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The Transformation of Technological Capabilities in Russian Defence Enterprises, with special reference to dual-use technology

Liudmila Bzhilianskaya

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Science Policy Research Unit
Mantell Building
University of Sussex
Brighton
East Sussex BN1 9RF

Tel: +44 (0)1273 686758
Fax: +44 (0)1273 685865
http://www.sussex.ac.uk/spru

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Contents

Summary

The former Soviet military-industrial complex is shown to be a sector subject to a mass of misconceptions and fantasies, but which nonetheless carries within it technological capabilities which could form the basis of significant breakthroughs in relation to Russian manufacturing export performance. The general area with the best prospects is that of *dual-use technology* - a category which is shown to encompass a large proportion of operational Russian high technologies. *Lasers* and *space launching* are picked out as two specific areas which exemplify the strengths of Russian dual-use technology. The obstacles - both internal and external - to the effective realisation of the potential for commercial application of Russian dual-use technology are analysed in detail. The author concludes that while these obstacles are serious, there is every reason to be optimistic about the chances of breakthroughs by Russian high technology firms in at least a few areas. Much will depend, however, on sensible domestic economic policies, which will in turn depend on the maintenance of the impetus of political reform in Russia, and on the forging of creative linkages with foreign firms.

1 Introduction

Interest in Russia has increased greatly of late, as a result of the political and economic transformations now under way. On the commercial side, interest is in the first instance aroused by Russia's natural wealth, and the tremendous size of her potential domestic market. No less strong, if less publicised, is the interest in Russian scientific technological potential. The purpose of this paper is to assess the real strength of that potential in a few, selected areas.

A palpable unevenness in the pattern of technological development seems to be a key feature of the Russian scene, a feature which fundamentally affects the economic development and prospects of the country. This unevenness has a very long history. During the socialist period, however, the differentiation in the pattern of technological development of different industries became more profound, as a result of non-economic influence, coming 'from above'.

A vivid illustration of this unevenness is the hypertrophy of the Russian (Soviet) military industrial complex (MIC). The 'concentration of military expenditures in particular industries and regions' which results in the 'exploitation of parts of society and enrichment of other parts' (Melman, 1991) is, indeed, a feature of all militarised societies. A specific Russian feature was the concentration of scientific and technological potential in the defence complex. The share of scientific cadres, equipment, advanced R&D and technology in the MIC was tremendously high, in both qualitative and quantitative terms aspects. The priority on the MIC was supported by vast budget allocations (in absolute and relative terms). Workers in the MIC earned 1.5-3 times more than people with similar qualifications and responsibilities in the civil sphere.

Here are a few figures, referring to the former USSR in the late 1980s, to illustrate the point. More than 10% of Soviet GNP was spent on defence at that time.[1] (Comparable figures for

[1]SIPRI gives a figure of 11.5% (SIPRI, 1990). Other estimates for the share of defence expenditure in GNP varies from 12 to 24%. For details, see Marlin (1993).

Western Europe were 1-5%, and for the US 6%) (SIPRI, 1990). As many as 13% of the total industrial labour force was employed in the manufacture of weapons and military hardware alone (Cooper, 1991). Fully 50-70% of Soviet R&D and 70-80% of basic research was conducted in the defence complex (either at the 'closed' enterprises and organisations of the so-called 'nine' - the nine Soviet defence industry ministries, or by the institutes of the Academy of Sciences, or by university laboratories and educational institutes working on contract from the Ministry of Defence).[2]

There is no single, universal answer to the question whether technological leadership belongs to the civilian, or to the defence sphere. But while in some Western countries, it is *spin-ons* that are typical,[3] in Russia the concentration of technological resources in the defence industry, and the lack of competition and marketing orientation elsewhere under the Soviet system, have created a situation where only spin-offs are worth considering. The process of defence conversion that started in Russia at the end of the 1980s accordingly focused on the questions: can Russia retain and develop its huge scientific and technological capabilities located in the defence complex? And how successful will Russia be in redeploying these resources for civil purposes?

2 Russian defence conversion: myths and reality

The similarity of the problems facing defence enterprises as transition began, combined with their common characteristics on other parameters (predominance of defence contracts, traditional dependence on priority state financing etc) resulted in the formation, in the mass consciousness of various groups of people, of certain myths concerning the MIC and conversion. These myths had currency amongst the population at large, managers and workers in the former MIC enterprises, and even in government circles. Such myth-making is,

[2]Note, however, that in the former USSR (as I will show later on in this article) the 'defence share' usually included all military-related production and research activities, plus some which were applicable for military purposes (fully or partially) only potentially and/or in the distant future. The 'pure military share' was therefore lower than indicated here.

[3]See, for example, Gummet & Walker (1992); Markusen (1992), Alic (1990).

it must be said, no monopoly of Russia.[4] They have, however, been especially important in that country. Different myths have been particularly significant at different times, but all of them have had a serious impact (largely a negative one) on the economic situation of MIC enterprises, and on the state of the accumulated technological potential of those enterprises.

Myth 1. *'The Russian MIC is an integral, indivisible whole.'*

This myth was never declared as an official principle. But it is deeply rooted, and has had a profound impact on the course of conversion, and of economic transformation in general, in Russia. Of course, there is no denying that MIC enterprises do possess certain common features. (These have already been touched upon, and will be referred to again below.) That does not, however, mean that you can take the same approach to the conversion of every single MIC enterprise. The lack (at least at the start of the reforms) of genuine sub-sectoral priorities for defence industry development, and the failure to differentiate the approach to conversion at different enterprises, was a serious negative outcome of the existence of the myth of MIC uniformity. As early as 1992, before the start of the conversion programme as such, defence enterprises were being forced to take on production of consumer goods (that is why this kind of conversion was called 'pots and pans' conversion), without any estimates of the cost-effectiveness of this at particular enterprises being done. The conversion of 1992-93, by contrast, was 'headlong', in that its main feature was across-the-board financial cuts. After the failure of 'pots and pans' conversion, this virtually killed off most of the enterprises concerned, with the consequent loss of numerous R&D facilities in the strategic sphere, and of certain competitive advantages possessed by Russia in a range of branches. All this resulted in the strengthening of *Myths 2 and 3*.

[4]On the mythology of American conversion see: Bischak & Yudken (1993).

Myth 2. *'There has never been real conversion in Russia, and there never will be.'*

This myth is very widespread, and extremely dangerous. It has been nurtured by both workers (managers) of defence enterprises dissatisfied with the sharp curtailment of defence orders, and representatives of parties and fractions in opposition to the government. At the enterprise level, conversion has even been viewed simply as a kind of diversification.[5] At the beginning of 1993 we conducted a survey of defence R&D managers' attitudes.[6] It is striking that in answer to the question: 'What do you personally understand by conversion?' a third answered 'the maintenance of defence orders at the former level, combined with an increase in the volume of civilian projects'.

Myth 3. *'As a result of pseudo-conversion, all advanced R&D capabilities have been lost'*

Under conditions of economic crisis, Russia could not possibly preserve to the full all its scientific and technological potential, accumulated over decades. But sometimes the perception of this situation has spilled over into an assertion that R&D achievements and high technologies have been lost entirely and irrevocably. This is in fact a recurrence of *Myth 2*. Significantly, it is particularly prevalent among opponents of the government.

Myth 4. *'The priority which the MIC enjoyed over decades is a perfectly natural one'*

It was this myth that deluded MIC workers that all the privileges they had enjoyed in the past would continue for a long time, perhaps for ever. Today this myth is practically dead. But in 1993 it still had wide currency, and it seriously hindered the progress of conversion. When, within the framework of the above mentioned survey, the respondents were asked: 'Should

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[5]According to Melman (1992), diversification 'can be achieved through acquisition and divestment, with no attempt to utilise (or convert) existing capital and human assets'. Thus the implications of diversification and conversion are very different. A detailed analyses of conversion and diversification definitions are given by Southwood (1991).

[6]The investigation was carried out in February-March 1993 on behalf of the Ministry of Science and Technology of the Russian Federation, with Leonid .Kosals in charge. It was based on a survey of 223 managers in five Russian Defence (Military) R&D institutes. See Kosals (1994).

defence institutes have privileges vis-à-vis civilian ones?', 70% of those polled gave a positive answer.

If we want to make sense of the realities of Russian defence conversion, we must bear these four myths firmly in mind. But we must also have a clear understanding of the kinds of technologies involved. It is to this that we turn in the next section.

3 Categories of technologies at Russian defence enterprises

The further conversion progresses, the greater the differences between the development trends of individual enterprises/organisations become, and the more and more every enterprise (and even its sub-units) begins to resemble a living organism, possessing unique features. If we want to shatter the myths, and understand what is really happening to the former defence enterprises, we need to choose a particular group of technologies and try to investigate their characteristics. But let us start be breaking down MIC output in terms of broad categories. We single out three types of technologies - civil, military and dual-use.

3.1 Civilian technologies which cannot be deployed for military purposes

For Russia (to be more exact, for the former USSR) a high concentration of civilian technologies in the MIC was typical from the early years of the Soviet system. Almost all sewing machines, refrigerators and more than 75% of vacuum cleaners and food industry equipment were produced in the defence complex (Cooper, 1993). At the same time almost half of all the country's civil industrial research was conducted within the defence complex (Cooper, 1991).

For producers of civilian goods, it looked initially as if conversion would be relatively painless. In 1992-93, when the consumer market was not yet saturated, products of this kind were in extremely high demand, and that allowed MIC enterprises that made them to compensate for the losses incurred on account of the decrease of state financing on the military side. For example, according to data from Gosoboronprom (State Committee for Defence Industries of the Russian Federation),[7] the average drop in aggregate production in 1993 at enterprises subordinate to the State Committee was 19.6%, while the average decrease in consumer goods production in its enterprises was only 4.8%.[8] By 1994, however, owing to the saturation of the market, and also because of increased competition from imported products, the demand for consumer durables produced by MIC enterprises decreased sharply, though they continued to offer substantially keener prices, with comparable quality levels.

3.2 Military technology which cannot be used directly for civil purposes

The position of enterprises trying to retain and develop technologies such as these is particularly difficult. A sharp decrease in state orders and purchases, and the collapse of traditional export markets, resulted in a drop in production of military goods at Gosoboronprom enterprises under conversion of 23% in 1993 (compared with an average decrease in industrial production of 16% in the same year).[9] And attempts to win back former export markets ended in failure - because the markets had already been taken by competitors, and because of palpable technological shortcomings.

3.3 Dual-use technology which can be used for both military and civil purposes

Dual-use technologies, a sort of intermediate link between the first and second types of technology, 'premise military superiority and have commercial potential as well' (Markusen, Yudken, 1992). In the scientific literature, authors often limit themselves to a consideration of just straight military and straight civil technology[10] or even speak about dual-use in terms of

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[7]Gosoboronprom, or Rosgosoboronprom, is the ministry which has had charge of the majority of conventional defence enterprises in Russia. Nuclear industry enterprises have normally been under the Russian Ministry of Atomic Energy.

[8]Calculated from data of the State Committee for Statistics of The Russian Federation (Goskomstat). See *Segodnya*, February 1, 1994.

[9]*Obshchestvo i Ekonomika*, No.11-12, 1993.

[10]See, for example: DiPilippo (1991); Gummet & Walker (1992).

'civilian technology for major weapons systems' (Flax, 1980). The reason why we are particularly interested in dual-use technology flows from our interest in the spin-off problem, which in this case takes place in the most simple and organic way. Here is a typical example. While the technology of finished, laser-based product creation might be either civil (medical laser device) or military (laser armaments), lasers as sub-systems or sub-components are archetypally dual-use.[11] That' is why enterprises possessing dual-use technology appear to be generally the most flexible ones, and the most successful in terms of conversion. The other reason we are particularly interested in dual-use technology is that in Russia the number of enterprises and plants possessing dual-use technology is very high - according to official government estimates, about 70% of the technology Russia possesses is of a dual-use character.[12]

In Russia, the government has begun to pay special attention to dual-use technology only quite recently. Furthermore, the new state programme *Dual-Use Technology* is above all aimed at creating specific types of product (for example, the IL-96MJ aircraft, underground atomic stations). In my view, following the American experience,[13] it is the basic dual-use *technology* (eg electronics) that should be the starting point, rather than specific final products. Still, the attention given to dual-use technology through the state programme is a good sign.

In my opinion, the dual-use technologies possessing at present the greatest prospects for civil application in Russia are to be found in the sphere of certain advanced materials, lasers and optic electronics, space launching and aircraft construction. There are branches in which, up to now, and in defiance of Myth 3, Russia continues to hold definite advantages.

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[11]On hierarchical systems of defence technologies and lasers as sub-systems see Molas & Walker (1990).

[12]This estimate was given by the president of the RF, Boris Yeltsin, at the Council for Science & Technological Policy on the 15th of August, 1995. It is not, however, absolutely clear how the figure was estimated. (*Segodnya*, 16 August 1995).

[13]See *Aviation Week & Space Technology*, 17 January, 1994.

4 Economic and technological development - the basic problems

4.1 Resource problems , innovation, and the creation of new products

At the beginning of the reform period (1992-93) Russian defence enterprises were all in the same boat. The problems facing them were conditioned by both the economic changes taking place in the new Russia, and by the legacy of the seventy-year history of the Soviet/Russian MIC. We will highlight these difficulties by using the production cycle (resources -> product development -> marketing) approach. Almost all the illustrations will be from the laser industry. We chose lasers for a variety of reasons:

- Lasers are a typical example of dual-use technology. Even in the Cold War period, many Russian laser producers were addressing the civilian market, although they all officially belonged to the MIC.
- While the laser sector exhibits special features, its experience is susceptible to generalisation.
- As mentioned earlier, Russian laser technology is really advanced. In these areas Russia has genuine prospects of penetrating the world market.

Resource Problems (see Table 1) present serious obstacles to the normal development of enterprises.

Sociological investigations and interviews conducted at defence enterprises indicate that *shortage of finance* has been seen as the main problem since 1992. For example, 74% of managers of the Vavilov Optical Institute in St. Petersburg (*Gosudarstvennyi Opticheskii*

Table 1

Resource Problems:		Key Reasons:	
1	***Financing:***		
1.1	Shortage of core funding	1.1	Sharp cuts in state funding; lack of alternative sources of funding; defaults
1.2	Working capital problem	1.2	Inflation; delays in payment
2	***Supply of materials and equipment:***		
2.1	Physical and technological wearing out of equipment	2.1	Financial problems, general recession, tradition of keeping equipment in service for a long time
2.2	Lack of key components	2.2	Shortage of money, rupture of ties with old suppliers and uncertain ties with new suppliers
2.3	Poor quality of sub-components and ancillary parts	2.3	Tradition of underestimating the quality factor; lack of knowledge about world quality standards; very high prices for high quality sub-components
2.4	Need to obtain new, super-precise devices	2.4	Transition to civilian mass-production, increasing competition
3	***Manpower resources:***		
3.1	The 'technical obsolescence' of personnel:		
3.1.1	Ageing of the labour force	3.1.1	Outflow of workers of the most productive age cohorts, poor recruitment of young people
3.1.2	Inadequate labour productivity	3.1.2	Low wages, loss of status of R&D and production work
3.1.3	Deterioration in human capital	3.1.3	Recession, part-time employment, de-skilling
3.2	'Physical outflow' of the best cadres:		
3.2.1	Domestic outflow to other spheres	3.2.1	Low wages in the sphere of S&T, absence of visible career prospects, buoyant Russian labour market in the business sphere
3.2.2	External 'brain drain'	3.2.1	Comparatively low standard of living, political and social instability, demand for Russian specialists in Western countries

Institut imeni Vavilova - GOI) polled in March 1993 were of this opinion. The institute in question is the leading one in Russia in the field of optics and lasers.[14]

It has been quite difficult for enterprises to get accustomed to the need to earn money by themselves, after years of budget funding, not for real, identifiable projects, but just according to the plan. High inflation and long delays in payments have turned money into 'dust', and ruled out the possibility of any financial plough-backs. Budgetary support, even in the case of projects with real prospects like civilian lasers, continues to decline ($4-6m in 1992, $3-5m in 1993 and $2m in 1994[15]).

To a degree the collapse of state financing has been compensated by an upward trend in funding from non-state sources, particularly in the form of:

(a) grants from foreign and Russian charitable foundations (for the financing of both basic and applied research);

(b) funding from foreign firms and state structures (for the development of cooperative ties and joint projects, including production projects, etc);

(c) funding from Russian industry and Russian commercial and financial structures.

As early as 1992, German business circles were financing 19 joint projects in the Russian laser industry, involving a total of DM1.5 m.[16] In 1993/94 a multifunctional, technological laser complex was created by five Russian firms on the basis of financing from the Gazprom financial-industrial conglomerate. In 1994 a new, laser-based, high-quality dental system,

[14]As already mentioned, the survey done in GOI constituted part of an investigation carried out in five defence R&D institutes. In the course of the investigation, conducted by the author, 60 GOI managers were questionnaired - more than a fourth of the total number of managers polled. The GOI results are published here for the first time.

[15]All figures quoted in this paper on the Russian laser industry are taken from the data base of the Laser Association. On the laser industry in Russia see also Bzhilianskaya (1995).

[16]*Kommersant Daily*, 12 May 1993.

OPUCH Multiwave, was created on the basis of cooperation between the Russian Institute for Precision Mechanics and Optics and the Austrian Laser Medical Systems Centre.

Lack of materials and *equipment* has effectively killed off many potentially competitive enterprises. Quality problems in material and equipment supply often create insurmountable barriers to the production of a finished product. As many as 95% of the interviewed sample of managers at GOI considered their material and equipment supply base to be below world standards, and about 50% considered it to be quite obsolete.

Today the classical 'socialist shortages' of materials, key components, complementary parts and equipment are a thing of the past. However that does not mean that there are no longer any supply problems! There *is* still a serious problem of quality of materials and sub-components. To be competitive on the market (even on the domestic one), it is necessary to use sub-components of world quality standard. Unfortunately, the 'debris' of the monopolism of the former socialist system continues to clog the contemporary Russian system of foreign trade. Enterprises are only just starting to establish direct supplier-producer ties. The taxes on imported sub-components are high, and domestic Russian producers have tended to cut back production. As a result, the prices of high-quality materials and sub-components on the Russian market are often higher than on the world one.

However, we can observe a new tendency now. Many former defence enterprises (usually in the engineering industry) facing contraction or disappearance of their traditional markets, have gone over to the production of sub-components for competitive industries (eg the laser industry). In the opinion of customers, they manufacture goods of a quality comparable with the world level - and sell them much more cheaply.

Because of shortage of money, many enterprises are still faced with a problem of equipment quality. Re-equipment requires substantial one-off expenditures, and this is beyond the means of Russian R&D institutes and enterprises. In the laser industry, it is the producers of powerful industrial lasers that have the biggest problems in this connection. That is why the support of the new Russian commercial structures, in the form of money and credits for re-equipment and credits, is so important.

The various problems of *manpower* are closely interconnected and mutually reinforcing. In 1993 15% of the managers in GOI considered the outflow of skilled manpower to be one of the most serious problems. Relatively better laser and optics development prospects has meant that GOI has been able to maintain greater stability in staffing, as compared with other R&D institutes (over the five institutes, the problem of manpower was singled out as being very serious by 27% of managers). As many as 62% of those polled in GOI considered that their research group was stable (compared to 38% over all five institutes). GOI also reported relatively much higher shares of total outflow for those who left for other units in GOI (22%), other R&D institutes (12%), or commercial organisations dealing with R&D and high-tech (43%). The comparable figures for all five institutes were 17%, 9% and 37%, respectively.

That said, it must be emphasised that the manpower situation at laser and optics industries enterprises is far from good. The 'brain drain' to foreign countries continues apace (though the rate has decreased to some extent during the last few years). The advanced level of the Russian optics and lasers, and the high skill levels of the specialists involved, has meant that a higher proportion of researchers have ambitions to go abroad than in other categories of R&D institute. GOI managers estimated in 1993 that 30% of their R&D workers wanted to go abroad, compared to only 22% for all five institutes. The desire to work abroad was even stronger among researchers under the age of 33 - 44% according to GOI managers, as compared to 38% over all the institutes surveyed.

If external brain-drain is characteristic of theoreticians, internal brain-drain is typical of those engaged in applied science (Bzhilianskaya and Kosals, 1994). The outflow of people of the most productive age groups (30-45 years) is the biggest problem in applied R&D (the average age of laser specialists is 45). The loss must be measured against the fact that it takes 10-15 years (five years of training and ten spend gaining experience) to produce genuine specialists in this field.

As a result of domestic migration and emigration, the number of specialists working in Russia in the field of laser physics and laser technology fell from over 30,000 in 1992 to just 15,000-17,000 at the beginning of 1995. Comparable trends are cited by the managers of individual laser enterprises (eg Polyus R&D Institute, GOI).[17] I Kovsh, the president of the Laser Association, estimates that the number of people directly engaged in designing and producing lasers has decreased by two-thirds since 1991-92. We must add, as a footnote, that in our investigation into the Russian R&D sphere we did find cases of specialists, who had left laser units some time previously, returned to their former posts.

The problem of ***innovation and the creation of new products*** (see Table 2) is the most serious, and most difficult to address in present-day Russia. Formerly, to a great extent because of departmental barriers, technological lead-times tended to be excessive (by up to two/three times) and very often the process broke off entirely, so that the products in question never saw the light of day (Glaziev, 1990). However, as a result of the priority on the defence sphere, products emanating from it normally passed through all the stages of the technological process of product creation, and often won recognition on the world market (if they were not kept secret). Today, Russia often fails to bring its R&D projects to fruition even in the defence sector. Certainly, the situation is easier at enterprises which have already been working for the civilian sphere for a long time already, and therefore have some capability in terms of setting up mass production. Our research shows that Russia, in developing dual-use technology 'under the cloak of secrecy', has in many cases developed civilian R&D as well. A number of enterprises, located under the 'roof' or producing to the orders of defence ministries, and working on dual-use applications, created the 'technology of

[17] *Laser Inform*, May 1995; *Business MN*, 30 November 1994.

Table 2

Essential innovation problems:		Key Reasons	
1	Fragmentation of the chain leading from innovation to the introduction of new products (especially on a mass scale).	1.1	Traditional**:** departmental barriers; secrecy; dispersion of different stages of the technological cycle among different enterprises
		1.2	New: lack of resources; disruption of economic ties between long-standing partners; lack of know-how for new product creation and innovation on a mass scale
2	Weak consistency between technology level and production level	2	Discrepancy between the high level of new technology and the poor state of materials and equipment; weakness of technological and production links
3	Assimilation of new technology and technique	3	Shift to civilian production; world technological progress; increasing competition.
4	Poor design; narrow range of criteria taken into account in the innovation process	4	Underestimation of the importance of many central characteristics of the innovation process, as a result of traditional socialist shortages and orientation towards the former socialist market
5	Weakness of technology assessments and innovation forecasts, and underdeveloped innovation management	5	Socialist innovation system.

the future'. By way of illustration, we can cite research done in the field of thermonuclear synthesis, which has been carried out for the last 20 years in the Physics Institute of the Russian Academy of Sciences as an assignment for the military. In practice, this technology is likely to bear fruit in terms of civilian applications long before it has any practical military use.

Production, and especially mass production, has always been (and still is) a serious problem for Russian high-tech enterprises. As a result, the final stage of technology development in Russia is often no more than a working model. Only 35% of the GOI managers polled in 1992 had actually handed over completed R&D to the defence industry. Of that 35%, one-third said that the R&D transferred was never put to practical use. In 1993 a catalogue of products developed by the Russian radio electronics enterprises, laser enterprises included, was published. The existence of huge volumes of finished R&D which has never been implemented and/or 'translated into products' was highlighted by the fact that approximately one-fifth of the catalogue consisted of information about finished technological products under the title 'Searching for a Customer', and four-fifths described R&D 'achievements' - under the title 'Searching for a Funder'.

With a unique piece of military hardware, it is possible to make adjustments to components right up to the initial stage of utilisation. With mass production that kind of continuous adjustment becomes impossible; it becomes absolutely vital that the whole range of components should exhibit the same parameters of quality and reliability. Russia, unfortunately, has a long history of reporting a high percentage of defective goods in mass production (alongside very high quality in individual components), which has given rise to the proverb: 'The Soviet Union [Russia] can produce anything - but only in a single sample'. Today, the problem of increasing the reliability of Russian high tech has emerged as one of critical importance for the whole future of manufacturing in the country.

4.2 International collaboration as a way of strengthening the capacity to innovate effectively

These critical weaknesses of the innovation process in Russia are all areas in which Western companies have been forced by the discipline of competitive markets to develop strong capabilities. It is clear, then, that Russian high-tech companies need Western companies. It is equally clear that there is a whole range of reasons why Western high-tech companies can hope to do profitable business with their opposite numbers in Russia, viz:

1 The cheapness of Russian scientific manpower. In March 1993 the average wage of GOI researchers was Rb 8,283 roubles, or US$11-12 a month, with the maximum wage equivalent to US$15. The situation today is less absurd; still, earnings equivalent to US$ 400-500 a month are considered high for Russian researchers.

2 In many spheres of technology, Russian R&D is at a very high level (in direct contradiction to myth 4), or even unique. In the world exhibition of scientific research and innovations Brussels - Eureka 94, 92 exhibits of Russian former defence firms were on display - approximately 8% of the total number of exhibits. Of the 92, 82 received awards.[18]

3 Because of the autarkical profile of many scientific branches, the Soviet Union tended to 'go its own way'. This sometimes produced uniquely original results. Foreign partners may find that these original results can, in some cases, provide a better basis for cost-effective innovation than mainstream Western innovation.

4 Russian high-tech producers continue to underestimate the value of their technological and intellectual products. As a result, Russian high technology and advanced R&D are often underpriced.

5 Russian technology is also often available on very attractive terms. In general, Russian high-tech enterprises are quite prepared to help a competitor, by selling him their technology or collaborating with him.

6 The inadequacy of the Russian laws on intellectual property protection, and the fact that Russian managers are often unfamiliar with patent procedures and other ways of legally establishing intellectual property rights, makes it easier for foreign organisations to buy cheaply - or even steal - both R&D and the rights to its commercial use.

In practice, it has not been so easy for defence industry enterprises to globalise their activities. From about the end of the 1980s up to 1992/93 enterprises tried to go into the foreign market with non-embodied technology (licences or even know-how). In 1993 scientific products and services constituted 20% of the total exports of Gosoboronprom.[19] While 43% of those

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[18]*Laser Inform*, February 1995.
[19]*Kommersant -Daily*, 26 November 1993.

polled in GOI in the summer of 1993 confirmed that defence institutes are compelled to sell their R&D abroad, none of them knew of a case in point involving delivery of more than a single product or design. At that point, then, the commercialisation of R&D had clearly not yet been adequately mastered. Nevertheless nearly 70% of the managers questionnaired at GOI in 1993 were already collaborating with foreign firms and research organisations. (The comparable figure for all five institutes surveyed was 40%.) Just 15% of those polled at GOI carried out joint research with foreign partners, and 20% carried out contract research for foreign organisations. (Comparable figures for the entire group of institutes were again lower.)

The situation has changed radically since then. Today, almost all Russian firms and organisations with any prospects at all collaborate with foreign partners in one way or another. And though most enterprises continue to export components and technologies, because they lack the finance to production as such, the pattern is beginning to change as far as researchers are concerned. The most forward-looking ones are managing to master the complete innovation cycle, from R&D through to final implementation. We will look more closely at the challenges and problems they face in this in Section 5.

4.3 The special role of high-tech small and medium-sized enterprises (SMEs)

More and more innovations are being channelled through high-tech SMEs, which have greatly increased in numbers over the last year or so. Today, almost 50% of laser enterprises and organisations are classified as small firms.

Among high-tech SMEs, one can single out five main groups.

1 Scientific centres operating under the aegis of Academy of Sciences R&D institutes and educational institutes engaged in applied science. These scientific centres are created with

a view to siphoning off income from contracts. Such firms economise on rent and overhead expenses, since they make use of the production area and equipment belonging to the institute.

2 Small firms, similar to those discussed under A), but engaged in full-cycle R&D activity. Such firms are usually created on the basis of laboratories belonging to Academy of Sciences institutes or applied R&D institutes.

3 New small firms formed in response to demand for special kinds of technological products. They may be engaged in R&D activities, in production, or in the whole process of product creation. Here is a typical example: high demand for medical lasers has resulted in the appearance of a large number of new, small firms making lasers for that specialised market. Among them there are lots of medical firms which have never been involved in military production (or even, up to now, in production of lasers!).

4 Small innovation-production firms which have been hived off from Science Production Associations (SPAs), plants and other organisations, or formed by specialists who formerly worked at such enterprises. For example, the breaking-up of the Polyus SPA - formerly a laser industry leader - has resulted in the formation of around 20 smaller firms, all active on the laser market.

5 Small firms as intermediaries in the technology transfer process. Such firms are usually formed by specialists in specific technology fields. They play a definite role, especially in outlying districts where scientific-technical and marketing ties are weaker than in the centre.

5 Economic development and technology transfer - the marketing side

Whether Russian high-tech products are successful on the world market depends critically on the technological characteristics of the product - but not only on them.

5.1 Marketing difficulties

These (see Table 3) are for the most part new to Russia, but they have already 'shown their teeth'. The severity of the problems involved flows from the underdeveloped nature of the market, and a certain inability to cope with new marketing challenges.

Little by little, far-sighted managers have realised the necessity of pushing forward towards the foreign market with a finished high-tech products. As to the demand for these products on the domestic market, some revival is now observable, with the weakening of the production recession and the reining-back of inflation. However, distrust towards Russian products on the part of both domestic and foreign customers continues to makes itself felt here. The tradition of viewing the products of a socialist/post-socialist country as 'second-rate', on account of poor delivery discipline and defective design, dies hard. The conservatism which permeates the foreign market can be summed up as follows: 'we have never bought anything from the Russians and have managed to live well enough all the same'. Customers demand proof of the quality of new products. Russian industry is still not geared to providing that proof.

After-sales service is a big problem. It is difficult to provide an adequate level of after-sales service in Russia itself, never mind in other countries. For undercapitalised fledgling Russian innovator-firms it is particularly difficult to open service centres. Sending a specialist to adjust or repair a device, say, for example, in the north of Russia, may cost more than the device itself. Thus after-sale service is effectively provided only in large Russian and CIS cities, or in the case of direct, long-term contracts (often including provisions for technological link-ups) between producers and customers. In the laser and optics industries, such link-ups are quite well developed between Russia and Germany.

Table 3

Marketing Problems:		Key Reasons	
1	***General problems:***		
1.1	Disruption of old ties between suppliers and customers	1.1	Disintegration of the USSR and CMEA; recession and lack of liquidity
1.2	Undeveloped marketing ties; lack of a reliable mechanism for search and selection of customers	1.2	Undeveloped centralised information system; lack of skills and experience
1.3	Weakness of market and demand analysis	1.3	Absence or weakness of marketing services at enterprise and state level; lack of knowledge and skills in the marketing sphere.
1.4	Difficulties in fulfilment of after-sales service	1.4	Absence of servicing network in Russia and abroad; high transport costs; only recent transition to mass production
2	***Problems on the domestic market:***		
2.1	Low demand for R&D and new technology	2.1	Recession, severe problem of technological incompatibility
2.2	Low effective demand for all technological products	2.2	Lack of money, comparatively poor quality of components, poor design
2.3	Increasing competition between Russian firms	2.3	Increasing number of SMEs
2.4	Competition generated by foreign firms entering the Russian market	2.4	Struggle of leading international firms for new markets; absence of laws to defend the Russian technological market
3	***Problems on the foreign market:***		
3.1	Lack of knowledge about laws (procedures) in foreign markets	3.1	Lack of practical experience and theoretical knowledge
3.2	Underpricing of Russian high-tech products	3.2	Need for money; poor information about world prices for similar products
3.3	World market difficult to break into	3.3	Significant degree of oligopolisation of the foreign market in technology; failure to meet world standards and quality levels
3.4	Prejudice against Russian technological products and conservatism	3.4	'Socialist past' and present political and economic instability; absence of Russian brand marks; no tradition of Russia as a partner

What defines the *potential competitiveness* of Russian high-tech products? Our research shows that it is primarily determined by the following two considerations:

- Cheapness
- Technological superiority/uniqueness

However, as we mentioned at the beginning of this paper, there is a huge range of variation among Russian technologies. In terms of the *scale of competitiveness* of Russian technologies, we can distinguish four main groups (Bzhilianskaya, 1991).

The first group comprises technologies that can make breakthroughs on a world scale. Russian space launching technology is a very good example of this group. Space was the top priority within the Russian defence complex - so it was certainly a priority within the economy as a whole. The Russian space industry has long been considered a 'national champion' in the West - after all the word 'sputnik' has been borrowed from Russian by all the major world languages.

In the second group there are technologies that have the potential to occupy a global technological niches. That potential is clearly visible in the sphere of lasers. The world laser market is growing by up to 24% increase a year.[20] And Russian high-quality lasers are substantially cheaper than foreign ones.[21]

The third group includes technologies competitive (according to technical economic parameters) only on the domestic market. Here, Russia is engaged in 'technological catching up'. Under this heading we can list Russian electronics in the aggregate, although

[20]All the data on the world laser market are from *Laser Focus World*, January 1995.
[21]Though as components have become more expensive in Russia, the differential has narrowed. While in 1992-1993 Russian lasers were at least 60-70%, and in some cases 90% cheaper than Western analogues, the difference at the present time is of the order of 30-50%.

microelectronics, avionics, optic electronics and lasers dispose of some types of technology that belong to the second, or even the first group.

The fourth group comprises entirely obsolete and non-competitive technologies. It is striking, and typically post-Soviet, that we can find examples of this group even in the sphere of advanced technologies.

We now present studies of the situation with respect to dual-use technology in relation to two industries:

1 laser technology;

2 space launching.

In the laser industry we find technologies belonging to the second, third and fourth groups, while space launching is clearly a group 1 sector. Thus our two case studies cover the gamut of the scale of competitiveness, as laid out above.

5.2 Marketing possibilities: the laser industry

Russian enterprises produce all kinds of laser products with world market potential. On the other hand, due to the difficulties mentioned above, the situation on the Russian laser market is not so easy. Russian laser sales on that market (which constitute about 85-90% of total Russian laser sales) reached $50m in 1992; but they accounted for only $30m in 1993, and fell further to $10-15m in 1994. Exporting firms do not publish data on laser exports, or on the prices they charge. However, there is evidence of some increase in laser exports (over the period 1992-1994 Russia's sales of laser products abroad amounted to $10m). This in turn gives some grounds for hoping that the trend for Russian laser sales to decrease will be broken sooner or later. At the *Laser 95* international exhibition in Munich alone, Russian firms received orders amounting to $3-3.5m.

The share of Russian lasers in the world laser market is 1% (45% of the world market belongs to the USA, 25% to the Pacific countries and 30% to the European countries). Experts of the Laser Association reckon, on the basis of their estimate of the scientific-technological level of the Russian laser industry, that it could win 10% of the world laser market. Russian lasers for material processing (technological lasers) and medical lasers dominate the domestic market, and stand out as having particularly high international competitive potential. What are the chances of that potential being realised?

According to the forecasts of the experts of the Laser Association, there should have been rapid growth in *technological laser* production capacity in Russia in 1992-95. But this growth has not materialised. In 1992 alone production of technological lasers fell by almost 50%. Lack of solvent demand and defaults (especially on the part of the machine-building industry) prevented any increase in the production of technological lasers through the extension of the domestic market. For example, the stock of technological lasers in the aviation industry decreased by 5 times from the end of the 1980s up to 1994.[22] There can be no doubt as to Russia's basic technological strength in this area. In the sphere of technological lasers, Russia has prototypes that are really better than their foreign analogues, or do not have analogues at all. For example, in 1993 a 'unique' high-powered gas laser was created by the corporation *Russkie Technologii* ('Russian Technologies'). Japanese specialists working in the same field had still not got beyond the drawing-board stage at that time. But the weakness of the domestic market makes it that much more difficult for Russia to break through on the export side.

In contrast, production of *medical lasers* is increasing. Domestic demand is much more buoyant for medical lasers than for technological ones, because the Russian market for medical lasers is not saturated. The demand for medical lasers originates from state clinics (medical lasers are very simple to use, and comparatively inexpensive) and also from private clinics and dentists. The Russian services sector is not in such serious recession as the

[22]Data from V.Blinkov, department chief in the National Institute of Aviation Technology of the RF.

production sphere, and there are many people ('new Russians', so to speak) who are ready to pay a lot of money for good medical services. At the same time, according to Laser Association experts, about 10-15% of Russian medical laser devices are potentially competitive on the foreign market as well.

The combined share of other types of lasers on the Russian market constitutes about 30%. It is impossible to single out any one of these as being of particular importance. Lasers for Inspection, Measurement and Control (IM&C), lasers for telecommunications and optical storage, and lasers for entertainment (laser shows, etc), all have roughly equal shares. Lasers for telecommunications account for 25% of the world market, so there is potential here. But Russian lasers for telecommunications are very much group 3 technologies, and Russia is still very much at the 'technological catching up' stage in this sub-sector. So it is unlikely that she will be able to exploit the potential for increased exports in this sub-sector in the immediate future. In contrast, Russian lasers for IM&C - produced in samples and small batches - are of a high technological level. Though IM&C lasers account for only 4% of the world market, specialisation in this sphere could help Russia to find niche markets in the era of the 'quality revolution'. The prioritisation of the quality problem which transition has imposed on Russian producers has ensured that lasers for IM&C are in high demand on the domestic market. For example, Yuli Kaminsky, the director of one of the most successful Russian firms in this sphere, 'Optcontrol Ltd.', has said that his company obtains enough orders from Russian and CIS customers, and that export orders are a marginal, though welcome, addition.[23] 'Optcontrol', it should be noted, was organised on the basis of a Moscow R&D institute laboratory had been working in the sphere of civil industrial laser devices for 15 years before active conversion began. So here conversion was, to say the least, easy.

As to Russian lasers for military (strictly speaking, dual-use) applications, they are certainly in demand. Worthy of special attention are Russian laser range-finders, and devices and telescopic sights for night and submarine vision. The telescopic sights produced by the

[23]Interview of June 1995.

Russian firm Toorn were appraised by NATO experts at the *Laser 93* exhibition in Munich to be among the best in the world.[24] The success of the firm is underlined by the fact that at *Laser 95* Toorn was one of only seven CIS firms to have its own stand.[25]

5.3 Marketing possibilities: space launching

For decades Russian technology of the space launching has belonged to group 1 on the scale of competitiveness, ie to the leading edge in terms of global technology. From 4 October 1957, when the Soviet Union launched the first sputnik in the world, up to the beginning of 1995, the Soviet Union (and its successor, Russia) launched about 3000 booster rockets. The peak period for the industry was 1981-82, when there were more than 100 launches. In 1991, however, the level of budget financing for the space industry dropped sharply to 37.8% of the 1990 level. In 1992 it fell to just 14% of the already low level of 1991.[26] The situation began to change for the better in the years that followed, and currently there are 40-50 launches a year.

In 1993/94 Russia possessed about 60% of the world capacity for commercial launching, but held only 3% of the world space launch market (54% was controlled by the European Arianespace consortium and 35% by American firms - Lockheed- Martin and McDonnell Douglas.[27] The world market, it seems, is already well and truly carved up, and there is no country (or firm) that wants to leave its 'warm seat'. But there is every reason to believe that the Russian space industry deserves to be admitted to the table. It has a very high level of successful flights. Of 49 space missions Russia launched in 1994, only one failed.[28] In 1995

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[24]Data from the Russian Space Agency. See *Kommersant-Daily*, 26 May 1993; *Moskovskie Novosti*, 11 April, 1993.

[25]However, the results, in terms of orders, of the *Laser 95* exhibition showed that the general demand for devices for night vision has sharply decreased as compared with two years ago.

[26]Data from the Russian Space Agency. See *Kommersant-Daily*, 25 February 1995.

[27]*Business MN*, 31 August 1994.

[28]*Aviation Week & Space Technology*, 16 January 1995.

Russia is planning to execute 45 space missions. For comparison, it is estimated that, if everything turns out well, Arianespace will launch just 10-11 missions in 1995.[29]

Russia's chances of breaking into the world space launching market in a big way are being enhanced by a number of collaborative projects. The international space station Alpha (based on the Russian space station Mir) is being build as a joint operation between the Russian Space Agency (RSA) and NASA. In June 1995 a successful docking of the Russian Mir and the American Atlantis was effected. Within the framework of a special Russia-US cooperative programme of manned space flights, it is planned to carry out at least six more missions involving the docking of Atlantis with Mir.[30] A $215m contract concluded at the beginning of 1995 between the Russian Khrunichev State Space Scientific and Production Centre and NASA for $215m[31] envisages the creation of a functional freight block for an international orbital station. (Khrunichev built Proton, the well-known Russian space rocket).

In the sphere of space launching some specific types of deal have been developing over the last few years that can further help Russia enter the world market. Among these should be specially mentioned:

1 the use of Russian space rockets for the launching of foreign satellites

2 the renting out of Russian satellites to foreign firms, and the creation of joint systems of space communication.

In 1993 the joint venture Lockheed-Khrunichev-Energiya International was founded. (The Energiya corporation built the Russian Buran space shuttle.) This joint venture has already clinched a number of contracts for space launching for the period 1995-99. At the beginning of 1995 Russia launched its first US satellite. Over the period up to 2000, the American Final

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[29]*Aviation Week & Space Technology*, 2 January 1995.
[30]*Aviation Week & Space Technology*, 16 January 1995; *Kommersant-Daily*, 29 June 1995.
[31]*Izvestiya*, 28 January 1995; *Kommersant-Daily*, 11 July 1995.

Analysis Inc. intends to launch 26 satellites on Russian launchers.[32] In the summer of 1995 discussions were held between Khrunichev and Daimler Benz Aerospace (Germany) concerning the possible launching in 1997 of a series of German sputniks with the help of the rocket *Rokot*, a modified version of a combat tactical rocket.

A number of Russian space firms are now re-orienting their activity towards the sphere of satellite communications (the well-known Russian Lavochkin SPA, Avtomatica SPA, etc). Several firms and scientific institutes are co-operating in the field of satellites with the German company Satkon, working on the Courier commercial satellite communications project. The Russian government is a shareholder in the holding company Iridium - a leading creator of satellite communications systems. Joint communications programmes and renting-out of satellites to foreign firms is also a way of obtaining money for the development of the communications industry in Russia itself. According to the estimates of I Tsirlin, the director of Informkosmos (the Russian joint-stock company which unites the best firms working in the sphere of space communications and satellite development), commercial contracts account for 80% of the funding for Russian programmes of satellite communications development.[33] These programmes are also supported by Russian business at large. Commercial funding is supplemented by a special Russian Federal Programme of Satellite Communications Development.

One of the key technological initiatives of the Russian space industry is space launching from submarines or heavy aircraft (without using a spacedrome). In 1994 the Russian space association Ramson formed a joint venture with the American company Sea Launch Investors for the development and commercialisation of this unique technology. The operations of the joint venture were primarily aimed at the utilisation of Russian rockets (produced by the Makeev design bureau) for sea launching. A space consortium involving Energiya (Russia),

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[32] *Kommersant-Daily*, 24 May 1995; *Aviation Week & Space Technology*, 16 and 30 January 1995.
[33] *Izvestiya* (*Finansovye Izvestiya*) 26 May - 1 June 1994.

Boeing (USA), a Norwegian shipbuilding company and a Ukrainian SPA is planning to build a naval rocketdrome to place commercial satellites in orbit.

Among other central trends in the activities of Russian firms engaged in space launching, it is worth mentioning the programme for launching Mars research vehicles within the framework of the *Mars-96* initiative. Russian organisations have also assisted India with the construction of spacedromes, and with space launching itself. There has also been collaboration with Australia.

5.4 Other factors of competitiveness

Our investigations of the factors lying behind the technological achievements and breakthroughs of Russian firms reveal that success is determined not only by objective factors of competitiveness (technological level, availability of skilled cadres etc), but also by subjective ones.

As mentioned several times already, a significant role is played by state support. To this day, approximately 80% of the Russian laser market depends, directly or indirectly, on budget funding. The more successful laser enterprises tend to receive more financial support than the others. Optcontrol, for instance, was created on the basis of an R&D institute which had the status of 'State Scientific Centre', and therefore received regular financial support from the state - even through 1992-1993, which was the worst time for high-tech enterprises.

The refinancing of the space industry effected by the Ministry of Science of the Russian Federation in 1993, which was 48% above plan (and was to the detriment of other industries) seems to have been a sort of endorsement of SPA Energiya on the part of the Russian prime minister. Then, at the end of 1993, seven enterprises of the rocket-space industry were picked out for priority financing. In the main these firms - including Khrunichev, Energiya and Energomash - have subsequently turned out to be the most successful ones.

The 'regional' factor also plays a very significant role. Our investigations show that the situation of high-tech industries in the outlying regions of the country is much worse than in the centre. The enterprises there are 'furthest from the head offices', have weaker networks and fewer opportunities to build networks, and their managers are, as a rule, more conservatively minded. Here is an example: the Omsk (Western Siberia) association Polet, which formerly produced carrier rockets for the Buran, possesses a very high level of space launching technology (their success rate in space launching is 97.8%), and is licensed to carry out satellite launches. But Polet cannot compare with Khrunichev in terms of success in gaining access to the commercial market, and it did not manage to get onto the list of priority space enterprises.

The laser and optics industries did not exist in the Soviet Union as formal organisational structures (there was no single ministry). Only in 1991 did special, united structures aiming to support the industry (the Laser Association, the Optical Society) began to appear. But these were independent, non-governmental organisations, created as a reaction to the imperatives of market economic transition. The Laser Association gives indirect support to firms in establishing marketing ties, finding money for advanced projects. It also plays a significant role as a link between government structures (Gosoboronprom, Ministry of Science, etc) and enterprises.

The 'degree of organisational freedom' of the given company also plays a far from negligible role in relation to its economic and technological development. Private investors have shown substantial interest in the enterprises of the MIC, and the leaders of the space industry have been turned into joint-stock companies. Even the top-secret Energiya was privatised by special permission of the government as early as the summer of 1994.[34] It is now poised to become the nucleus of a future financial-industrial group. Privatisation has had a big impact

[34]Roughly two-thirds of the total number of enterprises in the rocket-space industry are under Gosoboronprom, with the rest under the Russian Space Agency (SPA). Of those under Gosoboronprom, more than three-quarters are in principle permitted to privatise.

on the laser industry as well. Around 160 out of 400 Russian laser firms and organisations are non-state, and about 100 are private enterprises or joint ventures.

6 Conclusions

It would be fair to say that the Russian defence industry as a whole is currently at something of a dead end. Why, indeed, preserve the Russian MIC as it existed during seventy years of socialism? The Russian defence enterprises that possess progressive technology, especially dual-use technology, are the most 'hardy' strains, with the best prospects for Russian technological development. Little by little, these enterprises are learning how to cope with difficulties, how to create collaborative ties and marketing networks with foreign partners (and customers) - and how to make breakthroughs on the world market. Of course, not all Russian high-tech firms will remain active and competitive, and only a few of them will be able to find a stable technological niche in the global market-place. In order to succeed, Russian defence enterprises need to meet the following specific requirements.

- Possession of competitive technology and/or products;
- Access to a broad network of production, technological and economic ties (including international) - and continual search for new ones;
- Possession of competencies in the areas of technology assessment and innovation management, and a sound grasp of international procedures and laws in the field of marketing of high tech and innovation.

Whether a given Russian firm is successful or not will be critically dependent, not only on its technological advantages and the capabilities of its managers, but on the 'wisdom' of the government as well. The new Russian *Dual-Use Technology* programme may, with its special emphasis on electronics, turn out to be a very fruitful one - or it may turn out to be another ineffectual political campaign, like Gorbachev's 'acceleration' at the end of the 1980s and the 'pots and pans conversion' at the beginning of the 1990s. My own view is that, if Russian political reform continues, sensible economic policies will emerge. On this basis I believe that Russian high-tech firms will survive and develop - and that some of them will manage to make a real impression on the world market, and develop into key players on a global scale.

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