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UNCLASSIFIED

DEPARTMENT OF STATE
AGENCY FOR INTERNATIONAL DEVELOPMENT
Washington, D.C. 20523

PROJECT PAPER

249p

Proposal and Recommendations
For the Review of the
Development Loan Committee

SRI LANKA - AGRICULTURAL BASE MAPPING - VOLUME I

AID-DLC/P-2270

UNCLASSIFIED

DEPARTMENT OF STATE
AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D.C. 20523

UNCLASSIFIED

AID-DLC/P-2270

September 26, 1977

MEMORANDUM FOR THE DEVELOPMENT LOAN COMMITTEE

SUBJECT: Sri Lanka - Agricultural Base Mapping

Attached for your review are recommendations for authorization of a loan to the Government of Sri Lanka (the "Cooperating Country") of not to exceed Four Million Five Hundred Thousand United States Dollars ($4,500,000) (the "Authorized Amount") to help in financing certain foreign exchange and local currency costs of goods and services required for the Project.

No meeting is scheduled for this loan proposal. However, please advise us of your concurrence or objections as earl as possible, but in no event later than close of business on Thursday, September 29, 1977. If you are a voting member, a poll sheet has been enclosed for your response.

Development Loan Committee
Office of Development Program
Review and Evaluation

Attachments:
Summary and Recommendations
Project Analysis
Annex A (A-H)

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AGENCY FOR INTERNATIONAL DEVELOPMENT

PROJECT PAPER FACESHEET

1. TRANSACTION CODE: A (A = ADD, C = CHANGE, D = DELETE)

PP

2. DOCUMENT CODE: 3

3. COUNTRY ENTITY: Sri Lanka

4. DOCUMENT REVISION NUMBER:

5. PROJECT NUMBER (7 digits): 383-0045

6. BUREAU/OFFICE: A. SYMBOL: ASIA; B. CODE: 04

7. PROJECT TITLE (Maximum 40 characters): Agricultural Base Mapping

8. ESTIMATED FY OF PROJECT COMPLETION: FY 83

9. ESTIMATED DATE OF OBLIGATION: A. INITIAL FY 77; B. QUARTER 4 (Enter 1, 2, 3, or 4); C. FINAL FY 83

10. ESTIMATED COSTS ($000 OR EQUIVALENT $1 =)

A. FUNDING SOURCE	FIRST FY B. FX	FIRST FY C. L/C	FIRST FY D. TOTAL	LIFE OF PROJECT E. FX	LIFE OF PROJECT F. L/C	LIFE OF PROJECT G. TOTAL
AID APPROPRIATED TOTAL						
(GRANT)	( )	( )	( )	( )	( )	( )
(LOAN)	(4,300)	(200)	(4,500)	(4,300)	(200)	(4,500)
OTHER U.S. 1.						
OTHER U.S. 2.						
HOST COUNTRY						
OTHER DONOR(S)					1,918	1,918
TOTALS						6,418

11. PROPOSED BUDGET APPROPRIATED FUNDS ($000)

A. APPROPRIATION	B. PRIMARY PURPOSE CODE	PRIMARY TECH. CODE C. GRANT	PRIMARY TECH. CODE D. LOAN	E. 1ST FY 77 F. GRANT	E. 1ST FY 77 G. LOAN	H. 2ND FY H. GRANT	H. 2ND FY I. LOAN	K. 3RD FY L. GRANT	K. 3RD FY M. LOAN
(1) FN	180B		053		4,500				
(2)									
(3)									
(4)									
TOTALS					4,500				

A. APPROPRIATION	N. 4TH FY O. GRANT	N. 4TH FY P. LOAN	Q. 5TH FY R. GRANT	Q. 5TH FY S. LOAN	LIFE OF PROJECT T. GRANT	LIFE OF PROJECT U. LOAN
(1) FN						4,500
(2)						
(3)						
(4)						
TOTALS						4,500

12. IN-DEPTH EVALUATION SCHEDULED: MM 10 YY 83

13. DATA CHANGE INDICATOR. WERE CHANGES MADE IN THE PID FACESHEET DATA, BLOCKS 12, 13, 14, OR 18 OR IN PRP FACESHEET DATA, BLOCK 12? IF YES, ATTACH CHANGED PID FACESHEET.

2 (1 = NO, 2 = YES)

14. ORIGINATING OFFICE CLEARANCE

SIGNATURE: [signature]

TITLE: CAPITAL DEVELOPMENT - USAID RESOURCES OFFICER, COLOMBO

DATE SIGNED: MM 08 DD 26 YY 77

15. DATE DOCUMENT RECEIVED IN AID/W, OR FOR AID/W DOCUMENTS, DATE OF DISTRIBUTION: MM 08 DD 26 YY 77

AID 1330-4 (1-78)

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PART I. PROJECT SUMMARY AND RECOMMENDATIONS

A. Borrower: The Government of Sri Lanka

B. Implementing Agency: Survey Department
Ministry of Agriculture and Lands

C. Recommendation:

1. AID Contribution:

Loan: $4,500,000

Terms: Repayment of principal and payment of interest within 40 years, including a ten year grace period of repayment of principal, with interest at two percent (2%) per annum during the grace period and three percent (3%) thereafter.

2. Borrower's contribution: Rs 13,982,000
= $ 1,918,000
@ RS 7.29 = $1.00

D. Description of Project:

The project will provide over a six year period capital equipment, expendable supplies, technical assistance and facility renovation to the Survey Department of the Ministry of Agriculture and Lands as well as long and short term training to selected other Ministries and Departments of the Government. These inputs will result in the production of a 1/50,000 and 1/10,000 scale base map of Sri Lanka which will be continuously updated as well as the production of larger scale area and project specific maps as needed by user agencies. The project will also provide for the establishment and operation of a "User Assistance Center" within the Survey Department which will serve both as a resource center for other agencies to use in their analysis and interpretation of maps and related information, and as a research center for the Survey Department enabling it to keep abreast in areas related to aerial surveys and remote sensing.

The project has been technically reviewed by experts in the field of aerial photography and mapping who confirm that project design and implementation plans provide a sound basis for believing that the inputs will produce the outputs projected. At the end of the project Sri Lanka will have base maps at 1/50,000 and 1/10,000 scale; project and area specific maps requested by various user agencies; a functioning User Assistance Center providing resources for maximum utilization of maps by agencies of the government involved in the planning and implementation of rural development projects; and the Survey Department will have the capability and capacity to continually update the base map series and provide additional larger scale maps as needed. In sum, the project will permit the achievement of the project purpose which is to meet the mapping requirements of rural development in Sri Lanka.

E. Summary Findings

The project is technically and financially sound and is the most cost effective means of achieving the project purpose. There are no environmental or social implications except that since the project will provide accurate information for development planners, it will contribute to the genesis of sounder rural development projects. The implementing agency is experienced in all aspects of the project and with minimal technical assistance and short-term, primarily familiarization training, is competent to implement the project. The project meets all applicable statutory criteria. A copy of the Statutory Checklist is available in ASIA/PD for review. The AID Representative has certified that Sri Lanka has the capability to effectively maintain and utilize the project (Annex A).

F. Project Development Team

The initial project proposal was prepared by the Survey Department, Ministry of Agriculture and Lands, Government of Sri Lanka. The PID was drafted by Clark Billings, USAID, Colombo. Major project analysis was performed by a team of specialists from Resources Development Associates under an IQC with AID.

The RDA team consisted of:

Ken Craib	RDA Operations Director Remote Sensing Specialist
John Cain	Photogrammetrist/Mapping Specialist
Earle Knibiehly	Photogrammetrist/Facilities Specialist
Warren Ketler	Economist/Resources Survey Specialist

The RDA team prepared two project reports, "A Program Assessment and Evaluation" in November 1976, and "Program Design and Recommendations" in April 1977. The PRP was prepared on the basis of the initial RDA report by Charles Antholt, then ASIA/TR.

The RDA reports were reviewed by the Survey Department, primarily the Deputy Surveyor General, Christopher Nanayakkara; by the United States Geological Survey International Activities, Photogrammetry, Mapping Requirements, and Research and Technical Standards offices; and by USAID Colombo and AID/W.

The Project Paper was drafted by Jeff Evans, USAID, Colombo and Steve Freundlich, ASIA/PD with substantial contributions from RDA. Frank Kenefick, ASIA/PD was a primary AID project analyst.

AID/W Project Committee:

Jeff Evans	ASIA/PD	Chairman
Steve Freundlich	ASIA/PD	
Rollo Ehrich	ASIA/TR	
Peter Bloom	GC/ASIA	
Dick Nelson	ASIA/BIS	
Tom O'Connor	ASIA/DP	

USAID/Colombo

Jeff Evans	Project Manager
Charles Antholt	Agricultural Economist

G. Project Issues

During and subsequent to the PRP review of this project held on November 23, 1976, the following issues were raised and resolved:

Issue: APAC requested that the linkages between project purpose (to meet the mapping requirements of rural development) vs. project goal (generate rural development which increases domestic food production, expands employment opportunities, and improves rural population standard of living) be more clearly defined in the project paper; that the paper note the relationship of the project to AID's target population; and that the paper discuss the impact of the project on current or planned development projects.

Response: The Sri Lankan economy is primarily an agrarian one. Economic development has traditionally been associated with the production of tree crops for export—tea, rubber, and coconut—and the agricultural sector accounts for 55% of all employment (IBRD report, March 1976). In 1973 it was estimated that the agricultural sector provided 33% of the Gross Domestic Product and 78% of all export earnings. In recent years, however, a falling international market and a prolonged drought have resulted in a substantial decrease both in the volume of export crop production and in the amount of available foreign exchange. The drought has also led to a decrease in production of domestic food grains. At the present time, over 25% of all rice supplies (by far the most important food grain) must be imported. This situation has been compounded by owner anticipation of land reform and concomitant permissive deterioration of cropland. The IBRD report concludes that Sri Lanka must "accelerate the task of adjustment to the circumstances in which the country now finds itself so that the required policies can be implemented with a minimum of delay."

Given the unlikelihood of expanding export earnings at any substantial pace, development policy must depend heavily on import substitution as a means to conserve foreign exchange for investment purposes. Increased emphasis must then be placed upon increasing agricultural production for

domestic consumption. The Government of Sri Lanka has recognized this fact, and has placed the highest national priority on increasing production of domestic foods. This is effected through a "Land Policy," which includes land reform, intensification and optimization of land use, and support to increased food production. In Sri Lanka, where 60% of the total crop land in production is composed of individual "small holdings" of less than five acres (28% of total crop land is held in units of less than one acre), such a program must be, and is directed at the small farmer, the "poor majority" of Sri Lanka.

If development of the agricultural sector is to proceed along efficient lines, it must be based upon an adequate understanding of the present position and the forces determining future demand and supply. Development of some sort will certainly occur in the absence of such knowledge and understanding, but it can hardly be termed efficient and may be counter-productive.

Government decision-makers normally rely heavily on statistical data, as a guide to establishing development policy and determining its effects. In the agricultural sector, such policy can include price supports, fertilizer, subsidies, agricultural credit, land reform, etc. In most developing countries, however, statistical data are both deficient in coverage and poor in quality. The problem is compounded by the fact that much of production is on a subsistence level, the production units themselves are small and scattered, and processing is limited.

In an effort to determine the need for and importance of a mapping program in Sri Lanka, the RDA team met with a variety of agencies and organizations, representing the major users of maps and photographic products. Organizations contacted included the Ministry of National Planning, Ministry of Agriculture, Ministry of Irrigation, Power and Highways, Department of Census and Statistics, Department of Agriculture, Irrigation Department, Land Use Division, Agricultural Project Preparation Unit, University of Sri Lanka, and the Mahaweli Development Board.

These "user organizations" are for the most part well staffed and professionally run. They are thoroughly familiar with the utility and method of use of standard aerial photography, maps, and photogrammetric products. These materials are required and are in daily use within these organizations.

Illustrative of the need for and application of maps and photographic products to development in Sri Lanka are the following specific instances:

1. Census

Agricultural statistics in Sri Lanka are compiled by the Department of Census and Statistics. The most recent agricultural census was conducted in 1973 (published in 1975). This census relied on "field enumerators" and an area frame sampling technique. The sample frame in turn was based on a land-use map prepared (in 1961) from aerial photography

taken in 1956. In addition to being 20 years out of date in a country where land use is characterized by rapid change, the present land-use map aggregates land use at a minimum ten-acre unit level. Since 60% of all productive units are less than five acres in extent and thus must be shown incorrectly if shown at all, such a map is of limited reliability and utility. This in turn directly affects the sample design, the resulting statistics, policy determination and resources allocation decision.

The Department of Census and Statistics has a stated requirement for new and current land-use data over the entire country, aggregated at the two-acre level, or smaller. The proposed Agricultural Base Mapping Program would provide the basic material and data needed to compile such a land-use map.

2. Irrigation

If Sri Lanka is to approach self-sufficiency in food-grain production, it must rely heavily upon irrigation projects designed to bring new lands under cultivation and to insure adequate supplies of water in presently cultivated areas. Planning, design, engineering, and construction of such projects are responsibilities of the Irrigation Department. The Department conducts soils and land-use surveys in support of irrigation project planning and design. Accurate maps and geo-specific land-use information at appropriate levels of detail are necessary inputs. Similarly, detailed and accurate topographic maps are required to support engineering and construction operations. These programs cannot be completed in the absence of such basic information.

The Udawalawe area provides one interesting (and typical) example of the quality and completeness of the existing information base and its impact on development planning. This area is the site of a proposed major agricultural development and resettlement program. Aerial photos of the same area produced in 1956 (the basis for the current national base map) and 1972 are so different th they seem to be of two separate areas. Various maps compiled from the rly photos based on more recent field surveys exclude major featur including a sizeable reservoir.

Photographs taken in 1976 by the RDA team show that the changes in land use that have taken place in the last four years are of such magnitude that it is almost impossible to orient these photos with the 1972 mapping photography. Obviously, project planning based on existing outdated maps would have serious implications for the development of a viable project. This is not an isolated example. It is repeated may times throughout Sri Lanka.

3. Land Use and Agriculture

The Land Use Division of the Irrigation Department has noted a minimum requirement for new aerial photography and mapping of over 750,000 acres per year for "priority areas" alone, and have pointed out that they could both use and would like to have much more than this.

The Department of Census and Statistics noted that the 1961 land-use maps aggregate land use at the ten-acre unit level, and that with the recent emphasis on land reform, resettlement, and small farmer production this level of aggregation alone make the data unusable for current purposes. A definite requirement for new land-use data, aggregated at the two-acre unit level or smaller, exists for the entire country. The Director of the Department of Agriculture has stated that new and current aerial photography is essential to the completion of projects for which he is responsible. It is required as base material for agro-ecological analysis, efficient definition of areas suitable for multiple-cropping, for soils conservation planning and effective watershed management.

Similar requirements for aerial photography, photogrammetry, and map production were expressed by almost every agency or organization visited by the RDA team.

In summary, there is a definite need for improved agricultural and land-use information in Sri Lanka to support current programs and future development. In the absence of such information, these programs and development plans will be seriously and adversely affected. This in turn will have a direct and adverse impact on the economy of the country and the lot of the poor majority who are primarily dependent upon the agricultural sector. A properly designed and executed agricultural/land-use base mapping program can provide this necessary information base. GSL agencies charged with the conduct of development plans and programs need and can effectively utilize this information.

B. Issue: APAC noted that PP should contain a priority listing of areas of the country to be photographed and mapped and should indicate how these relate to GSL agricultural plans.

Response: Figures 11 and 12 of the Technical Annex show the priorities for initial aerial photography for preparation of the 1/50,000 and 1/10,000 base map. It is anticipated that these areas will be modified depending on when the aircraft is first available for flight and the corresponding prevailing cloud cover in Sri Lanka. Since basic photography for use in both 1/50,000 and 1/10,000 scale maps will be available relatively early in project life, the Survey Department will have the flexibility to concentrate on production of those maps that are most needed at the time. It is not realistic at this time to project which maps will be produced first beyond the broad priorities in Figures 11 and 12. Subsequent GSL decision will determine production priorities.

C. Issue: The PP should contain an analysis of the additional Survey Department staff necessary to handle the increase workload the project will permit and should identify the source of this staff.

Response: Essentially the Survey Department is currently staffed to implement the project. Provision of equipment, modifications to procedures, and on the job and short-term familiarization training will increase

significantly the productivity of existing staff. Current judgment is that less than 20 additional personnel will be required in the area of photo-compilation and scribing (now there are 139). These will be recruited and retrained personnel already in the Department. Professional staff of the Department now number approximately 963, not all of whom are needed on the project.

D. Issue: APAC noted expendable supplies equalled roughly 25% of the proposed loan and wondered what proportion of Survey Department expenses for expendables this total represented. If it represented a high proportion of expendables APAC suggested the Mission work out an arrangement for GSL FX financing of expendables in increasing proportional amounts during the life of the project to insure GSL FX financing for expendables once AID participation in the project ends. A corollary issue is the FX cost of maintaining output at the level required to provide needed maps once AID participation ends, and the GSL commitment to provide funds for this purpose.

Response: Under the revised project budget the cost of expendable supplies under the project is $854,700, which represents 19% of the total loan and 13% of the total project costs. It includes all of the expendable supplies under the project which must be purchased with foreign exchange and no expendable supplies for the many other Survey Department activities. Foreign exchange expenditures to maintain output level after AID participation in the project is completed are estimated to be $338,000 at current prices. This represents 6% of the Survey Department's normal annual budget. Given these proportions and the extent of the host country's contribution to the local costs of the project, the Mission feels it is not necessary to require the borrower to make a further contribution to the FX costs of the project. The loan agreement will contain the normal covenant regarding host country contribution of funds necessary to implement the project. Whether or not the small amount of foreign exchange resources will actually be allotted within the GSL to the Survey Department six years from now will of course be dependent on a number of factors, not the least of which will be the usefulness of the Department's product to the various organizations within the government.

E. Issue: APAC suggested consideration during project analysis be given to changing the Survey Department's budget system to require user agencies to pay the Department for the products they require thereby justifying such expenses in their budget presentation rather than in the Department's budget request. It was thought this arrangement would flush out other agency interest in the project.

Response: The procedure suggested would require revamping the entire GSL budget system and met with no enthusiasm by either the Survey Department or other organizations in the GSL. Since the change is not important to the project, the Mission does not feel it is useful to pursue the idea further within the context of the project.

F. Issue: APAC stated the PP should detail contractual arrangements to implement the project.

Response: Such arrangements are outlined in the implementation plan and detailed in the technical annex.

G. Issue: While the necessity for, and advisability of, AID financing a plane for the Survey Department was agreed to during the PRP review, alternative arrangements were pursued during the period of PP preparation. Once again the necessity for a plane in the hands of the Survey Department was confirmed. Contract flying was found to be much more expensive and would leave the Department without the capacity to update maps with new photography and provide project-specific and area maps of larger scale. To minimize risks and give greater assurance of an early photo resource for maps, it was agreed that initial flying would be done by a contract pilot and photogrammetrist who, while photographing a large proportion of the country would also train Sri Lanka Air Force pilots in the special techniques of flying for aerial photography and who would familiarize Department photogrammetrists with the new equipment.

H. Issue: APAC suggested amplifying arrangements to insure maximization of use of map and photo products, noting that while a Survey Research Center as proposed in the PP looked good, other approaches might be feasible.

Response: The concept of the Survey Research Center was broadened to a "User Assistance Center" to include training in country and abroad (short term) for user agency personnel.

Part II. PROJECT BACKGROUND AND DETAILED DESCRIPTION

A. Background

Sri Lanka has a population of about 14 million people. Although the population growth rate has slowed to 1.7 percent per annum, a population of about 20 million by the turn of the century is predicted. In 1973, roughly 80 percent of the population was rural. Farming provided 50 percent of the total employment with the rural non-farm population directly dependent on agricultural related activities for employment. In the same year, the agricultural sector was estimated to provide 33 percent of the Gross Domestic Product and 78 percent of all export earnings. Sixty percent of crop lands in production are composed of holdings of less than five acres and 28 percent in held in units of less than one acre. Major structural transformation in the Sri Lankan economy is not anticipated, and the relative importance of the agricultural sector is likely to remain.

Traditionally Sri Lanka has relied on the agricultural export sector to provide the wherewithal to purchase food to meet domestic consumption needs. Food, particularly food grains, represent roughly 50 percent of Sri Lanka's import bill. The GSL has a major policy objective the achievement of rice self-sufficiency. In the political economy of Sri Lanka, agricultural development is also viewed as a principal means to expand employment opportunities, as well as central to improving the absolute and relative welfare/income levels of the rural population.

Agricultural and rural development require planning and decisions on resource allocations at many levels. These range from macro and large scale project planning by the central government ministries to small scale projects carried out by local government.

A basic requirement for this planning process at all levels is up-to-date information on land-use patterns, physical terrain, location of infrastructure, property boundaries, location of villages and population centers, and dimensions and layout of project areas. A major tool for providing this information in Sri Lanka, as in other countries, is a national base map as well as more specific area and project maps. In Sri Lanka, however, these maps are both deficient in coverage and poor in quality. The major reason for this is that the existing base maps was prepared from aerial photography taken in 1956. While area and project maps have been produced from aerial photography flown in 1972, acquisition of up-to-date photography on a wider scale, and now even on a small scale, is not possible since the only aircraft which was modified and available for this purpose is twenty years old, has long outlived its useful life, and is now permanently grounded. In addition, even if photography were available, existing map production equipment is insufficient to produce the national base maps in a timely fasion. Current inadequate facilities and production procedures compound the problem.

Thus, while demand for maps by the Ministries of Agriculture and Lands, Planning, Irrigation Power and Highways and a host of other Ministries,

Departments and Boards has increased manifold, the ability of the Survey Department within the Ministry of Agriculture to provide these maps has decreased substantially.

Consequently, the Survey Department has developed a program which provides for the renovation and replacement of existing facilities and equipment, the acquisition of new equipment, and the provision of technical assistance and short term training which will enable it to meet current and projected demands for maps and related information products. The Government of Sri Lanka has requested AID assistance in financing and implementing this program.

The project proposed by the Survey Department was reviewed in November 1976 and Spring 1977 by technical experts provided by Resource Development Associates (RDA) under an IQC with AID. RDA prepared two extensive reports on the project: "A Program Assessment and Evaluation" and "Program Design and Recommendations" which confirmed the validity of the proposed program, flushed out project details, implementation procedures and timing, and which provided accurate cost estimates for the project. As a result of these investigations a "User Assistance Center" was added as a component of the project in order to maximize use of maps that will be produced. The RDA findings were reviewed and accepted by the Survey Department and at the request of AID were further reviewed by the U.S. Geological Survey (USGS). Following a series of meetings with the Deputy Survey General of Sri Lanka, AID personnel and RDA consultants, USGS also confirmed the technical validity of the proposed project.

B. Detailed Description

The project described in this section aims at meeting the current and continuing national photogrammetric and cartographic requirements of the various governmental agencies responsible for development planning and project implementation in Sri Lanka. Analysis of alternative means to providing the maps and information required on a continuing basis has confirmed that the appropriate approach is to enhance the existing capacity of the Survey Department.

The U.S. contribution will finance the foreign exchange cost of the inputs which are: (1) capital equipment consisting of photographic, triangulation, compilation, laboratory equipment and vehicles as well as an aircraft; (2) expendable supplies including film, paper, and chemicals; (3) technical assistance both long term (36 pm) and short term; and (4) short term training in-country and abroad.

The Government of Sri Lanka will finance the sizeable local cost of inputs such as facility renovation, manpower, and local maintenance, fuels, and supplies. In addition much of the map preparation, production, and printing will be done with existing Survey Department equipment.

During the first year of the project, implementation activities will relate primarily to renovation of existing facilities, equipment and supply procurement, reorganization of production procedures, familiarization training, flight planning and contractual arrangements for technical

assistance and aircraft equipment maintenance. This will lead to initiation of aerial photographic coverage with the plane to be provided under the project within one year of satisfaction of conditions precedent. During this first stage of the project an expatriate pilot (6-9 pm) and photogrammetrist (4-6 pm) will fly and photograph the country while training Sri Lankan Air Force (SLAF) pilots in the special techniques of flying for aerial photography and familiarizing Survey Department photogrammetrists with the techniques to be used. Subsequently, the plane will be flown by SLAF pilots and crewed by Survey Department personnel.

Trained pilots and photogrammetrists will be available in the second year of the project. Familiarization training related to map production will be completed in the first 18 months of the project.

As photos become available the Survey Department will begin production of a base map of the country at 1/50,000 scale and 1/10,000 scale. Flight lines and coverage will be planned to coincide with priority mapping needs.

Nationwide map coverage at 1/50,000 scale (a major project output) will be completed within 18 months of initiation of flying. Complete coverage at 1/10,000 (another major output) will be available within six years of initiation of flying. The initial 1/10,000 maps produced will utilize the same photography used for the 1/50,000 map series. Later 1/10,000 maps will utilize new photography to insure that in general the 1/10,000 maps are based on photography no older than two years. Following project completion the Survey Department will continually update the 1/10,000 base map series.

The output of larger scale (1/1000 - 1/10,000) maps will occur throughout the project beginning late in the second year on a project specific or area specific basis.

During the second and third years of the project the User Assistance Center will be equipped and Survey Department staff for the Center will be provided with familiarization training to maximize its potential. During this period training will also be initiation for staff of the Agencies that will need to use the Center for interpretation and analysis of maps and photography they require. This Center will provide a facility for analysis by the user Agencies. The Survey Department will not be charged with carrying out the analysis the user agencies may require. While the Center will be operable in the third year, it will reach its major potential toward the end of the project.

The achievement of these outputs, a 1/50,000 base map, a continually updated 1/10,000 base map, larger scale maps as requested by user agencies, a functioning User Assistance Center, and trained Survey Department staff will meet the mapping requirements of rural development in Sri Lanka - the project purpose.

The availability and utilization of the up-to-date information derived from the maps produced by the Survey Department will be a key ingredient in the planning necessary to achievement of the sector goal of improvement of the living standard of the rural people in Sri Lanka.

PART 3 - Project Analyses

(A) Technical Analysis

The technical analysis of the project was prepared by Resources Development Associates and reviewed by staff of the U.S. Geological Survey. The analysis is included as Annex B. The analysis includes a detailed description of the project, an explanation of possible alternative approaches to project design; confirmation of the validity of the proposed project; detailed cost estimates; and positive conclusions regarding the appropriateness of the technology selected and its suitability for application to Sri Lanka by the implementing agency.

The thorough RDA and Survey Department analysis, coupled with review of the RDA report by USGS give assurance that the technical design is reasonable, the cost estimates are reasonably firm, and that adequate planning has taken place. The project meets the requirements of FAA Section 611 (a) and (b). The project has no negative environmental implications, however it will provide key data important to an understanding of the environmental effects of rural development projects. An IEE has been prepared for this project recommending a negative determination.

B. Financial Analysis and Plan

1. Implications for the Budget of the Implementing Agency

The budget of the Survey Department during the years 1972-1976 has averaged the local cost equivalent of $5.5 million/year ($1=Rs7). The 1976 budget was $6.2 million equivalent. The local cost contribution of the Department to the six year project of $1.9 million equivalent equals $316,000 year. This contribution equals 6 percent of the average longer term budget and 5 percent of the 1976 budget. Thus, the project will have a negligible impact on the budget of the implementing agency.

Once AID participation in this project terminates the ongoing local costs of maintaining output (essentially staff salaries and local maintenance) will be subsumed under the ongoing budget of the Department with little impact on the current level of expenditures. Additive foreign exchange expenditures of $338,500/ year as detailed in the following pages will be required to maintain production at the level intended. This additive cost represents 6 percent of the five year average budget. It is assumed that six years from now the GSL will be willing to allocate this small amount of foreign exchange to the Department's foreign exchange account.

The Survey Department has budgeted sufficient funds for the initial yearof the project. The loan agreement will contain a covenant that the GSL will provide the local financing required over the life of the project.

2. CONTINUING FOREIGN EXCHANGE COSTS

At the end of the six-year period covered by the proposed project, Sri Lanka will have new and complete national map coverage at 1:50,000 and 1:10,000 scales, and nationwide photo coverage at 1:50,000 scale which will be no more than five years old. These data will provide a solid information base for regional and detailed planning and development activities, and in fact such activities will be well underway before the six-year point. Some of these will be direct outgrowths from or supported by the new User Assistance Center, which may well experience significant growth during the latter years of the project as more GSL professionals become familiar with new techniques and equipment available. If these data and the Center are to continue to serve Sri Lanka's information needs, then some new photography and map up-dating will be required, and some foreign exchange will be involved. Estimates presented here assume a 10% annual updating requirement. Some parts of Sri Lanka will certainly require updating at a faster rate, and the aircraft system will be in continuous use for other lower altitude projects, outside the scope of the present Agricultural Base Mapping Program. The 10% figure provides only a reasonable average guideline.

A. Equipment

Reserve for equipment replace/overhaul, estimated at 10% of original cost annually beginning at completion of currently planned Agricultural Base Mapping project. $176,000

B. Materials

Photo Acquisition, Aircraft Operations

1.	Aviation fuel and oil, per year	$ 2,100
2.	Reserve for engine overhaul (overhaul costs allocated totally to this program)	9,500
3.	Miscellaneous items (total allocation)	1,000
4.	Aircraft insurance (total allocation)	9,000
		$21,600

Photographic Laboratory (Air Survey and Map Production)

Film, paper, chemicals and related items $21,200

Map Production (Drawing Office) . . . . . $ 4,700

Map Production (Litho Branch) $33,000

User Assistance Center

Assumes expanded use of color and color infrared materials, and additional work with data from an improved LANDSAT satellite series . . . . . $ 5,000

TOTAL MATERIALS $85,500

C. Technical Training

Continued training and attendance at key international conferences to maintain technical proficiency and knowledge of state-of-the-art . . . . . $ 17,000

D. Maintenance and Fuel for Field Operations . . . . . $ 60,000

TOTAL ANNUAL COSTS (Including Reserve as Annual Cost) $338,500

3. Financial Plan/Budget Tables

Total project costs are $6,418,000 of which AID will finance the foreign exchange and certain local costs totaling $4,500,000, and the GSL will finance project costs of $2,041,000 equivalant. The host government counterpart contribution is 30 percent of the total project cost.

SUMMARY COST ESTIMATE AND FINANCIAL PLAN

Source	AID	GSL
Equipment		
Photo Acquisition, Aircraft and Accessories	$ 552,500	
Field Control and Edit	360,000	
Triangulation	167,400	
Compilation	258,400	
Photographic Laboratory	194,400	
Map Production (Drawing Office)	41,600	
Map Production (Litho Branch)	108,800	
User Assistance Center	68,200	
Doppler Satellite Positioning	10,000	
Total, Equipment	$1,761,300	$ 642,000
Facilities		
Total, Facilities.	$ 100,000	36,000
Materials		
Photo Acquisition, Aircraft and Accessories	$ 242,800	123,000
Photographic Laboratory	212,200	
Map Production (Drawing Office)	46,700	
Map Production (Litho Branch)	330,000	
User Assistance Center	17,000	
Total, Materials	$ 848,700	
Technical Training		
Total, Technical Training. . .	$ 254,000	
Technical Assistance		
Total, Technical Assistance...	$ 503,000	
Personnel		940,000
Fuel and Maintenance		300,000
Subtotal	$3,467,000	
Contingencies (@ 10%).	346,700	
Subtotal	$3,813,700	
Inflation Factor (@ 18%)	686,300	
TOTAL COST	$4,500,000	$2,041,000

DETAILED LOAN BUDGET [1]

EQUIPMENT		Order
Photo Acquisition, Aircraft and Accessories		
1. Aircraft, Cessna 421C or equivalent (pressurized, twin-engine, reciprocating, 30,000 feet service ceiling), delivered in Sri Lanka. To include basic pilot checkout/ maintenance training program in Sri Lanka.	$385,000	12/77
2. Equipment spares and special tools	110,000	12/77
3. Aircraft modification for aerial photography (NF-2, B3, and RC8/10 installation)	40,000	12/77
4. B3 Driftsight	1,000	12/77
5. Statoscope	500	12/77
6. Renovation of existing Survey Department RC8 cameras	16,000	/12/77 12/78
Subtotal	$552,500	
Field Control and Edit		
Vehicles for establishment of ground control (4-wheel drive, long wheel base, canvas top, plus spares and shipping) 40 ea. @ $9,000	$360,000	3/78
Triangulation		
1. Kern PG2-AT Stereoplotter/Digitizer/ Coordinatograph (2 ea. @ $55,000)	$110,000	3/78
2. IBM 545 Card Punch (2 ea. @ $6,200)	12,400	3/78
3. Kern MK-2 Monocomparator	45,000	3/78
Subtotal, Shipping Costs included	$167,400	

1/ As Revised August 1977

Compilation			Order
1.	Wild A8 Autograph, with PPO-8 Orthoplotter	$150,000	3/78
2.	Aviotab TA Coordinatograph attachments for B8 units (4 ea. @ 25,000)	100,000	3/78
3.	Wild ST-10 Strip Stereoscope	600	3/78
4.	Wild glass scales	4,100	3/78
5.	Mini-computer (Hewlett Packard 3060 or equal)	3,700	3/78
	Subtotal (Shipping costs included)	$258,400	

Photographic Laboratory (Air Survey and Map Production)			
1.	Kodak Model 11C-M Versamat Roll Processor	$ 25,000	3/78
2.	MAFI Processor	2,000	3/78
3.	Litho Sheet Processor, Kodalith 324	22,500	3/78
4.	Mark IV Log-E Printer, with roll head	25,000	3/78
5.	Vacuum back for Lanston copy camera	4,000	3/78
6.	Pulsed Xenon lamps (6 pair)	10,200	3/78
7.	Whirler Coating Machine	4,300	9/78
8.	Graining Machine (3 @ 8,600)	25,800	9/78
9.	Map reproduction machine	43,300	9/78
10.	Printing down frame	3,700	3/78
11.	Color sensitometer	2,000	3/78
12.	Transmission/reflection densitometer	2,000	3/78
13.	Point light source (for vacuum frame)	450	3/78
14.	Photographic equipment (miscellaneous)	2,500	3/78
15.	Darkroom and process equipment (miscellaneous)	4,000	3/78
16.	Shipping costs (= 10%)	17,650	3/78
	Subtotal	$194,400	

Map Production (Drawing Office)

			Order
1.	Scribing tool holders (10 ea. @ 15)	150	3/78
2.	Scribing cutters (100 ea. @ 5)	500	3/78
3.	Registration punch machine	2,000	3/78
4.	Reflecting projector, Map-O-Graph or equal	4,200	3/78
5.	Line contact screens (16 ea. @ 125)	2,000	3/78
6.	Photo composing machine, Photron	25,000	3/78
7.	Drawing room equipment (miscellaneous)	4,000	3/78
8.	Shipping costs (@ 10%)	3,750	3/78
	Subtotal	$ 41,600	

Map Production (Litho Branch)

1.	Litho offset printing machine (AO size, print 33 1/8 x 46 3/4 inches)	$ 87,000	3/78
2.	Guillotine Paper Cutter (AO size)	7,900	3/78
3.	Litho room equipment (miscellaneous)	4,000	3/78
4.	Shipping costs (@ 10%)	9,900	3/78
	Subtotal	$108,800	

User Assistance Center

1.	Richards 940 Light Table (3 ea. @ 2,000)	$ 6,000	6/78
2.	B & L 240 R Stereomicroscope, with bridge attachment for 940	10,000	6/78
3.	B & L Zoom Transfer Scope, Model ZT4-H, with photo attachments	7,000	6/78
4.	I^2S Multispectral Camera	10,000	6/78
5.	I S AddCol Additive Color Viewer, Model 6040-PT-210, with print frame head, exposure control, ND filters and film kit	19,000	6/78
6.	Portable spectrometer	5,000	6/78
7.	Ground truth camera, projector and accesories	1,500	6/78

			Order
8.	Miscellaneous test, calibration and support equipment	1,000	6/78
9.	Reference material, publications and training aids	2,500	6/78
10.	Shipping costs (@ 10%)	6,200	6/78
	Subtotal	$ 68,200	

Doppler Satellite Positioning

Equipment lease	$ 10,000

TOTAL, EQUIPMENT. $1,761,300

Facilities (As Revised August 1977)		Order
Air conditioning, temperature and humidity control system, positive air pressure (Triangulation, Compilation, Photo Lab, Drawing Office, Litho Branch, Survey Research Center) Foreign exchange component only	$100,000	12/77

TOTAL, FACILITIES. $100,000

3. MATERIALS

Photo Acquisition, Aircraft Operations

1.	Aviation fuel (based on Cessna 421C operation, ref. section 4.5.1) 12,900 gallons/year @ Rs. 15.91/US gallon, Rs. 10:US $1, $20,500/year, six years	$123,000
2.	Aviation oil (ref. section 4.5.1) 96 gallons/year @ Rs. 48.10/US gallon $460/year, six years	2,800
3.	Reserve for engine overhaul (based on Cessna 421C (ref. section 4.5.1) $9,500/year, six years	57,000
4.	Miscellaneous (tires, lights, lubricants, cable, connectors, etc.) $1,000/year, six years	6,000
5.	Aircraft insurance, $9,000/year, six years	54,000
	Subtotal	$242,800

Photographic Laboratory (Air Survey and Map Production)

1.	Original negative film, Plus-X Aerographic or equal, including reflight allowance, 25 rolls in 1st year, 5 rolls/year for 5 years @ $100/roll	$ 5,000
2.	Diapositives, Aerographic Positive, 25 rolls in 1st year, 5 rolls/year, 5 years, @$110/roll	5,500
3.	Transparency duplicates, Aerographic Positive, 25 rolls in 1st year, then 5 rolls/year, 5 years, @ $100/roll	5,000
4.	Photo indexes, single weight, glossy, matte dried, 10,000 prints, 100 boxes (100 sheets/box) @$65	6,500
5.	Contact prints, double weight, semi-matte 4,600 exposures @ 3 prints each 276 boxes (50 sheets/box) @ 65	17,900
6.	Copy paper, 24x30 in., 2,000 sheets, 80 boxes (25 sheets/box) @ 35	2,800
7.	Litho films, 24x30 in., 17,000 sheets	60,700
8.	Diapositives, Aerographic Positive, 10" x 10" sheets, 7 mil Estar base (to replace current ¼" glass plates) 50 sheets/box, 100 boxes in 1st year, then 20 boxes/year for 5 years, @ $50/box	10,000

*to be financed by GSL per APAC cable.

9.	Color proofing plastic		18,000
10.	Processing chemicals:		
	Dektol	500	
	Kodak Rapid Fix	400	
	Versamat Type B	2,400	
	Litho Developer	3,000	
	Hypo	1,500	
	Diazo Sensitizers and Solutions	1,800	
	Litho Plate Chemistry	2,000	11,600
11.	Color proofing emulsions		1,100
12	Glass marbles (16,000 kg)		40,000
13	Plates, zinc and aluminum		8,800
14.	Shipping and miscellaneous (≈ 10%)		19,300
		Subtotal	$212,200

Map Production (Drawing Office)

1.	Ink	1,400
2.	Adhesives	1,400
3.	Negative opague	700
4.	Stripping films	2,200
5.	Peelcoat material, 6,000 sheets	11,000
6.	Plastic drafting material, 20,000 sheets	24,000
7.	Miscellaneous items	6,000
	Subtotal	$ 46,700

Map Production (Litho Branch)

1.	Machine dressings, litho materials	$ 12,000
2.	Litho printing paper	300,000
3.	Printing ink	6,000
4.	Miscellaneous items and parts	12,000
	Subtotal	$330,000

1.	Color IR film and processing	$ 3,000
2.	Color film and processing	3,000
3.	B/W IR film and processing	2,000
4.	Cibachrome film, print materials and processing	3,000
5.	Duplicate transparencies	3,000
6.	Contact prints; copy paper	500
7.	Miscellaneous items	2,500
	Subtotal	$ 17,000

TOTAL MATERIALS $854,700

4. Technical Training (As Revised August 1977)

		Order
1. Remote sensing training course/seminar in Sri Lanka	$ 40,000	9/78
2. International conference/symposia attendance 4 trips/year, six years, 24 @ 2500/trip	60,000	
3. USGS training courses in US (transportation and per diem only), 3 courses, 1 month each, 6 attendees at each course, 18 man-trips @ 3500 each	63,000	
4. International study fellowships 10 each @ 8000, 3 months each	80,000	
5. Equipment familiarization course (Kodak) in Sri Lanka	11,000	

TOTAL, TECHNICAL TRAINING. $254,000

5. Technical Assistance (As Revised August 1977)

One "long-term" technical advisor (36 months) and 25 man-months of "short-term" technical specialists over a five year period, including 6 months for a photo pilot and 3 months for a photographer for Sri Lanka crew training. Contract costs, including mobilization-demobilization, per diem, and related expenses $503,000

TOTAL, TECHNICAL ASSISTANCE. $503,000

(c) SOCIAL ANALYSIS

A central concept of AID policy is the need to assure that the institutional and other developmental benefits which result from AID programs have a direct and positive effect upon the lives of the poor majority of the people in the nations to which AID provides assistance. In order to accomplish this "spread effect" certain basic data is essential. To quote AID Handbook 3 on Social Soundness Analysis;

> "... a first step should be a mapping of the area to be affected by projects and programs in such a way that population density, location, ethnic or significant tribal affiliations, languages, religions, and political orientations, are all depicted in relation to prevailing patterns of economic activity...."

The purpose of the project being described in this paper is "to meet the mapping requirements of rural development in Sri Lanka."

The present situation in Sri Lanka is that the governmental agencies depend upon the Survey Department for the provision of such essential data and maps and that the Survey Department's capability to compile and produce such data and maps is seriously inhibited. By providing the Survey Department with the commodities, training and technical assistance necessary to perform various mapping and data collection assignments, the project will enable the GSL to move ahead in its developmental efforts.

In tandem with developing the capability to produce the necessary data and maps the project implementation plan calls for the formation of a "User Assistance Center." The function of such a Center will be to provide the analytical facility necessary for proper utilization of Survey Department material by various governmental agencies charged with program planning and project implementation. During the initial feasibility studies of the proposed project RDA interviewed fourteen major governmental agencies that continually request the type of information that will be supplied by the Survey Department as a direct result of the implementation of the project.

Each of these agencies has a program which directly affects the GSL's ability to initiate projects and programs impacting upon the lives of the target population. The way in which data of the type that will be produced under the project has been and will be used is described in the response to the first issue noted on page three of this project paper.

The project, of itself, will have only an indirect impact upon the lives of the target population. The data and maps which will continuously be generated as a result of the implementation of the project will have a very definite and direct impact upon the GSL overall ability to plan and implement development projects and programs which are socially sound and have a positive effect upon the lives of the people of Sri Lanka.

(D) Economic Analysis

The project is not a "...revenue-producing project or a project whose outputs translate realistically into monetary equivalents." Rather the project is one "...whose primary outputs are technical assistance and/or institution building" in nature. It therefore becomes appropriate to view the economic analysis of the project in terms of "cost-effectiveness rather than "cost-benefit". The following section will be devoted to such a cost-effective economic analysis, which thoroughly examines the various alternative means of achieving the desired output levels and to the project design recommendations resulting from such an analysis.

1. Ground Survey vs. Aerial Photography

In order for an initial choice to be made for the overall technique to be used in the collection of primary data for the required resource survey and/or mapping essential to the achievement of the project purpose, the technique chosen must satisfy one or more of the following conditions;

1. It must provide the required information,

2. It must do so in a least costly or most timely manner, and

3. If more costly than other alternative techniques, the chosen technique must provide the information in less time and time must be shown to be a critical parameter of the project's success.

Once an overall technique has been chosen, a selection of the particular combination of methodology to be recommended in the project design must be made. The key questions to be answered by these recommended design combinations are:

1. How should the data be collected (ground vs. aerial survey methods)?

2. How should the data be compiled and presented (cartographic maps vs. alternative formats)?

3. Who should do the job (contract services vs. internal capability)?

In most countries of the world, regional surveys and mapping operations are seldom undertaken without the support of some form of aerial survey technology. A substantial number of studies have been performed in recent years comparing both costs and effectiveness of airborne vs. ground survey. These studies, done primarily in the United States and Latin America, have shown that aerial surveys can be accomplished in much less time and at 2 to 10 times less cost than ground methods of comparable or less accuracy. In many cases, aerial methods provide the only practical solution to the problem at hand, as for example when physical

access to a region is impossible on the ground or when the phenomena to be investigated changes with time. In other cases, where large-scale close-contour surveys are required over accessible and relatively small ground areas, the traditional ground survey methods may be more appropriate.

Agricultural and land use information is vital to the existing and future requirements of development planning in Sri Lanka. The information which is now available is for the most part either 20 years out-of-date, or totally unavailable. Given that the Government of Sri Lanka is desirous of moving ahead on planning and implementation of projects as soon as possible, it becomes obvious that the element of time is a critical determinant of which technique, aerial vs. ground survey, will eventually be selected as the major method of primary data collection.

As noted earlier, previous studies have shown that agricultural and land-use surveys can usually be accomplished in much less time and cost through aerial methods than by more traditional ground-based surveys. Aerial surveys, however, require substantial investment in equipment. Aircraft are more expensive than automobiles. Photogrammetric plotters are more expensive than plane tables. In general, then, aerial surveys tend to be more capital intensive than comparable ground surveys.

Although the above is an undeniable reality, it is essential that the project design consider the fact that the relatively short period of time needed to accomplish the project purpose utilizing aerial survey technology, will enable the various user agencies to move ahead on their own developmental plans and implementation programs. As such, there will be a broad-based generation of employment opportunities of a much larger scale than any which might be the result of the selection of the slower, but more labor intensive ground survey technology.

A hypothetical example will be instructive in providing the background for making the essential choice between aerial and ground methodology. Assume a map is to be produced of a 5,000 acre area. Moderate scale maps of small areas can in general be made with equal accuracy from ground or aerial survey.

Labor and level of effort will vary with type of map desired. A topographic map with 20-foot contours is assumed here. Basic data collection for such a map is well within the capabilities of both ground and aerial survey operations. Given these assumptions, the following comparison appears:

*Ground Survey, 5,000 Acres, 20-foot Contours

Direct Labor		
1 Surveyor @ Rs. 600/month	7,200	
10 Laborers @ Rs. 250/month	30,000	
Supervision	1,800	
Travel and Camp Expenses	1,900	
Depreciation of Equipment	600	
TOTAL COST		Rs. 41,500
COST PER ACRE		Rs. 8.3
TIME REQUIRED		12 months

*Aerial Survey (Photogrammetric Plotting), 5,000 acres, 20-foot Contours

Cost of Photography	Rs. 2,500	
Direct Labor		
2 Operators @ Rs. 600/Month	300	
Supervision	38	
Ground Control	500	
Field Checking and Revision (3 Field Days)	290	
Depreciation of Equipment	135	
TOTAL COST		Rs. 3,763
COST PER ACRE		Rs. .75
TIME REQUIRED		1 Week

*Based on data furnished by the Survey Department, Ministry of Agriculture and Lands

These operations do not depict the total cost of producing a final map. Drafting, scribing, plate preparation, printing and various other tasks still remain. These other tasks, however, are common to both ground and aerial survey, with identical costs. The ground and "aerial" operations described here will produce "base manuscripts" of comparable quality, one in 12 months at Rs. 8.0/acre, the other in 1 week at Rs. 0.75/acre. The basic cost comparison is therefore overwhelmingly (by 11to 1) in favor of the aerial approach.

The total land area of Sri Lanka is approximately 16 million acres. Utilizing the productivity rates developed here, 17 photogrammetric teams could complete the job in less than 4 years at a cost of Rs. 4 million. The same job would require 800 ground teams (8,800 individuals) at a cost of Rs. 132.8 million.

An additional indication of relative productivity of ground and aerial surveys may be seen in that between 1968 and 1972, the only years during which adequate aircraft maintenance and operational support was available (reportedly a result of incentive contracting with Air Ceylon), total Survey Department output was more than doubled.

The aerial approach would then appear to satisfy not one but all three of the basic evaluation criteria: it is less costly, it is more timely, and it provides needed information impossible to obtain by alternative means.

With this point established, attention must be directed to the question of what is to be the project specific combination of methodology to be used. Most resource analysis tasks may be done through direct interpretation of the aerial photography or through the use of photomosaics, without the intervening cartographic step. Development planning, however, requires a planimetrically accurate base. The base maps currently available in Sri Lanka are 20 years out of date and are at too small a scale (1:63,360) to be useful for development planning. It would appear, therefore, that the Agricultural Base Mapping Project should produce both photography (for interpretation and analysis) and cartography (for development planning purposes).

The next issue is whether the project should aim at the establishment of a continuing national capability as opposed to contracting for services required. It seems obvious, however, that contract photo coverage, at least, would be a one-time affair. There are no commercial aerial survey operations in Sri Lanka. This would mean a contract with a foreign firm which would mobilize to Sri Lanka, collect data currently required in as short a period of time as possible consistent with job requirements, and then depart. It has become evident through conversations with the several user agencies that such a service would not adequately serve their needs. They have expressed desires for photography at multiple scales and at various times of the year, and exact requirements are difficult to forecast five or more years in the future.

Alternatively, the Survey Department has the nucleus of an aerial survey group and the basic equipment necessary. The biggest and most obvious lack is an operational aircraft.

In the opinion of the RDA team, the needs of the Government of Sri Lanka would be best served through a strengthening and re-establishment of a national air survey capability.

A final alternative method of data collection which was considered is the use of the U.S. LANDSAT satellite system. It is evident, however, that LANDSAT cannot provide the data with the degree of resolution required for the majority of current programs in Sri Lanka. In some areas, however, it may be of substantial use. The Survey Department has initiated experiments in this technical area that may lead to important applications in the future. Further experimentation and the development of pilot projects will be encouraged as part of the User Assistance Center.

The following detailed description of possible alternatives is useful in making the final selection of the most appropriate and most cost effective method of providing the aerial photography and other essential inputs to attainment of project purpose.

2. A COST COMPARISON OF ALTERNATIVES FOR AERIAL PHOTOGRAPHY

Given the existing structure and organization of the Survey Department in Sri Lanka, there are essentially three principal alternative approaches to producing the 1:10,000 agricultural base map series for the country:

A. Contract Operation

A package contract is let to a private firm, which conducts all necessary operations, and produces and delivers all of the required 1:10,000 base maps

B. Combined Contract/GSL Survey Department Operation

A contract is let to a private firm for aerial photography only. All photogrammetry, field work and related map production is performed by the Survey Department with financial and technical assistance assumed to be provided through USAID

C. GSL Survey Department Operation

The Survey Department undertakes the entire task, with financial and technical assistance provided through USAID

Each of these alternatives is presented in detail.

A. Contract Operation

Package contract, to produce 1:10,000 scale four-color maps, 5-meter contours, 3,000 copies each, including photo acquisition, ground control, all photogrammetry, field edit, and map production:

1. 25,000 square miles @ $600/mi^2 = $15,000,000*
2. 5,000 square miles/year, 5 years @ $640/mi^2 = $16,000,000*

These figures appear to be reasonable for a completely contracted package operation. As a further check, it might be noted that the Pa Mong (Thailand) mapping project, involving 1:10,000 scale base maps on an area of 15,000 square miles, was completed by Aero Service Corporation in 1968 at a cost of $525/mi^2. At that time, it was the largest single commercial mapping project in the world. Aero Service is the oldest and largest photogrammetric firm in the world.

* Based on quotation received from Aero Service Corporation, April 4, 1977.

B. Combined Contract/GSL Survey Department Operation

Contract Aerial Photography

It is assumed that a contract is let to a private commercial firm to produce 1:50,000 scale aerial photography at a coverage rate of 5,000 square miles/year for five years. This photo coverage rate would match the anticipated GSL Survey Department throughput rate, assuming the required financial and technical assistance is made available. Costs are calculated on the following basis:*

1.	Mobilization-demobilization, aircraft and flight crew. $3,000 plus 18,000 miles @ $2.25/mile	= $ 43,500
2.	Aircraft and crew standby. 30 days @ $2,800/day	= 84,000
3.	1,660 flight-line miles @$15/linear mile	= 24,900
4.	Support lab mobilization-demobilization	= 6,750
5.	Support lab stand-by. 30 days @$300/day	= 9,000
6.	Per diem. 75 man-days @ $32/day	= 2,400
		$170,550/year**
Five-year program @ $170,550/year		= $852,750
Inflation factor (@ 10%)		85,250
	TOTAL	$938,000

* Based on rate quotation received from Mark Hurd Aerial Surveys, Inc., November 10, 1976

** Production rates, stand-by time, mob-demob, and costs are consistent with those experienced on a similar aerial photography project on 34,000 square miles in Chile, completed by Mark Hurd in early 1976 for the InterAmerican Geodetic Survey.

Survey Department Contribution

USAID Supported:

Equipment (less photo acquisition, aircraft and accessories)		=	$ 915,000
Facilities		=	100,000
Materials (less photo acquisition, aircraft and accessories)		=	486,400
Technical training		=	110,000
Technical assistance		=	315,000
	Subtotal		$1,926,400
Contingencies (@ 10%)			192,600
	Subtotal		$2,119,000
Inflation factor (@ 10%)			212,000
	TOTAL		$2,331.000

GSL Supplied:*

Equipment (less GSL value attributed to inoperable Beech aircraft)		=	$ 434,400
Facilities		=	402,900
Labor and field support**		=	745,000
	TOTAL		$1,582,300

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* Based on Survey Department estimates and valuations contained in GSL proposal of January 1976, and on exchange rate of Rs. 7: US $1

** Aircraft operation and aerial photography support is a very small percentage of this figure, and is accordingly not deducted here. To that extent, this figure is overstated.

Total cost of combined contract/GSL Survey Department operation is then estimated as:

Contract	$ 938,000
GSL/USAID	2,331,000
GSL	1,582,300
TOTAL COST	$4,851,300

C. GSL Survey Department Operation

USAID Supported:

Equipment and Services (Pilot & Photographer)		=	$1,474,500
Facilities		=	100,000
Materials		=	643,700
Technical training		=	110,000
Technical assistance		=	315,000
	Subtotal		$2,583,200
Contingencies (@ 10%)			257,800
	Subtotal		$2,841,000
Inflation factor			284,000
	TOTAL		$3,125,000

GSL Supplied:

Equipment		=	$ 434,400
Facilities		=	402,900
Labor and field support		=	745,000
	TOTAL		$1,582,300

Total cost of GSL Survey Department operation as described in this report is then estimated as:

GSL/USAID	$3,125,000
GSL	$1,582,300
TOTAL COST	$4,777,300 1/

1/ Does not include costs of approximately $1,305,000 in later estimate of project funding requirement. These additional costs would hold true for any of the three alternatives.

D. Summary and Conclusions

The following conclusions are reached as a result of this comparison of alternatives:

1. Contract Operation $15,000,000

Advantages:	Simplicity, reliability, and speed of production. Project could be completed in a period of approximately two years. No technical assistance required to complete the project.
Disadvantages:	High cost (twice that of other alternatives) no institution-building aspects. GSL will require additional assistance to prepare more detailed maps and engineering plans for development projects. No GSL capability to collect aerial data for resources or environmental survey purposes. Additional contracts will be required for larger-scale photography to support detailed project development.
Comments:	Price quote could probably be reduced by about 10% as contractor becomes more familiar with specific conditions in Sri Lanka. In this case, contract price of $13,500,000 would still be twice that of other alternatives.

2. Combined Contract/GSL Survey Department Operation $4,851,300

Advantages:	Simplicity of photo acquisition, no aircraft maintenance or operation problems. Institution-building in areas of photogrammetry, map production, resources survey and assessment, and development project support. Much less costly than Alternative 1.
Disadvantages:	Map production rate the same as for all-GSL operation, at slightly higher cost. No GSL capability to collect other aerial data for resources or environmental survey purposes. Additional contracts will be required for larger-scale photography to support detailed project development. Technical assistance required to complete project as scheduled.

Comments: A flat inflation factor of 10% has been included for a five-year aerial data collection contract which in turn is estimated on current rates. If a 10% yearly inflation rate is assumed, typical for US aerial survey contractors in recent years, then data collection costs will increase to approximately $1,040,000, resulting in a total cost of $4,953,300 for this alternative.

3. GSL Survey Department Operation $4,777,300

Advantages: Institution-building in all areas of aerial survey, photogrammetry, map production, resources survey and assessment, and development project support capability. Provides continuing GSL data collection capability to support current and planned development programs. Least expensive alternative.

Disadvantages: Slightly more complex than Alternative 2. Technical assistance required to complete project as scheduled.

Comments: Cost advantage over Alternative 2 is not significant, however, lack of an aerial data collection capability to support development projects is one of the biggest problems currently facing the GSL. This is the only Alternative to address this problem.

Summary Economic Conclusion

Ground survey techniques in lieu of aerial photography would result in significant delays in providing information required by the GSL at greater cost than aerial photography techniques; would require a tremendous expansion of Survey Department staff with attendant problems of training, management, and facility capacity; would fail to build on the existing capacity of the Department for processing aerial photography; and would not lay the foundation for utilization of the many significant by-products of aerial photography in the future.

Of the three alternatives for providing aerial photography, Alternative C is slightly less costly than Alternative B; however for these marginal costs the Survey Department would have the capability to procure and produce larger scale maps during and after the project and continually update base maps after the project. Thus even if alternative B was less costly it would not result in achievement of project purpose.

The project as designed is the most cost-effective approach to meeting the project purpose.

PART 4 - Implementation Arrangements

(A) Analysis of the Recipient's and AID's Administrative Arrangements

(1) Recipient Organizations

(A) Survey Department:

The implementing agency is the Survey Department, Ministry of Agriculture and Lands. Within the GSL, the Department has primary responsibility for (1) mapping the country; (2) surveying, and recording all state lands; (3) providing photogrammetry and cartography for interpretation and analysis; and (4) survey training. Typical projects include engineering and topographic surveys, close-contour surveys, regional resources mapping, town assessment, land marking, and land reform surveys. The Department has been involved in mapping from aerial photography since 1952. Aerial photography for the existing national base map was flown by a contractor in 1956. Subsequent photography was flown and maps prepared by the Department with their own plane until it was no longer operable. The Department has not had the capability to fly new photography for the past three years. The Department has a total professional staff of approximately 960. The key units, the Air Survey Branch and the Map Publication Branch, have a combined professional staff of 185. Annex B, Appendices B-E, provides detailed information on the Department's history, activities, and composition.

In summarizing their analysis of the project, Resources Development Associates came to the following conclusions regarding the capability of the Department and the impact of the project on its operations:

> "The introduction of the first large-scale mapping program in 20 years represents a substantial undertaking by the Survey Department. Since their only aircraft has been inoperable for nearly two years there has been no new photography on which to work. Consequently, the maps which have been made recently were mostly prepared from ground surveys. This does not require the same process nor does it impose a large load. The 1:10,000 scale mapping project will necessitate the conversion of that portion of the Survey Department involved into a large-scale production operation, with all its attendant ramifications.
>
> "The Survey Department is capable for performing the Agricultural Base Mapping Project. However, they will require financial support to procure the necessary additional equipment and materials and to make improvements in their present facility. Also, to accomplish the work which will be required to complete the 1:10,000 scale mapping project within five years they will have to introduce some operational changes.

"To cope with the production load to be imposed will require changes in the organization, procedures, and facilities as well as the requisition of new equipment and materials. The major items to be purchased include a suitable aircraft, plotting instruments and film processing equipment and a litho press. To obtain the best use of the new as well as existing equipment requires the renovation of the existing offices to accomodate the air conditions necessary for temperature and humidity control. For more efficient map production some changes in procedures and organization have to be made. The major change in methods involves the use of a more modern technique for preparing the map manuscripts which reduces manual effort to a manageable level.

"With the recommended equipment and improvements the Survey Department will be capable of completing the Agricultural Base Mapping Project within a period of five years. However, to assure that the required production level and quality is maintained, continued technical assistance should be provided the Survey Department."

With the addition of the inputs to be provided under the project, the experienced, well-staffed Survey Department is capable of implementing the project.

(b) Other Organizations

The aircraft to be provided under the project will be piloted and maintained by the Sri Lanka Air Force under an agreement drafted by the Survey Department. The Air Force is experienced in maintaining and flying the type of plane proposed for the project. Major engine overhaul will be performed in Singapore approximately every four years. On-the-job training of Air Force pilots in the special techniques of flying for aerial photography is included in the project. AID approval of the final agreement with the Air Force will be required.

The major users of mapping data that will be produced by the project have staffs familiar with use and interpretation of the data. A "User Assistance Center" will provide additional resources to maximize product use. On-the-job training and short-term training abroad for the appropriate staff of these agencies is included in the project to insure these personnel are aware of the latest appropriate techniques of product utilization.

2. A.I.D.

While the technology involved in the project is complex, administration of the project, involving as it does essentially one major implementing agency, is fairly straight-forward. AID approvals of major procurement, the host country technical assistance contract, and the agreement for maintenance and services by the Sri Lanka Air Force will be required. The project will add to the current workload of the Mission staff particularly during the initial year of implementation when major procurement activities will occur. The size of the Mission staff was planned with an awareness of the requirements of the project. This project does not in itself require additional Mission staff. It will require TDY assistance of the regional legal and contract advisors, and perhaps of an AID/W procurement officer.

AID/W will be the purchaser for the GSL on major project equipment. Disbursements for technical assistance and some procurement are likely to be via a direct letter of commitment. Some technical assistance and short-term training in country and in the U.S. will be provided under an arrangement between AID and the U.S. Geological Survey. Disbursements for aircraft and equipment maintenance as well as spare parts, calibration, etc. will be made by AID to the foreign exchange account of the Survey Department based on periodic requirements and will be replenished as planned under the project budget. Disbursements for local costs will be made on the basis of vouchers submitted by the Survey Department.

In order to implement the project, source and/or proprietary procurement waivers will be necessary for the following items:

Source Waiver (For Justification see Annex A, Appendix H) *

Item	Source	Amount
1. Renovation 2 unit of Survey Dept. RC8 cameras	Switzerland	$16,000
2. 1 unit Wild A8 Autograph with PPO-8 Orthoplotter	Switzerland	$150,000
3. Attachments for 4 units Aviotab TA coordinatograph B8 units	Switzerland	$100,000
4. Wild St-10 Strip Stereoscope (1 unit)	Switzerland	600
5. Wild glass scales 1 unit	Switzerland	4,100
6. Kern PG 2 with EK-22 Digitizer and Aviotab TA Coordinatograph 2 units	Switzerland	110,000
	TOTAL	380,700

* This equipment may be provided by the Government of Switzerland, in which case the waiver would be unnecessary and the monies reallocated within the project or deauthorized.

Proprietary (U.S. Source)

Item	Company	Amount
1. 1 Aircraft Cessna 421C (pressurized, twin engine, reciprocating 30,000 ft. servic ceiling) delivered to S.L. Include training for pilot/mantenance in S.L.	Cessna	$385,000
2. Appropriate equipment spares & special tools	Cessna	$110,000
3. Aircraft modification for aerial photography (NF-2,B3, RC8/10 installation)	Cessna	40,000
4. 40 - 4 wheel drive Jeeps long-wheel base, Canvas - covered, right hand drive (include essential spare parts + establishment of maintenance facility)	AMC	(ea./9,000) $360,000
5. IBM 545 Card Punch 2 units	IBM	12,400
6. Mini-computer (1 unit) (Hewlett Packard 3060 or equal)	Hewlett/ Packard	3,700
7. Model 11C-M Versamat (1 unit) Roll processor (includes installation & 1 wk training, inoperation and maintenance)	Kodak	25,000
8. MAFI Processor (1 unit)	MAFI	2,000
9. Litho sheet Processor, Kodalith 324 (1 unit) (installation, & 1 wk training in operation & maintenance)	Kodak	22,500
10. Mark IV Log - E printer, with roll head (1 unit) (includes installation, & 1 wk training in operation & maintenance)	Log-E-Tronics Corporation	25,000
11. Vacuum back for one Lanston copy camera	Lanstom Corp.	4,000
12. Photo composing machine, Photron (1 unit)	Photron . Co.	25,000
	Sub-Total	1,014,600

Item	Company	Amount
13. Litho offset Printing machine (1 unit) (AO size, print 33 1/8 X 46 3/4 inches)	Harris Press	87,000
14. 940 Light table (3 ea. @ 2,000)	Richard Co.	6,000
15. B+L 240 R Stereomicroscope, with bridge attachment for 940 (2 ea. @ 5,000)	Bausch&Lomb Inc.	10,000
16. B+L zoom Transfer Scope, Model Z+4-H, with photo attachments (1 unit)	Bausch&Lomb Inc.	7,000
17. I^2S Multi Spectral Camera (1 unit)	International Imaging Systems Inc.	10,000
18. I_2S Additive Color viewer (1 unit)		
18. I^2S Additive Color viewer (1 unit) Model 6040-PT-210, with print frame head. exposure control, ND filters & film ket.	International Imaging Systems Inc.	19,000
19. Original negative film, plus-x Aerographic ($100/roll, 10 rolls/yr, 5 yr.) 50 rolls	Kodak	5,000
20. Diapositives, Aerogrpahic Positve ($110/roll, 10 rolls/yr., 5 yrs) 50 rolls	Kodak	5,500
21. Transparency duplicates, Aerographic positive ($100/roll, 10 rolls/yr, 5 yrs) 50 rolls	Kodak	5,000
22. Photo indexes, single weight, Gloss Matte-Dry 100 boxes (5,000 prints, 100 bx, 100 sheet/bx) (65)	Kodak	6,500
23. Contact prints, double weight, semi-matte 2,300 exposures (@ 3 prints ea. 276 boxes (50 sheet/bx) (@ 65)	Kodak	17,900
24. Copy paper, 24X30 in. 1,000 sheets, 80 boxes (25 sheets/bx) @ 35	Kodak	2,800
25. Litho films, 24X30 in., 17,000 sheets	Kodak	60,700
	Sub-Total	242,400

Item	Company	Amount
26. Drapositives, Aerographic positive, 10"X10" sheets, 7 mil Estar base, 50 sheets/bx, $50/box, 200 boxes	Kodak	10,000
27. Color Proofing Plastic	Kodak	18,000
28. Processing Chemicals Dektol, Kodak Rapid Fix, Versamat Type B, Litho Developer, Hypo, Diazo Sensitizers & solutions, Litho Plate Chemistry	Kodak	11,600
29. Color Proofing emulsions	Kodak	1,100
30. Color IR Film & Processing 6 rolls(est)	Kodak	3,000
31. Color Film & Processing 6 rolls (est)	Kodak	3,000
32. Duplicate transparencies 12 (est)	Kodak	3,000
33. Contact prints copy paper	Kodak	500
34. Black & White Infra-red film and processing 7 rolls	Kodak	2,000
35. Cibachrome film	Kodak	3,000
36. 1 unit Kern MK II	Kern Instruments Inc.	45,000
	Subtotal	100,200
	TOTAL	1,357,200

(B) Implementation Plan

1. Plan

The basic implementation plan provides for early arrival of the long-term technical assistance contractor, followed in the first year of the project by major equipment procurement, facilities renovation, some staff recruitment and familiarization training, and internal survey department reorganization. During the second year of the project various personnel will be familiarized with the newly procured equipment, aerial photography of the country for the 1/50,000 and 1/10,000 base map will be completed, production of 1/50,000 scale maps will begin, user assistance center staff will be trained, and user assistance center equipment will be ordered. In the third year of the project the 1/50,000 base map production will be completed, the user assistance center will be operational, familiarization training for user organizations will begin, and initial 1/10,000 base maps will be produced. Subsequent years will see continued 1/10,000 base map production leading to full coverage in 1983, continued updating of aerial photography and the base map series, production of larger scale maps, additional user agency training, and continued application of new techniques for maximizing the use of the Survey Department's products.

The Survey Department will be responsible for overall implementation. AID/W will be the purchaser for the bulk of project procurement. The technical assistance contractor, under a host country contract, will assist with specifications for production, department organization, development of the User Assistance Center and some training. Other training will be provided by USGS under an agreement with AID. Initial aerial photography will be flown by a host country contracted team of a pilot and a photogrammetrist, who will also train SLAF pilots and Survey Department photogrammetrists. Subsequently the plane will be piloted and maintained by the Sri Lanka Air Force and crewed by the Survey Department.

Project monitoring will occur throughout the project by the Department, USAID, and the technical assistance contractor. Project evaluation will include the participation of user agencies, and independent experts (perhaps USGS) as well as the aforementioned entities.

The detailed implementation schedule and attendant responsibilities which follows was prepared with the advice of the Deputy Surveyor General. There are no unresolved issues regarding the plan.

2. Implementation Schedule

	Activity	Timeframe	Responsibility 1/
1.	Loan Authorization	Sept. '77	AID/W
2.	Solicit for TA Contractor	Oct. '77	SD/USAID/AID/W
3.	Loan Agreement signed, C.P.'s satisfied	Nov. '77	GSL/USAID/RLA
4.	Service Agreement with SLAF	Nov. '77	SD/SLAF/USAID
5.	Contract for T.A.	Dec. '77	SD/USAID/ACO
6.	Direct L/Comm for T.A.	Dec. '77	GSL/USAID/AID/W
7.	Long Term T.A. Arrival	Jan. '78	SD/Contractor
8.	Initiate Facilities Renovation	Jan. '78	SD
9.	Initiate Capital Equipment Procurement	Feb. '78	SD/Contractor/USAID and GSA
10.	Contract for Aircraft	March '78	" "
11.	Procurement expendables	April-June '78	" "
12.	Reorganization of elements of Survey Department	Summer '78	SD/TA Contractor
13.	Aerial Photography Flight Planning	Summer/Fall '78	SD/TA Contractor
14.	Recruitment/Training Additional SD Staff	April-Oct. '78	SD
15.	Contract for Pilot and Photogrammetrist	Summer '78	SD/USAID/TA Contractor

1/ SD = Survey Department
SLAF = Sri Lanka Air Force
RLA = Regional Legal Advisor
ACO = Area Contracting Officer
GSA = US General Services Administration
USGS = US Geological Survey

Activity	Timeframe	Responsibility
16. Completion of Facilities Renovation	Nov. '78	SD
17. Initial Evaluation Concentrated on adequacy of facilities and procedures	Nov. '78	USAID/TA Contractor/ SD
18. Arrival Plane and Pilot and Photogrammetrist	Nov. '78	SD/AID/W/GSA
19. Arrival other capital equipment and expendables	Nov. '78	" "
20. Initiation Aerial Photography and OJT for SLAF Pilots and SD Photogrammetrists	Dec. '78	SD/SLAF/Contractor
21. O.J. Familiarization SD Staff	Dec.-May 78/79	SD/Contractor
22. Begin 1/50,000 Map Production	Jan. '78	SD
23. Initiate Procurement Equipment for User Assistance Center	Winter 78/79	SD/TA Contractor/ USAID/AIDW
24. GSL-AID-USGS PASA	Winter 78/79	GSL/AID/USGS
25. User Assistance Center Staff Training	Spring '79	SD/USGS
26. Arrival User Assistance Center Equipment and Establishment of UAC	Summer '79	SD/GSA/AIDW
27. Second Evaluation - Production	Summer '79	SD/TA Contractor/ USAID
28. Completion of Aerial Photography for 1/50,000 and initial 1/10,00 Map Series	Sept. '79	SD/SLAF
29. Initiation Aerial Photography for Larger Scale Area and Project Specific Maps and Production these Maps	Oct. '79 1/	SD/SLAF
30. User Agency Staff Training	4-5 people each year 1980-1983	SD/USGS/User Agencies

1/ GSL planning needs may dictate earlier flying for project and area maps. Some such flying can be done early in project life without major disruption of base mapping schedule. Such flying will continue during (and after) project life.

Activity	Timeframe	Responsibility
31. Third Evaluation - Production Rates and Quality	Winter 79/80	SD/TA Contractor/ USAID
32. Completion of 1/50,000 Base Map	May '80	SD
33. First Full Evaluation (Production Rates and Quality, Usefulness of Information, SD Responsiveness, UAC Operation, Information Application)	Summer '81	SD/RD/USGS/TA Contractor/ User Agencies
34. Production Area and Project Maps	As Needed	SD
35. Aerial Photography to Update Source for 1/10,000 Maps	Periodic following Sept. '79	SD/SLAF
36. Completion T.A. Contractor Services	Winter 80/81	SD/TA/USAID
37. Completion of 1/10,000 Scale Base Map	October '83	SD
38. Final Evaluation - in addition to first full evaluation will cover future SD activities	Fall '83	SD/User Agencies/ USGS, USAID/ Consultant

3. Contracts and Logistic Support

Logistic support will be provided to the Survey Department by (a) the Sri Lanka Air Force, who will provide maintenance and pilot services for the aircraft; (b) AID - as the procurement agent for the project; (c) by the USGS, who will provide training in country and in the U.S.; (d) by the technical assistance contractor, who will provide some training and purchasing services; and (e) by the contractor for initial pilot and photogrammetry services and related familiarization training.

The following contracts are envisioned under the project:

A. Host country contract for long and short term technical assistance;

B. Host country contract for pilot and photogrammetry services;

C. Agreement between the Survey Department and SLAF for aircraft pilot and maintenance.

D. Agreement between SD-AID-USGS for some training services and evaluation;

E. Survey Department local contract for facilities renovation;

F. A variety of arrangements for set-up and calibration of equipment which will be a part of the equipment procurement.

(C) Evaluation Arrangements for the Project

Two types of evaluation for the project have been planned: routine evaluations at stated intervals during project implementation (see Implementation Schedule) to review primarily the adequacy of facilities and procedures, logistics, and progress toward production goals; and special evaluations in the fourth year of the project and at the end of the project to review responsiveness of the project to user agency requirements, alternatives for maximizing output utilization, information applications, new developments in the technological area, operations of the User Assistance Center, and appropriate future activities of the Survey Department. Both types of evaluations will review, albeit in different ways, progress toward achieving the project purpose of meeting the mapping requirements of rural development.

The routine evaluations will be performed by the Survey Department, the technical assistance contractor, and USAID. The special evaluations will include user agency staff and USGS personnel. The budget includes funding for USGS participation in evaluations.

(D) Conditions, Covenants and Negotiating Status

The following special conditions precedent to disbursement for equipment and supplies (not for technical assistance) will be included in the loan agreement:

1. Evidence of an agreement acceptable to AID between the Survey Department and the Sri Lanka Air Force for the maintenance and operation of the aircraft to be supplied under the project;

2. A signed contract for technical assistance;

3. Evidence of the availability of funds for and intention to carry out facility renovation.

The need for an agreement between the Survey Department and the Air Force has been agreed to and discussed by the Department and SLAF. A draft agreement has been prepared. The Department advises it has sufficient funds to initiate the local cost element of facility renovation in CY 1977.

No problems are envisioned in meeting the conditions precedent or in reaching agreement with the GSL on the covenants normally included by AID in loan agreements, and on the following special covenants:

1. The Aircraft provided under the project will not be used for any military purpose;

2. The Aircraft provided uder the project will be adequately insured to permit replacement for the life of the project.

3. The GSL will provide fuel needed for aircraft operations for the life of project.

ANNEX A

Loan Implementation

ANNEX A

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A. AID/W PRP Approval Message

B. Logical Framework Matrix

C. Mission Director's 611(e) Certification

D. Borrower's Request for Assistance

E. Draft Project Description (Disbursement Schedule)

F. Draft Authorization

G. Statutory Checklist

H. Waiver Justification

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A.

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APPROVED BY A/AA/ASIA:MHBADLER
A/DAA/ASIA:DCOHEN
PPC/DPRE:JWELTY (DRAFT)
ASIA/BIS:MOWYRE (DRAFT)
ASIA/PD/SA:BODELL (DRAFT)
ASIA/PD:JRMCCABE-TR/ARD:CANTHOLT
ASIA/DP:TO'CONNOR (DRAFT)
GC/ASIA:PBLOOM (DRAFT)
ASIA/PD:ARLOVE-/BIS:PBOUGHTON (DFT)
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TAGS:

SUBJECT: AGRICULTURAL BASE MAPPING -PRP REVIEW

1. THE ASIA PROJECT ADVISORY COMMITTEE (APAC) MET ON NOVEMBER 23 AND APPROVED THE SUBJECT PRP. CHANGES IN THE PRP AS WELL AS ISSUES TO BE ADDRESSED IN THE PP IN ADDITION TO THOSE TO BE TREATED IN ACCORDANCE WITH THE OUTLINE IN HANDBOOK 3 ARE AS FOLLOWS:
2. APAC FELT THAT THE PROJECT PURPOSE WAS IN FACT A RESTATEMENT OF PROJECT OUTPUTS AND RECOMMENDS THE PURPOSE BE QUOTE TO MEET THE MAPPING REQUIREMENTS OF RURAL DEVELOPMENT UNQUOTE. THIS REVISED PURPOSE WILL APPEAR IN THE CONGRESSIONAL PRESENTATION. PROJECT DESIGN, AS REFLECTED IN THE LOGICAL FRAMEWORK SHOULD BE REVISED TO REFLECT THIS PURPOSE. IN PARTICULAR BETTER MEASURES OF ACHIEVEMENT OF BOTH OUTPUTS AND PURPOSE THAN THOSE IDENTIFIED IN THE PRP SHOULD BE DEVELOPED.

3. MAJOR CONCERN WAS RAISED OVER THE RELATIONSHIP BETWEEN THE PROJECT AND AID'S TARGET POPULATION. THE COMMITTEE FELT THESE LINKAGES SHOULD BE MORE CLEARLY DEFINED IN THE PP. WE NEED TO BE ASSURED THAT IN MEETING PROJECT PURPOSE THERE IS IN FACT A CAUSAL RELATIONSHIP TO MEETING PROJECT

GOAL OBJECTIVES. WE RECOGNIZE THAT ACHIEVEMENT OF PROJECT GOAL IS A FUNCTION OF NOT THIS PROJECT, BUT MANY PROJECT/ACTIVITIES. THE PP SHOULD DETAIL HOW THIS PROJECT AT THE MARGIN IMPACTS ON SECTOR GOAL REALIZATION, THAT IS, WITHOUT THIS PROJECT WHAT WOULD THE IMPLICATIONS BE FOR REALIZATION OF SECTOR GOAL. THE PP SHOULD REVIEW THE ROLE AERIAL MAPPING HAS HAD IN PAST RURAL DEVELOPMENT ACTIVITIES AND WHAT THESE ACTIVITIES IN TURN MEANT TO AID'S TARGET POPULATION. THE PP SHOULD ALSO ESTIMATE THE IMPACT OF THIS PROJECT ON CURRENT OR PLANNED GSL DEVELOPMENT PROJECTS AND THE IMPLICATIONS OF NOT RE-EQUIPPING THE SURVEY DEPARTMENT.

4. THE PP SHOULD CONTAIN AS PART OF THE IMPLEMENTATION PLAN A PRIORITY LISTING OF AREAS OF THE COUNTRY TO BE PHOTOGRAPHED AND MAPPED INDICATING HOW THESE PRIORITIES RELATE TO OVERALL GSL AGRICULTURAL PLANS. PRESUMABLY, IN DEVELOPING A NATIONAL BASE MAP GREATER EMPHASIS WOULD BE PLACED ON MAPPING AREAS TARGETED FOR SIGNIFICANT DEVELOPMENT ACTIVITIES EARLY IN THE LIFE OF THE PROJECT.

5. THE PP SHOULD CONTAIN AN ANALYSIS OF THE ADDITIONAL SURVEY DEPARTMENT STAFF NECESSARY TO HANDLE THE INCREASED WORKLOAD THE PROJECT WILL PERMIT, AND IDENTIFY THE SOURCE OF THIS ADDITIONAL STAFF.

6. THE BUDGET IDENTIFIED IN THE RDA REPORT NOTES PROJECT COSTS OF MORE THAN DOLS 861,000, OR 21 PERCENT OF THE PROPOSED LOAN, FOR EXPENDABLE SUPPLIES FOR THE MAP PRODUCTION UNIT. IN FURTHER DEVELOPING THE PROJECT, THE MISSION SHOULD DETERMINE THE PROPORTION OF THESE PROPOSED AID FUNDED EXPENDABLES TO TOTAL EXPENDABLES REQUIRED BY THE MAP PRODUCTION UNIT AND SHOULD DEVELOP WITH THE GSL A PLAN TO INSURE CONTINUED GSL FINANCING OF EXPENDABLES ONCE AID PROJECT PARTICIPATION ENDS. IF THE PROPOSED FINANCING WILL IN FACT FINANCE ALL OR ALMOST ALL OF THE EXPENDABLE REQUIREMENTS FOR THE PROJECT THE MISSION SHOULD GIVE SERIOUS CONSIDERATION TO REDUCING AID'S SHARE OF THESE COSTS AND INCREASING THE GSL SHARE OF THE COSTS PARTICULARLY OVER THE LIFE OF THE PROJECT TO INSURE A GSL COMMITMENT TO FINANCE CONTINUING REQUIREMENTS. THE PP SHOULD ALSO PROVIDE EVIDENCE OF GSL READINESS TO FUND LOCAL COSTS OF THE PROJECT.

7. APAC BELIEVED THAT DURING PROJECT IMPLEMENTATION ADDITIONAL TECHNICAL ASSISTANCE/TRAINING MIGHT BE NECESSARY IN AREAS CURRENTLY NOT FORESEEN AND INCREASED ESTIMATED FUNDING TO ACCOMMODATE THIS NEED TO TOTAL PROJECT COST OF DOLS 3,500,000. COST ANALYSIS SUBSEQUENT TO PRP

PREPARATION HAD INDICATED A PROJECT COST OF DOLS 3,350,000.

8. IN DEVELOPING THE PP THE MISSION SHOULD ANALYZE WITH THE GSL THE POSSIBLE BENEFITS OF REVISING SURVEY DEPARTMENT BUDGETING PROCEDURES TO PROVDE FOR USER AGENCY REIMBURSEMENT TO THE SURVEY DEPARTMENT FOR WORK PERFORMED. SUCH A SYSTEM WOULD PERMIT THE DEPARTMENT TO OPERATE AT THE LEVEL USER AGENCIES REQUIRE. FORCE THOSE REQUIRING DATA TO JUSTIFY ITS COST, AND QUOTE PRIORITIZE UNQUOTE THE DEPARTMENT'S WORKLOAD. REACTIONS OF ACTUAL OR POTENTIAL GSL USER AGENCIES TO SERVICE CHARGE CONCEPT MAY ALSO BE FAIRLY ACCURATE INDICATION OF REALISTIC USER NEED FOR AND INTEREST IN SURVEY DEPARTMENT'S MAPPING SERVICES. AID/W REMAINS CONCERNED ABOUT DEPTH OF OVERALL GSL INTEREST IN PROPOSAL AND HOW WILLING IT IS TO MANIFEST SENSE OF BUDGETARY PRIORITY IN PROJECT SUPPORT. PROPOSING SERVICE CHARGE IDEA MAY HELP TO FLUSH OUT ANSWERS IN THIS REGARD. TECHNICAL ASSISTANCE COULD BE PROVIDED THE MISSION/GSL IN THIS AREA EITHER AS PART OF PROJECT DEVELOPMENT OR AS PART OF THE PROJECT.

9. AID/W AGREES WITH NEED NOTED IN PRP FOR BETTER SYSTEM TO PERMIT USER AGENCIES TO MAXIMIZE USE OF SURVEY DEPARTMENT PHOTO INTERPRETATION EQUIPMENT AND KNOWLEDGE AND BELIEVES PROJECT SHOULD CONTAIN PLAN OF ACTION IN THIS AREA. CAIN/CRAIB PROPOSAL FOR A SURVEY RESEARCH CENTER WITHIN THE DEPARTMENT APPEAR ATTRACTIVE BUT OTHER POSSIBILITIES MAY ARISE DURING PROJECT DEVELOPMENT.

10. THE PP SHOULD DETAIL THE CONTRACTUAL ARRANGEMENTS ENTAILED IN PROJECT IMPLEMENTATION INCLUDING ARRANGEMENTS TO MAINTAIN PLANE AND PROVIDE PILOT AS WELL AS TO PROCURE, MODIFY AND DELIVER PLANE AND TRAIN GSL STAFF IN MAINTENANCE AND OPERATION. A MAINTENANCE/OPERATION CONTRACT SATISFACTORY TO AID SHOULD BE A PRECONDITION TO LOAN DISBURSEMENT.

11. THE PP SHOULD CONTAIN JUSTIFICATION FOR ANY WAIVERS THAT MAY BE REQUIRED TO PERMIT PROCUREMENT OF NEEDED EQUIPMENT.

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12. HANDBOOK 3 PROVIDES GUIDANCE ON ADDITIONAL ANALYSIS REQUIRED IN THE PP INCLUDING ECONOMIC, FINANCIAL, AND SOCIAL, PARTICULARLY THE ROLE OF WOMEN.

13. WHILE ALL OF THE AREAS NOTED IN ANNEX B OF THE PRP WILL NEED TO BE ADDRESSED AT SOME POINT IN THE PROJECT THE PP MAY NOT NEED ALL OF THE DETAILED INFORMATION LISTED. DEVELOPMENT OF MUCH OF THIS INFORMATION, PARTICULARLY THE DETAILED EQUIPMENT LISTS AND SPECIFICATIONS COULD BE PRODUCED FOLLOWING LOAN AUTHORIZATION, HOWEVER IF THIS CAN BE DONE RELATIVELY EASILY WHILE PREPARING THE PP IT WOULD BENEFIT IMPLEMENTATION. KISSINGER

AID 1020-28 (1-72)

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

Project Title & Number: AGRICULTURE BASE MAPPING - Sri Lanka

Life of Project: From FY 77 to FY 83
Total U. S. Funding $4,425,000
Date Prepared: August 19, 1977

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Program or Sector Goal: The broader objective to which this project contributes: Improve the living standard of the rural people in Sri Lanka	**Measures of Goal Achievement:** 1. Increased number of employment opportunities for rural people. 2. Improved nutrition level of rural people. 3. Increase income for rural people.	G.S.L. Annual Statistics IBRD Annual Statistics	**Assumptions for achieving goal targets:** More and better maps will assist the GSL to improve the standard of living of the rural people.
Sub-Goal Increase the agricultural production of food for consumption domestically in Sri Lanka.	1. Increased % of agr. production of food for domestic consumption. 2. Decreased % of food products imported for domestic consumption. 3. Improved ratio of production to land under cultivation.		The GSL will continue to initiate policies favorable to increased agricultural production of food for domestic consumption.
Project Purpose: To meet the mapping requirements of rural development in Sri Lanka.	**Conditions that will indicate purpose has been achieved: End of project status.** 1. Base Maps less than 5 yrs. old. A. 1/50,000 B. 1/10,000 2. Increased number of requests for Survey Dept. to provide relevant information for user agencies. 3. Larger scale maps provided to user agencies within 6 mos. of request. 4. 10% of base maps at 1/10,000 are updated per year. 5. An operational User Assistance Ctr.	- Survey Department records of maps produced and distributed to requesting user agencies. - Records of annual percent of updating process. - Record of use of UAC facilities	**Assumptions for achieving purpose:** The GSL will provide continuing budget support to the Survey Department.
Outputs: 1. Maps to the scale of: A. 1/50,000 B. 1/10,000 C. 1/1000 - 1/10,000 2. Modern equipped & trained staff for UAC 3. Trained pilots and photographers 4. Trained staff for S.O. & user agencies.	**Magnitude of Outputs:** 1. Completed Maps A. Total nation B. Total nation C. As per request of User Agency 2. 14 user agencies utilizing UAC 3. 4 trained aerial photography teams 4. 34 trained staff members of SD and UAC	1. Records of user requests for various maps 2. Records of utilization of UAC 3. Flight records & aerial photography of aerial survey unit. 4. Records of completion training.	**Assumptions for achieving outputs:** - Survey Department personnel will correctly utilize aircraft and equipment - User agencies will continue to make requests for maps & arial photographs - User agencies will utilize the "User Assistance Center"
Inputs: 1. Equipment for: A. Photo Acquisition; Aircraft and Accessories B. Field Support C. Compilation D. Photo Lab E. Map Production F. User Assistance Center 2. Facility Renovation 3. Expendable Equipment 4. Technical Training 5. Technical Assistance 6. Contingencies (10%) 7. Inflation Factor (10%)	**Implementation Target (Type and Quantity)** 1. Equipment — Order Date A. 552,500 — 2-3/78 B. 537,400 — 1-2/73 C. 258,400 — 12/77-3/78 D. 194,400 — 1/78 E. 150,400 — 1/78 F. 68,200 — 6/78 2. 100,000 — 1/78 3. 848,700 — 1/78 4. 254,000 — 11/78-3/79 5. 503,000 — 11/77-78 6. 346,700 *Aircraft fuel to be financed by GSL. 7. 686,300	USAID Records and Reports GSL Records and Reports	**Assumptions for providing inputs:** No capacity exists in Sri Lanka Survey Department to provide the up-to-date mapping requirements of various gov't. agencies responsible for rural development planning & implementation. 2. Existing maps are based on 1956 aerial photography at a scale of 1/63,000. 3. No user assistance capability now exists in Survey Department

ACTION COPY

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Department of State

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FM AMEMBASSY COLOMBO
TO SECSTATE WASHDC 8074

UNCLAS COLOMBO 3266

AIDAC

E.O. 11652: N/A

SUBJ: AG BASE MAPPING

REF: STATE 208284

SRI LANKA - AGRICULTURAL BASE MAPPING CERTIFICATION PURSUANT TO SECTION 611(E) OF THE FOREIGN ASSISTANCE ACT OF 1961, AS AMENDED.

I, THOMAS ARNDT, PRINCIPAL OFFICER OF THE AGENCY FOR INTERNATIONAL DEVELOPMENT IN SRI LANKA, HAVING TAKEN INTO ACCOUNT AMONG OTHER THINGS THE MAINTENANCE AND UTLIZATION OF PROJECTS IN SRI LANKA PEVIOUSLY FINANCED OR ASSISTED BY THE U.S. AND THE COMMITMENT OF THE GOVERNMENT OF SRI LANKA TO CARRY OUT AN EFFECTIVE AGRCULTURAL BASE MAPPING PROGRAM, DO HEREBY CERTIFY THAT IN MY JUDGMENT SRI LANKA HAS THE FINANCIAL AND HUMAN RESOURCES CAPABILITY TO IMPLEMENT, MAINTAIN AND UTILIZE EFFECTIVELY THE SUBJECT CAPITAL ASSISTANCE PROJECT FOR AGRICULTURAL BASE MAPPING.

/S/ THOMAS M. ARNDT
A.I.D. REPRESENTATIVE
SRI LANKA
SEPTEMBER

WRIGGINS

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Department of State

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FM AMEMBASSY COLOMBO

TO SECSTATE WASHDC PRIORITY 8016

UNCLAS COLOMBO 3145

AIDAC

E.O. 11652: N/A

SUBJ: AG BASE MAPPING

REF: STATE 200379

TEXT OF GSL REQUEST DATED JUNE 24, 1976 FOR SUBJECT PROJECT REQUESTED BY REFTEL READS AS FOLLOWS:

"DEAR MR. BILLINGS,

"AGRICULTURAL-BASE MAPPING PROJECT - REQUEST FOR ASSISTANCE FROM US AID - I AM SENDING YOU HEREWITH ONE COPY OF THE AGRICUTURAL-BASE MAPPING PROJECT PREPARED BY THE SURVEY DEPARTMENT AND THE AGRICULTURAL PROJECTS PREPARATION UNIT OF THE MINISTRY OF AGRICULTURE AND LANDS.

"IT WOULD BE APPRECIATED IF THIS LETTER IS TREATED AS AN OFFICIAL REQUEST FROM THE GOVERNMENT OF SRI LANKA TO US AID TO UNDERTAKE THE FINANCING OF THIS PROJECT.

YOURS SINCERELY,

/S/ M.A. MOHAMED

ADDITIONAL DIRECTOR,

EXTERNAL RESOURCES"

WRIGGINS

UNCLASSIFIED

DRAFT PROJECT DESCRIPTION FOR LOAN AGREEMENT

A. Definition of Project (Section 2.1 of Agreement)

The project will consist of the supply of commodities and equipment for photo acquisition, field control, triangulation, compilation, map production and printing, in order to upgrade the physical facilities and technical capacity of the Survey Department. In addition, the project provides for the establishment and operation of a User Assistance Center which will serve as a resource center for other Sri Lankan agencies involved in research and planning, and project implementation in rural development. The technical Assistance and Technical Training provided under the project will facilitate the implementation of the project and insure that the project outputs will include the production of a 1/50,000 scale and a 1/10,000 scale base map of Sri Lanka, as well as larger scale maps on a project specific or request basis.

B. Annex I Description

Over a six year period the project will provide for the production of a 1/50,000 scale and 1/10,000 scale base map of Sri Lanka and the production of larger scale area and project specific maps as well as the indigenous capability to continually update base maps and provide larger scale maps as needed following project completion. The project will also provide for the establishment and equipping of a "User Assistance Center" as a research and resource center for user agency and implementing agency personnel. An aspect of the User Assistance Center component of the project is the familiarization training of user agency personnel.

The project will be implemented by the Survey Department, Ministry of Agriculture and Lands, Government of Sri Lanka with technical assistance provided under the loan and the support of the Sri Lanka Air Force for aircraft maintenance, service, and piloting. Proceeds of the AID loan will be used to finance the foreign exchange costs of equipment, materials and supplies, maintenance, technical assistance, and training required under the project.

Disbursement Schedule

	FY 77		FY 78		FY 79		FY 80		FY 81		FY 82		Total	
	US	GSL	US	GSL	US	GSL	US	GSL	US	GSL	US	GSL	US	GSL
Equipment	1232.9	449.4	528.4	192.6	-	-	-	-	-	-	-	-	1761.3	642
Facilities	80	36	20	-		-		-		-		-	100	36
Material	141.5	20.5	141.5	20.5	141.5	20.5	141.5	20.5	141.5	20.5	141.5	20.5	849	123
Technical Assistance	-	-	125.75	-	125.75	-	125.75	-	125.75	-	-	-	503	-
Technical Training	-	-	50.8	-	50.8	-	50.8	-	50.8	-	50.8	-	254	-
Personnel	-	-	-	188	-	188	-	188	-	188	-	188	-	940
Fuel and Maintenance	-	-	-	60	-	60	-	60	-	60	-	60	-	300
Contingencies (@10%)	57.8	-	57.8	-	57.8	-	57.8	-	57.8	-	57.8	-	346.7	-
Inflation Factor (@18%)	114.3	-	114.3	-	114.3	-	114.3	-	114.3	-	114.3	-	686	-
Total	-	-	-	-	-	-	-	-	-	-	-	-	4500	2041

DEPARTMENT OF STATE
AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D.C. 20523

PROJECT AUTHORIZATION AND REQUEST FOR ALLOTMENT FOR FUNDS

PART II

SRI LANKA

Agricultural Base Mapping
A.I.D. Loan No.

Pursuant to Part I, Chapter 1, Section 103 of the Foreign Assistance Act of 1961, as amended, I hereby authorize a Loan to the Government of Sri Lanka (the "Cooperating Country") of not to exceed Four Million Five Hundred Thousand United States Dollars ($4,500,000) (the "Authorized Amount"), to help in financing certain foreign exchange and local currency costs of goods and services required for the project. The project consists of (1) upgrading the physical and technical capacity of the Survey Department of the Ministry of Agriculture and Lands to do aerial photography and produce base maps of Sri Lanka to meet planning and operational requirements of Cooperating Country rural development programs plus (2) the establishment and operation of a User Assistance Center within the Survey Department to serve as a resource center for other Cooperating Country agencies doing studies and research work associated with aerial surveys and remote sensing techniques (hereinafter referred to as the "Project").

The entire amount of the A.I.D. financing herein authorized for the Project will be obligated when the Project Agreement is executed.

I hereby authorize the initiation of negotiations and execution of the Project Agreement by the officer to whom such authority has been delegated in accordance with A.I.D. regulations and Delegations of Authority subject to the following essential terms and covenants and major conditions; together with such other terms and conditions as A.I.D. may deem appropriate.

a. Interest Rate and Terms of Repayment

The Cooperating Country shall repay the Loan to A.I.D. in United States Dollars within forty (40) years from the date of first disbursement of the Loan, including a grace period of not to exceed ten (10) years. The Cooperating Country shall pay to A.I.D. in United States Dollars interest from the date of first disbursement

of the Loan at the rate of (a) two percent (2%) per annum during the first ten (10) years, and (b) three percent (3%) per annum thereafter, on the outstanding disbursed balance of the Loan and on any due and unpaid interest accrued thereon.

b. Source and Origin of Goods and Services

Except for ocean shipping or as A.I.D. may otherwise agree in writing, goods and services financed by A.I.D. under the Project shall have their source and origin in countries included in A.I.D. Geographic Code 941 and the Cooperating Country. Ocean shipping financed under the Loan shall be procured in any eligible source country except the Cooperating Country.

c. Conditions Precedent to Initial Disbursement

Prior to the initial disbursement or the issuance of the initial commitment document for technical assistance under the Project Agreement, the Cooperating Country shall furnish the following in form and substance satisfactory to A.I.D.:

1. A signed contract for technical assistance; and

2. Evidence of the availability of funds for and intention to carry out facility renovation.

d. Conditions Precedent to Disbursements for Additional Procurement

1. Evidence of an agreement between the Survey Department and the Sri Lanka Air Force for the maintenance and operation of the aircraft to be supplied under the Project;

2. Evidence that provisions have been made to make aviation fuel available to the project aircraft commensurate with the needs of photographic missions to be flown during the training period run by the U.S. pilot and photogrammatrist trainers.

e. The Cooperating Country shall covenant the following:

1. The aircraft provided under the Project shall be reserved for project needs and will not be used for military purposes;

2. The aircraft provided under the Project will be adequately insured against mishaps to permit its repair or replacement throughout the life of the Project, and all maintenance and operational requirements, including fuel, shall be made available as required to meet the objectives of the Project.

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f. The following waivers to A.I.D. regulations are hereby approved:

Waivers to permit proprietary procurement of U.S. source origin equipment and aircraft as stated in the Project Paper.

Clearances:	Date	Initial
Herbert E. Morris, GC/Asia	9/23/77	Hm
Alexander R. Love, Asia/PD		
T. C. Clark, Jr., Asia/TR		
Robert W. Wiley, SER/COM		
Donald D. Cohen, Asia/DP		
Priscilla M. Boughton, Asia/BIS		
Michael H. B. Adler, DAA/Asia		

Signature _____
Assistant Administrator
Bureau for Asia

_____
Date

GC/Asia:PBloom:hp:9/22/77

G. STATUTORY CHECKLIST

A. GENERAL CRITERIA FOR PROJECT.

1. (a) Describe how Committees on Appropriations of Senate and House have been or will be notified concerning the project; (b) is assistance within (Operational Year Budget) country or international organization allocation reported to Congress (or not more than $1 million over that figure plus 10%)?	(a) Notification of the proposed project will be given to Congress. (b) yes
2. FAA Sec. 611(a)(1). Prior to signing of loan will there be (a) engineering, financial, and other plans necessary to carry out the assistance and (b) a reasonably firm estimate of the cost to the United States of the assistance?	(a) All plans necessary to carry out the assistance are completed. (b) The cost of assistance by the United States is firm.
3. FAA Sec. 611(a)(2). If further legislative action is required within recipient country, what is basis for reasonable expectation that such action will be completed in time to permit orderly accomplishment of purpose of loan?	Legislative action is not required.
4. FAA Sec. 611(b); App. Sec. 101. If loan finances water or water-related land resource construction project or program, is there a benefit-cost computation made, insofar as practicable, in accordance with the procedures set forth in the Memorandum of the President dated May 15, 1962?	Not applicable.
5. FAA Sec. 611(e). If loan is for Capital Assistance, and all U.S. assistance to project now exceeds $1 million, has Mission Director certified the country's capability effectively to maintain and utilize the project?	Yes.

6. FAA Sec. 209, 619. Is project susceptible of execution as part of regional or multilateral project? If so why is project not so executed? Information and conclusion whether assistance will encourage regional development programs. If assistance is for newly independent country, is it furnished through multilateral organizations or plans to the maximum extent appropriate?	Not applicable.
7. FAA Sec. 601(a). Information and conclusions whether loan will encourage efforts of the country to: (a) increase the flow of international trade; (b) foster private initiative and competition; (c) encourage development and use of cooperatives, credit unions, and savings and loan associations; (d) discourage monopolistic practices; (e) improve technical efficiency of industry, agriculture, and commerce; and (f) strengthen free labor unions.	(a) The loan will have little lasting effect on international trade other than to finance needed imports. (b) No effect on private initiative and competition. (c) No effect on cooperatives, credit unions and savings and loan associations. (d) No effect on monopolistic practice: (e) Will increase technical efficiency of industry, agriculture, and commerce by providing essential aerial photography and statistical data for planning and development. (f) No effect on labor unions
8. FAA Sec. 601(b). Information and conclusion on how the loan will encourage U.S. private trade and investment abroad and how it will encourage private U.S. participation in foreign assistance programs (including use of private trade channels and the services of U.S. private enterprise).	This loan is not expected to directly foster U.S. investment abroad
9. FAA Sec. 612(b); 636(h). Describe steps taken to assure that, to the maximum extent possible, the country is contributing local currencies to meet the cost of contractual and other services, and foreign currencies owned by the United States are utilized to meet the cost of contractual and other services.	The local currency costs of the project will be supplied by the Government of Sri Lanka.

10. FAA Sec. 612(d). Does the United States own excess foreign currency and, if so, what arrangements have been made for its release?

No.

FUNDING CRITERIA FOR PROJECT

1. Development Assistance Project Criteria

a. FAA Sec. 102(c); Sec. 111; Sec. 281a. Extent to which activity will (a) effectively involve the poor in development, by extending access to economy at local level, increasing labor-intensive production, spreading investment out from cities to small towns and rural areas; and (b) help develop cooperatives, especially by technical assistance, to assist rural and urban poor to help themselves toward better life, and otherwise encourage democratic private and local governmental institutions?

(a) By providing up-to-date maps and statistical data the project will enable various User Agencies of GSL to better implement & plan projects which will involve the poor in development.

(b) Not applicable.

b. FAA Sec. 103, 103A, 104, 105, 106, 107. Is assistance being made available: (include only applicable paragraph — e.g., a, b, etc., — which corresponds to source of funds used. If more than one fund source is used for project, include relevant paragraph for each fund source.)

(1) [103] for agriculture, rural development or nutrition; if so, extent to which activity is specifically designed to increase productivity and income of rural poor; [103A] if for agricultural research, is full account taken of needs of small farmers;

Yes, project will provide base maps and statistical data essential for the design of projects to increase productivity and income of rural poor

(2) [104] for population planning or health; if so, extent to which activity extends low-cost, integrated delivery systems to provide health and family planning services, especially to rural areas and poor;

Not applicable.

(3) [105] for education, public administration, or human resources development; if so, extent to which activity strengthens nonformal education, makes formal education more relevant, especially for rural families and urban poor, or strengthens management capability of institutions enabling the poor to participate in development;	Not applicable.
(4) [106] for technical assistance, energy, research, reconstruction, and selected development problems; if so, extent activity is:	Not applicable.
(a) technical cooperation and development, especially with U.S. private and voluntary, or regional and international development, organizations;	Not applicable.
(b) to help alleviate energy problem;	Not applicable.
(c) research into, and evaluation of, economic development processes and techniques;	Not applicable.
(d) reconstruction after natural or manmade disaster;	Not applicable.
(e) for special development problem, and to enable proper utilization of earlier U.S. infrastructure, etc., assistance;	Not applicable.
(f) for program of urban development, especially small labor-intensive enterprises, marketing systems, and financial or other institutions to help urban poor participate in economic and social development.	Not applicable.
(5) [107] by grants for coordinated private effort to develop and disseminate intermediate technologies appropriate for developing countries.	Not applicable.

c. FAA Sec. 110(a); Sec. 208(e). Is the recipient country willing to contribute funds to the project, and in what manner has or will it provide assurances that it will provide at least 25% of the costs of the program, project, or activity with respect to which the assistance is to be furnished (or has the latter cost-sharing requirement been waived for a "relatively least-developed" country)?	The Government of Sri Lanka will provide at least 25 percent of the cost of the activity.
d. FAA Sec. 110(b). Will grant capital assistance be disbursed for project over more than 3 years? If so, has justification satisfactory to Congress been made, and efforts for other financing?	Not applicable.
e. FAA Sec. 207; Sec. 113. Extent to which assistance reflects appropriate emphasis on; (1) encouraging development of democratic, economic, political, and social institutions; (2) self-help in meeting the country's food needs; (3) improving availability of trained worker-power in the country; (4) programs designed to meet the country's health needs; (5) other important areas of economic, political, and social development, including industry; free labor unions, cooperatives, and Voluntary Agencies; transportation and communication; planning and public administration; urban development, and modernization of existing laws; or (6) integrating women into the recipient country's national economy.	The project will indirectly contribute to increased food production and will directly improve the availability of trained worker power in the country. The project will also improve GSL planning and implementation capability.
f. FAA Sec. 281(b). Describe extent to which program recognizes the particular needs, desires, and capacities of the people of the country; utilizes the country's intellectual resources to encourage institutional development; and supports civic education and training in skills required for effective participation in governmental and political processes essential to self-government.	The project recognizes the capacities of the personnel of the Survey Dept, and by updating their skills encourage institutional development essential to GSL development planning & implementation.

g. FAA Sec. 201(b)(2)-(4) and -(8); Sec. 201(e); Sec. 211(a)(1)-(3) and -(8). Does the activity give reasonable promise of contributing to the development: of economic resources, or to the increase of productive capacities and self-sustaining economic growth; or of educational or other institutions directed toward social progress? Is it related to and consistent with other development activities, long-range objectives? And does project paper provide information and conclusion on an activity's economic and technical soundness?

The project gives reasonable promise of contributing substantially to development of economic resources, of increasing productive capacity and self-sustaining economic growth. It is vital to a variety of other development activities, and long-range objectives. The Project Paper provides information and conclusions on the activity's economic and technical soundness.

h. FAA Sec. 201(b)(6); Sec. 211(a)(5),(6). Information and conclusion on possible effects of the assistance on U.S. economy with special reference to areas of substantial labor surplus, and extent to which U.S. commodities and assistance are furnished in a manner consistent with improving or safeguarding the U.S. balance-of-payments position.

Various commodities will be provided by U.S. firms, thus improving U.S. balance of payments position.

2. Development Assistance Project Criteria (Loan only)

a. FAA Sec. 201(b)(1). Information and conclusion on availability of financing from other free-world sources, including private sources within U.S.

Not applicable.

b. FAA Sec. 201(b)(2). (1) Information and conclusion on capacity of the country to repay the loan, including reasonableness of repayment prospects.

(1) Foreign debt service payments in 1975 are estimated to be $134 million (Rs. 1,024 million converted at 7.65 to be $1.00 US) as compared to $102 million in 1974. (Rs. 684 million converted at 6.69 to $1.00 US.) The 1975 foreign debt service payment consists of $113 million (Rs. 862 million) for repayment of principal an $21 million (Rs 162 million) for interest payments. The debt service ration between 1974 and 1975 increasec to 22.9% from 17.8% in 1974. (Source: Central Bank of Ceylon's Annual Report for 1975.) Based on the foregoing

	and upon an expectation that other donors will continue to provide assistance on grant or concessional terms it is concluded that AID's concessional lending terms (i.e. repayment within 40 years, including a ten year grace period on repayment of principal; interest at 2% during the grace period, and 3% thereafter) are justified in Sri Lanka's case. On such terms, the proposed loan will not add significantly to Sri Lanka's debt service burden and the prospects for repayment of the loan are reasonab
(2) reasonableness and legality (under laws of country and U.S.) of lending and relending terms of the loan.	(2) The loan is legal under the lendin laws of both countries.
c. FAA Sec. 201(e). If loan is not made pursuant to a multilateral plan, and the amount of the loan exceeds $100,000, has country submitted to AID an application for such funds together with assurances to indicate the funds will be used in an economically and technically sound manner?	Yes.
d. FAA Sec. 201(f). Does project paper describe how project will promote the country's economic development taking into account the country's human and material resources requirements and relationship between ultimate objectives of the project and overall economic development?	Yes.
e. FAA Sec. 202(a). Total amount of money under loan which is going directly to private enterprise, is going to intermediate credit institutions or other borrowers for use by private enterprise, is being used to finance imports from private sources, or is otherwise being used to finance procurements from private sources?	One hundred percent of the loan proceeds will be used by the public sector in Sri Lanka. Ninety-five percent of the money will be used for procurement with less than five percent to be used for training.

f. FAA Sec. 620(d). If assistance is for any productive enterprise which will compete in the U.S. with U.S. enterprise, is there an agreement by the recipient country to prevent export to the U.S. of more than 20% of the enterprise's annual production during the life of the loan?	Not applicable.

3. Project Criteria Solely for Security Supporting Assistance

FAA Sec. 531. How will this assistance support promote economic or political stability?	Not applicable.

PROCUREMENT WAIVER
DRAFTED: ASIA/PD/SA:SJFreundlich
INITIALED
WAIVER CONTROL ASIA/77/35/Loan 0045

ACTION MEMORANDUM FOR THE ASSISTANT ADMINISTRATOR, ASIA

FROM: ASIA/PD, Alexander R. Love

Problem: Request for a Proprietary Procurement Waiver in order to procure a Modified Cessna 421C aircraft with appropriate spare parts, tools and familiarization training for four Sri Lankan Pilots.

(a) Cooperating Country : Sri Lanka

(b) Authorizing Document : Loan 383-0045

(c) Project : Agricultural Base Mapping

(d) Nature of funding : Development Loan

(e) Description of goods :
- Cessna 421C aircraft, pressurized, twin reciprocating engines, 30,000 ft. service ceiling
- Pilot and maintenance training
- Appropriate equipment spares and special tools
- Aircraft modification for aerial photography (installation for NF - 2, B3 + RC 8/10)

(f) Approximate value : $535,000

(g) Source : U.S. (Cessna Aircraft Corp.)

Discussion: The host country implementing agency, the technical consultant RDA and the USGS advise that the above aircraft and equipment is an essential element of the project in that the project aims at improving the Sri Lankan Survey Department's capacity to carry out its assigned responsibility to do aerial photography and produce maps in support of other GSL rural development agencies. At present the GSL operates five Cessna 377 aircraft and has adequate maintenance support for them. By obtaining an aircraft supportable by similar parts and maintenance procedures, the project will promote operations and maintenance standardization and thus reduce the requirement for extensive long-term training and additional support equipment. In addition Cessna is the only aircraft company which maintains facilities for parts supply and complete overhaul of its aircraft in this part of the world (Singapore) through a factory authorized representative.

Primary Justification: The subject equipment is essential to this AID-financed project, it has been certified by the technical consultant as the least cost alternative aircraft having the necessary fusilage capacity for housing the aerial photography equipment and personnel, will promote standardization, is compatible with the equipment on hand, will be subject to available and dependable servicing, and is manufactured and supplied solely by Cessna.

Recommendation: For the above reasons, I conclude that exclusion of procurement of this equipment from the source requested above would seriously affect the success of this development project and impede attainment of the objectives of the foreign assistance program in Sri Lanka. Authority for approval of this action is provided for in Handbook 11, Chapter 3C9a: "Proprietary procurement for which AID has determined that, in order to assure the interchangeability or standardization of equipment, or because of special design requirements, or for any similar reason, purchase of a commodity by reference to a particular specification, trade name, or designation is necessary."

I recommend that you approve this request for a Proprietary Procurement Waiver to allow the purchase of this equipment and services from the Cessna Aircraft Corp.

APPROVED: _____

DISAPPROVED: _____

DATE: _____

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DEPARTMENT OF STATE
AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D.C. 20523

PROCUREMENT WAIVER
DRAFTED: ASIA/PD/SA:S.J.Freundlich
INITIALED _____
WAIVER CONTROL ASIA/77/36/Loan 0045

ACTION MEMORANDUM FOR THE AA/ASIA

FROM: ASIA/PD, Alexander R. Love

Problem: Request for a Proprietary Procurement Waiver in order to procure equipment and appropriate spare parts essential to the implementation of the Agriculture Base Mapping project in Sri Lanka.

(a) Cooperating Country : Sri Lanka

(b) Authorizing L ment : Loan 383-0045

(c) Project : Agricultural Base Mapping

(d) Nature of funding : Development Loan

(e) Description of Goods :

	Company
- 40, 4 wheel right hand drive Jeeps, long-wheel base, canvas-covered, diesel fuel	- AMC
- IBM 545 Card Punch (2 units)	- IBM
- Model 11C-M Versamat Roll Processor (1 unit) (Include installation and training in operation and maintenance)	- Kodak

- Litho sheet Processor Kodalith 324 (1 unit) includes installation and 1 week training in operation and maintenance	- Kodak
- Mark IV Log-E printer, with roll head (1 unit) includes installation and 1 week training in operation and maintenance	- Log-E-tronics Corp.
- Vacuum back for one Lanstrom copy camera	- Lanstrom Corp
- Litho Offset Printing Machine (1 unit) (AO size, 33 1/8 x 46 3/4 inches)	- Harris Press
- 940 Light tables (3 units)	-Richard Co.
- B & L 240 R Stereo-microscope, with bridge attachment for 940 table	- Bausch Lomb Inc.
- B & L Zoom Transfer Scope, Model Z T 4 - H with photo attachments (1 unit)	- Bausch & Lomb Inc.
- I^2 s Multi Spectral Camera (1 unit)	- International Imaging Systems Inc.
- I^2 s Additive Color Viewer (1 unit) Model 6040 - Pt - 210, with print framer head, exposure control, ND filters & film kit	- International Imaging Systems Inc.
- Original negative film, Plus - x Aerographic (50 rolls)	- Kodak
- Diapositives, Aero-graphic Positive (50 rolls)	- Kodak

- Transparency duplicates, Aerographic positive (50 rolls)	- Kodak
- Diapositives, Aerographic positive sheets, 7 mil Estar base (200 boxes)	- Kodak
- Processing Chemicals; Dektol, Kodak Rapid Fix, Versamat type B, Litho	- Kodak
- Developer, Hypo, Diazo, Sensitizers and solutions, Litho Plate Chemistry	- Kodak
- Color IR Film and Processing (6 rolls est.)	- Kodak
- Color Film and Processing (6 rolls est.)	- Kodak
- Black and white Infra-red film and processing (7 rolls)	- Kodak
- Cibachrome film	- Kodak
- 1 unit Kern MK II	- Kern Instruments Inc

(f) Approximate Value $681,000

(g) Source See above list

Discussion: The host country implementing agency, the technical consultant RDA and the USGS advise that the above equipment is essential to the project and that no equipment or manufacturer other than those indicated above will meet the technical specifications required by the project or be compatible with the equipment inventory already in use by the GSL Survey Department.

Primary Justification: The subject equipment is essential to this AID-financed project, has been certified by the technical advisor as the least cost alternative able to meet the project's technical specification, will promote standardization, is compatible with equipment already in use, and will be subject to available and dependable service.

Recommendation: For the above reasons, I conclude that exclusion of procurement of this equipment from the sources requested above would seriously affect the success of this development project and impede attainment of the objectives of the foreign assistance program in Sri Lanka. Authorization for approval of this action is provided for in Handbook, chapter 3C9a: "Proprietary procurement for which AID has determined that, in order to assure the interchangeability or standardization of equipment, or because of special design requirements, or for any similar reason, purchase of a commodity by reference to a particular specification, trade name, or designation is necessary."

I recommend that you approve this request for a Proprietary Procurement Waiver to allow the purchase of this equipment.

Approved_____

Disapproved_____

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DEPARTMENT OF STATE
AGENCY FOR INTERNATIONAL DEVELOPMENT
Washington, D.C. 20523

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PROJECT PAPER

158p

Proposal and Recommendations
For the Review of the
Development Loan Committee

SRI LANKA - AGRICULTURAL BASE MAPPING - VOLUME II

383

383-T-020

AID-DLC/P-2270

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AGRICULTURAL BASE MAPPING

Sri Lanka

Loan $4,500,000

Volume II

Annex B - Technical Analysis

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RDA P106/11

TECHNICAL ANALYSIS

ANNEX

Corrections and Additions

AGRICULTURAL RESOURCES INVENTORY AND BASE MAPPING IN SRI LANKA: PROGRAM DESIGN AND RECOMMENDATIONS ADDENDUM

Prepared For

United States Agency for International Development

Washington, D.C. 20523

Contract Number: AID/afr-C-1135, W. O. #11

Prepared By
Kenneth B. Craib and Earle M. Knibiehly, Sr.

August 1977

Resources Development Associates, P.O.Box 239, Los Altos, Calif. 94022

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1.0 INTRODUCTION

Reports prepared for USAID by Resources Development Associates in November 1976[1] and April 1977[2], regarding the proposed Agricultural Base Mapping Project in Sri Lanka were reviewed during the month of July 1977 by several departments within the U. S. Geological Survey, including the Branch of International Activities, Branch of Photogrammetry, Office of Research and Technical Standards, and the Mapping Requirements Office. During the first two weeks of August, a series of meetings were held at the USGS/Reston, Virginia facility with representatives of the USGS, AID/Washington, AID/Colombo, the Sri Lanka Survey Department, and Resources Development Associates to discuss possible modifications or improvements in the program for Sri Lanka. A list of personnel attending these meetings is attached (Table 1).

Goals and objectives of the Sri Lanka program were reviewed, together with existing constraints and circumstances peculiar to developing country operations in general and Sri Lanka in particular. Technical and operational procedure questions arising from the USGS review were discussed and satisfactorily resolved. In general, it was agreed that the program, as originally designed, was appropriate and would meet the information and mapping needs of Sri Lanka. The principal changes recommended were:

1. Inclusion of a 1:50,000 map series, using a new photo-reduction technique employed at the USGS
2. An increase in the number of field vehicles for ground control
3. Substitution of Kern PG2-AT and MK-2 triangulation equipment for the Wild A10/EK-22/Aviotab TA unit
4. An increase in the overall level of technical assistance.

1. Craib, K.B. and J.W. Cain, Agricultural Resources Inventory and Base Mapping in Sri Lanka: A Program Assessment and Evaluation," Contract No. AID/afr-C-1135-4, Resources Development Associates, November 1976

2. Craib, K. B., W.R. Ketler, J.W. Cain, and E.M. Knibiehly, Sr., "Agricultural Resources Inventory and Base Mapping in Sri Lanka: Program Design and Recommendations," Contract No. AID/afr-C-1135-7, Resources Development Associates, April 1977

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Table 1: Attendance, Sri Lanka/USGS/AID Meetings, August 1977

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These items and related minor changes recommended are discussed separately here, and presented as an addendum to the technical analysis which follows:

2.0 THE 1:50,000 SCALE MAP SERIES

As originally proposed, aerial photography will be acquired at a scale of 1:50,000. Manuscripts are machine-compiled at a scale of 1:10,000 from this photography. These manuscripts then form the base for the 1:10,000 scale map series. As produced by the B-8/A-8 equipment, these manuscripts typically contain minor errors and irregularities that are subsequently corrected manually before the 1:10,000 maps are produced. This manul correction and scribing process is time-consuming. While procedural changes recommended earlier will result in considerable improvement in this area, the function will not be totally eliminated.

The USGS has proposed that the 1:10,000 base manuscripts as produced by the machine be directly copied and photoreduced to 1:50,000 to produce a new national map series at that scale. This will require some additional effort in the Photo Laboratory and Map Producrion branches, and will involve a minor increase in materials required. It will not require increases or any change in the triangulation or compilation procedure and only a minor reorganization and increase of effort in Field Edit. It may extend the overall program time schedule by as much as a year.

The principal advantage from incorporating this change is that a new national map series may now be produced approximately one year after photography is completed, or an estimated two years after project initiation. This 1:50,000 series will directly replace the existing 20-year old 1:63,360 map series and will provide an immediately useful tool for regional planning purposes. The 1:10,000 series, now estimated complete at the end of the sixth year instead of the fifth year after project initiation, will be produced from the same photographic materials and form the necessary base for more detailed project planning and development activities. No new equipment, other than that required for the 1:10,000 mapping project itself, will be needed to produce this interim 1:50,000 map series.

3.0 FIELD VEHICLES[3]

The USGS review expressed concern over the ratio of field vehicles to field control and edit teams. The number of vehicles should be increased beyond that recommended in Section 4.4 1 of the April report, particularly if the 1:50,000 map series is to be produced within two years of project start.

As noted on page 57 of that report, a total of 10 field control and 38 field edit teams were suggested. Following discussions at USGS, concensus was reached that field control and edit functions can be performed simultaneously by one team on a single visit without materially affecting the accuracy of the final product. This reduces the total time required in the field (from two visits to each point, to one visit). As the field edit function was the pacing item, then a total of 38 control/edit teams will be necessary. If these teams are to meet the two-year schedule, then a 1:1 vehicle-to-field team ratio is recommended.

It is recommended that 40 field vehicles be purchased and specifically designated for use on the Agricultural Base Mapping Project. These vehicles should be four-wheel drive, long wheel base, with trailer hitch and a canvas top.

[3] Ibid, Section 4.4.1, pages 56-57

4.0 TRIANGULATION

Recent unpublished tests at USGS have indicated that the Kern PG2-AT stereoplotter/digitizer/coordinatograph unit is comparable in accuracy and quality of output to the Wild A10 stereoplotter/digitizer/coordinatograph. These results are particularly significant in that the Wild A10 has been considered to be the standard of the industry, and is priced significantly higher than the Kern equipment. The USGS also recommends purchase of a monocomparator.

It is recommended that two Kern PG2-AT units and a Kern MK-2 monocomparator be purchased for this project, replacing the Wild A10 system originally indicated. This combination of equipment will improve both production rates and quality of output.

* Ibid, Section 4.4.2, pages 57-58

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5.0 TECHNICAL ASSISTANCE[5]

With the inclusion of a 1:50,000 scale map series to be published within the first two years of the project, the availability of a technical advisor thoroughly experienced in all phases of photography, cartography and map production becomes even more important. Following the recent meetings at USGS, it is recommended that the services of the Principal Technical Advisor (ref. April report, pg. 72) be extended from 24 to 36 months.

Concern was expressed over the relatively high photo re-flight rate anticipated. To meet this problem and to insure the timely availability of high-quality photography, it was suggested that services of an experienced photo pilot and cameraman be acquired as part of the TA component.

It is recommended that the TA budget include an estimated six man-months of photo pilot time and three months for an aerial photographer. During a six month period, the pilot could be expected to adequately train and check out at least three SLAF pilots in aerial photographic flight procedures and techniques. If the photographer TA were carefully coordinated, then over a three month period 1:50,000 scale aerial photography might be obtained over nearly the entire country, while at the same time providing training to GSL counterparts.

With this photography available at the beginning of the program instead of phased over a several-year period as originally planned, production of the 1:50,000 map series can begin immediately Portions of Sri Lanka where land use change is particularly dynamic or critical should be re-photographed in subsequent years to permit up-dating for the 1:10,000 map series. The aircraft would then be operated by the GSL crew to obtain this supplemental photography as required, and to acquire lower altitude photography to support detailed development activities.

[5] Ibid, Section 4.7, pages 69-72

An additional three man-months of "short-term specialist" technical assistance was also suggested to support expanded activities within the User Assistance Center (previously termed Remote Sensing and Survey Research Center, ref. April report, page 72). With these changes incorporated, the timing and level of technical assistance indicated on page 72 would become:

Approximate Timing		Long Term	Short-Term
Year 1:	Principal Technical Advisor	12 mm	
	Geodetic Survey Specialists		2 mm
	Other Short-Term Specialists (Remot Sensing, Photo Lab, Others as Required)		3 mm
Year 2:	Principal Technical Advisor	12 mm	
	Photo Pilot		6 mm
	Aerial Photographer		3 mm
	Other Short-Term		4 mm
Year 3:	Principal Technical Advisor	12 mm	
	Short-Term Specialists		3 mm
Year 4:	Short-Term Specialists		2 mm
Year 5:	Short-Term Specialists		1 mm
Year 6:	Short-Term Specialists		1 mm
TOTAL		36 mm	25 mm

The Principal Technical Advisor should mobilize to Sri Lanka at the beginning of the project to assist with facilities renovation planning, equipment planning and implementation. Assuming delivery of the survey aircraft to Sri Lanka in mid-1978, the Photo Pilot should mobilize to Sri Lanka about October 1978, with the Aerial Photographer to follow in January 1979. The six-month period of performance for the Photo Pilot would thus include the two best "photo seasons" in Sri Lanka, and the Photographer would be available for the primary January-March season when total country cloud-free coverage is most likely to be possible. The remainder of the short-term specialists should be available to visit Sri Lanka on relatively short notice to support the program as required. The indicated schedule represents probable utilization.

6.0 OTHER ITEMS

Several additional items with less overall impact on the proposed project were also reviewed and discussed. Areas of change or improvement are discussed separately here.

6.1 Overlap

The USGS recommends, and RDA concurs, that the planned sidelap be increased from 20% to 30%, particularly for photography acquired from an altitude of 25,000 feet above mean terrain.

With 20% sidelap, an estimated 31.7 photographs will be required to cover each "Index" area. If a reflight rate of 25% is assumed for planning purposes to cover errors and changes in terrain, then 40 photos per sheet are indicated, or approximately 2,300 photos (and stereo models) for the entire project.[6] If a 30% sidelap is assumed, then approximately 26.3 photos are required per Index area. If a reflight rate of 10% is then assumed (normal reflight rate with 30% sidelap is 5% or less, 10% allows for weather problems); then 40 photos should be required for each sheet, leaving the original estimate of 2,300 stereo models unchanged.

6.2 Film Storage[7]

Kodak recommends that the film storage area (ref. April report, page 51) include both "cool" and "cold" storage sections. Cold (freezer) storage will permit storage of infrared films for periods in excess of one year, and will greatly extend the shelf-life of other photographic materials. "Freezer storage" can be included in current plans for building renovation at essentially no increase in cost.

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[6] Ibid, Appendix A, Derivation of Map Production Rate, pages A2-A4

[7] Ibid, page A4

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6.3 User Assistance Center Equipment[8]

With one exception, it is recommended that equipment originally suggested for the User Assistance Center (originally Remote Sensing and Survey Research Center) be acquired, and in some cases the number of items should be increased to support the expanded role now anticipated for this Center.

The exception is the Video Processing Equipment. Subsequent discussions with GSL personnel indicate that maintenance for this item could be a major problem in Sri Lanka. Accordingly, this should be deleted from the recommended list and replaced with comparable equipment, more "optical" than "electronic" in nature. A Multispectral Camera and Additive Color Viewer are recommended. These units in combination will cost slightly more but will be easier to maintain than the Video Image Processor, and will serve much the same purpose. In addition, the Additive Color Viewer may be used to support research and investigations of the utility of LANDSAT satellite data for related applications in Sri Lanka.

6.4 Staffing and Training Requirements

Recent changes in the Sri Lanka government situation make possible a multiple-shift working operation in the Survey Department. To maintain a production rate of 3.2 models per day in the Compilation section will require a two-shift operation (ref. April report, Appendix A, pages A6-A10). With the added objective of a 1:50,000 map series within the first two years of the project, this area becomes more critical. It is felt that the required production rates can be achieved and maintained with the additional equipment now proposed. Some increases in Survey

[8] Ibid, Section 4.8.1, page 74

[9] Ibid, Section 4.6, pages 66-69

Department personnel assigned to this project may now be desirable, however.

As shown in Table 7, Survey Department Staffing Requirements,[10] of the 23 people currently assigned in the Photogrammetry section, 20 will be required to support the 1:10,000 scale Agricultural Base Mapping Program. Fifteen additional photogrammetric technicians might be required in the compilation operation to complete the 1:50,000 scale mapping program as scheduled. These personnel are presently available within the Survey Department and will essentially only require reassignment. An estimated 10 additional draftsmen might be required in the Drawing Office; these people are currently available in that office.

Such assignments to this project would of course increase the total GSL contribution. Assuming a total of 25 additional people at an average salary of 5,000 Rs p/a for a period of about two years, then the total GSL contribution increases from an estimated $1,582,300[11] to approximately $1,618,000.

6.5 Aircraft Insurance

It is recommended that liability and hull damage insurance be obtained for this aircraft, concurrent with purchase, and be maintained in effect for at least the anticipated lifetime of this project. If this insurance is underwritten by Lloyds of London (the most likely underwriter in this case), $1,000,000 liability coverage would be $1,250 annually at current rates. All-risk hull insurance, specifically excluding personnel insurance (flight crew personnel are assumed covered under separate and existing policies through their respective organization), would be about 1.85% annually at current rates. Assuming

[10] Ibid, Section 4.6.2, page 68

[11] Ibid, page 111

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an aircraft value of $385,000 after modification, and allowing for "no claim" rebates and anticipated rate changes, a budgetary figure of $8,400/year should be adequate to cover basic insurance needs.

As an added option, "breach of warranty" coverage would be available for up to 90% of the original aircraft value. This would protect against losses resulting from "incorrect" operation of the aircrafr by "unqualified" GSL personnel (qualifications to be defined by the underwriters. Typically might require pilots to have a minimum 500 hours multi-engine time). With this option added, total insurance costs would be approximately $9,000/year. As this would be an annual cost, it might appropriately be included as a line item under Section 7.4, Materials (page 104 of the April 1977 report).

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1.0 SUMMARY

An analysis of the Survey Department, Government of Sri Lanka was made to establish the requirements for the Agricultural Base Mapping Project. The investigation involved all of the major aspects of mapping operations from acquisition of the aerial photography to the printing of the resulting three-color map series.

The introduction of the first large scale mapping program in 20 years represents a substantial undertaking by the Survey Department. Since their only aircraft has been inoperable for nearly two years there has been no new photography on which to work. Consequently, the maps which have been made recently were mostly prepared from ground surveys. This does not require the same process nor does it impose a large load. The 1:10,000 scale mapping project will necessitate the conversion of that portion of the Survey Department involved into a large scale production operation, with all its attendant ramifications.

The Survey Department is capable of performing the Agricultural Base Mapping Project. However, they will require financial support to procure the necessary additional equipment and materials and to make improvements in their present facility. Also, to accomplish the work which will be required to complete the 1:10,000 scale mapping project within five years they will have to introduce some operational changes.

To cope with the production load to be imposed will require changes in the organization, procedures, and facilities as well as the requisition of new equipment and materials. The major items to be purchased include a suitable aircraft, plotting instruments and film processing equipment and a litho press. To obtain the best use of the new as well as existing equipment requires the renovation of the existing offices to accommodate the air conditioning necessary for temperature and humidity control. For more efficient map production some changes in procedures and organization have to be made. The major change in methods involves the use of a more modern technique for preparing the map manuscripts which reduces manual effort to a manageable level.

With the recommended equipment and improvements the Survey Department will be capable of completing the Agricultural Base Mapping Project within a period of five years. However, to assure that the required production level and quality is maintained, continued technical assistance should be provided the Survey Department.

2.0 CONCLUSIONS AND RECOMMENDATIONS

The analysis of the Agricultural Base Mapping Project and the Survey Department has resulted in a number of conclusions and recommendations. They touch upon nearly every facet of the project and are, therefore, scattered throughout the report. To emphasize the most important findings and make them more visible they are summarized here in very concise form.

1. The Survey Department will be capable of performing the Agricultural Base Mapping Project if they obtain the necessary support. It is, therefore, recommended that financial assistance be made available to the Government of Sri Lanka for this purpose. The estimated loan cost of the program is $3,125,000. This is the least costly and most effective approach to accomplishing the objectives of the proposed project.
2. The Government of Sri Lanka should be responsible for and undertake those portions of the facilities work which do not require foreign exchange, essentially everything but the air conditioning equipment and chemical tank farms included in the costs above.
3. The Survey Department should agree to make the recommended operational changes. Primarily, these pertain to adoption of the subtractive filtration method of preparing color separations, establishing a central wet lab for photo processing, substituting polyester film diapositives for glass, and incorporating a quality assurance monitoring function.
4. A Remote Sensing/Survey Research Center should be established to develop and test new and improved methods.
5. A new aircraft, suitably modified, will be required to obtain the aerial photography required for this project. There are no aircraft currently in the SLAF inventory or otherwise available that meet the minimum operational requirements of this project. This alternative is less costly than contracting separately for aerial photographic services and is preferred on technical grounds.
6. As a prerequisite to procurement of an aircraft, the Survey Department should provide a suitable agreement with the Air Force concerning maintenance and the conditions under which the Air Force might use the aircraft.

7. The Survey Department should designate an individual to be responsible for the availability and operational readiness of the aircraft.

8. The aircraft should be insured against loss or damage.

9. Major items of equipment should be procured directly rather than through the GSL to minimize cost and delay.

10. The operations plan for the Agricultural Base Mapping Project should be based upon completing portions of the country in roughly equal segments in accordance with national priorities. This will provide an even continuous flow of work and provide for additional capacity to perform other, larger scale, mapping assignments as required.

11. Data from the LANDSAT satellite is not sufficiently accurate, by an order of magnitude, for mapping at the 1:10,000 scale required by this project.

12. The concept of "user charges" by the Survey Department does not appear to be practical at this point in time.

13. Air conditioning and facilities renovation work should be initiated as soon as possible. An estimated six-eight months will be required to complete this work. This must be completed prior to initiation of production operations.

14. Orders should be placed as soon as possible for the aircraft and other major cost items. Aircraft costs in particular are expected to increase by 10% within three to four months. This item has an estimated six months lead time.

15. Color filters and pens required for the color separation scribing technique should be obtained as soon as possible to permit operators to practice this new method.

16. A technical assistance component is recommended.

17. The project should be examined at the following points:

    - At completion of facilities renovation, to insure adequate temperature, humidity, and power control
    - Six months after initiation of operational program, to evaluate progress, preliminary production rates achieved, and organizational structure
    - 12 months after initiation of operational program, to evaluate progress, production rates, and product quality
    - Similar evaluations at 24, 36, 48 and 60 month points.

3.0 OBJECTIVE OF THE REPORT

The United States Government, acting through the Agency for International Development, desires to aid the Government of Sri Lanka in preparing for and conducting an Agricultural Base Mapping Project. To this end, a team of specialists from Resources Development Associates visited Sri Lanka during the period January-March 1977, to assist the AID mission and the GSL Survey Department with a review of program requirements and development of a final plan.

The specific objectives of this effort included the following items:

1. Map Production Unit
   - Perform a work flow analysis, identifying problem areas and recommended solutions
   - Develop recommendations concerning organization and operations for more effective use of existing and new equipment
2. Staff Requirements
   - Determine staff requirements to implement the project
   - Review requirements for phasing of additional staff
   - Review alternatives for meeting work load requirements
   - Evaluate staff training needs
3. Facilities Requirements
   - Review existing physical plant and facilities
   - Define needed improvements
4. Equipment and Materials
   - Perform detailed review of all equipment and material needs and costs to support the project
   - Recommend phasing of equipment/material orders
   - Define requirements and costs for field vehicles
   - Assist the Survey Department with development of specifications and tender documents for equipment and materials needed

5. Aircraft

- Develop detailed recommendations for and specifications of aircraft requirements, instrumentation and modification
- Evaluate possibility of modifying existing SLAF aircraft.
- Review economic/technical feasibility of contracting for flight services
- Identify procurement sources and prepare cost estimate for required aircraft
- Identify ground support equipment requirements
- Define requirements for personnel and/or training
- Review film handling and operations procedures
- Assist the Survey Department with preparation of draft tender/contract documents

6. Remote Sensing/Survey Research Center

- Review feasibility and make recommendations concerning establishment and organization
- Develop specifications, identify sources and costs of data analysis and interpretation equipment required
- Identify personnel training requirements

7. Implementation Plan

- Estimate photography/cartographic needs by region and type
- Develop initial implementation plan
- Identify mapping priorities

8. Other

- Identify relationship/complementarity between LANDSAT and Agricultural Base Mapping Project
- Identify continuing local and foreign exchange costs that must be borne by the GSL to maintain the project
- Review and determine feasibility of "user charges" system
- Identify key project evaluation points

3.1 The Process of Aerial Photographic Map Production

A short description of the mapping process appears to be an appropriate preamble to further discussions on the subject of the proposed Sri Lanka Agricultural Base Mapping Program.

Maps which depict both horizontal (planimetric) and vertical (contour) detail generally are termed "topographic." The final map product desired by the Government of Sri Lanka (GSL) will be at 1:10,000 scale with a contour interval of five meters, and falls into this category.

In order to size (scale), locate and orient the map on the surface of the earth, some "ground control" must be established. Simply, this consists of a series of points whose geographic positions and elevations are known precisely, and which later can be identified in aerial photography. This series (network) of points is called a geodetic net because it is referenced mathematically to the geoid - a geometric shape computed and assigned to the particular area of the earth being mapped. (Unfortunately for cartographers, the earth is not a sphere, its surface is not of the same radius at all places, and maps are generally printed on flat paper.) Starting from a basic astronomic observation point, in conjunction with a precisely measured distance on the ground, a series of angles can be measured (with theodolites) which extend the original measured distance trigonometrically into other "legs," forming a network of computed distances related to each other. When the area of interest has been thoroughly measured (surveyed), with legs generally being as long as a line of sight will permit, another astronomic observation point can be made and another base line precisely measured. Those can then be checked against the computed position and distance for that point and leg. Disagreement, caused either by compounded instrument angle-measurement errors, or from an incorrect assumption of the geoid shape, will then be adjusted mathematically, proportionately throughout the net, with a new geographic coordinate being

established for each point measured - which in turn can be identified on the aerial photography. All of the information amassed by this process forms the basic "ground control" for the topo-map.

A series of aerial photographs is then exposed over the area of ground control. The photographs are usually taken to allow a 60% overlap, one over the previous one. This is necessary to allow for stereoscopic viewing of the photography, and subsequent secondary control extension, which is needed to properly orient and locate each photograph onto its proper place on the earth. The original ground control might appear in only a few of the photos of the series. The secondary control is established by orienting photographs of a stereo-pair in a photogrammetric plotting instrument, and in the process locating them with respect to the original network of ground control. The instruments used for this purpose are necessarily quite precise (and correspondingly expensive) in order to be able to relate horizontal and vertical (through stereo) measurements from 1:50,000 scale photography (in this case) to a map scale of 1:10,000 at an accuracy which allows the placing of ink lines on the map to the tolerance of the line width.

Once stereo photographs are oriented with respect to one another (relative orientation), they are then oriented as a pair (absolute orientation) to the net of ground control. The first series of photos is paralleled by another strip, overlapping by about 30% usually, and another, and so on until the desired area is covered and secondary control established - thereby locating precisely every photograph.

The same plotting instrument can be used both for tracing the contour lines and the ground detail onto a "manuscript." This is generally not done, as the actual plotting of detail can be done more efficiently on other, somewhat less expensive, instruments using the secondary ground and photo control established by the more complex instrument.

The manuscript, with all photographic information traced into it in proper geographic position, is then placed on a light table, overlaid with translucent material, and detail traced by cutting lines (scribing) into the surface of the overlaid material. A separate overlay is scribed for each color desired to be printed on the final map; a process known, appropriately, as "color separation." (This is a generic term, used liberally in other applications also.)

Each of these color separations is photographed on a large (copy) camera at 1:1 scale, and a negative is made. Meanwhile, zinc plates of proper size have been coated with a light sensitive emulsion. A negative is overlaid onto a plate, exposed to light, and the plate is chemically developed - it is now a printing plate, which is placed into a lithographic printer. After inking the plate in the proper color, paper is passed by the plate (or vice versa) and the map printing process has begun. After the first pass and inking, successive passes are made using the other color separation plates and correspondingly colored inks, until the map sheet shows the information originally determined from the photography.

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4.0 TECHNICAL ANALYSIS

To assist the USAID mission/Sri Lanka in the development of the Agricultural Base Mapping Project an analysis of the Survey Department was made. The purpose of this investigation was to define the flow of work, identify potential problem areas and develop recommendations for solving these problems. The output of the analysis forms the basis for more efficient and effective map production.

The process of making maps from aerial photography is, at least in concept, fairly simple. Basically, to produce maps requires the following ingredients:

1. The means to obtain aerial photos
2. Technical knowledge of the methods of photogrammetry and geodesy
3. A suitable facility
4. The necessary equipment
5. Materials with which to work
6. The manpower to do the work
7. An organization and management to see that the work is accomplished.

In actuality producing maps is somewhat more complicated. There is no single best way to perform the necessary tasks. For each step of the process there are alternative ways of achieving the desired result. To determine the most efficient methods, considering the circumstances, requires an assessment of their benefits in the light of cost and other constraints.

4.1 The Map Production Process

In general, the production of maps from aerial photographs requires the same basic steps regardless of where or how they are made. These basic steps, and the outputs of each, are listed in Table 1. These are the steps which were examined in detail to

Step in Process	Product/Output
Photo Acquisition	Aerial Photos
Film Processing	Original Negative, Paper Prints and Diapositives
Field Control	Additional Ground Control Points
Triangulation	Oriented Models (Stereo Pairs)
Compilation	Draft Manuscript
Field Edit	Completed Manuscript
Scribing	Color Separations
Plate Making	Litho Plates
Printing	Map Sheets

Table 1: MAJOR STEPS IN MAP MAKING

determine the efficiency and effectiveness of Survey Department Operations, identify problems and indicate ways in which the process should be improved

4.1.1 Present Work Flow

The Survey Department is not currently making maps from aerial photos in a production mode. While some maps are being made, they are either from old aerial photos or are based upon ground survey data. Nevertheless, the Survey Department does have a certain latent capability for map making based on the existing facility and equipment as well as the methods which have been employed in the past. This provides the point of departure for recommendations regarding enhancement of the map making capability in general and initiation of the 1:10,000 scale Agricultural Base Mapping Project in particular.

4.1.1.1 Photo Acquisition

The area for which maps are required is determined on the basis of a long term Survey Department plan and individual requests from other government agencies. Both are the result of national priorities related to agricultural requirements. Flights are scheduled in accordance with the capacity of the map making resources.*

Prior to each photo mission a flight plan is prepared based on the existing 1:63,360 map series. Flight lines are east-west with a maximum length of 150 miles. A 60% forward lap is used to provide stereo coverage. A 20% side lap is provided to allow for navigational errors. Because the existing photography does not provide an adequate basis for aerial navigation to maintain a 20% side lap, the Survey Department expects to have a maximum of 50% reflights.

* At the present time, the Survey Department does not have an operable aircraft, and thus has no photo acquisition capability.

The mission duration varies according to the requirements for coverage and the capacity of the map making process. A standard aerial cassette contains 250' of film which provides up to 300 exposures in the 9"x9" format. However, partial rolls can also be used by respooling in the dark room.

The photo acquisition process is shown schematically in Figure 1.

4.1.1.2 Film Processing

Because of the low volume of aerial film that has been processed in the past, the film is developed, fixed and washed manually. The film is unloaded from the cassette and placed in a reel to reel type processor. Although these may be motor driven, the film is usually processed by winding the film back and forth by hand.

After development of the original negative it is titled by hand indicating mission, roll, date, etc. Contact paper prints are made from the negative. One set becomes the photo index. It is used to check forward and side lap and determine the necessity for reflight and given to the pilot to plot new flight lines. One set is sent to the Photo Library for storage and reference. One set is used to indicate if and where additional ground control points are needed based on existing ground control identified on the 1:63,360 map sheets. This set is forwarded to the field survey parties for addition of field control information. Glass diapositives of each stereo pair (model) are prepared on manually controlled contact printers. These are later used in triangulation.

At the present time the only means of making paper prints is a contact print box. The obsolete model LogETronic printer is inoperative.

The film processing and indexing operation is illustrated in Figure 2.

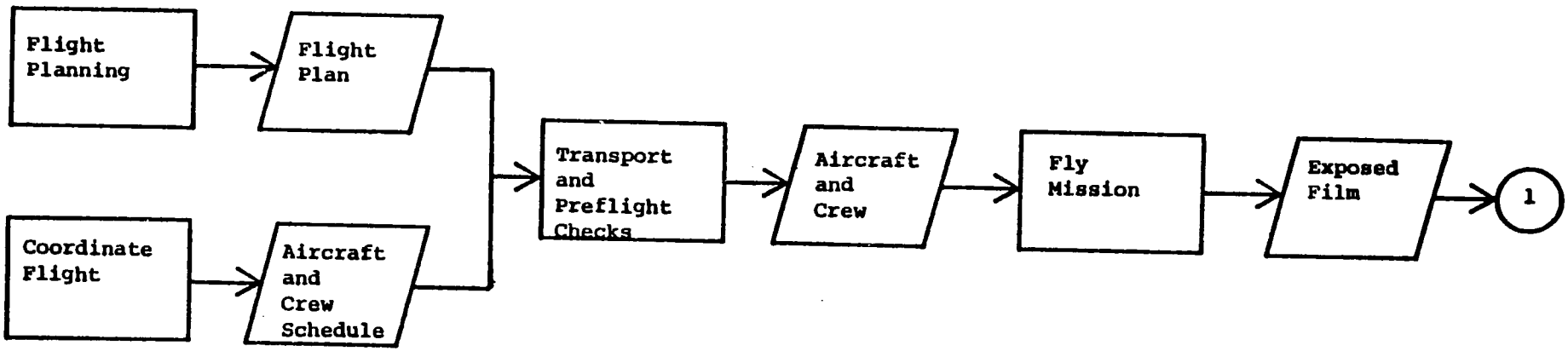

Figure 1: PHOTO ACQUISITION PROCESS

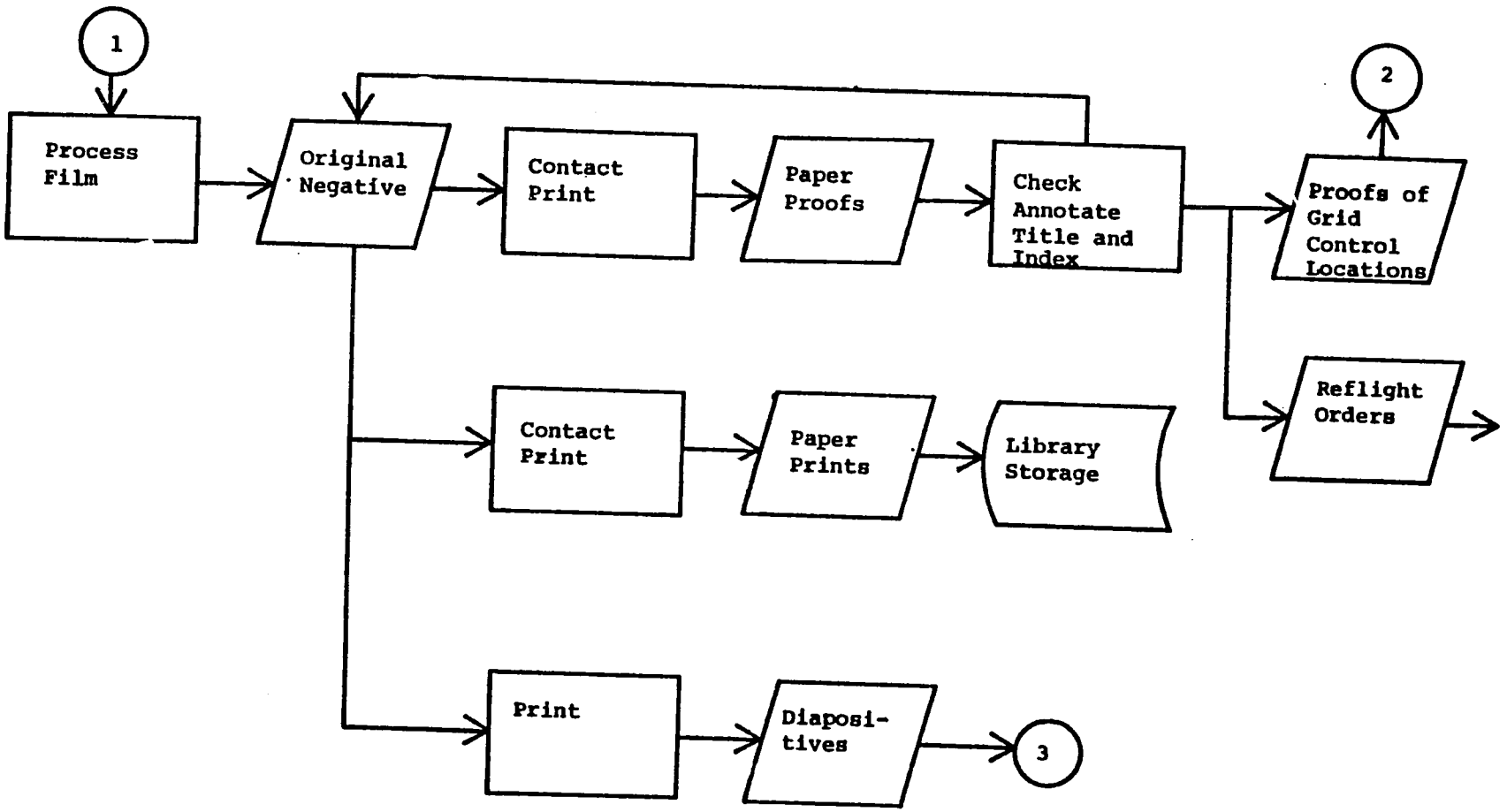

Figure 2: FILM PROCESSING AND INDEXING

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4.1.1.3 Field Control

The prints of aerial photos with ground control points identified are sent to field survey teams. These teams locate the position and elevation of the points. Insofar as possible control points are located for convenience of access. However, due to the sparse network of roads and the terrain in parts of the country, the points on the ground are not always readily accessible.

The Survey Department has estimated on the basis of the 1:63,360 scale maps that a minimum of 920 control points will be necessary to complete the 1:10,000 scale map series. To be consistent with other planning figures, this number should be increased about 25%. This would result in approximately 1150 points to cover the entire country.

4.1.1.4 Triangulation

The original control net (horizontal and vertical) from the 1:63,360 maps supplemented by the additional field control points is used for relative and absolute orientation of each stereo model (pair).

The glass diapositives prepared by the Photo Lab are used in the single Wild A-7 to bridge seven stereo pairs. A block adjustment of the horizontal and vertical pass points between terminal models is accomplished analytically by computer to fit the geodetic control net of the country.

The steps in field control and triangulation are shown in Figure 3.

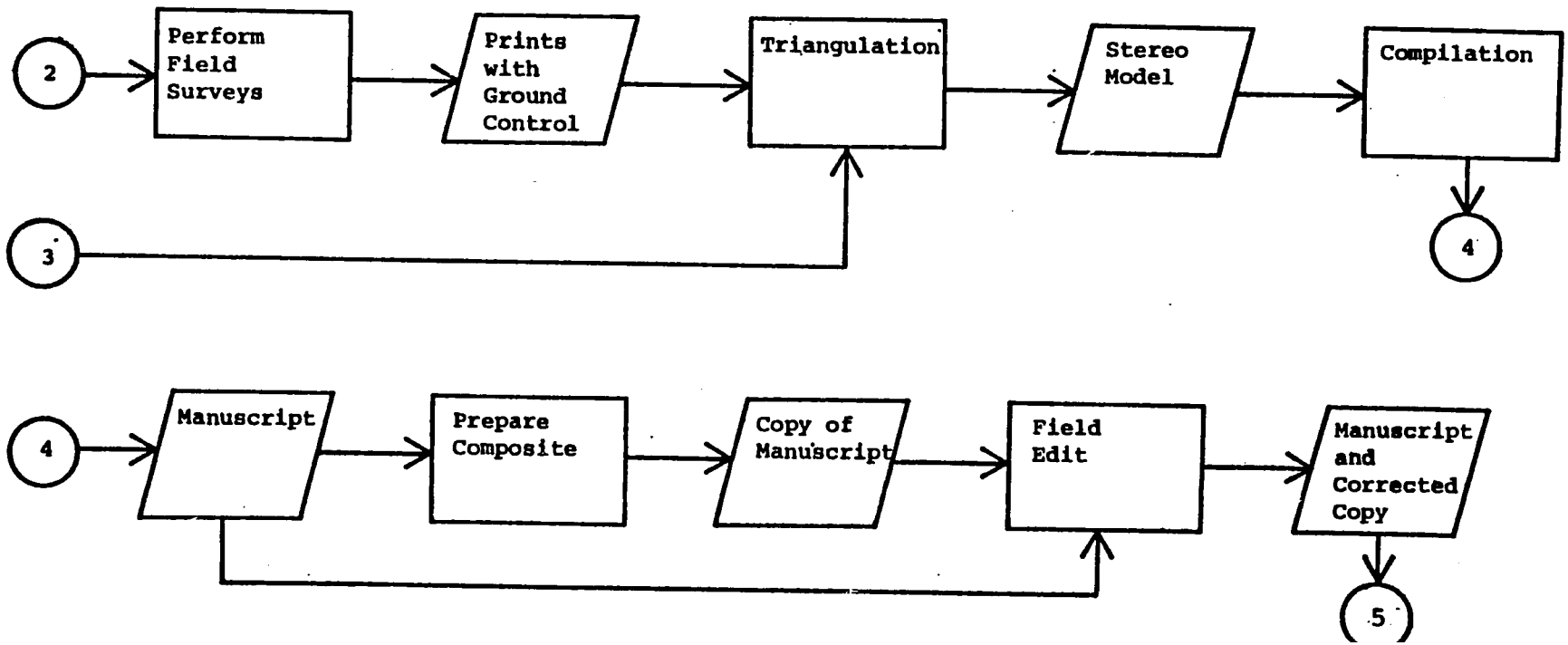

Figure 3: FIELD CONTROL, TRIANGULATION, COMPILATION AND FIELD EDIT

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4.1.1.5 Compilation

Compilation of the individual stereo models is accomplished using three Wild A-8's and four Wild B-8's. The Wild A-7 can also be used for this purpose when it is not needed for triangulation. Manuscripts are drawn in pencil by coordinatographs capable of about 7X magnification. The manuscripts are produced in three colors using brown pencil for topography, blue for hypsography (drainage) and black for planimetry. Place names in three languages (Sinhala, Tamil and English) are added later.

The Survey Department currently uses two men to do the compilation; one operates the Wild and the other monitors the coordinatograph. The latter is also qualified to do the compiling. Presumably these individuals take turns doing the compiling to maintain proficiency.

A composite or proof copy of the manuscript is prepared for office and field editing.

4.1.1.6 Field Edit

The original manuscript as well as a composite or proof copy of the manuscript is sent to the field for editing and correction on the ground. The field party consisting of a surveyor and ten laborers checks the manuscript against ground conditions using a copy of the existing 1:63,360 scale maps as a guide. Changes, corrections, and additions are noted on the composite. The original manuscript is supposedly used only for reference purposes. On completion of field work the original and edited copy are returned to the Survey Department.

Compilation and field edit steps are included in Figure 3.

4.1.1.7 Scribing

The original manuscript is corrected in accordance with the field edit. Three blue line prints of the revised manuscript are then made on scribecoat material by exposing the original in a copy camera. Each of the three copies is scribed by hand to produce a color separation for each of the types of features to be printed on the map sheet. One of the copies contains the contour lines (topography), another drainage (hypsography) and the third the cultural features such as roads, dams, buildings, etc.

While the hand scribing is in progress type is set manually for the place names. Three sets are made, one for each language required, and the names located on an overlay.

A composite is made to determine conflicts and overlaps and perform final edit. The necessary changes are then made on the appropriate color separation negative. If major changes are necessary a

Scribing, plate making and printing steps are shown in Figure 4.

4.1.1.8 Plate Making

The corrected negatives (3) are used to make metal press plates for printing. In this process, zinc plates are coated with egg albumen and sodium dichromate in a "whirler." A coated plate and a negative are mounted in a vacuum frame and exposed to sunlight on the roof of the building. Three plates are thus prepared for each manuscript. Separate plates are also made for each of the three languages in which place names are required.

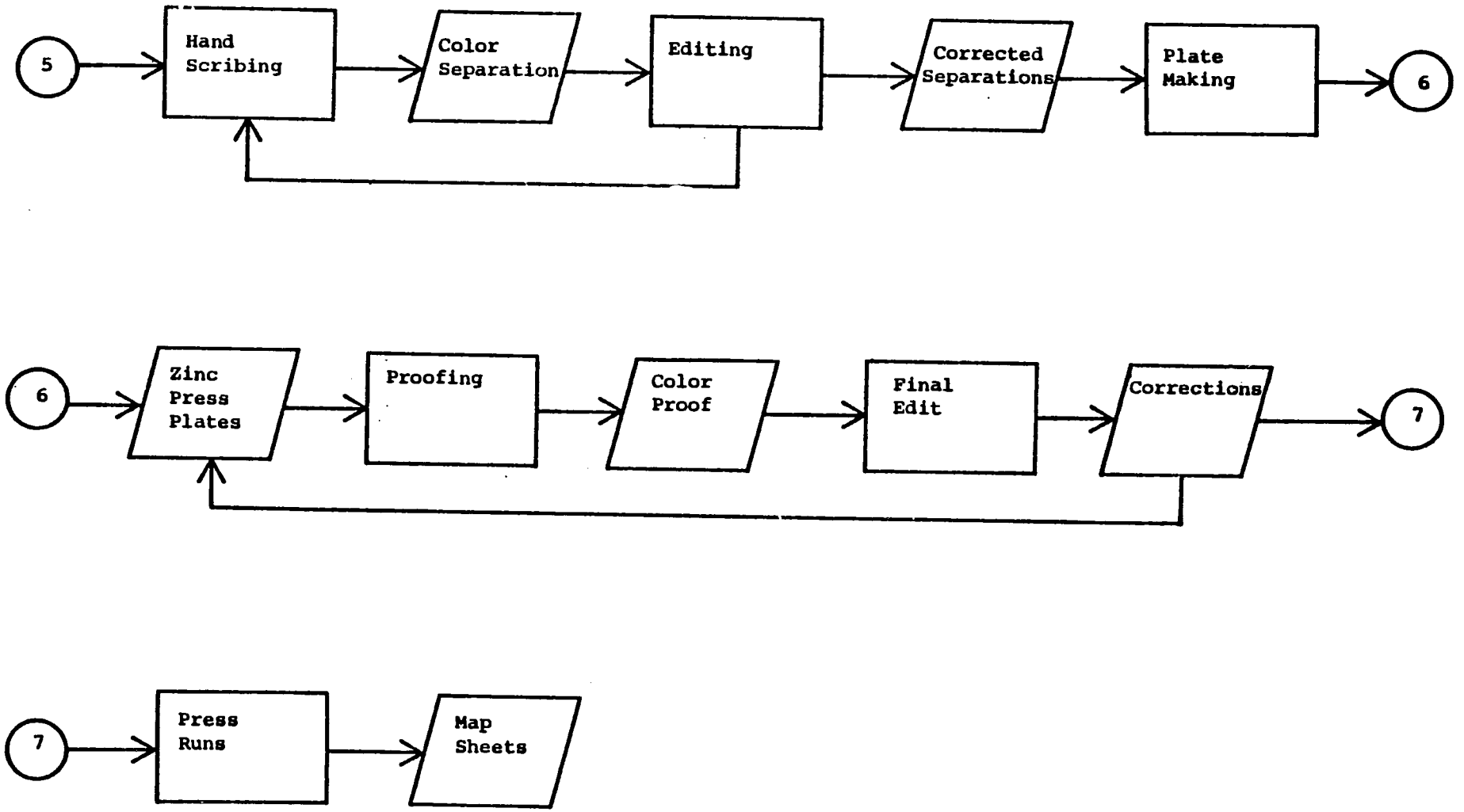

Figure 4: SCRIBING, PLATE MAKING AND PRINTING

4.1.1.9 Printing

Each of the three plates is placed on the single color sheet fed proof press. With the application of appropriately colored ink for each, a final litho color proof is produced. A final edit is then performed. If only minor corrections are necessary they are made on the press plates. Major corrections may entail making a new negative and another press plate.

After final corrections the plates are transferred to the single color offset press for runs of approximately 3000 impressions for each color. Six passes through the press are required for each map sheet, one for each of the three basic colors plus one for each of the languages identifying places names.

The map sheets are then sorted and trimmed for distribution to users.

4.1.2 Problem Areas

The problems encountered in the analysis of the Survey Department mapping operations range from critical to trivial. This discussion is limited to consideration of only those which would either preclude or adversely affect the successful accomplishment of the Agricultural Base Mapping Project.

The problems to be resolved in preparing the Survey Department to undertake the 1:10,000 scale mapping project can be classified in one of four general categories. The difficulties either involve equipment, facilities, materials or operations. These are discussed separately in the following sections.

4.1.2.1 Equipment

The most serious, as well as most obvious, problem is the lack of an aircraft with which to acquire the necessary aerial photos. Without the means to obtain up-to-date photo coverage of the country

the 1:10,000 scale mapping project is not possible at all. Because of its importance to the whole project and its complexity, this problem is discussed separately in section 4.2.

The present method of developing aerial film in a reel to reel processor leaves much to be desired. It is a slow process requiring about two hours per roll of film, not counting drying time. It is also difficult to control quality by this method and it is not very economical from a materials standpoint. The chemicals are used once and discarded. It thus poses something of an ecological problem as well.

There are also several other equipment problems relating to the Photo Lab. The Survey Department currently has no adequate means for making the paper prints which will be required in the map making process. They have neither an operating roll print processor nor an adequate sheet film processor. Such equipment is a necessity for any sort of production operation. The present method of making contact prints on a manual light box will be totally inadequate for a production operation. To eliminate remakes, obtain the quality required, and provide the necessary production capacity, more modern equipment is required.

The Survey Department is using a Lanston Copy Camera. The camera is not equipped with a vacuum back to hold the negative flat and motionless during exposure. Instead the glass plate against which the negative is to be held is placed on top of the negative. Although this does tend to keep the negative flat, the glass introduces unwanted distortion in the copy. In addition, the camera has not been auto-collimated in many years. Therefore, it is unlikely that the copy, negative and lens are parallel as they should be.

Exposures are made on the copy camera by means of carbon arc lamps. As these lamps burn in the open they produce dirt and smoke which contaminate the air in the room. They are seldom used in modern operations.

There are currently eight photogrammetric instruments, one (Wild A-7) which can be used for triangulation and compilation and seven (four Wild B-8's and three Wild A-8's) which can be used only for compilation. These instruments are all, except one, in good working condition. That instrument requires servicing by a factory representative. Once restored to operating condition there are still some potential problems in performing triangulation and compilation. The coordinatographs attached to four Wild B-8's do not lend themselves well to modern methods of preparing manuscripts. This is discussed further in relation to scribing. There are also questions regarding whether the necessary rate of production can be achieved with the present equipment. This is discussed further in Sections 4.4 and 5.0.

Considerable field surveying work is contemplated in making the 1:10,000 scale maps. Field work is required in establishing additional control points and in doing editing of manuscripts. Both of these require moving a number of survey parties over many miles. The number of parties required and the time it takes to accomplish the tasks is a function of the ground transportation available. At this time there reportedly are 125 field vehicles of which only 80 are operational. These are used to transport approximately 800 surveyors and their support staff in the field. It therefore appears that additional vehicles will be required to support the Agricultural Base Mapping Project. This subject is explored further in Section 4.4.1.

The Survey Department has little capacity for performing any research or development related to remote sensing and aerial surveys. To a large extent many of the antiquated methods and procedures being used are directly attributable to this fact. An active involvement in pursuing more advanced techniques would pay dividends in the future. However, a worthwhile research effort cannot be undertaken without the necessary equipment and organization. Even a modest investment here could provide the base for a worthwhile program.

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4.1.2.2 Facilities

Basically, the physical plant is not in condition to properly maintain the level of quality required for the Agricultural Base Mapping Project. The main problem is the general lack of temperature and humidity control. A lesser, but nevertheless important, shortcoming is the lack of an adequate centralized photo lab to handle all film and print processing in a properly controlled environment.

The room in which the photogrammetric work is performed is presently air conditioned, although not adequately so. The two Carrier units mounted on the floor of the room do not provide uniform temperatures throughout the room. They also take up valuable floor space which is needed for the addition of new equipment. A central air conditioning system would provide a more uniform temperature throughout the room.

The room in which the Map Production Branch is located has no air conditioning. The ambient temperature and humidity are essentially the same as outside. Since this group is currently doing the hand scribing, manual additions and corrections to manuscripts and drawing the maps from ground surveys, some temperature and humidity control is necessary. The productivity of this unit is understandably low under these circumstances. In addition to encouraging poor work habits the temperature and humidity extremes contribute to rework and corrections caused by perspiration.

The life of film and chemicals is adversely affected by high temperature and humidity. At present, film, paper, wet and dry chemicals are stored in common areas which are unsuitable. Not only do the films and papers deteriorate, they are often damaged by the presence of chemical vapors. This results in excessive negative retouching, as noted earlier.

There are presently four separate darkrooms in which chemical processing of films and paper takes place in close proximity to expensive and fairly delicate photo-optical equipment. This

processing is performed in open trays and sinks and poses a definite hazard to the nearby equipment. Furthermore, the separate facilities are quite inefficient.

The impact of the deficiencies in the facility are hard to quantify. Nevertheless, they are conditions to be avoided. Every modern map making facility has taken steps to avoid these problems.

Another potentially major facility problem may exist. Voltage fluctuations in Colombo are apparent. Measurements of voltage and frequency were requested, but were not obtained. Variations in line voltage and frequency beyond the tolerances of the equipment, particularly the photogrammetric, could affect the accuracy of the maps. The variations in building power should be known and corrective action taken if necessary before the 1:10,000 scale project begins. If the voltage does fluctuate more than about 10%, voltage regulation is required.

4.1.2.3 Materials

The Agricultural Base Mapping Project will require a large supply of expendable items, much more than the Survey Department has had to cope with in the past. These range from aviation fuel to zinc plates. The major problems related to these materials are in identifying the range and depth of items and maintaining adequate stocks so as not to inhibit the map making operation once in full gear.

In the past the Survey Department has had difficulty in obtaining the materials they want. This seems to be a combination of being unfamiliar with how to specify requirements and an unresponsive procurement system. As a result, for example, the Survey Department has had to use a variety of aerial photographic films. This creates unnecessary problems of quality control and results in extra costs because the films required different chemicals.

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4.1.2.4 Operations

The most glaring operational problem stems from the practice of hand scribing color separations. This poses a major production bottleneck if a more modern method is not adopted. In the United States and Western Europe the accepted ratio of compilation to drafting (scribing) time is of the order of 1:1.5. According to the Survey Department, their ratio is 1:20. This is due almost entirely to the very large effort required to manually scribe each of three color separations from each manuscript. Extensive manual scribing is generally regarded as impractical in most modern mapping operations.

Glass diapositives are currently being used in the photogrammetric process. They are about five times as expensive as the 0.007" polyester film popularly used today. The polyester film is sufficiently stable that no loss of accuracy results from its use. In addition, polyester film is much easier to handle and store, requiring considerably less space than glass.

The difficulties the Survey Department has had in obtaining materials and equipment is to some extent a purchasing problem. If the 1:10,000 scale mapping project is to function smoothly, a prompt and sympathetic procurement process is essential.

4.1.3 Suggested Solutions

None of the problems identified in the analysis of the map production process of the Survey Department are insurmountable. On the contrary, most of them can be resolved quite readily. The solutions, like the problems, fall into fairly distinct categories. Financial assistance is required to provide equipment, materials and facility improvements. Improved methods and procedures are needed to eliminate bottlenecks and achieve the necessary level of quality. Some organizational changes need to be made to assure that the improvements made are carried out. Finally, some

additional training and continuing technical support should be provided to assist the Survey Department in performing the Agricultural Base Mapping Project.

4.1.3.1 Financial Assistance

Many of the existing problems facing the Survey Department in undertaking the 1:10,000 scale mapping project can only be resolved by the provision of funds. The need for financial assistance is summarized in Table 2. More detailed requirements are discussed in subsequent subsections and a detailed cost breakdown is contained in Section 8.0.

The largest portion of the funding, about 45%, is for new equipment which will be needed to meet the production requirements of the mapping program. About half the funds are necessary to replace inoperative equipment and half to augment production capability to bring it to the required level. The largest single item of cost is the aircraft. These funds will have to be expended prior to the actual start of mapping operations.

The second largest financial requirement is for the materials which are required to make the maps. The major items are the paper on which to print the map series, the photographic and dark room materials and the supplies with which to operate the aircraft.

The remainder of the funds required is distributed among facility improvements, training and technical assistance. These subjects are discussed in subsequent paragraphs of this section.

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Equipment.		$1,414,500
Photo Acquisition, Aircraft and Accessories	$499,500	
Field Control and Edit	120,000	
Triangulation	122,400	
Compilation	258,400	
Photographic Laboratory	194,400	
Map Production (Drawing Office)	41,600	
Map Production (Litho Branch)	108,800	
Remote Sensing/Survey Research Center	59,400	
Doppler Satellite Positining	10,000	
Facilities		$ 100,000
Materials.		$ 643,700
Photo Acquisition, Aircraft and Accessories	$157,300	
Photographic Laboratory	161,000	
Map Production (Drawing Office)	38,900	
Map Production (Litho Branch)	275,000	
Remote Sensing/Survey Research Center	11,500	
Technical Training		$ 100,000
Technical Assistance		$ 315,000
Subtotal	$2,583,200	
Contingencies (@ 10%)	257,800	
Subtotal	$2,841,000	
Inflation Factor (@ 10%)	284,000	
TOTAL COST		$3,125,000

Table 2: ESTIMATED FUNDING REQUIREMENTS

4.1.3.2 Facility Improvements

The physical condition of the Survey Department is such that substantial improvements are needed to adequately support the Agricultural Base Mapping Project. It is, therefore, recommended that:

1. A number of changes be made to the facility
2. Any loan be contingent upon assurance that the improvements will be made.

The facility improvements which must be made involve changes to the Survey Department building to efficiently accommodate air conditioning and to provide more effective map making operations. The addition of central air conditioning will involve structural modifications as well as electrical and plumbing work. The building renovation portion of the work should be financed by the Government of Sri Lanka. The air conditioning equipment which must be procured outside the country might appropriately be supported by loan funds.

The building modifications recommended include: construction of a central photo lab, separate storage rooms for photo supplies (one for film and paper, one for chemicals), and preparation of the rooms to be air conditioned. Except for the room in which triangulation and compilation is performed, all work areas have to be properly sealed and insulated for the air conditioning equipment to function properly.

Prior to the installation of any additional equipment it is necessary to know what the voltage fluctuations in the building actually are. If the voltage varies more than about 10%, central supplementary voltage regulation should be considered. The alternative is to install separate voltage regulating transformers in each room containing affected equipment or on each individual item.

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4.1.3.3 Operational Changes

The major operational change recommended is the abandonment of the present hand scribing method to prepare color separations of original manuscripts. Two alternatives have been suggested as practical approaches to reducing the excessive time and labor associated with manual scribing. The Survey Department should test both methods. However, the method which is recommended for adoption is the photographic method of preparing color separations by subtractive filtration. This procedure requires that the manuscript be prepared in the three primary colors, one for each of the types of features (topography, hypsography and planimetry) This is accomplished by producing each on the appropriate base material in red, blue and green ink. Color separations for each feature are then produced by subtractive filtration on the copy camera.

It is also recommended that the glass diapositives now being used be replaced by the seven-mil polyester film. This presumes, however, that proper temperature and humidity control be maintained to achieve the necessary dimensional stability and physical properties of the film.

The Survey Department needs a separate organizational unit responsible for performing remote sensing and aerial survey research and development. This unit must be devoid of any direct responsibility for map production and able to devote its efforts exclusively to exploring ideas and developing methods and techniques to improve the department's capabilities.

To maintain the quality standards which will be required in the 1:10,000 scale mapping project, an organizational unit responsible for quality assurance should be established. This unit, like the R & D function, should be separate from and not directly controlled by production operations.

Aircraft maintenance and operation has in the past been the responsibility of Air Ceylon, operating under contract to the Survey Department. An earlier report by RDA recommended that an

arrangement for maintenance and operation of any future aircraft be reached with the Sri Lanka Air Force. Such an arrangement has apparently been drafted. This should be finalized prior to procurement of a new aircraft. Also, to avoid problems of the type experienced in the past, one individual within the Survey Department should be clearly charged with the responsibility for monitoring aircraft maintenance and operational status. This individual should ideally be a regular member of the photographic flight crew, and should be thoroughly familiar with the electrical, mechanical, and operational characteristics of the Survey Department aircraft.

Finally, the Survey Department should have its own procurement activity for purchasing expendable materials. In this way, uniformity of supplies can be maintained and the time of the procurement cycle reduced.

4.1.3.4 Organization

That portion of the Survey Department which will comprise the Agricultural Base Mapping Project is organized along more or less conventional lines. The major segments of the organization and their functional relationship are illustrated in Figure 5. The actual management structure is somewhat more complicated.

To meet the requirements of the proposed project only minor changes in the organization will be necessary. These correspond to operational changes which are deemed to be required to improve production and maintain quality as discussed in section 4.1.3. The recommendation to consolidate all wet photographic processing in a single photo lab unit requires that a corresponding organizational unit responsible for the function and its quality be established. The simplest and most direct approach would seem to be to assign the centralized responsibility to the entity now identified as the Photo Lab and transfer the people now performing these duties elsewhere to that unit.

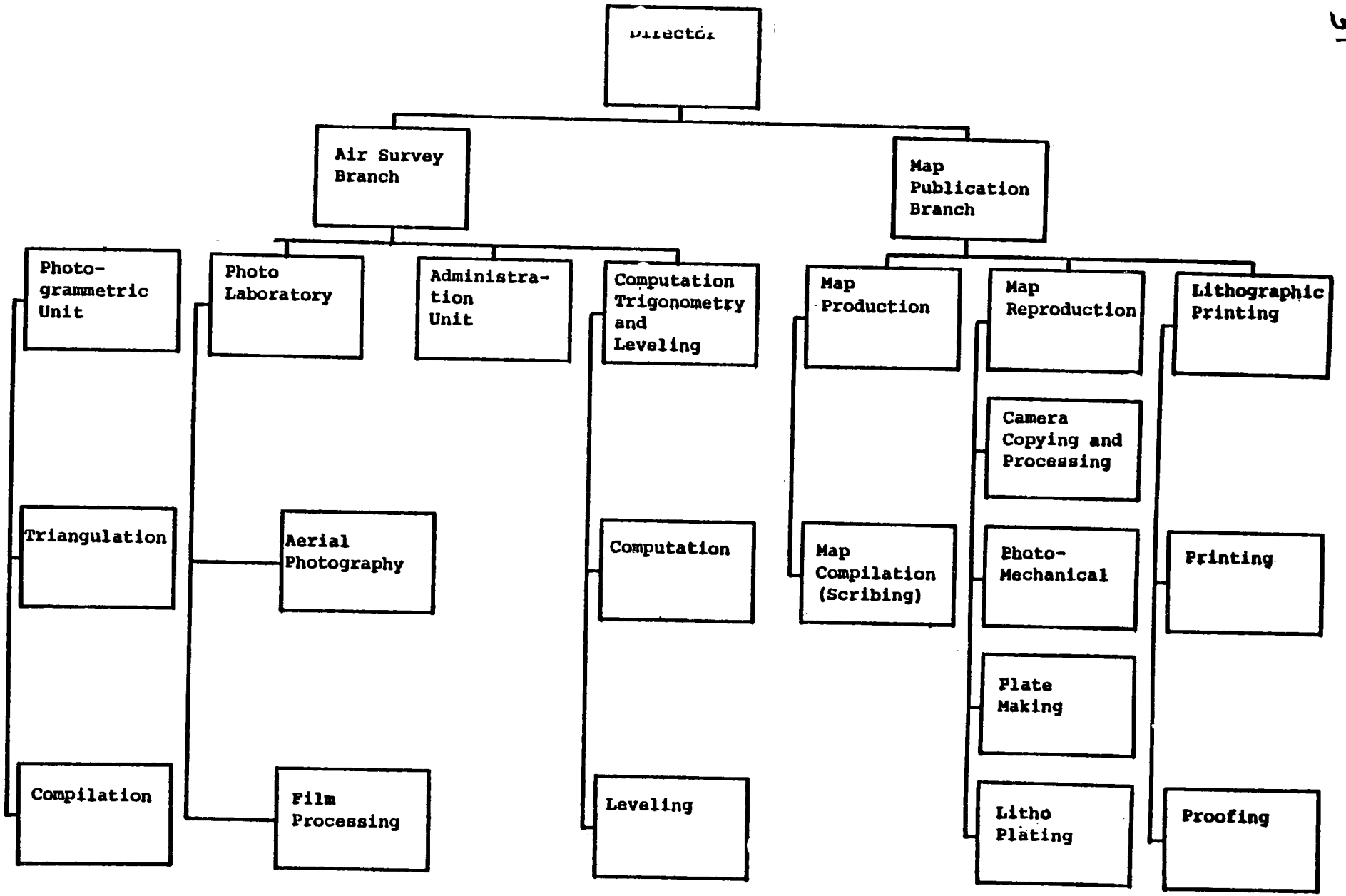

Figure 5: FUNCTIONAL ORGANIZATION OF AGRICULTURAL BASE MAPPING PROJECT

The recommendation to avoid manual scribing by producing color separations photographically will not reduce the need for the current Drawing Office. Rather, it will merely eliminate the requirement to greatly increase its size. Considerable manual work will still be required in preparing manuscripts. The Map Production Branch can also then devote time to other requirements which it could not otherwise undertake.

The present organization does not make provision for several staff functions which will be required. A Remote Sensing and Survey Research Center is being proposed. This is discussed in more detail in section 4.7.1. In addition, it is suggested that three more staff functions be considered each of which is intended to maintain efficient and effective operations and apprise the Director of potential problems. They are:

Plans, Requirements and Technology

- Specifying project requirements
- Determining area priorities
- State of the art of:
  - Materials
  - Equipment
  - Procedures
- Impact of advanced technology on project operations
- Developing mid- and long-range plans

Programs, Production and Operations

- Quality assurance
- Current work load
- Resources available
- Completion dates
- Program changes and impacts
- Priorities
- Production plans
- Adherence to schedules
- Logistics support requirements

Administration

- Personnel
- Budget and finances
- Purchasing
- Logistics support

The recommended organizational structure to accommodate these suggestions is shown in Figure 6.

4.2 Aerial Photography

The principal product of the Agricultural Base Mapping Project will be topographic base maps at a scale of 1:10,000, with a contour interval of five meters. These maps can, in general, be produced more accurately at less cost and in less time through the use of aerial photography than by ground survey methods. The ground area covered in a single aerial photograph is determined by:

$$G^2 = \frac{HW^2}{f}$$

where

G^2 = area covered

H = altitude above terrain

W = film format width (short side)

f = camera focal length.

Since the ground area covered in each photograph increases as the square of the altitude, it would seem desirable to take these photographs from as high an altitude as possible. This would decrease the cost of film and materials, and more importantly, the number of stereo models (photographic pairs) required in the mapping process. Unfortunately, resolution, or the ability to distinguish fine detail, decreases as altitude is increased. Typical photogrammetric plotting equipment requires a minimum

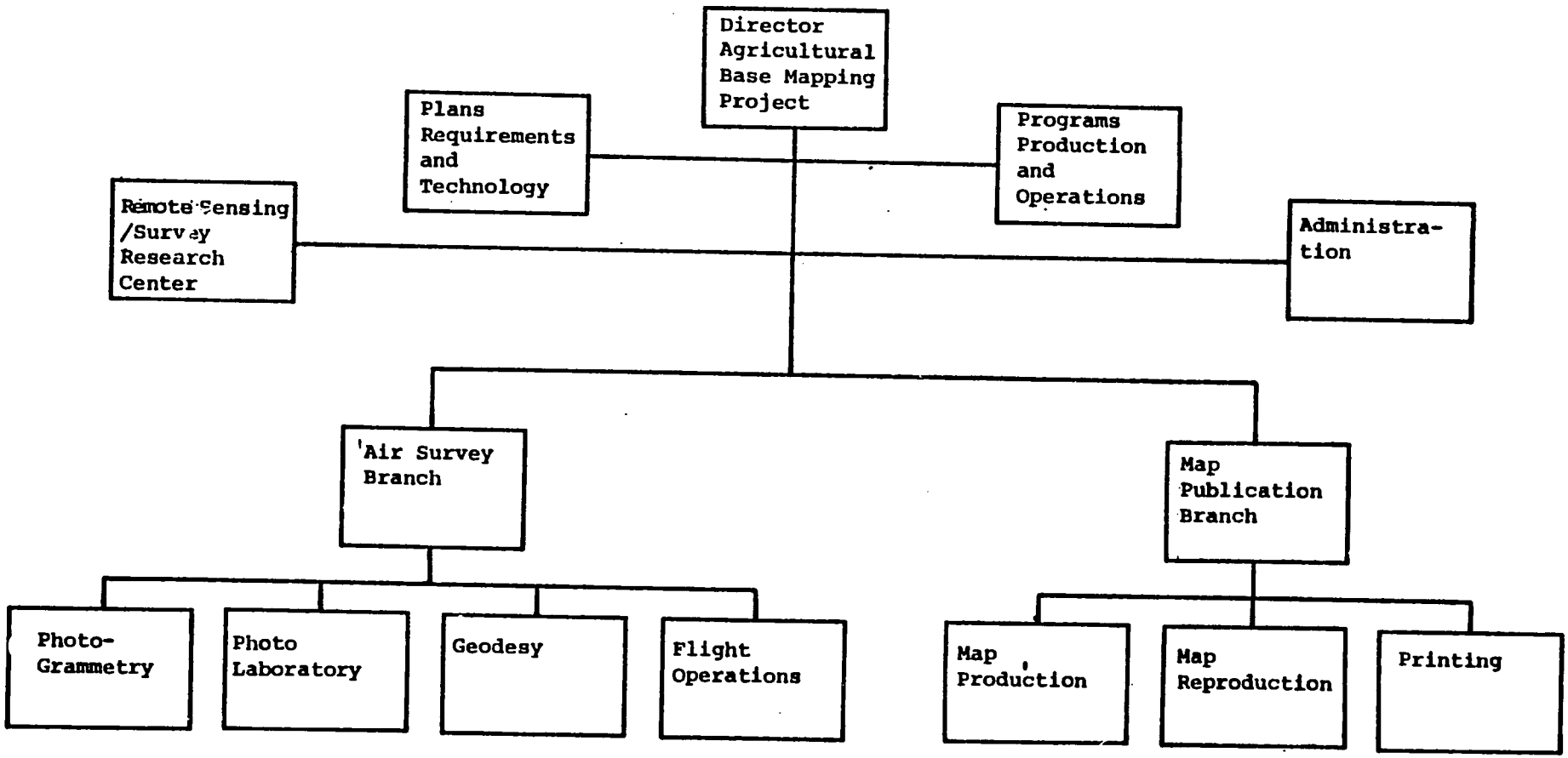

Figure 6: PROPOSED AGRICULTURAL BASE MAPPING ORGANIZATION

ratio of approximately 1:5 input photo resolution and output map contour interval. Thus, to achieve a contour interval of five meters in the resulting maps, the aerial photograph must have a "resolution" of one meter. This resolution is determined by:

$$GRD = \frac{H}{fR_s}$$

where

GRD = ground resolved distance ("resolution")
H = altitude above terrain
F = camera focal length
R_s = resolution limits of the camera/film system.

The Sri Lanka Survey Department presently owns and operates two Wild RC8 aerial mapping cameras which will be used to acquire the photography for the Agricultural Base Mapping Project. Although exact figures will vary from unit to unit, the AWAR (area weighted average resolution) of Wild RC8 camera is typically 45-50 lines per millimeter. Plus-X aerographic film (type 2402) is normally used in typical photo mapping operations. When developed in D-19 for eight minutes in a sensitometric processing machine, this film displays a resolving power of 50 lines/mm at a target-to-object contrast ratio of 1.6:1. The "system resolution" of an RC8 camera and 2402 film should then lie between 45-50 lines/mm.

The focal length of the RC8 camera is 6 inches. With a GRD limit of approximately one meter (to permit five meter map contour intervals) and an R_s of 50 lines/mm, the optimum altitude for aerial photography is then:

$$\begin{aligned} H &= (GRD)\ FR_s \\ &= (1m)\ (6\ in.)(50\ell/mm)\frac{(25.4\ mm)}{1\ in.}\ \frac{(3.281\ ft.)}{1\ m} \\ &= 25001.2\ ft. \end{aligned}$$

or approximately 25,000 feet above mean terrain. At this altitude each photograph will cover an area on the ground of:

$$G^2 = \frac{(HW)^2}{f}$$

$$= \frac{[(25{,}000 \text{ ft.})}{(6 \text{ in.})} \frac{(9 \text{ in.})}{} \frac{(1 \text{ mile})]^2}{5280 \text{ ft.}}$$

$$= 50.41 \text{ mi}^2$$

or approximately 50 square miles.

As all photography is dependent upon reflected light, sun angle is an important factor in planning aerial photo missions. If the ultimate objective is geological analysis, for example, then a low sun angle may be preferred as this will result in longer shadows which can improve detection and analysis of geologic structure. For topographic mapping and most agricultural analysis purposes, however, a high sun angle usually a minimum of 60° above the horizon is preferred as this results in minimum shadow to obscure ground detail. Sri Lanka lies wholly within 10° of the equator. Aerial photography for topographic mapping purposes should then be possible between the hours of 0900-1500. In most tropical areas, clouds tend to build up in the early afternoon making aerial photography difficult if not impossible. For practical purposes then the photo mission window in Sri Lanka will typically be a four-hour period, from 0900-1300 hours.

4.2.1 Aircraft Requirements

These mission constraints define the type of aircraft required for aerial photography in Sri Lanka. The aircraft must be able to operate at an altitude of 25,000 feet above mean terrain for a four-hour period. When times to ascend and descend are included this means the aircraft must have sufficient fuel capacity for a minimum of five hours flight operations. The aircraft must accommodate a minimum flight crew of three (pilot, navigator and photographer) and a large aerial mapping camera. Assuming 180 pounds per crew member (standard) and 300 pounds for camera and film, the minimum payload will be 840 pounds.

Approximately 95% of Sri Lanka lies at an elevation of 3,000 feet or less. If the aircraft is to maintain an altitude of 25,000 feet above mean terrain then its typical flight altitude will be 28,000 feet above sea level. At any altitude greater than about 10,000 feet above sea level, supplemental oxygen is required. To operate at 28,000 feet, the crew must either wear oxygen masks continuously for a period of nearly five hours or the aircraft must be pressurized to a cabin altitude approaching 10,000 feet. Outside air temperature at 28,000 feet is typically -30° to -40° C (-22° to -40° F). For efficient crew operations then the aircraft cabin should be closed, pressurized and heated. A high quality optical glass window must be installed in the aircraft below the camera to insure an adequate and safe pressure seal without limiting camera performance.

The Survey Department presently plans to operate with a flight crew of five, consisting of pilot, copilot, navigator, driftsight operator, and photographer, on many routine flights. The survey aircraft must then accommodate three crew positions in the cabin area plus modification and installation of a Wild NF-2 navigation sight, a B3 driftsight, and an RC-8 camera.

In summary then, the aircraft must be pressurized and capable of a minimum of four hours operation at 28,000 feet above sea level, with an absolute minimum payload of 840 pounds and a "normal" payload of 1,200 pounds. There is currently no aircraft in the SLAF inventory or otherwise available in Sri Lanka that meets these minimum requirements.

4.2.2 Aircraft Comparison and Recommendations

There are several types of aircraft which meet these requirements, ranging in price from approximately $300,000 to well over $1,000,000 when equipped with the necessary navigation equipment and modified for aerial photography. Four typical aircraft, a Cessna 340-II, Cessna 421C-11, Piper PA-31P, and a Beechcraft C-90, were recently flight tested by RDA in the United States to confirm operational ability. The Cessna and Piper aircraft are turbosupercharged

reciprocating dual-engine equipped. The Beech C-90 is equipped with twin PW turboprop engines. These four aircraft, fully instrumented and modified, range in list purchase price from $300,000 to about $825,000.

Published performance data and actual flight test results are presented in Tables 3, 4 and 5. All aircraft tested performed satisfactorily at altitudes up to 28,000 feet. Above this altitude, however, performance of the Cessna 340-II was marginal, becoming unsatisfactory for aerial photographic work at about 30,000 feet. Also at 28,000 feet, cabin altitude in the 240-II was 13,000 feet and supplemental oxygen masks would be required for any extended operation. For these reasons, this aircraft and others in its class should not be considered for purposes of this project. Performance of the remaining three aircraft was equally satisfactory at altitudes up to 31,000 feet, the highest altitude attempted, with cabin pressure altitudes of approximately 10,000 feet at aircraft altitudes of 28,000 feet. The Cessna 421C-11, Piper PA-31P, or Beech C-90 would appear to meet the basic requirements of the Sri Lanka Survey Department.

There is a substantial price difference between the Beech C-90 and the other two aircraft, reflecting the turboprop design of the C-90. This matter deserves additional comment. As may be seen from both the published performance figures and flight test results, time-to-climb, range, cruise speed and operational ceiling are similar for all three aircraft. Although the C-90 turboprop carries twice as much useable fuel as the other aircraft, it uses almost twice as much per hour.

The two major advantages of the turboprop design over the turbosupercharged piston engine are 1) single-engine performance and 2) decreased maintenance. If a C-90 at maximum gross weight should lose an engine on takeoff under typical conditions in Sri Lanka (for example 35° C at sea level), it could continue with its takeoff and still maintain a rate of climb of 440 feet/minute. The 421C and PA-31P would climb at only about 200 feet/minute under similar conditions and would require over 12,000 feet of runway to

	Cessna 421C-II (Pressurized)	Piper PA-31 (Unpressurized)	Piper PA-31P (Pressurized)	Beech C-90 (Pressurized)
Basic Aircraft Weight (Including Unusable Fuel)	4,838	4,003	4,878	5,717
seable Fuel (Standard)	1,236	1,124	1,116	2,573
Payload (Estimated as Three Crew @ 180 Pounds Plus 300 Pounds Equipment)	840	840	840	840
Total T.O. Weight	6,914	5,967	6,834	9,130
Maximum Gross T.O. Weight	7,450	6,500	7,800	9,650
Available Balance	536	533	966	520

Table 3: PUBLISHED AIRCRAFT WEIGHT LIMITATIONS (IN POUNDS)

	Cessna 421C-11 (Pressurized)	Piper PA-31 (Unpressurized)	Piper PA-31P (Pressurized)	Beech C-90 (Pressurized)
A. Time to Climb (Minutes)	28	28	-	37
Fuel to Climb (Pounds)	135	180	-	290
Distance to Climb (Nautical Miles)	70	50	-	105
B. Time to Descend (Minutes)	24	30	-	23
Fuel to Descend (Pounds)	78	70	-	110
Distance to Descend (Nautical Miles)	88	95	-	77
C. Range (Maximum Gross Weight) (Nautical Miles):				
At 24,000 Feet	1,110	---	1,173	1,330
At 28,000 Feet	1,125	1,000	---	1,400
D. Endurance Hours (At 24,000 Feet)	6.2	5.0	6.0	7.0
E. Cruise (At 24,000 Feet) (Knots True Air Speed)	185	182	174	194
F. Cabin Altitude (At 28,000 Feet)	10,900	28,000	9,500	12,000
G. Published Service Ceiling (Feet)	30,300	---	29,000	30,000

Table 4: PUBLISHED AIRCRAFT PERFORMANCE
(Based on 35° C @ Sea Level, 40° C @ 28,000 Feet)

	Cessna 421C-II	Piper PA-31P	Beech E/C-90	Cessna 340-II
Aircraft T.O. Weight as Tested With Three Crew and Fuel (Pounds)	5,900 (1,550 below gross)	5,300 (1,200 below gross)	10,350 (700 above C-90 gross)	5,150 (850 below gross)
Performance - Time to Climb (Minutes):				
At 20,000 Feet	13	17	11	13
At 25,000 Feet	18	22	19	18
At 28,000 Feet	21	29	25	22
At 30,000 Feet	25	31	30	26
At 31,000 Feet	27	35	32	31
Performance - Rate of Climb (Feet per Minute):				
At 20,000 Feet	1,500	1,300	1,500	1,200
At 25,000 Feet	1,000	800	1,000	1,000
At 28,000 Feet	1,000	500	1,000	500
At 30,000 Feet	500	500	500	500
At 31,000 Feet	500	500	500	400
Performance (At 28,000 Feet):				
Outside Air Temperature (°C)	-40	-30	-40	-38
Knots True Air Speed	235	230	220	200
Fuel Flow (Pounds)	215	288	360	180
Cabin Altitude (Feet):				
At 28,000 Feet	10,000	10,000	11,000	13,000
At 30,000 Feet	12,000	11,500	12,500	---
At 31,000 Feet	---	13,000	---	14,500

Table 5: OBSERVED FLIGHT TEST PERFORMANCE

take off. This difference is a substantial margin of safety in favor of the C-90. This, however, is of most importance when operating out of airfields at high altitudes or in mountainous terrain. The three fields in Sri Lanka that this aircraft might operate from are all effectively at sea level and are not surrounded by mountains. Should a 421C or PA-31P at maximum weight lose an engine on takeoff at sea level, it will require less than 4,300 feet of runway in which to stop. The runway at Katunayaka is over 12,000 feet in length and represents a safety factor of almost three. This difference in aircraft performance should not be a major factor in aircraft selection in Sri Lanka.

The second matter relates to engine maintenance and reliability. The mean time between major engine overhaul (TBO) for the 421C and PA-31P is approximately every 1,200 operating hours. The PW turboprop engines on the C-90 have a TBO of about 3,500 hours, or almost three times greater engine life before major repair. Balanced against this is the fact that turboprop engine overhaul can be more complex than reciprocating engine overhaul. The aircraft selected for Sri Lanka will be operated at about 300 hours/year for aerial survey purposes. At this rate, major turbo-recip engine overhauls can be expected every four years, with normal maintenance. The PW turboprop engines could theoretically operate for almost 12 years at this rate without major overhaul. Typical engine overhaul exchange costs might be on the order of $64,500 for two turboprop engines vs. $38,000 for two turbo-recip engines. With TBO's of 3,500 and 1,200 hours respectively, and assuming 300 hours operation per year, the reserve for overhaul should be about $5,530 per year for the turboprop and $9,500 per year for the turbo-recip engines.

Costs of aircraft modification for aerial survey operation also vary considerably with aircraft type. The cost estimate for modifying the Beech turboprop exceeds $100,000; the Piper modification has been estimated at $60,000, and the Cessna modification at $40,000. When these costs plus recommended spares are included in the basic aircraft purchase price, the turboprop cost is nearly three times that of a turbosupercharged aircraft with similar performance characteristics.

On the basis of cost, performance, and maintenance available in Sri Lanka, a turbosupercharged aircraft is recommended. Of the aircraft tested, believed to be the best available for this particular task, the Cessna 421C is recommended over the Piper PA-31P for the following reasons:

1. The Sri Lanka Air Force presently operates a fleet of five Cessna 337 aircraft with avionics similar to those available in the Cessna 421C. This commonality will reduce the requirement for additional test and support equipment, and should lead to more reliable operation.
2. The Cessna 421C has the widest cabin in its class, significantly wider than the PA-31P. This will be a definite advantage in view of the Survey Department's desire for three operating positions in the cabin area (ref. Figure 7).
3. On the basis of both published figures and flight test performance, the 421C appears to have a slight but significant advantage over the PA-31P in altitude capability, speed, fuel consumption and endurance. Forward visibility, a factor in air survey operations, is also substantially better.
4. A complete Cessna overhaul and maintenance facility is available in Singapore through a factory-authorized representative. This facility was visited and inspected by the RDA team and is comparable to any first-class repair facility in the United States. Similar maintenance support for Piper aircraft does not appear to be presently available in this part of the world.

4.2.3 Survey Flight Operations

In the past, the GSL Survey Department has operated with a four-to-five man flight crew, composed of one or two pilots, a photographer, a navigator (operating an NF-2 viewfinder for navigation and flight line acquisition) and a driftsight operator (operating a B3B driftsight). This is an unusually large crew complement. Similar flight operations in other parts of the world are routinely undertaken with a crew of three (one pilot, one navigator, one photographer) and often by crews of only two people.

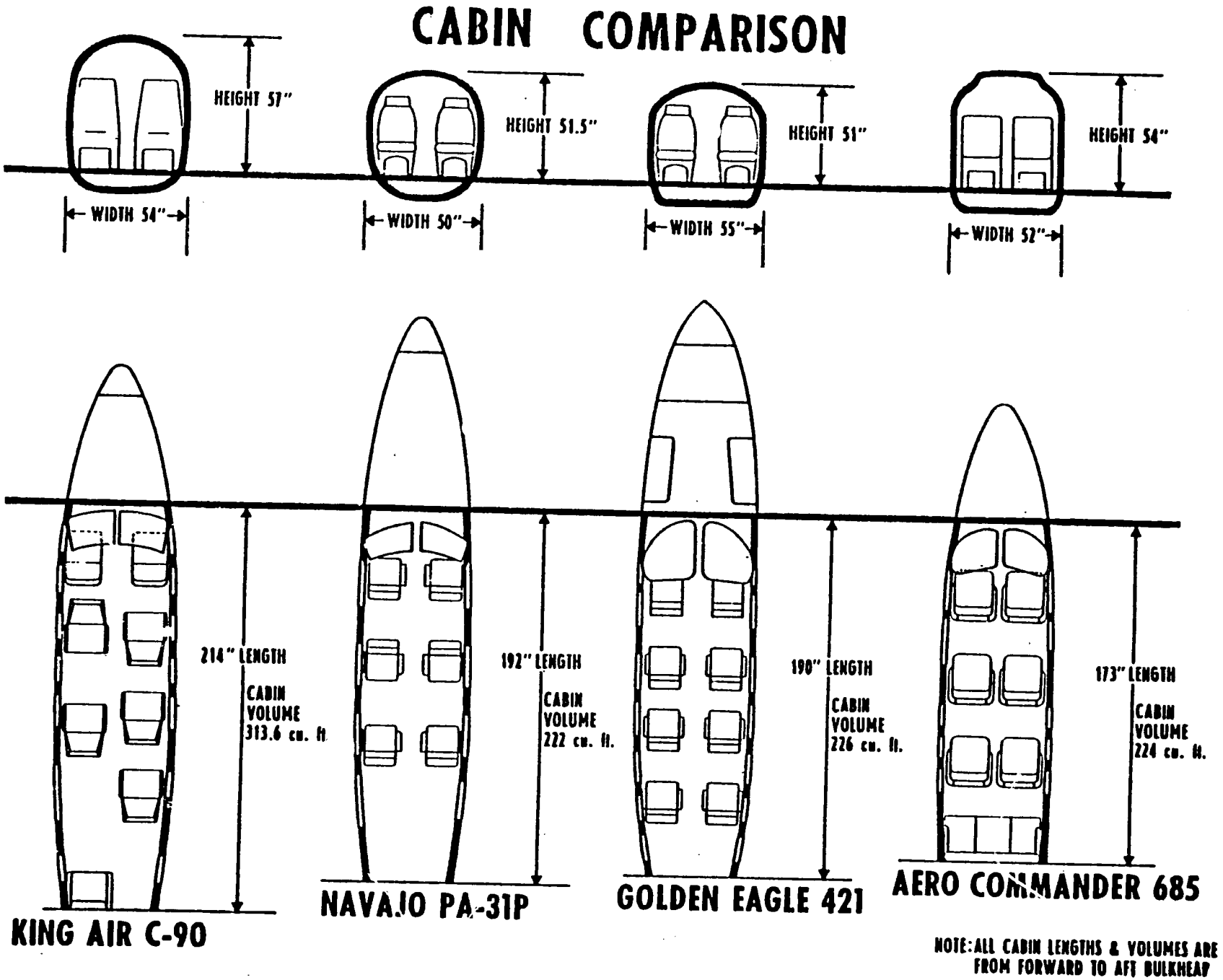
CABIN COMPARISON
HEIGHT 57"
WIDTH 54"
HEIGHT 51.5"
WIDTH 50"
HEIGHT 51"
WIDTH 55"
HEIGHT 54"
WIDTH 52"
214" LENGTH
CABIN VOLUME 313.6 cu. ft.
192" LENGTH
CABIN VOLUME 222 cu. ft.
190" LENGTH
CABIN VOLUME 226 cu. ft.
173" LENGTH
CABIN VOLUME 224 cu. ft.
KING AIR C-90
NAVAJO PA-31P
GOLDEN EAGLE 421
AERO COMMANDER 685
NOTE: ALL CABIN LENGTHS & VOLUMES ARE FROM FORWARD TO AFT BULKHEAD

Figure 7

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The Survey Department has obtained reasonably good results in the past using a crew of four to five and the aircraft recommended for this project can accommodate a crew of this size. Accordingly, no change in flight crew composition is recommended at this time and the aircraft should be modified to incorporate three crew positions (navigator, driftsight operator, photographer) in the aft cabin. Space will be at a premium with such a configuration, however, and the installation must be carefully designed to minimize operational interference. The aircraft cabin width will be an important consideration.

Photographic flight operations are presently planned for three principal altitudes, 25,500 feet, 28,000 feet, and 30,000 feet. This is to maintain a 25,000 feet clearance above mean terrain, and 1:50,000 photo scale, in separate portions of the country (separated into blocks of 500 feet, 3,000 feet and 5,000 feet altitude for planning purposes). A small portion of Sri Lanka, estimated at approximately 1,250 square miles or less, lies between 5,000 and 7,000 feet altitude, with nine mountain peaks above 7,000 feet. Although not absolutely essential for purposes of this project, it would be highly desirable to obtain 1:50,000 scale photography over this area. This would require the aircraft to operate at altitudes up to 32,000 feet for short periods of time.

The aircraft evaluated for this project are capable of reaching and maintaining this altitude.* It is doubtful, however, that they can do so carrying four or five crew members. Accordingly, it is recommended that the NF-28/B3B/RC8 camera installation be so designed as to be operable by one crew member for at least short periods of time. With a crew of two (pilot and photographer navigator) and approximately 500 pounds of fuel, the aircraft should be capable of one to one and one-half hours operation at altitudes of 31,000 or 32,000 feet with an adequate reserve.

* A recent Cessna flight test has confirmed a maximum operating altitude of 34,000 feet for the 421C aircraft.

4. 4 Film Handling

Aerial film, Plus-X Aerographic or similar, should be kept in a cold storage facility (40°-50° F and 50% relative humidity) at the Survey Department until ready for use. Transportation time to and from the airport should be minimized, particularly after a flight mission to prevent deterioration of the latest image due to high temperature and humidity. This handling procedure becomes particularly critical if color infrared (CIR) films are used, as the infrared sensitive emulsion layer decays rapidly as temperature is increased. CIR and similar films are best stored at near freezing temperatures.

Upon receipt of initial film order, a color wedge should be exposed on a small sample of film and processed to determine actual D-Log E curves. The film is then placed in frozen storage. When it is subsequently removed and used, a second color wedge is exposed on the trailing edge just prior to processing. After processing, the second set of D-Log E curves are drawn and compared to the originals. Assuming correct processing, the difference will be a function of film sensitivity decay due to handling. If these differences are substantial then improved procedures are required.

4.2.5 Control of the Aircraft

The aircraft will technically belong to the Survey Department although it will be in the physical custody of the GSL Air Force. An Air Force pilot will fly the plane and the Air Force will provide the maintenance. Presumably the navigator, driftsight operator and cameraman will be members of the Survey Department. Under such circumstances the responsibilities of each party must be clearly established. Furthermore, it is incumbent upon the Survey Department to exercise the necessary control to assure insofar as possible that the aircraft is available when needed and remains in proper operating condition. Regardless of the precautions taken,

however, there is always a finite risk of accidental loss or damage. Consequently, several precautions are necessary to preserve the integrity of the Agricultural Base Mapping Project.

It is recommended that as a precondition to any loan USAID be provided with:

1. A copy of the written agreement between the Survey Department and the Air Force regarding maintenance of the aircraft
2. A copy of an agreement concerning the conditions under which the Air Force has use of the aircraft if any
3. The necessary assurance that an individual within the Survey Department of sufficient stature and authority has responsibility for the aircraft.

The required documents should be reviewed critically to assure that they do, in fact, provide the necessary control.

In view of the experiences in providing the present photo aircraft, it is also recommended that the aircraft be insured against loss or damage. If this can be done in-country, it might be considered as an item of cost to be undertaken by the GSL. Alternatively, all-risk insurance might be arranged through the aircraft supplier.

4.3 Facilities

The Survey Department building does not appear to have been designed and built for some of the purposes envisioned in the Agricultural Base Mapping Project. In particular, the structure does not lend itself readily to air conditioning. Therefore, some modifications to the building will be necessary. A very large portion of most outside walls are glass. Although some are fixed windows, many are the louver or jalousie type. Except for the Photo Lab and Photogrammetric room, cooling is provided by overhead fans and open windows.

An additional problem as far as air conditioning is concerned is that the rooms to be used for the major steps in the map making process are physically separated on different floors, mostly the top and ground-as indicated in Figures 8, 9 and 10 Consolidation of activities was given serious consideration as a means of simplifying the air conditioning problem and achieving the intangible benefits of closer proximity. However, the time and cost of such a move precludes it as a practical approach. Consequently, the recommended approach is to make only those changes necessary to bring the spearate rooms to an acceptable operating condition.

The specific areas considered in the analysis were those in which the physical conditions might have some adverse affect on the map making process. These rooms and the steps performed in each are listed in Table 6.

4.3.1 Photo Lab and Studio

Although physically adjacent, the Photo Lab and Studio areas are functionally the responsibility of separate organizational entities, the Air Survey Branch and Map Production Branch respectively. This may account for some of the unfavorable operating conditions observed. The Photo Lab is responsible for developing and printing the aerial photography, the Studio for copy camera work.

The Photo Lab area is air conditioned except for the film drying room. An air conditioning unit provides cooled air to six separate rooms by means of ducts. The seventh, a storage room, is not really air conditioned. The Studio area, consisting of a large open space for copy cameras (54' x 39') and four smaller dark rooms, is not air conditioned.

Chemicals, film and photo paper are stored in a 10' x 17' room. There is a vent connecting it with an air conditioned area. However, the vent is located near the ceiling and does not have a fan or blower. The daytime temperature was approximately 85°F with an 85% relative humidity.

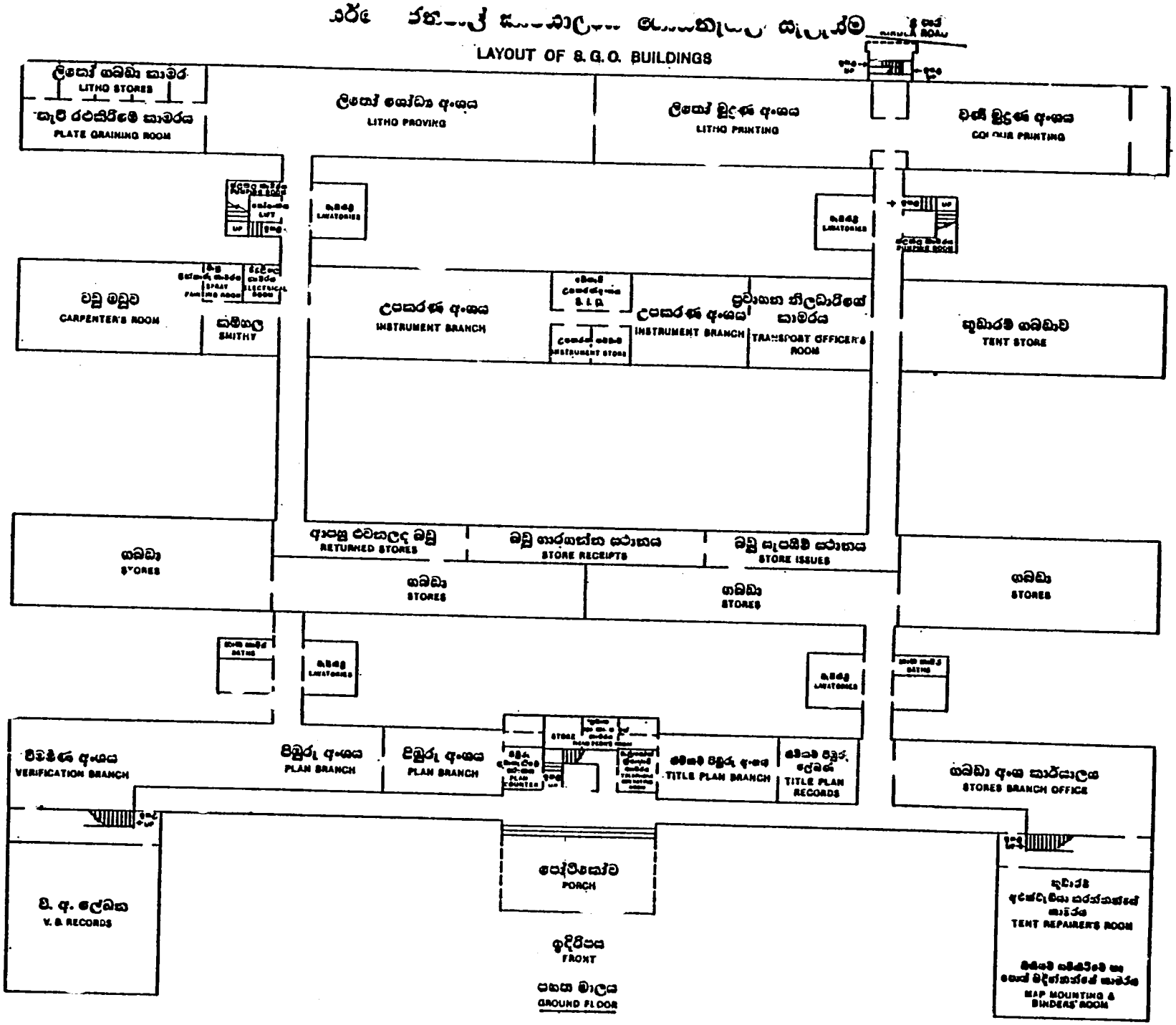

Figure 8: SURVEY DEPARTMENT GROUND FLOOR

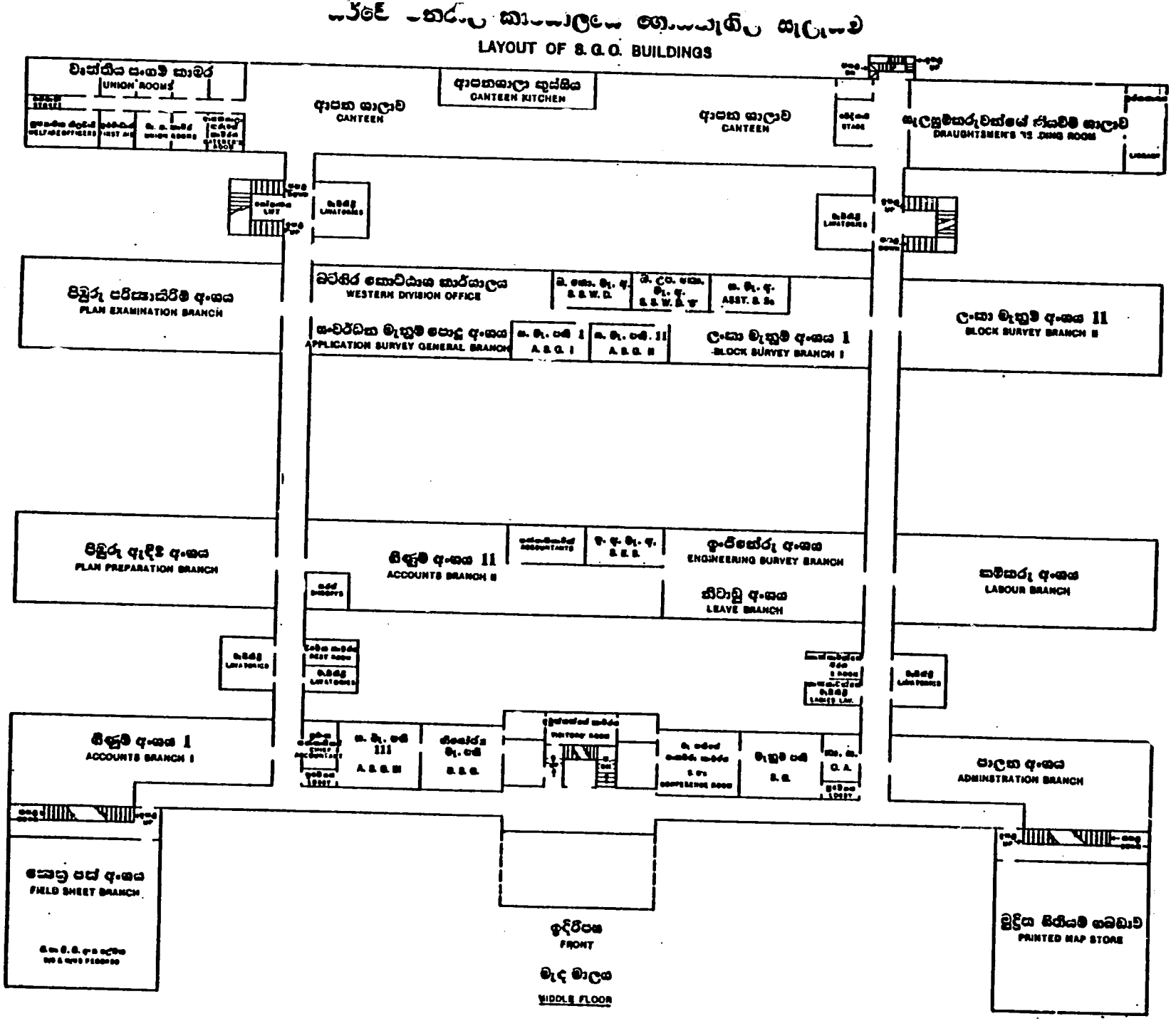

Figure 9: SURVEY DEPARTMENT: MIDDLE FLOOR

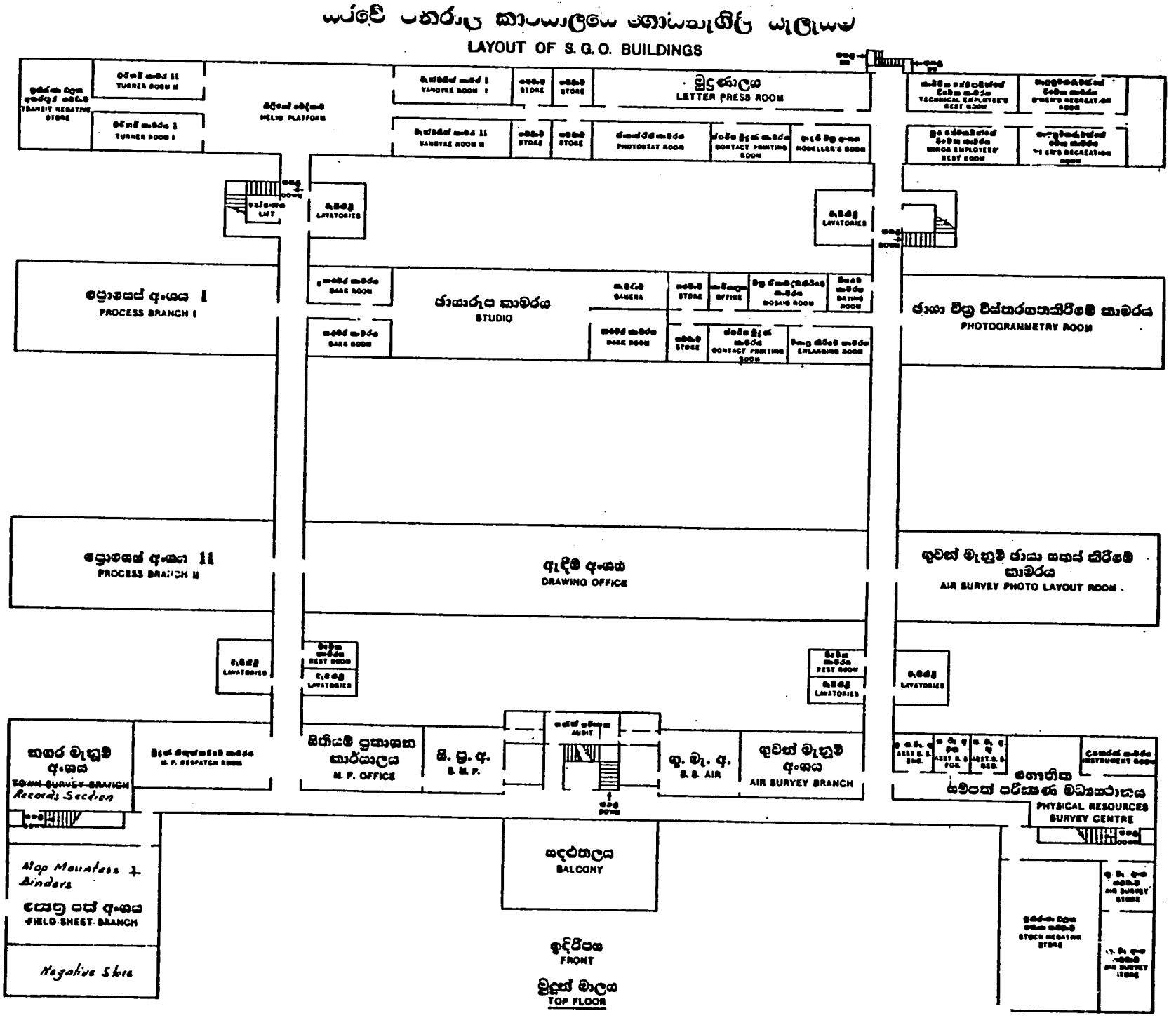

Figure 10: SURVEY DEPARTMENT TOP FLOOR

Room	Floor	Process/Function
Studio and Photo Lab	Top	Film Processing Camera Copying Contact Printing and Processing
Photogrammetry Room	Top	Triangulation and Compilation
Drawing Office	Top	Scribing
Litho and Color Printing	Ground	Map Printing

Table 6: ROOMS CONSIDERED IN FACILITIES EVALUATION

There are two deficiencies associated with the photo storage area. Black-and-white photographic materials should be stored at 50°F and 40% relative humidity if a normal shelflife of at least one year is to be achieved. With color or color infrared materials the requirements are even more stringent. Photo film and paper should not be stored in the same room as chemicals. Fumes from the chemicals can create "pin holes" in the emulsions. This is likely the cause of the considerable amount of manual retouching of negatives noted.

Film and paper is processed in several rooms in which expensive photo-optical equipment is located. This processing is usually done in open trays and sinks. The fumes from these chemicals are corrosive and can damage the equipment. Items such as rectifiers, contact printers, and vacuum frames should be located in areas physically separated from chemical processing.

Processing in open trays and sinks has another disadvantage. Chemical oxidation and depletion is accelerated by exposure to air. This necessitates more frequent replenishment or replacement and, hence, increases the cost of processing. In addition, it is virtually impossible to maintain densitometric control and, therefore, cinage quality in open trays.

The Photo Lab and Studio areas do not have adequate plumbing or means of disposal for even the present processing, let alone future loads. Chemicals for processing are transported to the trays, sinks and tanks by hand in buckets. When depleted, the used chemicals are disposed of into the sewer system.

To alleviate the present problems and prepare for the increased workload in the Photo Lab and Studio which would accompany the 1:10,000 scale mapping project will require some changes in facilities. Prior to the start of the Agricultural Base Mapping Project it is recommended that the following be accomplished:

1. The entire Photo Lab and Studio areas be air conditioned, preferably by means of a central system. This will necessitate removal of the separate unit now serving part of these areas as well as the two in the Photogrammetry Room (section 4.3.2). It will also require additional ducting and the possible replacement or alteration of windows in much of the Studio area. For best results these rooms should be maintained at 76°F and 50% relative humidity.
2. A single wet lab separate from optical equipment be established to do all chemical processing. This will require relocation of some equipment and the acquisition of new processors (see section 4.4).
3. A tank farm for storage of chemicals be installed above floor level along with the necessary plumbing to provide gravity flow to processing machines and trays.

4.3.2 Photogrammetry Room

Among the most important functions in achieving high quality in making the 1:10,000 scale maps are triangulation and compilation. Both of these steps are performed in the Photogrammetry Room. It is necessary, therefore, that a proper working environment be provided in this area.

Two free-standing Carrier air conditioning units in the Photogrammetry Room presently provide a reasonably acceptable environment, considering the precision inherent in the measuring equipment. There is, however, an obvious temperature variation across the room because ducting is not used for air distribution. The temperature increases as the distance from the units.

The actual temperature and humidity levels are not as important as is consistency. If for example it is more practical to maintain 76°F, rather than the 68°F favored in the United States, it is equally acceptable provided it is kept within ± 2°F. With the high humidity level common to Sri Lanka it may be advisable also to relax those requirements somewhat. While the standard is 50%, a humidity level of 65% ± 5% would be acceptable.

It will be necessary to accommodate additional equipment in the Photogrammetry Room (section 4.4). It appears necessary in view of the space available there now, that some of the present equipment has to be moved. The Kelsh plotter and the Pantophot horizontal enlarger are seldom, if ever, used. To relocate any of the other plotters, even a few inches, would require major disassembly, reassembly and complete recalibration. This would have to be performed by an engineer/technician from the factory This would be time consuming and costly Consequently relocation of any of the equipment which will be necessary to the Agricultural Base Mapping Project should only be considered as a last resort.

In addition to the space which would be available by moving unused equipment, additional space could become available by the introduction of a new central air conditioning equipment unit installed outside the building. In such an event, the two floor mounted Carrier units and the equipment located in a separate enclosure within the Photogrammetry Room could be displaced. The room in which the air conditioner serving the Photo Lab area is located presently occupies an area of about 11' x 17' This could either be modified to accept a new plotter or the walls removed to open up additional space.

The windows in the Photogrammetry Room are adequately sealed for the present air conditioning. No additional modification seems necessary.

The additional plotting equipment needed should not increase the load sufficiently to create any problems. However, questions still remain regarding voltage and frequency fluctuations. The accuracy of the plotting equipment may be adversely affected by excessive voltage changes. Variations up to about 10% should introduce no problem. Fluctuations in excess of this will require voltage regulation, either for the whole room, or on individual pieces of equipment.

Since the facility modifications required do not involve any substantial structural work, it is perfectly feasible to perform them with the equipment in place. The plotting equipment should

be covered to protect it from dust and dirt. The work should also be monitored continuously by the Survey Department to ensure that the equipment is properly protected during alterations.

To prepare the Photogrammetry Room for the 1:10,000 scale mapping project the following is recommended:

1. The present air conditioning equipment be replaced by a central system shared with several other rooms. The present units may be used elsewhere in the building.
2. The Kelsh plotter and the Pantophot enlarger be removed.
3. The room in which the air conditioning unit for the Photo Lab is located be renovated for use as additional space for a plotter.
4. Voltage and frequency variations be determined and voltage regulating transformers installed if fluctuations exceed 10%.

4.3.3 Drawing Office

From a facilities standpoint the major problem of the Drawing Office is the temperature and humidity. Some cooling is provided by movement of ambient air by overhead fans and through cross ventilation by opening the windows on opposite sides of the room. These measures do not result in an environment that is suitable for the scribing and drafting functions performed there. Although there is no critical equipment to be concerned with, it is felt that human performance will be improved by a more comfortable atmosphere in the Drawing Office.

To air condition the Drawing Office will require the introduction of overhead ducting and, very likely, the modification of the existing windows. The office occupies an area approximately 40' x 154' with 56 windows, all on the long walls.

It is recommended that the Drawing Office be air conditioned from the same central system to be installed for the other areas.

4.3.4 Litho and Color Printing Area

The Litho Branch occupies the largest single area of the offices directly involved in the Agricultural Base Mapping Project. Located on the ground level, printing occupies a space approximately 41' x 330', consisting of several large rooms and small storage areas. None of the area is air conditioned. However, a water tower presumably for the Photo Lab air conditioning system is located about 10' outside the louvered windows. Since the windows are open to obtain some air movement (supplemented by three overhead fans!) the humidity is even higher than normal, about 80-90%. Despite these extreme conditions the Litho Branch has managed to attain the necessary color registration accuracy, although at times with great difficulty.

Both the high temperature and humidity adversely affect the printing process as well as the people working there. It requires considerable skill along with excessive time and waste to achieve the sheet feed and registration on the offset presses. The press room should be held at levels similar to those recommended for Photogrammetry for best lithographic reproduction.

Paper is stored in several locations, one of which is a separate walled room; the other two are screened enclosures open to the press rooms. In neither case are the storage conditions really adequate. All of the storage areas should be enclosed in areas where the temperature and humidity are the same as the press room.

Air conditioning the Litho and Color Printing Areas poses the same problem as that of the Drawing Office only on a larger scale. There are about 110 louvered windows in the area. To effectively air condition this space the windows will have to be sealed. Overhead ducts will also have to be installed to distribute the cooled air.

In view of the problems of press feed, color registration and storage it is recommended that:

1. The Litho and Color Printing Areas be air conditioned
2. The Graining Room not be air conditioned (because there is no obvious advantage to doing so and it would be difficult to do)
3. Paper storage areas be enclosed but included in the air conditioned areas.

4.4 Production Equipment

Producing maps from aerial photographs requires a variety of equipment. In general, equipment is necessary to process film, make prints, do the plotting, perform field survey work and print the maps. The Survey Department already has much of the needed equipment. However, the Agricultural Base Mapping Project will impose greater than normal demands on the production capacity and introduce requirements that do not now exist. Consequently, it was necessary to review and analyze the need for additional equipment in terms of the 1:10,000 scale map project.

The current methods of performing the major steps in the map production process were discussed and the problems associated with them identified in section 4.2 above. Here the items of equipment, other than the aircraft, which are needed to eleviate those and other problems are discussed.

4.4.1 Field Control and Edit

The Survey Department currently possess most of the equipment necessary to establish control in the field and to perform the field edit function. The biggest need in this area is for field transport.

The Survey Department has indicated that at the present time they have approximately 800 survey teams in the field, consisting of one surveyor and a ten-man crew, with 80 vehicles available to support them. This ratio of vehicles to crew is inadequate, and

much of the actual field movement must be carried out by bull cart or, where possible, by using the public bus system. Neither method is to be recommended in support of a production mapping operation with definite goals, schedules and budget.

If this project is to be completed as scheduled, then a minimum of ten field control and 38 field edit teams will be required, for a total of 48 teams (ref. Appendix A, sec. 4.0, Operational Map Production Rate). The vehicle-to-field team ratio for a typical modern mapping operation would be 1:1 or 1:2. With a 1:2 ratio, the field teams should be able to maintain the required production rates (as shown in Table A-2).

This will require the purchase of 24 field vehicles, specifically designated for use on the Agricultural Base Mapping Project. These vehicles should be of the Jeep or Toyota Land Cruiser 4-wheel drive type, with an enclosed body and trailer hitch.

4.4.2 Triangulation and Compilation

The Survey Department presently has only one instrument on which to do the triangulation, a Wild A-7. Another instrument is needed, both for triangulation and to provide back-up support to the compilation effort. Since compilation is estimated to be the primary production bottleneck (see Appendix A) it will be necessary to have additional plotting equipment if the Survey Department is to have the capacity to produce anything other than the 1:10,000 scale maps during the five-year program (see section 5.0).

To achieve the necessary production rates (ref. Appendix A) one Wild A-10 and one Wild A-8 Autograph will be required. Coordinatograph attachments are required if the (unsatisfactory) alternative of manual scribing is to be avoided. The only known source of these units is the Wild-Heerbrugg factory in Switzerland. No comparable units are manufactured in the United States. In

addition, an IBM 545 Card Punch (to be compatible with existing equipment), and an electronic mini-computer (Hewlett Packard 3060 or equivalent are required. The card punch will reduce errors caused by manual transcription of data and permit the required production rate. The mini-computer is necessary to support required triangulation and block adjustment calculations. A strip stereoscope and glass scales will also be required as part of the A-10/A-8 installation.

4.4.3 Photographic Laboratory

A number of recommendations have been made to increase productivity and improve quality in the photo lab operation. Implementation of these recommendations will require purchase of several items of capital equipment. Without these items, the photographic laboratory will be unable to support the 1:10,000 mapping program, either in quantity or quality of product. Required items include:

- Kodak Model 11C-M Versamat Roll Processor (required as alternative to present, unsatisfactory, hand processing)
- MAFI Processor (required for orthoprinting)
- Kodalith 324 Litho Sheet Processor (required as alternative to hand processing)
- Mark IV Log-E Printer (required to replace present unsatisfactory contact printer)
- Vacuum back for Lanston Copy Camera (required for copy prints)
- Pulsed Xenon Lamps (required to replace unsatisfactory Carbon Arc Lamps)
- Whirler Coating Machine (required to replace inoperable unit)
- Graining machines, 3 each (required to meet anticipated plate production rates)
- Map reproduction machine (required to produce inexpensiv small-lot map copies - <u>not</u> a Xerox-type office copier)

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- Printing down frame (to support copy camera operations)
- Point light source (to support copy camera operations)
- Color sensitometer (to support R & D operations with color and CIR films)
- Transmission/reflection densitometers (for quality assurance control in film exposure and processing operations)
- Miscellaneous items of photographic and process equipment (i.e., 4 each 50-gallon mixing/storage tanks, 4 each 10-gallon replenisher tanks, 1 portable mixer, similar commonly required items)

4.4.4 Map Production

The major items required in the Drawing Office area are a registration punch machine, to insure proper registration of color separation sheets, a reflecting projector, as an aid in drafting changes, and a photo composing machine. The latter item is required to maintain production rates without loss of quality.

The Litho Branch presently has one Mann sheet-fed two-color offset press, originally installed in 1931. Inking and dampening rollers in this unit are worn out and replacement parts are not available, and only one cylinder (one color) is currently operational. A second Crabtree-Mann single-color press was purchased in 1971 and is in generally good condition, although it should be equipped with a sheet counter. Operating with single-color presses means that each map sheet must be passed through the press at least three times to generate the final color map. If temperature or humidity vary between these separate passes, which are often days apart, then color registration may not be within acceptable limits. This is often a problem even with standard temperature and humidity controls. A new two-color litho offset press is recommended.

A new powered paper cutter is also required. The unit presently in use at the Survey Department is quite old, positioning belts are broken and missing, and replacement parts are unavailable.

4.4.5 Remote Sensing/Survey Research Center

The Remote Sensing/Survey Research Center would be a new organizational unit within the Survey Department, charged with research and development of new techniques of data collection, data analysis, and resources survey. This would include study of the utility and cost-effectiveness of new techniques of data analysis, using light tables, film transparencies, stereo microscopes and video image processing; new techniques of data collection, including evaluation of LANDSAT data and color and color infrared films; and new methods of data presentation, such as orthophotography, overprinting on orthophotos or radial-controlled mosaics, etc.

The center will require a minimum of two light tables to handle film transparencies in roll form (Richards 940 or equivalent), one stereomicroscope (B & L 240R or equivalent), one Zoom Transfer Scope (B & L Model ZT4-H), and a video image processor (I^2S VIP). A portable field spectrometer and 35 mm ground truth camera should also be obtained to support applied remote sensing research projects. This equipment would be available to other GSL resource agencies, such as the Foresty Department, Land Use Department, Department of Agriculture, etc., on an available basis to support current programs.

As new techniques are developed and proven cost-effective, these departments may require additional similar equipment items dedicated to their particular use. For example, at the present time, panchromatic paper prints at 1:20,000 scale are routinely used for purposes of large area land use survey. If light tables and stereomicroscopes are used to study film transparencies, this same level of detail can be obtained from 1:50,000 scale photography. This could easily reduce the total number of photographs required to be analyzed by a factor of eight or more, with comparable reductions in time and cost.

4.4.6 Maintenance of Map Production Equipment

An important element of any map production process is maintenance of the equipment. The term "maintenance" is intended in the broadest sense of the word. It includes the functions of preventing or minimizing failures, making repairs when failures do occur and performing tests and adjustments to assure proper operation. Failure to observe at least minimal maintenance requirements will result in unscheduled down time and consequently, reduced production. The absence of regular performance tests and adjustments results in loss of quality. The characteristics of much of the equipment are such that gradual changes occur which, though imperceptible to the eye, may degrade performance.

The maintenance required falls into two general categories, that which can and should be performed by Survey Department personnel and that which must be done by the manufacturer. In the former category are such routine tasks as checking, testing and minor adjustments in accordance with the instructions accompanying each equipment. The maintenance required by the manufacturer includes damage, major failure and periodic inspection, and calibration.

4.4.6.1 Photographic Laboratory

By the nature of its functions and design, photo lab equipment is generally quite reliable and requires but minimal preventive maintenance to avoid failures and loss of quality. It seldom requires factory service if given proper care. Consequently, all that is required for the photo lab equipment is regularly scheduled attention in accordance with instructions contained in the operating manuals provided. This usually consists of inspection, cleaning, lubrication and in some instances test, calibration and alignment.

In general, film processors and printers require only periodic cleaning and lubrication. The most complex item recommended for acquisition, the LogETronic Printer, has electronic controls. In the event of failure the four solid state circuit boards are removed and replaced with spares provided. The removed boards are shipped to the factory for repair or replacement. The Kodak Versamat processor requires little more than regular cleaning. The same is true for the Kodalith and Mafi processors. These units will have a standard spare parts package for five year use.

Copy cameras require periodic testing, collimation and alignment as optical elements will get out of alignment with use. To achieve the optical quality inherent in the camera, a vacuum back must be used. This requires that the vacuum system be properly maintained in accordance with equipment operating instructions. The Survey Department currently does not have a vacuum back for their copy camera.

4.4.6.2 Photogrammetric Equipment

Although the equipment required for triangulation and map compilation is quite sophisticated, the preventive maintenance requirements are minimal. Aside from frequent careful cleaning, oiling of the ways and lead screws, little else is necessary. Occasionally, each instrument should be checked for parallax.

Because instrument characteristics may change with use, it is necessary that the machines be periodically tested and adjusted by factory representatives. For this reason it is recommended that a service agreement with the manufacturer be made at the time of procurement of additional equipment. This agreement should include all instruments, new as well as old. The frequency of service would generally be a function of use rate. With the production schedules necessary for the Agricultural Base Mapping Project, annual service is suggested. This should include all of the Wild instruments, old as well as new, and the IBM card punch.

4.4.6.3 Lithographic

Offset presses are quite rugged and require little more than regular lubrication and periodic replacement of items subject to wear. The latter includes the blanket and rollers. With the use envisioned for the presses the blanket should last for about a year, the rollers for three years.

4.4.6.4 Maintenance Responsibility

Primary responsibility for routine maintenance of equipment should rest with the organizational unit operating it. The operators are familiar with the equipment they use. They should also be familiar with the operating manuals supplied by the manufacturer. All new equipment will be provided with such manuals. If manuals are missing for some of the older equipment. copies should be requested from the manufacturer.

Particularly for the photogrammetric equipment, formal service agreements should be executed with the factory. Such agreements must specify the services to be rendered, frequency, cost and contain some assurance that performance standards will be met during reasonable periods of time.

Since maintenance is related directly to quality, it is suggested that the individual assigned responsibility for quality assurance be authorized to monitor and evaluate maintenance activities and procedures. This individual will, thus, have overall responsibility for adherence to performance standards for the entire mapping operation.

As part of the purchase price of the plotting equipment, it will be installed and training provided by factory representatives. For the Photo Lab equipment it is recommended that technical support be obtained by contract for installation and training. The latter would include the operation and maintenance.

4.5 Materials

Large quantities of a variety of expendable supplies will be required in the Agricultural Base Mapping Project. In fact, these supplies account for the second largest dollar volume of funds. Therefore, it is necessary that both the range of items and the quantities be carefully examined.

4.5.1 Aircraft

If reserves for engine overhaul/exchange, propeller overhaul and avionics repair are considered as maintenance category items, then fuel and oil are the only expendables directly related to aircraft operation. The amount, and cost, of these items will be directly related to the type of aircraft purchased.

For a twin-engine turbosupercharged piston aircraft of the Cessna 421C-II or Piper PA-31P type, expendables will be approximately as follows:

- Fuel (Av gas) - 43 gph[1], 300 hours/year = 12,900 gallons
- Oil - 2 pints/hour, 300 hours/year, plus oil change @ 14 quarts/50 hours = 96 gallons

For a five-year program, expendables then become 64,500 gallons of aviation gasoline and 480 gallons of oil.

For a twin-engine turboprop aircraft of the Beech C-90 type, expendables will be approximately:

- Fuel (Av kerosene) - 64 gph[2], 300 hours/year = 19,200 gallons
- Oil - 1 pint/5 hours, 300 hours/year, plus oil change @ 26 quarts/300 hours = 14 gallons

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[1] Based on 421C operation at 21,000 feet maximum cruise power, standard temperature conditions.

[2] Based on C-90 operation at 21,000 feet, maximum cruise power, standard temperature conditions.

For a five-year program, expendables for a turboprop aircraft are estimated as 96,000 gallons of aviation gasoline and 70 gallons of oil. (Note oil type specified for C-90 aircraft is approximately five times more expensive than oil specified for 421C or PA-31P aircraft, based on current US prices.)

Aviation gasoline, kerosene, and oil of the required grades and types are currently used by the Sri Lanka Air Force and adequate storage facilities are available.

4.5.2 Photographic

The Photo Lab will require a number of items whose quality does not decay with time (i.e., glass marbles, zinc and aluminum plates, dry chemicals) and thus may be purchased in bulk and stored. Other items have a definite shelf-life, usually a minimum of one year under controlled temperature and humidity conditions, and should be purchased on a periodic basis. It is strongly recommended that purchase of these items be handled directly by the Survey Department, as opposed to central procurement by the GSL, for reasons noted elsewhere in this report.

The following items should be purchased on a yearly basis (ref. section 8.4):

- Aerial film, Plus-X Aerographic, 9½" x 250', five rolls/year
- Diapositive film, Aerographic Positive, 9½" x 250' ten rolls/year
- Direct duplicating film, Aerographic Positive 9½" x 250', five rolls/year
- Photo index paper, swsm, 1,000 sheets or ten boxes/year
- Contact print paper, dwsm, Kodabromide, 1,400 sheets or 28 boxes/year
- Copy paper, 24" x 30", Kodabromide, 200 sheets or eight boxes/year
- Litho films, 24" x 30", 2,800 sheets/year
- Diapositive sheet film, 10" x 10", 7 mil, Aerographic Positive, Estar base (to be used in place of present ¼" glass diapositives), 1,000 sheets or 20 boxes/year.

4.5.3 Map Production

Ink, adhesives, machine dressings, etc. do not in general decay significantly with time and with a few exceptions may be purchased in bulk. Peelcoat, plastic drafting material, and litho printing paper should be purchased on a yearly basis similar to that for photographic material. A complete list of expendable materials is presented in section 8.4.

4.5.4 Remote Sensing/Survey Research Center

The color and CIR films, copy films and paper suggested for the research center should not be purchased over one year in advance of planned use, and then only when cold storage facilities (both in transit from manufacturer and at the Survey Department) are assured. The ordering schedule for this material should be prepared after an R & D program operations plan is completed for the research center.

4.6 Staffing and Training Requirements

To meet the requirements of the Agricultural Base Mapping Project it will not be necessary to recruit and train additional personnel, if the recommendation to eliminate manual scribing is accepted. A possible exception is in the area of field control and field edit.

4.6.1 Staffing

The current staff of the Air Survey Branch and Map Publication Branch which are the major organizational units comprising the map production activity consists of the following:

Supervisory and Management	=	22
Technicians	=	163
Laborers (approximate)	=	25
		210

An estimate of the technical personnel needed to perform the 1:10,000 scale mapping by specialty is shown in Table 7. Even in the most critical area, photogrammetry, the project will not utilize all of the manpower available. This presumes that color separations of the manuscript will be made by the subtractive color photographic method. Otherwise, scribing would require some 154 technicians. This would impose obvious problems of hiring, training, multiple shift operations, and management. It is, therefore, assumed that manual scribing will be eliminated.

The only other possibility for additional hiring is surveyors for field control and field edit. This would only be true if the number needed cannot be drawn from the existing staff of some 800 surveyors. Even if this is the case, it would pose no particular problem since the Survey Department is hiring and training surveyors more or less continuously.

4.6.2 Training

Since no additional personnel are required, there is no requirement for training new personnel. However, there is some need for on-the-job training and practice with new techniques.

The proposed method of preparing color separations directly during compilation rather than by manual scribing is new to the Survey Department personnel. Training will be provided by the Wild factory representative as part of the new equipment installation. Actually, it is mainly practice and experience that is required to attain the necessary proficiency.

	Number of Personnel Current	Proposed
Air Survey Branch		
Aerial Photography:		
Photographers	5	5
Lab Technicians	4	4
Mosaicers	2	2
Photogrammetry:		
Triangulation Compilation	23	20
Administration	5	5
Computation	6	4
Map Production Branch		
Drawing Office (Scribing)	35	10
Map Reproduction:		
Camera Room	3	3
Typographers	12	7
Photomechanical	23	14
Photo-Writers	10	6
Litho-Writers	11	7
Lithography:		
Head Operators	4	4
Printers	17	10
Apprentices	3	3
Subtotals	163	104
Field Surveyors	800	48
TOTALS	963	152

Table 7: SURVEY DEPARTMENT STAFFING REQUIREMENTS

If the surveyors needed for field control and field editing are not drawn from the 800 currently employed, they will be trained in the institute which the Survey Department currently operates for that purpose. No additional training effort needs to be incorporated in the Agricultural Base Mapping Project.

The management personnel of the Survey Department have almost all received excellent training in the technical fields necessary for map making. They are well read and current in their knowledge of the technical aspects. However, technical skills alone may not be sufficient. If the proposed project is approved by USAID, the portion of the Survey Department responsible for it will embark upon a genuine production effort. It will require a continuous high level of effort which will impose managerial problems not now being encountered. While management is to a considerable extent an art, a body of knowledge has been accumulated which can help a motivated individual to be a better manager. Consequently, it is recommended that management personnel be provided with training which will apprise them of the methods which are being employed to make effective use of resources in production operations. This can be achieved both through management personnel participation in professional seminars and by providing technical support to the Survey Department during the early critical years of the program.

4.7 Technical Assistance

The Survey Department has a long and distinguished history in Sri Lanka. It is staffed by a group of well-educated professionals in key positions, experienced in traditional survey operations. High altitude small photographic scale survey is, however, new to the department. Their earlier aircraft operated at a maximum altitude of about 12,000 feet. The aircraft recommended for this new mapping program will operate routinely more than 2½ times higher, or above 30,000 feet, with a speed more than twice that of the previous aircraft. It is capable of collecting aerial photography at a rate five times as great as has previously been accomplished here.

Similarly, the department has not previously attempted orthophotography or direct preparation of color separation manuscripts in compilation. This latter technique is required if the proposed Agricultural Base Mapping Project is to be accomplished without an eight-fold increase in drafting and scribing personnel, with attendent management problems. The department also proposes to establish a Remote Sensing/Survey Research Center to conduct applied research in new techniques of mapping and resources survey in Sri Lanka. At the present time, only one individual in the Survey Department has direct experience and training in remote sensing, and there is a general lack of experience with newer analysis techniques and methods, including color and color infrared films, transparency analysis, video image processing, etc.

Perhaps most significantly, the 1:10,000 scale Agricultural Base Mapping Project will be the largest and most complex program ever undertaken directly by the Survey Department. The most recently completed project of comparable scope was the 1:63,360 National Mapping Program. That project, completed almost twenty years ago with the assistance of a Canadian aerial mapping firm, covered the entire country with a series of approximately 75 map sheets. The present 1:10,000 scale mapping project will involve a total of approximately 2,000 map sheets at considerably greater level of detail. This is a major project by any standard, with a reasonably tight time schedule, and incorporates aerial mapping, processing, and cartographic techniques not previously employed in Sri Lanka. Only large and well-organized international photogrammetric firms would undertake to do this job on a contract basis, and then only after careful planning. Considerable management skill, experience and effort will be required to keep the program on schedule and operating within budgetary constraints.

For these reasons and others cited elsewhere in this report it is recommended that the Government of Sri Lanka seriously consider a technical assistance component in this program. Such assistance would be most useful in the following areas:

1. Program Management - to develop scheduling, cost control, and overall program management techniques
2. Map Production - to develop production scheduling, quality assurance control, assist with initiation of automated scribing (color separation) techniques
3. Photographic Laboratory - to develop a centralized photographic laboratory, quality control and assurance in all areas, and to assist with equipment set-up and training
4. Air Survey - to assist in development of flight operations procedures, experimentation with color and color infrared films
5. Remote Sensing/Survey Research Center - to develop training programs in remote sensing technology and applications, utilization and maintenance of analysis equipment, assist in the design and development of programs to evaluate costs and effectiveness of new resources survey, inventory and environmental analysis techniques
6. Geodetic Survey - to assist in strengthening the geodetic net with the aid of satellite geoceiver stations.

The principal objective of this technical assistance is to assist the Survey Department in completing the Agricultural Base Mapping Project on schedule and within budgetary constraints. An important secondary objective is to improve the overall capability and effectiveness of the Survey Department and their several "customer agencies" in the areas of resources survey, agricultural crop assessment, and environmental analysis.

There are three principal means by which such assistance might be provided in Sri Lanka:

1. Specialists hired directly by the Government of Sri Lanka
2. Short-term specialists, provided under contract from a qualified private firm.
3. One longer-term specialist, supported as required, under contract from a qualified private firm.

The principal specialist and supporting personnel must be individuals with substantial technical and management experience on major international mapping programs. Such individuals are in

constant demand, and it is highly unlikely that qualified personnel can be found for direct-hire positions in any reasonable period of time. Short-term specialists are available, however mobilization and per diem expenses for short-term personnel can easily exceed labor costs, reducing the effective assistance available for any fixed budget.

It is recommended that Sri Lanka obtain the services of one "long-term" technical advisor, experienced in all phases of aerial photography, cartography, and map production, for a period of two years, supported as required by additional technical specialists under an Indefinite Quantity Contract or similar arrangement. This would permit the maximum flexibility to deal with any problems that might arise. The following schedule of technical assistance might be appropriate:

		Long-Term	Short-Term
Year 1:	Technical Advisor	12 mm	
	Geodetic Survey Specialists		2 mm
	Other Short-Term Specialists (Remote Sensing, Photo Lab, Other as Required)		3 mm
Year 2:	Technical Advisor	12 mm	
	Short-Term Specialists		2 mm
Year 3:	Short-Term Specialists		2 mm
Year 4:	Short-Term Specialists		2 mm
Year 5:	Short-Term Specialists		2 mm
		24 mm	13 mm

4.8 Remote Sensing and Survey Research Center

As noted in an earlier report,[1] a "Survey Research Center" (or "Remote Sensing Research Center") should be established within the Survey Department, Ministry of Agriculture. This center would

[1] Craib, K.B., and J.W. Cain, "Agricultural Resources Inventory and Base Mapping in Sri Lanka: A Program Assessment and Evaluation," Resources Development Associates, AID/afr-C-1135-4, November 1976, pp 36-37.

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provide a focal point for applied research and operational evaluation of new photogrammetric and resource survey techniques. These might include comparisons of cost and effectiveness of orthophotography, both for general mapping and cadastral survey, the use of color and color infrared films for forest and watershed analysis and agricultural crop inventory, the utility of satellite data of the LANDSAT type, machine-assisted interpretation and analysis of aerial and satellite data, the use of light tables and stereomicroscopes for high resolution analysis, and investigation of similar operational applications.

The Survey Department is the logical organization to house such a center. It is presently engaged in similar work on a reduced scale and currently holds a small NASA Research Grant to investigate potential applications of LANDSAT technology. Although additional training might be desirable in certain areas as new procedures are attempted, the department currently has a nucleus of trained personnel who could form the core of the center staff.

At the present time, a number of agencies are using photo interpretation techniques. None of these "operational" agencies have the facilities, equipment, training or budget required to conduct research in these areas. Photo interpretation work is done directly from panchromatic prints using hand lenses and pocket stereoscopes, supplemented with a few simple mirror stereoscopes. No analysis work is done using even basic light tables, transparencies and stereomicroscopes. As a consequence, as noted in earlier reports, <u>less than half</u> of the latent information contained in this photography is available to the interpreter, simply because of a lack of adequate equipment and technique.

The "Remote Sensing and Survey Research Center" will require certain basic items of equipment to support applied research activities. Training in maintenance and operation will also be required. This equipment would be available at a central location for use by other agencies once operational feasibility is demonstrated in particular areas. These "customer agencies" should be encouraged

to participate in applied research activities as appropriate. As new techniques are developed and operationally proven, the center should establish the necessary training programs to provide for technology transfer to these customer agencies.

4.8.1 Equipment

The Remote Sensing and Survey Research Center will require the following items of equipment, or their technical equivalent, to accomplish its role:

• Richardson 940 Light Tables (2 each)	$5,500
• B&L 240R Stereomicroscope and Bridge	5,000
• B&L SIS-95 or Zoom 70 Stereomicroscope	4,000
• B&L Zoom Transfer Scope, Model ZT4-H with photo attachments	7,000
• I^2S Video Image Processor	25,000
• Miscellaneous test, calibration and support equipment	3,000
• Reference materials, publications and training aids	1,500
• Color infrared film and processing	2,000
• Color film and processing.	2,000

4.8.2 Facilities

The center should be housed within the Survey Department, physically near the photogrammetry operation. The majority of equipment could be installed in one or two rooms. The rooms should be air conditioned, to prolong the life of the equipment, and should be interior rooms (no windows) with independent light control.

4.8.3 LANDSAT Data

The Survey Department presently holds a small NASA grant for research with LANDSAT data. Under this grant, they have completed some basic data processing using computer facilities available in Sri Lanka. The equipment recommended for the center will provide for continued experimentation at larger scales.

LANDSAT data is not sufficiently accurate (by an order of magnitude) to prepare base maps at the 1:10,000 scale as required by the Agricultural Base Mapping Project. It is expected to be quite useful, however, for regional resources assessment purposes, once adequate base maps are available. A principal objective of the Remote Sensing/Survey Research Center would be to determine the utility and cost-effectiveness of LANDSAT data as applied to particular problems in Sri Lanka.

4.8.4 Training

Personnel within the Survey Department and other GSL resource agencies have been trained in photogrammetry and basic photo interpretation. Additional familiarization and training will be required in the areas of high resolution transparency analysis, video image processing, LANDSAT data applications and orthophotography. This training could be accomplished partly through organized training seminars conducted in Sri Lanka and partly through attendance at international conferences and symposia.

The following typical training program is suggested. This may of course be modified and should be flexible to accommodate new requirements:

Training Seminars in Sri Lanka

1. Remote Sensing Technology - Review of fundamentals, history, development, current state-of-the-art, experimental programs. Geographic applications,

land use, vegetation and watershed management, agricultural inventory, geological exploration. Use of small-scale photography, transparencies, stereomicroscopes, video image processors, color density slicers. Pan, color and color infrared photo interpretation.

Typical training seminars could involve four senior instructors for two weeks, with a class of 20-30 people and training materials.

2. Orthophotography - International conferences and symposia.

- International Remote Sensing Symposium, University of Michigan, Ann Arbor, Michigan. (Held every 18 months. Next symposium is April 1977)
- International Conference on the Economics of Remote Sensing. (Held annually in January)
- ASP/ACSM Conference (American Society of Photogrammetry/American Congress of Surveying and Mapping, Joint Conference), Washington, D.C. (Held annually in March)
- Pecora Memorial Symposium on Remote Sensing USGS/EROS Data Center, Souix Falls, South Dakota (Held annually in November)
- Other conferences on application of remote sensing in agricultural services, geography, geological exploration, photogrammetry and cartography held irregularly at a variety of universities and government facilities.

Typical attendance would be two individuals attending one conference each every year. Attendance at two conferences each in the first year of the Agricultural Base Mapping Program is recommended.

4.9 Geodetic Net

The primary control system of point positioning presently in use is adequate for the production of 1:10,000 scale maps. However, strengthening of the net is deemed to be necessary for mapping at larger scales - 1:5,000 for engineering purposes and 1:2,000 and 1:1,000 for cadastral use.

The best means for strengthening the geodetic net would be through use of the Doppler signals from the presently operating U. S. Geodetic Satellite. Geoceiver stations would have to be installed to obtain the necessary data.

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A peripheral benefit from such signals will be the mathematical basis for a recomputation of the entire Sri Lanka First Order Net. Also, this will provide the necessary data for relocation of the net onto the presently accepted international spheroid figure, rather than the currently used Everest spheroid figure.

It is estimated that the geodetic readjustment program will involve support from the U.S. Geological Survey Department and NASA. About three months will be needed for the basic observations at five selected geodetic points, four on the periphery of the island, one in the center.

The geoceivers can be leased. Because of the relatively short period of time they are required, this would be less expensive than purchasing them. The cost of leasing the five instruments is estimated to be approximately $10,000. An estimated two man-months of short-term technical assistance would be required to support this operation.

5.0 OPERATIONS PLANNING

The Survey Department, although currently preparing some maps, is not actually operating on a production basis insofar as map making is concerned. A true production basis can only be achieved when an aircraft is available and operating on a regular schedule to obtain the necessary aerial photos. Since there is, therefore, no historical data on which to base plans, they have to be developed on a theoretical basis.

The photo acquisition portion of the map making project is by nature a batch process. The aerial photos are obtained in a batch or roll consisting of 250 individual 9" x 9" frames, or less depending on the requirements of the mission. The number of photos taken, the altitude of the aircraft above average terrain, the focal length of the lens and the scale of maps produced all influence the amount of work to be done in making maps. This, in turn, determines the time and manpower required. Consequently, in developing a plan for the production of maps which will efficiently utilize resources it is necessary to combine a forecast of requirements with an estimate of map production capacity. This is also necessary to plan and schedule production, balance work flow and avoid backlogs and delays.

5.1 Production Requirements

As discussed in Appendix A, it is estimated that approximately 2,300 photos will be required to obtain complete coverage of the country. This figure includes an additional 25% for remakes due to terrain, etc. For planning purposes, this is also assumed to be the number of models or stereo pairs which will be required. The Survey Department plans to acquire the photos and make the maps within a five-year period. With a total of 2,300 photos estimated, this is about 460 per year. This figure, then provides the basis for planning and scheduling production operations.

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5.2 Production Capacity

The additional equipment and improvements proposed will provide the Survey Department with the capability to complete the Agricultural Base Mapping Project well within a five-year period. It will also provide the capacity to undertake other mapping work which almost certainly will arise when portions of the country are mapped at the 1:10,000 scale.

To produce approximately 460 maps per year will require a production rate of 1.9 models/day (460 models/year ÷ 240 days/year). Since the estimated potential production rate will be 3.2 models/day (Appendix A) the 1:10,000 scale mapping project alone will account for only 59% of the capacity over a five-year period.

This "excess" capacity can be utilized in either of two ways. The Survey Department could use their full capacity to work exclusively on 1:10,000 scale mapping, and thus complete the task in less than five years. This would mean that all current survey projects, mapping operations, and the development projects dependent on them would have to be postponed for at least three years. The other alternative is to use the "excess" capacity to accommodate the current and continuing work load. This latter approach appears more compatible with the economic objectives of the country, and the only logical choice.

It is also expected that there will be considerable demand for larger scale maps, once the 1:10,000 series is available. In considering the amount of additional work the Survey Department will be able to devote to other than 1:10,000 scale mapping, it should be noted that the time and effort to make maps increases as the square of the increase in scale. In other words, to map an area at 1:5,000 scale requires four times the number of models, and thus, work, that it does for 1:10,000 scale. In Table 8 this effect of map scale on the number of models is illustrated for those cases which are most likely to occur. Also shown is the approximate ground area covered by each scale.

Scale	Models	Area/Model Square Miles	Excess Capacity* Square Miles
1:10,000	1	16.18	4,983
1:5,000	4	4.05	1,247
1:2,500	16	1.01	311
1:2,000	25	0.65	200
1:1,000	100	0.16	49

* Yearly estimated production mapping capacity, in excess of that required to support the 1:10,000 Agricultural Base Mapping Project

Table 8: RELATION OF MAP SCALE AND MAP PRODUCTION

With an estimated production rate of 3.2 models/day and 240 working days/year, the Survey Department will be capable of making maps from 768 models each year. On the average that means the excess capacity over that required for 1:10,000 scale maps is 308 models. On that basis, the third column of Table 8 indicates the corresponding additional ground area that can be mapped each year for any given scale.

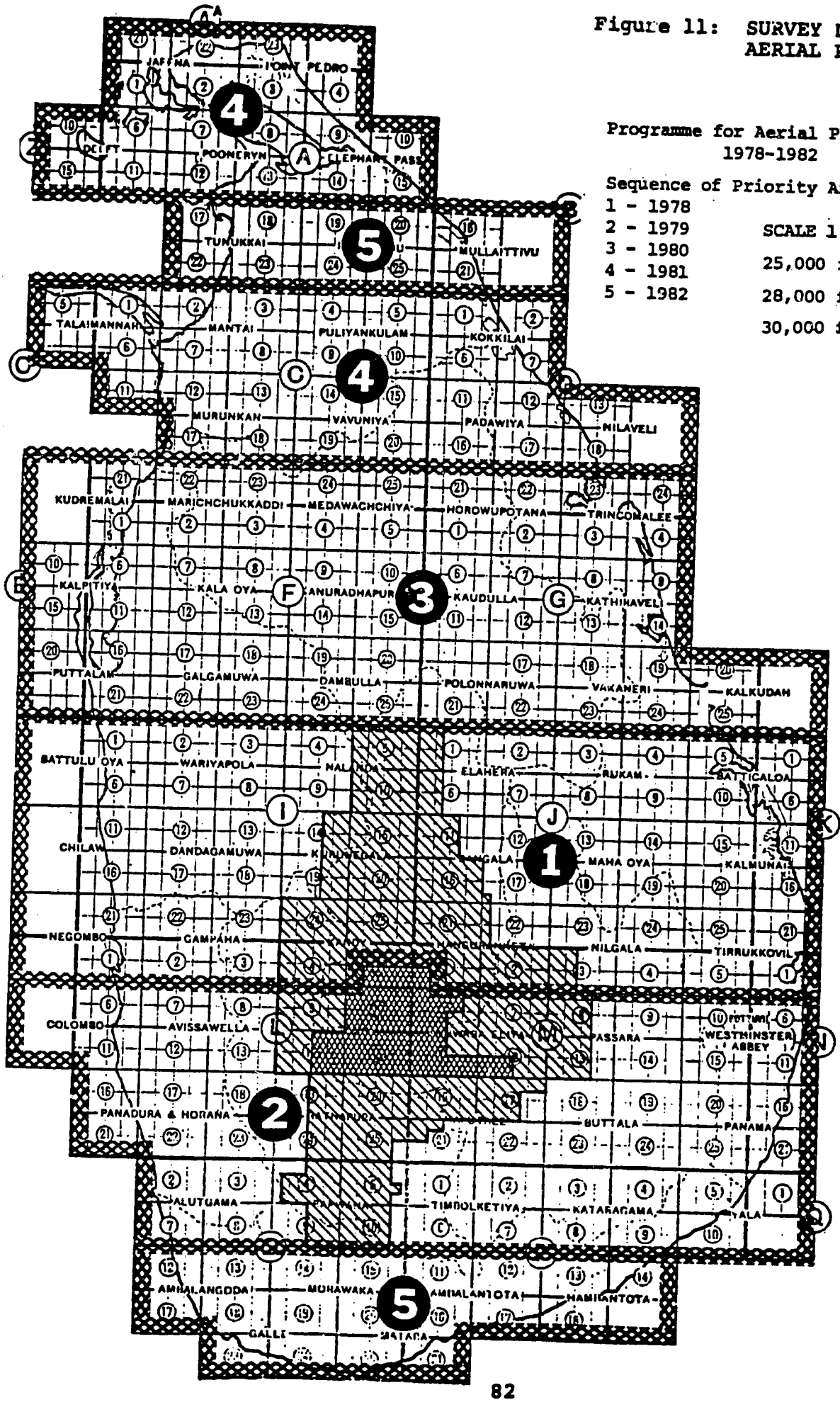
5.3 Survey Department Proposed Schedule

The Survey Department has provided a general schedule of operations. The sequence in which aerial coverage would be flown, and maps made, reflects national priorities concerning agricultural development. Each area of the country and the year in which coverage is planned is shown in Figure 11. These areas, as indicated, vary considerably in size and, therefore, in the amount of work necessary to map each. The cross hatched areas in the lower center of Figure 11 indicate those areas which have to be flown at higher altitude.

The program as indicated by Figure 11 would result in the heaviest effort in the first year, tapering off steadily thereafter as shown in Table 9. This schedule will obtain 1:10,000 scale maps of the high priority areas of the country very quickly. In fact, it will cover half the country in the first two years and three-quarters in three. The disadvantage, though, is that this leaves little capacity for making larger scale maps during this period, as indicated by the last two columns of Table

To put this in perspective, consider as an example the potential need for 1:5,000 scale maps from aerial photos. According to the above schedule, the Survey Department will have the excess capacity to handle about 155 models (768 - 613 = 155) during the first year. A 1:5,000 scale map covers a ground area of 4.045 square miles. In terms of ground area, then, the Survey Department would be able to map 627 square miles (155 x 4.045 = 627). This is equivalent to an area just a little larger than one of the 28 x 18 mile 16 chain grid area.

Figure 11: SURVEY DEPARTMENT AERIAL PHOTO PLAN



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Year	Number of Models Per Year	Portion Country Covered	Cumulative Average	Capacity Utilized	Excess Capacity
1	613	27%	27%	80%	20%
2	574	25%	52%	75%	25%
3	518	23%	75%	67%	33%
4	355	15%	90%	46%	54%
5	241	10%	100%	31%	69%

Table 9: PRODUCTION IMPACT OF SURVEY DEPARTMENT AERIAL PHOTOGRAPHY PROGRAM

5.4 Proposed Alternative Schedule

The photo coverage of the 1:10,000 scale Agricultural Base Mapping Project will not match perfectly the grid lines and, thus, the priority areas identified in Figure 12. Therefore, the schedule as shown is only approximate. If the boundaries of the priority areas are adjusted slightly, as recommended, to more closely approximate the area to be covered in 1:10,000 scale mapping, a somewhat more evenly balanced program will result. If the country is divided as shown in Figure 12 for the photo project, the results will be as indicated in Table 10. It can, of course be adjusted further to provide even better balance.

The alternative photo plan provides for eight flight lines (east-west) in each priority area for most of the country. All but the most northerly two sections are comprised of 45 mile wide strips. Since the distance between flight lines will be 5.68 miles to provide 20% overlap, eight flight lines will cover a strip 45.4 miles wide (5.68 x 8 = 45.44).

The alternative photo coverage plan forms the basis for a preliminary implementation plan for the Agricultural Base Mapping Project. On initiation of the project a detailed final work plan will have to be developed. That plan would specify the exact flight lines and areas to be included in each map sheet and the specific areas of the country to be flown in each year. Priorities may change somewhat before the project gets underway. The specific area of the country covered has little impact on map production. However, the size of the area covered does. A fairly constant load or input makes planning and management somewhat simpler than if the requirements vary within a year or from year to year.

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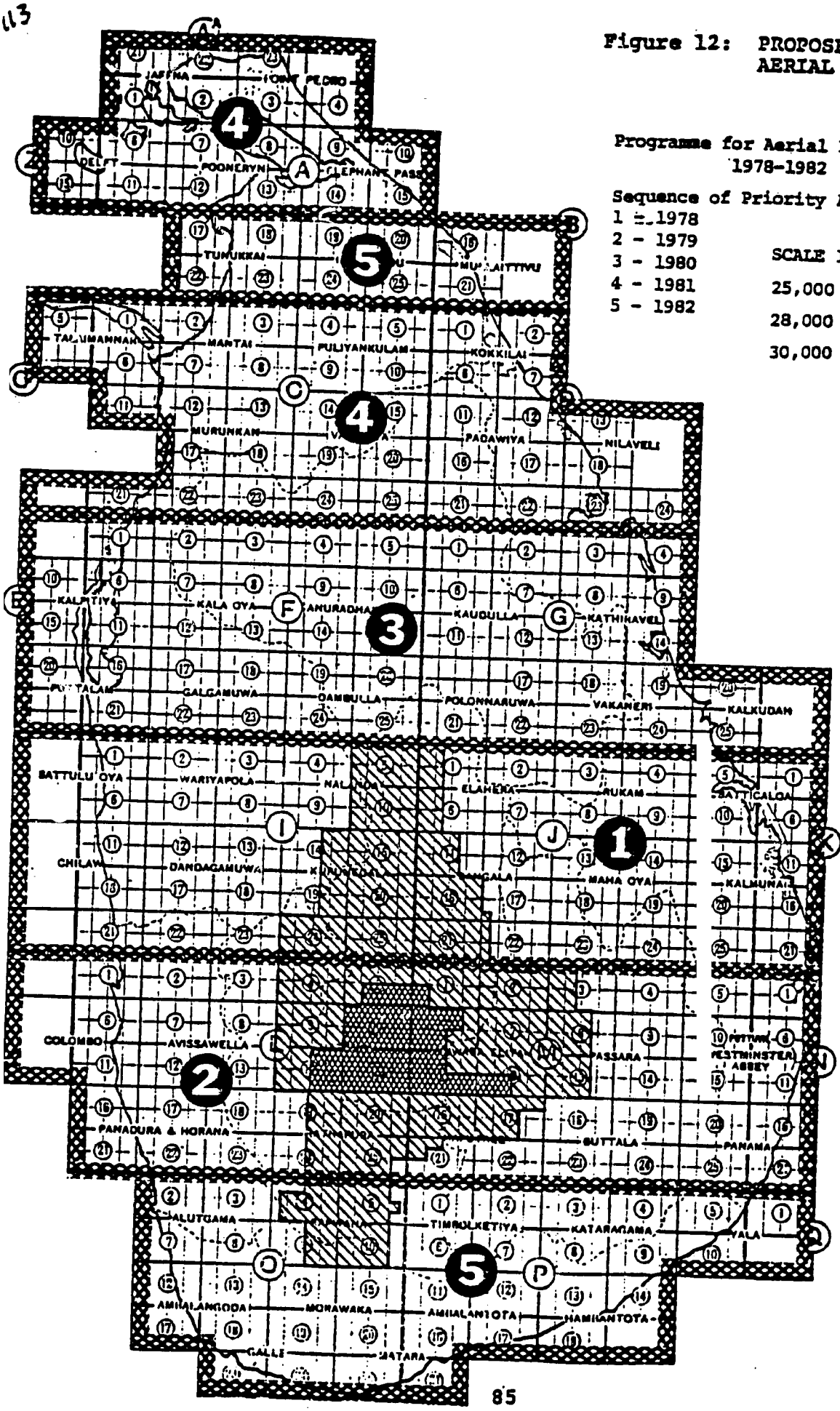
Figure 12: PROPOSED ALTERNATIVE AERIAL PHOTO PLAN



Year	Number Of Models Per Year	Portion Country Covered	Cumulative Average	Capacity Utilized	Excess Capacity
1	508	22%	22%	66%	34%
2	546	24%	46%	71%	29%
3	448	19%	65%	58%	42%
4	431	19%	84%	56%	44%
5	367	16%	100%	48%	52%

Table 10: PRODUCTION IMPACT OF ALTERNATIVE AERIAL PHOTO PROGRAM

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5.4.1 First Year

In accordance with the proposed alternative plan, the requirements for the first year of operation would be as follows:

Number of Models		508
@ 25,000' altitude	408	
@ 28,000' altitude	100	

Photo Missions

8 flight lines @ average 150 miles each @ 25,000'
6 flight lines @ average 35 miles each @ 28,000'
2 flight lines @ average 50 miles each @ 30,000'

Flight Schedule

One 150 mile mission + one 35 mile mission every 6-7 weeks for first six flights

One 150 mile + one 50 mile mission every 6-7 weeks for last two flights

Elapsed time 48-56 weeks

Map Production

Rate 1.9 models/day x 5 days/week = 9.5 models/week
Input approximately 64 models every 6-7 weeks
Time to map mission:
@ 9.5 models/week = 64 ÷ 9.5 = 6.7 weeks
Time to make 508 maps:
@ 9.5 models/week = 508 ÷ 9.5 = 53.5 weeks
@ 9.8 models/week = 508 ÷ 9.8 = 51.8 weeks

Rather than break flight lines and risk the problems of properly matching discontinuities, it is planned to make continuous flight lines over terrain of higher altitude. To maintain the proper distance above terrain the higher elevations will then be reflown at the proper altitude.

5.4.2 Second Year

The proposed plan for the second year contains coverage of the area of highest elevation in the country. If mapping this area is not really a high national priority it could easily be deferred until subsequent years, thus reducing the effort in the second year to be more in line with the others.

Number of Models		546
@ 25,000' altitude	370	
@ 28,000' altitude	130	
@ 30,000' altitude	46	

Photo Missions

8 flight lines @ average 150 miles each @ 25,000'
8 flight lines @ average 40 miles each @ 28,000'
4 flight lines @ average 25 miles each @ 30,000'

Flight Schedule

One 150 mile mission every 6-7 weeks
One 40 mile mission every 6-7 weeks
One 25 mile mission every 6-7 weeks

Map Production

Rate 1.9 models/day x 5 days/week = 9.5 models/week
Input approximately 68 models every 6-7 weeks
Time to map mission:

@ 9.5 models/week = 68 ÷ 9.5 = 7.2 weeks

Time to make 546 maps:
@ 9.5 models/week = 546 ÷ 9.5 = 57.5 weeks
@ 10.5 models/week = 546 ÷ 10.5 = 52.0 weeks

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If in fact it is necessary to map all of the year indicated in year two, it will be necessary to devote slightly more resources to the effort than planned. To complete maps of the area within 52 weeks it will be necessary to increase the production rate to 10.5 models per week or 2.1 models per day. An alternative is, of course, delaying the 30,000' photography to a later year.

5.4.3 Third Year

During the third year all photography would be taken from the same altitude, 25,000'

Number of Models 448

Photo Missions

8 flight lines @ average 130 miles each @ 25,000'

Flight Schedule

One 130 mile mission every 6-7 weeks

Map Production

Rate 1.9 models/day x 5 days/week = 9.5 models/week
Input approximately 56 models every 6-7 weeks
Time to map mission:
@ 9.5 models/week = 56 maps ÷ 9.5 maps/week = 6 weeks
Time to make 448 maps:
@ 9.5 models/week = 448 ÷ 9.5 = 47 weeks
@ 8.7 models/week = 448 ÷ 8.7 = 51.5 weeks

5.4.4 Fourth Year

The fourth year of the project involves somewhat shorter flight lines, and more of them, and covers the north end of the country and areas of the most irregular coastline. All of the photography will be flown at the same altitude, 25,000'.

Number of Models 431

Photo Missions

8 flight lines @ average 90 miles each @ 25,000'
6 flight lines @ average 45 miles each @ 25,000'

Flight Schedule

One 90 mile mission every 4 weeks for 32 weeks
One 45 mile mission every 2 weeks for 18 weeks

Map Production

Rate 1.9 models/day x 5 days/week = 9.5 models/week
Input approximately 56 models every 6-7 weeks
Time to map mission:
@ 9.5 models/week = 56 models ÷ 9.5 models/week = 6 weeks
Time to make 431 maps:
@ 9.5 models/week = 431 ÷ 9.5 = 45 weeks
@ 8.3 models/week = 431 ÷ 8.3 = 51.9 weeks

5.4.5 Fifth Year

The coverage of the last year of the project is split between the southern tip of the country and a band in the far north. The flight lines are therefore generally shorter than average.

Number of Models 367

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Photo Missions

3 flight lines @ average 125 miles each @ 25,000'
3 flight lines @ average 90 miles each @ 25,000'
4 flight lines @ average 60 miles each @ 25,000'
3 flight lines @ average 30 miles each @ 28,000'
2 flight lines @ average 45 miles each @ 25,000'

Flight Schedule

One 125 mile mission every 6 weeks for 18 weeks
One 90 mile mission + one 30 mile mission every 6 weeks for 18 weeks
Two 60 mile missions every 6 weeks for 12 weeks
Two 45 mile missions the 48th week

Map Production

Rate 1.9 models/day x 5 days/week = 9.5 models/week
Input: approximately 56 models every 6-7 weeks
Time to map mission:
@ 9.5 models/week = 56 models ÷ 9.5 models/week = 6 weeks
Time to make 367 maps:
@ 9.5 models/week = 367 ÷ 9.5 = 38.6 weeks
@ 7.1 models/week = 367 ÷ 7.1 = 51.7 weeks

6.0 EQUIPMENT PROCUREMENT (CAPITAL ITEMS)

Items of capital equipment required by the Survey Department are listed in sections 4.4 and 8.2. In the majority of cases, required items are available from only one manufacturer (as in the case of Wild Autograph and Kodak Versamat equipment) and that item is designated by trade or manufacturer's name. The source listed is either the only manufacturer of this type of equipment, or the specific equipment type is required to properly interface with existing equipment. Where directed procurement is not essential, a suggested source is given for major items, followed by an "or equal" qualification.

The only major exception to the above is in the case of aircraft procurement. On the basis of both published data and actual flight test performance, the Cessna 421C aircraft is recommended. With the required modifications included, it also appears to be the least expensive aircraft. This is, however, a major procurement item and competitive bidding may be required. Accordingly, performance, equipment, and other specifications considered essential to this project are presented here as an aid in equipment procurement.

Certain items relating in general to equipment procurement for this project should be noted. These include the following:

1. It is recommended that USAID strongly consider furnishing major items of capital equipment to the GSL in kind instead of in cash. Several equipment suppliers have indicated their costs may increase by factors ranging from 50% to 80% if purchase is made directly by an agent in Sri Lanka. This would appear to particularly apply in the case of aircraft purchase and the purchase of triangulation and compilation equipment. Purchase of smaller items, or of expendables directly by the Survey Department, does not seem to have this type of problem.

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2. Modification of a pressurized aircraft is not a simple task and requires skilled and experienced personnel. Only one aircraft manufacturer (Beech Aircraft) provides this modification directly; all others are on a contract basis by independent organizations. Aerial survey companies purchasing aircraft so modified normally monitor this modification procedure and subsequent test phase to insure aircraft flight safety. It is recommended that USAID or the GSL closely monitor this modification, or arrange for other independent verification.

6.1 Aircraft Procurement and Modification

The aircraft purchased for aerial photography in Sri Lanka should meet or exceed the following technical specifications.

6.1.1 General Description

A twin-engine pressurized aircraft modified for aerial photography, capable of sustained flight operations with five crew members and camera (estimated crew and camera weight of 1,200 pounds) for four hours at an altitude of 28,000 feet, with a minimum operational service ceiling of 30,000 feet.

6.1.2 Equipment Configuration

The aircraft should be equipped with the following minimum instrumentation and equipment. Bidders should supply a complete itemized and priced list, including optional equipment or systems they may recommend:

Dual Nav/Com (Cessna 400 series or equal), dual ADF, with Glide Scope, Marker Beacon, DME, basic electronic kit and antennas, dual-pointer RMI with slaved compass and heading bootstrap. Single side-band HF transceiver with long antenna (ARB-130 HF or equivalent). 24-hour 8-day clock, flight hour recorder, and synchronous tachometer. Fuel economy mixture or EGT indicator.

High intensity strobe lights, locator beacon, heated static source, OAT indicator, autopilot, dual controls and standard flight instruments on copilot panel.

Additional items desired include:

Cabin air conditioning, corrosion proofing, propeller de-ice system, complete with partial plumbing for remainder of de-ice system; fuselage ice protection plates, engine fire detection and extinguishing system, cabin fire extinguisher, relief tube, low-level fuel warning system, supplemental oxygen system (minimum 100 cu. ft.), and fully adjustable pilot and copilot seats. Pilot and copilot oxygen masks should include integral microphone.

6.1.3 Special Instructions

Aircraft must be modified to accept either an RC-10 camera or an RC-8 camera with adapter, a Wild NF-2 viewfinder, and B3 driftsight. Viewfinder and driftsight should be located in aft cabin area. Seating should be such as to allow simultaneous operation of viewfinder, driftsight, and camera by three separate crew members.

A glass plate should be installed below the camera to insure pressure integrity of the aircraft. Glass should be Grade A material, ground and polished in accordance with Group M (MIL-G-1366E) specifications, and should be approximately 90% transparent over a minimum range of 4,000-10,000 Angstroms wavelength. Spectral transmittance curves should be provided for the particular glass plate installed in aircraft.

A sliding door, electrically or manually operated, should be installed to protect camera glass during takeoff and landing. Door should be operable in flight.

All cabin windows should be of clear material, without tint (cockpit windows may be tinted).

GSL Survey Department NF-2 viewfinder and B3 driftsight should be provided to successful bidder to facilitate installation in aircraft and to insure integrity of pressure hull.

A full pressure test and inspection should be performed after completion of all modifications to confirm pressure integrity.

Aircraft modification should include power leads for NF-2, B3 and RC8 camera as required, together with facilities for mounting RC8 control unit near camera.

6.1.4 Known Sources of Supply

The following aircraft are capable of meeting minimum performance specifications:

Cessna 421C (Executive Commuter) - Address bid request to:

Mr. R. A. Brown
Manager, Cessna Division
Heli Orient (Pte) Limited
P. O. Box 17, Jalan Kayu
Singapore 28

(Telephone: 4815311)

with bid request copy to:

Mr. Sam Jantzen, Jr.
Manager, Far East and Pacific Sales
Cessna Aircraft Company
P. O. Box 1521
Wichita, Kansas 67201

Piper PA-31P - Address bid request to:

Mr. R. H. Utterback
Western Airmotive Company, Inc.
Oakland International Airport
Oakland, California 94614

with bid request copy to:

Mr. C. Raymond Johnson
Director of Sales
Piper Aircraft Corporation
Lock Haven, Pennsylvania 17745

Beech King Air C90 - Address bid request to:

Mr. Frank Steffey
Regional Manager, International Division
Beech Aircraft Corporation
Wichita, Kansas 67201

6.1.5 Training and Familiarization

The successful bidder on the aircraft should provide a training and familiarization program for pilots and mechanics in Sri Lanka. Training requirements are estimated as a one week ground/transition flight training school for pilots, and a one week maintenance school or mechanics and maintenance personnel.

Most aircraft manufacturers include similar transition training programs, at their facility, at no additional cost. Round trip air fare from Colombo to Wichita, Kansas, is on the order of $2,000. When per diem and other travel related expenses are included, the estimated cost to send two trainees (one pilot and one mechanic) is approximately $5,000. The same course brought to Sri Lanka could train ten or more people for this same amount, or less, if the supplier maintains a facility in the Far East area.

6.1.6 Materials, Supplies and Spares

Aircraft manufacturers commonly recommend a minimum 10% of aircraft purchase price as a guideline for yearly procurement of miscellaneous aircraft/avionics spares and materials. The SLAF presently operates Cessna aircraft and maintains a stock of standard parts and test equipment. If the 421C aircraft is purchased, then a reserve of $100,000 for spares and tools plus $47,500 for engine overhaul plus $5,000 for miscellaneous items, or a total of $152,500 is suggested. This figure should be increased by an estimated $30,000-$50,000 for additional test equipment and parts if an alternative aircraft is selected.

6.2 Aircraft Support

The Survey Department has drafted an agreement with the Sri Lanka Air Force for aircraft support and maintenance. Under the terms of this agreement, the SLAF will perform all necessary maintenance and provide pilots at no cost to the Survey Department. The Survey Department will provide funds (foreign exchange) for fuel, equipment, and maintenance items requiring foreign exchange. In return, the SLAF may use the aircraft for training purposes. Survey Department requirements will have priority over any other use.

Survey Department costs for expendables and reserve for engine overhaul/exchange have been estimated on the basis of 300 hours operation/year. Engine overhaul/exchange is a major expense item, estimated at $35,000 every 1,200 hours, or once every four years at this utilization rate. It is recommended that the SLAF contribute toward engine overhaul on a pro-rate basis reflecting their use of the aircraft for other-than-Survey Department requirements in excess of 300 hours/year.

APPENDIX A

DERIVATION OF MAP PRODUCTION RATE

1.0 INTRODUCTION

To estimate the capability of the Survey Department to produce 1:10,000 scale maps under various conditions it was necessary to begin with the aerial photographic requirements. The output in terms of stereo pairs or models was then used to determine the time it will take to perform the major functions necessary to producing map sheets.

Of the seven major functions in map making discussed in the main body of the report all but two, film processing and printing are considered here. Neither contributes significantly to the processing time and can therefore be disregarded. Photo acquisition although it requires little time relative to other functions is important from the standpoint that it provides the input upon which the map making activities are based. Consequently, photo acquisition was taken as the point of departure. The output of that function was then used to estimate the time it will take to produce maps.

2.0 PHOTO ACQUISITION

The Survey Department has determined the Agricultural Base Mapping Project requirements on the basis of the Index to 16 Chain Record Diagrams.* The Index, in the form of a grid overlaying an outline map of the country provides a foundation for determining the number of aerial photos required. This, in turn, determines the inputs to the map production operations.

The Index shown in Figure A-1 divides the country into some 73 areas identified by name. Each full rectangle is 28 miles long and 18 miles wide. Since the country itself, however, is not rectangular, the grid overlay does not match the borders. Consequently, many of the rectangles are incomplete. Nevertheless, the Index does provide a means of estimating the photo requirements for the 1:10,000 scale maps.

The photography is to be flown at 25,000 feet above mean terrain with 60% forward overlap and a sidelap of 20% ± 5%. Relating this to the Index results in an estimate of a minimum of 32 photographs to cover each 28 by 18 mile rectangle. This is explained in the following paragraphs.

The linear miles gained per photo at 1:50,000 scale where 1 inch = 4,166.6 feet is:

4,166.6 feet/inch x 9 inches/photo = 37,499 feet/photo

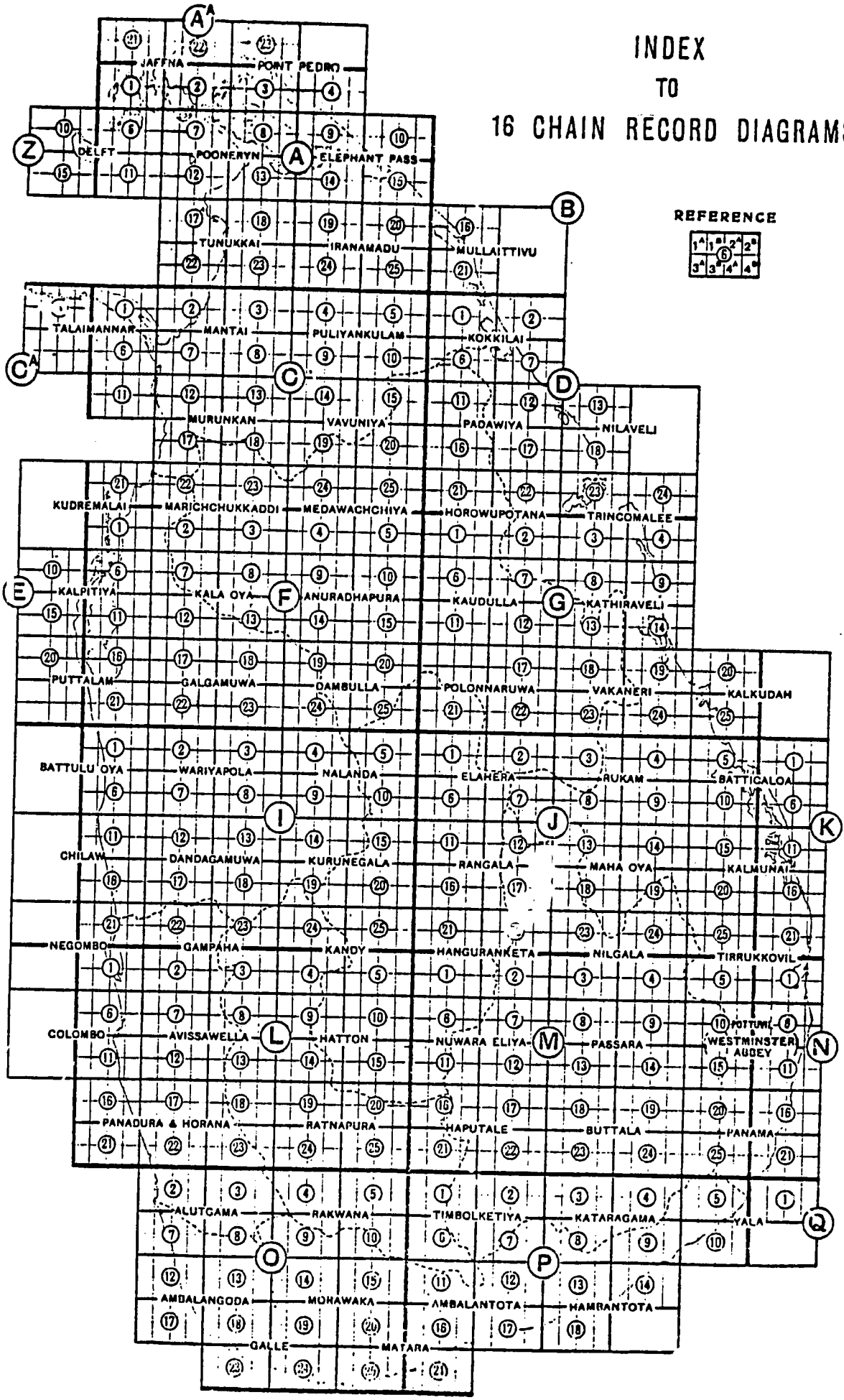
$$\frac{37{,}499 \text{ feet/photo}}{5{,}280 \text{ feet/mile}} = 7.1 \text{ miles/photo on the ground.}$$

With 60% forward lap,

7.1 miles/photo x 0.4 gain = 2.84 miles forward gain/photo.

The longitudinal ground distance of each Index rectangle is 28 miles. Therefore, it requires ten photos at 1:50,000 scale to cover that distance in the direction of an east-west flight line (28 miles ÷ 2.8 miles per photo).

INDEX TO 16 CHAIN RECORD DIAGRAMS



A3

With a 20% sidelap the distance between flight lines is approximately 5.68 miles (7.1 miles x 0.8 = 5.68 miles). The ground width of the map area is approximately 18 miles. Therefore the number of flight lines to cover that width is 3.17 (18 miles ÷ 5.68 miles per flight = 3.17). The number of photos to cover each Index area is, then, 10 x 3.17 = 31.7 or 32 photos. This happens to coincide with the number of grids within each area.

The figure of 32 photos per sheet is a minimum value. This does not account for changes in altitude to account for terrain or errors and rework. Consequently, a factor of 25% has been added for planning purposes. This results in an estimated 40 photos per Index area (32 x .25 = 8 + 32 = 40).

The Index contains 73 named rectangles. However, portions of many of these are water. The partial areas amount to about 15 equivalent rectangles. Therefore, the number of full land equivalent rectangles was estimated to be 58 (73 - 15 = 58).

The total number of photos estimated to be necessary at 1:50,000 scale then is:

58 map sheets x 40 photos per map sheet ≈ 2,300 photos.

For simplicity, this is also the number of stereo pairs or models assumed to be required. To meet the time goal of the project, this means that the Survey Department must, on the average, complete 460 models per year for five years.

The proposed aircraft is capable of the following performance:

Cruise speed = 213+ miles per hour
Flying time = about 4 hours for photo purposes.*

* Limited by lighting requirements and weather conditions. Actual Aircraft endurance exceeds 6 hours.

then, more modest coverage per mission is considered. For planning and estimating it can be assumed that photo missions of about 400 miles on the average are more likely.*

Based on the 1:63,360 scale index the average flight line across the country east and west is 128 miles. Three such flights would amount to about 400 miles (384 linear miles) for a typical mission. This would result in:

$$\frac{128 \text{ miles per flight line}}{2.84 \text{ miles per photo}} = 45 \text{ photos per flight line.}$$

In turn, this would produce 45 x 3 = 135 photos or about 107 feet of film per mission or less than one-half a standard cassette of 250 feet of aerial film.

To cover the country north-south will require approximately 51 flight lines (76 map strips of 1:63,360 x 3.17 flight lines per map strip = 50.7 flight lines). To obtain complete coverage of the country at 1:50,000 photo scale, then, will require an estimated 17 photo missions (51 lines ÷ 3 lines per mission. The photo coverage can obviously be obtained in a relatively short time compared to that required by other functions as is noted in section 3.0. Consequently, two choices are available: proceed with the aerial photo missions as rapidly as they can be made or schedule them in consonance with the map production capacity. The latter is the recommended approach. Otherwise, maps made in subsequent years of the project would be based on photography one to four years old. One of the objectives of the Agricultural Base Mapping Project is to obtain current maps.

* This is a reasonable average for typical aerial photography projects in tropical areas, and will require three to four hours flight time, including time-to-climb, turns on line, and descent.

3.0 BALANCED MAP PRODUCTION RATE

To determine the capacity of the Survey Department to make maps, identify where bottlenecks might occur and provide a basis for planning it was necessary to generate production rates and times for the various steps in the process. In so doing it was intuitively obvious that certain steps were not critical. Film processing can be accomplished quite rapidly with the new equipment recommended and could probably keep pace with photo acquisition Similarly, litho printing is a high speed process which has no inherent bottlenecks. Consequently, the emphasis in determining the map making capacity of the Survey Department was placed on five steps in the process: field control, triangulation, compilation, scribing, and field editing.

In estimating production rates and production times for the important steps in map making, the unit of measure chosen was the model or stereo pair. The functions performed in each step can be expressed in terms of this unit. The number of models produced per unit time is, thus, an expression of production rate common to all five steps.

Production rates in terms of the number of models produced per day are presented in Table A-1. These rates represent the best estimates in view of the various considerations discussed in subsequent subsections. The figures are, of necessity, greatly influenced by the assumptions made. The Survey Department does not have sufficient historical data upon which to base precise production rates. Nevertheless, the information presented is believed to represent reasonably accurate forecasts of future performance based on knowledge of similar operations in other countries.

Because of the combination of individual productivity rate and number of plotting instruments available, compilation is the limiting function in the map making process. The best rate of production which can be realistically achieved in compilation thus sets the pace for the entire operation. There is no point in having

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Field Control (11 man teams)

10 days/point and 1 point/2 models =
1/5 models/day = 0.2
16 teams (176 people) x 0.2 models/day = 3.2 models/day

Triangulation

2 models/day and 2 instruments
2 models/day x 2 instruments x 1 shift = 4.0 models/day

Compilation (including automated scribing)

5 days/model and 8 instruments
5 days/model x 8 instruments x 2 shifts = 3.2 models/day

Field Editing (11 man team)

20 days/model
1/20 model/day/team = 0.05
64 teams (704 people) x 0.05 models/day/team = 3.2 models/day

Scribing (manual)

4 months per model (manuscript)/person
1/20 x 4 = 1/80 model/day/person = 0.0125
256 persons x 0.0125 models/day/person = 3.2 models/day

Table A-1: PRODUCTION RATES FOR MAP MAKING FUNCTIONS

other steps operate at a greater rate because it would not reduce the time required to complete the 1:10,000 scale mapping project. It would, though, result in fluctuations in workload which achieve nothing and complicate management scheduling and planning.

3.1 Field Control

The production rate for establishing additional ground control points is based on estimates of the time required to survey a point and the number of points to be added. The number of teams used is that necessary to match the compilation rate of 3.2 models per day and, thus, balance production. The time required to survey a point and, therefore, the number of teams required is also a function of the transportation available in the field.

The figure of 10 days per point per survey team was a figure provided by the Survey Department based on prior experience. The figure of one point to be added for every two models is based on an estimate of the need for an additional 920 points throughout the country plus a 25% contingency for a total of 1,150 points (920 + 230 = 1,150). Presuming the points fairly evenly distributed, this means an average of one point for every two models (1,150 points and 2,600 models).

3.2 Triangulation

Estimates by the Survey Department of productivity in performing triangulation varied from 1 model per day to four models per day per instrument.

Our best estimate of productivity in triangulation is that based on the completion of two models per day per instrument. It is unlikely that even the most skilled operator will be able to accomplish much more than that. This compares with experience elsewhere and is a rate which if not immediately reached, should be with production experience.

The production rate of four models per day with two instruments sets the pace for map production operations. Ideally, the other functions should be brought up to this level, either through improvements in productivity or by addition of people to balance the flow of work.

It should be noted that the rate of four models per day assumes the addition of a second plotter (Wild A-10). Without the instrument, the output would be two models/day with one shift operation. A second shift would be needed to achieve four models/day.

If the production rate of four models per day can be maintained, as expected, the excess capacity can be utilized to help reduce any backlog in compilation. This is possible since compilation can also be accomplished on the same equipment (the Wild B-8 and A-10) as necessary.

3.3 Compilation

The production rate of the compilation function is based on an estimate of five days per model per instrument. While this rate appears somewhat low it may well be realistic, particularly in view of the necessity to do the compilation in ink rather than pencil as has been the practice. This is absolutely essential, however, if the extremely large manpower requirement of manual scribing is to be avoided.

To maintain a production pace reasonably close to that of triangulation, it will be necessary to either provide two shift operation, increase productivity or some combination of both. The production rate of 3.2 models/day is based on eight rather than the present seven instruments, otherwise the production rate of compilation would only be 2.8 models/day ($1/5 \times 7 \times 2 = 14/5 = 2.8$). Since the compilation rate is the limiting function of the process, it is necessary that it be maintained as high as possible.

It is felt by the Survey Department that two shift operation is possible. A third shift would be very difficult, if possible at all.

3.4 Field Editing

The work involved in checking the manuscript in the field and noting the necessary changes is estimated to require 20 days according to the Survey Department. Each manuscript will cover a little over 11,000 acres (11,264) which means a team must average about 560 acres per day.

To maintain pace with compilation requires 64 field survey parties. Since each party consists of a surveyor and ten laborers, the total manpower required is 704 people. This personnel requirement can be met from among the present Survey Department staff. They currently have some 800 surveyors. The field editing plus the field control work would thus account for about 10% of the present surveying manpower (64 + 16/800 = .10).

The time to edit each manuscript, and hence the manpower required to maintain the production rate, is, in part, a function of the transportation available in the field. If the survey parties can be transported more quickly some savings can be attained. The estimate of 20 days is an average figure. The actual time required is likely to vary considerably according to the terrain, vegetation and cultural features.

3.5 Scribing (Manual)

The productivity figure of 1/80 model/day/person is based on the statement of the Survey Department that hand scribing requires four months per manuscript. In the case of the 1:10,000 scale maps, one model will equal one manuscript.

The hand scribing operation should be largely eliminated as discussed in the main body of this report. If for no other reason, this should be done on the basis of the severe manpower problems which would be imposed if it were not. The large number of skilled technicians who would have to be recruited, trained and managed makes hand scribing a very undesirable method. The requirement to maintain pace at least with compilation would mean hiring roughly eight times the present staff. The problems of acquiring, housing and managing such a group would prove formidable. Unless three shift operation were possible, additional space would be required.

Since it is presumed that color separations will be prepared by the photo process recommended, the manual scribing process is only considered for illustration. If for some unforeseen reason this changes, the figures of Table A-1 provide guidance as to the manpower requirements.

4.0 OPERATIONAL MAP PRODUCTION RATE

If the scribing operation is automated as recommended here, then line balancing indicates that the compilation operation will then be the pacing item ("bottleneck"). The Survey Department has indicated their normal working year consists of 240 days. Therefore, at a maximum production rate of 3.2 models/day and an estimated 2,300 models for the entire country, the base mapping program can be completed in three years (2,300 ÷ 3.2 ÷ 240). This rate, however, requires a mapping program totally dedicated to the production of 1:10,000 scale maps. This is unrealistic in view of existing demands on the Survey Department to produce additional maps at larger scales. Further, these demands can be expected to increase as the 1:10,000 map series becomes available to support planning operations.

A program to complete the 1:10,000 map series within five years would require a production rate of 460 models/year, or approximately 1.9 models/day, assuming 240 working days per year. Production rates and available "excess" capacity for each operation would then be as shown in Table A-2. Aerial photographic operations, at four flight missions per year, would seem to be the most under-utilized area. A typical photographic operation in a tropical region where cloud cover is always a problem might be expected to accomplish one such "mission" (often broken up into two or three flights) per week during the "photo season," or that period of time when cloud cover, solar illumination and other conditions are such that acceptable (cloud-free) photography can reasonably be expected. In Sri Lanka, the normal photo season is estimated to be approximately 16 weeks long. Given these constraints, a requirement of 460 cloud-free photo models per year would represent about 25% of average available capacity. The remaining photo capacity is expected to be utilized for lower altitude photography to support detailed development projects and natural resource assessment programs. For example, the Department of Agriculture has indicated a requirement for 1:20,000 scale photography over

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	Estimated Additional Available Capacity
Aerial Photography	
135 photos or models/flight mission	
4 missions/year = 540 models/year	75%
Field Control	
0.2 models/day per 11-man team	
10 field control teams = 480 models/year	-
Triangulation (2 instruments)	
4 models/day = 960 models/year	50%
Compilation (8 instruments)	
1.6 models/day, one full shift	
3.2 models/day, two full shifts = 768 models/year	40%
Field Editing	
0.05 models/day per 1-man team	
38 field teams = 456 models/year	-

Table A-2: PRODUCTION RATES FOR FIVE-YEAR PROGRAM

an area of 7,000 square miles to support a wetlands and vegetation assessment program. This one request alone could result in 75% utilization of the aircraft in one year, leaving no available capacity to support other programs.

The "excess" capacity shown for the triangulation and compilation efforts is similarly expected to be utilized to support other current and continuing requirements. For example, at a production rate of two models/day, the one existing instrument would be utilized 100% to support the 1:10,000 project, and all other aerial mapping operations in Sri Lanka, and the development projects dependent on them, would have to be postponed for a minimum period of approximately five years.

APPENDIX B

SURVEY DEPARTMENT PERFORMANCE SUMMARY 1970-1975

SURVEY DEPARTMENT PERFORMANCE SUMMARY, 1970-1975

Year	Ground Survey Requested	Ground Survey Accomplished	Percent Accomp-lished	Aerial Survey Requested	Aerial Survey Accomplished	Percent Accomp-lished	Photo-grammetry Requested	Photo-grammetry Requested	Percent Accomplished
1970	904,585	682,668	75%	3,200,000	-0-	0	284,975	222,000	78%
1971	1,084,330	587,636	54%	6,400,000	80,250	1%	265,209	160,509	61%
1972	1,105,000	656,641	59%	9,520,750	1,635,200	17%	1,142,603	977,000	86%
1973	857,788	399,808	47%	11,185,550	1,377,000	12%	1,484,277	1,303,000	88%
1974	528,405	319,082	60%	13,008,550	2,408,900	18%	1,522,321	1,025,600	67%
1975	751,239	541,232	72%	10,599,650	922,500	9%	1,751,000	807,000	46%

All figures given in acres. Channel trace surveys, geodetic unit, and similar work expressed in line miles is excluded on this summary.

APPENDIX C

MEMORANDUM ON THE AIR SURVEY BRANCH - SURVEY DEPARTMENT OF SRI LANKA

Memorandum on the Air Survey Branch - Survey Dept. of Sri Lanka

The Air Survey Branch of the Sri Lanka Survey Department had its beginning in 1955. A small Unit was established with Canadian assistance for preparation of medium and small scale maps. Since then the Unit has expanded its scope with additional equipment and trained personnel. The officers in this Department have now gained experience in Aerial Surveys and Resources Studies of large areas for various projects. In addition to the resources of the Survey Department which consists of all conventional and modern types of surveys and cartographic equipment, the Air Survey Branch is well equipped and is manned by trained personnel. At present it is composed of the following Units :-

(a) Photogrammetric Unit : This Unit is equipped with a Wild A 7, three Wild A8^{S} and 4 Wild B8^{S} and 2 Kelsh plotters. The A 7 and one of the A8^{S} are coupled with the E K 5 Electronic Read-out Mechanism for recording of Model Co-ordinates. Auxilliary equipment such as Pantaphot Optical Enlarger, Wild PUG, Scanning and Mirror Stereoscopes etc. are also available.

(b) Photographic Unit : The Super 18 - Twin Engine Beechcraft fitted with Wild NF 28 Navigation sight and B 3 Driftmeter is used for flying on Aerial Photography. Two Wild RC 8 cameras with wide and narrow angle lens cones are used. The Unit is fully equipped with instruments and materials for photographic processing and printing. A Zeiss SEG V Rectifier and a Wild E 4 Rectifier are also in use.

(c) Computation Unit : The numerous computations involved in Photogrammetry and Geodesy are done in this Section. Electronic Frieden Calculators and other desk calculators are used. In addition, there is access to an ICL 1901/35 Computer. The following Computer Programmes (Fortran IV) specially prepared for a small computer are available :-

(a) Strip Triangulation using 3rd order Polynomials,

(b) Independent Model Triangulation,

(c) Block Adjustment,

(d) Helmert Transformation,

(e) Camera Calibration using field data from our Camera Test Field,

(f) Least Squares adjustment of Triangulation and Level Nets,

(g) Least Squares adjustment of Traverse Nets,

(h) Reduction and Adjustment of Tellurometer and other Precise Traverses,

(i) Computations of Zero- order Traverses,

(j) Conversion of Spherical to Transverse- Mercator and Lambert Conical Co-ordinates and inverse problem,

(k) Matrix operations.

Contd.Page 2.

(d) Preparation Unit : Trained personnel are available in the Unit for Photographic Flight Planning, checking of Negatives and Annotation of the film. The Unit also has trained personnel for mosaicing and preparation of Photographs.

(e) Resources Survey Centre : Capable of performing all physical resources studies. The staff includes specialists in the various Branches of Photo-interpretation.

2. Personnel : The Air Survey Branch and Resources Survey Centre consists of about 100 officers. Most of the Technicians and all the Technical Officers have been trained in Universities and Training Institutions abroad. Annexure 'A' gives a list of trained personnel. The services of a large number of the technical personnel of the Survey Department (over 1000) are also available.

3. Present Jobs : The basic ground control required for Strip or Block Triangulation is obtained from the field. The additional control required is extracted through Aerial Triangulation using the Wild A 7 Autograph and Computer Programmes. Plotting is done on the following scales :-.

(a) 12 Chain to an Inch with 10 ft. contours,

(b) 1/10,000 with 5 Meter Contours,

(c) 1/5,000 with 2 Meter Contours,

(d) 1/2,000 and 1/1,000 for Mapping of Towns,

(e) 8 Chains to an Inch with 10 ft. Contours,

(f) Rectifications using the Zeiss SEG V and Wild E 4 Rectifiers,

(g) Land capability, Land Use Mapping and other Resources Studies.

4. Capabilities : The Air Survey Unit is well equipped to carry out the following tasks :-

(a) Block and Strip Triangulation,

(b) Small Scale, Medium scale and Large scale Mapping with appropriate contour intervals,

(c) Cadastral Mapping,

(d) Camera Calibration,

(e) Rectification,

(f) Soil Surveys and Land Classification,

(g) Land Use Surveys,

(h) Soil Erosion and Conservation Studies,

(i) Forest Surveys and Vegetation Mapping,

(j) Forest Type and Inventory Surveys,

(k) Aerial Photography, processing and printing.

Annexure 'A'

PANEL OF TRAINED PERSONNEL

Name	Qualifications
1. S.D.F.C.Nanayakkara Deputy Surveyor General	B.Sc.(Hons.) Cambridge University Tripos II in Geodesy M.Sc.(Geodetic Science) Ohio State University,U.S.A.
2. S.T.Herat Assistant Surveyor General	B.Sc.(Hons.) Diploma in Surveying (Lond.) M.Sc. (Geodetic Science) Ohio State University, U.S.A.
3. K.M.Kulatunga, Supdt. Air Surveys	B.A.(Hons.) Diploma in Photogrammetric Engineering (I.T.C.)
4. H.B.Sanders Chief Photogrammetrist	B.Sc. (Hons.) Cambridge Tripos II in Geodesy Post-graduate work in Photogrammetry N.S.W.
5. M.P.Salgado Navigation & Photo Lab.	B.Sc. (Hons.) Cambridge Tripos II in Geodesy B.Sc. Survey Navigation (I.T.C.)
6. S.Sridas Resources Survey Centre	B.Sc. Diploma in Photo-Forestry (I.T.C.)
7. E.K.Nanayakkara, Resources Survey Centre	B.Sc. (Hons.) Diploma in Soil Conservation (I.T.C.)
8. S.D.Unnantenna, Resources Survey Centre	B.Sc. (Hons.) Diploma in Soil Science (I.T.C.)
9. E.Seneviratne Computations Branch	Departmental Senior Exam. Computor Programming
10. K.J. de Alwis Photogrammetrist	Photogrammetric Engineering (I.T.C.) 15 Years - Experience
11. P.Theagarajah Senior Technician	Photogrammetric Technician Diploma - I.T.C., Netherlands 13 Years - Experience
12. N.A.Gunawardena Technician	- do -
13. A.Neethinarachchy Technician	Trained in Australia - 13 Years Experience
14. S.Sinnadurai Technician	- do -
15. S.A.C.Perera Technician	Trained in Australia - 9 Years - Experience

Contd. P.2/

Name	Qualifications
16. S.Sivapalasundaram Technician	Presently on training at (I.T.C.) Netherlands 9 Years - Experience
17. V.Kandasamy Technician	Trained in Australia 9 Years - Experience
18. V.G.Poobalan Chief Air Photographer and Lab. Technician	Trained in U.S.A. - Certificate of Merit - General Photogrammetry and Photo Laboratory Technique - Coast and Geodetic Surveys - U.S.A. 18 Years - Experience
19. P.Heenkenda Air Photographer and Laboratory Technician	Trained locally by Foreign Experts 17 Years - Experience
20. M.D.H.Abeyratne	Diploma in Photographic, Systems Engineering,(I.T.C.) Netherlands 18 Years - Experience
21. G.Speck	Trained locally by Foreign Experts 16 Years - Experience
22. M.Ratnavel	Trained locally 3 Years - Experience
23. C.Gangoda Apprentice Air Photographer and Laboratory Technician	

Plus many more technicians and experienced surveyors (from a total departmental technical staff of over 1000)

Consultants :

1. Dr.(Ms) L.S.K.B.Herat Deputy Director, Agricultural Development, Ministry of Agriculture & Lands	B.Sc. (Geology); Degree in Photogeology (I.T.C.), Diploma in Soil Surveys (I.T.C.), Ph. D. University of Paris; Speciality:- Ground Water, Diploma in Project Identification & Evaluation, U.N.Asian School, Bangkok, Member of the Rostor of U.N.Experts in Photogeology & Hydrogeology.
2. Mr.A.D.N.Fernando Senior Deputy Director (Planning) Ministry of Irrigation, Power & Highways	B.Sc.; Degree of Photogrammetric Engineering (I.T.C), Degree of M. Sc. in Photogrammetric Engineering (I.T.C.), Diploma in Public Administration, U.N.Courses in Water Resources Management, Hydrology & Geomorphology.

APPENDIX D

REPORT TO COMMITTEE OF INQUIRY ON AIR SURVEY BRANCH

AIR SURVEY BRANCH

The Air Survey Branch was inaugurated in 1956 with equipment handed over from the Photographic Survey Corporation of Canada on Canadian Air under the Colombo Plan. A fully equipped Photo Laboratory was made available for development and printing of Air Photos and enlargements and rectified enlargements. One Kelsh Plotter was installed for photogrammetric plotting. An Asst. Supdt. and two Surveyors functioning as Photogrammetric Technicians manned the Branch at this time.

2. Air Photography and Photo Laboratory

Air Photography in Ceylon commenced in 1952. This was by the photographic Survey Corporation of Canada. In 1956 they did a complete photo-cover of the Island on the scale of 1:40,000. Large scale photography was also done in certain areas, e.g., Sinharajaha Forest and Kirindi Oya basin 1:20,000. City of Colombo 1:10,000, Trincomalee Area 1:6,000.

3. This photo-cover was adequate for the immediate needs of the country and therefore the emphasis of work by the Survey Dept. at the inception was on photo laboratory work production of contact prints, enlargements and rectified enlargements.

4. The Govt., however, was aware of the need for the development of our own Air Photographic Unit. As no Aircraft was available a start was made to undertake Air Photography in collaboration with the R.A.F. with their Aircraft (Dove) and Camera. One Asst. Supdt. of Surveys functioned as Navigator assisted by two others - a Surveyor and a Draughtsman.

5. Our Air-craft (Beechcraft under Canadian Aid) arrived in 1958, and a Pilot and Co-pilot were recruited to fly this. This Aircraft crashed during familiarisation flights by the Pilot. The next Aircraft ordered as replacement crashed on the way. The third Aircraft (Beechcraft 4R-AAU) arrived in Sept. 1959, and is still in use.

6. In view of the first accident, the proposal of having our departmental Pilot was abandoned and the Aircraft was handed over to Air Ceylon for flying and maintenance under an Agreement.

7. In 1958 two Wild RC8 cameras were obtained on Canadian Aid and a separate photo laboratory was created and the staff was increased by 6. Photography was made one of their duties and they were designated Air Photographer and Lab. Technicians. In 1960, four Lab. Assistants too were recruited.

8. Air Photos are used in every development project. They are used -

(i) directly as a base Map,
(ii) to produce base maps with contours by photogrammetric plotting,
(iii) for Resources Survey - Land Use, Soil, Forestry, Geology, etc.

9. It was the intention of the Department to meet all the requests for photographs from other Departments and also take photographs on larger

scales

scales whenever the necessity arose -e.g., for Town Surveys, Gal Oya Project for detail photo interpretation. The Island cover done in 1956 on 1:40,000 was sufficient for most of the purposes and is still used.

10. In terms of the maintenance contract with Air Ceylon a minimum of 250 flying hours per year has to be done, and a minimum of 4 flights per week. However in practice Air Ceylon has been able to give us only about 100 hours a year. The figure for the last 6 years are as follows:-

1968 - 22 hours
1969 - 165 "
1970 - 136 "
1971 - 163 "
1972 - 174 "
1973 - 49
up to now.

11. The major jobs that were done are -

Year	Name of Project	Scale	Extent (sq. miles)
1962	Forest Reserve - Ganga Palatha Korale Kandy Nuwara Eliya District.	1/20,000	431
1963	Soil Survey Mapping - in 1" Sheets Gal Oya	1/25,000	2000
1966 -67	M.R.B.D.	1/25,000	312
1968	Kala Oya Basin	1/10,000	
1968	Mullativu - Iranamadu Specification Sys.	1/20,000	110
	Uda Walawe Scheme	1/20,000	85
1969	Dewahuwa Scheme	1/10,000	30
1969	Gal Oya Demonstration Project	1/15,000	570
1970-71	Mahaweli H and I.H Area	1/10,000	725
1970	Vakaneri Specification Survey	1/25,000	75
1970	Iranamadu Specification	1/8,000	60
	Mahaweli Ganga R & L Banks	1/10,000	72
1970-73	Photography of the Island	1/25,000	9120
	Sinharajah Forest	1/20,000	43

12. Navigation for Air Photography is a task needing a high degree of skill and training. In the absence of a trained navigator we utilized the services of a navigator from Air Ceylon. In 1971, an Asst. Suplt. of Surveys was trained at the I.T.C. He followed the B.Sc Aerial Photography and Survey work in Air Survey Navigation. (1 1/2 years Course) and from 1972 he has been in charge of this work.

13. As the Island cover done in 1956 was out of date, the Department had planned to re-photograph the entire Island. However, owing to the non-availability of sufficient flights this project was commenced only in 1970. The scale of the proposed Island cover is 1:25,000 and at present about 9,000 sq. miles have been covered leaving a balance of 16,000 sq. miles. The flying height of the Beechcraft with its present equipment is limited to 15,000 ft., and photograph on scale smaller than 1/30,000 are not possible.

14. Main equipment available is listed below:

1.	Aircraft Beechcraft Super 18	1
2.	Aerial Cameras RC8	2
3.	Aviogon lenses	2
4.	Aviotar lens	1
5.	Densitometer	1
6.	Enlarger - Durst	1
7.	Refregerator	1
8.	Print washer - Richards	1
9.	Contact Printers FE 30	2
10.	Vacuum Printer - Klimsh	1
11.	Glazing machine Kodak	1
12.	Print dryer - Kodak	1
13.	-do- Pake 44"	1
14.	Print washer Kindermann	1
15.	-do- Richard	1
16.	Log Etronic Contact Printer	1
17.	Film developing Units - FE 120 Zeiss	1
	- Wild	1
	- B-4	1
18.	Rectifier - SEG V	1
19.	- Wild E4 (April 73)	1
20.	Aerial Hand held camera - Linhoff(1970)	1
21.	Electric Hot water gazer	1
22.	Film Dryers - Smith	2
	- Wild	2

15. Photogrammetric Mapping

In most parts of the World, Photogrammetric mapping has become the sole method employed in the production of topographic maps. In Ceylon the 1" topographic map covering the entire Island was produced by field methods during the period 1908 - 1924. These maps have been utilized for the initial planning of development projects in the pre 1956 era. Final planning was done by Ground Surveys usually on the scales of 4 Chs. and 8 Chs. to one inch with contours at 2 or 5 ft. intervals.

16. For the reconnaissance planning of development projects the need for a medium scale Topographic Map was long felt and photogrammetric plotting was utilised to fill the gap by producing the 5" national map series with 20' contours. Under the Colombo Plan Aid Programme certain areas were plotted abroad, e.g Kirindi Oya Basin and large areas in Kandy and Nuwara Eliya and Polonnaruwa Districts required for investigations of the Mahaweli and other Irrigation Projects and Hydro Electric Schemes.

17. 1956 - 1958 In 1956, the photogrammetry Unit of the Air Survey Branch made a modest start with one Kelsh Plotter and two Surveyors to operate same.

1958 - 1964 In 1958 four other autographs were added one A7, two A8s and another Kelsh Plotter. The number of operators increased to 3 in 1958 and to 10 in 1964.

18. Bulk of the work was medium scale mapping, i.e., 16 ch., 12 ch, to One Inch with 20' contours, and the average output was about 30,000 acres per month. Large scale work was mainly for Town Surveys.

19. 1964 - 1970 Four B8 Autographs were purchased in 1964 together with a Jeris Analogue Computer and one Pantaphot Enlarger. The equipment in this period was :-

A7	1
A8	2
Kelsh	2
B8	4
Jeris Analogue Computer	1
Pantaphot	1
Staff - 20 Operators and 2 Draughtsmen.	

The average plotting output increased to 50,000 acres per month and the major schemes done were medium scale mapping for Mahaweli Development Project, Kalani Ganga Project, Uda Walawe Project.

20. The importance of Air Surveys is fully demonstrated by the fact that within a short period of six months an extent of 61 million acres was mapped on 40 ch. and 16 ch. scales with 20 ft. contours for the planning of Mahaweli Development Project. The feasibility studies of this Project would not have been possible without these maps. Many years of work would have been involved if those had to be done by conventional methods of ground surveys.

21. 1970 -1973 During this period one A8, one EK5, one Rug IV were purchased.

Up to this time a large amount of work had to be done by field surveys to supply control for Photogrammetric Plotting. This ground work was reduced to some extent by the adoption of strip triangulation. In 1970 after the purchase of Electronic Recorder (EK 5) Computer Programming was introduced to the Survey Department. This supplemented strip triangulation and cut down computer time and increased accuracy. The field Surveyor require to supply only very few control points and all the other control points required were obtained with the help of the computer. The computer at the State Engineering Corporation is used for this.

Major Schemes undertaken during the period are the Mahaweli Diversion Scheme, Crop Diversification Scheme (9000 sq. miles), South Ceylon Development Project, all of which use scales of 1:10,000 and 16 ch. with 20' contours. Large scale work is mainly town surveys.

Present rate of production is 90,000 acres per month.

Major Projects undertaken were:-

(i) Mahaweli - 40 ch., 16 ch.	with 20' contours		61 million acres
(ii) Kalani Ganga - 16 ch.	-do-		475,000 acres
(iii) Uda Walawe -do-	-do-		110,000 "
(iv) Agricultural Div. Project	-do-		in progress covers 5 1/2 million acres and is in progress.

During the period April 1960 and April 1969, i.e. 9 years total extent on 16 ch. and 40 ch. with 20' contours was 8 million acres, i.e., 1/2 the extent of Ceylon.

COMPUTATION AND LEVELLING UNIT.

This Unit was formed in January 1969 when the Levelling Section dealing with the Island's control level network was shifted from Diyatalawa to Colombo (S.G.O) The Unit consisting of 4 Draughtsmen functioned under the direct supervision of the Superintendent of Air Surveys. With the purchase of the Tellurometer for precise distance measurement and the Friden Electric Desk Computer in late 1968, it was considered desirable to form a Unit to undertake precise measurement and computations. This Unit was formed in March 1969 with a staff of 4 Surveyors, supervised by the Chief Photogrammetrist.

In October 1969 the Trig. Section dealing with the Island's trigonometrical control and precise traverses was also shifted from Diyatalawa to the S.G.O in Colombo. The work of the Levelling Section, Trig. Section and the Computation Section then combined in November 1969, under the supervision of an Asst. Supdt. of Surveys with a staff of 4 Surveyors and 5 Draughtsmen. More equipment has now been added such as -

(a) Two Wild T3 Theodolites (for precise angular measurements)

(b) Friden one Electronic Desk Computer in 1971.

The Geodimeter available with the Institute of Surveying and Mapping at Diyatalawa was also made available whenever required.

The Unit is now fully responsible for the establishment, checking and maintaining of all precise controls done by the Department in Surveying and Levelling. Gradually it has been possible to centralise the precise computations done in the Dept. some of which was formerly entrusted to the field surveyors. Improvements and refinements in speed and accuracy was made possible with the increased use of the Electronic Computer at the State Engineering Corporation using programmes for computations. All computer Programmes are prepared by the Survey Dept. staff.

Apart from the routine of Departmental requirements the Unit has been able to undertake the following control work:-

(a) Maldive Island Mapping Project - Establishment of Level Control and establishment of Ground Control Points. This was done on contract with the WHO and the Department earned $ 6,000 in Foreign Exchange.

(b) Ceylon Electricity Board - Establishment of control required for setting out a Tunnel at Maskeliya.

(c) Mahaweli Development Board - Establishment of control required for setting out the tunnels at Bowatanne and Polgolla. The control provided was of a very high accuracy, This was proved by the fact that the 5 mile long Polgolla Tunnel met to witin 3 inches.

Preparation Section

At the beginning it did not form a separate Unit, but existed as part of the Photogrammetric Unit. The main functions was to check the Air Survey Boards that were returned after field revision. Field revision comprised

of inserting

of inserting missing details and checking of details and contours that were originally plotted in the Photogrammetric Unit.

Professor Vanior Veel from the International Training Centre, Delft, Holland visited Ceylon on invitation in 1962 to check and report on the working of the Air Survey Branch. In his report he stressed the paramount importance of having a separate Unit to attend to all preparation work. As a result the Preparation Section started functioning as a separate Unit around 1964. Staff consisted of an Asst. Supdt. of Surveys, one Photogrammetric Technician, 3 Surveyors, and 2 Draughtsmen. Flight Planning, Annotation of Air Photographs, preparation of Index Sheets, checking of Air Surveys Boards were all attended to in this Unit.

In 1964 the Irrigation Department wanted 40 chains to an Inch Maps with 20 ft. contours for an area covering 1/2 of the Island. These maps were to be used for the Planning of the Mahaweli Project. A combination of Air Survey and Ground Survey methods was used. The newly created Preparation Section functioned as the co-ordinating body and 4 more Surveyors were assigned to the Section.

Specification Surveys using photographic enlargements was started in 1966. Boundaries of individual paddy holdings were identified in the field with the help of these. Transferring of these boundaries to Polyester Sheets and the rest of the plan work was completed in the Preparation Section. Listed below are the Specification Surveys completed from 1966 - 1969:-

		Scale	Extent
1. Dedura Oya Specification Surveys		4 ch.	270 Sq. miles
2. Uma Ela	-do-	4 ch.	1000 acres
3. Giants Tank	-do-	4 ch. 8 ch.	200 Sq. miles
4. Diyature	-do-	4 ch.	1000 acres
5. [illegible]wela	-do-	4 ch	4600 "
6. Nagallewewa	-do-	4 ch	500 "

These Surveys were mainly for the collection of Water Tax.

Pilot Project (Gal Oya Demonstration Project) for the application of Photogrammetric methods for Cadastral Surveys was started in 1970. Here the selected area was photographed on 1/15,000 scale. Perimeter control was fixed by conventional methods and control required for rectification was extracted by aerotriangulation. Photographs were rectified and enlarged to 4 Chain scale with new control points. Boundaries of individual lots were identified and interpreted on the rectified enlargements to Surveyors in the field, who also recorded the individual tenement ary information. Transferring of these details on to Cartelon Sheets, writing tenementary lists and the rest of the plan work was attended to in the Preparation Section. Present staff on this work is one C.C.P and 5 Surveyors.

Flight planning for the Island cover on 1/25,000 and 1/20,000 scal was completed in 1971. At present there are 2 Surveyors attending to flight planning annotation and indexing work. In addition they also attend to the revision of 1" Sheets using aerial photography. In view o the re-photography of the Island, Air Survey revision has become very extensive and therefore the staff for this work is being increased.

Up to 1971 the Mosaicing Jobs were undertaken by the Resources Survey Unit of the Department. Presently this work is also handled by the Preparation Section. There are two Mosaicers attending to this work. Some of the Mosaics prepared in 1972 and 73 are as follows:-

	Scale	Sq.miles.
Mosaic Colombo - Katunayake Road		
Controlled Mosaic - Sugar Area Uda Talawe	1:10,000	115
Mosaic of Mahaweli H & IH Area	1/10,000	70
Mosaic Mahaweli G & D Area (in progress)	1/25,000	1000
Mosaic Badulla Town (in progress)	4 Chains	
Mosaic Sinharaja Forest	1/15,000	43
Mosaic Katunayake Airport & Environs	1:10,000	
Mosaic Kalpitiya Bay	1:25,000	

APPENDIX E

REPORT TO THE COMMITTEE OF INQUIRY
A BRIEF HISTORY OF THE SURVEY DEPARTMENT

A BRIEF HISTORY OF THE SURVEY DEPARTMENT

The Survey Department was formed in 1800, even before the country had become a Crown colony, by special proclamation which read in part as follows : -

"Whereas the present mode of survey and measurement of land within these settlements has been found imperfect and ineffectual. We have deemed it necessary to establish a new system for that purpose.

We therefore hereby publish and make known such parts as are necessary for general information, viz : -

" That a Surveyor-General shall be appointed, who will reside principally at Colombo and correspond with ~~th~~ and receive orders directly from Government....."

From the inception of the Department in 1800 till about 1865, it was a very small organisation consisting of about 20 - 30 officers in both field and office. The surveys were mostly for the sale of lands, as shown in one of the opening paragraphs of the Administration Report of the Surveyor General for 1869.

"During the year 1869, 4,490 lots containing 25,831 acres, 2 roods 9.59 perches were disposed of for £ 43,249 6s. 9½d or at the rate of £1. 13S. 5d per acre, exclusive of survey fees which amounted to £\6,560. 4S.".

The Triangulation of Ceylon which was necessary to tie up all the scattered surveys and to provide a framework for future work, was commenced in 1857 and completed in 1906

From 1866 to 1900 the total staff increased from 95 to 275 and the total expenditure in 1900 was Rs. 675,000. Apart from the usual surveys for the sale of land, increasing attention was given to Triangulation for Control, Topographical Surveys, for the production of the well known 1 mile to 1 inch sheets and "Block Survey" for separating Crown Land from Private Land in villages, for settlement purposes. This is demonstrated in the figures given in S.G's Administration Report for 1901 : -

Block Surveys -	209, 789	acres
Topographical Surveys -	1,871,360	"
Application	41,047	"
Misc :	612	"

It may be noted that no mention is made of Engineering Surveys for Irrigation purposes and Acqn. Surveys.

A landmark event in the history of the Department during colonial times was the visit, on an inspection tour, of Brigadier Winterbotham in 1930. The Ceylon Daily News of 7th August,1931 carried the following news item : -

"The Hon'ble Mr. D.S.Senanayake, Minister of Agriculture & Lands, will move an item of Rs. 4,110.57 which he explains as follows :- In the estimates for 1929-30, a sum of Rs. 4,729 was provided as Ceylon's share of the cost of a comprehensive tour of inspection of Colonial Survey Departments performed by Brigadier H. St. J. L. Winterbotham, C.M.G., D.S.O., R.E., at the invitation of the Secretary of State for the Colonies. A proportion of the cost of the tour was borne by the War Office. Brigadier Winterbotham, who is a member of the Colonial Survey Committee and Air Survey Committee and has since been appointed Director-General of Ordinance Survey, arrived in Ceylon on 7th February,1930 and spent 26 days in inspecting the various branches and office of the Ceylon Survey Department. In addition to much valuable instructions and advice given in the course of inspection, Brigadier Winterbotham furnished a report indicating the lines of policy and methods which the Department might follow with advantage in the future. His technical advice based on wide experience in many countries was of great value to the Department".

Brigadier Winterbotham was impressed by the work of the Ceylon Survey Department. In the opening paragraphs of his report, he said

" It is proper to begin by saying that the Survey is a well organised efficient machine and that it possesses in its present Director a controlling force which is felt in every Branch of the Department".

Further on, he wrote

" The present leadership of this survey is progressive and technically competent, but the standard is sub to decay in the hands of any officer who neither reads current surveying literature nor keeps in touch with the work of other Survey Departments. As regards survey literature, I hear that the issue of technical periodicals has been in question. It is essential in a technical Department to keep in touch with modern progress. To take one single instance, no map printing office can keep upto date without following the trade printing and process journals. Similarly such matters as the journal of the Royal Geographic Society, the new Survey Journal which is, shortly to be produced by the Colonial Survey Committee, the South African Survey Journal, the ~~kind~~ literature of the United States Coast and Geodetic Survey, the publications of the Ordinance Survey and the Survey of India should be passed round and really read".

At the time of Brig. Winterbotham's visit in 1930 the Field Staff consisted 12 Supts. of Surveys, 36 Asst Supts of Surveys and 305 Surveyors. The Office staff consisted of 438 Clerks and Draughtsmen. The work done that year consisted of Land Settlement Surveys 184,000 acres, 1,104 Waste Land Ordinance Sketches, 224 Applications for purchase of Crown lands, 1 inch mapping of 1,653 square miles, Town Surveys of 5 Towns and 4 re-measurement of the principal bases and a re-computation of the triangulation network as recommended by Brig Winterbotham. The primary level net had been observed between 1925 - 1930. The Head Office staff

(67)

was organised according to subjects, as shown in the annexed chart. (This type of organisation continued till the decentralisation and reorganisation of 1966).

The strength of the Department was reduced during the War years and during the 1940's and early 50's, there were about 250 - 275 Surveyors and about 300 Clerks and Draughtsmen. The organisation and the type of work remains much as before.

With Independence, a major task was given to the Department. This was the Close Contour Surveys for irrigation purposes and surveys for alienating land under the Land Development Ordinance and to Colonists. In the mid fifties, Government felt that the Survey Department was inadequately staffed for these development projects and the number of surveyors was rapidly increased till in 1966 it reached 770. The number of Survey Labourers increased in proportion to the Surveyors. Further after 1956 they were placed on monthly pay and absorbed into the permanent cadre after 10 years service. But the number of Draughtsman did not increase correspondingly because in 1957, in the words of the Surveyor General Mr V.Rasaratnam.

" ... the Deputy Secretary to the Treasury appointed a Committee to report on the matter and ~~changes~~ changes accepted are as follows:

(a) that the Survey Clerks and Draughtsmen's Service should be brought in line with the Draughtsmen's Service on the same salary and service prospects.

(b) that purely clerical work relating to the Establishments, Accounts and Stores Branches should be done by G.C.S. officers and a separate Store keeper Service for the work of Storekeeping. The changes are to be effected in stages.

(c) that the date of implementation of the scheme be 1.10.56.

" During the latter part of the year and as a first step in the reorganisation of the Clerks and Draughtsmen's Service to a Draughtsmen's Service, the Treasury was requested to transfer to this Department 14 G.C.S. Officers, 9 Typists and 6 Storekeepers by suppression of 29 Draughtsmen's post but only 7 Typists were assigned to this Department". (Adm. Report of S.G. for 1957).

Thus, the Survey Department, which had been a 'Closed' Department, was opened to G.C.S. officers in 1957. Their strength has progressively increased from 33 in 1958 to 161 in 1971. On the other hand, the number of Draughtsmen after reaching a peak of 611 in 1961, has dwindled to 510.now. Please see Table annexed, showing actual number of Surveyors, Draughtsmen and Clerks for each of the years 1947 to 1970/71.

Meanwhile, the increased number of Surveyors were engaged on the major irrigation and colonisation schemes. From the 1940's to the late 60's, in Minneriya, Kantalai, Gal Oya, Allai, Iranamadu, Giritale, Inginiyagala, Samudra, Andaviyiya, Elahera, Walawe, Rajangana, Kaudulla, Randenigala, Samanalawewa, Chandrikawewa, Hinipe, Trincomalee, Maskeliya Oya, Mahaweli Diversion and in several other schemes contour surveys, setting out channels, staking out allotments, putting colonists in possession, landmarking improved allotments were done.

As the number of Surveyors increased and the number of survey records grow, managing the Department on the old pattern proved difficult. This xxx resulted in decentralising survey records and payments to the Divisions in 1966. This was accompained by an organi-ational change in Head Office.

In the words of Mr P.U.Ratnatunga, then S.G.

" With the object of ensuring good organisation and efficient supervision, a major change was introduced at manag rial level in April this year. The survey tasks were divided into 2 groups, development surveys and revenue surveys and each group was placed in charge of a Deputy Surveyor General who was responsible for programming the work in that group and deciding on policy relating to that".

"The Divisions were then grouped into 4 Ranges. Each of these Ranges have been placed under an Asst Surveyor General who is responsible for the progress of all categories of surveys in that Range. His area of responsibility xxxx has been limited to a compact block but he is in charge of the progress of about 200 surveyors or nearly three fourths the responsibility of a pre 1956 Surveyor General."

"In the past, the functions had been ~~prepared~~ performed by several Asst Surveyors General or Headquarters Supdt. of Surveys, each of whom had been responsible for policy and pro-ress of one category of surveys only. While this created expertise in each category of work the efforts of the management were distributed over tasks scattered in different parts of the island and the efforts of the Divisional Sup ts. of Surveys who were responsible for executing programmes of all categories of surveys, under Divisions had not been sufficiently coordinated". (S.G. Adm Report 1966/67).

This organisation continues to the present day and is shown in the present organisation chart.

Another aspect of interest in th recent history of the Department is the establishment of the Air Survey Branch and the Resources Survey Centre in 1957/58. A large volume of mapping, particularly those of an urgent nature, such as the Crop Diversification Project, has been done by Air Survey methods to assist in the development of the country.

A wide variety of maps have been produced and are available for the use of Government Departments other organisations and the public. These includes ~~only~~ well known maps as the 8 mile to 1" motor map, the 4 mile to 1" Wall maps, General Soil Map, Parliamentary Electoral District Maps, Land Use and Forest Cover, Historical maps etc.

The department is frequently called upon to undertake work in response to urgent social needs. Acquisition Surveys for various purposes have been increasing over the years. In 1967, the Government decided to regularise all genuine encroachments and the department undertakes the survey of all encroachments in the country and encroachments were regularised on the basis of these plans.

The major tasks of Engineering Surveys and Settlement Surveys done during the last few decades are drawing to a close. But the department has yet 2 major tasks. One has already commenced, this is the survey of lands under the Land Reform Act. The other is a pre-requisite of any modern State; Registration of Title to Land. Every parcel of land in the country has to be surveyed and drawn, lotted and the ownership determined and put on a Register of Title.

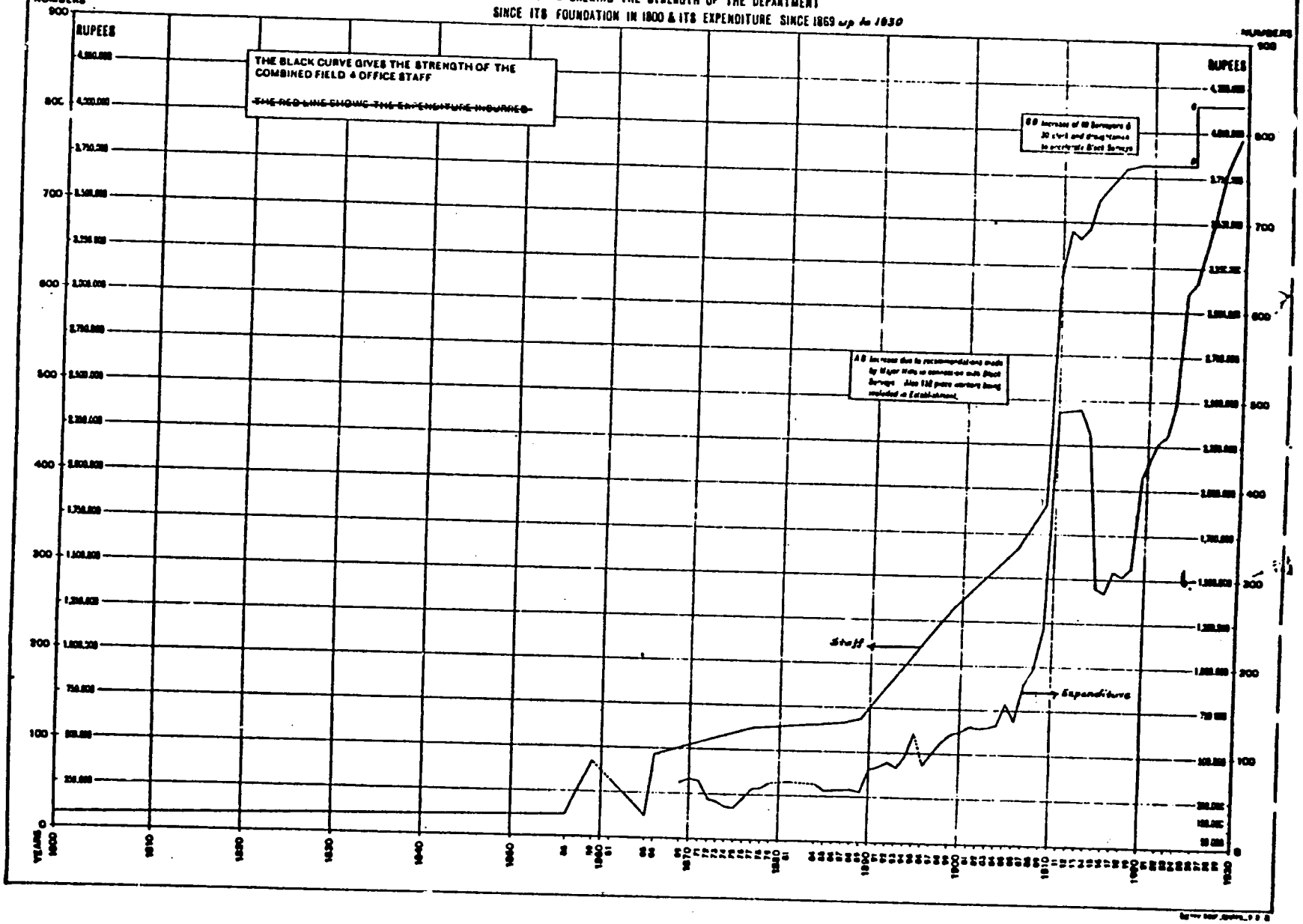
(Admit strength)

SCHEDULE

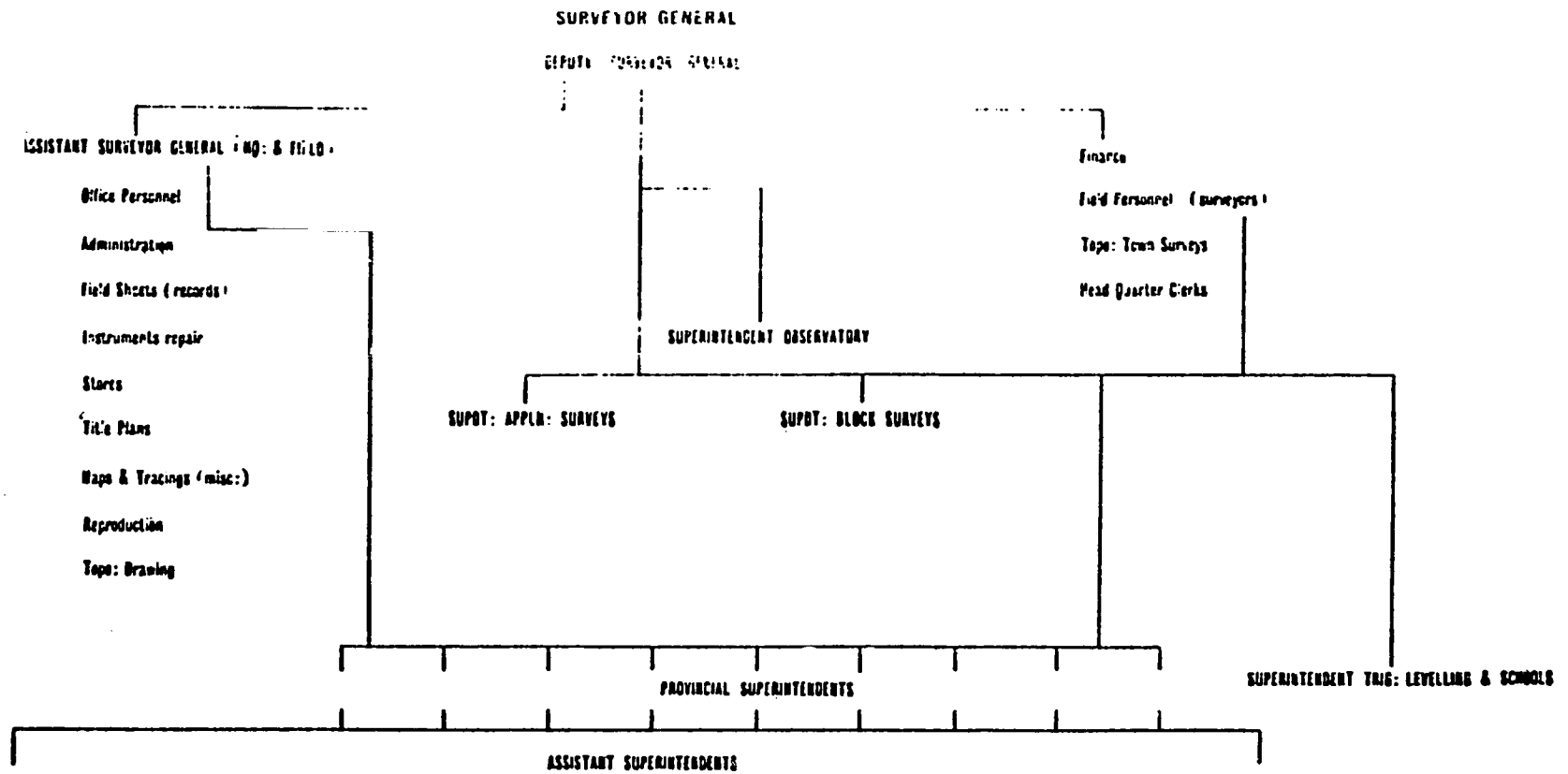
	Syrs.	D'man	Clerks
1947	257	298	
1948	253	304	
1949	257	318	
1950	266	986 ?	
1951	231	291	
1952	246	286	
1953	265	303	
1954	273 ?	303	
1955	200	394	
1956	294	358	
1957	331	400	
1958	408	425	33
1959	493	574	33
1960	595	590	35
1961	623	611	35
61/62	660	611	34
62/63	658	585	40
63/64	647	575	62
64/65	660	557	82
65/66	770	550	98
66/67	768	557	132
67/68	760	555	149
68/69	731	553	169
69/70	777 ~~(82)~~	548	168
70/71	806 ~~(127)~~	532	161
71/72	806 ~~Under preparation~~	532	166
1973	787	510	145

SURVEY DEPARTMENT

DIAGRAM SHEWING THE STRENGTH OF THE DEPARTMENT
SINCE ITS FOUNDATION IN 1800 & ITS EXPENDITURE SINCE 1869 up to 1930



ORGANISATION OF SURVEY DEPARTMENT *in 1930*



Nelson

APAC MINUTES

REVIEW OF PROJECT PAPER FOR SRI LANKA

AGRICULTURAL BASE MAPPING (383-0045)

September 9, 1977

9p

The Agricultural Base Mapping project was approved pending action and reply by USAID/Colombo on the following items:

A. In that the project requires specialized non-code 941 equipment for aerial photography and map production (only available from Wild-Herrbrugger of Switzerland) and therefore a substantial procurement source waiver, USAID/Colombo has been requested to contact representatives of the Swiss Government in order to ascertain their willingness to participate in the project by contributing the items listed below (total estimated value - $383,000):

1. Renovation of 2 units of RC8 Cameras
2. One unit wild A8 Autograph w/PPO-8 Orthophotter
3. Attachments for four units aviotab TA Coordinatograph B8 units.
4. Wild St-10 strip sterescope, one unit
5. Wild Glass Scales, one unit
6. Kern PG2 with EK-22 Digitizer and Aviotab TA Coordinatograph, two units (or equal)

B. In that a question was raised concerning USAID financing of the FOREX component of aviation fuel, USAID/Colombo has been requested to contact the Survey Department and appropriate GSL agencies in order to ensure that the GSL will provide fuel as required. A specific C.P. has been included, in the project authorization relating to the availability of this fuel during the critical first year of photography, when U.S. financed pilot and photogrammetrist instructors will be in Sri Lanka.for project training missions.

C. In addition to the above items the APAC review requested that USAID/Colombo continue to discuss with GSL the development of a rational budgeting system which will provide for some reasonable form of inter-agency and customer charges for information and maps provided by the Survey Department.

No other discussion points were raised by the APAC review and the project approval process was to continue upon receipt of positive replies from mission concerning the issues raised above.

AID 1020-28 (1-72)

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

Life of Project:
From FY 77 to FY 83
Total U. S. Funding $4,425,000
Date Prepared: August 19, 1977

Project Title & Number: AGRICULTURE BASE MAPPING - Sri Lanka

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Program or Sector Goal: The broader objective to which this project contributes: Improve the living standard of the rural people in Sri Lanka	**Measures of Goal Achievement:** 1. Increased number of employment opportunities for rural people. 2. Improved nutrition level of rural people. 3. Increase income for rural people.	G.S.L. Annual Statistics IBRD Annual Statistics	**Assumptions for achieving goal targets:** More and better maps will assist the GSL to improve the standard of living of the rural people.
Sub-Goal Increase the agricultural production of food for consumption domestically in Sri Lanka.	1. Increased % of agr. production of food for domestic consumption. 2. Decreased % of food products imported for domestic consumption. 3. Improved ratio of production to land under cultivation.		The GSL will continue to initiate policies favorable to increased agricultural production of food for domestic consumption.
Project Purpose: To meet the mapping requirements of rural development in Sri Lanka.	**Conditions that will indicate purpose has been achieved: End of project status.** 1. Base Maps less than 5 yrs. old. A. 1/50,000 B. 1/10,000 2. Increased number of requests for Survey Dept. to provide relevant information for user agencies. 3. Larger scale maps provided to user agencies within 6 mos. of request. 4. 10% of base maps at 1/10,000 are updated per year. 5. An operational User Assistance Ctr.	- Survey Department records of maps produced and distributed to requesting user agencies. - Records of annual percent of updating process. - Record of use of UAC facilities	**Assumptions for achieving purpose:** The GSL will provide continuing budget support to the Survey Department.
Outputs: 1. Maps to the scale of: A. 1/50,000 B. 1/10,000 C. 1/1000 - 1/10,000 2. Modern equipped & trained staff for UAC 3. Trained pilots and photographers 4. Trained staff for S.D. & user agencies.	**Magnitude of Outputs:** 1. Completed Maps A. Total nation B. Total nation C. As per request of User Agency 2. 14 user agencies utilizing UAC 3. 4 trained aerial photography teams 4. 34 trained staff members of SD and UAC	1. Records of user requests for various maps 2. Records of utilization of UAC 3. Flight records & aerial photography of aerial survey unit. 4. Records of completion training.	**Assumptions for achieving outputs:** - Survey Department personnel will correctly utilize aircraft and equipment - User agencies will continue to make requests for maps & arial photographs - User agencies will utilize the "User Assistance Center"
Inputs: 1. Equipment for: A. Photo Acquisition; Aircraft and Accessories B. Field Support C. Compilation D. Photo Lab E. Map Production F. User Assistance Center 2. Facility Renovation 3. Expendable Equipment 4. Technical Training 5. Technical Assistance 6. Contingencies (10%) 7. Inflation Factor (10%)	**Implementation Target (Type and Quantity)** 1. Equipment — Order Dat A. 552,500 — 2-3/78 B. 537,400 — 1-2/78 C. 258,400 — 12/77-3/78 D. 194,400 — 1/78 E. 150,400 — 1/78 F. 68,200 — 6/78 2. 100,000 — 1/78 3. 848,700 — 1/78 4. 254,000 — 11/78-3/79 5. 503,000 — 11/77-78 6. 346,700 7. 686,300	USAID Records and Reports GSL Records and Reports	**Assumptions for providing inputs:** 1. No capacity exists in Sri Lanka Survey Department to provide the up-to-date mapping requirements of various gov't. agencies responsible for rural development planning & implementation. 2. Existing maps are based on 1956 aerial photography at a scale of 1/63,000. 3. No user assistance capability now exists in Survey Department

File

SEP 30 10 29 AM '77

29 SEP 1977

ACTION MEMORANDUM FOR THE ASSISTANT ADMINISTRATOR, ASIA

FROM: ASIA/PD, Alexander R. Love

Problem: To authorize the Sri Lanka Agricultural Base Mapping Loan ($4.5 million).

Discussion: The project will provide over a six year period capital equipment, expendable supplies, technical assistance and facility renovation to the Survey Department of the Ministry of Agriculture and Lands, as well as long and short term training to personnel of selected other Ministries and Departments of the Government of Sri Lanka. These inputs will result in the production of a 1:50,000 and a 1:10,000 scale base map of Sri Lanka which will be continually updated and will provide for the production of larger scale maps on an area and/or project specific basis as per the requests of the various user agencies of the Government of Sri Lanka. The project also provides for the establishment and operation of a "User Assistance Center" within the Survey Department which will serve as both a resource center for other Sri Lankan agencies and departments and as a research center for the Survey Department, enabling the department to keep abreast of the latest scientific developments in areas related to aerial surveys and remote sensing. The project has been technically reviewed by experts in the field of aerial photography and mapping. These experts have confirmed that the project design and implementation plans provide a sound basis for believing that the inputs will produce the projected outputs. In sum the project will permit the achievement of the project purpose which is to meet the mapping requirements of rural development in Sri Lanka.

As a result of the APAC meeting on the project, the following issues were raised with the GSL and USAID/Colombo;

Issue:

1. That the GSL and the Survey Department of the Ministry of Agriculture and Lands agree to finance the required aviation fuel (Forex Expenses) as part of the annual budget of the Survey Department.

Resolution:

A Condition Precedent to disbursement for materials and equipment procurement under the project provides for, "Evidence that provisions have been made to make aviation fuel available to the project aircraft commensurate with the needs of photographic missions to be flown during the training period run by the pilot and photogrammetrist trainers". A covenant in the project authorization will provide that, "The aircraft provided under the project will be adequately insured against mishaps to permit its repair or replacement throughout the life of the project, and all maintenance and operational requirements, including fuel, shall be made available as required to meet the objectives of the project".

Issue:

2. That USAID/Colombo contact the office of Swiss Technical Cooperation (OTC) in Bern concerning the possibility of Swiss government participation in the project by financing the purchase of specialized aerial photographic and cartographic equipment, which is produced only in Switzerland.

Resolution:

USAID/Colombo has been instructed to include a Condition Precedent in the project agreement which will provide that an answer be obtained prior to 12/31/77 on the possibility of Swiss Government project participation through the provision of Swiss made photographic and cartographic equipment, and that if the Swiss Government is unable to make a firm commitment to participate in the project in the manner suggested above by 12/31/77, a proprietary and source/origin waiver would be signed by the AID Administrator. If the Swiss Government can contribute the necessary Swiss made equipment, the monies currently assigned in the project budget for this purpose could be reprogrammed or deauthorized from the project.

There are no other outstanding issues or questions concerning the implementation or authorization of the Sri Lanka Agricultural Base Mapping Loan.

Recommendation: That you authorize the proposed $4.5 million Sri Lanka Agricultural Base Mapping Loan.

Attachments:
PAF Parts I & II

APPROVE: _____

DISAPPROVE: _____

DATE: _____

ASIA/PD/SA:SJFreundlich:baa:9/28/77
ext. 58910

Clearances:
GC/ASIA:HMorris
ASIA/PD:JRMcCabe
ASIA/TR:TCCLark
SER/COM:RWiley
ASIA/DP:RCohen
ASIA/WIS:PBoughton
DAA/ASIA:MHBAdler

AGENCY FOR INTERNATIONAL DEVELOPMENT

PROJECT AUTHORIZATION AND REQUEST FOR ALLOTMENT OF FUNDS PART I

1. TRANSACTION CODE: A (A ADD, C CHANGE, D DELETE)

2. DOCUMENT CODE: PAF 5

3. COUNTRY ENTITY: Sri Lanka

4. DOCUMENT REVISION NUMBER:

5. PROJECT NUMBER (7 digits): 383-0045

6. BUREAU/OFFICE: A. SYMBOL ASIA; B. CODE 04

7. PROJECT TITLE (Maximum 40 characters): Agricultural Base Mapping

8. PROJECT APPROVAL DECISION — ACTION TAKEN: A (A APPROVED, D DISAPPROVED, DE DEAUTHORIZED)

9. EST. PERIOD OF IMPLEMENTATION: YRS. 05 QTRS. 20

10. APPROVED BUDGET AID APPROPRIATED FUNDS ($000)

A. APPROPRIATION	B. PRIMARY PURPOSE CODE	PRIMARY TECH. CODE C. GRANT	PRIMARY TECH. CODE D. LOAN	E. 1ST FY 77 F. GRANT	E. 1ST FY 77 G. LOAN	H. 2ND FY — I. GRANT	H. 2ND FY — J. LOAN	K. 3RD FY — L. GRANT	K. 3RD FY — M. LOAN
(1) FN	180B		053						
(2)									
(3)					4500				
(4)									
TOTALS					4500				

A. APPROPRIATION	N. 4TH FY — O. GRANT	N. 4TH FY — P. LOAN	Q. 5TH FY — R. GRANT	Q. 5TH FY — S. LOAN	LIFE OF PROJECT T. GRANT	LIFE OF PROJECT U. LOAN
(1) FN						
(2)						4500
(3)						
(4)						
TOTALS						4500

11. PROJECT FUNDING AUTHORIZED (ENTER APPROPRIATE CODE(S)) 1 - LIFE OF PROJECT; 2 - INCREMENTAL, LIFE OF PROJECT

	A. GRANT	B. LOAN
		1

C. PROJECT FUNDING AUTHORIZED THRU FY 83

12. INITIAL PROJECT FUNDING ALLOTMENT REQUESTED ($000)

A. APPROPRIATION	B. ALLOTMENT REQUEST NO. — C. GRANT	D. LOAN
(1) FN		
(2)		4500
(3)		
(4)		
TOTALS		4500

13. FUNDS RESERVED FOR ALLOTMENT

TYPED NAME (Chief, SER/FM/FSD): Dannie Baker

SIGNATURE:

DATE:

14. SOURCE/ORIGIN OF GOODS AND SERVICES: [ ] 000 [X] 941 [X] LOCAL [X] OTHER 899

15. FOR AMENDMENTS, NATURE OF CHANGE PROPOSED

FOR PPC/PIAS USE ONLY	16. AUTHORIZING OFFICE SYMBOL	17. ACTION DATE (MM DD YY)	18. ACTION REFERENCE (Optional)	ACTION REFERENCE DATE (MM DD YY)

AID 1330-6 (7-76)

PROJECT AUTHORIZATION AND REQUEST FOR ALLOTMENT FOR FUNDS

PART II

SRI LANKA

Agricultural Base Mapping
A.I.D. Loan No.

Pursuant to Part I, Chapter 1, Section 103 of the Foreign Assistance Act of 1961, as amended, I hereby authorize a Loan to the Government of Sri Lanka (the "Cooperating Country") of not to exceed Four Million Five Hundred Thousand United States Dollars ($4,500,000) (the "Authorized Amount"), to help in financing certain foreign exchange and local currency costs of goods and services required for the project. The project consists of (1) upgrading the physical and technical capacity of the Survey Department of the Ministry of Agriculture and Lands to do aerial photography and produce base maps of Sri Lanka to meet planning and operational requirements of Cooperating Country rural development programs plus (2) the establishment and operation of a User Assistance Center within the Survey Department to serve as a resource center for other Cooperating Country agencies doing studies and research work associated with aerial surveys and remote sensing techniques (hereinafter referred to as the "Project").

The entire amount of the A.I.D. financing herein authorized for the Project will be obligated when the Project Agreement is executed.

I hereby authorize the initiation of negotiations and execution of the Project Agreement by the officer to whom such authority has been delegated in accordance with A.I.D. regulations and Delegations of Authority subject to the following essential terms and covenants and major conditions; together with such other terms and conditions as A.I.D. may deem appropriate.

a. Interest Rate and Terms of Repayment

The Cooperating Country shall repay the Loan to A.I.D. in United States Dollars within forty (40) years from the date of first disbursement of the Loan, including a grace period of not to exceed ten (10) years. The Cooperating Country shall pay to A.I.D. in United States Dollars interest from the date of first disbursement

of the Loan at the rate of (a) two percent (2%) per annum during the first ten (10) years, and (b) three percent (3%) per annum thereafter, on the outstanding disbursed balance of the Loan and on any due and unpaid interest accrued thereon.

b. Source and Origin of Goods and Services

Except for ocean shipping or as A.I.D. may otherwise agree in writing, goods and services financed by A.I.D. under the Project shall have their source and origin in countries included in A.I.D. Geographic Code 941 and the Cooperating Country. Ocean shipping financed under the Loan shall be procured in any eligible source country except the Cooperating Country.

c. Conditions Precedent to Initial Disbursement

Prior to the initial disbursement or the issuance of the initial commitment document for technical assistance under the Project Agreement, the Cooperating Country shall furnish the following in form and substance satisfactory to A.I.D.:

1. A signed contract for technical assistance; and

2. Evidence of the availability of funds for and intention to carry out facility renovation.

d. Conditions Precedent to Disbursements for Additional Procurement

1. Evidence of an agreement between the Survey Department and the Sri Lanka Air Force for the maintenance and operation of the aircraft to be supplied under the Project;

2. Evidence that provisions have been made to make aviation fuel available to the project aircraft commensurate with the needs of photographic missions to be flown during the training period run by the U.S. pilot and photogrammatrist trainers.

e. The Cooperating Country shall covenant the following:

1. The aircraft provided under the Project shall be reserved for project needs and will not be used for military purposes;

2. The aircraft provided under the Project will be adequately insured against mishaps to permit its repair or replacement throughout the life of the Project, and all maintenance and operational requirements, including fuel, shall be made available as required to meet the objectives of the Project.

g. The following waivers to A.I.D. regulations are hereby approved:

Waivers to permit proprietary procurement of U.S. source origin equipment and aircraft as stated in the Project Paper.

Clearances:	Date	Initial
Herbert E. Morris, GC/Asia	9/23/77	
Alexander R. Love, Asia/PD	29/IX/77	
T. C. Clark, Jr., Asia/TR	9-29-77	
Robert W. Wiley, SER/COM	9-29-77	
Donald D. Cohen, Asia/DP	9-29-77	
Priscilla M. Boughton, Asia/BIS	9/29/77	
Michael H. B. Adler, DAA/Asia		
Edward Hogan, PPC/DPRE		

John H. Sullivan

Signature

Assistant Administr
Bureau for Asia

SEP 30 1977

Date

GC/Asia:PHipom:hp:9/22/77

Chron
Subject
Reading
GC Files