TECHNOLOGY TRANSFER TO A DEVELOPING NATION

A Report of the AID/NASA Pilot Project in Technology Transfer to the Republic of Korea

IIT Research Institute

FINAL REPORT

AID/NASA PILOT PROJECT IN TECHNOLOGY TRANSFER TO A DEVELOPING NATION - KOREA

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For

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and
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SUMMARY

In 1970, an experimental project was undertaken by AID in collaboration with NASA to determine if selected types of technology developed for the aerospace program during the past decade are relevant to specific industrial problems of a developing nation and to test whether a structured program could facilitate the transfer of relevant technologies. The Korea Institute of Science and Technology (KIST) and the IIT Research Institute (IITRI) were selected as the active transfer agents to participate in the program. The pilot project was based upon the approach to the transfer of domestic technology developed by the NASA Technology Utilization Division and utilized the extensive data and technical resources available through the Space Agency and its contractors.

U. S. specialists assisted the Koreans in searching the aerospace data banks and adapting the methodology for relating the data to specific industrial problems. Korean technologists were responsible for adapting the most promising technologies to specific Korea needs, with particular emphasis on those industrial opportunities which could generate employment, develop export opportunities, and utilize indigenous raw materials and local skills. The study has led to a number of specific developments which could yield direct economic benefits to Korea ten or more times the program investment during the next three years. The process of problem oriented technology transfer has been validated, although some alterations in the methodology are indicated for any future programs. This pilot project has also helped to clarify some aspects of the international technology transfer process and to upgrade Korean technological capabilities.

Major findings and results of the project are:

General

1. An AID input--in terms of program design and relatively little financial support--can serve as an important catalyst to facilitate the international transfer of technology to developing nations in two ways; first, by stimulating improved coupling between U. S. sources of technology and developing nation transfer agents, and, second, in improving relationships between the agents and manufacturing firms of the developing country.

2. Transfer agents in a developing nation can serve a crucial role in the selection and adaptation of technology which individual firms in the country could not duplicate in dealing directly with foreign industry or foreign transfer agents.

3. Industrial skills and resources necessary to implement solutions to expressed needs are very important to the ultimate commercialization of the technology transfer. As such, an assessment of the training, financial support and technical assistance required to achieve production should be an integral part of the need definition/selection process.

4. A significant commitment of time, effort and funds by the developing nation is required to pursue transfers to the point of economic impact.

Impacts

1. Two Korean electronic firms are now capable of manufacturing more sophisticated products for the domestic and government markets.

2. The concept of investment in R & D has been advanced within segments of the Korean electronics industry in addition to increased confidence in KIST's ability to develop marketable products and processes.

3. KIST awareness of the importance of providing training for industrial manufacturing personnel has been increased.

4. The project has resulted in direct Korean support for nine development projects at KIST.

5. The need for economic studies as well as consideration of the licensing and capital requirements associated with technology transfer has become more apparent to KIST.

6. The technical competence and morale of the KIST staff has been increased through exposure to advanced technology.

7. The ability of KIST to advise upon and make decisions to "buy or build" technology has been improved.

Methodology

1. The methodology applied in the program has been successful in transferring technologies, both technical and commercial, to Korea, and is generally applicable for continued use in assisting in the technical development of Korean industry.

2. The selection of needs to be pursued should be based upon national economic plans, identified industrial interest, local technical expertise and economic studies of the market and required investment. The number of solutions pursued should be small enough to permit adequate resources for each, but large enough to allow for the possibility of delay and/or failure on one or more.

3. While the NASA technology data bank contains much information related to the needs of a developing nation, the U. S. transfer agent should be familiar with and have access to a broader data base more responsive to the highest priority problems of low income nations.

4. Direct interaction between the U. S. technologists and the participating specialists is vital to achieving the understanding necessary for useful transfer. Dialogue on a "face to face" basis is the best way to overcome the barriers to effective technical communication and to relate the new technology to the needs of the developing nation.

5. Given a transfer agent in the developing country with skills and experience comparable to KIST and given a major commitment in time and funds by the developing country, the time required to begin to achieve commercialization is a minimum of two years and more probably three to five years.

Based on the results of this study, we recommend continued support of U. S. assistance to Korean technology transfer initiatives as well as additional technology transfer programs modeled after this pilot project. We suggest conducting two types of programs, one program for a nation at a stage of development similar to that of Korea, and a second program directed to stimulating entrepreneurs in a country with less industrialization.

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I. INTRODUCTION

Since June 1961, the U. S. Government through the Agency for International Development (AID) has funded a concentrated program of assistance to underdeveloped areas of the world under the Foreign Assistance Act to contribute to the social and economic advancement of the world's developing nations. One of the objectives of the Office of Science and Technology of AID is to assist developing countries in establishing processes of technological transfer and adaptation. In particular, the strengthening of the capabilities of local industries to make better technological choices is an important step in the overall economic development of a developing nation.

The National Aeronautics and Space Administration (NASA) has been actively concerned with the transfer and utilization of aerospace research to U. S. Industry. The NASA Technology Utilization Program has developed a systematic framework of methods and resources to promote the transfer and adaptation of technology. In 1968, NASA commissioned a study to assess the applicability of technology generated by the space program to the needs of developing nations. The study concluded that aerospace generated technology appeared applicable and transferable. Encouraged by these findings, the AID Office of Science and Technology invited NASA to enter into a cooperative pilot project to test this conclusion.

The pilot project was designed to test the feasibility of transferring selected types of industrial technology, developed in support of the U. S. space program, into the mainstream of industrial activities of a developing country.

The project objective was to demonstrate whether recently developed technology can be introduced into developing countries in such a way as to accelerate industrial development and enable them to "leap frog" some intermediate development steps. The institution in the developing country selected for involvement in the program was a critical part of the study design. It needed to be attuned to local industrial needs, capable of adapting U. S. technology to local requirements, and interested in establishing a continuing program of technology transfer. Furthermore, the participating U. S. institution required experience in technology utilization as well as familiarity with and access to NASA and other technology resources.

The Republic of Korea (ROK) was selected by AID as the developing country to participate in this pilot project because:

1. The ROK has a high interest in increased industrialization.

2. A comprehensive national plan for achieving increased industrialization exists.[1]

3. The Korea Institute of Science and Technology (KIST) has the requisite background and interest in technological assistance to industry.

Korean industry is labor intensive and, in many cases, based on foreign technology components and processes. The growth of foreign investments and loans has spiralled since the enactment of the Korean Foreign Capital Inducement Law in 1962. (Appendix I presents data on the growth and status of the Korean economy.)

1. The Third Five-Year Economic Plan (1972-1976), Government of Korea, Seoul, 1971.

In recent years, the government of Korea has been systematically developing institutions to support the expanding industrial economy. KIST, founded in 1966 with aid from the U. S. Government, is a not-for-profit organization that carries out research and development for Korean industry and government. By providing excellent facilities and working conditions, KIST has been able to recruit an unusually competent staff to conduct scientific research, technical and engineering investigations, and economic analyses. Through its reservoir of scientific talent, KIST provides technical support for Korea's industrial expansion, and is becoming financially self-sufficient as evidenced by the 143 projects conducted in 1972. Research is carried out in many diverse industrial areas including electrical equipment, metals, food processing, and non-electrical machinery. In summary, KIST had demonstrated that it can contribute substantially to Korea's industrial progress.

IIT Research Institute (IITRI) was selected as U. S. participant on the basis of its more than ten years experience as a consulting contractor to the NASA Office of Technology Utilization and on the basis of the many areas of technical expertise covered by the IITRI staff. Directly applicable experience included the Institute's ongoing participation in NASA's program of Technology Applications Teams. These teams are engaged in the identification of needs in the public and private sectors, restatement of specific needs in technological terms and the location of technologies relevant to the fulfillment of the needs.

The pilot project was initiated in June, 1970 following a preliminary trip to South Korea to visit typical industries and to establish the project outline in conjunction with the

KIST participants. This report reviews the technology transfer methodology which was initiated along with the evolutionary changes in methods which took place as the project progressed. The project implementation and accomplishments are detailed with discussions of each transfer activity. While there was a unifying technical theme, the electronics industry, each transfer attempt provided different learnings and accomplishments. The report presents a retrospective critique of the pilot project and attempts to relate these findings to other developing countries, although it is recognized that each country will have requirements peculiar to its needs and capabilities. Technology transfer to the ultimate stage of commercial application is a slow process and most of the individual transfers had not reached the final stage at the end of 1972. Nonetheless, this report summarizes the impacts (real and potential) which have accrued as a result of the pilot project together with the key learnings that have been achieved. Efforts, past and future, to disseminate the results of the project are briefly reviewed in the context of possible adaptation of the same or similar technology transfer activities by other countries. Finally, recommendations for related technology transfer activities are made.

II. METHODOLOGY

The two individual words, technology and transfer, have fairly precise and well understood meanings; technology--the application of science, especially in industry or commerce; transfer--to convey, shift, or change from one person or place to another.[2] However, when the words technology transfer are used in combination to connote a process or method, the term is ambiguous. Technology may be transferred in many ways. Education, dissemination of publications, mobility of knowledgeable people are but a few of the widely recognized ways in which 'the application of science is conveyed from one place to another'. Thus a particular definition of technology transfer as it applies to this project is in order.

The pilot project employed a specific technology transfer method consisting of six discrete (albeit sometimes iterative) steps.

1. Identification and Restatement of Korean Needs.
2. An Organized Search for Potentially Relevant Aerospace Technology.
3. Evaluation and Selection of Possible Solutions.

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2. American Heritage Dictionary of the English Language, American Heritage Publishing Co., 1969

4. Follow-up to Obtain Technological Details.

5. Applications Engineering to Adapt the Technology to Local Needs.

6. Industrial Utilization.

The method is illustrated as a flow chart in Figure 1.

This approach was predicated upon the nature of the aerospace data bank and most other sources of U. S. technology. That is, the bulk of the technological literature describes an incremental improvement such as a modified material, process step, circuit design, new component, etc. Only infrequently is a new device (product), a total process, or a complete technology accessible from a discrete reference or single source. This is not surprising since much of our technological progress is achieved through a multiplicity of incremental advances.[3] However, the incremental approach proved to be an impediment to the location of technological solutions to Korean needs and will be discussed in more detail in Chapter III, Project Implementation.

The initial (and very critical) step in the methodology was the identification by KIST, of needs which had potential economic benefit and which were amenable to technological solutions. This was accomplished through knowledge of the areas of emphasis in the Third Five-Year Economic Plan and by contact with industry and government representatives. The result was a large and heterogeneous group of needs ranging from improved food packaging for military rations to a new

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3. cf. - Myers and Marquis, Successful Industrial Innovations, NSF 69-17.

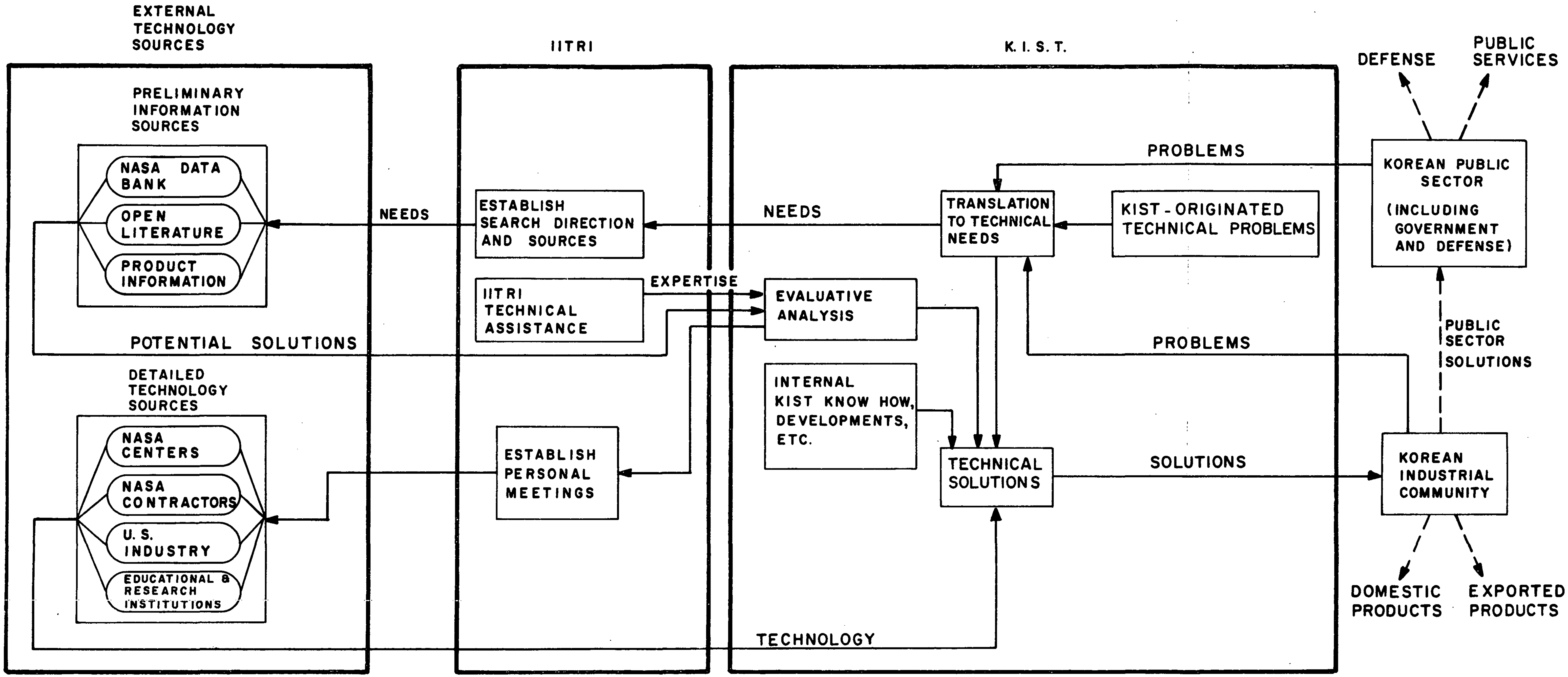

FIGURE I. FLOWCHART OF METHODOLOGY

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process to convert natural graphite into a form suitable for use in steel-making. It was then necessary to translate the basic need into technical terms so that a search for potential solutions could be undertaken through computer data banks and personal contact with experts in the appropriate technical areas. This part of step one was undertaken by the team of five KIST scientists while in residence at IITRI. Interaction with the staff of IITRI as well as computer search experts ensured that technical and semantic usages were correct. Since the actual process of translation is difficult, and a lucid explanation of the process is even more difficult, we present the following example to illustrate the process.

> Need -- A means to reduce or eliminate carbon monoxide poisoning which results from the burning of large, formed "briquets" of charcoal in unvented floor furnaces in the Ondol room of Korean homes. The large number of existing dwellings precludes alterations in the house or furnace since these would represent a major economic investment.
>
> Translation -- Find an inexpensive and reliable monitor for carbon monixide concentration; find an inexpensive additive which will chemically or catalytically convert carbon monoxide to a non-toxic form without significantly reducing the energy content of the briquet; find an inexpensive substance which will absorb large amounts of carbon monoxide before requiring replacement and an indicator to signal the end of useful performance; etc.

Clearly a variety of technologies might provide a useful solution. In some cases the initial need was so broad in character that the technological translation created what amounted to a long list of sub-needs, each of which was a potential technology transfer in and of itself. Resource limitations dictated the elimination of such items from consideration in the pilot project. However, subsequent learnings suggest that an attempt should be made to approach broad needs on a segmented basis to see if this is a viable approach since many of the pressing needs of a nation with a limited technological base are broad in nature.

Step two in methodology consisted of identifying technologies related to the needs and retrieving sufficient information to be able to evaluate the applicability of the technology. Several parallel approaches to technology identification were employed. Key words and descriptions were taken from the technical version of the need statement and used to make a computer search of the NASA data bank and other technological information resources. Additional information on U. S. data banks is contained in Appendix II. These searches were made by the Aerospace Research Applications Center (ARAC). ARAC, run by the Indiana University Foundation, is a facility established by NASA which provides data search and information retrieval services to clients on a fee basis. IITRI knowledge of activities at the NASA centers formed the basis for phone and letter contact with NASA scientists and engineers working in related technical areas. In addition, contact was made with firms, universities and laboratories known to be engaged in relevant research and development. As a result of these searches, literally hundreds of documents and informational inputs were obtained. A preliminary screening was sufficient to reveal that much of the technology retrieved by the broad based search was not suitable and that some needs elicited no potentially interesting solutions. However, over one third of the needs resulted in interesting technology requiring further evaluation.

The detailed evaluation of the pertinent technical information and the selection of opportunities to be pursued in depth was carried out by KIST management and staff upon the return to KIST of the Korean project team. This third step, evaluation and selection, led to the identification of four problems which appeared to meet the major criteria established:

a. Relevant U. S. technology existed and was accessible.

b. The potential economic impact was significant.

c. An industrial user had been identified.

d. KIST had the technical skills necessary for adaptive engineering.

e. The resources (KIST time and funds) necessary to pursue the transfer were within the budgetary allocations.

Some of the reasons for the final selection are discussed in the KIST Final Project Report.[4]

The technical information which formed the basis for evaluation and selection was in the form of reports and notes of initial conversations with U. S. scientists and engineers. Effective transfer of technology requires a much greater detail of information sometimes including components, test data, construction specifications, etc. The requirements vary with the technology and the application, but it is uniformly agreed that by far the best mechanism to acquire such information is personal discussion between the original innovator(s) and

4. AID/NASA Pilot Project for Technology Transfer to a Developing Nation -- Republic of Korea, KIST, Seoul, Korea, June, 1972, page 5.

the specialist who will perform the adaptation and implementation of the technology. Thus, the fourth step in this particular technology transfer method, the acquisition of specific detailed information, was accomplished through visits to the U. S. by the four KIST engineers assigned to pursue each of the selected transfers. The visits, which ranged from two to four weeks in duration, entailed trips by the KIST specialist and an IITRI team member to the various laboratories and firms having the desired expertise. These trips were interspersed with periods of review and evaluation to ascertain the degree of completeness of the information and, where necessary, to establish requirements for inputs on related technology which would be needed to support the transfer.

Upon return to Korea, each engineer initiated efforts to develop prototype devices which embodied the technologies that had been obtained. The adaptive engineering, step five, was planned and executed entirely by the management and staff of KIST. Schedules and proposed accomplishments were forwarded to IITRI for review and approval by cognizant NASA and AID staff. During this period there were occasional requests to IITRI for supplementary information or special materials and/or components, but basically KIST was responsible for this very important link in the transfer chain. The final objective was to construct working prototypes which exhibited the characteristics and performance felt to be necessary for successful Korean utilization.

The sixth and final step of the technology transfer process was the manufacture (and sale) or use of the end item. In concept and in practice this involved a variety of interactions between KIST and Korean industry. Where a similar or related product was already being manufactured (assembled), it was still essential to provide on-the-job training for industry employees. This was necessary to transfer the production skills required to maintain end item performance in a manufacturing environment. In the case where a very significant change in manufacturing processes was involved, it was incumbent upon KIST to prove not only that the required skills and technology were available in Korea but also that the start up and production costs were economically justified by the then existing market size. The transition from the prototype stage to commercial production has always been a difficult step in the innovation process and this pilot project has not proven to be an exception to the rule.

One can see that the methods rely heavily on the total involvement and commitment of the foreign participants to solve their own problems. The project utilized discreet needs and technologies to meet the objective of examining the relevancy of aerospace technology and testing a structured transfer methodology. In addition, the project was aimed at the establishment of procedures to provide a tool - a technical information resource - which would open up selected sectors of U. S. technical data banks to the participants so that they might tap them and adapt the findings for their own use.

III. PROJECT IMPLEMENTATION AND ACCOMPLISHMENTS

The pilot project participants established a set of goals in support of the primary objective of demonstrating whether recently developed technology can be introduced into developing countries in such a way as to accelerate industrial development. These goals were as follows:

1. Train Korean personnel in the specific transfer methods and technology resources to be used in the project.

2. Achieve specific transfers of technology which result in economic and social advantage.

3. Evaluate the techniques used with Korea and assess their general applicability to other developing nations.

4. Recommend a revised training and implementation plan based on lessons learned.

5. Disseminate relevant information on the program methodology and results to other developing nations.

A. PROGRAM SCHEDULE

In order to accomplish the goals of the program, the phasing and timing of activities was developed as shown in Figure 2. Phase I consisted of a technical mission visit to the Republic of Korea and KIST by representatives of AID, NASA, IITRI, and ARAC (Appendix III). At the conclusion

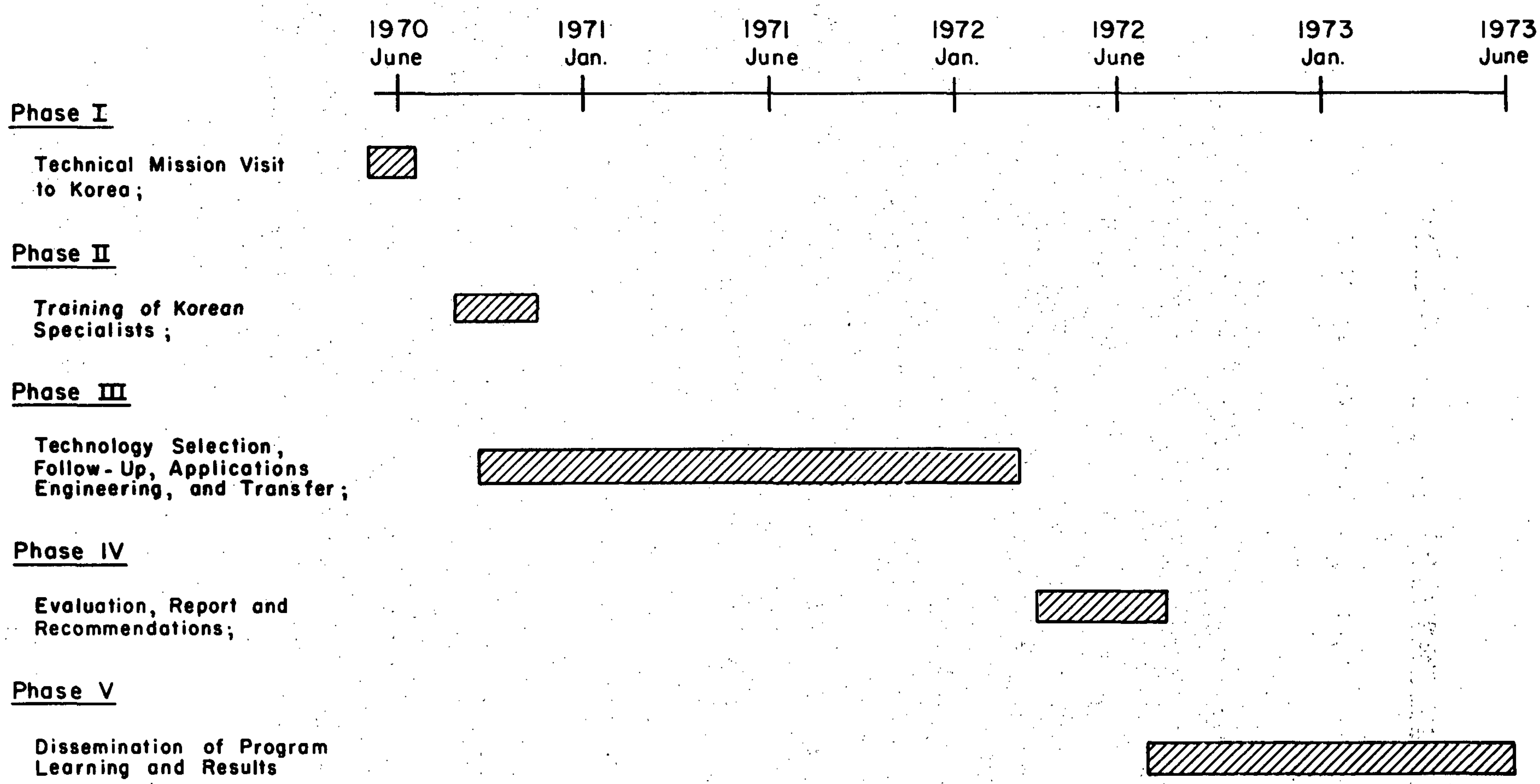

FIGURE 2. INITIAL PROGRAM PHASING AND TIMING

of Phase I, KIST management proposed a group of senior staff members as candidates for the project team and the five KIST staff finally selected possessed extensive technical experience and had bilingual capability (Appendix III). A list of technical needs prepared by KIST in preparation for this visit was briefly reviewed and formed the start of the set of needs examined for relevant technology in Phase II.

Phase II involved a trip to the U.S. by the KIST Project Team. It was a working indoctrination session to instruct the participants on the operation of NASA's Technology Utilization Program and included methods of transferring technology, processing of an initial number of Korean needs and performing preliminary follow-up information gathering efforts. Based on this visit, the KIST Team returned to Korea to identify additional suitable industrial needs for pursuit in the program, to select items for in-depth effort to perform necessary applications engineering, and to assist in introducing the technology to Korean industry.

The KIST Team was in the U.S. for 37 regular working days and completed the following tasks:

- 50 needs were defined and processed.
- 60 separate literature searches were performed and submitted to the Team.
- Relevant technology was identified for 13 of the 50 needs.
- KIST spent 4 days on site at ARAC to learn computer search techniques.
- The Koreans prepared 29 computer search strategies.
- Two NASA Field Centers were visited by the Koreans.

- The Team made 26 industrial contacts related to the problems defined in Phase II.
- The KIST Team toured an industrial technical Research Center to see how the services of a regional dissemination center were used in industry.
- Presentations were made to the KIST Team on four areas of technology transfer by four specialists in the field.

Phase III began after the departure of the KIST Team for Korea in October of 1970. While Phases I and II laid the ground-work and provided relevant background material, Phase III was devoted to doing the actual work of effecting technology transfers and in terms of the total time for the program, represented the major portion of the study. Although the team returned to Korea in October, it was several months before they could devote any significant time to the program due to the pressures related to responsibilities of their respective functions at KIST. Time then had to be devoted by KIST to studying the results of Phase II evaluations and to selecting items for detailed follow-up in the United States.

In Phase III, three additional KIST staff became involved in the program because their technical backgrounds were relevant to specific problems being pursued. The involvement of new staff members had the benefit of broadening the KIST exposure to the technology transfer mechanisms. During the first half of 1971, four KIST researchers spent a total of four man months in the U. S. working with IITRI personnel on the selected problems. Forty-four organizations were contacted in the course of the visits including NASA field installations, NASA contractors, private industries, industry associations, and other U.S. Government agencies. During the visits, the Korean researchers obtained extensive data for each of their technical needs relative to such factors as design, applications, commercial equipment, manufacturing considerations, cost information, etc.

At this point in the project it became apparent that significant slippage in the schedule had begun to take place. The project was initially programmed for 18 months but by May 1971 it had just been possible to acquire the detailed technology required to satisfy the selected needs. It was clear that the six months remaining until the scheduled evaluation and reporting period was not adequate time in which to assimilate the technology, to perform adaptive engineering and to initiate commercialization. Coincidentally, some questions had arisen among the U.S. participants concerning the focus on electronics which had become apparent in the selection of the in-depth studies. As a result, an interim evaluation meeting was held in the U.S. with participation by KIST management. Dr. Hyung Sup Choi, at that time KIST president and currently Minister of Science and Technology, Dr. Yoon, KIST project leader, and Mr. Kim, a representative of the Ministry of Science and Technology, participated. Dr. Choi had played an active role in the project since its inception through his assistance in choosing the KIST Team, help in identifying and selecting the Korean technical needs for study, and in his overall support for the KIST project involvement. This meeting reviewed the progress to date, the rationale for the selection of in-depth transfers, and produced an agreement to extend the project duration by six months to June 30, 1972.

The Phase IV evaluation was initiated in April 1972 with a ten day site visit to Korea by representatives from AID, NASA and IITRI (Appendix III). During the evaluation trip, discussions were held with each of the KIST principal investigators concerning the progress to date. In those cases where commercialization had begun, the U.S. team visited the Korean firms involved and discussed the factors involved in acceptance (or rejection) of the technology with company management. The entire program was then reviewed and critiqued with KIST management. The review assessed the impacts on KIST, Korean industry and the economy, and analyzed the project from the viewpoint of design and procedures.

The fifth and final phase of the project is still in progress. Dissemination of the pilot project findings is proceeding along two lines. Seminars are being held for other developing countries to describe this and other technology transfer programs. The format of the seminar includes opportunities for the participants to describe their needs, experiences and reactions to the methodology. The first of two seminars was planned during the evaluation visit to Korea and was held at KIST in November 1972. There were 11 participants from six Southeast Asian nations as well as observers from four international organizations. The seminar is the subject of a separate report.[5] A second seminar for Latin American participants is in the planning stage and is scheduled to be held in 1973. In addition to the seminars, talks and papers describing the pilot project have been presented to a number of interested groups and delegations.

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5. An International Seminar on Dissemination of Technology: The KIST Pilot Project, IITRI report in publication.

B. NEEDS SELECTED FOR TECHNOLOGICAL TRANSFER

The resources of the program were limited, and only a few needs could be selected for detailed follow-up and implementation efforts. Those that were finally chosen by KIST had common characteristics; all dealt with electronic technology and they all required some amount of commercial technology in addition to that available through the aerospace data bank to effect a complete solution. KIST made the decision to devote their efforts to electronic technology for the following reasons:

1. Concentration of resources on a single industry would insure technology transfers which could be used to demonstrate the success of the transfer concept to other Korean industries.

2. The Korean electronics industry was reasonably well advanced and was being promoted in current governmental plans which would obviously facilitate transfer activities.

3. Technology, both aerospace and commercial, applicable to electronics problems was readily located during the Phase II activities.

Four major electronic need areas were chosen for application and transfer to Korean industry. As the project evolved in Phase III, two of the areas subdivided into a number of closely related applications. Interrelationships between the technologies also became apparent and some prototype devices ultimately utilized several technologies originally considered to be discrete items.

Korea is both a producer and consumer of a wide range of electronic devices. They assemble and manufacture radios, walkie-talkies, telephone central office equipment, television sets, etc., but rely heavily upon imported components and designs for their production. The private and government purchase of electronic equipment has kept pace with the growing Korean economy but domestically produced products have not always successfully competed with imports either in price or quality. Also, recent changes in the military aid provided to the ROK by the U.S. have served to stimulate the domestic supply requirements of the defense sector of the Korean government. Thus there are a number of ways in which electronic technology can impact industry and the Korean economy. The value added to export items assembled in Korea can be increased through component import substitutions and through improved design (performance) reflected in increased sale price. The share of the domestic market can be increased through cost reductions and/or increased performance, and, similarly, direct export markets can be opened if the product is sufficiently improved and can be manufactured locally.

Miniaturized Radio Transceivers

Domestic Korean consumption of transceivers of this type was estimated at 20,000 units or $800,000 in sales by 1974. KIST also anticipates an export market to develop within the United States if the Federal Communication Commission will allocate the 49 MHz band for citizen use. The estimated U. S. market demand for transceivers similar to Korean design is approximately 3 million units. However, there is only a 20 percent probability of a U. S. export market developing for this product. The technological need which this potential export market creates is a smaller size unit with reduced power drain. However, the size of transceivers for domestic use is restricted to larger units because of security regulations.

Han-Jin Electronics Company was interested in developing a miniature unit which could be housed in the standard size Korean case without sacrificing performance and which could be used in a small case for future export. Han-Jin sponsored the applications engineering necessary to design and construct a miniaturized radio transceiver employing several technologies which had been found in phase II of the pilot project.

A mixture of levels of sophistication was determined to be the best approach for Korea. This decision was based upon the current manufacturing skills as well as the availability and cost of components. Thus the final device employed discrete components, hybrid circuits (a combination of thin or thick film and integrated circuits), and advanced circuit designs for low power drain amplifiers. This device and the other transfers are discussed in more detail in Appendix IV. Production of units for the domestic market was being initiated at the time of the evaluation trip in May 1972.

The Korean army is presently using vacuum tube designs for their transceivers. The Korean Ministry of Science and Technology sponsored a two phase applications engineering program. Phase one was to develop a miniaturized transceiver to fit in the existing case which would allow additional battery capacity. This will result in increased operational range and lifetime. This design has been completed and the

Oriental Precision Company has manufactured approximately 15 experimental units. The army is planning to conduct field and environmental testing of these units. Army certification would be expected to lead to a production contract. Phase two involved the design and development of a completely miniaturized unit. Present practice has the receiver separate from the transmitter and clipped to the soldiers helmet. The bulk and weight of the transmitter requires hand held operation. KIST has completed a prototype unit which is greatly miniaturized and which allows both receiver and transmitter to be combined in a single unit attached to a helmet. Commercialization of this second design awaits the results of army tests on the phase one unit.

A third application of the miniature transceiver technology is for pocket paging devices and citizen alarm devices. The Korean Ministry of Communications was interested in the development of this class of instruments. The paging unit is a receiver which responds to a signal from a central location and audibly notifies the wearer to call or contact "central". The citizen alarm is a two tone transmitter which can send either of two signals to a central station to indicate personal danger, a disaster or other prearranged code. A prototype device was constructed on the basis of circuit design information provided by Bell Labs and the Jet Propulsion Laboratory. Any decision on commercialization (Gold Star Electronics Co.) awaits further technical development and increased market potential.

High Sensitivity Receivers (Transceivers)

One of the innovations produced by aerospace research has been phase-lock-loop circuitry. An oversimplified description of the technology is that it uses a set of very stable frequency (phase) standards or "locks" to compare with incoming signals. The technique permits the discrimination or detection of desired signals in the presence of noise. In other words, weak signals may be more easily received. The phase-lock-loop system has direct application to FM radio and television reception. Both urban areas and mountainous rural areas such as found in Korea have a limited signal reception range because the signal is attenuated or distorted by physical obstructions.

The addition of phase-lock-loop circuitry to a radio or television set represents a very small fraction of the total cost but may add disproportionately to the value. The total Korean demand for radios and television is forecast as growing rapidly. Figure 3 presents market estimates prepared by the Korean Economic Planning Board.

KIST has developed an improved tuning system for FM radios and television sets using phase-lock-loop technology. Prototype devices embodying this system have been built and demonstrated to have much higher sensitivity. Current efforts are directed to establishing lower cost approaches. If KIST succeeds in their attempt to demonstrate economically satisfactory manufacturing methods, there will be the opportunity to participate in the large domestic market indicated in Figure 3. The television application is new even in developed countries and export potential is also a possibility.

The same technology has been applied to television repeater stations. The number of such stations required to

Product	1970 (Million$)	1976 (Million$)	Percent of Total Electronic Product Demand		Percent of GNP (1)	
			1970	1976	1970	1976
Radio sets	$37	$275	34%	56%	0.5%	2.6%
Television Sets	-	63	-	13%	-	0.6%
Others	72	151	66%	21%	1.2%	1.8%
TOTAL	$109	$489	100%	100%	1.7%	5.0%

(1) 1970 GNP was $6.4 billion and estimated as $10.8 billion in 1976 (values in approximate 1972 dollars and equivalent exchange rates).

FIGURE 3: KOREAN DEMAND FOR TWO MAJOR ELECTRONIC PRODUCTS*

*Source: Korean Economic Planning Board

be able to employ television in the social development of remote and mountainous rural communities is large. A significant increase in the range of repeater stations could reduce the number of stations required and it has been estimated that this application of phase-lock-loop techniques could realize a $600,000 import savings. KIST designs should be completed in 1973 and the Han-Jin Electronics Company has expressed interest in manufacturing and marketing these repeater stations if the designs prove satisfactory.

KIST has also been funded by the Korean government to develop a design for mobile transceivers which would be produced domestically rather than imported as is presently the case. A device in the 450-MHz range operating at 12 volts, incorporating micro-miniature integrated circuits and utilizing phase-locked-loop techniques for improved sensitivity, should be completed and ready for transfer sometime in 1973. An estimated $500,000 in import savings could be achieved in this way. Closely related are KIST efforts to develop a military transceiver with a larger number of usable channels. The electronic "clock" (digital frequency synthesizer) replaces the crystal oscillator now used with a gain in stability and ease of frequency change which makes possible a larger number of discrete channels. Laboratory units have been constructed and are undergoing test. No plans for commercialization have been made pending the outcome of these initial studies.

Inductorless Circuit Technology

The previous technology transfer examples have highlighted the Korean need for technology and skills in electronic miniaturization to aid in increasing their share of the rapidly growing markets for electronic devices. In spite of the many advances that have been made in miniaturizing electronic circuits, until now, inductors have been a limiting constraint on further size reduction for most applications. Electrical inductors have relied upon iron or ferrite (a magnetic ceramic) cores to achieve the desired electrical properties. As a consequence, inductors represent a significant fraction of the bulk, weight, and cost of modern electronic devices.

Work performed at Goddard Space Flight Center and by aerospace contractors had developed the beginnings of an inductorless circuit technology based upon the characteristics of solid state circuit elements (see Appendix IV). Although laboratory data obtained in the U. S. was not totally satisfactory, it was decided to pursue this technology since success would represent a major technological advance and be a positive contributor to the other miniaturization projects. The Koreans were able to develop an approach which makes inductorless circuits less sensitive to temperature and practical for use outside of the laboratory. Design and construction of prototype miniature FM receivers of 50, 150, and 450-MHz have been successfully completed; however, practical industrial products are still 1 to 2 years away.

Tantalum Capacitors

Electrolytic capacitors made with sintered tantalum have larger capacitance per unit volume, a low power factor, no requirement for hermetic sealing and improved temperature characteristics as compared with conventional electrolytic capacitors. As a result, tantalum capacitors are being specified in an increasing array of electronic applications. Korea presently imports all tantalum capacitors used in the assembly and manufacture of electronic devices and has the need to acquire the manufacturing technology.

KIST has performed a brief survey and analysis of the domestic Korean market. They conclude that a major demand for tantalum capacitors will be in the production of electronic calculators and military communication equipment. The Min-Sung Electronics Co., Tai-Han Electric Co., and Dong-Nam Electronics Co. are all preparing to enter the electronic calculator market and will be producing about 210,000 calculators per year. These products will require approximately 900,000 tantalum capacitors yearly. The requirements of the military for tantalum capacitors in their equipment is estimated at 150,000 units annually. Additional requirements in other industrial and consumer products such as radios, transceivers, TV sets and instrumentation are expected to enlarge this market to about $1,000,000 in sales over the next several years.

Through detailed literature searches, visits to leading U. S. companies and discussions with laboratory scientists working on tantalum capacitors, an overview of the technology was obtained. The proprietary nature of specific manufacturing procedures restricted the information available to KIST and led to the establishment of a laboratory program to develop the details of the three major process steps; sintering of tantalum powder, anodization of the sintered pellets and the pyrolysis of impregnated pellets. KIST has succeeded in producing high quality capacitors in the laboratory but needs to pursue the development further to perfect the process for economic high volume production.

Three Korean companies have expressed a desire to manufacture tantalum capacitors but indicate that the market should be at least $1,000,000 to justify the capital investment and start up costs. Commercialization will be contingent upon further economic feasibility studies.

Other Transfer Activities

In addition to the four needs pursued in depth, several other needs for which relevant technology was identified in Phase II were carried beyond the initial screening. These five items are briefly reported here.

During Phase II the KIST team obtained data on the construction and operation of a weather satellite picture receiving station which would be a substantial improvement over the system in use by the Korean Office of Central Meteorology. The purchase price for such a system is approximately $11,000 and KIST initially decided to build the receiving station to reduce expenditures.

Discussions with NASA Goddard Space Flight Center during Phase III visits emphasized the problems associated with the construction of a reliable unit. As a result, KIST altered its decision and has purchased an initial system from EMR Aerospace Sciences Corporation, a NASA licensee. Using the experience gained with the purchased equipment, KIST plans to construct a second system incorporating inductorless circuits and other advances developed under the pilot program. The experience gained in arriving at the difficult "build or buy" decision has been a valuable product of the program.

There is a need to develop a replacement for the tinplate can used for food packaging in Korea since tinplate is expensive and is not produced domestically. The Phase II search revealed that Continental Can Company had developed a proprietary plastic pouch which had been tested by the U. S. Army Quartermaster Corps and by NASA. This pouch was capable of being heat sterilized after filling and appeared promising. Samples were obtained for evaluation by KIST, and Continental Can was informed of the Korean interest but has not pursued the interest further; apparently because of negotiations being carried out in Japan.

The expanding chemical and process industries in Korea require pressure vessels for a variety of storage tanks and chemical reactor vessels. The technology for manufacturing domes for such tanks by explosive metal forming was developed in the U. S. for defense and space needs. The requirements to establish a pilot explosive metalforming facility were judged to be too expensive at the end of Phase II. However, expanding needs of Korean industry may make this project economically viable in the near future.

The Koreans do not presently have compact survival rations which are compatible with national tastes and dietary habits. The extensive research on dehydration, compaction, and fortification for astronauts was reviewed and discussed with U. S. technologists by members of the Korean team. There was no direct transfer because of the dietary differences. The information gained about general processes and problems has formed the basis for KIST research to develop survival rations based on Korean foods.

C. RETROSPECTIVE CRITIQUE

A review by the KIST and IITRI participants of the design and conduct of the pilot project has revealed a number of weaknesses and has reconfirmed the strength of certain project elements. We conclude that the use of two broadly based technological institutions, one in a developed country and one in the developing nation, to locate technology applicable to specific needs can greatly facilitate the transfer of technology to local industries. Minor changes in the project could improve its efficiency and impact, however.

The steps of initial problem selection and technical translation should be combined and performed while in residence at the developing country institution. In addition, preliminary economic evaluation should be performed on each problem which successfully emerges from the translation step. These changes will result in an extended Phase I but will greatly increase the efficiency of Phase II activities and ensure that any technical solutions found would have a reasonable chance of adaptation. The literature searches could be initiated by the U. S. participants and the output could be subjected to a preliminary screening prior to the arrival in the U. S. of specialists from the developing country.

While the NASA technology data bank contains much information related to the needs of a developing nation, the U. S. transfer agent should be familiar with and have access to a far broader data base which would be more responsive to the priority problems of developing countries. The information and technology base from which the solutions are sought should include test, hardware, and manufacturing data as well as specific technical designs or processes. Those needs with potential economic impact for Korea were broad, did not emphasize specific incremental advances, and generally required a number of technologies, including both supporting processes and machinery.

The importance of person to person contact between the specialist who will adapt the technology and the scientist or engineer who developed the technology was repeatedly demonstrated. Details not present in the published accounts of the technology but which surfaced during discussions proved to be critical to the follow-on activities time and time again. The inputs to the "buy or build" decision on the weather satellite receiver and unpublished laboratory data on inductorless circuits are but two examples of the benefits to be derived from personal contact. In retrospect, more interaction between KIST and IITRI on site in Korea would have been beneficial to the project.

The needs selected for detailed followup should be subjected to further economic analysis before proceeding with Phase III activities. This analysis should include limitations, if any, on initial costs (capital investment and production start up) and on the acceptable manufacturing costs for the volume projected for the first year or two of commercialization. This analysis should be performed in conjunction with the industry or industries that indicate a desire to adapt the technology. This economic analysis may eliminate some opportunities that are technically interesting but not really economically promising. It would also specify the key information to be obtained in Phase III for those needs which do appear worth pursuing.

The total process of selecting needs, searching for relevant technology, identifying transfer opportunities with sufficient impact, undertaking adaptive engineering, and helping industry to achieve commercialization is time consuming even in developed countries. A project to transfer technology to a developing nation can be expected to take a minimum of two years to achieve any demonstrable industrial utilization and three years is not an unreasonable time schedule. The addition of personnel and funds can serve to accelerate the project to some degree but the sequential nature of the process limits the useful time compression that can be achieved.

In the context of extended project timing, consideration should be given to an interim evaluation meeting at the point when the needs have been selected for in-depth transfer. This meeting should assess the expected impact, the availability of supporting technologies required, the resources required to carry the transfers to commercialization and the timing of the subsequent project activities.

D. IMPACT UPON KOREA

The economic gains from import substitution and from increased sales in the domestic and export markets due to technology transferred by this pilot project were largely unrealized at the time of the formal evaluation. The pilot production of miniaturized transceivers for domestic consumption has reasonable expectations for continued growth and significant return on investment. Two other devices awaiting government test and certification could yield measurable return within a year as well. However, a major economic gain for Korea is a number of years off. An evaluation in 1975 should reveal whether the anticipated increases in employment and balance of trade are real or illusory.

A number of significant short term impacts can be identified, however. These include positive changes in Korean industry, in KIST and in the interactions between the two. In summary form, these impacts are:

1. Two Korean electronic firms are now capable of manufacturing more sophisticated products for the domestic and government markets.

2. The concept of investment in R & D has been advanced within segments of the Korean electronics industry in addition to increased confidence in KIST's ability to develop marketable products and processes.

3. KIST awareness of the importance of providing training for industrial manufacturing personnel has been increased.

4. The project has resulted in direct Korean support for nine development projects at KIST.

5. The need for economic studies as well as consideration of the licensing and capital requirements associated with technology transfer has become more apparent to KIST.

6. The technical competence and morale of the KIST staff has been increased through exposure to advanced technology.

7. The ability of KIST to advise upon and make decisions to "build or buy" technology has improved.

8. KIST awareness of U. S. technology and information sources has greatly increased.

9. KIST has institutionalized the search for industrial needs and the technology search/transfer process.

E. KEY LEARNINGS

In addition to the understanding gained about the technology transfer methodology employed in this pilot project, four major learnings have emerged.

- An AID input--in program design and relatively little financial support--can serve as an important catalyst in facilitating the transfer of technology by stimulating improved coupling between U. S. sources of technology and developing nation transfer agents and between the agents and manufacturing firms of the developing country.

Developing nations traditionally rely upon equipment purchases, joint ventures, and licensing arrangements to acquire foreign technology. These approaches can be highly effective in the early stages of industrialization but they do not always maximize the value added nor do they develop local innovative skills. Confidence in the ability of local institutions to select technologies and adapt them in practical ways is often lacking, and, as a result, willingness to risk limited resources on new approaches to the acquisition of technology is also missing. AID involvement can provide important creditability to innovative programs involving local groups.

- Transfer agents in a developing nation can serve a crucial role in the selection and adaptation of technology which individual firms in the country could not duplicate in dealing directly with foreign industry or foreign transfer agents.

Industries in developing countries generally do not have personnel with the qualifications to search, evaluate, and adapt technology to their needs. Since this is not usually recognized by industry as a continuing process leading to expansion and increased profit, the lack of resident skills is not surprising. Indeed, many U. S. companies rely on external sources of expertise for technological inputs. This reliance on institutional experts must be cultivated in developing countries.

- Industrial skills and resources necessary to implement solutions to expressed needs are very important to the ultimate commercialization of the technology transfer. As such, an assessment of the training, financial support and technical assistance required to achieve production should be an integral part of the need definition/selection process.

Each of the four transfers which formed the central effort of this pilot project encountered the problem of lack of industrial skills and resources in different ways and in varying degrees. While the need for some training of production workers to assemble miniaturized transceivers was foreseen, the extent was underestimated. Similarly, the inability of the capacitor industry to undertake a new product development in anticipation of a growth market was not adequately appreciated in advance.

- A significant commitment of time, effort, and funds by the developing nation is required to pursue transfers to the point of economic impact.

In the context of the current program, although AID provided funds to support the U. S. activities, Korea provided support for all of the participating specialists including the transoceanic travel and applications engineering programs. The Korean investment of resources in this pilot effort in terms of money and technical personnel over the past two years has matched the U. S. investment. Institutional support of this nature is very important to the success of the project.

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IV. RECOMMENDATIONS

The learnings, impacts and findings from this pilot project for the transfer of technology to developing countries lead to three recommendations.

1. KIST has expressed a deep interest in continuing their technology transfer activities by further identification of needs, technology search and application engineering. If the Korean Ministry of Science and Technology and Korean industry are willing to support the KIST effort, we recommend that AID provide the nominal dollar investment required to provide continued U. S. assistance for an additional 12 to 24 months. This period should be sufficient to demonstrate economic utility and to achieve full Korean institutionalization of the technology transfer process.

2. The pilot project has shown that a number of significant improvements in the methodology are possible and should result in an improved technology transfer process. We recommend that a similar project be initiated with a country possessing a degree of industrialization and the local institutions for technology transfer which compare with that of Korea. The goal would be the demonstration of the efficacy of the revised need-oriented method.

3. Many developing countries are just beginning the process of industrialization and have major needs in agriculture, housing, roads, and employment for the unskilled. There is an expressed lack of entrepreneurial attitudes in local institutions as well as in the populace. A need/solution-oriented program coupled with the financial resources necessary to start new businesses or new ventures for existing firms, could serve to stimulate local entrepreneurship. We recommend that consideration be given to a pilot project to identify technological solutions for more primitive needs and to initiate a local venture to commercialize the most promising approach.

APPENDICES

AID/NASA PILOT PROJECT IN TECHNOLOGY

TRANSFER TO A DEVELOPING NATION - KOREA

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Involvement of Foreign Capital in Korean Economy

The relative importance of foreign investments and loans in Korea is shown in the following facts:

1. Since 1967, foreign investments have increased at an average annual rate of 33%.

2. Commercial loans from foreign sources have increased substantially, accounting for almost 68% of total foreign investment in 1970, as the Korean Government has embarked on a program to build up the economic infrastructure.

3. The increase in amount of commercial loans as well as joint ventures indicates that the Korean Government is pushing for reliance on private and equity investment as opposed to direct public assistance.

Increased capital outlays have played a major role in helping Korea achieve a GNP growth rate of nearly 12% per year for the last four years, while progressing from an agricultural economy to a state of industrialization. Korea's economic development during the past several years, and particularly the remarkable increase in exports to countries throughout the world, provides ample testimony of the abilities and competitive strength of Korean industry. In 1960 manufactured goods made up only about 22% of the thirty-two million dollars in Korean exports. However, by 1970 manufactured goods accounted for almost 80% of total exports.

There is Korean Governmental recognition that in a growing but still limited domestic market, exports offer an increasingly important method of achieving economic growth. Recent evidence has shown that countries having increases in exports averaging about ten percent, experienced growth rates in total output in excess of six percent. Alternatively, the nations having only a small increase in exports (less than 3 percent) experienced under four percent total output growth. The combination of a highly intelligent and abundant labor force, a relatively low wage structure, and aggressive and forward-looking government policies has made it possible for Korea to have one of the most rapidly growing economies among the developing nations.

However, the concept of investment for research and development is still relatively new to most Korean companies. Investigations determined that while many companies appear to be aggressive in the domestic market, their exports are tied directly to past foreign technical assistance. Korean industries are just beginning to plan aggressive marketing of their own products in the export market encouraged by the recent policy of the ROK Government to offer loan and tax incentives.

APPENDIX II

AEROSPACE DATA BANK

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Aerospace Data Bank

In order to enable its scientists and engineers to keep abreast of the constantly changing scene in the aerospace sciences, NASA in 1962 initiated an indexing service called STAR, Scientific and Technical Aerospace Reports, which was made available to NASA centers, their contractors, and libraries. Because of the extremely diverse nature of aerospace research, nearly all scientific and technical disciplines are represented in STAR. The information included in STAR covers all NASA and NASA contractor reports, selected Defense Department and contractor reports, Atomic Energy Commission reports, various other Government agencies such as The Bureau of Mines, The Federal Aviation Administration, The Department of Transportation, etc., relevant conference proceedings, and selected foreign research reports.

In addition to NASA's STAR, the American Institute of Aeronautics and Astronautics publishes an index called IAA, International Aerospace Abstracts. This contains announcements and selected articles from over 800 technical journals, both domestic and foreign. Selections to the index are made based on aerospace interests, but many references of interest to non-aerospace activities are cited. The IAA indexing files date from 1963.

These two indices make up the Aerospace Data Bank -- a file now containing nearly one million technical references. The chart on the following page shows a breakdown of the sources of information in the data bank.

NASA's AEROSPACE DATA BANK *

Source of Information	Per Cent Input	
NASA and its contractors	12%	
Department of Defense	17%	
Other U.S. Government Agencies	3%	
Other U.S. Sources	32%	
TOTAL U.S. Sources		64%
Free World	19%	
Soviet Bloc	17%	
TOTAL Foreign Sources		36%
TOTAL		100%

*(This breakdown includes both STAR and IAA.)

To make the process of searching and selecting relevant information quicker and easier, NASA went to a computer-based file to store this information. This mechanized data retrieval system offers a very useful method of locating indexed references by the following ways:

- Key Word
- Author's Name
- Contract Number
- Contractor Organization

Of course, the most important one, and the one used most is the Key Word search method. This enables an interested person to locate documents in a specific area or combination of areas.

NASA has helped to establish 6 Regional Dissemination Centers (RDC's) at Universities and not-for-profit research institutes across the country. These centers have access to the Aerospace Data Bank (and other literature sources) and provide search services on a fee basis to their clients. These centers were originally supported in their operation by NASA funds, but they are now becoming self-supporting through the fees charged for their services.

The first one, Aerospace Research Applications Center, was the one which participated in the NASA/KIST program and provided valuable assistance to the KIST staff on producing and running literature searches.

Another special information dissemination center which is part of the Aerospace Data Bank is called COSMIC - Computer Software Management Information Center. This organization has been established at the University of Georgia to evaluate, file, and disseminate (at a fee) computer programs developed by NASA and other agencies. As more and more businesses and research organizations are using the help of computers in their analytical studies, utilization of programs which have already been developed can save a significant amount of time and money.

So, all of this is what makes up the information file we call the Aerospace Data Bank. As large and formidable as it is, the input and output technologies have advanced to the point where identification of relevant or required reports is now quite easy. It can even be done on real-time interaction with the computer on video display terminals.

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APPENDIX III

U.S. AND KOREAN PARTICIPANTS

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U.S. and Korean Participants

Phase I - Technical Mission Team

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Office of Technology Utilization
NASA Headquarters
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Mr. Clinton A. Stone, Director
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Dr. Joseph DiSalvo, Director
Aerospace Research Applications Center
Indiana University Foundation
Indiana Memorial Union
Bloomington, Indiana 47401

Mr. William H. Littlewood
Deputy Scientific Attache
Embassy of the United States of America
(Mr. Littlewood, who is transferring to AID/Washington, joined the team in Tokyo).

Phase II - Participants

Dr. Young Ku Yoon (Head, Physical Metallurgy Lab. 1. Corrosion Lab.): Materials science. Ph.D. (1957-Brown University). Former research metallurgist, Argonne National Lab.

Dr. Kyung Ho Hyun (Head, Control & Instrumentation Lab., Technical Information Department): Electrical engineering. Ph.D. (1967-London University, U.K.). Former research member, Reactor Equipment Division, The English Electric Company, Ltd., U.K.

Dr. Tai Won Kwon (Head, Food Resources Lab.): Food technology, Ph.D. (1963-Forida State University). Former assistant professor, Iowa State University.

Dr. Young Ok Ahn (Head, Polymer Chemistry Lab.): Chemical engineering. Ph.D. (1966-Iowa State University). Former research engineer, Research Division, DuPont Company.

Mr. Joon Woo Nam (Head, Industrial Equipment Engineering Lab.): Mechanical engineering. M.S. (1960-University of Missouri). Former senior engineer, Chicago Technical Center, Continental Can Company.

Phase III - Participants

Dr. Man Young Chung (Head, Electronic System and Equipment Laboratory): Electronic Systems & Devices. Ph.D. (1960-University of Osaka, Japan). Former Chief & Senior Engineer, Ministry of Communication, Korea.

Dr. Sung Jai Sohn (Principal Investigator, Wireless Communication Laboratory): Electrical Engineering. Ph.D. (1968- University of Wisconsin). Former Senior Engineer, ADICM Division of Teledyne.

Dr. Song Bai Park (Head, Network Analysis Laboratory): Electronics. Ph.D. (1968 - University of Minnesota). Former Assistant Professor, Oregon State University.

Phase III Follow-up Visit

Follow-up Trip	KIST Principal	Time of Visit
1. Miniature Transceivers	Dr. Man Young Chung	March/April 1971
High Sensitivity Transceivers	Dr. Sung Jai Sohn	
2. Solid Tantalum Electrolytic Capacitors	Dr. Young Ku Yoon	June 1971
3. Technology of Inductorless Circuits	Dr. Song Bai Park	July 1971

Evaluation Visit Participants

Mr. Henry Arnold, AID Office of Science & Technology
Mr. Jeffrey T. Hamilton, NASA Technology Utilization Office
Mr. Clinton A. Stone, IITRI Study Team
Mr. Serge Uccetta, IITRI Study Team
Mr. James Blackledge, Denver Research Institute*

*Although not directly involved on this program, Mr. Blackledge participated in the evaluation meeting in conjunction with a project for AID to study research institutes in developing nations.

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APPENDIX IV

DETAILED CASE HISTORY OF TRANSFERS

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Listing of Technical Problems Processed

Materials Science

1. Processing of Tungsten Ore Concentrates (Scheelite) to Tungsten Powder
2. Inorganic Coating of Steel for Fabrication of Chemical Reactor Vessels
3. Production Technology of Graphite Electrodes from Natural Graphite
4. Sintered Tantalum for Solid State Capacitors
5. Preparation of Iron Oxide for Ferrites
6. Sintered Aluminum Powder Products
7. Explosive Metalworking of Mild Steel
8. Explosive Cladding of Lead Plate to Steel Plate
9. Manufacturing Process of Copper Sleeving Over Aluminum Wire
10. Agricultural Use of Blast Furnace Slag as Fertilizer or Soil Conditioner
11. Metal Ceramic Coating
12. Manufacturing Technology of a New Sheet Material for Use as the Flooring of Korean Ondol Room

Mechanical Engineering

13. Injection Nozzel Used for Diesel Engine
14. Magnetic Ink and Its Sensor
15. Die Casting Technology for Non-ferrous Materials
16. Computer Programs for Management
17. Sensor Technology
18. Manufacturing Technology of Self-Lubricating Steel Bearing by Squeeze Casting Method
19. Life Testing Method for the Deep-Grooved Ball Bearings

Food Technology

20. An Economical Retort Pouch as a "Flexible Can"
21. Filtration Methods for Removing Bacteria From Air
22. Bacteriophage Monitoring in Fermentation Industries
23. Continuous Maintenance of Reduced Oxygen and Carbon Dioxide Contents in Warehouse Atmosphere for Apples

24. All Purpose Survival Rations
25. Low Cost Process For Harvesting and Drying Micro Algae
26. Potential Food Additive Generating Heat With Water for Instant Rice

Chemical Engineering

27. Elimination of Carbon Monoxide in Anthracite Coal Burning
28. Light Weight Thermal Insulation
29. Improved Pressure Sensitive Adhesives
30. Clear Polyvinyl Chloride Bottles
31. Modacrylic Fiber Technology
32. Antioxidant for Nylon
33. Adsorbents for Gas Masks
34. High Alkali Detergents
35. Hydrogen Peroxide
36. Freon
37. Fiber Reinforced Plastics
38. Ball Explosive Process
39. Reflective Paints
40. Flame Retardants and Antistatic Additives
41. Technology for Solid Waste Treatment

Electronics

42. Miniature Transceivers for Personal Radios
43. Lead-Calcium Alloy Manufacturing Technology for Electric Battery Plates
44. High-Sensitive Transceivers
45. An Indicating Instrument to Specify the Charge-State of Secondary Batteries
46. Manufacturing of Solar Cells for a Power Source
47. Non-Destructive Testing by Microwaves
48. Solid State Display Device for Desk Calculators and Digital Instruments
49. Manufacturing Technology of Al-Foil Conductor
50. Laddic Techniques

51. Manufacturing Technology of Fractional Horsepower Mini-Motor

52. A Method for Determining the Usable Energy of Primary Batteries (Combined with EE-4)

53. Technology for Elimination of Static Electricity Due to Friction

54. High Voltage/High Current Pulse Generator

55. Small Electrical Power Sources for Remote Offshore Isles

56. Low Cost Electrical Utility Pole

57. Weather Satellite Picture Receiving Station

58. Inductorless Circuit Technology

59. Design Technique for 50 MHz FM Transceiver

60. Radiation Efficiency Improvement Whip Antenna

61. Stabilization Techniques of Solid State Microwave Sources

62. Analysis of Radiation Characteristics for Phased Array Antennas

63. Design Principles of Improved Ignition Systems for Automobile Gasoline Engines

64. Design Principles of Active Band Pass Filters for High Frequencies

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Transfer Case Histories

I. Problems for In-Depth Follow-up

EE-1 Miniature Transceivers

This problem actually consists of three separate but related sub-problems:

(1) The development of an improved citizens band transceiver.

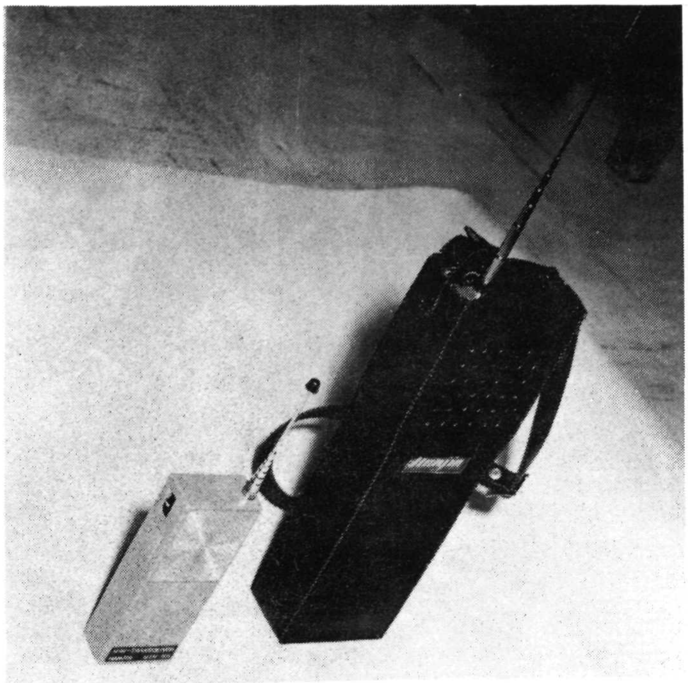
This work is being sponsored by the Han-Jin Electronics Company to produce miniature 49 MHz, communication devices for consumer and industrial uses. Initially, this product will be marketed only within Korea, but eventual exportation of this is also being planned.

The problem areas investigated here were receiver circuit miniaturization, reduced power drain, and improved sensitivity. The literature search through the data bank provided numerous relevant technologies for investigation and evaluation, involving developments produced by NASA, the Defense Department and private industry. These were all reviewed during the follow-up visits of Phase III.

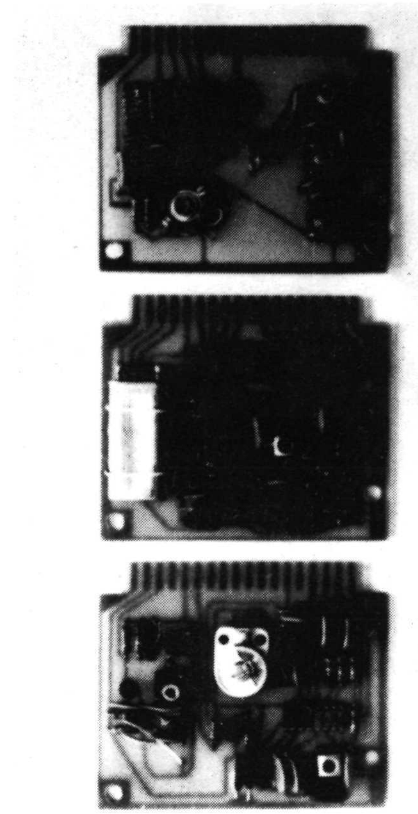
Various techniques to solve the problems were investigated. These involved the use of monolithic and hybrid integrated circuit, micro-miniature discreet components and special circuitry. The Koreans obtained information on these approaches through discussions with NASA personnel at the Goddard Spaceflight Center, the Manned Spacecraft Center, and the Jet Propulsion Laboratories; with NASA and DOD contractors such as Westinghouse, RCA, and Texas Instruments; and with private companies such as National Semiconductor, Motorola Semiconductor, Fairchild Semiconductor, and Silicon General. More specifically, the circuitry of the amplifiers and modulation circuits used in the Apollo Extra Vehicular Communication System and the U. S. Army's PRC-95 transcriber, provided the necessary designs for wider operational range and decreased inter-modulation distortion.

These improvements coupled with KIST's own unique designs will allow Korea to market these devices at home and abroad more competitively.

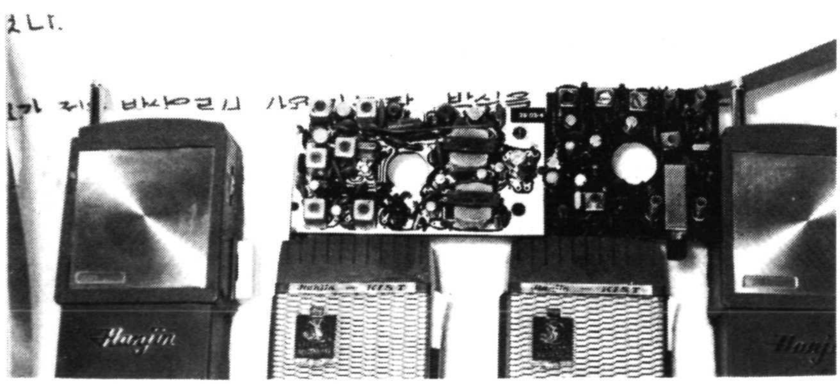
The photographs below show some of the KIST developments.



Transceivers utilizing modified audio receiver parts (for lower power consumption) and high sensitivity amplifiers.



Electronic parts distributio



Inside structure of the new transceiver utilizing a diode modulator (circuit at right) compared with the structure of the conventional transceiver (circuit at left)

The Korean Government regulates the size of the transceivers sold in Korea to standardized dimensions; thus, the larger unit will be for domestic use and the smaller one for export only. About 55 of the improved domestic unit have already been produced at KIST on a pilot basis.

(2) The development of "pocket" page communication devices.

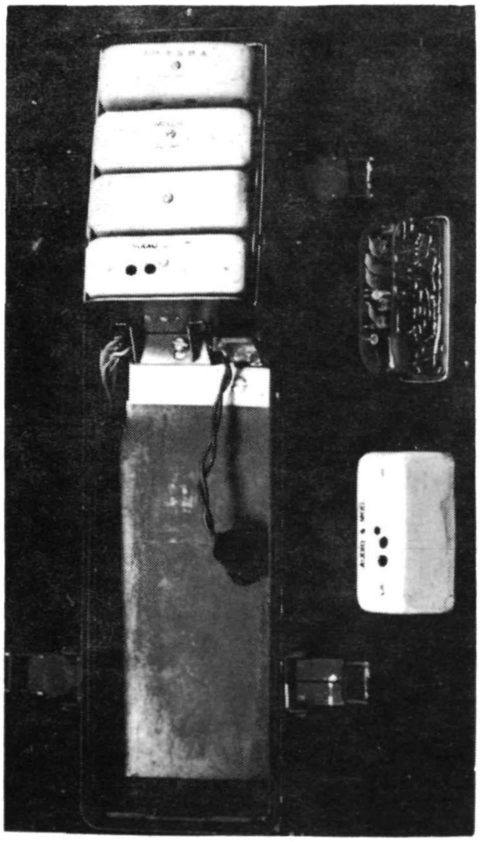
This is being sponsored at KIST by the Korean Ministry of Communication. It calls for KIST to develop an operational prototype of such a system so that they can be manufactured within Korea. KIST has been pursuing the design of a two-way tone signaling system, and required assistance in learning of applicable circuitry and design schemes for such equipment.

Two sources were identified and contacted which provided the required information and technical know-how. The Bell Telephone Laboratories, which developed such devices for use in the Bell System, provided a report describing their design in detail. Analysis of this data was very helpful to the KIST specialists in formulating their design approach. Further, NASA's Jet Propulsion Labs had developed a miniature, tone-modulated FM transmitter which had a number of features directly applicable to what the Koreans wished to build. Through study and evaluation of the technical report on this device, personal discussions with the innovator/designer, and inspection and test of the device itself, the KIST people were able to adapt several of the techniques applied by JPL. Namely, the circuitry of the miniature hybrid integrated circuits and the special integrated antenna were incorporated by the Koreans into their own design.

Thus far, a prototype of a two tone warning signal transmitter has been built and future efforts will involve development of a combination tone-transceiver device. No commercial sales impact has been estimated for this; however, KIST anticipates that these devices will be built and marketed by the Gold Star Electric Company in Korea.

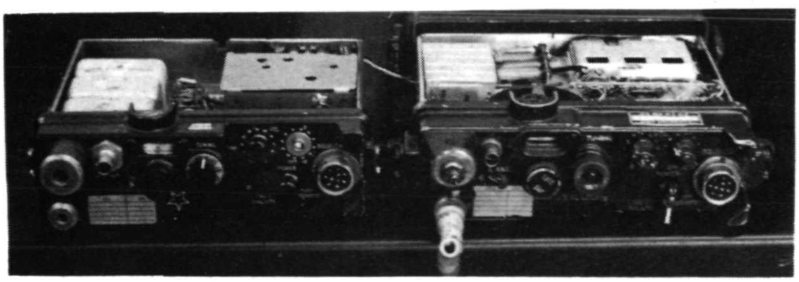
(3) The development of improved military transceiver equipment.

This project is sponsored by the Korean Ministry of Science and Technology and is related to the fact that Korea wishes to establish a capability to support its own defense. One phase of the project involves converting older tube-type units to an all solid state design. Technologies basically the same as that for the citizens band units have been used to produce the prototypes of the modified units shown below.



A new transceiver of module type inner construction

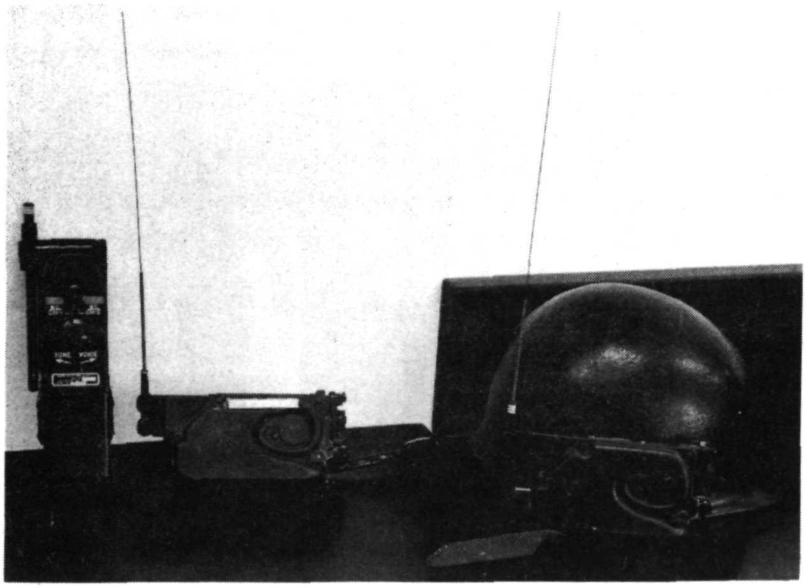
A new transceiver utilizing press-talk switch



Modified PRC-10 with module construction and frequency selection (at left) compared with old PRC-10 (at right)

This KIST effort has resulted in devices which are more reliable, consume less power, have increased power output, and have a multi-channel capability. A number of these units have been built and are now undergoing field testing by the Korean Armed Forces.

Another phase of this project at KIST has involved the modification of a military transmitter-receiver set obtained during the follow-up trip of Phase III. KIST has re-designed the system to incorporate two existing devices into one which mounts on the side of an infantry helmet.



Both the transmitter at the left of the picture and the receiver in the center, have been housed in the receiver casing alone by utilizing the micro-miniature electronics technology described earlier.

These units are experimental in design and their utility as combat devices is being evaluated by the Korean military. If they are approved, KIST will then assist Korean industry in gearing up for production. Future efforts along these lines at KIST will involve the application of these technologies in the development of a new, Korean-designed military transceiver.

EE-3 High Sensitivity Transceivers

This problem area consists of four separate sub-projects being supported at KIST by Korean government funding from the Ministry of Science and Technology. They are:

(1) The development of supersensitive receiving circuits for commercial FM radios and television receivers.

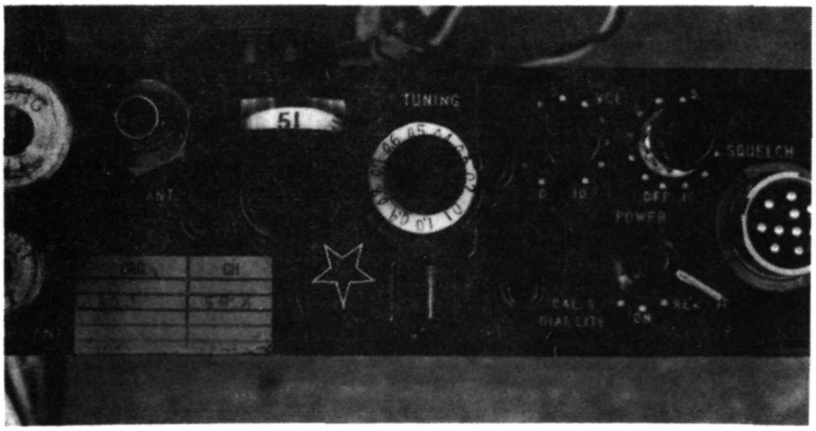
KIST is interested in developing an improved tuning system to incorporate into Korean made FM radios and TV sets which would give them a performance advantage over competitive products. Basically, this has involved the investigation of phase-locked-loop technology and its application to the tuning circuit of these devices. In the meetings with specialists from NASA Centers, DOD installations, government contractors, and private industry, the Koreans obtained schematic designs of special circuits, circuitry layout descriptions, and optimum component specifications. Based on these discussions the KIST participants devised discreet and integrated circuit designs for an improved tuning system. A prototype unit for FM radio use has already been developed at KIST, and efforts are now being directed towards producing a complete, consumer-oriented product design. This will then be transferred to a Korean company for manufacture and marketing.

The project to incorporate such designs into a television receiver is just being established. The use of these phase-locked-loop techniques to detect the video portion of TV signals is a new application. The basic problem is one of economics, that is, to incorporate an effective and efficient system in a TV set using low-cost electronic parts. KIST hopes to succeed in this effort within the next year.

(2) The development of a digital frequency synthesizer for multi-channel transceivers.

KIST is interested in incorporating a multi-channel capability in their transceiver developments; initially with the military units, and eventually with consumer devices. Phase-locked-loop digital frequency synthesizers are devices which can provide a large number of usable channels easily and inexpensively.

The Koreans have had discussions with a number of specialists in this area to evaluate potential designs and to obtain some commercially available units for testing. As a result, a prototype frequency synthesizer has been developed at KIST and has been installed in the modified military transceiver shown in the photograph on page A-21. The photograph below shows the frequency (channel) selection controls on the transceiver.



Front control dials of the radio
transceiver showing frequency
synthesizer selector

Design plans are now being developed to produce a similar system which will require only one-half the power which the present system consumes.

(3) The design of a television signal translator-repeater station.

Korea wishes to expand the beneficial effects that television can have on the overall social development of rural communities.

Thus, a critical factor is enlarging the effective range of the TV transmitting stations and penetrating the mountainous regions prevalent in Korea. So KIST has undertaken a project to design a special TV translator-repeater that would receive a TV signal and retransmit it through the air or by cable to a nearby community.

The Korean Broadcasting System and other Korea stations have expressed great interest in purchasing units for field installations in the next year or two. This project has just recently been initiated at KIST and the design should be completed in early 1973. The most difficult aspect of the project will be in the development of wideband UHF amplifiers and accurate oscillators operable in the wide temperature range of the natural Korean environment. The learnings made by the KIST participants regarding highly accurate oscillator circuits during their visits will help them in this development. The Han-Jin Electronics Company has expressed an interest in manufacturing and selling these repeater stations to Korean customers.

(4) The design and development of mobile transceivers.

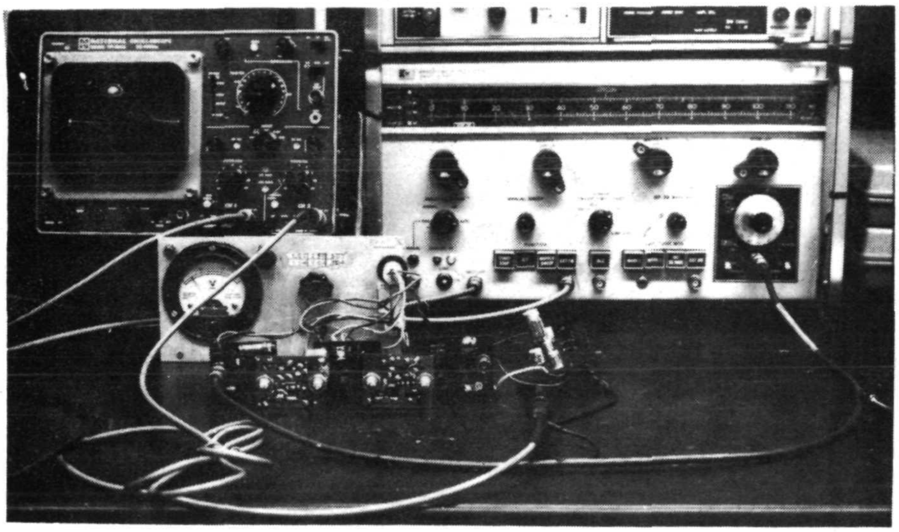
Korea has been importing thousands of mobile (automobile type) transceivers yearly, and now wishes to apply its technical expertise and manufacturing capability to supply this product domestically. KIST has been funded by the Korean government to develop a design which would be produced and sold to Korean customers, and could also eventually be exported. They are developing a 450-MHz, 12 volt transceiver incorporating microminiature integrated circuits and utilizing phase-locked-loop techniques for improved sensitivity. This should be completed and ready for transfer to a Korean company by the end of 1973.

EE-18 Inductorless Circuit Technology

This transfer case came about as a direct result of the miniature transceiver follow-up visits to NASA's Goddard Spaceflight Center by the KIST researchers. In meetings with the NASA specialists to discuss special microcircuit design and utilization techniques related to the general transceiver problem area, this novel technical development was described as a possible solution. Essentially, it involves the design of stable active filter networks and oscillators in the VHF and UHF range without the use of any inductors. As inductors can be bulky, expensive, and sometimes difficult to tune, the elimination of these devices can greatly simplify electronic circuits. Further, this would allow a considerable reduction in the overall size of the circuit and would make it amenable to micro-miniature design in the form of an integrated circuit.

The KIST principals felt that this technology has potential application to a broad range of electronic products which could be made more reliable, smaller, and cheaper by the use of these techniques. So this area was then selected as a transfer to be pursued in its own right, and a separate follow-up effort was made to learn more about the basic design principles from the U. S. specialists. Visits to the Goddard Spaceflight Center and its contractors, Martin Marietta and Gaertner Research, provided the necessary information and know-how to pursue this further at KIST. A factor made clear to the Koreans was that this technology was still in the experimental stage and that additional theoretical and experimental analysis was still required to allow practical production applications. KIST was provided with a sample inductorless UHF filter, and detailed information on the computer-aided design of active band-pass filters. The Koreans also obtained additional data on new commercially available electrical components and micro-electronic production facilities through visits with some of the leading companies in the field such as, Hewlett-Packard, TRW Semiconductor Division, Varian Associates, Lockheed Missiles and Space Company-Microelectronics Fabrication Division, and the COMSAT Research and Development Laboratories.

After the follow-up visits, KIST embarked on a detailed study and design analysis of the inductorless circuits. They have produced and tested several types of circuits and learned that their temperature stability needed substantial improvement if they were to be used in consumer products. So the Koreans developed a technique to make the circuit less sensitive to changes in temperature and thus practical for use outside of a laboratory situation. A breadboard 50 MHz FM receiver was built and is now being tested.



Experimental set-up of the VHF-FM receiver using active band-pass filters having no bulky inductors.

Further work by KIST to adapt and commercialize this technology has been structured into a three phase development program:

Phase I - Design and construction of Prototype Miniature FM receivers of 50, 150 and 450 MHz.

Phase II - Production of Receivers in Breadboard Integrated Circuit Form.

Phase III - Study of Mass Production Considerations.

Phase I has already been successfully completed, and the project is moving on to Phase II. KIST expects to apply the successful outcome of the project initially to their transceiver development programs and ultimately to other industrial and consumer electronic products. As these practical applications are still 1 to 2 years away, a quantitative estimate of their commercial impact is difficult to make; however, in a qualitative sense, KIST sees Korean industry making significant gains in the consumer electronics market by virtue of the product improvements they plan to develop and apply.

MM-4 Tantalum Electrolytic Capacitors

Korean industries have expressed great interest to KIST in acquiring the manufacturing technology for these capacitors. So KIST was interested in establishing a pilot manufacturing capability to make tantalum capacitors, which could be demonstrated and transferred to a Korean company.

In this problem area, the Koreans were interested in getting a broad range of information on the overall technology of tantalum capacitor production. The literature search supplied the names of the major U. S. producers of these capacitors and provided numerous relevant documents relating to Government sponsored developments in the area. The majority of these developments were related to advances in reliability and quality control for the capacitors in mass production, while little information was obtained relative to the basic process engineering. A number of visits were made by the Koreans to several of the leading U. S. companies to obtain the following data:

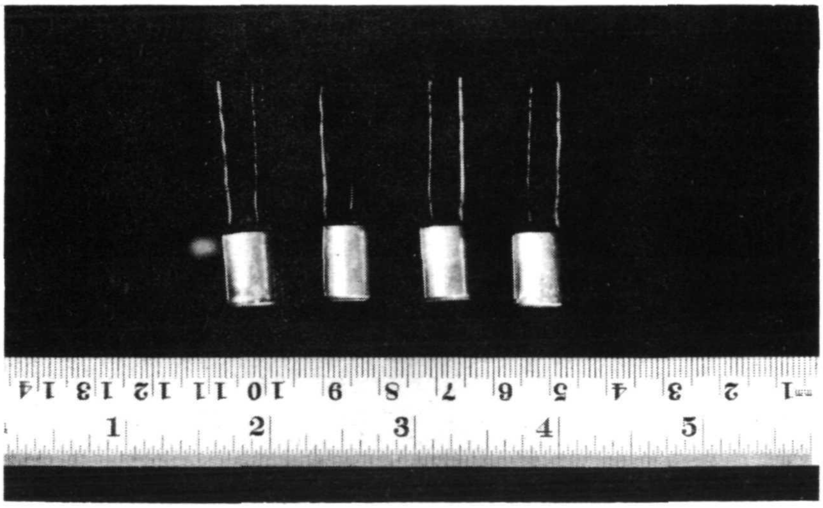
1. An overview of the tantalum capacitor industry involving production facilities, capital requirements, and overall technology contents.

2. The availability of production machinery equipment, and engineering technical support services from U. S. firms.

3. Technical discussion with specialists on the current R & D emphasis in the field and the market trend in the U. S. and overseas.

Additionally, the KIST researchers visited tantalum powder producers to assess their suitability to ultimately supply a Korean manufacturer, and to obtain sample materials for testing at KIST.

The project to establish a pilot manufacturing facility is progressing very well. The Koreans have succeeded in producing high quality tantalum capacitors from their process. The photograph below shows several samples of the capacitors produced at KIST.



What now remains to be done is to refine selected processing steps to improve the field and reduce the number of rejects. This work is progressing well and now the quality control information retrieved from the data bank will be reviewed and applied to establish a fully operational and efficient process.

Along with this development program, KIST is approaching three interested Korean manufacturers to support a thorough techno-economic and market study for tantalum capacitor production. The three companies include Tai-Han Electric Company, Sam Sung Electronics, and Sam Wha Condensor Company. The KIST specialists feel that the results of this survey, along with the availability of an operational pilot manufacturing line, will be instrumental in "selling" one of the industries to enter the market. At that time, KIST will transfer all of its know-how regarding the production procedures and facilities to the sponsoring Korean company, and will assist in the training of key industrial personnel.

EE-16 Weather Satellite Picture Receiving Station

During the Phase II session, the Koreans obtained a NASA report which described the construction and operation of a weather satellite picture receiving station. They brought the document back to KIST for analysis and evaluation, and subsequently met with Korea's Office of Central Meterology to discuss the possibility of establishing such a system at KIST. As a result of these meetings, the Meterology Office has provided the necessary funds to develop a receiving system. After studying the NASA documentation, the Koreans requested informational follow-up by IITRI to acquire a technical appraisal and a detailed cost estimate for the parts and supplies necessary to build a unit. Specialists at NASA's Goddard Spaceflight Center have assisted in providing the necessary information to KIST. They recommended that KIST purchase an existing commercially available system from a company licensed by NASA to produce them. The EMR Aerospace Sciences Corporation, which was the original Goddard Center contractor in this area, is one of the companies currently manufacturing systems under NASA authorization, and they have provided KIST with specific technical and cost data on all the system components.

KIST has made a decision to establish two new receiving systems, one to be purchased from a U. S. supplier and the other to be built at KIST using the NASA designs. By building one system themselves, the Koreans can incorporate some of their own developments in the receiver (specifically, they plan to use the inductorless circuit techniques in building the 135-MHz FM receiver section) and they can build up working experience with the system design so that they can perform any required maintenance and trouble-shooting. KIST plans to have both of these systems built and operational by Spring of 1973.

II. Limited Follow-up Problems

FT-1 Retort Pouch as a Flexible Packaging Material

This problem was investigated to identify packaging materials and techniques which could be used to replace standard tin cans for many foods packaged in Korea. Based on a search of the Aerospace Data Bank, Dr. Tai Won Kwon identified a new packaging material which would be useful to the Korean food industry. Rights to this technology belong to Continental Can Company, and we have conducted preliminary inquiries about obtaining a license. The Continental Can Company seems interested in licensing this technology and they plan to hold discussions soon with the interested Korean company. During the course of the project, Continental Can Company has supplied samples of the pouch for experimentation by Dr. Kwon at KIST. Dr. Kwon has been studying the pouch's applicability to both military and commercial packaging uses. His initial results have indicated that it works well; however, he plans more experimental verification of the shelf life and storage capability of the pouch and foodstuff. KIST expects continued government funding of this project and if the results of his work are favorable, mass production of these pouches in Korea would be strongly recommended.

FT-5 Survival Rations

This project at KIST is sponsored by the Korean Defense agency to develop military rations suitable to Korean tastes. A search of the data bank revealed a substantial amount of information concerning new food developments and survival rations. Much of this data helped Dr. T. W. Kwon in structuring and carrying out his research program at KIST. A NASA development in preparing and using freeze dried rice as a food ration was evaluated by KIST, but found unagreeable to Korean tastes and customs. The NASA freeze drying process made the rice too soft and starchy, and this is apparently unacceptable to Koreans. Nonetheless, this product provided an interesting approach at preserving precooked food which KIST is currently studying.

CE-1 Carbon Monoxide Elimination

Korea needs improved technology for producing industrial and military gas masks and appropriate carbon monoxide elimination chemicals. While a search of the Aerospace Data Bank did not reveal any immediately applicable technology, it did produce a large amount of technical information related to current research in this field. Additionally, the search disclosed that the Army Natick Laboratories had sponsored a substantial amount of research in this area with industrial contractors. Contact will be made with the appropriate specialists when KIST is prepared to move ahead in this area and the necessary project funding is secured.

MM-7 Explosive Metalforming

The Koreans expressed a desire to establish a pilot facility to demonstrate the effectiveness of explosive metalforming techniques. During Phase II, Dr. Yoon inspected a facility at the Denver Research Institute and received an engineering cost estimate to establish a facility at KIST. Dr. Yoon coordinated with Korean industry to determine the characteristics of the metals and parts that might be formed. Based on these inputs he concluded that such a facility was not cost effective at that time. However, a review of Korean industry requirements in this area was made during the Phase IV evaluation trip and it appears that this type of manufacturing facility may now be justified. Appropriate specialists will be contacted by KIST to evaluate this technical area in more detail. If an explosive forming facility is indeed warranted, then KIST will establish a project to actively pursue a transfer of this technology.