1. ANALYSIS
(W. G. Welchman)

At a brief meeting on Monday, November 27th, the first 6673 experiments with IS were discussed and it was tentatively agreed that computer time would be available in the mornings. Subsequently, as a result of a discussion with P. R. Everett, H. H. Taylor, C. W. Adams, and D. Israel, it was agreed that as far as possible 6673 work on the computer will be done between 4 pm and 6 pm.

Profitable work with the computer requires considerable preparatory study. Consequently, as more computer time becomes available, it will become increasingly important to share the responsibility for computer operations among the members of the 6673 group. The intention at present is that, during the 4 pm to 6 pm periods allotted to 6673, operations will be carried out either by J. A. Arrow and H. Saxonian or by E. L. Walquist and C. H. Caudetto. Additional computer time can be profitably used for training purposes. It is further intended that, when new recruits have passed through preliminary training, Walquist, Arrow, Caudetto and Saxonian will lead four separate operating teams.

Consideration of a simple program to demonstrate for course 6.535 the plotting of a circle by linear extrapolation showed that this method gives surprisingly accurate results. Further study seemed justified because this method might under special circumstances be of value for coordinate conversion. A note will be issued on this subject.

A little thought has been given to simple methods of obtaining random numbers for the preparation of synthetic radar data. It seems probable that continued multiplications by a suitable number, separated by operations, would give sufficient randomness in a set of digits selected from the middle of the word. It may be desirable to investigate this process on the computer.
1. ANALYSIS (continued)
(W. G. Velchnap) (continued)

Two representatives of the EOMAR project paid us a visit to discuss programming problems.

The possibility of using standard IBM equipment for punching programs and feeding them into W.W. was discussed with R. R. Everott and E. E. Taylor. A simple method of operation was proposed in which four W.W. words are punched on each card, so that the parallel sensing circuits of standard IBM equipment could feed into a W.W. flip-flop register at the rate of 2,400 words per minute, using much the same circuitry as that employed for the parallel feed in of radar data. This speed would be a big improvement on the punched tape system, and reliability should be high. The IBM cards would provide a very convenient form of program storage. This simple scheme could probably be put into operation with very little trouble. A more ambitious scheme with 32 words on a card and an input rate of 19,200 words per minute seems possible, but this would complicate both the card preparation and the auxiliary equipment. It seems possible that parallel output onto punched cards might also be helpful in 6673 work.

(J. M. Salzer)

Proposal for an Sc. D. thesis has been written and issued as an F-note. Briefly, the proposed thesis will deal with the general problem of treating control systems which incorporate a digital computer. A digital-computer program has the same relation to the system an analog unit has; i.e., it operates on an input quantity to produce a different output in real time. Although a program handles sampled, rather than continuous data, its operation can be represented in the frequency domain. The frequency transform of a digital operator is a transfer function, and consequently, it is amenable to all manipulations applied to transfer functions of analog units. There are, of course, important differences, but in a heterogeneous system of digital and analog units the frequency-domain approach has great advantages. Using this approach, the thesis is proposed to treat the following problems:

(a) analyse programs in terms of transforms; define relationship between characteristics of programs and of their transfer functions,

(b) determine conditions of stability and realizability of programs.
1. ANALYSIS (continued)
   (J. N. Salser) (continued)

   (c) synthesizing programs on basis of some characterization
       in the frequency domain.

   (d) define step-by-step procedures for dealing with
       composite, heterogeneous, closed-loop systems.

   (e) apply these methods to numerical analysis in
       general and to the estimation of truncation errors
       in particular.

Work on other phases of the project is continuing.
C. H. Gaudette and I seem to find it difficult to approximate
the arcsin curve in the total range \(-1 < x < 1\) by a fifth
degree polynomial with a maximum error of less than 1°C. The
need for determining the complexity of a satisfactory arcsin
approximation arises in an interception program being designed
by R. L. Walquist.

(D. R. Israel)

A program has been written to provide a means of testing
the "aided-tracking" equations to be used for obtaining values
of smoothed velocity and position from quantized radar data.
A second object of this program will be the selection of
coefficients \(a\) and \(b\) for these equations.

The program simulates the movement of an aircraft with
manually-adjustable \(x\) and \(y\) velocity components. Velocity
components of from 0 to 476 mph in steps of 4 mph can be
prescribed. By means of these velocities and an initial
position, the true positions of the aircraft are calculated to
a full 15 digits. These true positions are rounded-off to
7 digits, these rounded values being used as the quantized
radar measurements.

The program consists of three main parts — one which
generates the true positions and radar measurements, a second
which uses these measurements in conjunction with the tracking
equations to obtain smoothed values of velocity and predicted
position, and a third section which displays the errors in
these smoothed values as compared to the true values. The
program is repetitive, starting over at the initial conditions
after a simulated 32 minute flight or longer.
1. ANALYSIS (continued)
   (D. R. Israel) (continued)

   This program, now on Tape 16, has been successfully run several times on the computer. It is felt that after more familiarity with operating the program and adjusting the settings of constants and parameters, values of $a$ and $\gamma$ will be chosen. In general the tracking equations appear to be satisfactory for use in 6673 programs.

   One difficulty with the program mentioned above is the fact that $x$ and $y$ measurements are quantized, rather than $r$ and $\theta$ measurements. Although it is felt that no significant changes will be noted when $r$, $\theta$ quantization is introduced, if time is available in the near future an attempt will be made at simulating the actual conditions. This is not a trivial change in as much as a straight line path in $r$, $\theta$ coordinates must be generated.

   For viewing radar data, a revised main display program has been prepared on Tape 10. This is a combination of previous programs on 51 and 56, but also includes a subprogram for testing the light gun. This main display program was used in the Valley Committee demonstration on Friday, December 1.

   As noted in the Bi-Weekly of Arnow and Walquist significant progress has been made in the writing and testing of component parts of overall 6673 program. The computer time available through Tuesday, December 5, was all used for these programs and little time was available for reviewing the recorded radar data. It is hoped that this task can be completed when the computer again becomes available for use. Following completion of this and several minor matters, a start can be made on actual tracking of aircraft.

   As a means of initiating Saxonian and Gaudette to our work—objectives, programs, methods, etc., a number of indoctrination sessions have been held. These will continue for another week.
I. ANALYSIS (continued)

(B. L. Walquist)

During the past bi-weekly period, a program was written which calculates the collision course bearing angle for target interception. The program obtains a solution to the equation \( A \sin \theta + B \cos \theta + C = 0 \) by a trial-and-error process, the value of \( \theta \) satisfying this equation being the desired bearing angle. This program was tested in ES along with a program written by J. Arnow which displays \( \theta \) in a flip-flop storage register by means of a "binary-decimal" code (this code uses 4 binary digits to represent each decimal digit). The program worked quite satisfactorily, giving accuracies of about 1°. However, the trial-and-error process used for calculating \( \theta \) is increasingly time consuming as the accuracy of the solution is increased.

Other means for calculating the bearing angle are being investigated which should be less time consuming. The method of determining the bearing angle which was mentioned in the last bi-weekly report is awaiting the completion of an arc sine program. As soon as the arc sine program is finished, this alternate method will be tried out on the computer.

(J. A. Arnow)

A tape for a program to print a tabulation of the \( x \), \( y \), \( x \), and \( y \) positions of a target selected continually by means of the light gun is in the process of preparation. There is allowance in the program for the possibility of the radar set failing to give indication of the target on a given sweep of the radar antenna.

The program for data simulation was tried on the computer on November 27, 1950 with satisfactory results.

On December 4th, a program to convert semidecimal types to a 6-6-4 reversed code was tried. The program was tested using a tape containing a series of predetermined numbers and checking them visually. It is contemplated that, when the computer again becomes available, this conversion program will be used to convert another conversion program designed for a 6-6-4 reversed input program. (See N-2076). The test storage input program will then be changed to the one mentioned in N-2076, and the newly converted tape will be read in, thereby affording a test of the conversion program, and the input program.
1. ANALYSIS (continued)
   (O. H. Gendette and M. Saxenian)

   The program for the optimization of the arctangent approximation

   \[
   f(b, x) = \frac{\tan(b + x)}{2(x^2 + 2bx + 1)}
   \]

   has been completed. Class Notes 426, 27, 26, and 23 for course 6.535 contain the program and a description.

   The optimization of the approximation to the arccotangent by a five degree polynomial is still under investigation.
   The best result thus far has a maximum error about 5° in the vicinity of 90°.

   David Israel is introducing the main problems of project 6673 to us.
2. ENGINEERING
(C. H. Wiess)

During the computer demonstration on December 1, the first attempt was made to feed radar data direct from Bedford into WII. The performance was found to be erratic, and the equipment was checked after the demonstration. It was found that (1) the timing signal gain was too low and (2) Channel 5 was sending spurious digits due to a defective tube. Both troubles have been fixed and all channels have been examined and adjusted.

No further flight tests have been made, principally because of unfavorable weather. We have, however, continued to record data whenever Bedford reports that the system is working properly and that targets are being observed.

We have now recorded 14 rolls of data, and some of the earlier data are probably quite poor. It would be desirable to display the data and select the rolls or parts of rolls which are worth keeping. Since this would require considerable computer time, it may be advisable to wait until we get the digital PPI scope from ANGEL.

It was reported in the November 10 Bi-Weekly that ANGEL would supply the PPI scope, and we would build the decoder and synchronizer for the digital PPI. This plan has since been revised, and ANGEL is now planning to supply the complete display system.

The cursor and map for the plotting board are complete and will be installed soon.

(D. A. Back)

A modulator has been designed and constructed which will allow the utilization of the upper end of the nagsocorder frequency range for the recording of a voice channel originating either here or at Bedford.

Demodulation equipment is being designed and tests are underway to determine the amount, if any, of interaction between the voice channel and the multiplexed information channels.
2. ENGINEERING (continued)
    (D. A. Bueh) (continued)

    The monitor equipment, in addition to demodulating
    the voice-modulated carrier, will provide for listening
    to the multiplex tones (minus the timing-wave). Recent
    tests have shown that the tones seem to help coordinate
    the scope observers. They also provide a rapid means of
    recognizing the test pattern, and have been useful in
    detecting erratic operation of the individual multiplex
    digits.

    (R. J. Kirshner)

    The light gun equipment was tested with the computer
    on two separate occasions. The first trial indicated that
    while the light gun produced pulses when it was expected
    to, it also produced pulses when they were not expected.
    Additional test equipment, in the form of a D.C. Regulator
    Panel, was procured in order to study this phenomenon.
    The source of the spurious pulses was isolated at the
    photomultiplier-cathode follower section of the light gun,
    and the condition was apparently cured by loading the
    negative high voltage supply and by placing better grounds
    on the equipment. After these changes were made, the second
    trial with the computer was made and proper operation was
    obtained.

    Subsequent to this second trial, the spurious pulses
    were once again evident when the physical positioning of
    the chassis was changed. The pulses now appeared to be
    emanating from both the photomultiplier and the blocking
    oscillator stage. Some time was spent before the spurious
    pulses were removed. This was accomplished by by-passing
    the photomultiplier load resistor to ground with a small
    capacitor (100 mmfd), and by reducing the sensitivity of the
    blocking oscillator. The reduced sensitivity of the blocking
    oscillator was compensated for by increasing the gain of the
    cathode follower stage.

    Apparently, in the present breadboard equipment, a
    good deal of interstage coupling exists through lead
    capacitances. In the final assembly, efforts will be made
    to control this condition.

    During the past two days, spurious pulses have not been
    detected and it appears that the equipment is operating in a
    satisfactory manner.

    Tests are scheduled with the computer next week. Should
    operation prove satisfactory, and no further difficulties be
    encountered, construction of the final unit will commence.
2. ENGINEERING (continued)

(R. L. Rent)

The driving circuits for the Tektronix Type 420 High Voltage Power Supply have been completed, but not yet tested.

The circuit for the amplifier which will deflect the 16 inch display scope is about to be drawn up and given to the shop for construction. Auxiliary circuits for testing this amplifier have been completed, but not tested.

(R. E. Hunt)

Work continues on the display unit. A satisfactory method of red light illumination for the dials has been worked out, and incorporated into the design.

A preliminary but complete layout of the cathode ray tube amplifier panel has been made and will go to the drafting room shortly.

The mock-up of the proposed display unit is now in room 225 for display and comment.