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OFFICE MEMORANDUM

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TO : M. M. Kligerman, ADRT

DATE April 26, 1978

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MP-00

THRU: J. Bradbury, MP-3

FROM : P. A. Berardo, S. M. Zink

SUBJECT : PIPLAN STATUS REPORT

SYMBOL : MP-3

MAIL STOP: 809

I. INTRODUCTION

This memo briefly discusses, prior to and unbiased by third party consultants, the factors responsible for the delay of routine clinical use of PIPLAN, and considerations for the future. It is sincerely hoped that third party consultants will have some constructive suggestions. Although we have received many supportive offers of increased staff and a CRTC computer, these basically would not have helped. In fact, the delaying problems were largely beyond either your or our control.

Given the nature of pion scattering and capture, and the characteristics of our beam channel, direct 3-D dose accumulation in 3-D heterogenous volumes is a fundamental requirement for this project. No other clinical treatment planning has ever attempted this. High LET projects with small parallel beams of heavy particles with negligible scattering are able to use simple dose modules that are easily implemented. In some ways their problems are easier to solve than those of conventional radiation.

Dose calculations which combine accurate physics with detailed anatomy have always been our main objective. However, new and intermediate objectives have been achieved in response to clinical requirements. All of our current capabilities with CT data and the use of CT data in PIPLAN are examples. Other intermediate goals could have been achieved and should be explored in the future.

II. PAST PROBLEMS, ASSOCIATED DELAYS

A. CCF System Changeover

The conversion of PIPLAN from CROS to LTSS was accomplished in response to the changing computer operating system at the Central Computing Facility (CCF). The standard Fortran computer FTN, on LTSS could be accessed only through the interface SLOPE-2 where a number of system level problems occurred and caused delays. Problems occurred over a period of time, and were responsible for a total of 8-8-1/2 weeks delay.

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They included:

1) Replacement of a library routine by CCF in the library FTNMATH magnified the total calculational time with CT data enormously. Persistent detective work over a period of 1 1/2 weeks was required to identify the subroutine responsible for the large time factor.

2) A library subroutine doing a quick transfer of data from large-core to small-core-memory had an error and caused the program to abort. Completely documented runs with appropriate listings, maps and output were required to identify the problem. This effort absorbed approximately one week.

3) During the conversion process, extensive use was made of "CGFTN", a debugging tool. However, it was found that a "bug" existed in this CCF package. Our cooperation with the appropriate C-Division consultants resulted in a "fix" but a delay for PIPLAN. The error-handling package on SLOPE-2 was incomplete at the time of the conversion, and as a result, a means of filtering out arguments out of range for routine functions, such as exp (x), had to be developed. These problems caused at least a week's delay.

4) A change to the library subroutine ERFC(x), which calculates the error function values, brought about a subroutine call to itself, resulting in an infinite loop condition. Numerous runs and debugging efforts finally localized and identified the problem. The delay was about 1 week.

5) The software to handle overlays on SLOPE-2 was imperfect and the "Recall" parameter was unreliable initially. This inadequacy, in turn, propagated errors through the code that eventually absorbed 2 weeks.

6) During the past 6 months, the system libraries have been expanded twice, decreasing the amount of space for the user. Thus, PIPLAN's basic overlay structure has had to undergo modification so that it will fit into the allotted user core (2-2 1/2 weeks).

7) In addition, the remote port at Biomed has suffered from line transmission quality and, as a result, has produced a significant amount of "down-time" in terms of accessibility. This is being actively pursued by the appropriate personnel in C- and E-Divisions.

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B. RSX

The Biomed computer also presented problems during this period. Its frequent crashes, resulting in lost work, and resulting "down-times" to effect quasi-repairs were all frustrating and counter-productive. The delay caused by CCF problems, however, was in fact the deciding factor in determining which capabilities came on line. Thus, delays caused by the Biomed computer have not contributed to the overall delay. Since the two-week shutdown in January to solve the Biomed computer problems, this computer has been quite reliable.

Fixes and upgrades to the CT programs, CTBILD, CTVIEW, and CTEXAM, have absorbed additional time. These upgrades were deemed necessary in order to be able to design bolus for patients as efficiently and accurately as possible within the limits of the model.

C. Programming

As soon as a certain minimum capability of running with CT data at the CCF was obtained, a test case file was set-up and numerous test runs for single ports were made. This produced a working version, ready for real data. However, when a case file for a real patient was attempted, new problems developed:

1) We had overlooked part of the logic required for connecting anatomy sub-files for multi-port plans during the course of the calculation. The solution was to backtrack and resulted in new coding changes in the RSX and LTSS versions. This problem was easy to identify, but difficult to fix.

2) In order to achieve a run during prime-time on LTSS, we carried out calculations using only one slice of CT data. This conserved not only CPU time but I/O time as well. However, an unforseen logic problem arose for multi-port calculations where the program generates a volume in the case of a single slice for the calculation. This problem was very difficult to identify, but had a simple solution.

D. Bugs

The anatomy contours for the case file 43 had, by chance, overlapping edges. The algorithm that PIPLAN has used for determining the density codes within a given contour proved to be inadequate where an ambiquity existed. This problem was not only very difficult to identify, but also extremely difficult to fix. A completely satisfactory solution that will handle all the possible cases has still not been implemented.

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Another "bug" was an error in a common block that resulted in dose distributions being displaced one step. Numerous causes for this problem were investigated before the explanation became apparent.

E. CCF Priorities

During all the work with the CCF operating system, we have encountered from time to time a handicap in dealing with the CCF allocation of computer resource. This is accomplished through a bank account of points that are used up with computer usage at a slower or faster rate, depending on the user's priority. The bank account for MP-Division was inadequate for more than one calculational run per day. Attempts to alter this allocation scheme so that we had a larger share of the day-time points were very strongly discouraged at every level. We made every effort to accomplish the required work during evening, early-morning and weekend hours when the user load was light and the bank accounts large. However, the CCF policy of making this "production" time, with an intolerable long time-slice for interactive work, made it very difficult for the user to work effectively in any way other than a "batch" submit. We felt that we had tried to cope with the system as effectively as possible and were still unable to meet our goals. For this reason, we asked for the separate bank account of 50 points in the memo of April 10, 1978. This was approved, changing to 25 points on May 15, 1978. This measure, we hope, will help us in achieving the necessary turn-around for the coming deadlines.

F. New Bolus and Collimators

A new model for calculating bolus and collimator has been designed but not debugged. It will allow placing the collimator some specified distance above the patient and not necessarily on the surface. This was in response to clinical requirements. It had been originally scheduled to be ready for the coming cycle. It has been moved back in priority, however, so that the improved physics can be incorporated into the current version in time for the next cycle.

III. PRESENT PIPLAN CAPABILITIES

The current version of PIPLAN has the capability of calculating three-dimensional total dose distributions using CT data. There are discrepancies between PIPLAN-calculated depth-dose distributions and measured depth-dose curves. We believe that these discrepancies are due to inaccuracies in the physics model and we are currently addressing these problems. We hope to have new calculations to compare with measurements in the next few weeks. PIPLAN gives the relative high, low, and medium-LET components of the dose along the central axis. These dose distributions are all generated at the CCF and output to microfiche. Hard-copy plots can then be made from the microfiche.

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The first step in carrying out a calculation is to generate the patient case file with the Biomed version of PIPLAN and export it to magnetic tape. This involves a number of steps:

1) Loading the Biomed disk with the patient's CT data through CTBILD.

2) Generating the sub-file containing anatomy contours, including surface and treatment volume contours, as well as anatomical landmarks.

3) Creating a "plans and beams" file, which determines how a calculation will proceed. For example, multi-port calculations need the appropriate reference numbers to link the correct CT sub-file to the matching anatomy sub-file.

4) All rotations and transformations of the data should also be included in the case file so that once the magnetic tape is carried to the CCF, the calculation will proceed smoothly and without modifications.

The clinical limitations of the current version have to do with range-shifter functions and beam tunes. It is now possible to do a calculation with only one range-shifter or one beam tune per plan. Thus, an AP-PA opposed port calculation to yield a total summed dose distribution would require that both ports have the same range-shifter and the same tune. We have designed a scheme whereby PIPLAN will access range-shifter functions and beam tunes from libraries through a file directory. This will be implemented as soon as priorities permit. Additionally, the present automatic collimator model is limited to the surface. A new collimator model has been designed, but not debugged. This new model necessarily affects the bolus calculation and therefore, bolus cannot now be designed by PIPLAN. Dose distributions on microfiche output do not come out life-size. In spite of these limitations, however, we want to emphasize that PIPLAN is a unique product:

1) It is accessing CT data for its dose calculations.

2) It is carrying out a three-dimensional calculation and accumulating dose over a volume.

3) It is an interactive program designed for the unsophisticated computer user, with the emphasis towards clinical use.

4) Its structure is highly modular with user-libraries, standard FORTRAN and efficient coding. These characteristics support high efficiency of personnel and machine resources.

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IV. CONSIDERATIONS FOR THE FUTURE

We see three areas that should be considered: manpower, computers, and priorities.

A. Manpower

Additional personnel, inexperienced with PIPLAN, would have been a hindrance the past few months rather than a help. PIPLAN development, until recently has been limited by computer problems. Moreover, two people working simultaneously on the same code destructively interfere and the structure of PIPLAN generally makes impractical development of upgrade-modules independent of the program.

Nevertheless we do see where additional help could be well used as follows.

During the next month: One man-week for implementation of AS&E CT magnetic tape format conversion. One man-week to work with Harville Wright, ORNL, to run test cases with PION-1 which we recently installed at LASL.

During the Next 3 Months: This period is covered by Robert Nance for the summer. Complete the development of libraries of beam tunes, range-shifter functions, and analytical dose distribution. Complete the debugging of RSX output module. Complete the solution of intersecting contours.

During the Next 6-9 Months: Specify, install, program, and interface diagnostic terminal with PIPLAN. Dr. Irifune from Japan has expressed an interest in treatment planning and his involvement during the next year should be considered.

B. Computers

1) Short Term: CCF: Change after next cycle to LTSS stand-alone compiler. This provides improved response/cost ratio and allows full case file capabilities. RSX: Standardize backup capabilities to forestall unexpected delays.

2) Long Term: CCF: None. Operating system should be stable for 3-5 years, hopefully much longer than we will need it. RSX: Continue to push to get on-site treatment planning calculation.

C. Priorities

Last fall we presented to you, and all others on this project, a prioritized schedule of tasks that we were going to pursue. When full CT capabilities were finally achieved at the beginning of March,

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a new schedule was drafted and explained in detail to Jim Bradbury, Chuck Kelsey and Al Smith. In both instances no significant suggestions for changes were offered. This vote of confidence is appreciated. But perhaps more feedback would be useful. In fact, we have often made both minor and major changes in direction as constraints have changed. This has, as explained above, delayed certain capabilities, but others have been achieved earlier than originally expected. In the future our options may not be so constrained. At such times additional input from interested parties will help us.

PAB/po

cc: Chuck Kelsey, CRTC
Al Smith, CRTC
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