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An Estimation of R&D Manpower Requirement and the Relevant Graduate Program for the Telecommunication Industry †

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요 약

정보통신 산업은 괄목할 만한 성장을 보였으며, 정보산업시대의 핵심 육성 부문으로 지목되고 있다. 본 연구에서는 통신산업분야의 정책부서, 연구소, 기업 및 대학에서 활약하고 있는 70명의 정보통신분야 전문가들을 대상으로 설문조사를 시행하였으며, 설문조사 결과를 토대로 정보통신산업의 잠재적 수요예측과 함께 이러한 수요를 공급하기 위하여 선행되어야 할 연구개발 인력의 수요를 추정하였다.

본 연구결과에 따르면, 정보통신산업은 1991년에 Data Communication 분야에서만 약 48억불의 수요를 유발할 것으로 보이며, 이를 위한 박사 인력의 년간 수요는 1987년에는 500명, 1991년에는 990명에 이를 것으로 예상되었다.

반면, 최근 문교부에 제출된 바 있는 한 연구보고에 따르면, 88명－145명에 지나지 않은 것으로 나타나고 있어 심각한 고급인력의 수급난이 예상된다.

이에 따라 본 연구에서는 정부, 산업체 및 대학이 시급히 수립하여야 할 대응책을 제시하였다.

－정부가 지원할 내용으로서, 정보통신분야의 연구개발을 위한 관련학과 교수의 양적, 질적 향상이 요구되며 이를 위한 방안으로 교수진의 critical mass 형성이 촉구되었다.

－산업계 역시 통신산업의 폭발적 성장에 대비하기 위하여, 고급인력의 수혜기관의 입장에서 고급인력의 공급을 위한 대응책 마련에 적극적으로 참여하여야 할 것이다. 산업계의 참여방안으로서, 교수 1인, 박사 후보생 1인, 석사과정 학생 3인을 한 단위로 하는 "research unit"의 형성과 산업계로부터 이들을 위한 지원이 제안되었다.

즉, research unit 100개를 지원하기 위해 산업계는 연간 약380만불의 교육－연구비를 투입하며, 이러한 지원을 통하여 박사인력의 공급이 배가 될 것으로 예상된다.

－대학원 교육의 질적 향상과 함께 산·학 연계 기능을 강화하기 위하여, 정보통신 관련학과와 대학원 교과과정의 개선 방안이 구체적으로 제안되었다.

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부서, 산업계, 학계의 요구사항과 전문가 의견을 토대로 요약되었으므로, 제안사항의 체계적인 보완이 이루어지면 그 효과가 지대할 것으로 예상된다.

1. Introduction

The Korean government, Ministry of Communications and Korean Telecommunication Authority have been promoting numerous successful projects for modernization of telecommunication services as well as expansion of existing facilities. Ambitious plans for new services, equally attentive government support, plus the timely events such as Asian Games(1986) and the Olympiad(1988) have been harmoniously contributing to the swift, unforeseen telecommunication development in Korea.

Recently, however, with the bulk announcement of new services by the government and with the severe competition in the international market, this protected growth of telecommunication industry is constantly threatened. The Industry is abruptly exposed to an environment with poses new phenomena such as R & D, high technology and international collaboration. It has to cope with both the urgent requirement of high technology and the controlled ration of major technology from developed countries.

On top of these, as computer and communication technologies are rapidly merging, the industry not only has to expand the existing facility but has to develop the dual technology of telecommunication. Thus, simply stated, the telecommunication industry is on the verge of a major transformation.

The nature of this transformation can be summarized by

- the complexity and sensitivity of industrial taxonomy which stems both from the dichotomous nature of technology, i.e. computer and communication or analog and digital, and from the increasing protectionism,
- the ever increasing demand of R & D and high-quality manpower,
- the need of a more relevant graduate program in order to meet both volume and quality of manpower requirement.

The purpose of the study is to:

- identify the current assessment of the telecommunication service in Korea,
- estimate projected growth of telecommunication industry,
- estimate R & D manpower requirement in order to cope with the projected growth,
- develop recommendations for a graduate program.

2. Methods of Approach

Telecommunication industry, and therefore the manpower requirement, is a broad term pertaining to entities such as technology, equipment and services(Figure-1), user, vendor and government. Since the purpose of the study was to estimate manpower requirement, the study emphasized:

- in-depth analysis of government policy,

– tailored questionnaire survey,
– structural method of estimation, and
– priority of recommendations both for manpower supply and for graduate program.

The above principles were emphasized throughout the following steps of the study.

2.1 Literature Survey

About 350 related literatures were carefully studied and statistics and facts were classified and stored in diskettes. Special attention was paid to government policy, manufacturing statistics and long term plan.
Facts and figures of other countries were also collected. These countries include United States, United Kingdom, Canada, Japan, France, West Germany, Taiwan and Hong Kong.

2.2 Questionnaire Design

Three open-ended questionnaire formats were developed.

Format-1 was designed, aiming top managers and research engineers, to collect expert opinions on manufacturing status. Contents included technology level, R & D, technology import/joint venture, long term plan & critics and suggestions both to government and to university.

Format-2 was designed for high level technocrats, policy/planning personnel, university professors and researchers in national institutes.
A focus was geared to long term service plan, promotion strategy, national R & D plan, regulation and suggestions to manufacturers.

Format-3 was developed to further clarify any ambiguity existing in the response of the other two formats. Also, personal comments which may not be expressed in explicit written terms were discussed. Major contents included policy, criticisms to current service, desirable list of new services, comments on R & D and high-quality manpower supply plan.

The multi-dimensional nature of telecommunication service requires a questionnaire to include multiple attributes. From the literature survey, it was found out that related attributes and their interlocking relationships can be described by adopting six major groups of entities;

– government policy
– technology
– demand
– supply
– market and
– environment(see Tables 1 and 2)

The summary structure of the three formats is shown in Table-1. An example of the hierarchical nature of the questionnaire(government policy) is depicted in Table-2.
The questionnaire was disseminated to 73 expert and 96% of them(70) responded as shown in Table-3.

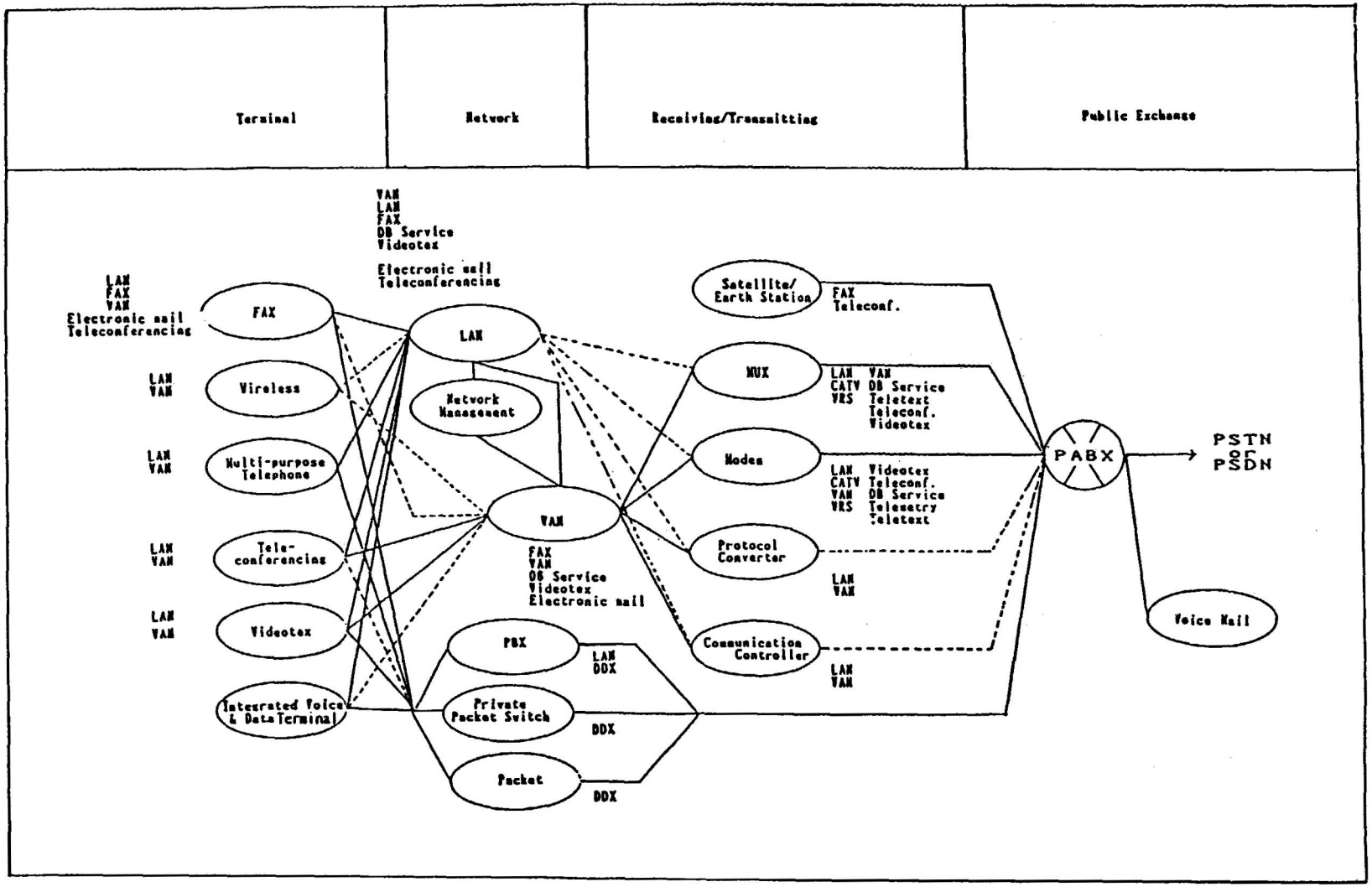

Figure-1. Functional Relationship among Equipment/Services

Table—1. Summary of Questionnaire Taxonomy

(unit:No. of Questions)

	Format 1	Format 2	Format 3	Total
Government policy	12	15	18	45
Technology	4	2	1	7
Demand	4	5	2	11
Supply	10	28	25	63
Market	13	18	11	42
Environment	0	0	12	12
Total	43	68	69	180

(Some questions were asked repeatedly in Format 1, 2 and 3)

Table—2. Hierarchy of Questionnaire Structure-Government Policy

〈POLICY〉

Subject	Nature	Related Question	Q-Form No.	No.	Nature of Response		
					Assessment	Projection	Potential Demand
Plan	R & D	R&D in University	1.	2-4	0		
		Status of Equipment Industry	1.	3-1	0		0
		Need of Government Support	2.	2-4	0	0	
		Promotion of Industry	1.	2-5		0	
		Promotion of Equipment	1.	3-2		0	
		Promotion of Service	1.	4-1		0	
		Priority of Activities	2.	2-3	0		
	Technology (Equipment / Service)	R&D in University	1.	2-4	0		
		Status of Equipment Industry	1.	3-1	0		0
		ISDN - Prospect	2.	2-1	0		
		Tax & Tariff	2.	2-8	0		
		Missing Eq. in Plan	2.	3-4	0		0
		Missing Ser. in the Gov't Plan	2.	4-5			0
		Strategic Equipment	2.	5-1		0	0
		Status of Service Deployment	3.	2-1		0	0
		Government Support - R & D	1.	2-1		0	
		Promotion of Equipment	1.	3-2		0	
		Promotion of Service	1.	4-1		0	
		Priority of Activities	2.	2-3	0		
	Manpower	Role of University	1.	2-3	0		
		Role of University	1.	2-3	0		
		Status of Equipment Industry	1.	3-1	0		0
		Promotion of Industry	1.	2-5		0	
		Promotion of Equipment	1.	3-2		0	
		Promotion of Service	1.	4-1		0	
		ISDN - Prospect	2.	2-1	0		
		Priority of Activities	2.	2-3	0		
	Budget	Budget	2.	2-5		0	
		Resource Allocation	2.	2-6		0	
		ISDN - Prospect	2.	2-1	0		
	Facilities	Government Support - R & D	1.	2-1		0	
		Promotion of Equipment	1.	3-2		0	
		Promotion of Service	1.	4-1		0	
		Priority of Activities	2.	2-3	0		
Policy	Regulation		2.	2-2		0	
		Government Regulation	2.	2-7		0	
		Government Support - R & D	1.	2-1		0	
		Promotion of Service	1.	4-1		0	
		Priority of Activities	2.	2-3	0		
	Tax & Tariff		2.	2-2		0	
		Government Regulation	2.	2-7		0	
		Tax & Tariff	2.	2-8	0	0	
		Charge Rate of New Service	2.	4-7		0	
		Government Support - R & D	1.	2-1		0	
		Promotion of Service	1.	4-1		0	
		Priority of Activities	2.	2-3	0		
	Gov't Support	Promotion of Industry	1.	2-5		0	
			1.	6-4			0
		Strategic Equipment	2.	5-1		0	0
			1.	7-1	0	0	
		Recommendation	2.	6-1	0	0	
		ISDN - Prospect	2.	2-1		0	
		Government Regulation	2.	2-2		0	
		Resource Allocation	2.	2-6		0	
		Suggestions for Future Plan	2.	4-1		0	0
		Modification of Gov't Plan	2.	4-6		0	
		Missing Eq. in Plan	2.	3-4	0		
		Missing Ser. in the Gov't Plan	2.	4-5	0		
		Government Support - R & D	1.	2-1		0	
		Promotion of Industry	1.	2-5		0	
		Promotion of Equipment	1.	3-2		0	
		Promotion of Service	1.	4-1		0	
		Priority of Activities	2.	2-3	0		
	Strategic R & D	Government Support - R & D	1.	2-1		0	
		Role of University	1.	2-3	0		
		R & D in University	1.	2-4	0	0	
		Promotion of Industry	1.	2-5		0	
		R & D Need - Government Support	2.	2-4	0	0	
	Organizations	Government Regulation	1.	2-2		0	
			1.	7-1	0	0	
		Recommendation	2.	6-1	0	0	
		Gov't Affiliated Org'n	2.	2-9		0	
		Enhancement of Role Function	2.	2-10		0	

Table—3. Summary of Survey Responses

Questionnaire	Target Subject	Period	Number Disseminated	Number Collected
Format-1	• Top Executives, Directors, Managers and Research Engineers in Manufacturing Organization. • University Professors	Aug. 5, 1986	32	31
Format-2	• Technocrats, Project Directors, Managers, Research Engineers in Government—Affiliated Organizations • University Professors	Aug. 19, 1986	29	27
Format-3 (Interview)	• Government Officers(higher level) • Presidents of Manufacturing Industry • Government Project Directors • Those who could not respond to Formats 1, 2	Sept. 5, 1986 Nov. 5, 1986	12	12
	Total		73	70

3. Survey Findings

The questionnaire response was analyzed by various computing facilities(IBM 5550, NOVA 8000, VAX 780). Personal status of each respondee was coded as shown in Table-4.

Table-4. Questionnaire Code

Subject	
Equipment	E
Service	S
Not specified	B
Organization	
Government	A
Research institute(public)	B
Industrial firm(affiliated research institute)	C
University	D
Others	E
Position	
Researcher/Engineer	1
Manager	2
Director	3
Executive Director	4
President/Vice President	5
Vice Minister/Bureau Chief	6
Professor	7
Others	8
Specialty	
Equipment	1
Service	2
R & D	3
Operation/Maintenance	4
Management/Administration	5
Others	6
Type	
Open-end	O
Closed loop	C
Response	
Subjective(Qualitative)	S
Objective(Quantitative)	O
Purpose	
Opinion	O
Weight/Priority	W
Format	
Format 1	1
Format 2	2
Format 3	3

Analysis of questionnaire response can be divided into two types, i.e. qualitative-judgemental analysis and quantitative-statistical analysis. In the following, major findings regarding government policy, manufacturing status, R & D manpower requirement and graduate program are summarized.

3.1 On Government Policy

Most of the respondees(58 out of 70), government personnel and business managers alike, felt that government should:

(1) Initiate and support high-quality manpower plan.
(2) Increase government support for technology development.
(3) Generate public awareness for new services and equipment by promoting both education and augmented participation of private industry(e.g.VAN).
(4) Provide an active role-function for improvement of hierarchical taxonomy of telecommunication industry by evaluating the infrastructure of telecommunication industry.
(5) Provide high priority-major efforts to
  —Expansion of existing equipment(PSTN)
  —National Network(Administration, Education, R & D, Finance, Public Security, National Defense).
  —Detailed, careful and steady transition plan towards ISDN.

Existing government(or government-affiliated) organizations should improve organizational efficiency by closely looking into interorganizational issues.
Major concensus was drawn on the followings.

(6) Role definition and collaborations among organizations should be reevaluated. Especially,
  — fine tuning is needed in MOC-KTA collaborations,
  — steering committee function is necessary for issues such as
    • evaluation and improvement of service quality
    • technology import
    • information clearing
    • development of software/application

(7)New organization should be installed for
  —standardization,
  —detailed classification of "Software Industry",
  —market promotion for new service,
  —provision of support for medium-small industry.

3.2 On Manufacturing Status

Current status of telecommunication industry can be termed as "Manufacturing Development" stage, i.e.,

—Major technology and major parts are imported,
—Major product is manufactured for domestic market, and/or most of them is designed for open-end market,
—Percent of domestic product is improving, but major part is imported.

Current status of technology is at "initial development stage" in the following area:

- Basic technology(Hardware, Software),
- PABX,
- 32-bit computer,
- System application,
- voice-data integration and voice synthesis,
- simple protocol converter, communication controller,
- Extension of TDX-1.

As yet, technology import is preferred to R & D, and most of industry-affiliated research institutes need a break-through both in scope (mostly manufacturing technology) and in depth (Technology import should be linked to in-house R & D). One of the common problems in technology import is that time to commercialization (from the point of technology import) is either too long or delayed by other problems.

(1) Telecommunication industry seems to have a hierarchy problem:
   a. Major manufacturers are involved in everything from part assembly to export of simple equipment(e.g. telephone).
   b. Most of the medium-small industry belongs to a few conglomerates.
   c. Small industry is producing limited number of parts for ESS, telephone, FAX and Telex terminal.

(2) The infrastructure of telecommunication industry still holds inherent problems such as:
   - Import dependent manufacturing,
   - Production of less than Economic-lot size,
   - Production which is not geared to international market.
   - Production is based on implied purchasement by the government.

(3) Considerable manufacturing technology has been accumulated in:
   - Switching equipment(M10CN, RSU, TDX-1),
   - PBX(circa 4000 line),
   - FAX, Telex,
   - Modem,
   - PABX,
   - Fibre optics,
   - Terminal,
   - Cabinet,
   - Assembly, and
   - Basic design in transmission.

(4) Competitiveness in international market is summarized in the following:
   - Competitive items in the international market are telephone and terminal.
   - Quality/reliability(other than telephone, terminal) should be imporved.
   - Lack of competitiveness among equipment is a major cause of limited success in QC.
   - Facility automation should be expanded.
   - Market strategy should be developed and it should be implemented continuously.
   - Design capability, especially for tailored-design efforts, should be improved based on a master development plan.

3.3 On Technology Import and Joint Venture Effort

Both technology import and joint venture seem to experience the following pitfalls:

(1) Lack of preliminary analysis leads to vicious cycle in technological import/joint venture:
- —More systematic approach is needed in collecting technological information.
- —Continuous and periodic updates regarding availability of new technology should be emphasized.
- —Both feasibility and compatibility of new technology to the existing hierarchy/ taxonomy should be evaluated.

(2) Selection process for technology import should be revised:
- —Selection of new technology/joint venture should be based on a long term master plan.
- —Hierarchical taxonomy of telecommunication technology should be prepared to promote effective technology import and joint venture.
- —Duplicated, unnecessary technology import should be avoided.
- —Competition among rival industries seems to be a major cause of duplicated, overlapped, repeated import of obsolete technology.

(3) Utilization of new technology:
- —Technology import should be followed by effective training, education program and R & D program.
- —Subsequent training program(abroad, usually provided by the technology source) should be organized more effectively.
- —Appropriate information exchange(on existence of technology, short-comings and overall evaluations) among government institutes, manufacturer and related organizations should be encouraged.

(4) Current efforts for a promotion of new technology need to be improved:
- —Further simplication of technology import procedure for timely import(1985:only 65 new technology imported).
- —Increase support for identification and search of new technology.
- —Professional evaluation of technology(duplicated, obsolete, incomplete, biased terms, etc.) should be provided.
- —Corrective guidances and continuing efforts for technology import and domestic R & D promotion should be provided by government.
- —Organization for screening, updating, diffusion of information and technology transfer should be installed.
- —provision of expertise is especially important for delicate, unfair contract terms.

(5) Scope of joint venture

Any joint venture effort should carefully evaluate the common fallacies:
- —Simple local assembly without new technology should be avoided.
- —Incomplete technology import(mainly manufacturing, missing know-how, incomplete software) should be prevented.
- —High royalty and unfair contract terms(e.g. sales volume guarantee, market

restriction, long contract period) should be discouraged by government.

3.4 On R & D Activity

Most of the respondees indicated that current R & D is experiencing conceptual weakness in various organizations. Some researchers complained that R & D budget is only a fraction of advertisement cost, that their R & D plan is made in yearly basis, and that major part of their R & D activity lies in product development under short notice.

ETRI has been very successful but it can not provide all the necessary support in transferring its product to manufacturers.
Its R & D scope is both narrow and selective so that industry feels that government should prepare both detailed national R & D plan and practical support for R & D activities. Government should also support university institutes and industry-affiliated institutes. In a long term, lack of high-quality researcher seems to be a major bottleneck.

(1) Current R & D activity should be evaluated further in the following aspects:
- —Long-term R & D plan should include detailed list of activities and role definitions among involved organizations.
- —Criteria of resource allocation should be firmly set and periodic updates based on performance evaluation should be made.
- —Collaborative means among research institutes should be enhanced.
- —Resource sharing(manpower, technology, information, facility) should be greatly emphasized, and incentive systems should be introduced to promote effective resource sharing.
- —Examplary efforts should be made for integration of existing manufacturing technologies.
- —Early announcement of R & D plans(DACOM, ETRI) would be helpful to industry-affiliated research institutes in revising their R & D plans.

(2) Steering function should be introduced in order to achieve periodic updates for various activities among organizations. Especially, the suggested function would provide means to:
- —minimize duplicated R & D investment,
- —prevent import of obsolete technology,
- —assess central function for information dissemination, trend analysis and marketing strategy.

(3) R & D efforts should be greatly increased:
- —Current R & D budget is below the critical mass(e.g. 1/8–1/10 of advertisement cost).
- —Follow-up efforts should be enhanced once a R & D project has been initiated.
- —Current facility investment is made on the basis of short-term, goal-oriented and pilot production.
- —Lack of test and evaluation equipment is one of the QC problems.
- —Lack of interdisciplinary collaboration limits the design capability.

4. R & D Manpower Requirement

With the land mass of 0.07% of the world, and the population of 0.85% of that, Korea virtually has no natural resources.

Thus, the only means of surviving with economical stability is to build the industrialization based on the human resources.

However, economic growth has resulted in a shortage of high-quality manpower in the midst of surplus labor, and a rise in real wages with mediocre productivity. Thus, Korea is inbetween two huddles, one being the rising protectionism in high-technology of the developed countries, and the other being the losing ground in the labor advantage by the developing countries.

Similarly, telecommunication industry faces two problems;

(1) Solidifying the established voice communication(PSTN) that has been leapfroged during the last five years, and

(2) coping with era of data communication(ISDN) that is rapidly emerging before her eyes.

4.1 R & D in Telecommunication Industry

In the era of satellite communication, the results of R & D are the products of industry. Since the results of R & D will be heavily dependent on the role of the brains, the demand of R & D manpower will be greatly enhanced with the growth of R & D activities. Still, the industry does not seem to be aware of the importance of R & D, and is stingy on R & D investment. In the survey, one prominent expert confessed that he is not optimistic in the future of telecommunication industry while his quota of total R & D budget is less than 1/8 of the advertisement budget. With a few exceptions, such as R & D efforts for the development of TDX-10, most of the current efforts can be termed as "product development" and "Process Technology". Most of the respondees were quite concerned on the fact that the industry would prefer technology import to R & D.

The heavy dependency of foreign technology can be seen in terms of the royalties paid for the technology import. For example, the total cost of the royalty doubled during 1980 to 1985. Industries have been emphasized the importance of technology import with just the production capability in mind. Recent statistics have shown that the Korean industry imported 21.3 billion dollars for the new technology, and less than 70% of the imported have been utilized.

If present state were to be maintained without any major change to achieve quality in manpower, and therefore in R & D, (1) the successful utilization of imported technology would not be possible, and (2) the telecommunication industry would never be able to escape from foreign dependence, and (3) further promotion of the industry would be economical waste.

4.2 Projection of R & D manpower Supply

In 1984 a survey had been made by Technological Manpower Development Committee, MOC. The committee disseminated questionnaires to 66 manufacturers in telecommunication industry. Annual demand of Doctorate, in fields of electronics, communication and computer,

was estimated by summing the respondees estimation, and Annual supply of Doctorate was projected based on the recent Ph.D graduates in the University(Table-5). In this projection, it is considered that both the demand and the supply of R & D manpower was underestimated.

Another estimation of R & D manpower was made by this study. By analyzing questionnaire responses(see section 2), potential requirement of the telecommunication industry was estimated for the period 1987–1991. As shown in Table-6, two projections on telecommunication market were compared;one by the government(1985) and the other by the SNU team(1986). Also, demand and supply of Doctorates in telecommunication industry were made.

From Tables 5 and 6, it can be summarized that the supply of Doctorates for R & D in telecommunication industry can not catch up the industrial demand. For example, the MOC study estimated that (Table-5) 253 Doctorates would be needed in 1987 while only 40 Doctorates could be supplied from the university. The estimation by SNU looks worse that the industry would require 501 Doctorates in order to cope with both the rapid expansion of the industry and the ever complex nature of new technology while Ph.D graduates from the university would be less than 88 (Table - 6).

The situation will not be improved in the near future. Until now only a few universities in engineering have strived to produce Doctorate in spite of heavy burden in undergraduate education with decaying facility. In 1984 twelve universities produced 186 Ph.D's in engineering, more than 70% of the total Doctorate production in engineering.

Table – 5. Demand and Supply of Doctorate—MOC Study(1984).
—Projection based on a Survey of 66 Manufacturers.

Year	Annual Demand	Annual Supply	Difference
1984–1985	88	30	–58
1987	253	40	–213
1992	486	65	–421
1997	841	90	–751
2002	1269	115	–1154

Table—6. Demand and Supply of Doctorate-SNU Study(1986).
—Projection based on the result of (1) a joint study between SNU and IBM(Asia Pacific Group). (2) MOE Committee Report on a Promotion of High-quality Manpower Supply.

Year	Potential Telecom Market (unit: $ Billion)		Doctorate Demand-Supply (unit: No. of Doctorates)	
	Government Projection (1985)	SNU Estimation (1986)	Demand (SNU Study, 1986)	Supply (MOE Study, 1986)
1987	1.94	2.04~2.17	501	During 1987~1991,
1988	2.29	2.44~2.54	594	(1) 510~710 Doctor in Engineering
1989	2.63	3.00~3.34	688	
1990	2.97	3.67~4.97	783	
1991	3.32	4.93~8.15	991	(2) 88~145 Doctor in Electrical & Electronics Engineering.

The size of the enrollment in the graduate schools has been increasing steadily in recent years. For last ten years, it has been about five times larger in total. The increase in the enrollments of Doctoral program is more rapid showing 7.2 times increase. Still, the average number of Doctoral degree awarded per department in 1985 was merely 1.1. Disregarding quality, this low productivity raises a serious problem even in quantitative sense. When it is considered that the Doctoral education in telecommunication require competitive efforts in education, it raises serious questions on the quality control of the products.

4.3 Quality of Graduate Program.

In 1985 there were 691 professors in departments of Electrical and Electronic engineering and 56% of them had the doctorate degrees.

The student-to-faculty ratio in universities is too high to have an effective and productive education, the ratio in colleges of engineering is 50:1. For a reference, it is compared to the ratio of Japanese, 11:1. In engineering colleges, over 78% of the professors teaches more than nine hours per week, a recommended load by MOE. It is believed that the majority of professors hold the teaching load of 12 to 18 hours per week.

Quality of university research is less than acceptable. Up to present, the university research is financed heavily by the university's own budget(72%). The government support is only 24% and the industry is sharing the mere quota, 6%. Even if the university research is supported by the government, the composition of the research fund showed that the salary of personnel occupied over 68% of the total budget.

Best stated, research in the university is experiencing a state of fast.

5. Remedial Action

There are several reasons why university should be assigned to play a key role in R & D for the

promotion of telecommunication industry.

First, university is the most cost-effective organization to carry on research which has a high risk-factor for the output. In other word, with the utilization of low-cost, high-potential Ph.D student, research can be carried out with the minimal support on facility and operating expense. Secondly, university is very flexible in the selection of research subject. Thirdly, the Ph.D students trained under a subject will have profound expertise in that area by the time the result of the research is to become in application stage. Lastly, but not the least, the university has the most prestigious access to various collaborative efforts. Also, it should be recalled that the university has heavy concentration of research-related personnels, and especially majority of Doctorate degree holder(over 84% of Doctorates).

Thus, it can be rightly stated that the graduate program should be the nucleus of

- R & D activity
- interdisciplinary effort
- resource sharing
- reinforced training center for field engineers.

In the following statement, suggestions are made on; government policy, industrial support and curriculum for the graduate program.

5.1 On Government Policy

A summary list of recommendatations to government which was drawn from the questionnaire responses in shown in Table-7. As listed in the table, highest priority among government plans should be given to "curriculum specialization of telecom industry". As for promotional effort towards research institutes and manufacturing industry, government should make commitment to tackle top issues such as "R & D", "Manpower Investment", "High Quality Manpower".

The government should promptly initiate actions to improve the size and quality of the graduate program. The average number of faculties in an engineering department is seven professors. In pursuance of quality of education, the number of faculty in the related department should be at least ten professors. In pursuance of research capability, at least three professors in a telecommunication subject would form a critical mass. This improvement program can be effectively executed in twelve leading universities.

Table—7 Questionnaire Responses—Priority of Promotional Efforts for Telecommunication Industry

GOVERNMENT PLAN/POLICY		R & D		MANUFACTURING	
PRIOR-ITY	EFFORT	PRIOR-ITY	EFFORT	PRIOR-ITY	EFFORT
1	Curriculum specialization of telecom industry	1	R&D for major technology	1	Technology knowhow accumulation
2	Specification of Gov't long term plan	2	Manpower investment	2	High quality manpower
3	Support of equipment industry	3	High quality manpower	3	Support for related Subcontractors
4	Access to foreign market	4	Resource sharing among Univ. Ind.	4	Improvement of quality performance
5	Expansion and modernization of existing facility	5	Information clearing house	5	Promotion of % of domestic parts
6	Prior purchase plan for required equipment/service	6	Continuing education and refreshment	6	Facilitate technology import
7	Installation of national network	7	Technical aid	7	International collaboration and joint venture
8	Deployment of new service(KTA)	8	International collaboration science and engineering	8	Quality assurance system
9	Improvement of existing service quality	9	OJT(abroad, foreign)	9	International market competition
10	OFF-SET program			10	Facility expansion
11	DACOM service expansion				
12	Improvement of accessibility & charge rate				
13	Tax & Tariff				
14	Import restriction				
15	Market regulation and protection				
16	Leased line(access, quota, expansion)				
17	Public enlightment to new service				

5.2 On University-Industry Cooperation

Telecommunication industry should step forward to participate in a remedial action for the future of the industry. It is suggested that one hundred "Research Unit" should be formed and be supported by the industry. One research Unit would be composed of one faculty, one doctoral candidate and two-three master students.

About $38,000 per Research Unit per annum(e.g. $ 23,000 for equipment purchase and maintenance, $ 10,000 for scholarship, $ 5,000 for research expense) would be required. This would make extra burden of $ 3.8 million per annum to the industry, which is less than two percent of the royalties paid to foreign technology sources in 1985. One hundred Research Unit would support 20% of the faculty members in the related fields, and the program could double the doctorate output. The productivity and quality of this program can be achieved by incentives to the better-qualified and by competitions among the less-qualified.

5.3 On Curriculum of Graduate Program

Curriculum improvement in the graduate program should reflect the following concerns.

(1) According to the survey findings, the industry needs R & D personnel who has competitive knowledge in
- R & D administration,
- Project Management,
- Technology Import and Technology Transfer, and
- Joint Venture effort and International Collaboration.

Therefore, the graduate curriculum should include Industrial Engineering Disciplines in order to provide the doctorate students ample exposure to the essence of R & D activities.

(2) Graduate Research topics on telecommunication should include some immediate concerns of the industry. The program should encourage:

Topics in equipment design such as
- communication controller,
- satellite/earth station,
- protocol converter,
- ESS, and

Topics in telecommunication service such as
- Human-Computer interaction,
- LAN,
- VAN,
- satellite/earth station,
- network management, and
- national network.

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