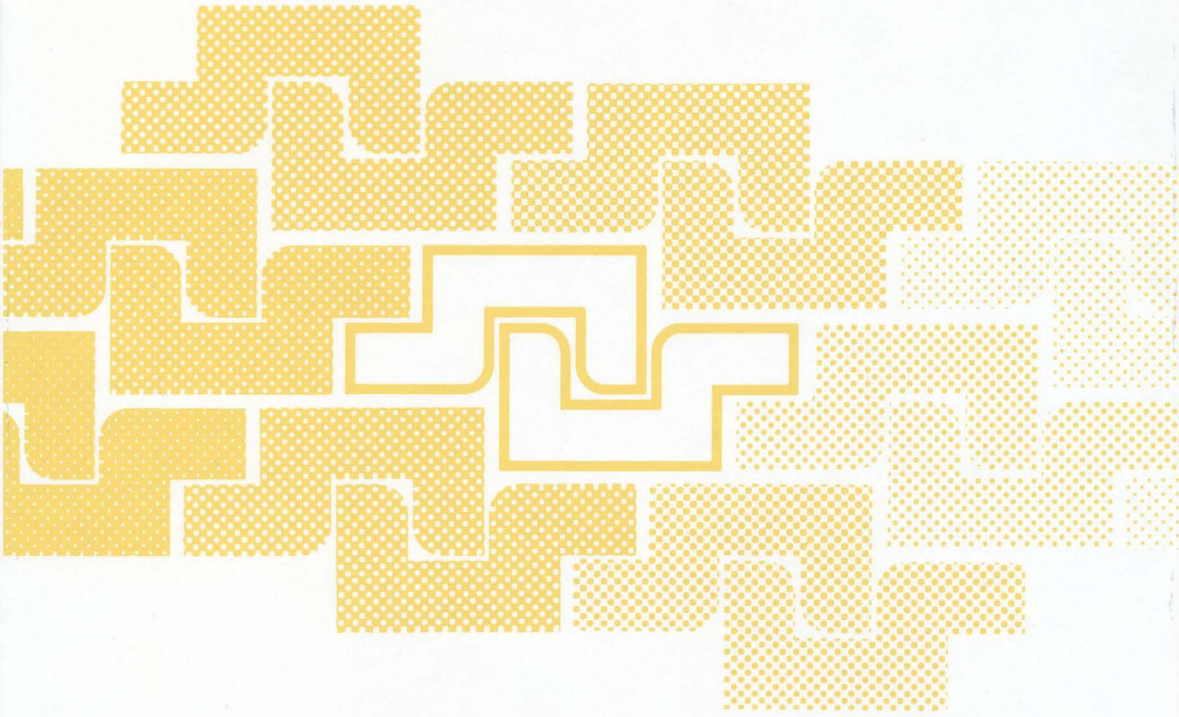

Defence Related SME's

Analysis and Description of Current Conditions

Edited by
Fernando Duarte Carvalho

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Defense Related SME's: Analysis and Description of Current Conditions
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Strategy of Small Defence Oriented Enterprises in a Time of Defence Budget Downsizing -Croatian Case Study-

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Abstract. A relatively large defence industry during the Cold War period has been significantly reduced in many transitional states in the last decade due to heavy defence budget downsizing. These heavy budget cuts caused the collapse of many large defence corporations. Furthermore, since the beginning of the 21st century in the post-Cold War period many transitional states do not need large defence industrial facilities and large defence enterprises for self-protection. But protection of their small and medium size defence-oriented enterprises (SME's) is important for protection of their economies, employment, social stability etc. In such situations, transformation and adaptation of these SME's to the new business environment and conditions is imperative for their survival. Survival strategy of these small defence related companies requires: increase of their international competitiveness, acquiring of new dual use knowledge, expertise and technologies, stronger orientation to the civilian markets, identification of a new niche in civilian and defence markets, education and shaping of future customers, acceptance of a new management and organizational culture which supports innovation and creativity, minimization of bureaucracy, a modern type of personnel management and diversification of production. Competitiveness of these SME's on the globalized markets will depend, first of all, on their efforts to increase their R&D activities and to put more R&D based innovations into their new products. The Croatian case study given here is related to the business strategy formulation of one small R&D based Croatian defence-oriented enterprise which is trying to survive in a time of heavy defence budget cuts through transformation of its old mainly defence-oriented business strategy and products to a new one.

Introduction

In the post-Cold War period in Eastern and Central Europe, many huge military industrial state owned companies and facilities collapsed, while many of the SME's are still searching for business survival in a time of heavy defence budget downsizing. For the first time, most of these companies are being forced to deal with new issues and challenges, such as: new product development, marketing to civilian customers, private-sector financing, adopting new competitive business practices, living outside the shadow of the defence business, etc. The failure of these SME's to reach a successful adaptation of their services and products to the new defence and civilian markets would cause devastating consequences for their national economies and national security of these states. Therefore, the importance of dealing with transformation and adaptation processes and conversion issues of these SME's

cannot be overstated. It is also very important to explore new ways in which these affected SME's can adjust their core businesses to the new economic situations, characterized by the heavy defence budget downsizing. In a case of successful transformation and adaptation, these SME's may play an important role in the economies of their countries and can make a substantial contribution to the creation of new jobs and prevention of social and political crises in these states.

On the basis of hypothetical statistics, we can guess that approximately up to 5% of these former defence oriented SME's have a chance to survive and to transform themselves into the new modern, internationally competent and competitive SME's, which will be capable of competing in the international defence industry business. Another 10 % of them have a chance to survive as in-state maintenance providers, while the rest will be definitely lost. This article concentrates mainly on the first group of only a small percentage of these SME's, which can transform themselves into small, modern, competent and competitive high-tech and R&D based enterprises. Such companies will be very important for the economies of their states, but they might be also very important for economic integration of those states in a new global digitized economy, integration into the EU, integration into a common European defence industry, etc. Such companies may also function as an interface between their transitional economies and economies of well-developed states, enabling diffusion of knowledge, technologies and modern type of business management into their states. Without such successfully transformed SME's, there is no compatibility and interoperability of these states with the NATO defence industry business sector and there is no tighter integration within the NATO structures.

1. Offsets and the New Specific Role of Defence SME's in Small Transitional States

There are many chances and opportunities for new specific positions and roles which defence oriented SME's may take in the near future in the small transitional countries. One among many may be related to the role of SME's in offset policy implementations and regulations. Implementation of offset policies in many transitional states should be very attractive for many small and medium-sized enterprises, as it is in the majority of developed states. In today's defence and civilian markets, offsets will have more and more acceptance and importance and this trend is not likely to be reversed in the near future. Creative, innovative and smart offsets techniques require specialized SME's for consulting assistance, education and training for intelligent and effective compensatory management transactions. It may be a challenging business opportunity for many consulting and management-oriented emerging SME's, which mainly do not exist yet in the majority of transitional developing states. A wide spectrum of activities contained in offset agreements related to the co-production and subcontracting, technology transfers or licencing of technology, in-country counter-procurements, marketing assistance, financial assistance, investments, joint ventures, etc., offers many new attractive and challenging additional opportunities for existing and emerging SME's. Offsets can bring jobs, technology and production experience to many transitional states and SME's, creating and maintaining a new more flexible, competent and competitive domestic industrial base and defence technologies. Offset programs can be very important for restructuring and developing of national economies in many transitional states, developing their defence industrial potential, opening new cooperation, organizational improvement of their enterprises, development of their scientific research institutions, better higher education, as well as restructuring of their regions threatened with unemployment. Some transitional states may also use indirect defence offset procurement as a tool for development of their civilian industry, such as in tourism, agriculture, the food industry, building their infrastructure, etc.

But many transitional states are not yet fully aware of the importance and potential of compensatory transactions in military procurements for their economic recovery and restructuring.

One specific role, which many defence-oriented SME's will have more and more of in the future in small transitional states, is the relation to the maintenance of their newly-procured military equipment. The main weapon systems and sub-systems in these countries will be procured in the future, mainly from developed industrial countries, due to limitations and inabilities of small transitional states to design and to develop modern sophisticated state-of-the-art weapon systems. Therefore, maintenance of their military equipment which needs servicing and repairing, even in some cases in the next 20-30 years, as a contractual agreement of direct offset arrangements, might be a very predictable and reliable long term business for many SME's in these states. The specific role of SME's in maintenance of these systems and sub-systems might be very challenging in a technical and technological sense as well as in many other aspects. General transformation of defence industries in small transitional states from the role of prime supplier into the role of maintenance provider is one of the guidelines for SME restructuring and their transformation mainly to maintenance provider. These facts bring us closely to a situation where small transitional states as buyers of complex defence equipment will function almost exclusively as maintenance providers based on their domestic SME's.

And finally, apart from a very few SME's which will function as defence-oriented Think Tanks in the areas of defence policy, defence industry conversion, SME restructuring and transformation, new type of PPBS strategy for a time of heavy defence budget downsizing etc., there is no competent public domain discussion related to many relevant strategic defence issues for these transitional states. There is no smart and competent political decision with long-term visions. There is no successful transformation of their SME's and, finally, there is no successful transformation of their states.

2. Some Guidelines for Transformation of Defence-Oriented SME's in Small Transitional States

Successful transformation of former defence-oriented SME's may provide new power and capacity in economic consolidation and economic recovery of small transitional countries and may have an important role in future international defence industrial cooperation. What do existing and emerging defence SME's need to know in order to cope with reduction of defence markets and with the increase of emerging civilian markets? What are the guidelines for transformation and restructuring of these small and medium-size transitional enterprises? What is the role of government? These are only a few of many important questions which require a detailed and careful analysis and appropriate answers. Some general remarks and guidelines regarding their successful transformation will therefore be outlined.

2.1 Organizational and Business Culture

Organizational and business culture of SME's is very important for their ability to be competitive and to be marketably self–adaptive in a changing world and a changing business environment. An organization where people can expand their intellectual capacities, where people can create the results which they truly desire, where new creative and innovative ways of thinking are nurtured, where individual and collective aspirations and objectives are harmonized, where the culture of innovation and creativity can flourish,

where people are continually learning how to work and learn together, might be a successful organization. Unique team vision, team cohesion and team discipline, even productive conflicts of ideas rather than conflicts of rigid individuals and rigid policies are important for a new modern type of organizational culture. Experience shows that talented engineers appreciate discipline when it is implemented in a way that makes sense for the particular company and project to help them to succeed. Identification of emerging long term stable civilian markets and customers, diversification and balancing among defence and civilian services and products, shaping and education of potential strategic customers, more innovative management and marketing, creative leadership, organizational flexibility and its fast adaptation to the rapid market changes and environment, flexible hiring and contracting of manpower, an innovative and modern type of management, minimization of bureaucracy, a level organizational structure, etc., would be very important characteristics of an SME's new business reshaping strategy.

2.2 Personnel Management

Small companies live and die on the engineering talent they are able to hire. Talent alone is not enough, but it is very essential. Small companies which wish to remain competitive on the global market, must find ways of attracting and retaining their talents. The battle for talent must be a crucial element of their new modern agile business strategy and the minimization of friction between talented individuals must be part of their market strategy survival. Certainly companies with a small staff must take great care to make the best use of what their current employees are capable of doing and what they want to do. In such uncertain and turbulent times, characterized by heavy defence budget reductions, companies with small staff are in a surprisingly stronger position in comparison to medium size and large enterprises. Tighter connection and cooperation with universities as a main source of highly educated and flexible manpower, part-time jobs and project-based hiring and contracting of manpower, are some elements of the smart self adaptive personnel SME strategy as a mechanism for avoiding financial risks with company personnel and the maximization of R&D and business potential.

2.3 Research and Development

Generally, competitiveness of defence-oriented SME's in the small transitional states in globalized markets will depend on their effort to encourage their internal innovation practice, to increase applied R&D activities, to establish and to increase cooperation within state R&D institutions and to put more R&D based innovations into their products and services. But only a very few of former defence-oriented SME's in transitional states support R&D or outsource this as a part of their innovation practice. Therefore, the governments of these transitional states must take a proactive approach to scientific and technology promoters, stimulating applied R&D-based innovation of products and services in these SME's. Firstly, they can encourage long-term relations between R&D scientific community and research institutions with SME's. However, the problem in developing transitional countries, like Croatia, is in the fact that R&D performed at government sponsored scientific institutions and universities is mainly not applicable and is too far from any serious market commercialization. On the other hand, the number of SME's in small transitional countries which have advanced technological capabilities and which may have an interest for applied R&D cooperation is very limited. The main reason for such a situation is a lack of entrepreneurship skills and competencies in state-sponsored research

institutions, a lack of financial support for application-oriented R&D projects, the level of technical competencies of the SME's management staff and sometimes the level of technical sophistication of their products and services. Researchers in state-sponsored scientific institutions enjoy their "safe haven" surroundings. Through a fear of living in the market, they do not want to taste the experience of the market's risks. Without integrated efforts of private SME's and state owned R&D institutions and commercialization of their joint products and services, there are no contributions to the overall technological in-state expertise, economic growth and new employment. The culture of evaluation of R&D only through the citation index, without an evaluation of the commercial free market in technical cooperation with SME's, will be a big failure for many small transitional states.

This means that successful and intelligent transformation of these defence SME's and their consolidation is not possible without smart government support and government funding. But government authorities must want and must know how to change the innovation practices in these SME's and how to improve their technological competitiveness. Smart strategy of changes and the innovation practice must be embedded in organizational routines of these SME's, by appropriate training and education of their leadership and management staff. However, the remaining communist mentality and culture in these states and their enterprises are the main obstacles to their transformation. Furthermore, we have to take into account that marketing of applicable R&D in small transitional states, like Croatia, is extremely difficult and barricades against its acceptance are very high. Management staff in the majority of these SME's is not yet fully aware that innovation based on R&D is better and more profitable than the old way of doing business. In a cultural sense, many SME's are cautious, suspicious of any change, because they hesitate to leave the old Cold War proven ways of doing business without innovation. A long-term contact between scientists and SME's can initiate a positive interaction which can result in new projects and innovation. A new type of doing business, based on dual use technologies, like software development and off-the-shelf hardware, might be very profitable. Some of the small transitional countries may also enter into the forefront of technology development, but the prerequisite is much higher R&D investment, at least 3% of their GDP annually into applied R&D. In addition, what is very important to stress and to anticipate is a significant reduction of conventional defence technology, as well as the advancing modern advanced defence technology market. In the past, technology development was pushed forward by military demands and military technology used to lead to civilian spin-offs. But today, civilian technology leads to military spin-offs. As an illustration, in the semi-conductor business 30 years ago the defence sector had more than 90% of the market, while today the defence sector has about 0.3% of the market.

2.4 Financial management

A smaller and smaller MOD budget has a direct negative impact on its structure for many reasons. Ideally, an MOD budget is based on the balance between total personnel income, acquisition and modernization programme costs and operational expenditures. However, in a period of heavy budget downsizing, due to social stability concerns personnel payments can cover more than 70% of the MOD budget. This MOD budget deficiency has a direct negative influence on acquisition and modernization programmes as well as in the state defence industry business. Without MOD R&D funds, lack of experience and familiarity with new high-technologies, lack of society's confidence in researchers and a remaining communist culture and mentality which presumes that investment in private enterprises leads only to corruption and criminal activities, it makes it very difficult to take a significant step forward toward successful transformation of these SME's in many

transitional states. Without state supporting programmes for defence SME restructuring in the form of appropriate loans and grants, their transformation in a majority of transitional states will remain very uncertain. With a lack of management skills and some other business risks, many SME's in a time of very uncertain MOD budget size and structure are not willing to take loans. Without the MOD, as a reliable and predictable customer and partner, there is no guarantee for any SME's that they will succeed and will have continuing revenues for loan rate payments. So it can be concluded that a loan is inappropriate, in an uncertain time and an uncertain environment, as the only means for a SME's successful business.

Venture capital still does not yet exist in developing transitional countries. The reason is in underdeveloped financial markets in these countries. Additional development of investment and pension funds, reform of the health care system and diversification of the insurance market, will lead to new trends in the financial markets of these countries. Hopefully, very soon in these states, new investors will seek for new opportunities to invest their funds into high return and high-risk assets. Venture capital funds could be one of the appropriate solutions. An excess of venture capital, for example in the USA, with an amount of more than $40 billion, will also seek for new opportunities in emerging markets. This could be a chance for the development of venture capital markets in these countries. But a fact, which has to be considered, is that small entrepreneurs in transitional states are mostly sceptical regarding venture capital and initially they reject any idea that has any connection with it because they are not willing to lose full control over their companies by giving or selling a part of company shares to venture capitalists. With such business logic, they are missing the chance for rapid growth and development of their companies. Better promotion and marketing of venture capital and promotion of the benefits which this can bring to SME's, may reduce entrepreneurs' rejection of venture capitalists. This kind of marketing could be done by the state agency for investment promotion and should be focused on the small and medium entrepreneurs.

In developed countries classic venture capitalists are investing into whole companies, increasing their values and exiting from them. But cooperation between entrepreneurs and venture capitalists could be based on specific projects and could be very attractive. Instead of investing into a company's equity, venture capitalists might invest funds and provide consulting services to the company in order to develop specific new products and services. The venture capitalist will benefit from a percentage of sold products or services in the future.

There is no doubt that transitional defence-oriented SME's, embedding some of the guidelines and recommendations outlined in this section may have a better chance of survival in the turbulent transitional time of defence market shrinking and restructuring.

3. Croatian Case Study

The case study described illustrates the programme strategy transformation of one former Croatian, mainly defence-oriented small enterprise, which is trying to survive in a time of heavy defence budget downsizing by making a balance in its defence and civilian programmes. This transformation and evolution is based on product diversification and transformation of the old business of defence-oriented strategy and products to the new more civilian markets focused on business strategy and products.

3.1 Old business strategy and products

The old business strategy and products were related to modernization and upgrading of some weapon systems for the Croatian Armed Forces with the objective of increasing their lifecycle by replacing an old analogue electronic sub-system with a new commercial state-of-the-art, off-the-shelf digital technology as well as improving their technical and tactical features including design and development of some completely new products. Some of these efforts and products were related to the modernization of the old analogue guidance unit for AT-2 and AT-4 guided missile anti-tank systems with state-of-the-art digital technology in order to reach greater maintainability and provide some new technical and tactical features, like improved IR CCM capability or improved hit probability of moving targets. This also included design and development of new maintenance and troubleshooting equipment for AT-2 and AT-4 missile systems which enable automatic testing of launcher and missile parameters; design and development of new sophisticated multi-level Hardware-In-the-Loop (HIL) simulators as a powerful infrastructure for modernization of guidance and control hardware and algorithms; design and development of PC-based training simulators for AT guided missile gunners based on a high performance multiprocessor system which provides facilities for a complex and highly realistic simulation of the real AT systems, such as a 3D terrain map for the tactical scenery, 2.5D photographic imagery of real landscape or artificial 3D scene, 6DOF model of the missile's dynamics, 3D model of the target kinematics, different terrain types, different targets and trajectories and different meteorological conditions; design and development of an air-defence, state-of-the-art simulator based on virtual reality technology for the man-portable air defence system "Igla", etc.

3.2 New business strategy

The new business strategy is trying to protect and to adopt company core competencies and expertise through more civilian-oriented and more profitable commercial projects which offer new business opportunities such as the Whiplash Injury Integrated High-Tech Diagnostic System (WI^2HTDS) project, primarily intended for assessment and classification of whiplash injuries, including rehabilitation and quickening of the recovery process of the injured. The system is based on virtual reality technology and biofeedback sensors and it immerses a client in a completely new virtual world, which alters his impression of the real head-neck range of motion. Virtual reality, biofeedback and appropriate digital signal processing algorithms and complex statistical aggregated correlation analysis detects the inconsistencies in the client's head-neck range of motion, thereby reducing the chances of faking an injury. From the results of the analysis, conclusions can be drawn, which can be used to create a complete and objective clinical profile of the client, thus enabling financial compensations to those who really need them and preventing unnecessary expenditures. Humanitarian high-tech multidisciplinary projects based on technologies of virtual reality and digital biofeedback related to the therapy of the Croatian war veterans who suffer from PTSD is also an example of a civilian-oriented project. The main objective of this project is related to the design and development of complex dynamically controlled biofeedback- based adaptive scenarios, which have the objective of relieving the therapist who guides the patient through a virtual reality scenario from routine tasks, thereby developing an expert system that could automatically select and adapt therapeutic scenarios based on the patient's current level of

emotional excitement. MOD projects related to the psychological assessment and selection of combat-ready gunners based on biofeedback measurements of their emotional characteristics and profile under stress, use similar dual-oriented technologies and expertise.

4. Conclusions

Competent and smart defence policy, competent and knowledgeable MOD decision makers, their appropriate training and education, think tank assistance in design and development of defence strategy, are some of the most important prerequisites for smart and predictable defence budget and defence industry business in these small transitional states. On the international scene, cooperation between NATO and Partner transitional nations can make a significant contribution to the process of successful defence SME transformation as well as their adaptation to the new reality, characterized by defence market shrinking and expansion of newly emerging civilian markets. A proposal for NATO assistance to the former defence SME's in the transitional states could be related to the selection of a very few defence SME's in each Partner transitional state by assisting them through workshops, seminars, conferences and symposiums to speed-up the process of SME adaptation to the new business and security conditions and environment. The topics of these seminars and workshops could be related to modern organizational structure and management; offsets and SME's; personnel management; venture capital funds, etc. The foundation of a NATO Venture Capital Fund for investment and assistance of former defence SME's in a small transitional state as a leverage for its transformation and adaptation to the NATO defence industry business standards and procedures, might also be a very attractive proposal.

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EKONOMSKA POLITIKA HRVATSKE U 2011. GODINI

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Izlazak iz recesije ili daljnja stagnacija?

STRATEŠKI ZNAČAJ TEHNOLOŠKOG SEKTORA U MODERNIZACIJI INDUSTRIJE NAORUŽANJA I VOJNE OPREME I GOSPODARSKOM RASTU I RAZVOJU REPUBLIKE HRVATSKE

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SAŽETAK

Ekonomska snaga gotovo svake države najviše ovisi o njenoj tehnološkoj inovativnosti i vitalnosti kao temelju njene gospodarske konkurentnosti. Nažalost, tehnološki inovacijski potencijal hrvatskog gospodarstva danas je vrlo ograničen, a zbog nedostatnih ulaganja u modernizaciju došlo je do njegovog ozbiljnog tehnološkog zaostajanja. Samo kompetentna, stručno i znanstveno osmišljena politika opremanja i modernizacije Oružanih snaga Republike Hrvatske, u kojoj će posebno mjesto i ulogu pored hrvatskog gospodarstva imati hrvatske znanstvene i visoko školske institucije, može na optimalan način zadovoljiti ne samo obrambeno-sigurnosne potrebe, nego i mnoge druge važne društvene ciljeve. Kroz suvremeno i moderno formuliran pristup opremanju i modernizaciji OS RH, mora se istovremeno voditi računa o sveukupnom tehnološkom i gospodarskom rastu i razvoju Republike Hrvatske, uvažavajući pri tome razna objektivna ograničenja. No međutim, treba znati da nema modernizacije naoružanja i vojne opreme u RH bez novih tehnologija, odgovarajuće strukture znanstvenih i razvojnih istraživanja, te visoke kvalitete posebno tehničkog obrazovanja. Očigledno je da Republika Hrvatska kao punopravna članica NATO-a na planu modernizacije svojeg obrambeno-sigurnosnog sustava mora izabrati svoj put. Novi koncept hrvatske industrije naoružanja i vojne opreme može se temeljiti i graditi na znanju utemeljenih srednjih i malih poduzeća, koja se tek trebaju profilirati u pojedinim tržišnim nišama, stvarajući svoju međunarodnu prepoznatljivost na vrlo zahtjevnim, a vrlo često i zatvorenim nacionalnim tržištima naoružanja i vojne opreme.

Ključne riječi: tehnološki razvoj, znanstveno-istraživačka infrastruktura, tehnologije dualne namjene, inovativni i patentni potencijal, strategija tehnološkog razvoja, srednja i mala poduzeća.

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1 UVOD

Tehnološki razvoj predstavlja temelj konkurentnog gospodarstva i dugoročnog ekonomskog rasta. No, unatoč tome, u Hrvatskoj danas nema ozbiljnijih javnih rasprava o inovacijama, znanju, tehnološkom razvoju i napretku, a gotovo sva pažnja usmjerena je na socijalnu, monetarnu i fiskalnu politiku. Iako se u povijesti rat pokazao i kao generator tehnološkog razvoja, nažalost u RH tijekom devedesetih nije donio značajnija ulaganja u razvoj znanstveno-istraživačke i tehnološke infrastrukture. U SAD-u su već od ranih 60-ih godina vodeći tehnički fakulteti kao npr. MIT, Stanford, Ann Arbor itd. imali izuzetno značajnu ulogu u modernizaciji američkog obrambenog sustava. Kao rezultat takve znanstvene i tehnološke politike razvijen je prvi tranzistor, prva superračunala, komunikacijski sateliti, novi programski jezici, Internet itd. Svakako nije bilo realno očekivati da se takvo nešto može dogoditi u Hrvatskoj. Međutim, u Hrvatskoj nije bilo osmišljenog ulaganja u razvoj tehnološke i razvojno-istraživačke infrastrukture, a izdvajanja za istraživanje i razvoj iz proračuna Ministarstva obrane bila su potpuno zanemariva. Razumljivo je, dakle, da se pozitivni *spin-off* u obrambenom tehnološkom sektoru RH nije ni mogao dogoditi. Nažalost, slična iskustva karakteriziraju čitav hrvatski gospodarski sustav (1), a sporiji gospodarski razvoj RH u odnosu na neke druge tranzicijske države posljedica je upravo takvog atipičnog ekonomskog modela (2). Ta se atipičnost manifestirala u poticanju razvoja trgovine, potrošnje i uvoza, te zapostavljanju proizvodnje, tehnološkog i znanstvenog razvoja, te izvoza. Sve to rezultiralo je u relativno visokoj vanjskoj zaduženosti i veoma nepovoljnim odnosima u trgovinskoj i platnoj bilanci. Takav atipični ekonomski model uvjetovao je i atipičnu strukturu investicija koje su uglavnom bile usmjerene u cestovnu infrastrukturu, bez pravih poticaja tehnološkog sektora (3). Zbog toga se u Hrvatskoj mijenja tehnološka struktura proizvodnje na krajnje nepovoljan način, tako da raste udio proizvoda niže tehnološke razine, a smanjuje se udio proizvoda više tehnološke razine. Takve strukturne promjene indikator su gubitka konkurentskih sposobnosti hrvatskog gospodarstva koje se odnose na proizvodnju s višom dodanom vrijednošću. Hrvatska tehnološki zaostaje te se širi jaz između domaće ponude koja je uglavnom niske tehnološke razine i domaće potražnje i investicija za proizvodima visoke tehnološke razine. Kako, dakle, u tim uvjetima modernizirati hrvatsku industriju naoružanja i vojne opreme kada domaća industrija ne može osigurati dovoljno proizvoda visoke tehnološke razine? Nadalje, vrlo je naivno očekivati direktne strane investicije u tehnološki sektor RH, kao i značajnija inozemna ulaganja u istraživanje i razvoj koje doprinosi jačanju konkurentnosti domaćeg gospodarstva. Upravo u tehnološkom sektoru u kojem se ostvaruju relativno visoke razine profita hrvatsko gospodarstvo potpuno je istisnuto s domaćeg tržišta (4). U takvim okolnostima će mladi, talentirani i dobro školovani mladi stručnjaci koji svojim inovacijama i kreativnošću mogu osigurati snažniji gospodarski rast i razvoj odlaziti iz Hrvatske, dok će oni ostali koji se ne mogu prilagoditi zahtjevima visoko konkurentnog globaliziranog gospodarstva vršiti sve veći pritisak na sve manji državni proračun. Iz tih razloga sasvim je razumljivo da će uglavnom zbog strukturnih razloga trenutna gospodarska kriza u RH u suštini biti dugoročnog karaktera.

2 SUVREMENI PRISTUP STRUKTURNIM PROMJENAMA U INDUSTRIJI NAORUŽANJA I VOJNE OPREME U REPUBLICI HRVATSKOJ

Samo kompetentna, stručno i znanstveno osmišljena sveukupna politika opremanja i modernizacije Oružanih snaga Republike Hrvatske, u kojoj će posebno mjesto, ulogu i značaj imati hrvatsko gospodarstvo, ali i hrvatske znanstvene i visoko školske institucije, može na optimalan način zadovoljiti ne samo obrambeno-sigurnosne potrebe, nego i mnoge druge

važne društvene ciljeve. Ciljeve, koji se trebaju i mogu odnositi na povećanje industrijske konkurentnosti i zaposlenosti kroz razvoj visokih tehnologija, jačanje uloge znanosti, istraživanja i razvoja, funkcionalnije i kvalitetnije obrazovanje, te jačanje međunarodne vojno-obrambene industrijske suradnje (5,6,7). Tako formulirana i osmišljena politika opremanja i modernizacije Oružanih snaga Republike Hrvatske u kojoj će hrvatsko gospodarstvo imati značajniju ulogu nego što je to bio slučaj do sada, treba i može jačati obrambeno-sigurnosni sustav Republike Hrvatske, ali i sveukupne hrvatske industrijske, gospodarske i znanstvene potencijale, pružajući na taj način nove poslovne prilike i izazove našim malim i srednjim poduzećima. Takav pristup i pogled na obrambenu potrošnju u cjelini je bitno različit u odnosu na današnja i sve više prevladavajuća, jednostrana gledanja i stavove, prema kojima je vojni proračun isključivo oblik nepotrebne društvene potrošnje. Moderno i suvremeno formuliran i oblikovan pristup opremanju i modernizaciji OS RH treba, dakle, omogućiti postizanje željenih sinergijskih efekata, prema kojima izdvajanja za obranu ne predstavljaju samo nužnu potrošnju, nego ona postaju i polugom gospodarskog rasta i razvitka, te jačanja znanstveno-tehnološke infrastrukture, specijalističkog visoko školskog obrazovanja, visokih tehnologija i industrijskog razvoja (7). Takvim pristupom jača se i konkurentnost hrvatskih tvrtki i hrvatskih proizvoda, što je osobito važno sa aspekta sveukupne strategije razvoja Republike Hrvatske u kojoj izvoz treba i mora imati posebno mjesto i prioritet. Kroz suvremeno i moderno formuliran pristup najvažnijem segmentu obrambene potrošnje koji se odnosi na opremanje i modernizaciju oružanih snaga Republike Hrvatske, istovremeno se moraju sagledavati sigurnosni i obrambeni aspekti, s onima koji se odnose na gospodarski rast i razvitak, makroekonomska ograničenja, kao i cjelovitu makroekonomsku strategiju. Sve to treba omogućiti oblikovanje i formuliranje potpuno novog pristupa ovim važnim obrambeno-sigurnosnim strateškim pitanjima i ciljevima koji se moraju odnositi i na rast konkurentnosti industrijske proizvodnje RH kroz jačanje istraživanja i razvoja, te jačanje primijenjene znanstveno tehnološke infrastrukture. Samo tako formulirana i oblikovana sveukupna obrambeno-sigurnosna politika u kojoj će posebno važno mjesto i ulogu imati hrvatsko gospodarstvo i hrvatska znanost u opremanju Oružanih snaga Republike Hrvatske, može doprinijeti poticanju i jačanju konkurentnosti hrvatskog gospodarstva, te rastu zaposlenosti i izvoza, kao i smanjenju javnog duga. U slučajevima kada je nužno nabavljanje naoružanja i vojne opreme u inozemstvu, umjesto dosadašnjih aranžmana koji su se uglavnom temeljili na raznim oblicima kreditnih plaćanja, treba istaknuti prednosti i pogodnosti koje mogu osigurati razni oblici ofset sporazuma i ugovora, koji se mogu odnositi na transfer i difuziju novih tehnologija u hrvatsko gospodarstvo (8,9,10). Kroz izdvajanja za obranu, mogu se i moraju jačati tehnologije dualne primjene (*dual use technologies)* zato jer imaju podjednaku važnost i značaj u vojnim i civilnim programima. Razvoj i promicanje takvih tehnologija u hrvatskom gospodarstvu može imati veliki sinergijski učinak (11).

Zbog svega toga sve države svijeta nastoje svoja ograničena proračunska izdvajanja za obranu investirati u svoja gospodarstva, zapošljavanjem svoje industrije kao i njenih tehnoloških, znanstvenih i visokoškolskih resursa. No međutim, treba znati da nema modernizacije naoružanja i vojne opreme u RH bez novih tehnologija, odgovarajuće strukture znanosti, istraživanja, razvoja i obrazovanja. Sve to zahtijeva mudro osmišljenu strategiju gospodarskog razvoja u kojoj će posebno mjesto zauzimati strategija tehnološkog razvoja Republike Hrvatske. Prema riječima W. Perrya (12), tri su značajna čimbenika omogućila uspjeh američkih tvrtki: *poduzetnički duh, kapital za financiranje tehnološki utemeljenog poduzetništva i vrsna tehnička sveučilišta.* Isto tako, naglasio je "*… klima inovacija bila je takva da se svaki razvijeni tehnički proizvod mogao prodati…".* Za stvaranje takve klime bila je odgovorna država, odnosno društvena klima u širem smislu. U Americi, naglasio je W. Perry, još uvijek je jako popularno citirati Kilbya: *"Budućnost pripada onima koji su inovativni".* Sve ovo pokazuje da je odnos prema poduzetništvu i kulturološki uvjetovan, te da

ga je kroz sustav odgoja i obrazovanja potrebno poticati i mijenjati. Perry nadalje ističe da su američke gospodarske prednosti proizašle iz njezinog tehnološkog vodstva, a da su vodeću ulogu u postizanju tog vodstva imala američka tehnička sveučilišta. Njegov je govor na Sveučilištu u Zagrebu bio vrlo jasan; ako Republika Hrvatska želi sudjelovati u gospodarskim profitima visokih tehnologija, kao najproduktivnije i najkonjunkturnije gospodarske grane budućnosti, onda hrvatska sveučilišta, te posebno tehnički fakulteti moraju u svemu tome imati ključnu ulogu. Isto tako treba naglasiti da nema modernizacije sustava obrane, kao ni strategije tehnološkog razvoja Republike Hrvatske bez sposobnog, kompetentnog i kvalitetnog sveučilišta i kvalitetnih znanstveno-istraživačkih institucija. Važnost ovih institucija u Hrvatskoj nije u dovoljnoj mjeri prepoznata i prioriteti su dani nekim drugim područjima. Učinkovitost kojom država, kao cjelina, razvija i promovira tehnološki utemeljeni ekonomski rast, važan je čimbenik za njenu bolju budućnost. Ekonomska snaga gotovo svake države danas najviše ovisi o njenoj tehnološkoj inovativnosti i vitalnosti kao jedinom i stalnom izvoru povećanja njene ekonomske učinkovitosti. Nažalost, tehnološki inovacijski potencijal hrvatskog gospodarstva vrlo je ograničen, a zbog nedostatnih ulaganja u njegovu modernizaciju došlo je do ozbiljnog tehnološkog zaostajanja hrvatskog gospodarskog sustava u cjelini. Iskustva iz posljednjih dvadesetak godina nam pokazuju da zbog opće društvene klime Hrvatska nije prepoznala važnost tehnoloških inovacijskih aktivnosti i procesa. S druge strane, sve industrijalizirane zemlje se danas natječu u privlačenju novih razvojno-istraživačkih djelatnosti, istovremeno čuvajući svoja strateška znanja, projekte i ključne tehnologije u svojim nacionalnim okvirima. Treba isto tako naglasiti da se ulaganja u znanost i tehnologiju podupiru ponajprije zbog rasta konkurentnosti i produktivnosti domaće industrije, te otvaranja novih radnih mjesta i novih poslova s visokim profitnim stopama. Nažalost, svi ti procesi potpuno su zanemareni zadnjih 20-ak godina u Republici Hrvatskoj. Samo pokretanjem složenih projekata koji se temelje na visokim tehnologijama, moguće je podići sveukupnu razinu tehnološke razvijenosti Republike Hrvatske.

3 ISTRAŽIVANJE I RAZVOJ U FUNKCIJI MODERNIZACIJE SUSTAVA OBRANE RH

S obzirom da se cijena samo jednog *Main Battle System-a* kreće od nekoliko stotina milijuna, pa do nekoliko milijardi eura, zbog naših trenutnih makroekonomskih ograničenja ozbiljnija modernizacija OS RH kroz nabavke novih borbenih sustava uglavnom neće biti moguća u idućih desetak godina i to prije svega zbog visokog vanjskog duga, relativno malog BDP-a, niskih stopa rasta, kao i tendencija daljnjeg smanjenja vojnog proračuna. U takvim okolnostima kao jedino prihvatljivo rješenje nameće se modernizacija postojećih sustava naoružanja i vojne opreme, te produljenje njihovog životnog vijeka kroz vlastiti tehnološki razvoj i vlastita znanja i tehnologije gdje god je to moguće. Međutim, bez dugoročno osmišljenog ulaganja u razvoj hrvatske znanstvene i tehnološke infrastrukture nema osnovnih preduvjeta za naš ozbiljniji tehnološki napredak, te izvozni uspjeh. Osim možda deklarativne potpore, teško je danas u okolnostima duboke recesijske krize za to očekivati previše razumijevanja. Jasno je, međutim, da bez jačanja razvojno-istraživačkih djelatnosti kroz male ekspertne jezgre u određenim nišama obrambenih tehnologija hrvatski proizvođači naoružanja i vojne opreme nemaju nikakvih šansi za bilo kakav ozbiljniji ugovor i posao na zahtjevnim svjetskim tržištima. U najvećem broju slučajeva znanstvena i stručna područja takvih ekspertnih skupina trebala bi biti kompatibilna, ali i komplementarna u odnosu na neka druga prioritetna područja tehnološkog razvoja civilnog sektora u RH. Organizirani rad na području obrambenih sustava i tehnologija mora se usmjeravati kroz poticanje složenih interdisciplinarnih tehničkih projekata koji mogu jačati OS RH, te istovremeno mogu

značajno pridonijeti podizanju sveukupne razine tehnološke razvijenosti Republike Hrvatske kroz jačanje njene znanstveno-istraživačke i razvojne laboratorijske infrastrukture.

Očigledno je da Republika Hrvatska na području istraživanja i razvoja za potrebe obrane mora izabrati svoj put. Taj put bi danas trebao uključivati stvaranje novih ekspertnih jezgri kao i stvaranje novih istraživača u određenim područjima, s obzirom da su u proteklom razdoblju određeni centri izvrsnosti na tom području u RH doslovno nestali. Jedan od rijetkih pokušaja takve vrste u RH bio je vezan uz Institut za obrambene studije istraživanje i razvoj, te organizaciju interdisciplinarnog sveučilišnog poslijediplomskog studija *Vođenje i upravljanje pokretnim objektima* koji je na Sveučilištu u Zagrebu utemeljio autor ovog rada sa suradnicima 1996. godine. Ovaj postdiplomski studij, koji je okupio najbolje studente elektrotehnike, strojarstva, fizike i matematike, poseban je naglasak dao na interdisciplinarnost i projektnu usmjerenost usvojenih projekata. To je bilo nužno zbog multidisciplinarnosti znanja i tehnologija potrebnih za modernizaciju složenih sustava naoružanja i vojne opreme. Pored svega, treba voditi računa da je po svjetskim kriterijima potrebno minimalno pet godina da bi se od vrhunsko mladog inženjera znanstvenog novaka stvorilo dobrog i produktivnog znanstvenika i istraživača.

Uloga države pri investiranju u takve projekte je ključna, jer moderna industrija naoružanja i vojne opreme u RH praktično ne postoji. Na tom planu komplementarnost i kompatibilnost istraživačkih i razvojnih programa u odnosu na civilni sektor je izuzetno važna jer država s vrlo ograničenim proračunom mora vrlo racionalno i učinkovito koristiti sve svoje razvojno-istraživačke i znanstvene potencijale i kapacitete. Razvojno-istraživačka djelatnost takvog karaktera morala bi se jedino i isključivo odvijati u okvirima postojećih znanstvenih i obrazovnih institucija Ministarstva znanosti i sveučilišta RH, a njihovu istraživačku djelatnost mogla bi koordinirati Nacionalna zaklada za znanost u suradnji s nadležnim ministarstvima Vlade, te našim srednjim i malim poduzećima zainteresiranim za sudjelovanje i komercijalizaciju tako osmišljenih projekata. Međutim, moramo biti svjesni kompleksnosti mogućih istraživanja, samo radi ilustracije ističem npr. Naval Research Labs SAD koji je imao 1999. godine 3003 zaposlena od čega 840 doktora znanosti, 396 magistara znanosti i 570 inženjera. Isto tako, radi ilustracije treba istaći da njihova godišnja znanstvena produkcija višestruko nadilazi znanstvenu produkciju svih znanstvenika u Republici Hrvatskoj. S obzirom na zastarjelost naoružanja i vojne opreme kojom raspolažu oružane snage Republike Hrvatske, razumljivo je da jedan od putova njihove tehnološke modernizacije mora biti sve više usmjeren na vlastiti razvoj ili na pametnu kupovinu kroz dobro osmišljene ofset programe koji mogu dati odgovarajući doprinos razvoju našeg tehnološkog sektora. To nažalost do sada nije bio slučaj, a bitne promjene teško je očekivati bez bitnih promjena društvenih vrijednosti.

Odnos najrazvijenijih država suvremenog svijeta prema izdvajanjima za obrambena istraživanja, te razvoj novih tehnologija najbolje ilustrira Tablica 1 koja je dobivena usklađivanjem i preračunavanjem raspoloživih informacija iz (13-19).

Država	**2003**		**2004**		**2006**		**2007**		**2008**	
	A	**B**	A	**B**	A	**B**	A	**B**	A	B
USA	485975 (3.8)	**54629 (11)**	529673 (4.0)	**54100 (10)**	563549 (3.9)	**68600 (12)**	578340 (4.0)	**75893 (13)**	616073 (4.3)	**77300 (13)**
UK	62618 (2.5)	**4322 (7)**	62352 (2.5)	**3400 (5)**	62274 (2.4)	**4759 (8)**	63042 (2.4)		65615 (2.5)	
Njemačka	50095 (1.4)	**1168 (2)**	48557 (1.4)	**1000 (2)**	46695 (1.3)	**1224 (3)**	46740 (1.3)		46759 (1.3)	
Francuska	65716 (2.6)	**4196 (6)**	67520 (2.6)	**3500 (5)**	66449 (2.4)	**4467 (7)**	66673 (2.3)		66009 (2.3)	
Italija	43956 (2.0)	**413 (1)**	44100 (2.0)	**400 (1)**	41053 (1.8)	**298 (1)**	39777 (1.8)		38906 (1.8)	

Španjolska	14835 (1.1)	**1914,47 (13)**	15313 (1.1)	**1915,23 (13)**	18030 (1.2)	**2348,18 (13)**	18627 (1.2)	**2211,81 (12)**	19196 (1.2)	**3296,14 (17)**

Tablica 1: A – obrambeni proračun izražen u milijunima dolara (udio u GDP izražen postotcima); B – R&D u okviru obrambenog proračuna izražen u milijunima dolara (udio u ukupnom obrambenom proračunu izražen postotcima).

Kroz ne mala ulaganja za primijenjena obrambena istraživanja i razvoj navedene države nastoje očuvati svoju vodeću tehnološku poziciju u suvremenom svijetu, a to sve više čine i neka druga relativno mala, ali tehnološki vrlo razvijena gospodarstva, kao npr. Danska, Nizozemska, Švedska, Južna Koreja itd. Danas npr. SAD iz svog obrambenog proračuna izdvajaju preko 80 milijardi dolara za *Defense oriented R&D*, a ove proračunske stavke su sve izraženije u obrambenim proračunima mnogih drugih razvijenih država. Bez namjere za bilo kakve usporedbe, treba napomenuti da ova stavka hrvatskog obrambenog proračuna danas gotovo da i ne postoji. Ako slična konstatacija važi i za naš civilni sektor, onda je sasvim razumljivo da budućnost hrvatskog društva utemeljenog na znanju i tehnološkom razvoju, te na tome utemeljenom konkurentnom hrvatskom gospodarstvu, nije osobito ružičasta.

4 ULOGA I MJESTO VISOKOŠKOLSKIH INSTITUCIJA U MODERNIZACIJI SUSTAVA OBRANE I STRATEGIJI RAZVOJA REPUBLIKE HRVATSKE

Vrlo ograničena ulaganja u gospodarstvo utemeljeno na znanju jedan je od najozbiljnijih ograničavajućih faktora dugoročnog gospodarskog rasta u Republici Hrvatskoj. Međutim, svjesni činjenice da se dugoročna gospodarska strateška konkurentnost i prednost upravo temelji na obrazovanju gospodarske i političke elite koja treba predstavljati temelj njihove globalne konkurentnosti u suvremenom globaliziranom društvu znanja, mnoge čak i male države tome posvećuju sve veću političku i financijsku pažnju. U okviru preporuka Nacionalnog vijeća za konkurentnost RH više je puta naglašena snažna potreba porasta broja studenata koji završavaju studij prirodnih i tehničkih znanosti, kao i unapređenja kvalitete njihova obrazovanja, jer se samo na taj način može jačati izvozna konkurentnost hrvatskog gospodarstva. Samo vrhunsko obrazovanje može imati značajan inovativni i patentni tehnološki, te izvozni potencijal. Sve ostalo nema smisla, jer primjena zastarjelih znanja i tehnologija nema pravi konkurentski potencijal, niti šanse za uspjeh na inozemnim tržištima. Međutim, u stvarnosti se događa upravo obrnuto, smanjuje se udio prirodnih i tehničkih znanosti na našim sveučilištima, dok snažnije privlačenje tehnološki intenzivnijih direktnih stranih ulaganja nameće kao zahtjev povećanje i unaprjeđenje kvalitete obrazovanja upravo u tehničkim i prirodnim znanostima. Kvalitetno obrazovanje upravo u tehnološkom sektoru predstavlja najvažniju odrednicu budućeg snažnijeg gospodarskog rasta i konkurentnijih srednjih i malih poduzeća u RH. Prema udjelu zaposlenosti u tehnološkom sektoru Hrvatska je pri dnu ljestvice EU. Kao izrazito slab dio našeg obrazovnog sustava i našeg stručnog obrazovanja mnogi poduzetnici u RH ocjenjuju kvalitetu naših poslovnih škola. Struktura primijenjenih istraživanja, struktura inovacija i patenata, koja mogu povećati prihode hrvatskih poduzeća, kao i njihovu produktivnost, vrlo je nepovoljna i relativno je ograničena. Samo jačanjem kvalitete naše radne snage može se osigurati povećanje konkurentnosti

hrvatskog gospodarstva i osigurati toliko željeni gospodarski rast. Zbog toga je mnogo odgovornije i profesionalnije upravljanje ljudskim resursima prioritetno strateško pitanje koje zaslužuje posebnu pažnju u javnom i korporativnom sektoru. Pored toga, jačanje globalne konkurentnosti hrvatskog gospodarstva i osiguranje visokih stopa dugoročnog gospodarskog rasta može se postići i kroz procese upravljanja ciljanim specijalističkim poslijediplomskim studijima u cilju stvaranja kadrovskih temelja za ekonomiju znanja u RH i njenu globalnu konkurentnost, što potvrđuju i iskustva nekih naših poslijediplomskih studija (8).

Potražnja za kvalitetnim obrazovanjem u jednom društvu raste samo onda kada se ono tehnološki i gospodarski razvija s ciljem jačanja svoje globalne konkurentnosti, ali istovremeno i kada društvo postaje bogatije. Samo tada se prirodno pojavljuje sve veća potreba za obrazovanom radnom snagom i obrnuto. Sva ova pitanja zaslužuju posebnu pažnju, a posebno sve manje potrebe za zapošljavanjem visoko obrazovane radne snage u hrvatskom gospodarstvu. Prema ovim indikatorima, može se zaključiti kako hrvatsko gospodarstvo ima sva obilježja strukturne stagnacije i recesije. Znanje još uvijek u Hrvatskoj nije vrijednost koja zaslužuje potrebnu pažnju, a posljedice toga se vrlo jasno vide i osjećaju i na nedostatnom gospodarskom rastu. Gotovo sve industrije koje u svijetu danas imaju veliki rast, a očekuje se da će ga imati i u budućnosti, temelje se na znanju i ljudskoj intelektualnoj snazi. U tom kontekstu sve više se govori i o novoj podjeli zemalja, i to na one s obrazovanom radnom snagom i one s neobrazovanom radnom snagom. Po nekim istraživanjima, jedino što danas omogućuje trajno održivu konkurentnost jest znanje koje poduzeće ima, ali i koristi, te jača kroz zapošljavanje visoko kvalitetne radne snage. Sposobnost učenja tj. usvajanja novih znanja svake organizacije vrlo se često definira i kao intelektualni kapital koji obuhvaća kompletno znanje koje stvara ili je u mogućnosti stvoriti novu vrijednost, te profit za poduzeće. Koncept intelektualnog kapitala posebno je značajan u kontekstu hrvatskih gospodarskih problema i poteškoća. Industrije koje u svijetu imaju veliki rast, a temelje se na znanju, ljudskom intelektualnom kapitalu i snazi teoretski se mogu locirati u bilo kojoj zemlji na svijetu koja je u stanju organizirati i koristiti takav intelektualni kapital.

Strateške smjernice u razvitku Hrvatske trebale bi biti sve više usmjerene na restrukturiranje gospodarstva, tako da ono sve više poprima obilježja tzv. *Knowledge based economy*. To je put koji su izabrale gotovo sve države koje danas karakteriziraju visoke stope gospodarskog rasta. Međutim, danas iz Hrvatske odlaze oni najbolji, a taj gubitak ljudskih potencijala u jednoj maloj državi kao što je Hrvatska bit će teško nadoknadiv. Naime, u razvijenim, visoko propulzivnim i konkurentnim gospodarstvima tehnološka znanja i iskustva će se koncentrirati, a neke prostore će zauvijek napustiti.

Kakav je danas doprinos hrvatskih visokoškolskih institucija industrijski orijentiranom istraživanju i razvoju u RH. Da li su, i u kojoj mjeri, mladi ljudi spremni studirati na tehničkim i prirodoslovno-matematičkim fakultetima?! U kojoj su mjeri visokoškolske i znanstvene institucije danas u RH osposobljene za stvarnu modernizaciju hrvatskog gospodarstva i tehnološku modernizaciju sustava obrane? Treba naglasiti da nema modernizacije sustava obrane, kao ni strategije tehnološkog razvoja Republike Hrvatske bez sposobnog, kompetentnog i kvalitetnog sveučilišta, te visokoškolskih i znanstvenih institucija. Da bi naši tehnički fakulteti mogli odgovoriti zahtjevima školovanja inženjera za industrijske potrebe novog doba, nužno je da održe visoke standarde i kriterije obrazovanja i u današnjim uvjetima. U tom smislu, jako je važno da rad na industrijski orijentiranim projektima i formalno bude prisutan kao kriterij pri izboru u nastavna i znanstvena zvanja.

Nažalost, u Hrvatskoj visokoškolske i znanstvene institucije nisu prepoznate kao važne institucije za razvoj i jačanje konkurentnosti hrvatskog gospodarstva. Međutim, pred današnje poduzetnike postavljaju se mnogobrojni zahtjevi koji se odnose na posebna interdisciplinarna tehnološka znanja iz različitih znanstvenih disciplina. Naše visokoškolske institucije moraju biti spremne poduprijeti i odgovoriti na zahtjeve koje pred njih postavlja suvremeno gospodarsko okruženje. Prema riječima W. Perrya (12) američke gospodarske prednosti proizašle su iz njezinog tehnološkog vodstva, a u čemu su vodeću ulogu imala američka tehnička sveučilišta.

Kako dakle, integrirati Hrvatsku u svjetske tokove kapitala, ljudi i roba kroz njen obrazovni i znanstveni potencijal koji predstavlja neophodnu osnovu za uspješan tehnološki razvoj? Odgovor na to pitanje može biti poticanjem hrvatskog poduzetništva u području visokih tehnologija. Iako je jedna od ključnih funkcija države i njezinih institucija da upravo potiču taj proces industrijski orijentiranog obrazovanja, istraživanja i razvoja to se u Hrvatskoj ne događa. Interes stranih korporacija za suradnju na razvojnim projektima s domaćim visokoškolskim i znanstvenoistraživačkim institucijama je razumljivo vrlo mali, budući da su one prisiljene svoje razvojne potencijale uglavnom držati unutar svojih nacionalnih okvira. Moraju li zbog toga naši mladi stručnjaci u tako velikom broju svake godine napuštati zemlju? Nastavni planovi i programi hrvatskih fakulteta trebali bi ostvariti značajniji iskorak prema gospodarstvu utemeljenom na znanju. Ako želimo da znanost pomogne rješavati određene probleme u sferi gospodarstva ne bismo se trebali previše zamarati s tradicionalnim akademskim podjelama jer su realni problemi najčešće interdisciplinarni i multidisciplinarni i mnogo kompleksniji nego što ih vidi akademska zajednica.

5 ULOGA I MJESTO SREDNJIH I MALIH PODUZEĆA U MODERNIZACIJI SUSTAVA OBRANE

Hrvatsko gospodarstvo krajnjim naporima tijekom ratnih godina uspijevalo je, uz vrlo česte improvizacije i snalaženja neprihvatljiva normalnoj mirnodopskoj vojnoj proizvodnji, Hrvatskoj Vojsci osigurati onaj neophodan dio naoružanja i vojne opreme koji je bio izuzetno važan za svakodnevne ratne aktivnosti i djelovanja. Međutim, takve urgentne ratne okolnosti i uvjeti nisu ostavljali mnogo prostora za ozbiljna, dugotrajna i vrlo često nepredvidiva znanstvena i razvojna istraživanja koja su u normalnim okolnostima sastavni dio svakog ozbiljnog projekta. S druge strane, krajem 1995. godine, nakon završetka Domovinskog rata, već relativno velika hrvatska industrija naoružanja i vojne opreme u izuzetno kratkom vremenu ostaje bez pravih prilika za svoje restruktuiranje i prilagođavanje novim mirnodopskim okolnostima zbog snažne kontrakcije obrambenog proračuna. To brzo i snažno smanjenje izdvajanja za obranu uzrokovalo je relativno brzi kolaps mnogih poduzeća koja su se početkom devedesetih počela baviti ratnom proizvodnjom, a koja su nesporno imala značajnu i važnu ulogu u obrani RH. Svakako, mnoga od tih poduzeća više nisu objektivno bila ni potrebna. Nažalost, konkurentnost naše ratne proizvodnje na globalnim svjetskim tržištima naoružanja i vojne opreme, razumljivo je, nije imala obećavajuću perspektivu. To se je uglavnom, vrlo brzo pokazalo i točnim. Osim streljiva i lakog pješačkog naoružanja kojim su obilovala hrvatska skladišta nakon završetka Domovinskog rata, izvozna bilanca hrvatske industrije naoružanja i vojne opreme vrlo brzo se je svela na pištolj iz Ozlja i kacigu iz Preloga. Dakle nakon potrošenih više desetaka milijardi kuna hrvatska industrija naoružanja i vojne opreme nije više imala što ponuditi svjetskom tržištu kako bi ojačala svoju izvoznu bilancu. Može se reći da Hrvatska jednostavno nije iskoristila prilike nametnute ratom da

ojača jedan važan segment svog gospodarstva. Istovremeno su zbog ratnih okolnosti i tzv. atipičnog ekonomskog modela, mnogi drugi sektori hrvatskog gospodarstva, nekada najsnažnijeg u bivšoj državi, jednostavno nestali. Sve u svemu, zbog ratnih šteta, ratom uništenog gospodarstva, atipičnog gospodarskog modela, te izgubljenih prilika za stvaranje izvozno konkurentne industrije naoružanja i vojne opreme, hrvatsko gospodarstvo se je danas našlo u dubokoj strukturnoj krizi čije posljedice upravo i osjećamo.

Kako dalje? Danas, s obzirom na veličinu i strukturu te prije svega konkurentnost hrvatskog gospodarstva, svako razmišljanje o velikoj vojnoj industriji u RH nema smisla ni utemeljenja kako u objektivnim potrebama, postojećim sektorskim znanjima, te iskustvu i raspoloživim tehnologijama. U takvim okolnostima novi koncept hrvatske industrije naoružanja i vojne opreme može se jedino temeljiti i graditi na nizu srednjih i malih poduzeća koja se tek trebaju profilirati u pojedinim tržišnim nišama i koja tek trebaju osigurati svoj identitet na vrlo zahtjevnim, a vrlo često i vrlo zatvorenim i privilegiranim nacionalnim tržištima. Svakako, sve te nove kompanije moraju nastojati održavati balans između tržišnih udjela vezanih uz naoružanje i vojnu opremu, te komercijalnih civilnih tržišta. Istovremeno suočavajući se s novim izazovima koji se odnose na razvoj novih proizvoda, ona se moraju prilagođavati novom geopolitičkom okruženju koje prije svega karakterizira činjenica da je RH već danas punopravna članica NATO saveza, a vrlo skoro i EU. Sve to, od takvih malih kompanija zahtjeva da apsolutno dobro razumiju svoje novo tržišno okruženje koje zahtjeva sasvim drugačiju strukturu proizvoda i usluga. Nedostatak takvih sposobnosti da se dobro razumiju novi politički, sigurnosni, tehnološki i gospodarski uvjeti poslovanja može imati negativne posljedice na poslovni uspjeh takvih poduzeća. Isto tako, traženje novih tržišnih niša i novih puteva u takvom novom poslovnom, ekonomskom, političkom i sigurnosnom okruženju pravi je izazov i izuzetno važna zadaća za sve. U uvjetima snažne konkurentnosti koju nameću slične kompanije koje dolaze iz država s puno snažnijom tehnološkom, znanstvenom i razvojno-istraživačkom infrastrukturom, daleko povoljnijim uvjetima i načinima financiranja, kao i mudrijom i kompetentnijom strateškom politikom, njihovo tržišno preživljavanje zahtjeva sustavno osmišljenu državnu potporu. Dok se s jedne strane čini da je u takvim uvjetima njihovo tržišno preživljavanje gotovo nemoguće, s druge strane treba biti jasno da bez takvih srednjih i malih poduzeća hrvatsko gospodarstvo i nacionalna ekonomija nemaju nikakvu perspektivu snažnijeg rasta i razvoja. Bez takvih kompanija najsposobniji, najobrazovaniji i najtalentiraniji mladi stručnjaci će nastaviti sve brže i brže odlaziti iz Hrvatske. Kako kompenzirati takve negativne efekte i zaustaviti takve negativne trendove? To je svakako jedna od najvažnijih tema za hrvatsku budućnost i nacionalnu sigurnost, te vjerujem da ona ipak zaslužuje daleko više pažnje. Sva ova pitanja zahtijevaju potpuno novu paradigmu i način razmišljanja kako na razini čitavog državnog i privatnog sektora, tako i državne uprave.

Stvaranje i preživljavanje takvih srednjih i malih poduzeća može imati važnu ulogu za hrvatsku nacionalnu ekonomiju, a ona isto tako mogu dati značajan doprinos stvaranju novih radnih mjesta u tehnološkom sektoru. Stvaranje novih modernih, međunarodno kompetentnih i konkurentnih srednjih i malih poduzeća koja će zauzeti odgovarajuće mjesto u međunarodnoj industriji naoružanja i vojne opreme, te u okvirima NATO-a i EU mora biti strateški cilj strukturnih reformi hrvatskog gospodarskog sustava.

Iz svega što je dosada rečeno, jačanje međunarodne konkurentnosti svih onih koji danas sudjeluju ili planiraju zauzeti svoje mjesto u industriji naoružanja i vojne opreme Republike Hrvatske, zahtjeva prije svega jačanje njihove znanstvene i tehnološke kompetentnosti. Razumljivo je da će konkurentnost takvih srednjih i malih poduzeća obrambenog sektora RH dugoročno najviše ovisiti o njihovim sposobnostima da u svoje

proizvode integriraju inovativna rješenja koja će se, prije svega, temeljiti na ozbiljnim znanstvenim i tehnološkim istraživanjima. Pronalaženje novih tržišnih niša, jačanje specifičnih znanja, te posebno jačanje inovacija i kreativnosti kroz personalnu politiku koja će se sve više usmjeravati na"rat za talente", mora biti njihova nova poslovna paradigma. Stalna transformacija i prilagođavanje takvih srednjih i malih poduzeća novim poslovnim prilikama i okolnostima uvjet je za njihovo preživljavanje. Samo povećanje njihove međunarodne konkurentnosti kroz usvajanje novih tehnologija, prije svega tehnologija dualne namjene, unaprjeđenje stručnih i ekspertnih znanja, te raspoloživih tehnologija, uz više inovacija i kreativnosti, a manje birokracije, može osigurati njihov dugoročni rast. Nekoliko primjera korištenja tehnologija dualne namjene prikazano je u radovima (20-29).

Ovaj rad nastojao je u prvom redu naglasiti nužnost stvaranja i poticanja upravo takvih kompanija, koje će na primijenjenim istraživanjima i razvoju, te visokim tehnologijama i na kvalitetno obrazovanoj, talentiranoj, kreativnoj i inovativnoj radnoj snazi graditi svoj put do svojeg komercijalnog uspjeha. Tako strukturirana srednja i mala poduzeća trebaju biti od posebnog značaja za gospodarski rast i dugoročnu konkurentnost hrvatskog gospodarstva, kao i za integraciju našeg nacionalnog gospodarskog sustava u euro-atlantske okvire, kao i u suvremenu globaliziranu digitalnu ekonomiju i euroatlantsku obrambenu industriju, te zbog toga zaslužuju poseban poticaj i pažnju. Samo kroz takve kompanije koje su u stanju stvarati inovacije i nova znanja, može se dogoditi reverzni inženjering i difuzija novih visokih tehnologija u naš nacionalni gospodarski sustav. Bez takvih kompanija naši udjeli u NAMSA-inim ugovorima ostati će baš kao i dosada beznačajni, a to znači da će čvršća integracija RH u NATO-ve industrijske strukture ostati samo iluzija.

6 ZAKLJUČAK

U mnogim tranzicijskim državama s izraženim gospodarskim i socijalnim problemima prevladavaju stavovi da su izdvajanja za obrambene potrebe upravo onaj dio javne potrošnje koji treba što je prije moguće maksimalno smanjiti. Takvi stavovi prema obrambenoj potrošnji, dakle i nacionalnoj sigurnosti, nažalost, danas se mogu sve češće čuti i u Republici Hrvatskoj. U uvjetima kada državna administracija ne uspijeva razriješiti mnoge važne gospodarske i socijalne probleme s kojima se danas suočava hrvatsko društvo kao što su sve veća nezaposlenost, pad životnog standarda, smanjenje socijalnih prava, nedostatan gospodarski rast, usporen razvitak itd., rješenja se traže u smanjenju javne potrošnje koja se prvenstveno usmjerava prema obrambenom sustavu Republike Hrvatske. Na taj način stvara se potpuno pogrešan osjećaj da se smanjenjem javne potrošnje u obrambenom sektoru mogu riješiti neka druga važna makroekonomska pitanja, te osigurati neophodan gospodarski rast i razvitak. Naprotiv, zaboravlja se da članstvo u NATO-u nije besplatno i da ne samo NATO, nego i EU, zahtijevaju određenu razinu izdvajanja za obranu, te obrambena istraživanja, kao prilog izgradnji zajedničkog transatlantskog obrambenog sustava.

Danas, s obzirom na veličinu i strukturu te prije svega konkurentnost hrvatskog gospodarstva, svako razmišljanje o velikoj vojnoj industriji u RH nema smisla ni utemeljenja kako u objektivnim potrebama, tako i u postojećim sektorskim znanjima, te iskustvu i raspoloživim tehnologijama. U takvim okolnostima novi koncept hrvatske industrije naoružanja i vojne opreme može se jedino graditi i temeljiti na nizu srednjih i malih poduzeća koja se tek trebaju profilirati u pojedinim tržišnim nišama. U sklopu modernizacije industrije

naoružanja i vojne opreme treba istovremeno voditi računa o jačanju konkurentnosti hrvatskog gospodarstva, te gospodarskom rastu i razvoju RH u cjelini. Zbog toga, u tom kontekstu treba inzistirati na čvršćem povezivanju znanstveno-istraživačkog rada i visoko školskog obrazovanja s usvajanjem i razvojem novih tehnologija, te industrijskom proizvodnjom. Ministarstva Vlade RH moraju selektivno ulagati novac za istraživanje i razvoj sukladno svojoj cjelovitoj strategiji razvitka, te posebno strategiji tehnološkog razvitka. Do sada se je vrlo ograničeni proračun Vlade RH za R&D uglavnom koristio za osiguranje i preživljavanja one znanosti koja je uglavnom imala vrlo ograničenu industrijsku primjenu. RH žurno treba nekoliko zahtjevnijih i kompleksnijih projekata koji trebaju omogućiti osmišljeni tehnološki razvoj i napredak. Koji su to projekti koje RH kao mala država može financirati i realizirati, drugo je pitanje. Isto tako, nužno je modernizirati nastavne planove i programe na većini fakulteta koji po svojim sadržajima prečesto ostaju u isključivo uskim akademskim okvirima. Hrvatska treba kvantificirati doprinos znanja i tehnologija kao strateške varijable povećanju njenog BDP-a, te što prije izraditi svoju strategiju tehnološkog razvoja. Izvoz je u ovom trenutku jedan od hrvatskih strateških prioriteta, no razumljivo je da njegova povećanja nema sa sadašnjom tehnološkom razinom hrvatskog gospodarstva. Dakle, potrebno nam je ono što se na Zapadu naziva industrijski orijentirano istraživanje i razvoj. U većini razvijenih zemalja poticanje takvog istraživanja i razvoja preuzima država, a izvore kapitala za takve investicije u Republici Hrvatskoj nije lako pronaći. No međutim, treba znati da svjetske multinacionalne kompanije neće tako lako investirati u znanstveno-istraživački potencijal Republike Hrvatske, jer one to čine u svojim državama ili tamo gdje im se to osobito isplati.

Na kraju treba svakako naglasiti da se neki opći principi koji se odnose na modernizaciju industrije naoružanja i vojne opreme predloženi u ovom radu, mogu isto tako odnositi i na restrukturiranje čitavog hrvatskog gospodarskog sustava.

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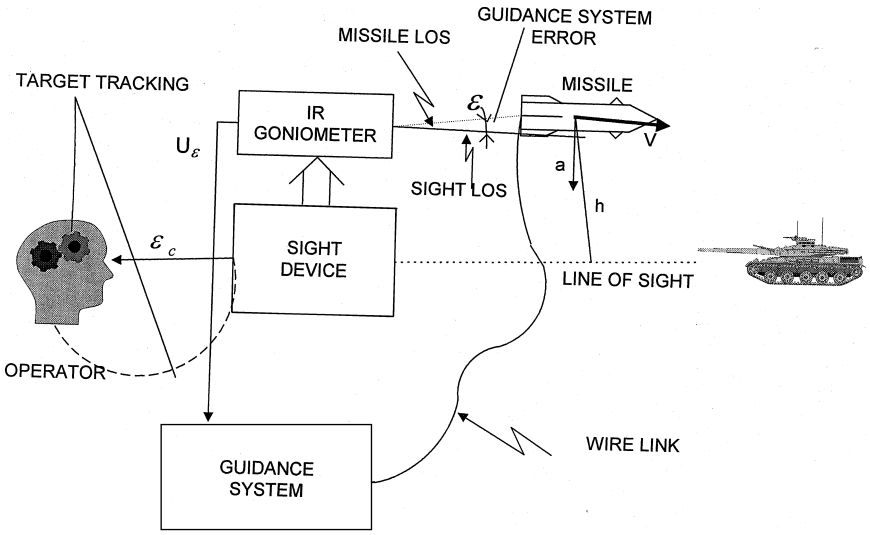


Fig. 1. Semi-automatic CLOS guidance system.

using a gyroscope with a lamellas transformer for distributing guidance signals to the pair of control fins.

2.1. Mathematical models

SACLOS guidance typically includes an up-link to transmit guidance signals from a ground controller to the missile. A basic block diagram of the SACLOS guidance scheme for a rotating missile is shown on Fig. 2.

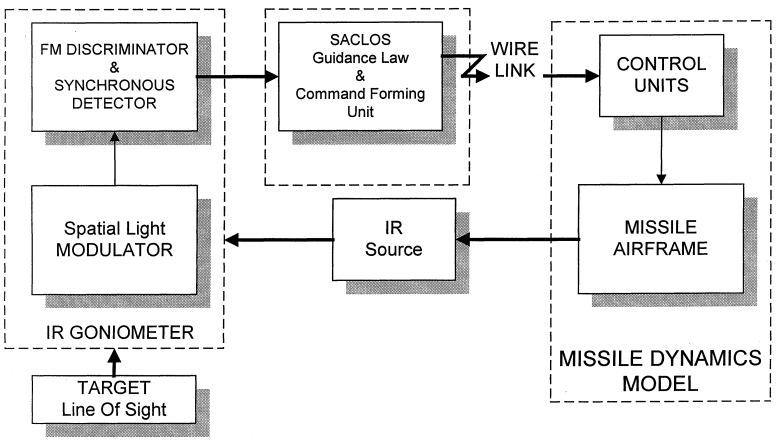


Fig. 2. SACLOS guidance block diagram.

The six degrees of freedom (6DOF) mathematical model of the missile's dynamics is a non-linear model of a flying 'rigid body' object. The general translation and rotation vector differential equations of the flying objects are as follows:

$$m\frac{\mathrm{d}\vec{V}}{\mathrm{d}t} = \vec{F}_{\mathrm{a}} + \vec{F}_{\mathrm{t}} + G, \tag{1}$$

$$I\frac{\mathrm{d}\vec{H}}{\mathrm{d}t} = \vec{M}_{\mathrm{a}} + \vec{M}_{\mathrm{t}}, \tag{2}$$

where $V = [uvw]^{\mathrm{T}}$ is the velocity vector, $F_{\mathrm{a}} = [XYZ]^{\mathrm{T}}$ the vector of the aerodynamic force, $F_{\mathrm{t}} = \left[F_x F_y F_z\right]^{\mathrm{T}}$ the thrust vector, G the gravitational force, m the mass of the body, I the tensor of the inertia, H the angular momentum, $M_{\mathrm{a}} = [LMN]^{\mathrm{T}}$ the vector of the aerodynamic moment and $M_{\mathrm{t}} = [L^F M^F N^F]^{\mathrm{T}}$ the vector of the thrust moment.

Eqs. (1) and (2) are defined in the missile's axis system. For a complete mathematical model of the SACLOS guidance system it is necessary to add equations of the SACLOS guidance law and command forming units, rotating missile control and actuator dynamics as well as the kinematics relations. Thus, the controls of forces and moments have to be added to the right side of Eqs. (1) and (2), respectively. In order to establish the relations between the missile and the target, transformations from the missile's or dynamical (D) co-ordinate to the spherical command point co-ordinate system (C) L_{CD} have to be used [13].

$$\begin{bmatrix} \dot{R} \\ R\dot{\lambda}_{\mathrm{M}}\cos\varphi_{\mathrm{M}} \\ -R\dot{\varphi}_{\mathrm{M}} \end{bmatrix} = L_{\mathrm{CD}}V, \tag{3}$$

where R is distance from the command point to the centre of the missile mass, λ_{M} the missile angle in the horizontal plane and φ_{M} the missile angle in the vertical plane.

Eq. (3) represents the geometric (kinematics) model. The matrix of transformation can be expressed as a function of the missile attitude angles (Euler's angles ϕ, ψ, ϑ) or alternatively by use of quaternion – parameters (e_0, e_1, e_2, e_3). These quaternions can be computed directly from dynamics Eq. (2), bypassing the computation of transcendental functions needed for computing the Euler angles. In the case when the components of the angular velocities are known in the body co-ordinate system, parameters $(e_0, e_1, e_2, e_3)^{\mathrm{T}}$ are defined by differential Eq. (4) [8].

$$\begin{bmatrix} \dot{e}_0 \\ \dot{e}_1 \\ \dot{e}_2 \\ \dot{e}_3 \end{bmatrix} = \frac{1}{2}\begin{bmatrix} -e_1 & -e_2 & -e_3 \\ e_0 & -e_3 & e_2 \\ e_3 & e_0 & -e_1 \\ -e_2 & e_1 & e_0 \end{bmatrix}\begin{bmatrix} p \\ q \\ r \end{bmatrix} \tag{4}$$

with,

$$e_0^2 + e_1^2 + e_2^2 + e_3^2 = 1 \tag{5}$$

The four variables e_0, e_1, e_2 and e_3 coupled by means of Eq. (5), uniquely describe the orientation of the missile in space.

A SACLOS guidance law can be described with a very simple model such as a proportional-integral-derivative regulator or with very complex description based on the non-linear inverse dynamics including different compensation forms which would offer potential modernisation of the existing guidance subsystem. The guidance controls expressed in the non-rotating co-ordinate system are transformed to the rotating co-ordinate system using Eq. (6).

$$U_1 = f_1(\phi)U'_{\mathrm{H}} + f_2(\phi)U'_{\mathrm{V}},$$
$$U_2 = f_1(\phi)U'_{\mathrm{V}} - f_2(\phi)U'_{\mathrm{H}}, \tag{6}$$

U_1, U_2 and $U'_{\mathrm{V}}, U'_{\mathrm{H}}$ are non-rotating and rotating guidance signals for two orthogonal planes respectively. ϕ is the missile rotating angle, $f_1(\phi)$ and $f_2(\phi)$ are modulation functions written as:

$$f_1(\phi) = \frac{1}{2}[\mathrm{sgn}\,(\cos\phi) + \mathrm{sgn}\,(\sin\phi)]$$
$$f_2(\phi) = \frac{1}{2}[\mathrm{sgn}\,(\cos\phi) - \mathrm{sgn}\,(\sin\phi)] \tag{7}$$

Each pair of the fin actuators has a finite bandwidth so that, for simplicity, action of the effective deflection angles can be modelled by a first-order system with surface position saturation and rate saturation.

2.2. Missile localisation system – IR goniometer

In a number of SACLOS systems the missile position is detected by using an IR source, placed in the tail of the missile, in combination with a special electro-optical system, an IR goniometer, that is based on a rotating reticle which is also called a modulating disk [15], Fig. 3. The role of the system, which is based on the rotating reticle and photodetector with appropriate spectral response, is to determine missile position by detecting infrared energy emanating from the missile IR source and to suppress unwanted signals from the background [7].

The rotating reticle modulates incident optical flux and is located at the focal plane of an optical imaging system. A photodiode detects the modulated optical signal, where modulating function $s(r, \varphi, t)$ is a function of the polar co-ordinates

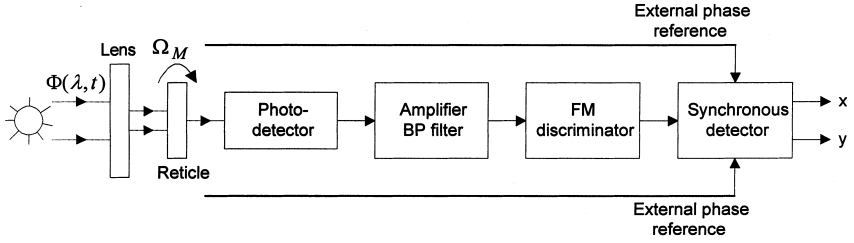


Fig. 3. IR goniometer for missile localisation.

of the projection of the IR source on the modulation disk area and also a function of the reticle type. Here r stands for the modulus and φ stands for the angle. For a reticle with fan-bladed pattern [15,9,19] the modulating function has the form:

$$s(r, \varphi, t) = \cos\,[\omega_0 t - \beta\,\sin\,(\Omega_M t - \varphi)] \tag{8}$$

which is a canonical representation of the frequency modulated (FM) signal, [20]. β, ω_0 and Ω_M are functions of the IR source co-ordinates and the optical modulator construction constants. It can be shown, [9,19], that deviation of the FM signal Eq. (8), β, is directly proportional with the polar co-ordinate r. The role of the FM discriminator, see Fig. 3, is to demodulate the FM signal Eq. (8). The amplitude of the demodulated signal will be directly proportional with the r co-ordinate while the phase will represent the φ co-ordinate. By providing external phase reference, the demodulated signal is transformed at the synchronous detector from polar to Cartesian co-ordinates. In reference to Fig. 2, it must be observed that the FM signal Eq. (8) has a much wider spectral bandwidth than all the other signals in the guidance and control loop. Depending on the amount of maximal missile displacement r, the effective signal bandwidth can be as large as 50 kHz, which will influence the design of the signal interface discussed in Section 3.2.

The process of FM signal demodulation as well as synchronous detection can be carried out digitally. This is one important aspect of the SACLOS system modernisation. By application of the HIL simulation the new digital solution can be tested and verified with a real electro-optical system included in the closed guidance loop. Furthermore, since the described type of missile localisation system is sensitive to certain types of IR jamming [19], new advanced signal processing methods [16] can be applied and tested in order to increase the IR jamming margin. The research and development in this field would be practically impossible to carry out without extensive use of the HIL simulation technology.

3. Hardware and software structure of the implemented HIL simulator

The main part of the HIL simulator is an industry PC chassis containing a standard Pentium 200 MHz motherboard, a multiprocessor PC board for digital signal processing and two PC boards with I/O subsystem. The host processor (Pentium) is used for code developing and downloading to the target DSP board, and for both simulation control and output data analysis.

This HIL simulator is primarily intended for laboratory testing and development purposes, thereby requiring some adaptation of the SACLOS system optics, designed for distances between 100 and 2000 m. With a small lens attached to the optics of the SACLOS launching unit real focus distance is corrected to a laboratory distance of 8 m between the launching unit and a plotter. A high-speed (compared to the missile dynamics) A3 plotter with a light emitting diode (LED) of appropriate

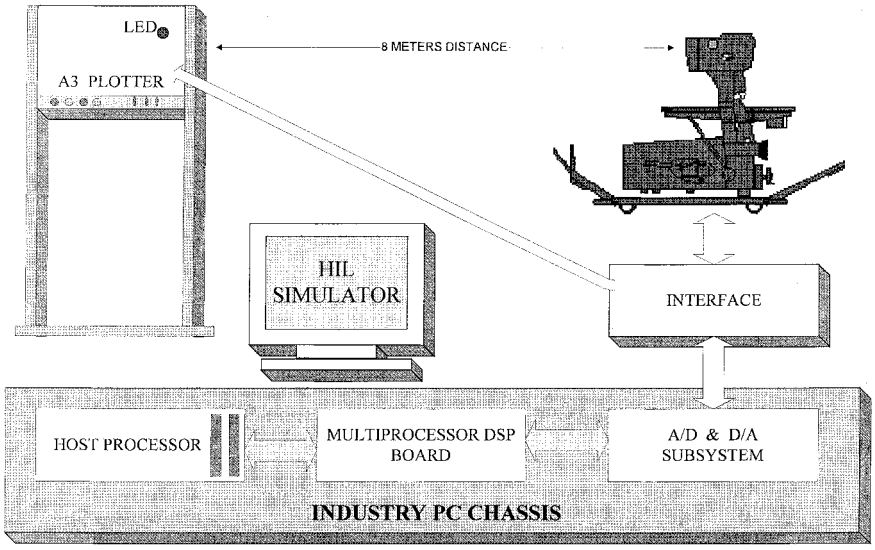


Fig. 4. Hardware structure of the HIL simulator.

spectrum is used as a low cost emulation of the moving missile's IR source. Information about actual co-ordinates of such an IR spot in relation to LOS is produced by a 6DOF missile model and sent to the plotter's analog inputs.

A custom signal interface between the real hardware of the SACLOS system's launching unit and simulator's I/O subsystem also had to be designed.

This hardware structure (Fig. 4) makes a closed guidance and control loop (IR spot – launcher optics – launcher hardware – simulator models – 6DOF missile model – IR spot co-ordinates), and provides platform for a realistic and modular testing as well as for a partial development and modifications of the SACLOS systems.

3.1. DSP board with four TMS320C40

Rafale F3R Fighter Jet - New Croatian Aircraft

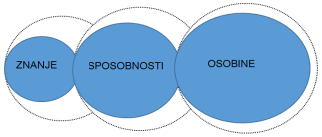
1

1

Inicijalne karakteristike pilotskih kandidata

POTREBAN JE ODREĐENI NIVO ZNANJA, SPOSOBNOSTI I OSOBINA

Kod kandidata je najmanji moguć utjecaj na osobine, te je bitna visoka razina poželjnih osobina *na* samom početku procesa selekcije i obuke.



Što može znanost?

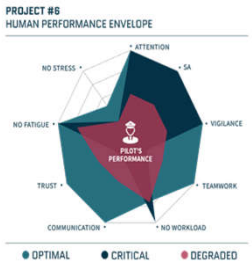
Znanost može proizvesti nove metode i alate :

- kojima se mogu pospješiti procesi selekcije i obuke
- za veću održivost borbenih sposobnosti i otpornost pojedinaca izloženih borbenim traumama i stresu
- "*Ne preživljavaju najjači, niti najinteligentniji pojedinci u vrsti već oni koji su najsposobniji prilagoditi se promjenama.*" - Charles Darwin

2

Relevant Former EU Future Sky Safety Project Illustration "Project #6: Human Performance Envelope"

Human Performance Envelope project proposes a variety of physiological, speech/voice processing, oculometric and neurometric approaches in order to evaluate the factors/axes of the Human Performance Envelope



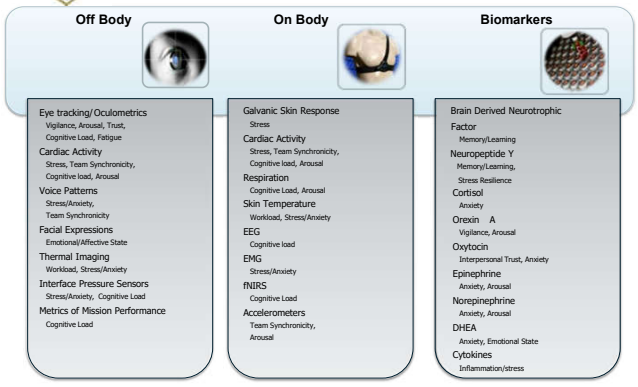
	WL	Stress	Fatigue	SA	Attention	Vigilance	Teamwork	Comm.	Trust
ECG	X	X	X	X	X	X			
EEG	X		X	X	X	X			
EMG	X	X	X						
EOG	X	X	X	X	X	X			
fNIR	X			X	X				
GSR/EDA	X	X	X						
Respiratory activity	X	X	X						
Eye-tracking	X	X	X	X	X				X
Subjective measures	X	X	X	X					
Primary / secondary task	X		X	X	X				
Expert observation	X			X	X		X	X	X
Communication analysis		X		X			X	X	
Seat sensors	X	X							
Voice analysis	X	X							
Pressure / grip sensors		X							
Polygraph sensor		X							
Electrochemical sensors		X							

Silvagni, S., Napoletano, L., Graziani, I., Le Blaye, P., & Rognin, L. (2017). Concept for human performance envelope. https://www.futuresky-safety.eu/wp-content/uploads/2015/12/FSS_P6_DBL_D6.1-Concept-for-Human-Performance-Envelope_v2.0.pdf

3

3

Relevant Former U.S. Project Illustration: Applied Neuroscience in Defense Setting Sense Technologies



4

EUROPEAN DEFENCE FUND

EUROPEAN UNION

EPIIC

Enhanced Pilot Interfaces & Interactions for fighter Cockpit

SELECTED PROJECTS EUROPEAN DEFENCE FUND (EDF) 2021

CALL TITLE:	Avionics and advanced air combat
TOPIC TITLE:	Enhanced pilot environment for air combat
DURATION OF THE PROJECT:	36 months
TYPE(S) OF ACTIVITIES:	Studies
ESTIMATED TOTAL COST:	€ 77,769,904.62
MAXIMUM EU CONTRIBUTION :	€ 74,999,974.60

5

The European project Enhanced Pilot Interfaces & Interactions for Fighter Cockpit (EPIIC) aims to identify, develop and evaluate disruptive cockpit technologies that will revolutionize the collaborative air combat of the future. Funded with €75 million from the European Defence Fund, this project, coordinated by Thales, brings together a consortium of 27 manufacturers and research organizations from 12 European countries. [1]

THALES, indra, DASSAULT AVIATION, AIRBUS, LEONARDO, SAAB, AALBORG UNIVERSITY, DIEHL Aerospace, DLR, ESG, gmv, HAT, INCAS, UNIVERSITY OF PATRAS, nlr, Collins Aerospace, tecnobit, TERMA, FER, INSTA, alma, eti, NEXT2U, FOI

Focus of FER Laboratory for Interactive Simulation Systems

Objectives

The EPIIC project aims to enhance air power capabilities and ensure air dominance for the European Armed Forces. To achieve this, the project has set clear and ambitious objectives that seek to address the techno-logical challenges of future air warfare and collaborative combat.

- Cockpit innovations consistency
- Adaptive HMI (Human-Machine Inter-face)
- Innovative Virtual Assistant
- Innovative Large Area Displays
- Eyes-out technologies
- Crew Monitoring Sensors and Physio-logical States
- Crew states identification algorithms
- Innovative Interaction Modalities

https://www.thalesgroup.com/en/worldwide/defence/press_release/thales-takes-lead-european-epiic-research-project-design
https://edf-epiic-project.eu/sites/default/files/2023-06/EPIIC%20Leaflet%20V2-%20Final%20Version.pdf

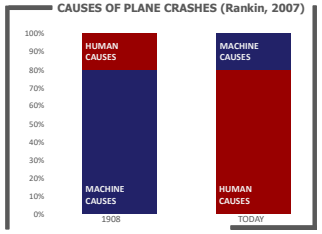
6

Human Factors in Military Aviation

Human factors refer to environmental, organisational and job factors, and human and individual characteristics, which influence behaviour at work in a way which can affect health and safety (Health and Safety Executive).

- Human factors research goals (Wickens et al., 2004):
  - Reducing error,
  - Increasing productivity,
  - Enhancing safety,
  - Enhancing comfort.
- Croatian Air Force Accidents:
  - Mi-8 helicopter crash (Jul. 2007)
  - Clash of two MiG-21 fighters (Sep. 2010)
  - MiG-21 fighter crash (Aug. 2014)
  - Kiowa Warrior helicopter crash (Jan. 2020)
  - School plane crash (May. 2020)

→ Objectivized assessment of stress and cognitive resilience in the early phases of pilot selection



→ 60-80% plane crashes are caused by human factors

Rankin, W. (2007). MEdA investigation process. *Boeing Commercial Aero.*
Wickens, C. D., Gordon, S. E., Liu, Y., & Lee, J. (2004). *An introduction to human factors engineering* (Vol. 2). Upper Saddle River, NJ: Pearson Prentice Hall.
Health and Safety Executive: Introduction to human factors, available at: https://www.hse.gov.uk/humanfactors/introduction.htm.

7

Human Factors in Military Aviation

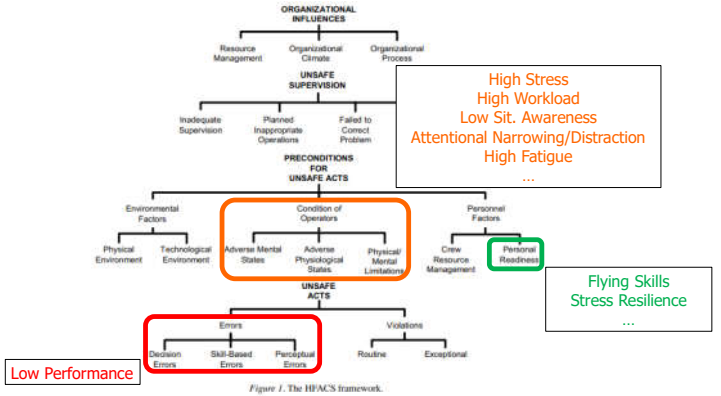


Figure 1. The HFACS framework.

High Stress
High Workload
Low Sit. Awareness
Attentional Narrowing/Distraction
High Fatigue
...

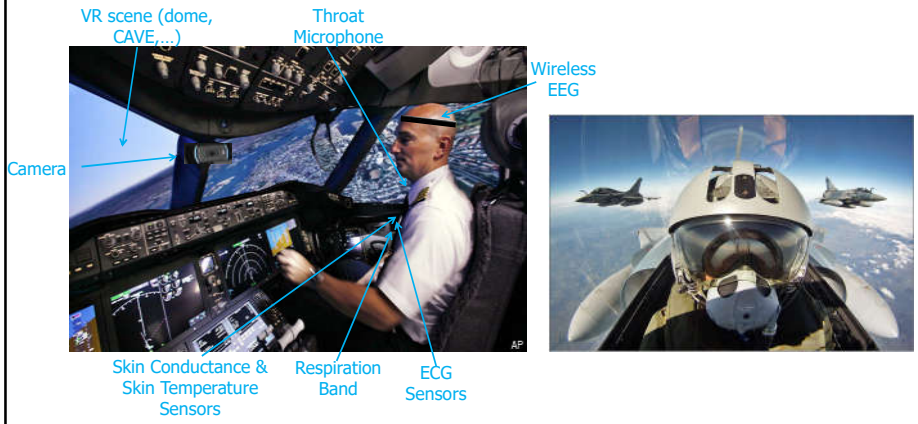
Flying Skills
Stress Resilience
...

Low Performance

Shappell, S., Detwiler, C., Holcomb, K., Hackworth, C., Boquet, A., & Wiegmann, D. A. (2007). Human Error and Commercial Aviation Accidents: An Analysis Using the Human Factors Analysis and Classification System. *Human Factors*, *49*(2), 227-242. Link. Cited by 515.

8

Multimodal Estimation of Pilot's Mental States



9

Stress Resilience: Important Characteristic for Task Performance under Stress

TO THIS day a variety of definitions, concepts, and theories of psychological resilience have been proposed, but most are based on two main concepts: adversity and positive adaptation, with resilience being defined as the process of positive adjustment to adverse events [1]. In the context of exposure to potentially traumatic events, resilience is seen as the absence of trauma-related psychiatric disorder sypmtoms [2]. However, in a task-related context resilience is defined as the ability of maintaining normal psychological and physical functioning, when exposed to extraordinary levels of stress and trauma [3].

Ćosić, K., Šarlija, M., Ivkovic, V., Zhang, Q., Strangman, G., & Popović, S. (2019b). Stress resilience assessment based on physiological features in selection of air traffic controllers. IEEE Access, 7, 41989-42005. Link.

[1] S. M. Southwick, G. A. Bonanno, A. S. Masten, C. Panter-Brick, and R. Yehuda, "Resilience definitions, theory, and challenges: Interdisciplinary perspectives," *Eur. J. Psychotraumatol.*, vol. 5, no. 1, 2014, Art. no. 25338. Cited by 2202

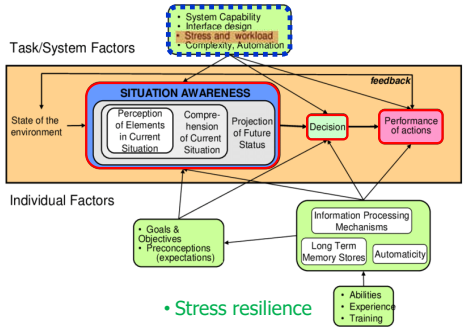
[2] F. R. Walker, K. Pfingst, L. Carnevali, A. Sgoifo, and E. Nalivaiko, "In the search for integrative biomarker of resilience to psychological stress," *Neurosci. Biobehav. Rev.*, vol. 74, pp. 310–320, 2017. Cited by 150

[3] S. J. Russo, J. W. Murrough, M.-H. Han, D. S. Charney, and E. J. Nestler, "Neurobiology of resilience," *Nature Neurosci.*, vol. 15, no. 11, 2012, Art. no.1475. Cited by 1122

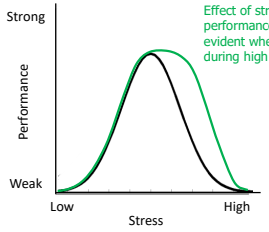
10

Stress Resilience Is NOT ... but Has Impact on All That

- Ability to do the task
- Ability to make right decisions
- Ability to understand complex operational situation



Endsley, M. R. (2017). Toward a theory of situation awareness in dynamic systems. In Situational awareness (pp. 9-42). Routledge. Cited by 10675.



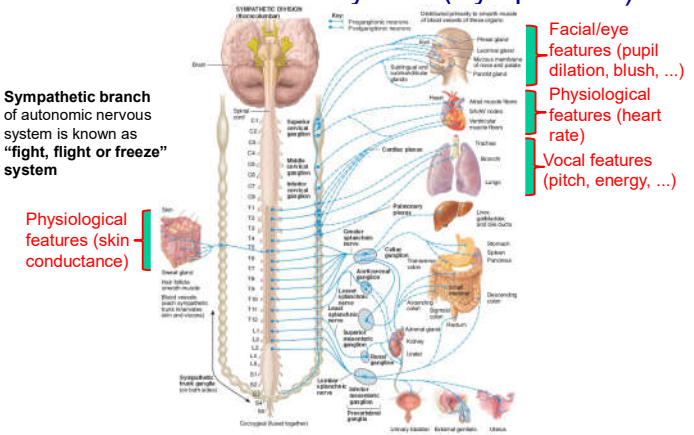
Effect of stress resilience on task performance should be most evident when performing tasks during high levels of stress

Russo, S. J., Murrough, J. W., Han, M. H., Charney, D. S., & Nestler, E. J. (2012). Neurobiology of resilience. *Nature neuroscience*, *15*(11), 1475-1484. Link. Cited by 1123.

11

Stress Effects on The Body via Autonomic Nervous System (Sympathetic)

Sympathetic branch of autonomic nervous system is known as **"fight, flight or freeze" system**

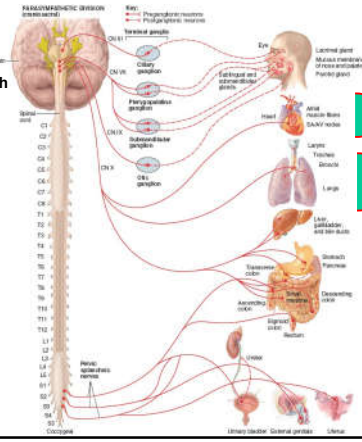


http://higheredbcs.wiley.com/legacy/college/tortora/0470565101/hearthis_ill/pap13e_ch15_illustr_audio_mp3_am/simulations/hear/sympathetic.html

12

Stress Effects on The Body via Autonomic Nervous System (Parasympathetic)

Parasympathetic branch of autonomic nervous system is known as **"rest and digest" system**



Facial/eye features

Physiological features (heart rate)

Vocal features

Nigdje nema inervacije kože! Na kožu utječe samo simpatička grana autonomnog živčanog sustava

13

13

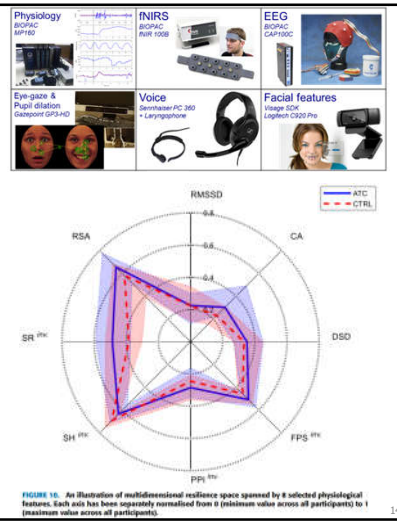
Stress Resilience Assessments

In terms of cost-effectiveness and reliability we can divide the resilience assessment tools into 3 groups:

1) Psychometric tools for stress resilience assessment which are time- and cost- effective, but are susceptible to self-report bias.
2) High-cost metrics that might allow a deep and accurate insight into the biological factors contributing to one's resilience, whose assessment is intrusive and highly demanding in terms of organisation and time (MRI, fMRI, fear conditioning/extinction, genes, gene expressions, etc.).
3) Various features based on the objectively measurable responses of the peripheral physiology that are relatively weakly associated to deeper traits/states like stress resilience.

Most expensive and time consuming

Ćosić, K., Šarlija, M., Ivković, V., Zhang, Q., Strangman, G., & Popović, S. (2019b). Stress resilience assessment based on physiological features in selection of air traffic controllers. IEEE Access, 7, 41989-42005. Link.



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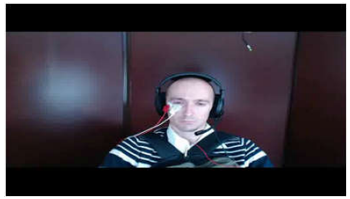
Akustička *startle* reakcija i njen značaj za predikciju rezilijentnosti

- *Startle* reakcija je obrambeni refleks za zaštitu od iznenadnih podražaja
- Važna je npr. jer je visoka anksioznost povezana s jačom *startle* reakcijom, strah/stres pojačavaju *startle* reakciju, osobe s PTSP-om imaju pojačanu *startle* reakciju, odnosno pojačani intenzitet *startle* reakcija povezuje se s vulnerabilnošću tj. nerezilijentnošću na visoke razine stresa
- Laboratorijska akustička *startle* stimulacija pouzdano proizvodi *startle* reakciju, kroz refleksni neuronski put koji sadrži 3 neurona
  - Bijeli šum, 40 ms, 108 dB



Eleonora Poli and Alessandro Angrilli. Greater general startle reflex is associated with greater anxiety levels... Front Behav Neurosci. 2015; 9: 10. Published online 2015 Feb 6.

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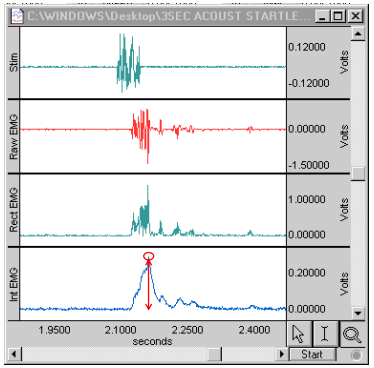
Akustička *startle* reakcija standardno se mjeri pomoću EMG fiziološkog signala očnog mišića



Akustička *startle* stimulacija

Sirovi EMG očnog mišića

Ispravljeni EMG (apsolutna vrijednost EMG-a)

Integrirani ispravljeni EMG, dobiven pomičnim prozorom određene širine
+
značajka koja predstavlja jačinu *startle* reakcije

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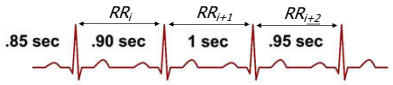
Značaj rada srca i disanja u predikciji rezilijentnosti na stres

- **<u>Srce ne kuca jednoliko!</u>**
- Varijabilnost srčanog ritma
  - Varijacije u trajanjima intervala između otkucaja srca
  - engl. Heart Rate Variability (**HRV**)

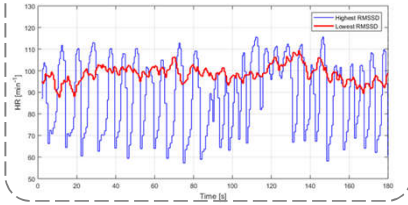


- Otkriva nam puno više od same informacije o srčanom ritmu (HR) ili njegove prosječne vrijednosti
- Osnovni primjeri značajki HRV-a u vremenskoj domeni

SDNN	Standard deviation of all RR intervals	$SDNN = \sqrt{\frac{\sum_{i=1}^{N}(RR_i - \overline{RR})^2}{N}}$
RMSSD	Square root of the mean of the sum of the squares of differences between RR interval	$RMSSD = \sqrt{\frac{\sum_{i=1}^{N-1}(RR_{i+1} - RR_i)^2}{N-1}}$

SIMPATIKUS
- Stimulira rad srca
- Povisuje srčani ritam i volumen otkucaja
- Odziv nakon nekoliko sekundi

PARASIMPATIKUS
- Inhibira rad srca
- Snižava srčani ritam i povećava HRV
- Odziv praktički odmah



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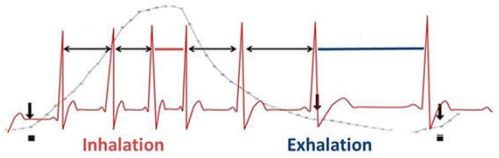
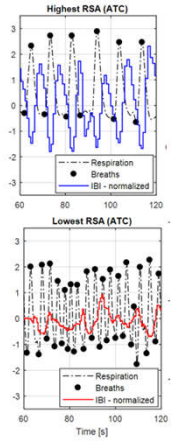
Respiratorna sinusna aritmija (RSA)

- RSA is defined as heart rate variability (HRV) synchronised with respiration, marked by heart rate increase during inspiration and heart rate decrease during expiration



- Physiologic role: enhancing the efficiency of respiratory gas exchange
- Psychophysiological importance: index (biomarker) of emotion regulation capacity
  - low RSA was observed in various psychopathological states related to emotion dysregulation (e.g. anxiety disorders, bipolar disorder, depression)
  - pronounced RSA was found to be a marker of protective traits like stress resilience



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Kognitivno opterećenje

- Kognitivno opterećenje je opterećenje kognitivnog sustava tijekom izvedbe određenog zadatka [1]
- Različiti faktori utječu na kognitivno opterećenje:
  - Težina zadataka
  - Razina stručnosti osobe koja izvodi zadatak
  - Dob
- Kognitivno opterećenje može se mjeriti:
  - Performancama na zadacima (npr. točnost i vrijeme odgovora na zadatak)
  - Subjektivnim mjerama iskaza (npr. NASA TLX, Instantaneous Self Assessment – ISA) prikupljenim tijekom i nakon izvođenja zadataka [2,3]
  - Neurofiziološkim mjerama prikupljenima tijekom izvođenja zadataka [4]
    - Kako anotirati zadatke?
  - Kombinacijom navedenih mjera [5]

Planning complex cognitive behavior, decision making, working memory ...:
PREFRONTAL CORTEX

[1] Paas, F. G., & Van Merriënboer, J. J. (1994). Instructional control of cognitive load in the training of complex cognitive tasks. Educational psychology review, 6(4), 351-371.
[2] Hart, S. G., & Staveland, L. E. (1988). Development of NASA-TLX (Task Load Index): Results of empirical and theoretical research. In Advances in psychology (Vol. 52, pp. 139-183). North-Holland.
[3] Jordan, C. S., & Brennen, S. D. (1992). Instantaneous self-assessment of workload technique (ISA). Defence Research Agency, Portsmouth.
[4] Ćosić, K., Popović, S., Šarlija, M., Mijić, I., Kokot, M., Kesedžić, I., ... & Zhang, Q. (2019). New Tools and Methods in Selection of Air Traffic Controllers Based on Multimodal Psychophysiological Measurements. IEEE Access, 7, 174873-174888.
[5] Arico, P., Reynal, M., Di Flumeri, G., Borghini, G., Sciaraffa, N., Imbert, J. P., ... & Betti, V. (2019). How neurophysiological measures can be used to enhance the evaluation of remote tower solutions. Frontiers in Human Neuroscience, 13.

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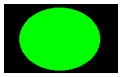
Ilustracije generičkih računalnih testova za kognitivne funkcije

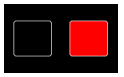
- *Simple reaction time test*
  - psihomotorička brzina
  - što prije treba pritisnuti tipku na tipkovnici svaki puta kada se pojavi krug na ekranu

Simple Reaction Time test



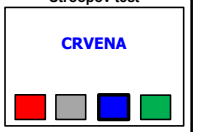
- *Go/no-go test*
  - psihomotorička brzina + inhibicija reakcije
  - što prije treba pritisnuti tipku na tipkovnici svaki puta kada se pojavi zeleni kvadrat, a ne smije se pritisnuti tipka na pojavu crvenog kvadrata

Go/No-Go test



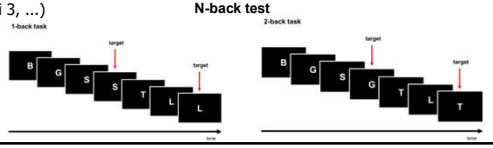
- *Stroopov test*
  - inhibicija kognitivne interferencije
  - svaki puta kada se na ekranu pojavi napisana riječ, odgovoriti kojom bojom je riječ napisana

Stroopov test



- *N-back* test (N = 1 ili 2 ili 3, ...)
  - radna memorija

N-back test



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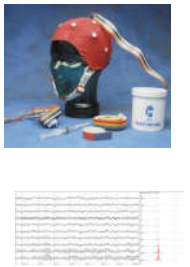
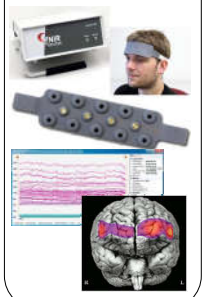
Tehnike oslikavanja mozga

- Magnetska rezonancija (engl. *magnetic resonance imaging* – MRI)
  - strukturni MRI
  - funkcionalni MRI (fMRI)
- Elektroencefalografija (engl. *electroencephalography*, EEG)
- Funkcionalna blisko-infracrvena spektroskopija (engl. *functional near-infrared spectroscopy*, fNIRS)

EEG



fNIRS



MRI/fMRI

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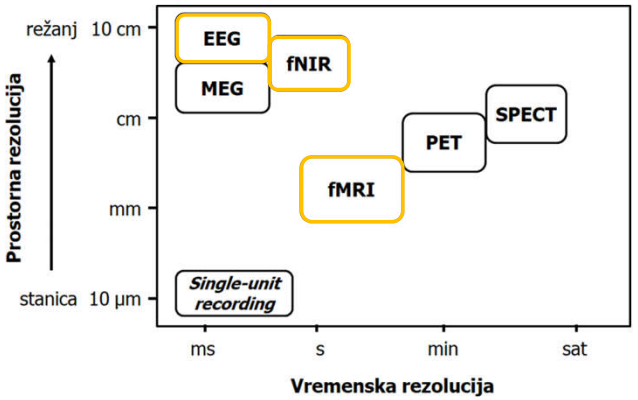
Prostorno-vremenska rezolucija tehnika oslikavanja mozga



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fMRI

- Neinvazivna tehnika koja prati promjene povezane s protokom krvi u mozgu
  - bazirano na pretpostavci da se prokrvljenost povećava u trenucima povećane aktivacije pojedinog dijela mozga
- Prednosti:
  - neinvazivan
  - dobra prostorna rezolucija
  - moguća su snimanja cijelog mozga
- Nedostatci:
  - niska vremenska rezolucija
  - nije prenosiv
  - nisu moguća snimanja na terenu
  - visoka cijena
  - uski prostor
  - visoka buka

Letter-word generation (LWG) task example

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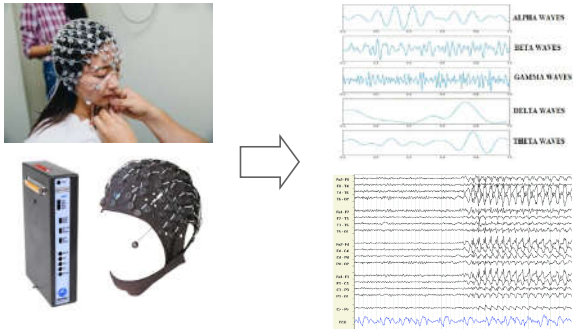
Elektroencefalografija

- Snimanje električne aktivnosti mozga
- Složena tehnika mjerenja moždane aktivnosti



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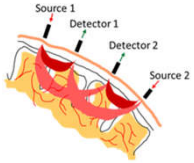
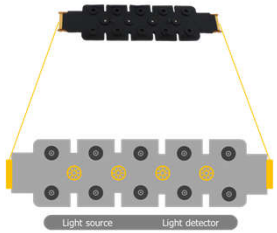
fNIRS

- Neinvazivna tehnika oslikavanja mozga
  - omogućuje praćenje prokrvljenosti prefrontalnog korteksa
  - mjerenje radne memorije, pažnje, rješavanja problema, odlučivanja
- Odziv mozga na pobudu
  - 2-6 sekundi
- Prednosti:
  - prenosiv, moguća snimanja na terenu
  - neinvazivan
  - pristupačna cijena
  - jednostavan za korištenje
- Nedostatci:
  - ograničenja s kosom ispitanika, moguća su snimanja samo na čeonom dijelu
  - ograničenja s regijama mozga koje se mogu promatrati
  - nepostojanje informacija o strukturama promatranih regija

fNIRS control box and sensor in Laboratory for Interactive Simulation Systems





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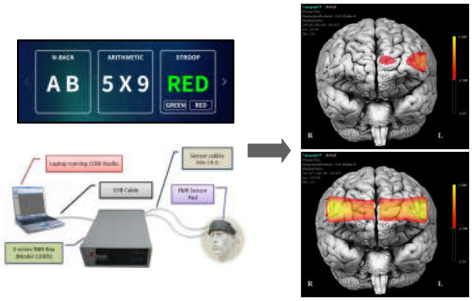
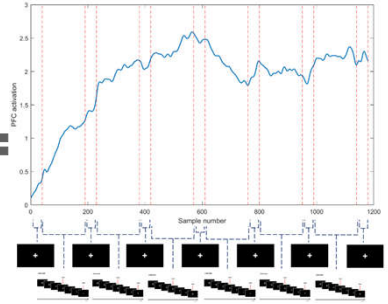
fNIRS





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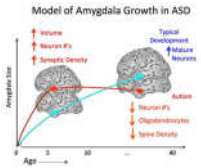
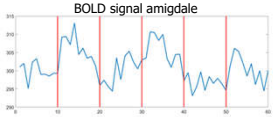
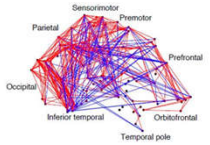
Informacije koje sadrže podaci snimljeni različitim tehnikama oslikavanja mozga

- MRI:
  - veličina i oblik struktura u mozgu

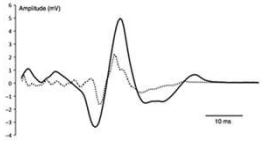


- fMRI:
  - blood-oxygen-level dependent (BOLD) signal
  - povezanost među regijama mozga

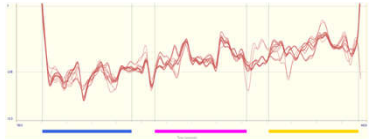




- EEG:
  - evocirani potencijali
  - spektralne snage u pojedinim frekvencijskim pojasima



- fNIRS:
  - zasićenost krvi kisikom



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