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15 December 1969

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MEMORANDUM FOR: DD/I Planning Officer

SUBJECT: RD&E Planning, FY 1972-76

REFERENCE: Your Memorandum, Planning FY 1972-FY 1976, dated 7 November 1969

1. Attached is the Research, Development, and Engineering portion of the National Photographic Interpretation Center's Five Year Plan for FY 1972-1976. It has been developed to serve three broad objectives:

- to increase the efficiency of the exploitation process and the quality of its product;

- to improve our capability and capacity to receive, process, reproduce, store, and retrieve imagery and imagery-related materials;

- to develop concepts for exploitation of new imagery acquisition systems, and to develop the equipment and procedures necessary to the implementation of these concepts.

Each of these objectives is addressed separately, and in terms of the progress and more significant accomplishments to date as well as research efforts planned for the coming years.

2. The nature and scope of these RD&E plans are responsive to two important considerations:

- The Center serves a community of intelligence production and imagery exploitation components through its research and development efforts. One aspect of this contribution which is peculiar to and best done by the Center, as a service of common concern, is basic research aimed at enlarging our understanding of imagery in its fundamental scientific and technical aspects.

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- The Center seeks to sustain and augment the quality and quantity of imagery exploitation through development of equipment, data handling systems, and other technical improvements rather than by increasing the manpower engaged in exploitation.

3. Questions regarding this submission or requests for further detail can be directed to myself or [redacted] of my Staff.

[redacted]
Chief
Planning, Programming & Budgeting Staff

NPIC RD&E PLAN FY 1972-76

Objective One

To increase the efficiency of the exploitation process and the quality of its product.

1. Discussion

The exploitation process is bounded at one extreme by the requirements of the intelligence community and at the other extreme by the characteristics of the collection system. Within those bounds, the significant factors are: (1) characteristics, limitations, and skills of personnel involved in the process; (2) equipment utilized; (3) procedures and techniques applied in the process; and (4) quality and character of the film or imagery medium.

2. Program Progress

a. Personnel Factor

(1) Comparative tests to measure the performance of imagery analysts and photogrammetrists on selected mensuration tasks were designed and administered; the results of these tests have served as a basis for decision in the areas of equipment purchase and procedural changes.

(2) Through a controlled test of mensuration performance, a statistically sound approach to mensuration accuracy statements was developed; this approach has increased the level of confidence in the Center's dimensional error statements.

(3) A comparison of achievements and skills was made between on-the-job experience and the 12-week training program for new imagery analysts, the Defense Sensor Interpretation and Application Training Program; the findings resulted in a decision to schedule all new imagery analysts for this training program.

(4) A preliminary validation of an Agency-administered imagery interpretation test battery for use in evaluating applicants was undertaken, and development of an Imagery Analyst Target Knowledge Inventory was initiated. This inventory will serve as the basis for development of an in-house training course supplemental to the Defense Training Program.

(5) Utilizing a five-year projection approach, the functions of the imagery analyst and collateral support officer were analyzed to determine possible areas of applicability for automation of manual operations.

(6) In the future, photographic imagery may well be supplemented for analysis purposes by line-scan imagery (cathode ray tube). An elementary study was undertaken to determine the level of resolution of line-scan imagery, as compared with photographic imagery, deemed necessary for exploitation by the imagery analyst.

(7) A review of articles pertaining to imagery exploitation research was conducted, and those relevant to Center operations were abstracted. Contacts were established with industrial and governmental research and development facilities for the purpose of obtaining, on a continuing basis, human factors information pertinent to exploitation equipment design. The PI Equipment Human Engineering Design Guide, a summary of physiological and engineering information applicable to the design of imagery exploitation hardware, was updated by inclusion of specific sections pertaining to acoustics and comparators.

(8) Recent studies have indicated that the convergence angle of microstereoscope eyepieces might influence visual performance; preliminary research was undertaken to determine the effect of the convergence angle of optical instruments on visual performance.

b. Equipment Factor

(1) In 1971, under multiple year funding, a precision stereo comparator will be completed and delivered to the Center. This instrument is intended for ultra-precise work by the photogrammetrists and incorporates many advanced features such as .5 micron accuracy, automatic correlation of the stereo imagery and the capability to use roll film on large format stages; i.e., the original negative for maximum fidelity.

(2) Utilizing FY 68 funding, an on-line comparator was produced for use by the imagery analyst. This is a stereo instrument for measuring stereo images on cut film chips and is designed for use in detailed interpretation. It can be used to measure heights and is on-line to the Center's centralized UNIVAC 494 computer. It is a medium-precision instrument with accuracy in the two-micron region.

(3) A digitized light table for use by the imagery analyst has been developed under FY 69 funding. This instrument, which will undergo operational testing during the next few months, is connected on-line to the Center's 494 computer and will permit immediate readout of either ground dimensions or film coordinates from roll film while the film is still on a standard operational light table.

(4) The 1540 light table, designed and developed for efficient exploitation of [redacted] imagery will be in production in FY 70.

(5) Stereo rhomboids, required for viewing [redacted] imagery in stereo, are under development.

(6) An automated Target Indexing Device is under development with the prototype scheduled to be delivered to the Center in FY 71. This instrument will provide a capability to automatically determine cloud coverage on roll film at the rate of 100 feet per minute.

(7) An Automated Stereoscanner under development is designed to permit automatically correlated stereo-scanning of roll film. It will be used to evaluate the operational feasibility and value of scanning in stereo.

(8) Detailed plans were developed for test and evaluation of two highly sophisticated pieces of equipment mentioned above, the High Precision Stereo Comparator and the Automated Stereoscanner. The comprehensive testing program designed for these two unique items includes development of simulated imagery having [redacted] characteristics, development of a special calibration device, and development of performance evaluation standards.

(9) Special consultation arrangements were made with the National Bureau of Standards to develop sensitometric and resolution test equipment for the "dry silver" or dry-process photo reproduction materials under development. As a part of this effort, a special sensitometric processor is being developed in FY 70.

(10) The best current method of evaluating the resolution performance of optical components and systems is to have a qualified phototechnologist read a resolution test target displayed through the optics. This evaluation approach is quite subjective. A special target is being developed for use in allowing objective measurement of the performance of optical components as it relates to resolution.

c. Procedures and Techniques Factor

(1) Two pilot studies, undertaken to determine the level of resolution necessary for satisfactory exploitation of imagery to meet existing intelligence requirements, were completed; a third such study is now in process.

[redacted]

(3) FY 69 and FY 70 funds were utilized to support certain critical in-house studies of mensuration errors and how they affect mensuration procedures and equipment. The information thus gained will be utilized as a foundation for further studies in the future development of advanced mensuration instrumentation.

d. Image Characteristics Factor

(1) Three contracts were concluded during the period FY 69 through mid-FY 70. The first defined the present state-of-the-art in photo-optical image evaluation; it recommended a general approach to finding a solution to the problem of relating subjective quality estimates to objective measurements. The second contract was an

initial effort directed toward applying the theory developed and toward establishing basic conditions for evaluating optical components. The third contract attempted to establish requirements for microdensitometric analysis of color and black and white photographic imagery for use in objective assessment of quality.

(2) The capabilities of digital, optical, and photographic manipulation systems are being explored by the Center with contractor support. Preliminary results of experiments designed to extract additional intelligence of value from degraded imagery through a digital process are favorable. The evaluation of results in each system will determine the maximum payoff to be gained by (1) the application of one of the above systems, (2) establishing a capability in each system to be applied selectively against specific conditions, and (3) development of a hybrid system to incorporate the relative advantages of more than one system. Time-phased plans are under development for evolution from experimental to operational status. As part of the manipulation effort, imagery enhancement techniques for improving degraded portions of film are being explored and developed for the digital and electronic modes.

(3) A literature search has been initiated and state-of-the-art capabilities are being investigated concerning image manipulation of unconventional (e.g., [redacted] Some limited feasibility experiments have been performed with existing equipment, utilizing optical, digital, and photographic processes. Development of the overall program is the planning stage.

3. Program Plans

a. Alternatives

(1) Personnel Factor

Alternatives are: (1) to accelerate the program somewhat by applying more funds thus reducing performance time; (2) to extend the performance time frame, thus reducing annual expenditures; (3) to reduce the scope of the program, thereby reducing total expenditures; (4) to continue as planned, with respect to both time frame and scope, an approach tailored to feed in data coincident with the advent of new systems and with bench marks in certain other R&D projects.

(2) Equipment Factor

This factor offers few alternatives since the Center must develop and incorporate into its inventory those equipments necessary to exploit fully the products of current and future acquisition systems. The few alternatives obtain, in fact, when dealing with questions of equipment sophistication; in such cases, it is NPIC policy to evaluate cost versus value tradeoffs.

Exploitation equipment developed for the Center is unique and increasingly complex; the techniques, standards, and instrumentation, however, necessary for test and evaluation of the performance of the equipment often do not exist. Due to the uniqueness of the equipment, industry often finds the development of performance evaluation instruments for use against this equipment to be unprofitable. Such a situation mitigates against any viable alternatives to further development of a test and evaluation program other than that of funding by the Center.

(3) Procedures and Techniques Factor

The two related areas of effort under this factor provide different alternatives. In the one case, mensuration error, alternatives are: (1) to perform the majority of the work in-house, utilizing operational personnel when and if available; (2) to contract out the major portion of the work; (3) to use a hybrid approach, supplementing in-house efforts rather strongly with contractual assistance. In the case of the other area of primary effort; that is, objective determination of what information and its intelligence value, additive to that afforded by conventional black and white photography, is provided by unconventional collection systems, alternatives are: (1) to rely on extrapolations of available and uncalibrated imagery obtained from conventional and unconventional collection systems for purposes of assessment of intelligence value and (2) to obtain simulated and operational imagery relating to the collection systems, along with the necessary ancillary information, to allow more effective intelligence value assessment.

of inter-related factors. A reduction in scope, eliminating research into some of these factors, would substantially and critically reduce the overall effectiveness of the program. Alternative 4 was selected because it will facilitate a systematic, integrated approach to the various subtasks of this effort and is designed to provide data in time to be applied to oncoming programs (e.g., [redacted] to provide a sound human factors basis for use in new equipment design and modification of existing equipment, and to enable the establishment of techniques and procedures which will take advantage of the capacities and skills of personnel while recognizing, adjusting for, and minimizing human limitations.

The plan is to accomplish this portion of the program through the medium of one major contractor, a number of minor contractors with specific areas of specialization supplemental in-house efforts, and support from the CIA Medical Staff. A significant portion of the in-house effort will be accomplished through the Technology Integration Check-Out Facility (TICOF) used for gathering imagery analyst performance data under controlled conditions. (TICOF itself was an earlier accomplishment under this program.) The analysis of inherent or acquired human characteristics involved in the imagery exploitation process will continue; specific characteristics which affect or are affected by new systems (e.g., [redacted] advanced hardware, or changed procedures will be investigated. Based on the research findings, determination will be made as how to best apply the results, such as establishing new recruitment standards, retraining or reorientation of personnel, modification of procedures, or redesigning equipment. Efforts will continue in investigation of potential applications of automation to the imagery exploitation process, specifically with respect to graphics display (FY 70-71), line-scan systems (FY 70-76), collateral material presentation (FY 70-76), and text editing (FY 70-76).

(4) Image Characteristics Factor

The three major areas of the image characteristics factor are image analysis, image manipulation, and unconventional imagery. Image analysis deals with improving conventional image quality measurement and determining the relationship and degree of correlation between objective and subjective imagery evaluation criteria; alternatives applicable here are: (1) to utilize and refine the work on objective measurement accomplished to date and concentrate upon subjective evaluation of imagery; (2) to concentrate heavily on what could be termed the theoretical aspects of subjective and objective image evaluation, and (3) to develop new objective evaluation techniques, where beneficial and to direct additional effort toward determination of significant subjective factors in image evaluation. Image manipulation deals with developing an operational image manipulation system with the capacity to compensate for image-degrading factors which occur during acquisition and/or the processing of conventional imagery. Because image manipulation is still in a preliminary phase with respect to future direction, it is too early to specify feasible alternatives to any useful degree. The same is true generally

b. Approaches Selected and Program Plan

(1) Personnel Factor

The first alternative was rejected because the overall timetable is designed to provide needed information in the proper time frames and acceleration would represent a situation of diminishing returns; that is to say, that the nature of the projects are such that beyond a certain point, the application of additional dollars purchases very little in terms of added results. Alternative 2 was rejected because of the necessity to accomplish a number of these projects within a given time frame, and if the results of the projects are to be applied meaningfully, Alternative 3 is not acceptable because the nature of the overall problem requires a simultaneous effort against a number

Identification of the human factors which affect the assessment of image quality and dictate the level of quality needed for exploitation will be continued. State-of-the-art knowledge of human factors research will be maintained, and the Human Engineering Design Guide will be updated as required.

(2) Equipment Factor

The Center will continue to program for equipment development utilizing contractors to meet established and anticipated exploitation needs. Major emphasis will be upon lowering the cost of production units and designing for high reliability and easy maintainability. Significant milestones are: FY 70, development of the Target Indexing Device; FY 71, [redacted] interpretation equipment available for use and Image Comparison Stereoviewer

[redacted]

To avoid total reliance upon contractor assurance that equipment specifications and performance standards have been met, the Center will continue its program, to include techniques and equipment, for such test and evaluation. In view of the limitations on the number of in-house personnel who can be assigned to the test and evaluation task, a supplementary contractual support program for the development of the highly specialized equipment and techniques needed for test and evaluation has been established. Milestones will be established in terms of timely provision of the required equipment and techniques; results will be in terms of objectively determined evaluations.

(3) Procedures and Techniques Factor

With respect to mensuration error, the third alternative, a hybrid approach, supplementing in-house efforts with contractual assistance, was selected as most advantageous because it achieves the overall objectives while minimizing the disadvantages attendant to the other two alternatives. The first alternative was rejected because of its potential great drain on in-house assets and the extended time frame for completion of the work. The second alternative was rejected in favor of the third because specific tasks related to the work will require major inputs of man-hours from operational personnel.

The plan is to perform basic and applied research to determine the relative and absolute values of the various factors in the mensuration process in order to improve mensuration accuracy. This involves determining the amounts of error contributed by factors such as the source material, the collection vehicle, the mensuration equipment, and the operator.

With respect to additive information and its intelligence value, the second of the two alternatives was selected because of its obvious merit. Additional investigations to those already undertaken will utilize various selected target types and imagery collection systems to determine the level of resolution needed to meet intelligence requirements and the additive informational value of unconventional systems.

(4) Image Characteristics Factor

In the area of image analyses, the first alternative is a high risk option with relatively low expected value; that is, even if accomplished successfully, at best the objectives would be attained only minimally. The second image analysis alternative would afford a firm scientific foundation against which to proceed; however, performance time and costs would be increased beyond those desirable or necessary. In effect, the second alternative would result in project performance being extended over a longer period of time without elimination of any of the

essential subsequent steps. The third alternative was selected because it embodies the best trade-off between risk, cost, and pay-off.

The plan then is to continue along the lines of the third alternative. Milestones anticipated are: FY 72, complete the study of objective evaluation techniques; FY 73, identify and codify the significant object measures; FY 74, complete the study of subjective evaluation measures; FY 75, determine the correlation procedures for objective and subjective evaluation; FY 76, operationally implement the evaluation techniques.

In the areas of image manipulation and unconventional imagery systems approaches utilizing digital, optical, and photographic concepts will be continued. An initial effort to determine applicability of these techniques to unconventional imagery will be undertaken. Significant milestones anticipated in the manipulation effort are: FY 70, establish in-house experimental capabilities in digital, optical, and photographic image manipulation; FY 72, determine and evaluate the operational applications for digital, optical, electronic, and photographic manipulation techniques; FY 73, specify operational equipment requirements; FY 74, develop prototype equipment; FY 75, test and evaluate prototype equipment; FY 76, implement the system for operational use.

4. Resources

[redacted]

Objective Two

To improve our capability and capacity to receive, process, reproduce, store, and retrieve imagery and imagery-related materials.

1. Discussion

The exploitation process includes and is dependent on: (1) recall of and reference to imagery from past missions, prior imagery analyses, and collateral information, and (2) the reproduction of conventional and unconventional imagery materials. The volume of data and material on hand, the growing volume of inputs, the exploitation timeliness requirement, characteristics peculiar to new collection system products, and a continuing constraint upon manpower demand that the Center develop new and/or better ways of conducting recall and reference and reproduction processes. The main thrust in the recall and reference process (handling, processing, storage, and retrieval of imagery and imagery-related products) will be toward automation. Emphasis in the reproduction area will be on the development of a total system, utilizing in large part the dry-process, to handle both conventional and unconventional imagery. The reproduction process will be directed toward a higher-speed, more efficient total system able to handle expeditiously both conventional and unconventional materials.

2. Program Progress

Various aspects of the recall and reference process have been investigated in-house in the Automatic Reporting Techniques and Equipment Study, TICOF studies, and by the advanced editing systems evaluation teams. Additionally, a contractual effort, comprising development of certain computer programs and techniques, demonstrated the feasibility of a cathode ray tube graphics and textual display system. Design objectives have been established for the development of a prototype display system incorporating this concept. Design objectives have also been defined for a system to display multiple images from film chips, microfilm, and collateral materials. A Chip Implementation Study was contracted for in FY 69; upon completion, it will present the Center with several alternative plans for utilizing chips in support of the exploitation process.

In the area of imagery reproduction, major progress has taken place in the dry-process reproduction of imagery. Film materials of good quality were produced by the contractor in a pilot production effort. Equipment "breadboards" to print and dry-process these materials have been developed to a reasonable level of success. Contact printing and photo enlarging papers are now scheduled for a scale-up

from pilot production. Useable photo enlarging papers will be available to the Center in June 1970. On the same date, a 40-inch wide enlarging paper processor plus a sheet film processor will be available. High-speed processors for roll film and papers have been fabricated and undergone a 6 to 12 month test and evaluation program by the contractor. A dry-heat processor (positive-to-positive image) for direct use by imagery analysts has been developed.

3. Program Plans

a. Alternatives

In the recall and reference process, the feasible alternatives are: (1) to rely on industry to develop pertinent equipment and techniques at its own expense and to fund the program at a later date utilizing industrial developments wherever possible, and (2) to fund the effort at the level and in the time frame required in order to insure achievement of such a capability within the planning period.

In the reproduction area, there are two sets of alternatives. These sets are: (1) to continue or halt efforts directed toward implementation of dry-process reproduction, initially for black and white materials but eventually applicable to all types of imagery as feasible, and (2) to rely on industrial development of wet-processes for unconventional imagery reproduction or to advance the Center capability to reproduce unconventional imagery materials by the wet process.

b. Approaches Selected and Plans

With respect to the recall and reference process, the second alternative, to fund the effort in order to insure achievement of the required capability within the planning period, was selected because the unique developments required by the Center in this area will not, in all probability, be achieved sufficiently by private industry at its own initiative within the time frame required.

The plan is to develop a cost-effective, integrated, automated system for storage, retrieval, manipulation, and display of imagery, information derived from imagery, collateral materials, and graphics used in the analysis and reporting cycles of the exploitation process. Significant milestones will be: (1) in FY 70-71, to develop and operationally evaluate prototype, automated, off-line, textual and graphic display consoles; (2) in FY 71-72, to investigate the basic technologies required to handle and display

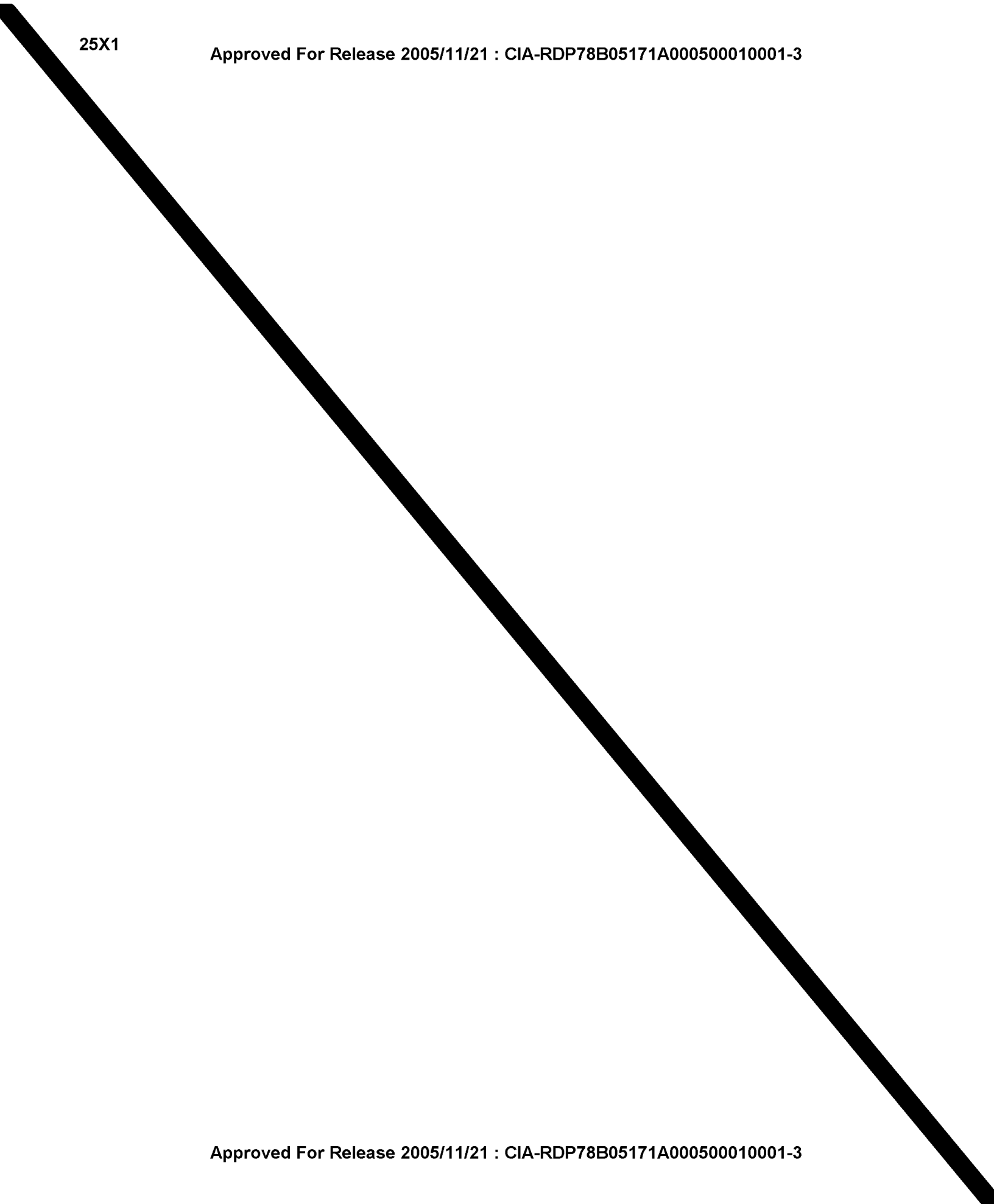
imagery in various chip forms; (3) in FY 72-73, based upon the knowledge gained from the evaluation of the prototype consoles, to develop operational models as required; (4) in FY 74-76, to incorporate the results obtained under this effort into the Center's Integrated Information System.

The alternative to proceed with development of the dry-process reproduction of imagery materials was selected because it provides an imminent capability for significant improvement in the Center's entire imagery reproduction system not otherwise possible. The dry-process effort has been under way since 1965. Specific advantages offered over the wet-processing system are: equipment units required are approximately equal in number to present units but are significantly smaller in size, thus affording savings in space; the dry-heat process does not require bulk liquid chemicals, thus avoiding the inherent hazards of such chemicals while including the possibility of additional space savings; the dry-process equipment is less complicated to operate than the wet-process equipment which affords a possibility for the Center to decentralize part of its reproduction system, resulting in savings in both the photo lab and imagery analyst areas; and a reduction in the amount of silver used, with resultant dollar savings. The plan is to proceed with the dry-process development, major milestones being the development of satisfactory dry-process films and paper in FY 70-72 and the development of operational equipment over the period FY 70-74.

With regard to wet-process reproduction of unconventional imagery materials, the selected alternative is to advance the Center capability to reproduce unconventional imagery materials by the wet-process. This alternative was selected because the Center reproduction facility will be called upon to handle [redacted] and it is unlikely that industry will develop such a capability for commercial application that would be within the standards required for intelligence exploitation. Reproduction of these materials is slow and far more complex than standard black and white imagery although the methods are basically the same. Dry-processing may be applicable eventually to these materials; however, it is necessary to plan for continued research and development in the wet-processing system.

4. Resources

[redacted]



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Objective Three

Develop concepts for exploitation of new imagery acquisition systems; develop the equipment and procedures necessary to the implementation of these concepts.

1. Discussion

It is anticipated that new acquisition systems will become operational late in the planning period. The Center plans to undertake the research and development necessary to assure a timely capability to exploit the products of such systems, as well as to assist those concerned with designing such systems. Efforts in this area will be focused mainly upon [redacted] 25X1

25X1

2. Program Progress

Planning for exploitation of [redacted] is in the early stages of development. Based upon preliminary information regarding the [redacted] acquisition system and the [redacted] Report, in-house studies directed toward formulation of general exploitation concepts are underway. 25X1 25X1 25X1

3. Program Plans

a. Alternatives and Approaches

The Center recognizes that the future of [redacted] or similar collection systems is uncertain at this point in time. The [redacted] concept, however, involves a major departure from exploitation procedures and equipment now in use or contemplated, and its implementation will require long research and development lead times. It is necessary therefore, that early investigations be undertaken, with contractual support, to develop the exploitation system concept and alternative approaches to system design. As the investigations progress, procedural, equipment, and staffing alternatives will be developed, providing choices with respect to costs, technical risk, degree of automation, etc. 25X1 25X1

25X1

b. Plans

The preliminary plan for research and development in this area comprises the following:

(1) System Definition (FY 70)

Develop several alternative [redacted] exploitation system concepts based upon current knowledge of acquisition system performance and intelligence requirements.

(2) System Design (FY 71-72)

Based upon these system concepts, investigate two exploitation systems utilizing significantly different technological approaches - one emphasizing advanced technology and the other, off-the-shelf components and existing state-of-the-art techniques.

(3) Equipment Design (FY 72-73)

Based on the system concept and technological approach selected, initiate development of [redacted] exploitation system equipment.

(4) Equipment Development (FY 73-74)

Develop prototypes of new equipment items necessary, and test and evaluate such prototypes.

(5) System Modification (FY 75-76)

Following evaluation under operational conditions, modify system components and procedures and develop additional equipment as required.

4. Resources

[redacted]

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