number of atomic bombs. The initial experiments showed that predictions made by a group had a higher probability of being correct than predictions made by the same individuals alone. Researchers have also found that individual estimates presented a tendency to converge as the experiment continued in rounds, given that the study was designed to reach a consensus (Linstone, 1978).

Within the development of the technique over the years there was a considerable broadening into a wider range of methodologies, which incorporate some common characteristics that still may differ in other details. Such an example is an application of the Delphi Method not to reach consensus but to investigate differences, mainly by employing the disaggregating analysis approach (Riggs, 1983). Other uses of the method – apart from looking into the future – is to define objectives of a project or to practice experiences of education for a certain group of interested individuals (Dalkey and Helmer, 1965).

6.2.2 Delphi features

Delphi as a method is based on two or more round structural surveys and makes use of the intuitive information of the participants who have two characteristics: they are mainly experts and anonymous to each other. In this multi-rounded expert survey the results of the previous round are given as feedback to the next one.

Therefore the involved stakeholders control their earlier predictions avoiding the disadvantage of possible bias during face-to-face panel deliberation. It is just an interactive group communication process in which knowledgeable experts are ensured that they are not under pressure to agree to the perceived views of senior colleagues but they only express their views, which are formulated by personal preferences and the existing qualitative data in order to shape policy decisions. Here discussions have a dominant role, while scientific prestige, louder voice or seniority do not directly influence the expression of opinions from everybody. Then, a sufficient time of 10-15 days is given to prepare their judgment on the survey topics.

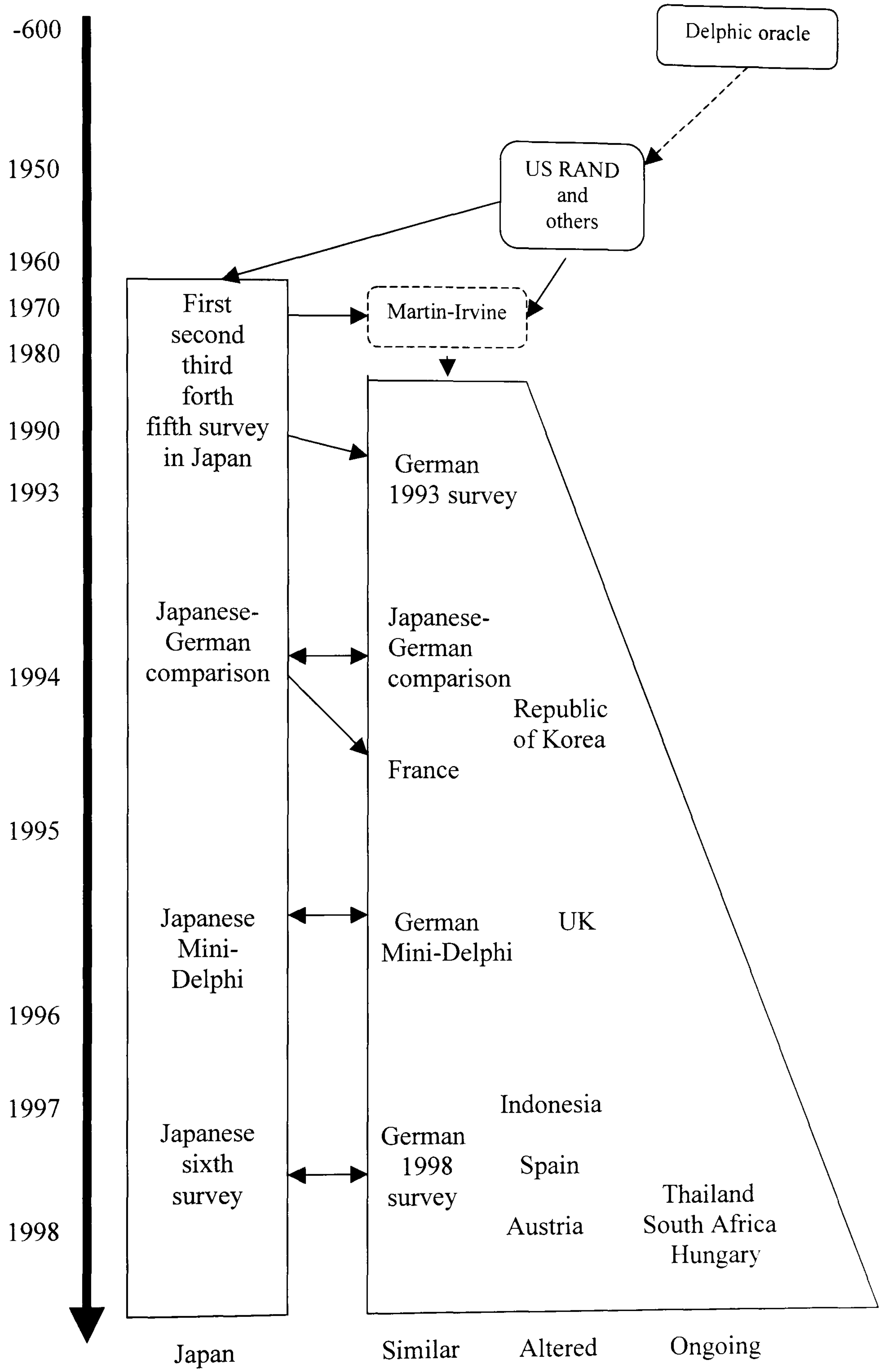

Figure 4. Career of the Delphi method: genealogical tree of national applications.

Given that there are people who are more knowledgeable and experienced than others it makes sense to use them as part of a panel for a Delphi experiment. So it is reasonable to include experts because they should produce more accurate anticipations of the future (Best, 1974). However there are others who insist that it is unnecessary (Armstrong, 1985) while Wonderberg (1991) stresses that the best reliability of Delphi derives only from the same set of scenarios and during the same period regardless of the panel synthesis. Rauch (1979), followed by many researchers, distinguishes three types of Delphi studies.

1) The Classical or Conventional Delphi as a tool to discover the group opinion of experts about future facts. Hence to reach a decision for today after looking into the future it ensures that the future evolves according to some laws or at least some regularity. Conventional Delphi can be distinguished into four branches as per the ways it is used

    - Possibility of future events or trends
    - Prioritizing alternative goals or objectives
    - Creating management strategies
    - Allocating scarce resources between competing options.

2) Policy Delphi has as a purpose to clarify the position of decision makers. It serves to highlight all the options and supporting evidence for the resolution of major policy issues by dealing with ideas and concepts not with data and facts.

3) Decision Delphi, on the contrary, tries to coordinate decisions with relevance to the future, if the future does not behave according to a law but is influenced by a large number of small, uncoordinated decisions. The main social function of Decision Delphi is rather to coordinate and push the way the experts are thinking towards unexplored fields of social relations and to modify future development from real accidental cases to carefully considered decisions.

6.2.3 Delphi and Foresight

The Delphi survey is a methodology, which has been widely used by advanced and developing countries in many TF exercises. In Japan it was selected for the Science and Technology Agency in 1969 for the first time to conduct a large study for predicting technological and scientific future of the country. The Delphi technique was implemented in the new wave of large-scale government Foresight in Europe and Germany, France and UK were the first to join in.

The Germans cooperated with the Japanese in their first Delphi and they were copied by the French, although different ministries have used in parallel the critical technologies approach. The UK in both rounds of TF has used Delphi successfully and Austria, Hungary, The Czech Republic and Spain have followed the same path. Recently, the European Union Commission has initiated translation of Delphi exercises while Mediterranean member states (Italy, France, Spain, Greece as well as Portugal) have begun dynamic participants in regional TF cases already.

Outside Europe other countries like South Korea, Turkey, New Zealand, South Africa, USA have also organised national Foresight programmes, which were based on Delphi (Taeyoung, 2000).

6.2.4 Delphi as an overarching approach

The Delphi technique is used in judgment and forecasting where pure model-based statistical methods are impractical and impossible. Delphi is not a scientific tool nor is related to a scientific experiment or a scientifically structured activity (Coates, 1975). It can be characterized as a systematic bottom-up method for eliciting and collating informed judgments on a particular issue, through the circulation of a carefully designed questionnaire (Andersen et al, 2004).

This method has a number of advantages. Firstly, it permits a synthesis of the views of large number of experts and disseminates those pieces of information. By doing so, contributes to consensus building or identifies dissenting views. Secondly, it is suitable for looking at the longer-term through the process of concentration. Lastly, it can be applied in different countries, thus allowing the researcher to compare the results and to identify the effect of any national influences (e.g. the Greek case).

In TF the true Delphi goal was unknown future events to be assessed by a diversity of experts using differing knowledge (Tichy, 2004). Through this useful tool the participants are alerted to the complexity of presented issues and they are urged to think and challenge their assumptions. The aerospace and defence environment is very fragmented, fractioned by disciplines, plagued by a polyglot technical language, polymorphic in its organizational structure, organized in bureaucratic lines and it is divided in authority and responsibility. Therefore the Decision Delphi we are using in the project is an attempt to deal with this crisis of ideas, alternatives, concepts and planning because our field is shaped by a mix of individual decisions rather by general rules of regularities. As "reality is not predicted or described; it is made" (Rauch, 1973:163) the participants in Delphi were recruited primarily with regard to their actual position in the decision-making hierarchy and in the second instance to their expertise. We believe that if developments are dominated by a multitude of independent and uncoordinated decision makers, a Decision Delphi is recommended to structure and co-ordinate them towards a path to a desired future situation.

This approach of selection can handle somehow the typical weakness of the Delphi method which is that insider's points of view are influenced by emotional investment, commitment or controllability. Experts are fascinated by their specific field tasks, the desirability of the outcome and they believe in their ability to influence. This optimism and overestimation often does not consider dependence on other technologies or need for organisational innovations as well as abilities to mobilise economics social and political resources to promote their goals (Burns, 1985). This is another one reason why we have chosen a non-homogeneous fair mixture of different grades of experts (from top experts to less knowledgeable) covering academia, public administration and business just to control elements of technological euphoria.

Finally we admit that Delphi alone is not sufficient to overcome all problems. So the systems approach has been followed and complementary methods including scenarios have been used to enhance the reliability and the validity of results.

6.3 The Other Methods

6.3.1 Documents

Documentary evidence is defined as all printed sources and other non-written ones which illustrate the recorded impressions of certain people (Stanford, 1994:146). As there are quite a few positive aspects of documentary evidence, they were used primarily when it was not possible to access key people. Alternatively it is a very useful means to complement information already obtained by other methods, such as interviews and questionnaires. Being a flexible method, it allows questions to be formed via source material or the reading of relevant literature first and then the preparation of questions. Archival materials were also very useful. These included industry reports, internal documents such as newspapers and magazines articles about the firms as well as relative information available on the Internet. Other material produced by the MoD, the EU, the professional associations and the companies themselves – employee handbooks, marketing publications, press releases – have also served as data sources describing the work, processes and culture of the institutions. The choice of documents and the time required to go through them, remain the difficulties in documentary evidence (Ghauri and Grohaugh, 2002). Anyhow the researcher did not face particular problems with this and then followed the secondary sources, thus it was easier to classify findings according to their significance (Thornhill et al. 2003: 190-1). A very significant part of documents consisted of the 24 case studies of TF exercises developed by other countries all over the world (see Chapter 10). This collected knowledge and experience helped the researcher to avoid similar mistakes and follow some approaches which are considered as successful.

6.3.2 Questionnaire

The questionnaire is the second applied technique to collect data. The concern for designing these questionnaires was to remain within the scope of the research plan so the questions should be not too many, too long or too short but simply written and accompanied by certain instructions when required. The Questionnaire I (Appendix 1) focused on the first and third aims of the research which were to locate the Aerospace and Defence technologies up to 2020 and to find out the dual-use products potential. The Questionnaire II (Appendix 2) examined the human factors integration into these high-technology systems which was the second aim of the dissertation. The main advantage of questionnaires is time gain even though it was not easy to prepare an adequate set of questions and to distribute it to 85 recipients (Oppentheim, 1966). The other advantage of this method is its lower cost. Of course there were difficulties, which were located in the structure of the questions themselves. After careful preparation it was possible to leave out impressions, vague assumptions, misleading wordings and sensitive issues too. An effort was also made to the general appearance of the questionnaire in order to be attractive to potential respondents who needed to answer questions in due time and return the package (Moser and Kalton, 1971:267-268). Sending a questionnaire remains a faster approach than carrying out the same number of interviews, while the results were much better when the researcher / interviewer dispatched the questionnaire himself (Appendix 1) to responding people. These respondents, after the receipt of the questionnaire were given a certain time allowance to review the set of questions and then the researcher personally interviewed all of them as per the Delphi method described previously. All recipients of the questionnaire were then asked to answer questions and send back the completed document. That is why we inserted filter questions (Saunders et al, 2003:302) to assist the flow of the survey when respondents needed facilitation to reply.

In this research the questionnaire included both types of questions, open and closed. The use of open questions permitted the interviewees to feel free to express their opinions more analytically. Closed or forced-choice questions were put to collect information efficiently over a specific subject. The closed-entered questions were of various types: list (yes/no or other item choices), category, ranking and rating. Analysis of questions was simple for list and category but more detailed for ranking and rating ones. Ranking questions did not exceed five items so respondents did not spend much effort. The Lickert-style rating scale was the approach used in rating questions with a five-point scale applied throughout the questionnaire to avoid confusing respondents (Dillman, 2000). Before starting the interviews – based on the previously sent questionnaire – the researcher carried out a pilot test to confirm the validity of the content. This trial run (Bell, 1999:218) helped our self-confidence because we obtained a positive idea for the questionnaire's face validity. The questionnaire is considered a rather complex tool so generally it was handled carefully because the more precise and tight it is the more comprehensible responses it gets (Webb, 1932:72).

The questions were categorized in groups and emphasis was given to relating the answers and cross-checking them in order to increase their level of reliability. The first group of questions (1 to 6) pertained areas of innovation and corresponding perspectives in the next 20 years connected with societal, environmental and developmental issues. The next set of questions (7 to 15) covered the domain of R&D and associated benefits for Greece from Aerospace and Defence technologies. The third group (16 to 29) tried to extract data by asking questions on TF importance, the policy impact of it, the coordination of involved organizations and funding decisions of the political administration. The following eight questions (30 to 38) had to do with the profile of respondents, their clientele and the network of cooperation. The last grouping (39 to 47) examined the Greek Aerospace and Defence potential and its characteristics/constraints as well as how it is positioned versus European or world competition and what is the participants' view of the future policy for technology transfer approaches.

6.3.3 Interviews

The interview is the third part of the multi-method used in this research. Although the interviewer used the pattern of the said questionnaire, the schedule is not standardized and the interview is semi-structured following an open approach style (Cohen and Mahion, 1994). They were face-to-face interviews conducted on a one-to-one basis. The semi-structured interview was used to help the qualitative character of the research as well as to explore and explain themes coming from the use of the questionnaire validating findings too (Healey and Rawlinson, 1994:130). The staged approach has utilized in depth interviews to probe further responses having a few alternative questions as a back up for clarification (Lane and Roberts, 1971:86). The interviews were not tape-recorded but notes were kept by the researcher. The interviews fulfilled all three aims of the research as explained in the beginning of this Chapter.

The long experience of the researcher (more than 35 years) in the field of Aerospace and Defence technologies enabled the collection of data during informal observations made at the various installations visited (keeping notes of the everyday working environment or in cross-company meetings and some project group's brain storming sessions).

6.3.4 Process and Implementation

Even though no method is infallible, a multiple-source data is the best solution (Hakim, 2000). Practically the way this research was conducted, apart from the documentary evidence, was a combined approach of interview and questionnaire. That is the questionnaire was prepared and sent to key people just to give advance warning of the topics to be discussed; then, when both rounds of responses were received, a semi-structured interview research was applied based on that questionnaire trying to get more information from a multistage convenience sample consisting of persons working at various private or state-owned companies, at universities, at research centers and in the public domain such as ministerial positions. An effort was made not to exceed fifty questions suitably prepared to obtain reliable and valid data about the issue of research. I was officially authorized to search relevant documentation and the assistance offered by the people involved is deeply appreciated. Moreover, interviewees were not tape-recorded but verbatim transcribed, they were allowed to look at the drafted report, and this has built a mutual level of confidence.

As part of the broader research agenda, interviewees were asked to comment on their experience in various programmes, the challenges dictated by the nature of their work and the ways used to sustain Foresight across different product categories and industry sectors (Andriopoulos and Gotsi, 2005). This focus was adopted in order to understand how people aknowledge, experience and embrace the processes involved in probing the future during their engagement in such a high-change industry.

By using all these means, the applied methodology in this case study tried to combine a triangular scheme of the previously mentioned research techniques. Thus both aspects of quality and quantity were met following the classic argument of J. Bell (1999:101).

"Case studies, which are generally considered to be qualitative studies, can combine a wide range of methods, including quantitative techniques. Methods are selected because they will provide the data you require to produce a complete piece of research".

The method of data analysis drew on classical recommendations by Glaser and Strass (1967) as well as Miles and Huberman (1994). Search foresees that highlighted future trends were the specific task. Once several emerging categories were identified then the data were studied again seeking other fragments that fitted each category. Thus interaction between the data and the categories helped us in locating the most prominent categories. The methodology of this inductive approach is based mostly on unstructured analysis of qualitative data collected and open coding is the process used (Maylor and Blackmon, 2005). This was dictated partly by the thematic categories of technologies and the iterative way of classifying voluminous data from various sources. Validity of gathered information has passed a cross-checked verification through interviews and not been misled by particular influencies. Also vigorous analysis is ascertained by the concrete findings and conclusions so this enhances even more validity of the research. The continuous use of existing literature sharpened the insights yielded by the followed inductive process and linked the findings with existing concepts and relationships. The analysis of many case studies was an important advantage of our research and gave a more generalized character to the Technology Foresight review. The reason is that the acquired knowledge of the 24 case studies (See Chapter 10.1) permitted to form a thorough perception of the TF philosophy established worldwide through the development of national and regional Foresight programmes. Moreover the comparison of Greek TF with other South- European cases facilitated the results classification of this research.

6.3.5 The dual role of the worker researcher

During the preparation of this project my double role as a worker and researcher was very clear. I have chosen the combination of research methods and knowing their limitations I proposed to my fellow workers ways to apply this methodology effectively in order to get objective and practical outputs. Then I have prepared both questionnaires (Appendices 1 and 2) as well as I have conducted personally all the interviews. Moreover, as an insider, I had access in many documentary sources (either primary or secondary) because key people in different governmental or entrepreneurial positions have trusted my ethical understanding. It must be underlined here that the defence environment since it includes various critical and complex communities is not easy to penetrate unless you belong to it. That is maybe the reason that only UK and Greece so far have included in their TF exercises such an assessment on defence matters.

In my case the results of the research were presented at the Working Group which has authorized the interdisciplinary analysis of the findings and the synthesis of texts. Of course I was always responsible as a team leader towards the Steering Committee.

Moreover I went further of the initial TF project tasks and in this dissertation I covered the following three new areas by doing my own separate research.

a. Technologies with wide applications (Chapter 5.5.2)
b. Dual-use technologies (Chapter 8)
c. Human Factors Interaction (Chapter 9)

In addition I probed more in the Delphi research by completing a 3rd round of interviews confirming the already collected results.

The deep knowledge of the questions to be researched and the structure of relative institutions in Greece have assisted my working practices during the whole research efforts. However sometimes I felt a slight influence of key people and of my personal expectations which was normal because of the duality of my roles. Anyhow, I admit that the market forces and the organizational culture did not have a serious impact on my objectivity as the professional experience itself had.

In conclusion, the duality of my role as an employee and a researcher increased my reflexivity since I disposed the insight about the pure context of the project being also able to minimize any problems appearing during the research.

6.4 The Greek case

The Delphi method has been used in Greek TF project. After selecting issues, as explained below, on Aerospace and Defence Technologies the following stages were involved for the application of the methodology (Haluk, 2002)

- Generation of variables and topics (events/statements)
- Selection of participants
- Feedback of tendencies
- Implementation of statements
- Final analysis of results

Due to time constraints our team had not the chance to implement further rounds. However the researcher, in the frame of this study, has completed a third Delphi round with an extended participants' list. The initial results were encouraging since this coincided and confirmed the outputs of the first TF report, as it will be analysed later.

The WG of Aerospace and Defence has thoroughly studied the Joint Medium Term Armament Programme of MoD, the R&D projects of GDDIR (Appendix5), the technologies transferred to industries through Offset Benefits (Table 3) and the dual-use technologies developed by Greek firms (Appendix 6). Then the WG has selected the issues on which the questionnaire (Appendix 1) was based.

In the Greek case the issues chosen (manufacturing, information society, economic restraints, European frame of directives/ perspectives, investments industrial defence priorities, human resources availability etc.) were not initiated from scratch and they were definitely interlinked. The experts have been asked to identify possible technological development in 20 years time as well as to estimate their occurrence and realization time. The advantage of complete anonymity did not apply in our case because the complete list of participants was announced except from some public servants who preferred not to reveal their names. Nevertheless during the whole sequence the panel members were not aware who has contributed in particular statements or assessments. The integration among involved people was done in anonymous manner through the use of written questionnaires. However it must be mentioned here that during the public presentation of our reports several interviewed experts appeared and supported their already expressed views.

The Greek TF Delphi was designed as a Decision Delphi (Gordon. 1994). This specific form was considered as the most appropriate because the target was not just to forecast new emerging fields of Defence and Aerospace technology but also to map those fields and niches examining where Greece could attain a certain position within the next twenty years.

6.5 Findings of Delphi

The questionnaire was sent to 85 people in June 2003 and the response rate in the two rounds was high – 78 per cent and 89 per cent correspondingly – while the knowledge of the respondents was very good (as judged by the responses) and the answers were highly consistent. This is judged from the level or response rate which was calculated following Neumann (2000) ratio where the numbers of ineligible and unreachable persons were very low (about 5 to 10 per cent). Both Witmer (1999) and Willimack (2002) admit that a response rate higher than 60 per cent for questionnaire based surveys is quite satisfactory. The design of the Greek Delphi intended to have representatives of academia, business and administration (civil servants. customers – i.e. MoD officials – lobbyists etc.) roughly equally represented 75 per cent among the correspondents. These representatives were classified as experts taking into consideration their specific knowledge in the relevant field accepted by the scientific community with an influence on other actors in their domain (Bogner and Meyr. 2001).

After the second round there were not significant differences in the shares. Functionally, almost 30 per cent worked in R&D. 20 per cent in market-related jobs. 20 per cent were operators and users of Aerospace and Defence technologies while 10 per cent indicated a combination of several functions. The age structure could be considered as representative 22 per cent between 30 to 40 years old. 35 per cent between 40 to 50 and 40 per cent above 50 years, but women were rather underrepresented since their participation hardly touched 5 per cent.

The participants were asked to indicate their specific knowledge using an ordinal five-point scale of integers (Lickert scale) as mentioned in research methodology. The state of the art (Cuhls et al, 1998) implies that all experts provide with a self-rating of one to three for respective questions. Again this was not collected by the questionnaire but it was covered through the personal interviews later on. The task of the participants was double: problem-oriented and future technologies development. Therefore the Working Group avoided the trap of focusing only on new technologies, urgently seeking just any application. Then the people had to comment on three hypotheses (the optimistic, the pessimistic and the conservative) pertaining three future scenarios as presented in Chapter 7. The discussion about scenarios was carried out during the personal meetings and the interviewees had to answer questions related to their specific knowledge, the innovativeness implied in the respective hypothesis, the importance of this hypothesis, its chance of realization in Greece and which policy measures were suitable to enforce the envisaged development. Within the TF project, the scenarios are understood as "possible future worlds" and not merely as desired and/or possible future states while in parallel they emphasize on the concept or knowledge society and on the way in which to approach and achieve this in connection with the various levels and fields under the TF exercise (Synthesis Report, 2005). However Cristensen and Raynor (2003) argue that the true effects of scenario planning and their hypotheses will not be known and will not become predictable until the phenomenon is examined rigorously in applied settings in which the circumstances of success and failure can be noted.

The questionnaire was not long (Appendix 1) and this was a good reason for the high response rate. In total 21 per cent of the respondents indicated a very high knowledge and 32 per cent a high knowledge of Aerospace and Defence matters 83 per cent considered the scenarios hypotheses to be very important or important and 85 per cent as desirable. The description of foreseen Aerospace and Defence technologies was quite clear, there was a pessimism (22 per cent) for Greek technologies or economic dominance in realizing the relevant innovation but they have given good chances – 61 per cent – with respect to social/organizational transposition. A good number of respondents supported that as innovation cannot be considered only solely technical but also organizational or even a mixed one. Another underlined point was that they also distinguished three stages of innovativeness. The most advanced is "Developed in 20 years", the medium is "Available within 20 years" and the least innovative "In general use within 25 years" (Tichy, 2004). It is emphasized that respondents' enthusiasm is more apparent for minor innovations than for major ones in the whole area of Aerospace and Defence technologies. This could reflect the pessimism regarding Greek innovativeness.

6.6 Some Conclusions and Suggestions

Experts with the highest self-rating of their specific knowledge seemed to be the most optimistic among the respondents. Especially the top experts coming from the business sector are considered to give unjustified optimistic assessments in comparison with the less specialised business experts in the same field. Probably, some elements of technological euphoria and the belief in continuous technical progress have marked the view of these respondents.

The over optimism of people working in business – to a large extent involved in R&D – is evidently consistent with the insider hypothesis because of the overestimation of the subjects the expert is working on (Weinstein, 1980). The same hypothesis may give satisfactory explanations for the over optimism between the experts in academia too, that in any case is weaker than in business. Anyway both as insiders have a predominately technical perspective (Kalinovski, 1994).

A similar top-expert optimism was remarked with regard to the long-term realizations of new technological achievements while a relative pessimism prevailed for the short– and medium–term projects. Here, we could say that the time factor was not underestimated and the predictions were realistic.

However the market over optimism among top-experts and insiders rings the bell that in TF exercises the panels must be based on a balanced mixture of experts from different backgrounds, types of knowledge/education and involvement/expertise not limited in top specialists of a unique field. The avoidance of homogeneous characteristics in panelists and of high educational degrees offers a better contribution to accurate TF results on average. Other variables can also contribute, like using panelists with a proven track record of similar experience in earlier efforts or by providing monetary or other personal incentives (Parente et al, 1984).

There was no time to apply an unstructured "zero round" offering the experts relative liberty and elaborate the issues they consider important (Martino, 1983). The thought is to follow this technique in the second generation Greek TF. Experience gathered during the first generation TF and study of other national TF showed that this familiarization phase is very useful for collecting valid data without losing valuable time for explanations.

7
FUTURE TECHNOLOGIES

The participants in Delphi survey were asked to propose certain future technologies in Aerospace and Defence for Greece – as required by TF sponsors – which could be developed up to 2020. As mentioned in literature review (Chapter 3) the "resources based" approach of business strategy (Cariola and Rolfo, 2004) has directed the realistic location of emerged technology categories. The knowledge-based economy also favors the transition towards flexible production and inter-organizational systems (Schwartz et al, 1999). Decentralization promotes regional development and some technologies and innovation ideas find fertile ground in certain areas in the periphery. Environmental issues and oil-dependent economy must find ways for new energy solutions. In parallel less transportation requires better communications and digital data transmission. All three scenarios planned (Chapter 5) demand autonomy in systems maintenance and self-defence ability. Uninhabited vehicles can limit many costs for human resources involvement. European Union defence and security framework on the other hand asks for certain Greek obligations (See Chapter 4) but we cannot abolish the existing serious defence infrastructure and innovation achievements. In conclusion after the research completion, the areas where Greece should focus in order to deploy affordable technologies up to 2020 are summarized as follows:

1. Weapons, Ammunitions, Explosives
2. Information Systems
3. Energy Production and Storage
4. Communications
5. Sensors
6. Unmanned Vehicles
7. Maintenance Technologies
8. New Materials

The analysis below covers every area mentioned above giving specific details.

7.1 Weapons, Ammunitions, Explosives

Greece has already been producing ammunition and explosives for more than 100 years. The rule followed by almost all countries with strong Armed Forces is to stay autonomous, at least in common ammunition types. The Greek companies PYRKAL and Hellenic Arms Industry (EBO) – now merged in Hellenic Defence Systems – require the corresponding technologies for battle and exercise ammunition of various calibres. Of course it is not cost-effective to maintain production lines for all types of ammunition therefore several of them are imported.

The same applies to other weapons and missiles (air-to-air / ground-to-air / air-to-surface / anti-armor), which are also imported limiting local participation in co-production of some parts covering other international markets of the manufacturer. Therefore it is not possible to absorb all the relevant technologies for modern weapons by establishing respective production lines. Besides, the merger of the five bigger European armament producers (MATRA / British Dynamics / Alenia / Aerospatiale / BGT) as well in Russia (Antey / ALMAZ) and in USA (Raytheon / General Dynamics) shows that markets are shrinking (Janes, 2000). Again, as in major weapon systems (aircraft, ships, submarines, tanks) the modernization of missiles is the tendency worldwide. Therefore Greek companies (HAI, EDS, Intracom, Elfon, Olympic Tool), which have acquired the necessary technologies because of their participation in various missile procurements programs (Eurostinger, Hawk, Mica, Exocet, Milan etc.) could undertake such efforts to upgrade armament systems by investing relatively affordable amounts.

Besides the above, there is a new section for the development of directed-energy weapons (DEW) such as the high-power microwaves (HPM), the electromagnetic pulse (EMP) or laser beams. International mobilization considers these technologies as future ones and some political efforts for a Greek company about certain applications have been successful.

An important domain is the destruction of obsolete ammunition and larger weapon systems because they have a life limit. The issues of safety and principally environmental protection are prevailing because of increasing ecological concern expressed mainly by the European Union. Therefore methods for disposing of these toxic materials into the sea or at deep wells or canyons belong to the past. Moreover, any controlled explosion for destruction purposes pollutes the atmosphere heavily and destroys the metallic parts, which could not be reused. A Greek company has designed and developed a new method which molecularly decomposes parts of ammunition, explosive or missile with fast and safe results. A significant advantage is the immediate recycling of materials (lead, copper, brass) including the phosphatic and nitric substances, which could be used immediately as fertilizers.

In conclusion, the technologies, where reasonably low investments could be done by Greek entities (industrial or academic), are the following

- New generation explosives
  1. Incentive
  2. Plastic
- Directed-Energy Weapons
  1. Electromagnetic Pulse
  2. Ultra-Wide Band Pulse
  3. High-Power-Microwaves (Magnetron / Klystron / Traveling Wave Tubes)
  4. Radio frequency warheads
  5. Laser-directed energy
  6. Low-power laser
- Advanced laser-protective technologies
- Building design for safety against electromagnetic pulses

7.2 Information Systems

Information systems have a decisive role in data collecting, proccesing and communications, which in turn form the areas of command, control and intelligence, vital for modern military operations. The key elements are computers, the associated software, fast data processing and transmission, together with the human machine interface.

Starting with computer technologies there are four which appear to be the most critical. First is the Application Specific Integration Circuits (ASIC), which will have a broad impact by reducing many characteristics of military systems (size. power. weight and cost) resulting to higher reliability. Wafer scale technology is linked with ASIC and gives also benefits to reliability by avoiding chip-to-chip bonding through monolithic or hybrid devices. Second in there are the terahertz electronics technology in conjunction with teraflop computers, which will provide improvement in speed (10^{12} operations per second) and sensitivity. Thus these ultra-fast computers will dispose high orders of computational power for intelligence related processing and battle management systems. Last but not least are the thin-layer semiconductors which by using various techniques lead to extremely complex multilayer structures providing revolutionary properties. The resulting reduction in size and weight will have a positive impact on mobility, transportability and deployability of military systems (AGARD. 1997).

Jumping to the development of software the offered capabilities are classified in battle management software (C2I, simulation / training, logistics, information warfare) battle control language, novel data management and manipulation, distributed processing, neural networks and synthetic environment.

International competition, the Commercial-of-the-Self (COTS) equipment and the relatively limited Greek market does not allow investments in hardware production lines. However the domain of development of software and communication protocols could and should be realized by Greek companies and the academic environment. The aforementioned future software requirements and the overall idea of C4ISR (Command, Control, Communications, Computers, Intelligence. Surveillance and Reconnaissance) cover all relevant operational needs. which are voluminous and require multi-level process speeds.

As the governmental services will be based on information technology which operates mostly on commercial type systems, the issue of information warfare is becoming very serious. Possible attacks from hostile software (virus. worms. trojan horses etc.), electromagnetic pulses, highjackers and so forth must be intercepted through a national strategy of security protection. Especially sensitive targets like the Ministry of Defence and Ministry of Public Order. which will be also obliged to apply interoperability rules and should adopt the local and international scientific knowledge by encouraging and supporting research efforts for developing electronic countermeasures and other types of safety instruments.

Generally the mentioned areas below are the future technology interests

- Interoperability of systems
    1. Automation of operational procedures and unceasing communication at all levels and situations (peace – conflict – war)
- Improvement of Information Command and Control
    1. Digital data transfer networks
    2. High-level data bases
    3. Electronic data mining and information filtering
- Electronic and information warfare countermeasures
- Crisis management analysis
- War games and simulation technologies
    1. Simulators of tactical plans and strategic philosophy
    2. Software for manpack military computers.

7.3 Energy Production and Storage

There is no sign that in coming years primary weapon systems will not be dependent on energy produced by fossil fuels to operate their engines (air, marine and land vehicles). Greece can only intervene in secondary systems energy requirements especially where there is a need for continuous operations in inaccessible areas.

Current electronic systems have reached desirable levels of performance but they demand huge energy amounts for their function. Therefore Greek industries must be directed to the development of technologies securing the production and storage of electrical energy (including high density power) for these systems, which will be also designed as energy savers. Rechargeable or not rechargeable lightweight batteries of various capacities are vital for military missions, which require continuous power generation. Existing technologies are developing rapidly and the current needs of MoD are covered partially from domestic industries. In parallel, environmental protection imposes the use of alternative material for energy storage. The target is two-fold: firstly to apply technology to upgrade battery production capability and secondly to neutralize and recycle their materials after their lifecycle ends since they are toxic. Moreover, special concern is given to this ecological procedure by the European Union, which has established a strict legislation. The forecast is that in less than 10 years cost-effective ways would permit the recycling of the metallic parts of batteries as well as the inactivation of their chemical substances.

Superconductivity is a means to decrease the electric resistance facing these problems of energy losses. The discovery of High Temperature Superconductivity (IEEE Spectrum, 2003) permitted the use of new materials where higher transition temperature needs only nitrogen and not expensive helium cooling. Therefore its use in power engineering technology and microelectronics allows the manufacturing of functional small-scaled electrical devices.

As mentioned in the section on materials, after 2015 it would be possible to start using hybrid systems made of reusable parts providing high energy capacity and life endurance. This could be feasible with the contribution of bio- and nanotechnology.

The areas where Greek industrial policy should try to make efforts and investments are:

a. Electric power generation technologies especially for future battlefield uses
b. Storage and distribution of electric energy (new design of lightweight batteries and upgrading of existing ones) to be available at all times in all areas
c. Renewable energies (solar, aeolic, biomass or sea waves)
d. Fuel cells

7.4 Communications

Communications are the backbone for the interconnection of Armed Forces. To send and receive information (voice, message/data, graphics/images, video) remains the most vital aspect of crises and conflict management both in peace and war. There are two main categories: fixed (terrestrial) and wireless (radio) communications. The first helped by photonic/fibre-optic and signal-processing technologies can have limitless capacity while the second based only on incremental technological breakthrough cannot expect any revolution for mobile equipment (RTO-MP-059, 2001).

The main developments of communications technology will be in the digitization of transmission and switching systems. The Integrated Services Digital Network (ISDN) is already trying to integrate all types of communications with very high data rates. Similarly, the Asynchronous Transfer Mode (ATM) is a very critical step towards the standardization of transmission protocols and interfaces. In parallel, the sector of advanced satellite communications includes various technologies (fibre-optic, millimeter-wave, sensory access etc.) especially for long distance information distribution. Tactical communications (LF, HF, VHF, UHF, S/EHF) on the other hand will provide secure seamless battlefield data transfer improving military information capabilities offering better encryption and resistance to interference (Hellenic Army Research, 1999).

In general, the exponential increase in the sector of commercial communications due to satellite and photonic networks will establish world spread-spectrum electromagnetic links. This defence environment has the challenge to absorb the availability of commercial aspects whilst maintaining high levels of security and protection through encryption and electronic countermeasures. The cryptographic techniques concerning national codes for both voice and data transfer can be developed in Greece and positive results have been shown by research institutes, universities and private companies.

The main future communications technologies in titles appear below

- Semiconductor material and associated techniques (epitaxic or lithographic) for manufacturing of monolithic microwave integrated circuits (MMIC)
- Micron-sized vacuum of transistors
- Multi-gigahertz analog to digital converters (ADS)
- Optical digital systems (photonic/fibre-optic/light-wave)

- Digital signal processing microprocessor chips
- Super conductive microwave circuits

Greek industries could not invest and compete foreign efforts already in development of these technologies. However, network management technology using multi-level security communication systems as well as command and control (C2I) for the high-confidence handling of voice and all types of data is within the range of Greek manufacturers. The above mentioned technological breakthroughs could be imported and embedded in production lines of traditional radios and communication systems made by local companies. Another one recommendation is the specialization of each industry to specific areas of products (networks, optical equipment, radios etc.), which will prevent overlapping of sectors favoring thus the marketing effectiveness.

Finally the proposed areas in communications development are summarized as

1. All types of tactical radios (airborne, marine, vehicular, mobile etc.) for various applications and ranges using modern technologies for either line-of-sight (LOS) or non-LOS contact
2. Design and manufacturing of alternate communication network for military, paramilitary (police, coast guard etc.) and other governmental use providing adequate security and protection
3. Encryption methods and associated development of national codes and algorithms as well as preparation of required software, which will be integrated in respective locally manufactured equipment.

7.5 Sensors

Sensor technology is one of the technologies expected to play a major role in the future and it is a rapidly growing area of research with many products already on the market. Sensors span all sectors of industry and often offer innovative products that lead to a competitive advantage. So knowledge about sensors and their future applications and development is important for a wide range of industrial domains in order to seize emerging opportunities (RTO-TR-072, 2002).

The various types of sensory data (optical, infra-red, multispectral, tactile, acoustical, x-ray, laser radar, millimeter-wave radar etc.) will be used widely for many applications in this century: surveillance, reconnaissance, exploration, environment monitoring, navigation, communication, command and control. The 24-hour, all-weather sensing capability is the key to achieve information dominance of dual-use for any conflict management or other civilian purpose. In general sensors will become more capable because of improved sensitivity, agility, resolution and automation requirements.

It is interesting here to formulate a definition of sensors as a preliminary delimitation of the sensor technology domain (Andersen et al, 2004).

> *"Sensors and sensor systems perform a diversity of sensing functions allowing the acquisition, capture, communication, processing and distribution of information about the states of physical systems. This may be chemical composition, texture and morphology, large-scale structure, position and also dynamics. It is a characteristic feature of a sensor that the device is tailored to the environment in which it is to operate".*

The Greek contribution cannot be large for advanced sensors design and development to face anti-stealth or stealth technologies like passive or active measures to reduce the radar cross-section or the infra-red signature emission. However, there is much room for further development in areas like microwave radiometry, multi spectral/hyperspectral radars and ultra-wideband which can penetrate non-metallic surfaces such as dry soil, vegetation, shallow water or camouflage. These are results from a study performed by HAF research center KETA where MoD needs were matched with Greek capabilities in this domain (2001).

Greek industries such as Hellenic Aerospace Industry, ECON and THEON have successfully produced certain types of optical sensors in the past decade integrating them also into existing weapon systems. Besides their design and manufacturing, the domain of sensors maintenance and support operates satisfactorily as well.

Microwave radiometers can be developed for high-quality, short-range imaging systems while multispectral or hyperspectral sensors for remote image sensing are not achievable in country. On the contrary, the area of distributed sensor systems where very large number of small and cheap sensors could work effectively replacing complex systems is feasible. THEON, a Greek firm specialized in sensors technology, has proved recently through a pilot effort that various types of inexpensive sensors could be designed and produced without large amount of investments. Miniaturization techniques and development of algorithms for multi-source information correlation and fusion can be applied by Greek researchers. The management of combined inputs from a multi-sensory environment is critical. This data fusion from a variety of sources such as unmanned air vehicles, airborne or land radars, ships, submarines, surface and sub-surface sound surveillance systems, different human sources, probes and weather stations must be accumulated and processed. The sensor signal processing and an automated data exploitation/classification/correlation are considered to be the most promising areas of Greek involvement. As development is not constrained to the military many commercial applications will also be boosted by this evolution, which will be supported by the expected increase in computer power and network communication bandwidth. It is known as the classification of sensors as per COMETMAN taxonomy: Chemical, Optical, Mechanical, Electrical, Thermal, Magnetic, Acoustic and Nuclear (McGhee et al, 1999).

The geographical dispersion of Greek islands and the extent of the country's borders require a vast deployment of sensor capabilities combining border protection from enemy invasion, illegal immigrant entrance, drug trafficking, as well as the localization of shipwrecks or any environmental pollution (radio-biological or toxic). Other possible mixed applications include approaches to identification friend or foe systems (IFF), personal detection, location and protection of fires or earthquakes. An evolutionary performance again can be expected for monitoring damages, strain, temperature and generally reducing the requirement for reliability, availability and maintainability in order to take most of them out of the loop.

To conclude, sensor technology can be developed as follows

- Every type of optical sensors (day or night vision) for observation and surveillance

- Opto-electronics targeting systems
- Environmental protection (atmosphere, marine and terrestrial applications) for detection and monitoring of hazardous substances
- Sensor network management and development of algorithms
- Embedded fibre-optics
- Self-defense of weapon systems (Army, Navy, Air Force)

7.6 Unmanned Vehicles

The unmanned vehicles either Unmanned Aerial Vehicles (UAV), Unmanned Underwater Vehicles (UUV) or Unmanned Surface Vehicles (USV) will continue to evolve becoming quite valuable in various roles: reconnaissance, surveillance, communications, electronic counter or suppression measures, anti-submarine warfare, air defence, strike mission of any kind on hunting and sweeping (RTO-EN-025, 2002).

This evolution will happen because of developments in two main areas, the miniaturization and the long-range/long-autonomy technologies. In particular, the UAVs will be able to stay aloft for many hours – the target is for many days and 24-hours a day – without any support from exposed personnel and associated equipment. These UAVs having different levels of stealth and a small size will provide low-level observation ability while requiring high costs for interception and destruction by the enemy. Their electric propulsion (novel batteries or solar cell technologies) and the advanced materials would make unmanned vehicles affordable for a variety of low-cost and low-risk missions (ibid).

The contribution of these remotely piloted systems to civil applications can compensate their development cost for the original designed military mission. Their versatility could serve a lot of purposes such as environmental studies and protection, border patrol, drug interdiction, agricultural or archaeological surveys, rescuing people or hauling wreckages, destruction of land / sea mines or any other kind of explosives, surveillance support for natural disasters and smuggling suppression. By changing the payload accordingly these systems could easily become multi-mission and flexible platforms with sustainable capabilities.

The Hellenic Air Force Research Center (KETA) has successfully designed and manufactured the first UAV fifteen years ago for reconnaissance purposes. Later on Hellenic Aerospace Industry proceeded in the preparation of TELAMON UAV in cooperation with Northrop Aviation (HAI presentation, 1998). These initial efforts proved the local capabilities but they were not backed up by further decisions so valuable time was lost. Afterwards the Engineering Corps of HAF made another brave effort and created a small remotely piloted airplane named PEGASUS, for short-range surveillance. This local achievement remained in stagnation until Hellenic Army imported two French UAVs for information management missions.

All unmanned vehicles are robots of a certain complexity for dangerous missions protecting and replacing specialized and skilful personnel successfully and cost-effectively. In the case where a large number of inexpensive vehicles is required, the respective production line is affordable in-country. Apart from the public services a few companies already operate this type of vehicles providing outsourcing services.

The technologies, which could be developed in Greece for all kinds of unmanned vehicles, are concentrated as follows

- Aeronautical and structural design
- Robotic technologies
- Command and control of autonomous missions
- Automatic control
- Secure communications
- Multi-spectral sensors able to absorb and process data.

7.7 Maintenance Technologies

The European Union is about to finalize the central policy for defence and security within state members (Papantoniou, 2003). In view of this announcement the significance of maintenance for high-technology systems is apparent since it is characterized by an extended techno-economical interest. For instance, Greece could be authorized to support and exclusively maintain certain types of European defence systems and this share might be quite considerable. In parallel, other countries could undertake their shares according to their capabilities and size. At a national level, the Hellenic Aerospace Industry and Hellenic Shipyards have been handling such programmes both domestically and internationally with great success. It should be mentioned here that design and production of a new aircraft (fighter, trainer, transport) is a very costly and time-consuming process, also framed by limited governmental budgets. The same applies for ships and submarines. Therefore the new international trend is to keep the original weapons platform (airplane, ship or armored vehicle) and to upgrade the functional systems on it (electronics, armament, electrical or hydraulic subgroups, engines, self-protection devices etc.) (AGARD, 1997).

This approach is directly linked with maintenance activities. Fighter aircraft need specific inspection of their structural integrity because of the accumulated fatigue during combat missions and flights in adverse weather conditions. Hellenic Aerospace Industry (HAI) has established a very fruitful cooperation in defence with Middle East and other Mediterranean Countries (HAI Bulletin, 2001). It is noted that the acquisition cost of a military airplane equals the maintenance expenses during a period of eight (8) years. HAI's capabilities have attracted the attention of original equipment manufactures in the western world who desire to participate in the associated maintenance works (HAI BoD, 2005).

Respective defence industries in eastern countries (i.e. ex-communist) are eager to maintain high-technology weapon systems especially airplanes (Sukhoi, Tupolev, Yakovlev, Antonov, MiG, Ilioushin) (Luftwaffe, 2004) but they do not possess the infrastructure and the financial resources to invest in this. Thus HAI and other Greek Companies would benefit a lot from undertaking similar projects. Firstly, there is the acquisition of so far inaccessible technologies at a considerable profit and secondly there is the increase in turnover and international clientele. Over and above these obvious benefits, is the extra political advantage for Greece to operate as an aviation center between two hemispheres.

Dual-purpose aeronautical technologies also cover the field of passenger airplanes and aero engines which also includes smaller airplanes (general aviation, VIP, aeroclubs etc.) requiring much less of a respective infrastructure. The new Athens airport operates as a hub of international flights, which facilitates civil airplanes to land on HAI's airport (Tanagra air base) to undertake all necessary maintenance on site.

The same applies to marine technologies, which are found in traditional Greek shipyards with the know-how at all levels. Distribution of sea vessels according to their missions is a very cost effective idea in order to economize resources (Nikitakos, Tzannatos, 2003). For instance, Skaramangas shipyards (Hellenic Shipyards) could support frigates and submarines while Elefsis could host corvettes, petrol carriers or destroyers while Neorion mine sweepers, patrol boats and cargo ships. The privatization of these companies has assisted in competition permitting multiple advantages. Moreover, existing installations after a careful modernization in areas such as anti-corrosion technologies, surface chemical treatment and international quality control standards (ISO, Six Sigma etc.) could absorb all domestic naval maintenance needs. These needs include not only Hellenic Navy and Coast Guard vessels but mainly the demand of the Greek commercial fleet which is the largest worldwide.

In summary, the present and future technologies covering the maintenance requirements of defence / civil airborne and sea vehicles are proposed as follows:

- Non-destructive inspections
- Software development for automatic operational control
- Quality assurance according to international standards
- Metallographic analyses
- Composite materials manufacturing
- Chemical surface treatments (Air Plasma, Spray, high Caducity and Oxygen Fuel)
- Computer aided design and manufacturing
- Engine test cells of various capacities
- Preventive engine maintainability
- Monitoring of aircraft structural integrity
- Supply chain management using smart labels

- New electronic material design and tests (surface mount technology, electromagnetic interference and compatibility etc.)
- Metrology and calibration of test equipments

7.8 New Materials

In spite of defining broad fields as panel topics to be analyzed, a strong emphasis was put by the Steering Committee on the so-called cross-cutting issues. Therefore our WG was encouraged to identify and adequately deal with these issues when analyzing major trends and developing alternative visions for the Aerospace and Defence Technologies. Areas like Energy, Air Transportation, Environment, New Materials, Information and Communications are falling into these categories. We have chosen the New Materials sector as the most precise technology-wise to be examined. Although they had prepared a complete thematic report we specified some technologies which are common with Aerospace and Defence ones. Therefore bilateral meetings were organized among respective WG members for close collaboration in defining interdisciplinary technological issues. This should be considered as a first approach so more systematic efforts accompanied by sophisticated methods are required to deal with these cross-cutting issues. Moreover, there is an obvious need to find appropriate – efficient, convincing – ways and means to convey these messages to decision makers and opinion leaders.

There are two categories here which cover this domain. Basic materials and the manufacturing of high technology systems.

7.8.1 Basic Materials

Materials are a key technology in achieving high performance for virtually all products. While performance improvements, such as high-temperature mechanical properties, should be the primary push, affordability also has to be included for the beginning in R&D goals. There are three main categories of traditional and advanced material which are used in Aerospace and Defence.

- Metals
- Ceramics
- Composites
- Operational Applications

TF Materials Report contains a SWOT analysis (pp.48-51) presenting the situation in Greece for the above materials.

More precisely for steels (soft and special) and aluminum alloys (Ti-Al, Ni-Al) it is recommended to invest in R&D for better production, methods and quality products. Concerning advanced ceramics, there is no competitive advantage and an extensive investment in this field is not cost-effective because it is very stricted by environmental limitations. On the contrary, composites and high-performance carbon fibres have a future and some small or medium-sized enterprises (SME), including Hellenic Aerospace Industry, could be engaged in the production and manufacturing of such items on condition of being able to ensure considerable volume. The anticipated increase of composite material needs will be five times higher up to 2020 because there is a trend to substitute traditional material (Al or St) in all structures demanding high resistance and light weight. Multifunctional composite materials are even more attractive since applications cover a much broader area than pure aeronautical. This domain has attracted a research interest from Greek SMEs and Universities while there is a potential in EU – funded research programmes.

The last category of Operational Materials includes uses in microelectronics, nanotechnology and other microsystems in general. Results from a recent conference (Democritus, 1999) have shown that Greek institutions have great research capabilities, patents, know-how and a significant human capital specialized in this field. Magnetic materials also belong in this category (permanent magnets - sindered/plastic bonded, magnetic sensors, magneto-electro-mechanical systems (MEMS) etc.).

7.8.2 Manufacturing

Manufacturing technology and quality are an integral part of materials and structures R&D and an integrated approach here results in affordable technology for improved products.

In Greece we could concentrate in the following areas in order to be in a competive position near the target year of 2020.

- On-site welding techniques for aeronautical structures (i.e. laser or friction)
- Aircraft light surfaces (composites with V, Mg, Ti alloys)
- Internal combustion engines parts (reaction synthesis in Si ceramic)
- Energy production and storage (ceramics treatment)
- Health monitoring of structures
- Defect detection (non-destructive tests)
- Process monitoring

Manufacturing can also play a significant role in energy and natural sources consumption which is a vital parameter for Greek economy and autonomy. Many thermal processes currently use very inefficient heating methods. The rising cost of oil imposes R&D for new methods. Technologies covering automated thermoset and thermoplastic composite processing for Aerospace and Defence products need to be developed further. It is within Greek capabilities to evolve some of these technologies in view of energy conservation

- Fibre placement
- Thermoforming
- Compression and injection molding
- Automated ply lamination, joining (diffusion bonding) and handling
- Net shape manufacturing for metals and metal-matrix composites (casting, spray casting, extrusion, forging, superplastic forming, powder metallurgy etc.).

8
DUAL TECHNOLOGIES

8.1 Introduction

A considerable effort was devoted to this research and as extension to the TF project towards the examination of interrelationship between military and civil technologies. This is a very old issue already researched by many western countries simply for economic reasons (Rappert, 1999). After the fall of communism many eastern countries, especially Russia, tried to convert a significant part of their defence industries to the production of civil equipment but the results are still not very encouraging. This is not only due to mere conversion difficulties but to other factors too, such as the general economy, non-competitive products, old manufacturing procedures and the lack of trained personnel with new skills (Solovey, 2001).

The term dual technologies is commonly used to describe technologies that are developed and utilized by both the military and the civilian sectors. As Smit (1995) maintains it is not possible to characterize technologies as military or as civilian or sometimes as a mixture of both. Only through their usage or development can they be classified. An example in Greece is the maintenance of military and civil aeroplanes. Hellenic Aerospace Industry already supports the maintenance requirements of the Armed Forces (Air Force, Army, Navy) and of some other private aircraft. However, it has failed to undertake the responsibility for another state-owned company, Olympic Airways, because the social network of the respective air transport technologies is different. The prevailing mentality and operational requirement differ in respective ministries and working environment, as well as international rules and standards for the airlines, which has prevented such cooperation, in spite of the obvious cost effectiveness of joint efforts.

The "dual-use policies" is a response to problems which arose because of the following three facts. The first is the dramatic reduction in defence budgets in NATO countries touching a 40 per cent between 1988 and 2003 (Molas-Gallart, 1997). The second is the growing cost of developing a new weapon system. As it was proved (Augustine Laws, 1988) the cost covering all the phases of a fighter or bomber aircraft preparation (from the design office to the production line) increases 400 per cent every decade. The corresponding cost increase for land or sea vehicles (battle tanks, ships, submarines) is 200 per cent for the same period of ten years. The third is that the relationship between defence and civilian technologies has changed, following a reverse path. Today the rapid growth of civilian technologies feeds the development of the military equipment while during the past century and especially its second half defence technologies have borrowed civil applications such as aerospace and computers (AGARD, 1997).

These three facts have compelled corresponding trends, therefore the manufacturers involved in defence business are having to adapt themselves. New technologies, new processes and new mechanisms must be developed to exploit broader markets and to face new challenges. Hence dual-use technologies are important and in addition the commercialization of products with dual-use potential are the main issue. As Molas-Gallart (2001) comments technology must be considered lying between mere artifacts and the system of social relations where these artifacts are developed and produced. In any case the meaning of the Greek word technology (techni + logos) is exactly this and the definition by Autio and Laamanen (1997 p.647) reflects it.

> *"Technology comprises the ability to recognize technical problems, the ability to develop new concepts and tangible solutions to technical problems and the ability to exploit the concepts and tangibles in an effective way."*

Since technology includes different kinds of knowledge (tacit and skills) together with various processes involved for the production of deliverables as well as software, capital equipment, blueprints and managerial abilities then all these are applicable to dual-purpose technologies. Thus they can be used both for military purposes and important civilian ends without discrimination. However the term "dual-use" cannot be precise because military and civilian technologies are not clearly defined as contrasting each other. In addition, many military products possess various degrees of similarity with civilian goods and several general technologies can be applied without distinction to both military and civilian developments at the same time.

Here the term "technology puch-over" applies introduced by Klein (2001) meaning that advanced defence technologies shift over to civilian sector looking for corresponding applications. This happens when the defence budget downturns so there is political pressure for counter-cyclical technology spending in other sectors (transportation, medical engineering, telecommunications, information technology, automation etc.). The so called "iron triangle" consisting of industrial forces, defence agencies and politicians (Gordon 1981, Adams 1984) press towards this cyclic movement from defence to civil and vice-versa according to Ministry of Defence budgetary cutbacks and surges. The simple reason for this is that combined spending in two sectors is more stable than either one alone[12].

A very good example for consideration of this are the maintenance technologies described in Chapter 3, for marine and aerospace cases in the private or the public sector. Of course there are no strict rules for the dual-use technology transfer mechanism from one side to the other due to the diversity of this dual-use potential.

8.2 Dual-use Technology Management

The state-owned Hellenic Shipyards moved into production of civilian items for the first time in 1995, when military orders faced a decline, they were awarded the construction of train wagons for the National Railways Organization (MoE, 2000). Today after ten years there is still a debate because of the long delay in deliveries of these products. This emphasizes the view that the transition through dual-use technologies is not easy even if the market is sheltered.

[12] It must be noted that a dual-use technology can be transferred within and across units without any intention to change its application. For example a company may sell a licence for a component to another firm that intends to use this technology for the same military application. Thus a transfer was done across economic units but not across purposes and this is not considered as a case of "dual-use technology transfer".

The transfer of dual-purpose technologies can be done either externally across units (i.e. from research centers to industry) or internally within the same business unit. The definition characterizing this transfer could be

> *"A special instance of technology transfer across application that takes place when a dual-use technology developed for a military (or civilian) use is transferred to a civilian (or military) application" (Molas-Gallart)*

Principally the dual-use technology transfer policy covers the case when there is a desire to modify the initial application of a technology. During this research we have perceived two instances of such diversifications. One was the Hellenic Arms Industry, which decided to modify the production line of guns to produce rifles for hunting and the PYRKAL ammunition producers who opened a new production line for all ammunitions covering hunting purposes. The last year (2004) these two companies have merged in a new one under the name Hellenic Defence Systems.

Hopefully in Greece there will not be an effort from a relatively big state-owned defence company to shift into the development of the commercial market because it would suffer from the common problems of large defence projects, which are summarized in high cost, late delivery times and poor quality control. The steps towards the diversification of production are very careful and concern certain specific products for in-country consumption avoiding risky generalization. In parallel, smaller companies have found the dual-technology ground comparatively easier since they are more flexible as they operate upstream in the defence markets by producing components or sub-systems and they undertake subcontracting jobs[13](Kollias and Rafailidis, 2003).

The opposite direction for technology transfer, from civilian to military operation, has not been very successful practically and it is limited to some research activities proposed from the academic environment to the Ministry of Defence for covering special needs or they still belong to the sector of emerging technologies. The case of the company Soukos Robots should be mentioned at this point, which has applied high frequency molecular decomposition for the old ammunition (Company's Profile, 2003). This material has passed the life-limit and is no longer useful, therefore it

[13] Greece examines the case to enable industry to access the skills and facilities in the defence research environments. MoD studies the examples of UK and Australia where selected technologies are transferred as spin-offs to industry through licensing. The target is applications to be directed in commercial markets to enchance local industry efforts.

must be destroyed because it is dangerous and useless. The applied practice internationally is to throw it into the sea or into deep canyons, which is a waste of material and worse a very anti-ecological approach. This Greek company by the speedy decomposition of the ammunition separately collects the metals (lead and bronze) and the chemical substances (phosphate and nitric unions), which can be recycled easily even as fertilizer pellets for agricultural purposes. The same technique has been used for some other military or paramilitary applications such as neutralization of land mines and the destruction of bombs and similar terrorist weapons without any risk for personnel.

However there are some other cases of civil-military integration where defence and civilian products are prepared in the same facilities. This is the example of crypto devices produced up to a certain level in Intracom (Troullinos interview, 2003). Some of them are directed to the Armed Forces incorporating ad hoc algorithms and electronic countermeasures while the rest have private clients who desire protection of their communications (by telephone and facsimile) as a destination.

8.3 Technology transfer

During this research special attention was paid to the ways used for the dual-technology transfer, but at the same time taking into account the parameters influencing the Greek business environment.

The first category was the absorption of technologies within the same industrial corporations, which is the case for many Greek business units. This transfer of dual-use technologies in most cases require adaptation and modification of processes because either the integration of military and civilian production lines will occur or a conversion with associated substantial organisational changes. Alternatively diversification policies can be applied or apart from these horizontal changes a vertical repositioning policy will drastically relocate the unit from its original direction (Cowan and Foray, 1995).

Besides these conventional ways towards the exploitation of emerging technologies we have also examined approaches to transferring dual-use technologies not internally but externally. Although this is considered as non-conventional in Greek standards it is something, which has been exercised for many years abroad. The idea of external transfer involves the creation of an institution-governmental or semi-governmental – which will transfer the technologies developed in defence research centers to interested parties under certain contracts of licensing. This agency will be supported by the MoD and acting as a broker or facilitator will improve the communications connecting sellers and buyers of available technologies.

Of course special attention will be paid to the necessary tacit knowledge of the technology developers, which cannot be simply transferred as the prototypes or the design data packages of the units. The debate about the tacit versus codification of knowledge has firm arguments because organizational learning does not follow a linear but a spiral evolution during which tacit knowledge is transformed into codified knowledge (Sefrati, 1999). Sometimes this movement is reversed when new kinds of tacit knowledge arise and interact with the new kinds of codified knowledge (Freeman, Soete, 1997). In any case the technical complexity of modern weapon systems is protected mainly by tacit knowledge for national security reasons. Nothing prevents the creation of a technology transfer office within other state research laboratories in universities or ministries, which could establish its own mechanism to commercialise and disseminate research outputs. These active methods will naturally be accompanied by the passive ones including participation, reports, studies, that at a certain level are realized by the General Secretariat of R&D. Going further, private companies and especially industries belonging to the government, should not exclude the renting out of the facilities to commercial firms which are in a need of fixed capital facilities. Hence the gain is double by compensating the decline of defence budget and by keeping alive installations ready to reactivate if there is a future need.

Governmental officials face this approach positively, as well as private entrepreneurs who incur a lot of start-up costs when they want to launch their operations. Nonetheless, the idea of a creation of a new specific research centre to develop a dual-use technology center seems somehow luxurious for such a purpose exclusively. This can be realised by GDDIR under the auspices of the joint Defence Research Center, which will coordinate the dual potential of industrial, academic and other governmental departments driving it according to different market requirements.

The possibility of establishing new spin-off companies. belongs to the externalization of dual-purpose technologies which could promote new ideas. Former employees of defence related companies and public laboratories have already created such Greek firms (no more than fifteen in twenty five years) (GSRT, 2001) in order to commercialise ideas developed during their research. At this time the ground is considered fertile because European Union programmes together with nationally backed projects of Ministry of Development are encouraging similar efforts by groups of scientists. The General Director of GDDIR was ready to provide a decent portion of the 100 mi € yearly budget to assist people who are trying to promote dual-use technologies development seriously.

8.4 Proposal of Studies

This research also revealed that there should be a study of a conceptual framework which will contain the characteristics of military and civilian systems and the description of the following data necessary for further analysis.

a. Classification

The main products need to be classified in order to demonstrate the similarities and differences between military and civilian. This classification would also identify the products that are identical in civilian and military context as well as others that are principally military.

b. Markets

The types of markets which exist in the civil and military field are important for the sales promotion of products.

c. Structural Analysis of Systems

The high relationship between structures for both military and civilian large systems such as communications, will enhance our understanding for the integration of total purpose technologies.

d. Generic Technologies

Innovation in generic technologies used at military and civilian systems shapes a critical path for judgment of their future common development.

e. Common Languages

Specific terms and definitions vocabulary must be agreed upon in order to use a common language and not overloaded general terms (i.e. technology, system).

8.5 Cost Consideration

As costs of individual weapon systems increase continuously and available national funds are being cut back, the only solution is to buy fewer systems every year. Therefore economies of scale cannot be materialized because a production line tends to be very small. In addition, a high overhead burden is also added, which comprises the administrative charges (management cost, reports, financial accountability etc.). Concerning production, this remains labour-intensive although automation has been applied. In spite of reducing the number of production workers extra people are involved (i.e. engineers) increasing thus other labour costs.

Performance maximization, regardless of cost, raise the final price of the system and productivity maintains a secondary role. Another important factor in cost increases is that development and production of these high-performance defence systems have been assigned to one company because of the small quantities. Therefore lack of competition does not favor cost saving through various efforts of the contractors.

Military specifications govern defence products and processes, so expensive special requirements do not permit commercial parts with similar performance and much less procurement costs to be used. Moreover, production processes (i.e. welding, surface treatment, quality assessment etc.) cannot be substituted by their commercial equivalents again losing opportunities for economies of scale.

The military-industrial complex, on the other hand, drives military programmes and defence budgets since the vicious circle works between the defence-oriented firms, which are totally dependent on MoD for business and which in turn depends on them for goods and services. This interrelationship continues when the MoD requires a number of items rapidly because of a certain political crisis, so the only way is to maintain excess capacity (plants, equipment and labour), which is not at all affordable. However, this is the only way to obtain critical output since there is no connection with the commercial sector.

Many of the above-mentioned cost items are not met in the Greek environment except in the case of the two large state-owned companies – Hellenic Aerospace Industry and Hellenic Defence Systems – after the privatization wave realized a few years ago.

8.6 Integration Benefits

Military and civilian technologies integration provide substantial benefits first for defence and second for the civilian economy. This research has shown that interviewees agreed on the following:

1. Any possible counter-cyclical reaction of both economies assures labour stability and more efficient industrial output.
2. Sole-source defence contractors will give their place to commercial firms allowing continuous competition and cost-effective results for Armed Forces. Similarly the mutual interdependence of the military-industrial complex will be dramatically decreased with the broadening of the

suppliers' base for defence contracting. Therefore political decisions will be replaced by economical and operational tasks.

3. Adaptation of commercial practices will permit design-to-cost engineering, stricter quality control, reduced management structure and economies of scales where applicable. Moreover, an abandonment of costly choices will start because the designers will become more cost conscious the more they get involved in broad commercial opportunities.
4. Access to the MoD R&D budget will encourage the commercial world to participate in long-term, high-risk developments although they are accustomed to short-term results.

8.7 Implementation

In order the Greek defence-oriented and commercially-oriented firms to benefit the most from conversion and integration, they must avoid the errors of the past already made by other countries of a higher industrial level and with bigger defence budgets. The next are some suggestions towards this implementation.

- It is not easy for an old structure to absorb new technologies and changeover so there should be an adaptation phase, which includes the initial planning time, to match the recipients characteristics.
- The government be the first buyer and the civilian sectors will follow for any output of integration because this action will stimulate common efforts.
- The principal assets, which should be maximized in spite of any conversion difficulties, are the capital equipment, production labour forces together with skillful management and engineering innovation.
- Priority should be given to converted commercial products, which will substitute imported ones for obvious economic attractiveness and political impact.
- Effective technology transfer happens mainly through the workforce cooperation. Thus human resources must accept changes which will be

either a significant reduction of personnel or reconstitution of the top management by using key people with civilian experience.

8.8 Conclusions

It seems that military procurement needs will move towards stagnation while the commercial markets will follow a continuous growth. Apart from stagnant military sales some additional factors like choking purchasing processes and the longer life of weapons systems (i.e. about 30 years for a fighter plane or 50 for a cargo aircraft) do not assist the advancement of R&D for defence technology. Of course Greece cannot think of developing complex weapon systems but instead the local industry will participate in the development of their sub-systems or of some components. Furthermore, if these are generic items adapted from or which could be adapted to civilian use, then there is an interesting field for in-country productivity over the next decades. The MoD/GDDIR together with Organization of Industrial Patents are willing to support these perspectives of technology exchange between defence researchers and potential civilian buyers by taking care of this codified knowledge (patents, blueprints, designs etc.). Moreover a proper use of human resources capital will preserve the tacit knowledge embodied in them as skills and "know-how" assets. The necessary fixed capital, which pertains to all the production and research facilities can be also adapted and diversified for the creation of dual-use production. Governmental agencies should attempt to blunt the differences between the technological and marketing cultures evolved during the thirty years of the Greek defence industries existence. Straight dual-use technology transfer mechanisms may have visible and short term results but the long term requirements of defence technology and production face important problems. Since the higher unit cost of defence products cannot ensure sustainable production, a civil-military technological integration is the better reaction.

We proposed that MoD officials lower the wall of separation of military and civilian activities and develop ways, through the use of universal tools, in the operational practices of defence firms and laboratories. Another proposal, which was accepted, was the reform of the defence procurement law which was completely modified during the last year and it is ready to be submitted for parliamentary discussions (revised law No 284/98).

European industrial integration between military and commercial activities is encouraged by the common defence policy. In so far as the size of US market and the superiority of US defence giants which oblige European firms to search transatlantic cooperation, it is well promoted by member states governments. The internalization process of US industry is not acceptable to the Europeans who in contrast favor defence globalization through trading, opening of bids to foreign competitors or outsourcing technologies via Offset Benefits. This process cannot be firm-centered since national governments have a decisive role to play and Greece undoubtedly believes in this policy (See Chapter 3).

9
HUMAN FACTORS IN AEROSPACE AND DEFENCE

9.1 Introduction

Another domain, which was researched individually after the completion of the TF exercise is the area of Human Factors (HF). The reason for this is that Greece has not been following so far any HF research policy or strategy to guide the initiation of proper activities as directives for the country's defence and aerospace industries. Consequently if we want to present future Aerospace and Defence technologies and propose them as a national focus for 2020, personnel and equipment cannot be separated. It is the interaction of people and equipment and/or systems, which produce capability for development (DTI/DAS, 2001). Moreover Greek products and services offered to our European customers on a share-based cooperation – as already mentioned – must be governed by HF principles accepted internationally. The aim of this research was to map the situation of HF involvement during the design and manufacturing of high-technology products and to prioritize some areas of HF integration where necessary efforts and investments should be made.

The broad definition of HF covers the professional discipline which concerns the improvement of human issues into the analysis design, development, implementation and operational use of systems (HF National Advisory Committee, 2002). The total knowledge supporting HF activities is the sum of various specializations including engineering, ergonomics and human physiology. The obvious branches of engineering involved are information technology, mechanical control and systems engineering.

The problem starts from the growing complexity of technological systems which are an order of magnitude more complex than they were in the 1980s. Improved understanding of the relationship between people and technology, the way the human brain processes and uses information and the socio-technical context in which people and organizations derive benefits from technology will all be needed to apply HF integration. There are two principal gaps here. One concerns the capability of technology and its ease of use and the other has to do with functionality and usefulness of systems. Additionally there are also two tendencies or trends. The first is to reduce public tolerance of organization risk the second is to reduce tolerance of social exclusions. In order to handle all these issues and find corresponding HF interfaces, this research focused on four general themes which are:

- To bridge the gap between human intelligence and what people are trying to control whether it be data or equipment
- To integrate, interpret and transform data into information and deliver it to those who need it and in a way which supports individual and group decision making and actions
- To understand how technology changes individual and organizational behaviors and what is the impact of the numerous and complex factors on the relationship between people and technology. Humans as a component of socio-technical systems should use inherently safe products, services and methods of working which are not socially exclusive and do not create risk for anybody
- Multi-cultural and multi-national operations require better understanding of the inter-personal, cultural and social issues for more effective communication and decision-making.

The respective questionnaire (Appendix 2) sent to 50 recipients had a 75 per cent rate of return and the second set of questions asked through interviews as per the normal Delphi practice followed for the main TF exercise. Again, participants were members of the scientific community (academia, research organization consultancies and the industry).

9.2 Findings of the Survey

Although the survey was limited, it has drawn many interesting observations. Being the first survey of this kind it establishes the beginning of a new requirement for generic and specific Aerospace and Defence technologies covering short, medium and long- term needs.

The initial efforts of this work were the localization of Greek customers for HF research, what are their drivers and who are the end beneficiaries. Humans are an integral part of the socio-technical solutions provided and the platform/operator/maintainer level will incorporate HF requirements ensuring also that the appropriate relationships between seller, buyer and end-user are established (HF/NAC, 2002).

The main findings start from the fact that engineers working in the defence and aerospace companies do not fully accept the contribution of HF to the design. Additionally, they were not aware that there are specialist skills to answer the HF questions. Consequently, there is a lack of standards and processes for HF requirements in design and products. Therefore HF inclusion in conceptual design will require costs in order to receive economic benefits from undertaking HF issues and meeting international emerging legislation. If there was transfer of scientific and technological knowledge from the research to the industrial sector it could be of help in this case.

One of the more interesting notes is the difficulty of recruiting experienced HF professionals and the lack of necessary skills is partially due to studies offered in universities programs (HELDIC Interview, 2003). Continuing professional development courses cannot do much to alleviate this situation. Nevertheless this shortage of high quality practitioners in HF, Applied Psychology or Ergonomics could be covered quite rapidly during the next eight years. Of course, not all of these people will be able to apply HF in design, engineering, manufacturing and other commercial environment.

Among the interviewers there is a common understanding of the inter-personal cultural and social issues, which govern communication and decision making in multi-cultural, multi-service and multi-national operations. This in turn means that the Greek

Armed Forces must function in an interoperable environment using systems confirming to HF integration.

The use of unmanned and remotely operated vehicles in all environments will be growing. Mainstream society and mass media follow attitudes, values and behaviors, which directly influence the military forces, which in turn must be able to carry various mission types in a single operation (combat, humanitarian aid or peace keeping). Thus the wider socio-technical structures of systems require high standards of HF integration for a better human-systems effectiveness.

9.3 Conclusions and Recommendations

We propose that investments be made on the next five significant areas of high priority.

1. The Design Process

Human Factors Integration (HFI) approach must incorporate all human issues into the design of large, complex and distributed systems/projects/programmes as they are essential for safe and efficient operation. The development of processes and tools to support HFI ensures the avoidance of accidents and other needs for expensive remedial modifications or upgrades.

Acceptable design standards will help overcome over-reliance on subjectivity and minimization of poor human-systems integration. Thus the associated commercial benefits include reduced cost of product development, lower life-cycle cost and better adaptation to current and emerging international standards as well as meeting of different occupational legislative frameworks (DTI/DAS, 2001).

2. Interface Technologies

These are the interaction products (either hardware or software), which provide an interface between the human operator and all the other components of the system/equipment.

The man-machine interface is achieved when three fundamental questions can be answered. The first pertains the kind of function the product performs, the second asks the expected use of it and the third wonders what is the optimal form of implementation of this application (peacetime/wartime, all-weather, 24-hour use and air-sea/land operation) (HF/NAC, 2002).

Some examples related to the Aerospace and Defence Technologies proposed for the 2020 are the next interaction technologies: operator displays and signals, synthetic environment (vision and data fusion), vehicle control handgrips input information management.

3. Automation

As more and more information is produced by processing capability it is increasingly difficult for operators to process and deal with the quantity of information. Thus systems are becoming more automated because they must produce this information and they have to assist in handling a great amount of it. Sometimes automation is considered responsible for involvement in human errors causing incidents or accidents. So the requirement of utilizing automation in the most optimal way remains vital.

The research has proved that almost 100 per cent of the interviewees consider human-automation interaction concepts in future Aerospace and Defence technologies a key factor in

- Reducing workload
- Supporting situational awareness
- Better decision making
- Avoiding human errors

- Training and skills development
- Creation of intelligent interfaces

Here situational awareness is referred too, which remains critical because inaccurate or impoverished situational awareness could contribute to man-made errors and other failures. However, it is quite paradoxical to acknowledge a pressure in design for reducing operators skill level and manpower quality while we need to provide information synthesis for the optimum decision making. In parallel. the new design philosophy removes humans from direct control of systems but at the same time asks for deeper human involvement to track the automation.

Finally, the development of pragmatic and genetic methods is indispensable for the effective design of HF in systems as well as the inclusion of tools for prediction and assessment of individual and team human factors integration.

4. Human Error

According to recent studies (Flight Safety Manual, 2002) human error is recognized as a major problem – up to 80 per sent – in aerospace and defence applications resulting always in considerable financial costs. An understanding of human error process and then the application of correction strategies to system design should lead to an increase in both operational safety and efficiency. An analysis of data has shown that information technology is changing the type of operator and technician tasks, shifting them towards more cognitive (unobservable) rather than physical (observable) forms (HF/NAC, 2002). Moreover teams are not able to predict human error adequately or early enough through the existing tools and techniques.

Resolution of any of the issues associated with human errors will have a great impact of all types of defence and especially aerospace equipment design, production, maintenance, training and final operation. The research should be extended to various areas in order to provide information to the engineering community, which will produce functionality thus enabling the interface of error tolerant/resistive systems. Human process research will also be conveyed to systems designers together with the research of systems behaviour for incorporating error prevention and error recovery tools. In general the final aim of all these types of research is directed at the design of new systems that could mitigate errors in new products areas.

5. Life Cycle Considerations

According to a recent NATO study (RTO/MP-059, 2001) the follow-on-support cost of an advanced weapon system (aircraft, submarine, air defence battery) equals its acquisition cost after eight years of use and ownership. This follow-on-support cost is made up of many factors such as logistic support requirements, maintenance tools, training of personnel, documentation upgrade, engineering change proposals, safety bulletins, stock control and supply chain management etc.

The Hellenic Air Force has examined many cases of fighter or trainer aircraft (Mirage F1CG, F5A/B, T-33, T-37 etc.) after their phase out. Using these aircrafts for more than thirty years they were able to analyse collected data on all the previously mentioned activities and confirm the results of the study. This researcher – as the first aeronautical engineer trained in this technology – was involved in the case of Mirage F1CG fighter, which was removed from the active service in 2004 completing three decades of interception missions over the Aegean Sea.

Interviewees with special experience in reliability, availability and maintainability issues were insistent on the importance of human costs. The review of human factors over the whole life cycle context (from concept to disposal) can provide many benefits to the user e.g. reduction of human errors in maintenance, better efficiency with updated maintenance process, new training methods and a general use of human-centric support aids.

10
COMPARISON WITH OTHER TECHNOLOGY FORESIGHT PROGRAMMES

10.1 Scope

Through this research 24 other national and regional Foresight programmes have been analysed (see Table 7). Being outside the scope of this study, not all of them could be compared with the Greek case. As the closest the French, the Italian, the Spanish and the Portuguese cases were chosen. There were various reasons such as similar culture, proximity of countries but mainly the same orientation of the five chosen studies, which is technological with an intensive participation of technology experts and a relatively limited consideration of socio-political interactions. These industry-led national Foresight exercises have been compared to each other using the criteria of how they were conducted and organized, what they have in common, what the relationships between results and the methods applied are and what lessons can be drawn for future studies.

In spite of the broad variety of objectives, approaches, institutional design and methodologies the comparison of the five programmes have indicated some important common elements

a. The studies assisted in the generation of increased awareness of the importance of forward thinking in the establishment of private and public science and technology strategies.
b. All the TF programmes were launched with policy objectives and their results have been directed into non-academic committees which have utilized them in various ways.

c. Although these projects started as one-off efforts, they found continuity in these five countries where new exercises (local or national) have been promised. Moreover the provisional organizational structures that have been prepared for supporting the studies tend to be turned into permanent situations.

The policy orientation also varied from country to country. In the Iberian Peninsula, the Portuguese and Spanish approaches were inclined to the strategic and management dimensions of TF while France and Italy have paid more attention to linkages with science and development. Greece has followed a combination of these trends although the original question for the Aerospace and Defence Technologies Working Group was to point out specific domains for technological focus.

The aim of this section of the research is not to attempt to carry out a benchmarking of the specific technology related aspects of the TF studies but to help to draw lessons on the advantages and disadvantages of the different approaches and methodologies followed by the separate initiatives. In addition, Greece was the only country, among the five examined, to have the preparation of a specific TF on Aerospace and Defence Technologies as an aim, thus no direct comparison can be made with the others' results.

10.2 Motivation

The Foresight processes in these countries were initiated by different actors going after different policy objectives and led by different incentives. Greece, Portugal and Italy were bottom-up but Spain and France were top-down efforts.

- The Portuguese study (2000) started from concerns about national industrial competitiveness within the context of the European Union market making the optimum use of Science, Engineering and Technology.

- In Italy the first phase was funded by industry in order to examine how the science and technology policy could assist the industrial requirements (Roveda, 2000).
- Spain, anxious about its industrial environment, has completed a three-phased report, funded by Ministry of Science and Technology, for identifying emerging technologies and mobilizing accordingly the existing technical research centers (Molas-Gallart et al, 2002).
- The French TF exercise, completed in 2000 with funds from the Ministry of Industry, had as a principal aim the identification of the 100 key technologies. The future industrial competitiveness of France within the European Union and other continents – aligned with demands and needs – was the driver for this study (Seelinger and Lacomme, 2001).
- Greece started its TF study in 2001 and finished March 2005 co-financed by European Union and General Secretariat of Research and Technology which belongs to the Ministry of Development. Based on the hypothesis that Science, Technology and Innovation drive the economic and social development, the Greek TF established a frame work of guidelines for planning the strategies of the public and private sectors.

The involvement of state in the TF exercises was quite variable too. Greece and France, for instance, issued a public bid through the Ministry of Industrial Development and involved in the programme management universities, private consultants, ministerial departments, public research centers and other private actors. In Italy, the linkage between TF and public policy was created after the private initiative started the programme and the first results were in hand.

10.3 Methodologies Used

The common characteristic of all five TF cases is the development of a networking mentality supported by the central work of experts panel groups and coordinated by a steering committee. However, important differences remain in the technologies used.

The French and Greek studies are technology-oriented comparing the attractiveness of various technologies. Nevertheless, Greece implied the development of alternative scenarios (global and specific) while France developed eight thematic sub-groups plus an "Interaction and Quality" working group examining the perspectives of demand and the interactions between technologies and sectors (Zappacosta et al, 2002).

The Italian case was structurally more similar with the French approach but they did not intend to identify 100 or so key technologies. Instead, under the leadership of well recognised authorities in every field, the allocated experts panels were asked to assess technologies and justify their choice according to two sets of indicators analysing their attractiveness and feasibility.

The Portuguese resembled partly to the Greek approach and built an analysis of major scenarios describing alternative European future situation. Therefore according to these scenarios and the foreseeable exelixis of markets they have chosen the appropriate technologies fitted to the country. The target here was not to define a list of technologies but a socio-political macro-scenario to frame a vision of the future through which the technology aspects could be derived.

Spain has used mixed techniques (Delphi, surveys, experts panels, scenarios) under the auspices of eight independent research centers, which processed the surveys covering corresponding sectors of the whole study.

The final conclusion is that the Spanish study lies in-between the technologically oriented French and Italian approaches while Greece, besides the similarities with the previous exercises, disposes institutional and policy elements of the Portuguese effort, which in any case is different from the other TF programmes.

10.4 Results and Impacts

Greece and France prepared their open-ended TF exercises because they aimed to help creating the framework of future thinking and to design national strategies. The outcome would be a kind of a technology map playing a significant role as an awareness and communications tool supporting any future decision on the allocation of resources across research projects. The limited funds, especially for Greece, imposed a rapid implementation of such a synthetic information instrument. Yet, TF for Greece is more suitable for strategic decision making since it is more long-term than the French one and also focuses on technological discontinuities or the possibility on any technological or economic rupture. Another more important common objective of both studies is that everyone (business units, organisations, researchers etc.) has access and can use the results according to each own purposes.

The next two technology-oriented South-European cases, the Spanish and the Italian, differ in the sense that the first is addressed to decision makers in private and public sectors while the second provides a better information pattern to the community of scientists and the technologists.

The fifth initiative, the Portuguese Foresight, tries to connect research and innovation improving critical institutional arrangements as it is targeted to political people and high-level private managers.

Different strategies too have been followed for the diffusion of the TF findings.

- Greece as the youngest member of TF Club does not expect the study report to become a best seller and disseminated the results through the Internet without paying much attention to the elaboration of this document.
- Similarly, Portugal prepared their work, which was handled by an independent non-profit Observatory in order to give continuity to the presentation of results.
- Spain has organised an international conference through their own Observatory, which has published the reports in an electronic format. Afterwards, during the last six years they execute follow-ups via a quarterly news bulletin and a number of national and regional workshops
- Italy went further by printing the results of their study in a book form, which is widely sold in bookstands. Moreover, a national conference gave the opportunity to governmental officials and private stakeholders to be informed about the TF proposals.

- Finally France, after any successive TF efforts, has published the key technologies, which are presented in specific formats including fields of application and the competitive position of French and European products and services.

The impact in all Foresights are mostly the same because, apart from the specific technical results and policy recommendations, the outcomes of the process itself are equally useful for every stakeholder at all levels. Across different societal groups there were significant benefits from the whole procedure of vast information exchange, opened communication avenues, strong networking activity and even policy debates among members of the involved teams.

Japan	Romania
United Kingdom	Bulgaria
Germany	Austria
France	Czech Republic
Italy	Hungary
Spain	South Africa
Portugal	New Zealand
USA	Netherlands
Australia	Sweden
Greece	South Korea
China	Cyprus
Thailand	Canada
Denmark	Finland
Russia	Ukraine

Table 7. Countries, which have conducted Technology Foresight studies.

10.5 Pan – European Aim

This comparison could lead to a common EU approach for Foresight. Therefore within the Frame Programme 6 (FP6) EU will initiate wide approaches on European issues which are based on monitoring Foresight data from various member states. The target is to develop mutual learning between member and associated states and regions.

Some questions concerning the shape of Foresight (Universities, Industries, research institutions, policy makers, international organizations and associations etc.) in Frame Programme 7 (FP7) were posed to target groups and the replies favored Foresight initiatives along the six major objectives of FP7 (Table 9). All stakeholders agrees that TF provides a means of contributing to the conception, strategy and socio-economic contextualization of actions related to FP7. In parallel, it allows disseminated activities (appropriate and suitable) according to the pre-defined issues in order to ensure the right implementation. The provision of a homogeneous pool of experts through TF for each of these EU objectives is also a decisive factor. Thus the allocation of more than 100 mi Euro is programmed to cover future TF exercises in the EU.

- Creating European Centres of Excellence through collaboration between laboratories
- Launching European technological initiatives
- Stimulating the creativity of basic research through competition between teams at European level
- Developing research infrastructure of European interest
- Improving the coordination of national research programmes

Table 8. The major objectives of EU research activities (Brichard, 2005).

11
GENERAL CONCLUSIONS AND RECOMMENDATIONS

11.1 Organizing Interaction

During the Greek TF exercise I had three responsibilities in the Aerospace and Defence Technologies team. One was that of Chairman of the whole sector, the second was to be the Rapporteur for the Sub-group of the Technology Scientists (Appendix 3) and the third was to act as a researcher to probe further into some areas such as 3rd round of Delphi (Chapter 3.2.4), dual-use technologies (Chapter 8), Human Factors Interaction (Chapter 9) and technologies with wide applications (Chapter 5.5.2) including new materials (Chapter 7.8).

The initial responsibility as a Chairman was to manage the team with tasks such as:

- Leading the project and organizing the multitude of involved participants in WG and SG
- Supervising the various narrower or wider concentric circles of participants which constitute a structured pattern of more than 300 individuals so far
- Keeping regular contacts with the stakeholders and the Steering Committee to maintain proper direction and time scale
- Ensuring integration in workshops, conferences, journals etc.
- Controlling the project alignment with original technical objectives and its relevance to broader activities and policies

As a Rapporteur I contributed to the experts' work which was more often not organized around panels and WG. This work consisted of

- Collecting all relevant information and knowledge
- Promoting new insights, creative views and strategies as well as new networks
- Disseminating the TF process and results to broader audiences
- Preparing follow-up actions

Because of our late entrance into the TF process there was no chance to pass through a pre-foresight stage. Thus no awareness seminars were held across the country to promote TF among experts and professionals. It was the personal influence of the researcher who exercised his 37-year involvement in the Aerospace and Defence environment of Greece to invite and convince key people who were both visionary and actively involved in the field to enlist in this campaign. Some of them, well-known figures as "champions and ambassadors" through their early enlistment put forward the arguments for Technology Foresight.

However ,in the widespread participation of players we have dared to apply to a very limited extent a casual approach which was sometimes occasional and episodic. Thus the legitimacy of the activity was strengthened and any required specific knowledge inputs were inserted. The active involvement of the various stakeholders from the beginning of the TF until the end of the activity was given much emphasis. The reason is that this is a core factor differentiating Foresight from other narrow futures and planning approaches.

In any case members of the various groups were selected carefully. The risk of creating an utopian "wish - list" of personalities was avoided but instead open-minded and creative individuals have been located who collectively had knowledge covering a wide range of the Aerospace and Defence topics under consideration and not strictly specialists. These participants were directed to share knowledge, to speak and relate to each other as experts and not as their own interest group representatives. Many times leadership and conflict management skills were required to maintain motivation and morale, to resolve disagreements by stimulating team-building as well as formation of new network and revitalization of established ones. An important correction was made in the later phase of the programme when it was perceived that too much autonomy started creating difficulties for synthesis of WG outputs and agreement on shared priorities.

It must be underlined here that in order to keep the willingness to participate high a balance had to be created between sophisticated and demanding methods leading to technological rigour and availability of group members. Respecting their time, busy researchers and business people who found it difficult even to attend all the WG, SG or other panel meetings could not be pressed. So it might be hard to persuade them to attend yet more meetings to learn certain modern methods without any incentive but the satisfaction of participation in TF framework prerogative and authority were absolutely vital for the stakeholders' representatives because TF activities must carry a stamp of approval to assure all participants that they are engaged in a worthy endeavour (Keenan and Miles, 2002). In this case, this was ascertained from the first contact with these people.

Apart from the proper reaction of participants, project management required the use of simple tools for monitoring. This consisted of continuously observing the activities undertaken during the implementation of each step in order to compare them against the targets. Similarly, the project play needed to be adopted to its environment because a TF exercise is expected to be flexible. Initially, it was thought to apply Project Evaluation Review Technique (PERT) management framework to follow the project milestones but unfortunately time constraints discouraged this effort.

Even though Greek TF in Aerospace and Defence could be characterized as a kind of navigation between the analysis of the approaches and an action-oriented programme the successful aim was to set up a combined process-based and a product-based activity, as it will be explained at the last paragraph of this sub-chapter.

Finally, the codified knowledge which pertains to all typical formal outputs was a considerable amount of work which had to be realized by using many of our own means (secretarial/technical assistance and accommodation). Informal outputs are more difficult to group since they take the form of knowledge integrated in people's practices and approaches to tackle problems. This is the main concern at present and reasonable benefits from the development of new network together with the parallel integration of

TF results and methods into the strategy and the projects of organizations and user groups (e.d. companies, trade unions, government agencies etc.) are needed.

This had to do with the previously mentioned process-oriented approach of the TF in Aerospace and Defence. One focus was on achieving better networking and exchanges of opinions between participants enabling carriers of relevant knowledge to share understanding about each other's expectations and pursue strategies while forging an evolving network for collaboration. The second focus was oriented toward achieving tangible outputs such as key technologies and critical list of priorities. This is the so-called product-oriented approach and was the main objective set by sponsor of TF, the General Secretariat of Research and Technology. The above mentioned may seem as dissimilar foci but indeed they constitute a synthesized output of the TF.

11.2 Concluding Remarks

Greek TF was the first integrated Foresight effort in our country and it is of course too soon to draw any conclusions about the effectiveness of the new programme. The size of Greece and the level of economic and social development played a decisive role in setting the objectives of TF in Aerospace and Defence Technologies.

As this TF did not start with a well-defined and rigid methodological blueprint, the major decisions were taken jointly by the participants, permitting some important details on methodology to evolve throughout the whole process. Several times when WG members were faced with various tasks the original objectives had to be rethought by not letting them to reach ambitious levels (given also the set timeframe) but to be adjusted to the Greek context.

The first step of TF was technology mapping to outline the playing field and to define and explain the content and concepts of the problem to be analysed. Mapping provides a platform for discussion and supports the foci of TF study. For this project the mapping task was not straightforward since there was a vast area of different technologies and sometimes the risk was faced of confusion, frustration and conflict in the subsequent part of the process. Fortunately, three members of the WG acted as qualified facilitators and created problem-solving interventions.

The adaptation of the scenarios method to WG conditions was imposed by the difficulties encountered during the applications of this technique. People could not easily understand the difference between planning and thinking about qualitatively dissimilar futures in order to formulate a vision building. Nobody had the opportunity to get involved in actual scenario-design exercises before, so TF remained a participative, continuous learning process from a methodological point of view which apart from advantages created inevitable drawbacks. Moreover this lack of advance planning increased the commitments from the participants and maybe deprived the final report from a well-presented format of results.

Since TF is a predominantly dynamic and learning process our recommendation is that some objectives must be reconsidered along with the evolution of some aspects of TF methodology. This is enhanced by the fact that Foresight stays a costly project in terms of money and the time devoted by participants, especially for Greece which is a small country with limited resources that is not found at the forefront of technological development but rather at the semi-periphery. Thus, our experts do not demonstrate much experience in leading-edge technologies, nor they have readily available previous TF products which could be obtained only through such national programmes. Analysis of real Foresight studies indicates that TF is an art as much as a science. Of course it is essential to evaluate previous studies and to learn from experience to maximize opportunities for success. However, a critique executed in the post-foresight stage showed that even the most careful planning cannot determine exactly what will happen during the project thus organized which must be open to chances for increasing authority, legitimacy and credibility as the study processes. It follows that the best way of learning about TF is to do it, because it is only the tacit knowledge built through experience and the willingness to seize opportunities during the study can make the difference between substantial or minor impact. We are convinced that the unique benefit of Greek TF could enhance our international competitiveness and position in the global context opposite to major trends through the analysis of domestic strengths, weaknesses, opportunities and threats (SWOT).

Technology Foresight not only requires technology insight but also the ability to choose the right set of methods and tools for firms and research institutes to make valid decisions for the future research and development of Aerospace and Defence Technologies. Hence TF was a clear success in attracting widespread support in industry, much of the science base and the governmental officials. However the rushed timescale inhibited the complete development of mature recommendations and the ability to get full advantage of methodologies. The panel in Aerospace and Defence mostly worked well and no significant barriers of communication emerged between members or among the other panels. The next phase of TF is proposed to have a more cross-sectoral approach and more permeable walls.

As proposed in the Programme Planning and Rationale/Module DPS 4521 (Tsolakidis, 2002) the project attempted to take forward the wider roles of all professional areas involved (government, companies and academia) and to enhance professionalism of public servants. Human resources management will be also able to keep in country high-quality individuals because of favorable employment conditions. Similarly professional approach in key domains such as standardization, dual-use products, intra-community transfers will permit better monitoring of defence and aerospace industries ensuring competitivity and effective use of national resources. The innovation proposed in the TF promises a genuinely creative approach to the future set by the vision of 2020 together with the changes in the structure for military research institutes and procurement law. We estimate that the new cycle of TF will have a real opportunity to capture the public imagination and foster a "Foresight culture" because this TF programme – even though has represented a step change in the members consulted about priorities – it is still very largely confined to a technical extent. As in the UK (Georghiou and Keenan, 2000), here too in some senses this first TF cycle can be seen as a "heroic era" in which the successes were achieved through the driving force of key individuals championing particular activities. In any case the expected excessive focus on technology as a driver led to over-emphasis on technical fix solutions relative to regulatory or social change in spite of the contribution of two sub-groups of Political Scientists and Defence Economics.

Almost in the middle of TF process national elections brought the opposition into power and the new government exercises strong criticism of preliminary reports because politicians always try to establish their own new policies by modifying perspectives as they have a shorter time horizon. According to our explicated opinion it must be acknowledged that Foresight cannot solve all the social. economic or political problems that beset a state. Foresight can generate visions. Ideally, a large amount of these will be shared visions and ones that are well-founded on the knowledge of relevant developments in social or technological affairs (Miles. 2002). But if TF is neither a "quick fix" nor a "magic wand" to impose a consensus in situation where there are profound disagreements, then political discretion needs to be exercised in cases where conflict is inevitable between sectors on highly contentious issues. Also TF has provided the information (e.g. a priority list) needed for a particular policy to be implemented. Governance should act and implement the generated outputs otherwise the involved people will feel that their expectations have been raised unduly and their time wasted. Without any doubt the sort of longer-term analyses that TF involves and the new networks and capabilities that it can forge cannot be expected to achieve results overnight. Often the processes of interacting ideas and seized opportunities in parallel with confronted challenges will take a long time to conclude in widely accepted motions in the way forward. To prepare people for the significant change requires long preparation and considerable groundwork.

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APPENDIX 1

QUESTIONNAIRE I

(Used for Delphi Method and Interview)

1 What areas of innovation are expected to offer significant advances during the next 20 years?

2 What are the success perspectives connected to these areas?

3 What is the impact of the previously mentioned significant advances on general economic development?

4 What is the expected special impact on work and employment?

5 Can this technological innovation assist in the solution of environmental issues?

6 What is the effect of innovation advances in the development of society?

7 Which are the main results of R&D, that will contribute the greatest improvement in human knowledge?

8 What is the time frame for the successful realization of these individual areas?

9 Which countries can be considered as leaders in the various R&D areas?

10 Which are the required steps in order Greece to be able to synchronize or even to be a leader in these areas of R&D? How can this be translated practically?

11 What possible benefit can arise after the realization and utilization of these technological innovations especially in the domain of disposing the resulting products?

12 What is the innovation potential (1 to 5)?

13 What is the timescale for research, development and application?

14 How can anyone show that there is a proper balance between basic and applied research in Aerospace and Defence technologies? How does this imply for the distribution of funds across disciplines?

15 What will be the cost of carrying out the strategic research and subsequent development needed before Greece can exploit the economic or social benefits of the particular technology?

16 Who are the players in the field of TF?

17 What are the key issues they have been working on?

18 What are the projects they are occupied presently?

19 Why are these issues of prime importance for every particular player?

20 Which methods do they use to get the answers that policy makers and the political administration need?

21 What kind of measures is taken to implement the results? How is the implementation process organized?

22 How do you rate (1 to 5) the policy impact of TF on areas of technology or innovation? Which is their importance (1 to 5) to market success?

23 Can you suggest another key priorities in relation to science and technology investments?

24 How could you classify these priorities to their importance (benefits to Greece and ability to harness benefits) and feasibility?

25 What role should national policy play in coordinating organizations?

26 How in conditions of uncertainty can some sense of direction and priority be given to research agendas?

27 What is the need to make decisions today for close future alternatives?

28 Who should be involved in deriving future scenarios?

29 How do funding decisions today be affected by expectations of the future, a future acknowledged as uncertain and yet "creatable"?

30 Which are your main fields of expertise?

31 Can you indicate the ratio of work done for public services to work done for private clients?

32 Do you wish to mention some of your clients?

33 List the co-operations and networks that you participate.

34 What human resources and skills will be required?

35 What market and technology opportunities are likely to arise?

36 Which of these will be best placed to adopt in Greece?

37 How Greece should organize itself to take the greatest advantage of the opportunities?

38 Who should take action?

39 What is the Greek Aerospace and Defence export potential (1 to 5)?

40 What is the civil market potential (1 to 5)?

41 Are Greek production capabilities commercially viable on domestic market (1 to 5)?

42 How high are the barriers to entry (1 to 5)?

43 Can Greek Aerospace and Defence industry succeed?

44 What is Greece's current position in Aerospace and Defence development versus advanced European Countries Concerning: S&T capabilities. exploitation of R&D results, quality of production or service and efficacy of regulation (options ranging from "unacceptable" "lower level, but acceptable", "fairly similar" to "higher level")?

45 What is Greece's current position versus the rest of the world? (same as above)

46 Are there any constraints: social/ethical, technical, commercial, economic. lack of funding, regulatory standards, education/skill base? (yes or no)

47 Can you rank the relevance of the three policy tools – domestic R&D, purchase of licence, know-how or ready-made products – in promotion of development and application?

APPENDIX 2

QUESTIONNAIRE II

(Used for Human Factors Integration)

1. What is the contribution of Human Factors in design of Defence and Aerospace systems?
2. Can you name some key areas which are directly influenced by human-automation interaction concepts?
3. Do you employ any Human Factors specialists? (Yes or No)
4. If yes, how many?
5. Have you had any difficulty to recruit suitable Human Factors staff? (Yes or No)
6. If no, was it easy to retain these professionals during the last 3 years? (Yes or No)
7. If the answer is negative, has any employee left the organisation as a result of difficulties in career progression within the Human Factors profession?
8. Specific skills, knowledge or abilities from Human Factors specialists are required by most organisations. Which methods do you employ to develop the Human Factors training of your staff?
9. According to your perspectives which is the short-term priority in the initial and continuing education/training of Human Factors professionals for Greek Defence and Aerospace industries?
10. Can you suggest correspondingly the most important longer-term priority?

APPENDIX 3

AEROSPACE AND DEFENCE TECHNOLOGIES WORKING GROUP

Chairman

Stefanos Tsolakidis, President, KLEOS S.A.

Coordinators

Daglas Vassilis, Researcher Nat. School of Public Health

Karabekios Nick, Researcher, University of Athens

Sub-group of Political Scientists

Rapporteur: Dokos Athanasios, Research Director of ELIAMEP

- Eliadis Theodoros, Consultant, Ministry of Education
- Kintis Andreas, Analyst, Ministry of Foreign Affairs
- Protonotarios Nick, Analyst, Ministry of Defence

Sub-group of Defence Economists

Rapporteur: Kollias Christos, Professor of TEI, Larissa

- Rafaelidis Apostolos, Lecturer of TEI, Patras
- Nikolaidou Eftichia, Lecturer of City Lib. Studies
- Moschovis George, Consultant DESMI S.A.

Sub-group of Technology Scientists

Rapporteur: Stefanos Tsolakidis, President KLEOS S.A.

- Douris Christos, Alternate Director, Hellenic Arms Industry
- Evangelou Panos, Director, Hellenic Aerospace Industry
- Miropoulos Nikitas, Major General HAF, Director MoD
- Giannopoulos George, Brig. General HA, Offsets Director MoD
- Goulios George, Director, Hellenic Shipyards
- Moulias Nick, President Association of Defence Industry
- Panayiotakis Kostas, Lt. General, Hellenic Army Chief

- Vekinis George, Researcher DEMOKRITUS
- Kantas Antonis, Professor, University of Thessaloniki
- Yfantis Vassilis, Colonel, HAF General Staff

APPENDIX 4

AEROSPACE AND DEFENCE TECHNOLOGIES SUPPORT GROUP

- Sarlis Makis, General Manager, ISOTRON S.A
- Theofilou Michael, Colonel HAF, MoD/GDA
- Papadoudis Costas, Vice President, KLEOS S.A.
- Tsakonas Panagiotis, Analyst, Ministry of Foreign Affairs
- Groppa Rouby, Consultant ELIAMEP
- Arkoumaneas Elias, President, SONAK S.A.
- Botsaris Akis, Professor University of Patras and SMA
- Tsitinidis Triant, President of Aeronautical Engineers
- Kepidis George, President ANTOSIS S.A.
- Troullinos George, General Manager INTRAKOM
- Koutsos Kostas, President MILTECH S.A.
- Polymenopoulos Alex, Dep.Director of R&T MoD
- Laios Vassilis, Lecturer, University of City. London
- Kantzis Alex, President of MICRON
- Kounnamas Gregory, Naval Engineer, Hellenic Shipyards
- Kostopoulos Vassilis, Alter. Professor, University of Patras
- Pintelas George, Director, Hellenic Defence Systems
- Angelidis Emmanuel, Director of Hellenic Navy Research Center
- Tsausopoulos Theodoros, Director of Hellenic Army Research Center
- Siannas Christos, Colonel, Dep. Commander of Hellenic Air Force Research Center
- Ladis Lakis, Director, Electronics Dpt Director, HAI
- Chrissos George, President ELFON Ltd
- Economidis Takis, ex-Chairman of ECON S.A.
- Niarchos Nick, Research Director of DEMOKRITUS
- Grivas Kostas, Consultant, Institute of Defence Analyses
- Ioannidis George, Admiral (Rtd) ex-chief of Hellenic Navy
- Katsimitros Nick, Director, THEON S.A.
- Romanos Loukas, President, THALES S.A.

- Panaras Argyris. Colonel (Rtd) HAF. Researcher NASA/NTUA
- Frangakos Antonis, Maj General HAF. C'Branch Director
- Liousis Nick, Consultant ISTAME
- Pissinou Georgia. R&D Director, HAI
- Spathopoulos Theodoros. EU Programs Researcher. HAI
- Tenekoudis Sakis, GDDIR General Director. MoD
- Buvry Stephane, Technical Director of TES

APPENDIX 5

RESEARCH PROJECTS COFINANCED BY GENERAL DIRECTORATE OF DEFENCE INDUSTRY AND RESEARCH

Projects Description

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1. Aero engines Test Stand Upgrading
2. Electronic Fuze for Ammunition and Bombs
3. Digital Voice / Data Transmission
4. Electronic Warfare Systems (Jammers and RWR)
5. Long Range Ammo
6. Batteries Multi charger
7. Digital Satellite Data
8. Radar Signature Supression
9. Environmental Impact for Military Activities
10. Mobile Fuel Cells
11. Surface to Air Missile Operation Center
12. Simulation Technologies
13. Chemical Warfare Agent Detectors
14. Unmanned Combat Air Vehicle
15. Virtual Cockpit Demonstrator
16. Logistic System Development
17. Passive Radar Development
18. Passive Detection for Submarines
19. Development of Various Ammunition
20. Frequency Hopping Radios
21. High Speed Communications Network
22. Small-sized Submarine
23. Industrial Upgrading of state-owned defence companies
24. Virtual Aeroturbines Lab
25. Hull design for fast patrol boats
26. Crypto systems design

APPENDIX 6

SOME DUAL-USE TECHNOLOGIES DEVELOPED BY GREEK AEROSPACE AND DEFENCE INDUSTRIES

Company	Technologies / Products
Hellenic Aerospace Industry	– Aircraft and Helicopter Maintenance – Turbines for aeolic energy generators – Training services to civil customers – Desalination equipment – Composite materials processing – CAD/CAM products – Chemical treatment of metals
Hellenic Defence Systems (Hellenic Arms Industry / Hellenic Ammunition Industry)	– Ammunition for hunters – Hunting rifles – Uniforms and boots – Aircraft fuel tanks – Boxes for sensitive equipment transportation – CAD/CAM techniques
Intracom	– Communication Systems – Crypto technology
ELFON	– Wiring harnesses
MILTECH	– Global Positioning Systems – Field telephones – Battery chargers
Hellenic Shipyards	– Merchant marine maintenance – Railways wagons
Hellenic Vehicles Industry	– Cars and jeep vehicles
Thales Electronic Systems	– Printed Circuit Boards – Air traffic control equipment
Soukos Robots	– Anti-terrorist robotic technology
Sunlight	– Batteries for civil and military application

APPENDIX 7

ABBREVIATIONS

ADC: Analog to Digital Converters

ASIC: Application Specific Integration Circuits

ATM: Asynchronous Transfer Mode

C^2I: Command, Control, Intelligence

C^3I: Command, Control, Communication, Intelligence

C^4ISR: Command, Control, Communication, Computing, Intelligence, Surveillance and Reconnaissance

CFSP: Common Foreign and Security Policy

CoTS: Commercial of the Shelf

DEW: Directed Energy Weapons

DID: Defence Industry Directorate

EDA: European Defence Agency

EMP: Electromagnetic Pulse

EMU: European Monetary Unification

ERA: European Research Era

ESDP: European Security and Defence Policy

ETAN: European Technology Assessment Network

EU: European Union

EUA: Economic University of Athens

FOREN: Foresight Regional Network

GDDIR: General Directorate of Defence and Industrial Research

GSRT: General Secretarial of Research and Technology

HA: Hellenic Army

HAF: Hellenic Air Force

HAI: Hellenic Aerospace Industry

HDS: Hellenic Defence Systems

HELDIC: Hellenic Defence Industries Catalog

HF: High Frequency

HFI: Human Factors Integration

HN: Hellenic Navy

HPM: High Power Microwaves

HR: Human Resources

ICT: Information and Communication Technology

IPTS: Institute for Prospective Technology Studies

ISDN: Integrated Services Digital Network

ISO: International Standards Organisation

IT: Information Technology

JMAP: Joint Medium Term Armament Programme

LF: Low Frequency

LoS: Line of Sight

MMIC: Monolithic Microwave Integrated Circuits

MoD: Ministry of Defence

MoE: Ministry of Economy

NATO: North Atlantic Treaty Organization

NIS: National Innovation System

NSPH: National School of Public Health

NTUA: National Technical University of Athens

OB: Offsets Benefits

R&D: Research and Development

R&T: Research and Technology

RIS: Regional Innovation System

RTD: Research and Technological Development

S&T: Science and Technology

SME: Small and Medium-sized Enterprises

STRATA: Strategic Analysis of Specific Political Issues

SWOT: Strengths, Weaknesses, Opportunities and Threats

TF: Technology Foresight

UAV: Unmanned Airborne Vehicles

UHF: Ultra High Frequency

UK: United Kingdom

USA: United States of America

USV: Unmanned Surface Vehicles

UUV: Unmanned Underwater Vehicles

VHF: Very High Frequency

WEAG: Western European Armament Group

WEAO: Western European Armament Organisation

WEU : Western European Union

WG: Working Group

APPENDIX 8

MAIN CHARACTERISTICS OF REGIONAL FORESIGHT ACTIVITY IN EUROPE

	Lombardy	West Midlands	Grand Lyon	Catalonia
Link with National Foresight	Strong (use of results)	Strong (financial support)	Very Weak	Independent
Time Horizon	5-10 years	5-10 years	5-10 years	5-10 years
Objectives	To support the region's industrial sectors	To involve the SMEs in the region	Very broad: social, economic, urbanistic	Very broad: social, political, economic
Participation mechanism	Meetings, panels, interviews of top managers	Five sector panels, seminars, workshops	Working Group, large open forums, key experts	Expert and opinion survey, Working Group
Methods	Data and Key Technologies analysis	SWOT analysis, regional scenarios	SWOT analysis, database construction	MICMAC METHOD, Delphi, micro and macroscenarios
Output	Final report 1998, Centre of excellence	3,5 million EURO of new investments, 3000 firms involved	23 themed reports, final document Millénaire3 (2000)	24 diffusion seminars, final report
Status	Extended to include new sectors	Extended until December 2004	Permanent monitoring council	Stand-by