Feasibility Study:

Armenian Scientific R&D Laboratory

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Contents

1.0 Introduction

The main objective of this feasibility study is to determine whether there is enough critical mass in what remains of the Soviet Armenian scientific R&D sector to reestablish itself today, minimally as a derivative, which has existed up until the early 1990s. I have used a qualitative methodology to determine the availability of professionals in fields which are related to specific R&D sector. The methodology includes targeted interviews, which aims to determine what technologies existed a generation ago in Armenia and if the technical expertise that still exists can still fit the requirements of today's research laboratory requirements. At the same time, it must be determined if the skill set of these last-generation scientists and engineering experts is viable in terms of physical abilities as many of these experts are aging. The professions I have investigated are physicists, chemists, radio-physicists, control system experts, nuclear scientists, biologists, optics and laser specialists, geneticists, and many others.

In this paper I will try to determine whether it is possible to put together a critical mass of scientists who can develop new technologies, systems, machinery and other similar developments for special purposes which are competitive in the modern world. According to Pisano (2012), to successfully accomplish the idea, we need to decide on four main strategic levels: architecture, people, portfolio and processes. With regards to high-level strategy, we need to accomplish three stages: find, identify scientists and their expertise, secure projects, and finally secure minimal financing.

2.0 Armenia SSR R&D Capability Historical Overview

The Armenian Soviet Socialist Republic had an abundance of extremely capable mathematicians and researchers from early 1950s throughout the early 1990s. For example, the first mass produced Soviet digital electronic computer “M-3” was created in 1953 at the PI AS USSR[1]. The “M-3” was relatively small, but universal digital computer for scientific calculations. It was widely used for integrating simple differential equations and equations in partial derivatives (linear and non-linear), solving of systems of linear equations with many unknowns, and solving algebraic and transcendental equations, and similar. This computer was pure “improvisation” not made according to any institute's plan. The project has not received any financial support, and its future was not clear. Only three prototypes of the “M-3” were built. The very first “M-3” remained at the A.G. Iosifyan's SRIEI[2], another was given to the design bureau of academician S.P. Korolev (for space researches), and the third one was sent to the Yerevan Institute of Mathematics (AS Armenian SSR) to its director academician Sergey Mergelyan (Рогачёв, 2008; Белынский et al., 1957; Нитусов, 2008).

Things turned serious in 1960 when Sergey Mergelyan designed first Armenian computer and the first semiconductor computer in the USSR “HRAZDAN” which was inspired by the “M-3” prototype which the “Mergelyan's institute” developed very intensively.

A new machine followed, based on Mergelyan's HRAZDAN, called the “HRAZDAN-2” was broadly used in scientific researches and in producing industry. In 1965 the next modification –

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[1] Physical Institute of Academy of Sciences of USSR
[2] Scientific Research Institute of Electrotechnical Industry

"HRAZDAN-3" was put into operation. Later on, one of the "HRAZDAN-3" implementations were named the "Marshrut-1" which was a computational complex system for automated booking-office operations on rail-junctions, produced at the YerSRIMM[3]. This system was also used many years at some railway stations of in the city of Moscow. The group of scientists and designers of "Marshrut-1" were awarded Armenia's state premiums (Nitusov, n.d.)

Throughout the seventies, the YerSRIMM had various models of the multipurpose machine NAIRI (NAIRI-1, NAIRI-2, NAIRI-3, NAIRI- 3.1, NAIRI-3.2, NAIRI-3.3, NAIRI-4, NAIRI-4.ARM). "NAIRI" was intended for solving various scientific, engineering and economic problems. The main particularity of machines NAIRI are - possibility to formulate the problems in terms similar to simple mathematical language and principle of multiprogramming. The main advantages of NAIRI family were: friendly interface, primitive networking (with the computer) in a language similar to the common mathematical one, and the principles of microprogramming which were widely in use at the time. In a further continuation of the NAIRI in the 1980s, the family was enhanced with multicomputer and multiprocessor complexes and known as NAIRI-4V, NAIRI-4VS and "COVIOR." NAIRI computers were program compatible in operating system level with the famous series of machines PDP (PDP-11/40, PDP-11/44) of DEC company. For these series of NAIRI machines, the Institute was awarded the State Prize of USSR.

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[3] Yerevan Scientific Research Institute of Mathematical Machines

Based on the well-deserved recognition of the Mergelyan Institute, work began on the creation of a series of middle-class machines ES-1030, ES-1045, ES-1046 and multiprocessor complexes. These computers were architecturally and program compatible with the famous IBM-360 and IBM-370 series of IBM Mainframes. In the late 1980s these computers found wide applications in science, industry and have been installed in many organizations of former USSR. For the ES-1045 and ES-1046 versions, more than 5000 machines were produced and installed in various organizations. For these accomplishments, members of Institute staff were awarded by State Prizes of Armenian SSR and USSR, Lenin Prize of USSR, Orders, and Medals of USSR.

The design and development of hardware and software for global (territorial) ACS[4] was a new direction of development for the Institute in the early '70s and became an important landmark in its history. ACS required to design and develop highly reliable real-time computing complexes (SVK, SEVAN), real-time operating systems and large application software of high reliability. Before the disintegration of the USSR, the Mergelyan Institute was one of the leading scientific research organizations in the field of computer machinery and ACS. Based on the scientific direction and practical activities of specific departments of the YerSRIMM, in 1992 YerACSSRI[5] was formed. YerACSSRI was engaged in the development of highly reliable, high-performance computers and complexes, including their operational systems, data transfer in global networks with the usage of the special transfer protocols, and development of applied software. Since the end of the ’80s, the team developed large software packages and applications

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[4] Automated Control System
[5] Yerevan Automated Control Systems Scientific Research Institute

automated control systems in modern computing environments, operation systems, and database control systems.

During the late 80s and early 90s YerSRIMM/YerACSSRI was engaged in the creation of special purpose ACS, including development of different software packages, drivers and blocks of exchange for special means, software packages of data transfer and application software for the ACS in Windows NT and (later) Linux environments with usage of C ++ and Visual C ++ programming languages.

2.1 Current Research & Development Sector in Armenia

International companies such as IBM have minimum thresholds for acceptable profit margins. For IBM, the number is around 30%. If the company did not gain 30% of profits from the project, the project would be rejected. Thus said, Armenia has a huge potential in receiving projects due to substantially lower costs. For example, the average salary of scientists in U.S.A. is about $100,000, and in Armenia it varies from $12,000 to $24,000, thus making costs lower and profit margins higher. Accordingly, if the company wouldn't invest in such project in U.S.A. - Armenian laboratory, due to lower costs, can bring such projects into life.

In Armenia, there was an abrupt discontinuity of scientist and engineering generation. There are many reasons why reestablishment should happen soon. Most of the scientists who have practical experience of working on projects are aging which causes issues such as memory or skill loss or even death. According to Vardan Sahakian number of Researchers and Technicians in R&D have decreased by 25% reaching from 5,671 to 4,234 people during 2008-2013 (Sahakian, 2015).

Table 1 Number of Employees

	Researchers and Technicians	Support personnel	Other	Total
2008	5,671	768	460	6,899
2009	5,895	614	417	6,926
2010	5,460	672	426	6,558
2011	4,748	566	404	5,718
2012	4,421	556	621	5,598
2013	4,234	605	391	5,230

3.0 Research Methodologies and Results

During the Soviet Union, all scientists were heavily monitored by KGB and people were afraid to talk about anything related to their projects (Soviet Dissident Scientist Goes To Tbilisi, 1975; Birstein, 2004). After the collapse of the Soviet Union, few specialists remained in Armenia with most of them moving to the United States, Russia, and relatively small part went to Europe as most state-initiated programs collapsed. This phenomenon is also known as brain drain, many people with higher education, especially engineers and scientists leaving Armenia. “During 1989-2001 from 250,000 to 300,000 professionals with higher and postgraduate education left the country. According to some estimates about 1/3 of the specialists in engineering and sciences left the country during 1991- 1997” (Yeghiazaryan et al., 2003). Even considering that the Soviet

KGB is not monitoring scientists anymore, scientists who worked during Soviet times are intensely afraid to give any type of information to anyone, as their perception is that the KGB will come after them. Thus, a specific methodology requiring a thoroughly polished approach was developed to extract the necessary information from them. Most effective approach is to conduct deep interviews. The questionnaire I have created aims to extract the maximum information with less possible questions.

1) Name and contact information.
2) Educational background.
3) What is your current workplace and position?
4) Where did you work?
5) What was your position?
6) What is your specialty? Be as specific as possible
7) Who was your manager, is that person still around?
8) What projects did you work on and how successful was it as it moved to practical implementation?
9) Do you have any documentation or notes on your projects or specialty?
10) How well do you remember your projects, work, or specialty? How much time would you need to get back?
11) Who else do you know who you worked with, worked for, or worked under who have impressive responses?

To receive such information, I used psychological (echo effect), emotional (mirror effect) and gesticulation (body language) methods to convince interviewers that I am a trustful person and enabling them to freely and without anxiety to provide the necessary information (Pease A. & Pease B., 2004; Kulesza et al., 2013).

Interviews were conducted with 23 people who have participated in various projects from the early 1980s to early 1990s. Specialists whom I have interviewed were working at the Mergelyan Institute, Yerevan Physics Institute, and National Academy of Sciences of the Republic of Armenia during the required period. All specialists have practical knowledge and experience either in Radio-physics, Chemistry, Biology, Nuclear Engineering and in the development of Automated Control Systems, and others. Much of these technologies were associated with the Soviet military, making them state-of-the-art at that time. Many basic principles known at that time have not changed, only their implementation. This means that even though the people are a generation late, there may be enough critical mass of experts whose capabilities are still needed by western research facilities outside of Armenia at a fraction of their normal cost. Also, the last generation of experts can mentor a new generation of young Armenian experts. The Specialty Count graph demonstrates how many professionals from which field I was able to find in Armenia. Least being a programmer and most being mathematicians and physicists. These experts are still live in Armenia and are still capable and interested in being actively engaged in reestablishment of such scientific R&D laboratory. Motives of this people are connected with two main causes. First is the most obvious part: the money. Most of this people do not work on in their profession. Second reason is purely patriotic. This people understand that it would be a lot harder to reestablish something like this years later, as younger generations would lack the experience they have, thus they are very positive about this initiative.

To understand which type of projects possible to accomplish with such expertise, I have created bar (Table 2) and radar (Table 3) graphs to visually assist the distribution.

Table 2 Specialty Count

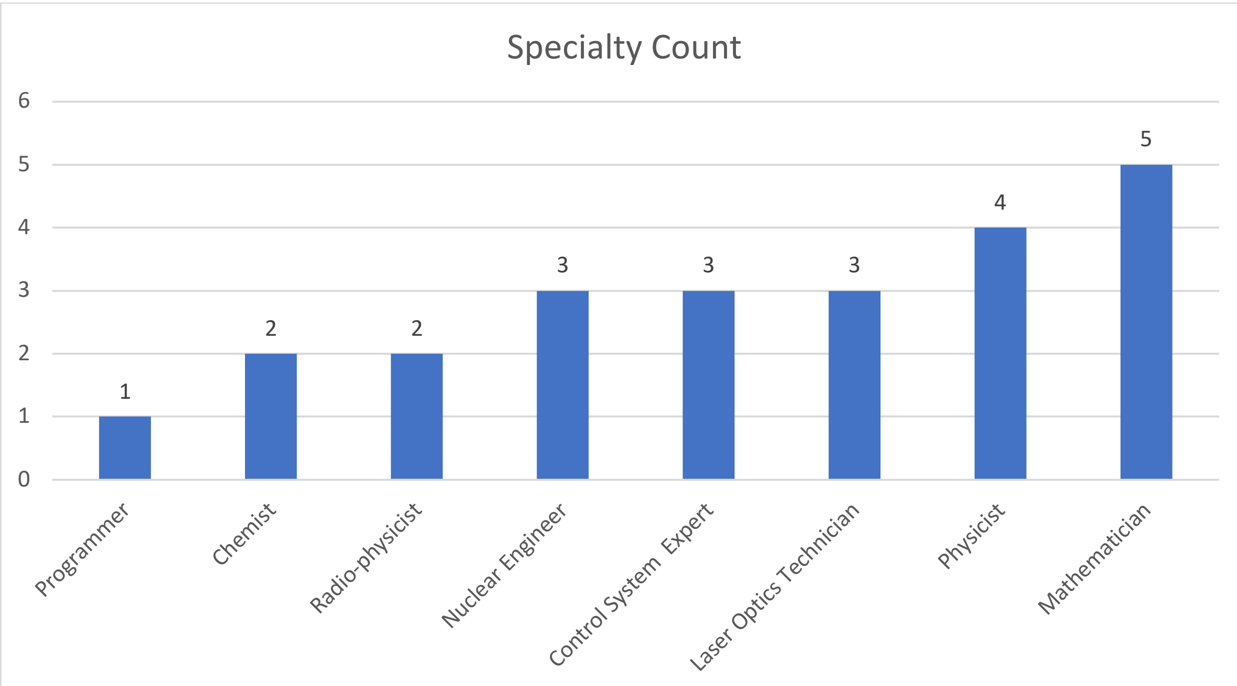
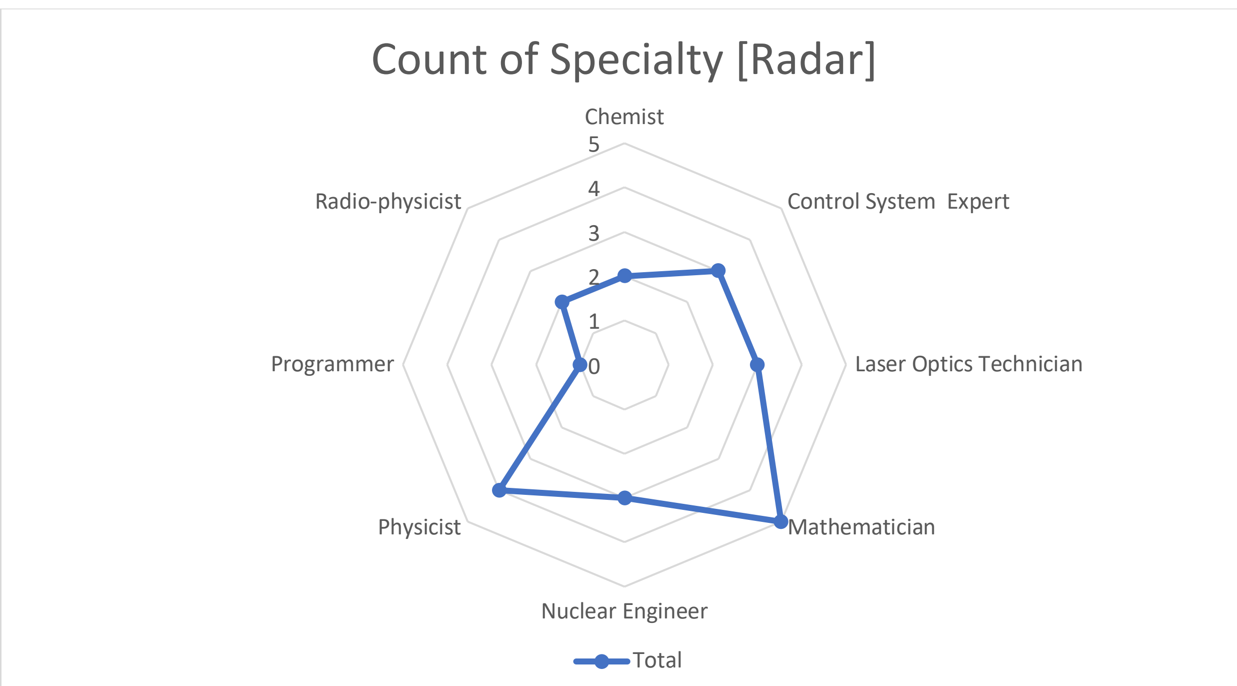
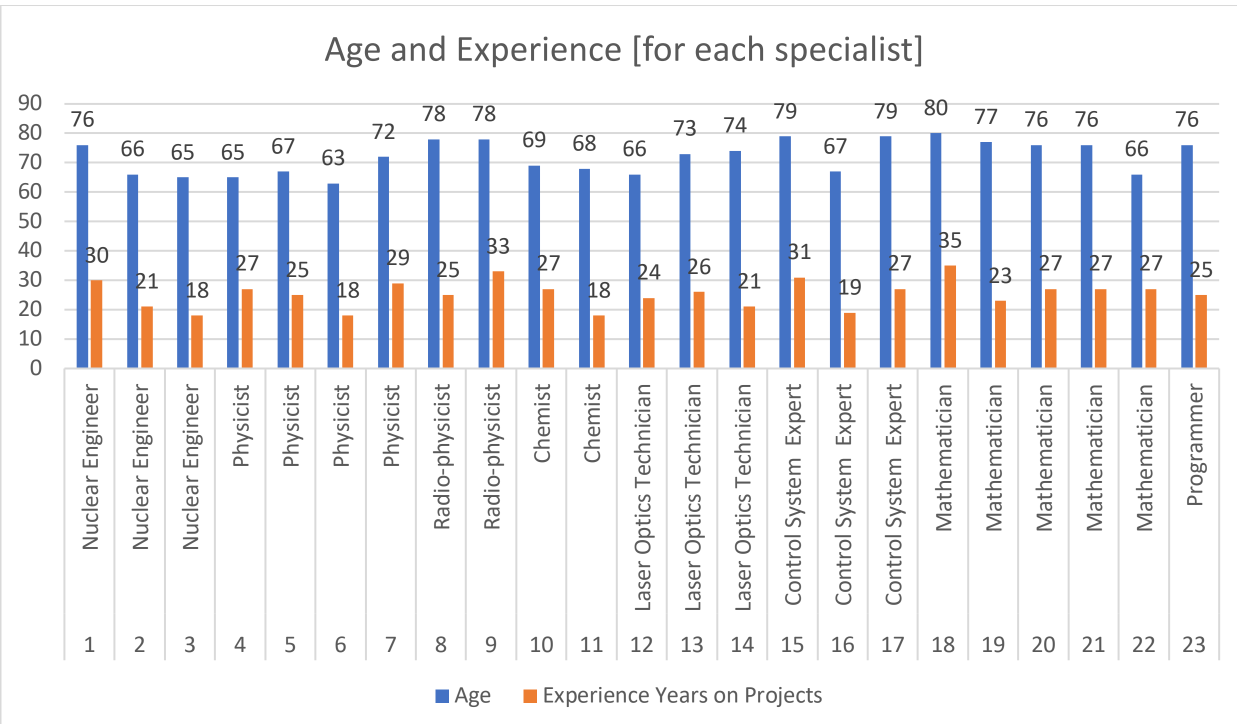


Table 3 Count of Specialty [Radar]



Analyzing the graph, we can notice that it is skewed towards CSE[6], LOT[7], Math, NE [8]and PS [9] directions. Thus, it would be preferable to receive projects such as the development of a semiconductor architecture, an automated control system, a nuclear power plant system, and advanced military technologies.

Table 4 Age and Experience [for each specialist]



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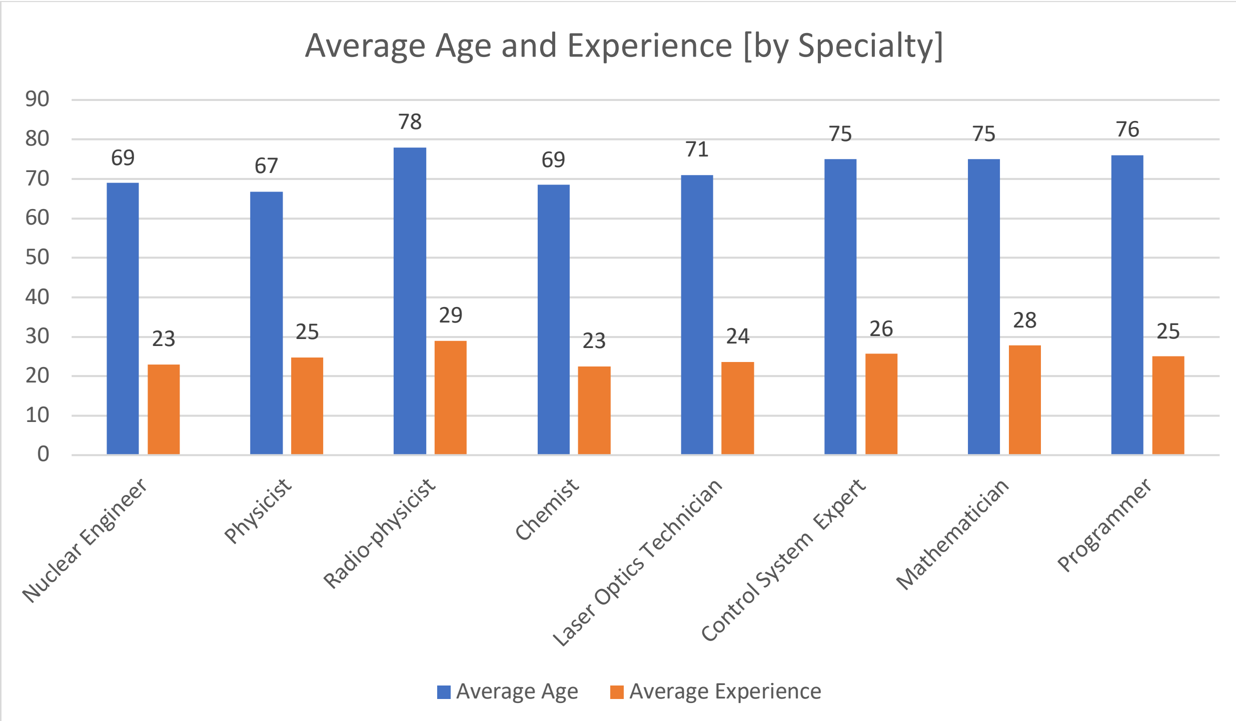
[6] Control System Expert
[7] Laser Optics Technician
[8] Nuclear Engineer
[9] Physicist

Table 5 Average Age and Experience [by Specialty]



It is clear from the collected statistics that we have aging expertise, but the years of practical experience is impressive. As more and more young college graduates are being engaged in start-ups, addressing business issues and the competitive environment pressure is being put on the pure sciences. This issue is not only referring to developed countries but also to developing, as the pressure to “make a living” is not a given, especially in the post-Soviet space. As less demand and emphasis is placed on continued education, the role of those who were in a position of advanced R&D based on an advanced degree is becoming rarer. There are three general types of knowledge experienced scientists may possess:

1. **Specific knowledge:** specific expertise or skills, such as understanding a critical legacy database. Experienced experts have actually made products or discoveries that have been tried and tested in the marketplace or battlefield. Many laboratories keep their best-

experienced workers, at a minimum in consulting positions, since they, in many cases, posses the ability to understand the broader big-picture – an unknown to young up and coming experts. Moreover, if nothing else the mature researcher known not to go down "rat holes" of endeavors that might seem promising but has been attempted earlier. R&D failures are certainly not as documented as successful ones. Just as nothing can replace persistence, little replaces experience

2. **Social knowledge:** relationships between people, such as the networks cultivated by senior leaders. understanding the way things actually get done in an organization, such as how to quickly find the right person to answer an important question. There is a reason why diplomats are rarely under 50 years old.
3. **Cultural knowledge:** is crucial part of the cultural competence. People often focus on culture specific information when they interact, thus this knowledge can be useful in a specific situation, however it is not necessarily transferable to other cultures. Cultural knowledge provides a way of understanding the difficulties which can occure due to country specific habits such as mistrust, minformation, exaggeration and etc.

After consulting with specialists from multiple international companies I have estimated three scenarios for a research laboratory, scenarios being: Worst, Best, and Moderate. Each scenario has a specific number of scientists required to start the company which is povided in Table 6. During the initial research phase, I identified twenty-three specialists which if we distribute across specialty we will get the satisfaction rates for each scenario. Thus, calculating the satisfaction rate I received 94% for Worst, 64% for Moderate and 43% satisfaction rate for the Best scenario.

Table 6 Scientists Required [by Scenario]

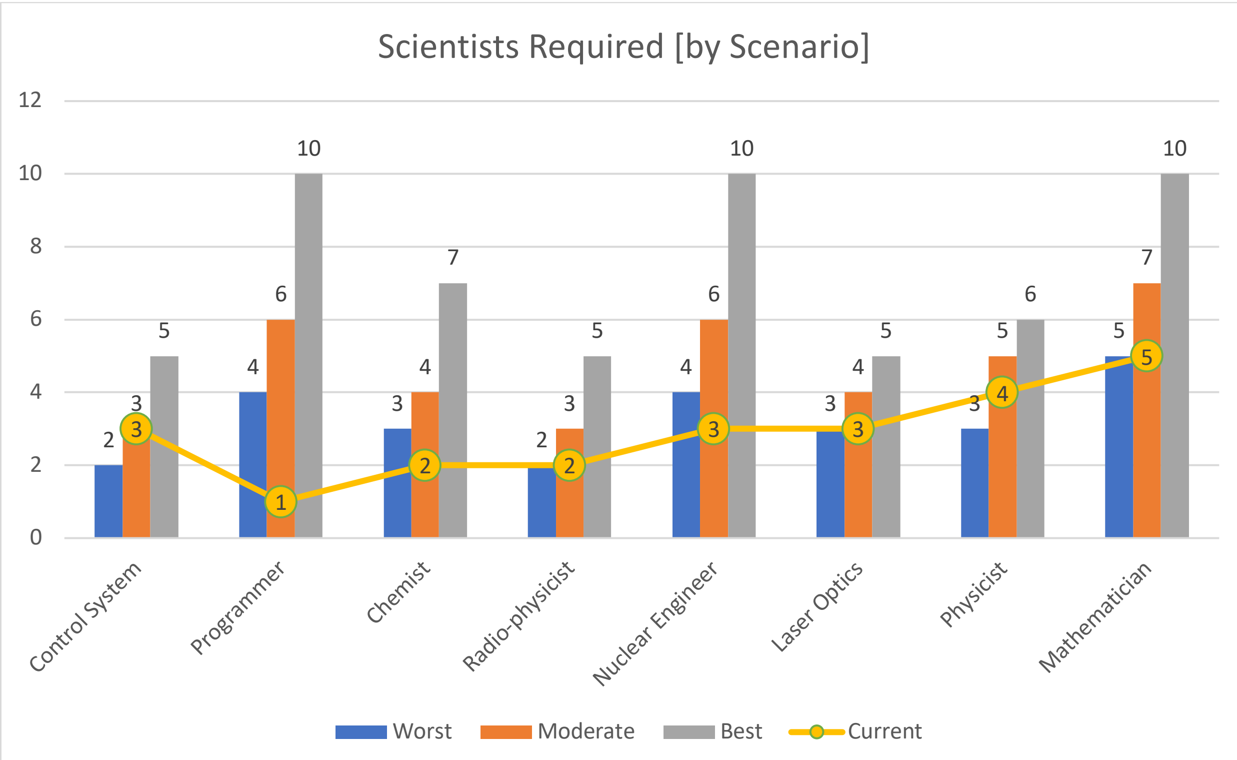


Table 6, as well as, Table 8, Table 9 and Table 10 have been developed with the help of two professionals from IBM company, however they wished to stay anonymous.

4.0 Reconstituted R&D Organizational Structure and Personnel Criteria

To operate such a complex organization, one needs the appropriate people and an organizational structure. Starting with people: I have noticed that the most effective way is to find scientists is through personal connections a.k.a.[10] Networking, however, there are also multiple databases which mention names of the scientists who worked on certain projects during Soviet times. The networks in Armenia are a crucial component in finding people or information. In our case, I was

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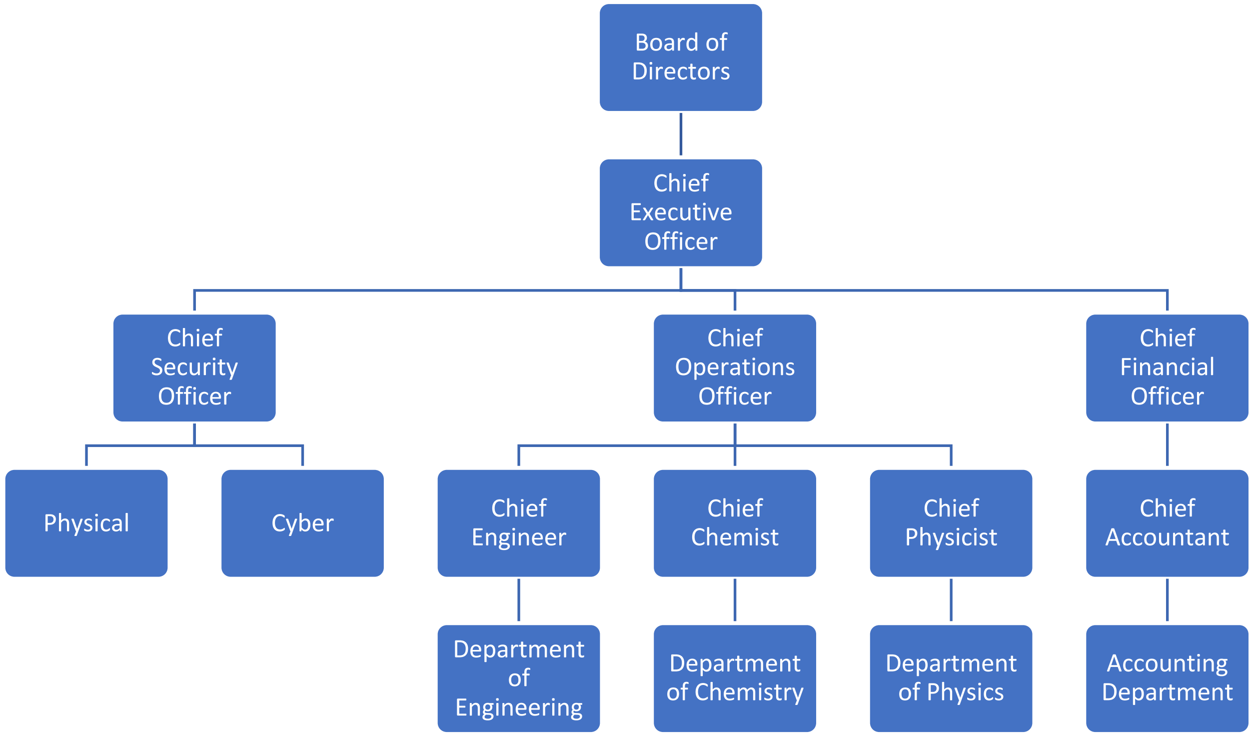
[10] As known as

able to find multiple archived documents from government security service providers, which greatly increased the number of potential employees.

The architecture of the organization is the highest level which can significantly vary from company to company. Analyzing the pros and cons of the geographical location the company should be centralized, small to medium-sized, focused on technology rather than market and for sure outsourcing all of its projects (Pisano, 2012). Looking from the other side of the coin we might conclude that a decentralized laboratory strategy would mean higher costs, more risk of information leakage and harder communication between different departments. Big enterprises require huge investments and a good company portfolio, which we will take a closer look further in our observation. Focusing on outsourcing by specialty is the only way the company can operate because Armenia lacks local investments in R&D sectors. Due to a shortage of various scientists, we can only target via technology. During the first couple of years due to the lack of a good portfolio and unproven track record, the organization cannot develop projects of high complexity. Thus, it can be only established as small or medium sized. For the very same reasons, the Processes should be carried out in a highly structured way thus the Organizational Structure should be established as a Divisional Structure (Lumen Learning, 2018).

After the start-up phase, the company can move from structured to more flexible strategy which will allow executing more complex and more valuable projects.

Table 7 Proposed Organizational Structure



People: it is tough to find the balance between generalists and specialists, both are very important while developing new technologies, however, we identified that during the first couple of years we need to rely on specialists and later on increase the number of generalists for accomplishing more complex projects. The primary personnel should have at least six years of practical experience in the project(s). Nowadays most of the scientists are specializing on writing research papers and theoretical concept generations. Thus, those scientists will have a higher probability of making mistakes and will work less efficiently as they will need more time to do the same job as the scientist with practical experience. The inefficiency of "theoretical" scientists will cause higher costs for the laboratory and eventually the project will fail to operate further. The last section is the Portfolio. All the levels mentioned above aim to improve the portfolio. I have already contacted many big corporations in Europe and the U.S.A. which are leading companies in the R&D sector, to receive preliminary agreement on having a project. The contacted companies include IBM, Alphabet, Boeing, and others.

5.0 Security, Legal, and Financial

An R&D laboratory is a risky endeavor with an undefined probability of success; thus, company's legal structure should be defined as a Limited Liability Company, in order to avoid possible legal issues regarding secondary liabilities resulting from alternative uses of R&D subsequently developed.

For financial projections, I have estimated the initial finances required to establish and run the company for one year. Calculations were done for each of the before mentioned scenarios: Worst, Moderate and Best. Estimations were done with the help of financial specialists from IBM.

Table 8 Worst Scenario

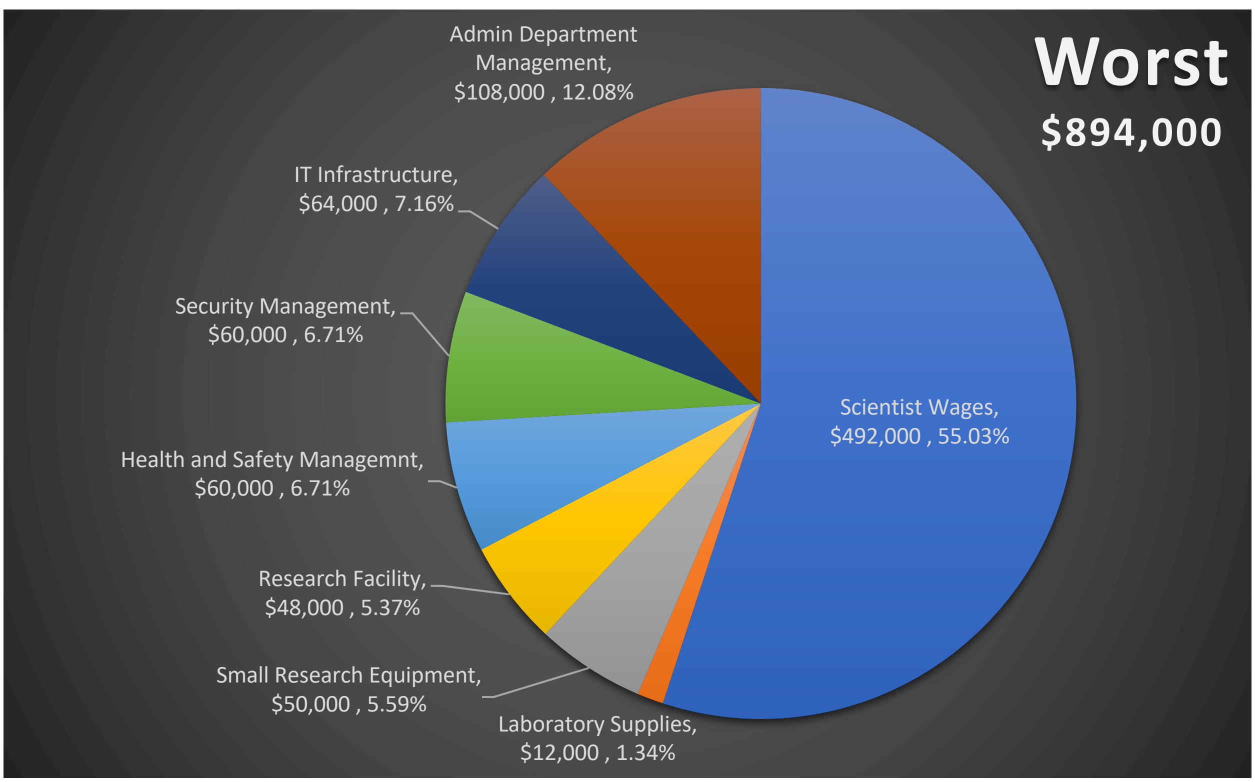


Table 9 Moderate Scenario

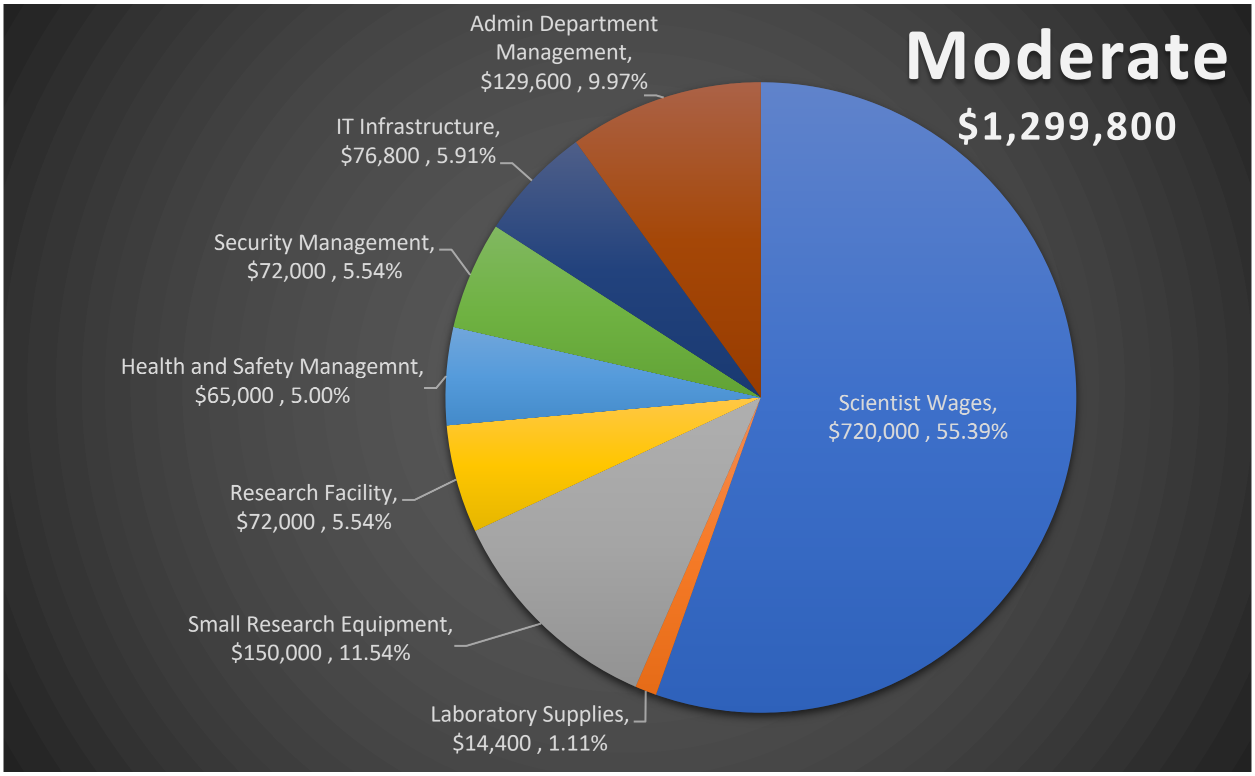
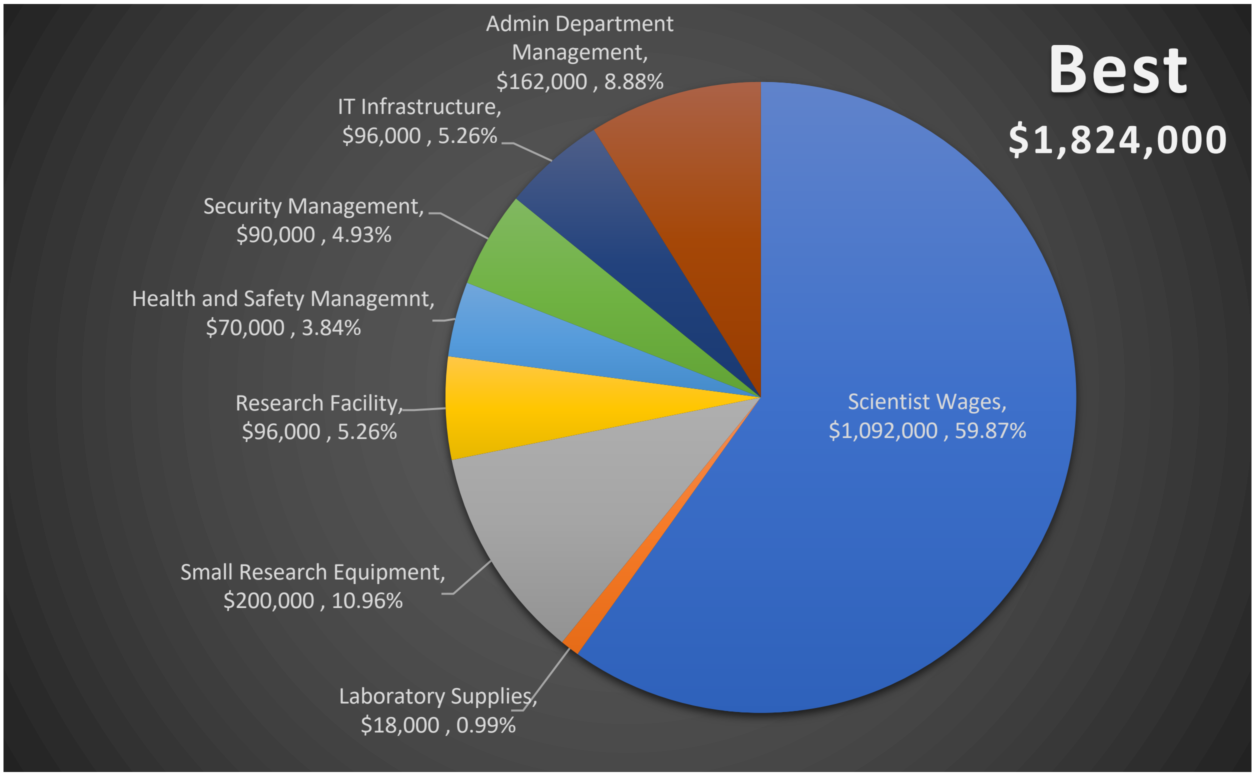


Table 10 Best Scenario



Assuming only the wages for scientists in the U.S.A. we will require around $2,600,000 for Worst (26 scientists), $3,800,000 for Moderate (38 scientists) and $5,800,000 for Best (58 scientists) scenarios.

6.0 Conclusion

It was a tremendous loss for the future of Armenia and its integration into the world infrastructure that it allowed such tremendous national treasure; state-of-the-art expertise in the form of multiple thousands of highly educated scientists, to dissolve away. The clock cannot be turned back, but an attempt will be made to determine if a critical mass of this remaining expertise can be harnessed to both fulfill research requirements of existing international laboratories and pass the touch to the next generations of scientists and engineers.

I know of two attempts at organizing small R&D centers in Armenia under the auspicious of two large IT companies in the United States. One was Sun Microsystems and the other IBM. Both failed because it was attempted by remote control with no local (Armenian) support.

Note, what is being proposed is not an extension of an existing firm simply looking for cheap labor, such as large-cap firms searching in places such as Ireland, Romania, or India for cheap labor.

The research showed that it is feasible to establish a small scientific research and development laboratory in Armenia, however as the average lifetime expectancy in Armenia is almost 75 years, one should hurry to execute the reestablishment of the laboratory, as most of the scientists are nearly 80 years old (IndexMundi, 2018).

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Hereby I confirm that this work can be posted in library databases.