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Sponsor Contact Person (s):

Technical Matters

Contracting Officer's Representative (COR)

LTC Joseph Shine
U. S. Army Computer Systems Command
U. S. Army Institute for Research in Management
Information and Computer Science
313 Calculator Building
Georgia Institute of Technology
Atlanta, GA 30332

404/894-3104

Contractual Matters
(thru OCA)

See MOD 5

Office of Naval Research
Resident Representative
325 Hinman Research Building
Georgia Institute of Technology
Atlanta, GA 30332

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SCHOOL OF INDUSTRIAL AND SYSTEMS ENGINEERING

GITPASE USER'S GUIDE

PHASE II

GEORGIA INSTITUTE
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GITPASE USER'S GUIDE

AUTOMATED PROJECT MANAGEMENT SYSTEM
PHASE II

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ATLANTA, GEORGIA 30332

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BY
DONOVAN YOUNG
RONALD L. RARDIN

SCHOOL OF INDUSTRIAL AND SYSTEMS ENGINEERING
GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

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1. INTRODUCTION.

Under Task Order #5 of Contract DAAK-70-79-D-0087 with the U.S. Army Institute for Research in Management Information and Computer Science (AIRMICS), the School of Industrial and Systems Engineering of the Georgia Institute of Technology, better known as Georgia Tech, has developed a prototype interactive color graphics package for planning resource-constrained projects. The package is named GITPASE, Graphic Interactive Technique for Project Analysis and Schedule Evaluation system.

This document is a User's Guide to GITPASE. Important concepts in resource-constrained project planning are briefly reviewed, and instructions are provided for using GITPASE in planning moderate-sized projects. Appendix A lists related documentation of potential value to GITPASE users.

1.1 Formal Projects Planning

Projects are organized and planned work efforts extending over a significant period of time. Planning of them is subject to constraints on the start and finish dates of the work and budgets on the amount of resources that may be consumed. A project planner's job is to arrange the work so that it is accomplished as nearly as possible within the specified time and budget limits.

The identifiable parts of the work effort in a project are called activities. Each activity extends over one or more time periods, consuming substantially the same mix of resources throughout its life and ending in a recognizable event or product.

System Change Packages (SCP) on large U.S. Army computer software systems provide simple examples of projects. In such packages a number of computer programs of the system are modified to correct bugs or implement enhancements. The simplest case would involve only one or two programs. The SCP project begins with systems analysis work to design the required software changes. Later stages implement and test the program changes. Testing occurs at two separate levels: Level I tests each program separately; Level II tests the programs together.

Exhibit 1-1 shows how a very simple SCP with changes to only Program A and Program B would be organized into activities. The first activity is the Systems Design. It is followed by Programming and Level I testing of each of the programs, and then Level II testing of the entire SCP.

The arrows in Exhibit 1-1 define another characteristic of activities. Activities are subject to precedence limitations. In Exhibit 1-1, for

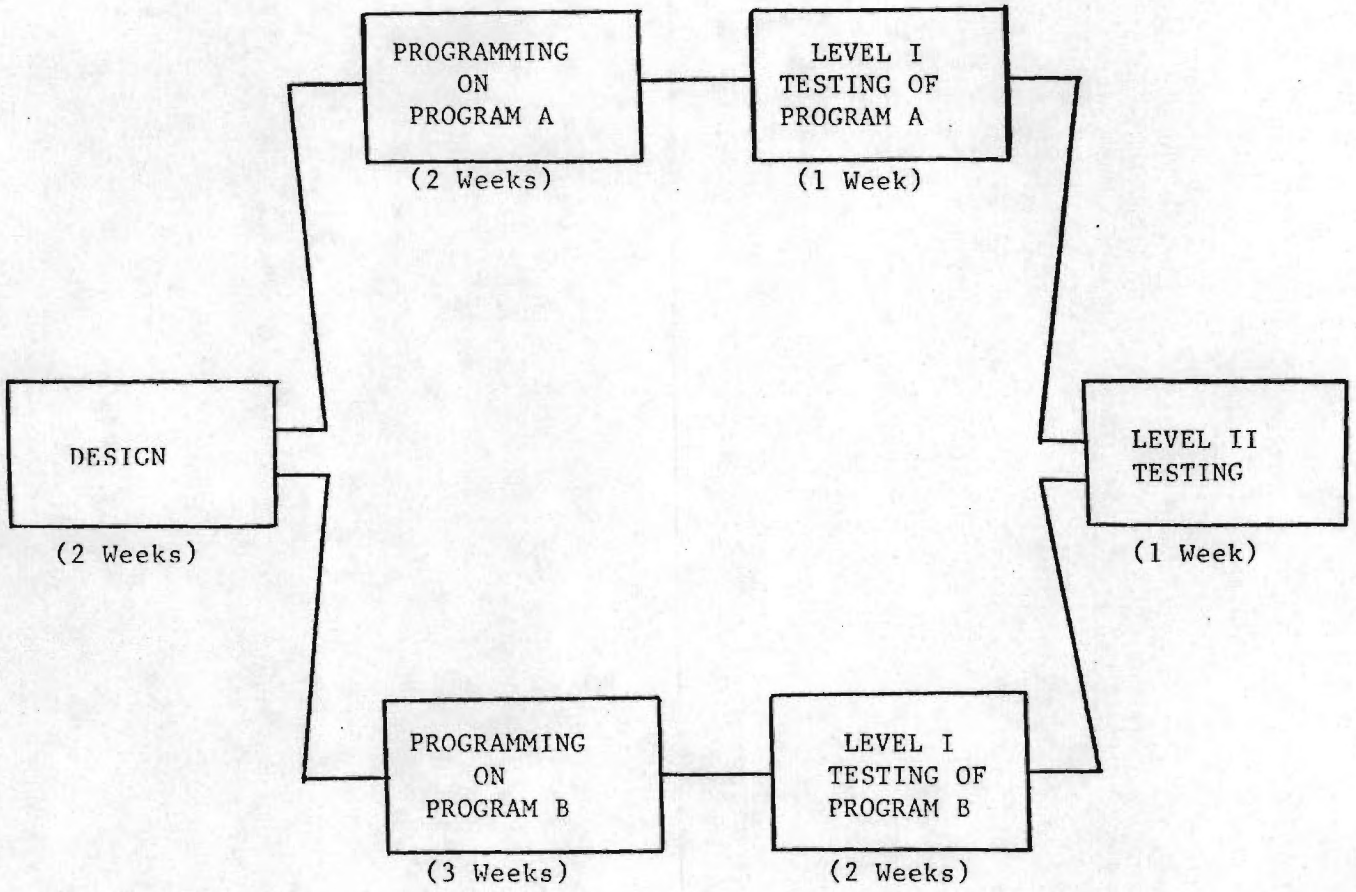


EXHIBIT 1-1: ACTIVITY STRUCTURE OF EXAMPLE SYSTEMS CHANGE PACKAGE PROJECT

example, Level I Testing of Program A" must follow Programming on Program A; Level II Testing must await completion of both Level I Testing of Program A and Level I Testing of Program B.

Notice that not all pairs of activities have a precedence arrow between them. For example, Programming on Program A and Level I Testing on Program B have no precedence connection. Either can start or finish independently of the other.

Every activity of a project has a planned duration. Hypothetical durations are shown below each activity in Exhibit 1-1. For example, Programming on Program B is expected to require 3 weeks.

If only durations and precedence relationships are taken into consideration, each project activity can be scheduled as soon as all its predecessors are complete. For example, Level I Testing of Program A in Exhibit 1-1 could begin in the 5th project week. The design and programming activities that must precede it require 4 weeks. Similarly, Level II Testing could begin in the 7th project week following completion of both Level I testing activities.

When project resource limitations are considered, scheduling may become more complex. If, for example, there are not enough available computer programmers to simultaneously undertake Programming on Program A and Programming on Program B, both activities could not begin in the 3rd week (immediately after Design). One or the other would have to be postponed until programmer resources are available. Of course, all activities following the postponed one in precedence order might also be delayed by the change.

A feasible schedule is a project plan that conforms to start date, finish date and precedence restrictions, while fitting within available resources. Postponing activities to avoid resource conflicts is one option open to a planner in developing a feasible schedule. A second is to modify planned durations. Most activities can be speeded or slowed by management decision. Of course, the resources consumed may not remain constant. In Exhibit 1-1, for example, Programming of Program B might be compressed to 2 weeks to avoid delaying the entire project. However, it is likely that more person-weeks of programmer effort would then be required because of the rush.

To plan a project with constrained resources, a user can adjust activity durations and start dates to seek the most favorable schedule. In addition to the concepts already introduced (project, activity, precedence, duration, resource, and schedule), three additional concepts are useful: consumption interpolation, schedule heuristic, and network hierarchy.

Although a scheduling precedure should be able to consider all possible durations of all activities, it is impractical to ask planners to provide separate estimates of resource consumptions for all durations. Therefore, a consumption interpolation procedure is adopted, whereby a planner provides consumption estimates for at most three different durations of an activity, and the consumption interpolation procedure automatically provides consumption estimates for any durations considered in planning a schedule.

Considered as a mathematical optimization problem, the problem of finding a best schedule is impractical to solve exactly; with many activi-

ties and resources, a computer could work for a long time without guaranteeing an optimal solution. It is also impractical, however, for a human planner to look at all the promising schedules for a large project. A compromise is to adopt schedule heuristics - mathematical procedures that generate "good" but not guaranteed-optimal schedules, so that a planner can restrict attention to variation of a few promising schedules automatically generated.

Sometimes it is difficult to generate reasonable possible durations for an activity, or to generate resource consumption estimates for it, because the activity is itself a complex of subtasks. Then it can be useful to break the activity into its component subtasks and schedule it as a subproject, using the same scheduling methods as for the project as a whole.

Sometimes it is convenient to think of groups of activities as separate entities, so that a complex project can be viewed at a macro level as a collection of only a few macro activities, each of which is a subproject.

In either of the above two instances -- when a project needs to be broken down into further detail for accuracy, or aggregated for conceptual grasp -- a network hierarchy can be defined to aid a planner in keeping track of all the parts of a large complex project.

1.2 GITPASE

Georgia Tech's prototype interactive, color-graphics, resource-constrained project planning package GITPASE receives, displays and modi-

fies schedule data for projects of up to 40 activities. Each activity is allowed to use one of up to 16 resources (6 of which can simultaneously be displayed in color). Projects may extend over a time interval subdivided into up to 104 periods.

The program runs interactively. All input and output is handled through a Chromatics CG1999 color graphics computer terminal. Significant computations and data storage are performed by AIRMICS' PDP 11/70 minicomputer operating in real-time communications with the Chromatics. Programming on the Chromatics is coded in BASIC; programming on the PDP 11/70 is in FORTRAN. See Appendix B for further details on required hardware and software to run GITPASE.

A straightforward signon procedure is required to initiate communications between the Chromatics and the PDP. Steps in this procedure are detailed in Appendix A. All main text of this manual assumes communication has been previously established.

2. USER INTERACTION CONVENTIONS

The GITPASE system has several operating modes directed to different input and scheduling tasks. However, all modes share a number of interaction conventions for displaying user information and receiving user input. The section reviews such conventions.

2.1 Window Format

GITPASE uses a Chromatics screen composed as in Color Exhibit 1. A menu is displayed along the left boundary, and the screen is divided into four windows.

- The Title Window is used for resource and activity titles.
- The Main Window is where most important schedules and data tables are presented.
- The Message Window is reserved for brief informational and error messages.
- The Lower Window is used for auxiliary menus, plots and tables.

A small area above the Title Window is used to provide a running indication of system processing and communication, giving a blue message each time the host computer successfully completes a task and sends a valid message to the terminal, and a cyan message each time the host computer sends an invalid message detected at the terminal.

2.2 Menus

Menus along the left margin of the GITPASE screen allow the user to select commands and other options. As indicated in Color Exhibit 1, the top menu item is distinguished in red. It is reserved for changing modes. The next five, white menu items are the Mode-Specific Command Menu. Within each GITPASE operating mode, three-letter codes on the menu items key the command functions they invoke. The final six menu items are for the Color Menu. Each of the six (other than black and white) colors available on the Chromatics is provided one menu block. Color-coded program functions are invoked via the Color Menu.

The user activates a menu item by touching its menu block with the Chromatics' light pen. When active, the menu item throbs, reminding the user of what processes are under way.

2.3 Wait/Ready Indicators

All GITPASE processing is controlled by a sequence of light pen hits, sometimes interspersed with keyed input of numbers and titles. After almost every input, the Chromatics must redraw some part of the screen and/or communicate with the PDP minicomputer. To avoid confusion about when the system is ready for input, and what input is expected, several standard indicators are used throughout the system.

- Terminal Bells sound whenever the Chromatics has successfully received a typed or light pen input, and again when the terminal is ready for another input. In the time interval between these paired bells new input is not allowed.

- TOUCH, TYPE, WAIT or CONFIRM instructions appear constantly in the Message Window as illustrated in Color Exhibit 2. TOUCH indicates that the system is prepared to receive a light pen hit. TYPE tells the user that the system is awaiting typed input. WAIT means the system is processing, and no user input is presently allowed. CONFIRM indicates that the system is awaiting an additional light pen hit on a command menu item such as DEL or SAV, to confirm that the user really wants to invoke that command. Any other touch aborts the intended action.

- RETOUCH and RETYPE are versions of TOUCH and TYPE that appear upon the error conditions of invalid light pen touches or invalid keyboard entries. An error message also appears in the Message Window upon any condition of unacceptable input.

2.4 Add Asterisks

At many stages of GITPASE processing the user may wish to add information such as a new resource, a new resource availability segment, a new activity, etc. Such additions are always accomplished in the same manner: an asterisk on the Chromatics screen reserves a spot for the new information. As soon as TOUCH appears in the Message Window, the user touches the asterisk with the light pen. GITPASE responds by positioning a cursor at the add location and instructing the user to TYPE the new data.

During data entry, the cursor may automatically go to the add asterisk or item where the system anticipates the user will next want to enter data.

2.5 Scrolling and Default Data Entry

When TYPE appears in the Message Window and the cursor goes to a place where the user does not desire to add or change data, the user may respond in two ways: (1) To skip the next data slot but continue adding data in the same sequence, the user types a comma followed by a carriage return. The cursor will skip the slot and appear at the next anticipated location in the same sequence. TYPE will appear in the Message Window; (2) To avoid adding any further data of the same kind in the sequence, the user simply types a carriage return. The cursor will skip all further data slots in that sequence.

Sequences are sometimes nested, so that the cursor goes to an anticipated place for another TYPE input sequence after completion of a TYPE sequence. For example (see section 5), after the user adds an activity, the cursor will go to allow a sequence of inputs of duration and resource consumption data within the sequence of adding activities; after the last resource consumption is entered for a new activity, the cursor will go to allow input of the next activity name. Another example of nested TYPE input sequences is availability segments within resource declarations (see section 4). Except for such nestings, TOUCH always appears in the Message Window after the user either fills or skips the slots in a TYPE input sequence.

2.6 Deleting Data Items

Whenever GITPASE permits the user to delete a data item, a special DEL menu item will be present. To delete a data element, the user first

touches the DEL menu item with the light pen and then touches the element being deleted. To delete an entire resource or activity, the user touches its name. To delete more specific numerical data, the user touches those data as precisely as possible. The system will then blink the item it assumes is to be deleted, and CONFIRM will appear in the Message Window. The user must then touch the DEL menu item again to complete the deletion. This will immediately erase the indicated item from the project data. If the user does not confirm, but instead touches any other valid point on the screen, the deletion will be aborted.

2.7 Time Scales

In all modes except Transition Mode, a time scale is shown in the Main Window. Up to 104 time periods are allowed; GITPASE initially shows time periods from 1 to 52, and the time range is automatically changed according to the data and schedule. The first period in the scale is the Desired Start Period, the Scheduled Start Period, or the lowest period mentioned in resource availability data, whichever is smallest. The last period in the scale is the Desired Finish Period, or the highest period mentioned in resource availability data, whichever is largest. (See sections 3.3 and 4.2 for definitions of these terms.) If the WIN menu item is used in Activity Mode (see section 5.7), the time scale in Schedule Mode will be set by the user's action; otherwise it will match the scales in other modes.

An activity cannot have a duration less than one time period. One GITPASE time period commonly represents a week, or a month, or a day, depending on the user's preference in modeling. Light pen touches are

rounded to the nearest tick mark, which marks the end of one period and the beginning of the next.

3. FUNCTIONS COMMON TO ALL MODES

The GITPASE system operates in four separate modes:

- o Schedule Mode allows the interactive design of a schedule to meet due dates and precedences while fitting within resource availabilities.

- o Activity Mode allows the input or correction of activity data, including activity names, precedences, durations, and resource consumptions of each activity.

- o Resource Mode allows the input or correction of resource data, including resource names, color assignments and availability levels for each resource for specific time periods.

- o Transition Mode allows the user to select one of the above modes (SCH, ACT, or RES), to rename the current data file (REN), to recover a stored data file (OLD), to begin creating a new data file (NEW), to end the GITPASE session (END), to save the current data file (SAV), and to handle the management of networks within a hierarchy of networks representing a single project.

Generally, the functions available to the user differ among the modes. Sections 4, 5, 6, and 7 detail and illustrate functions of the Resource Mode, Activity Mode, Schedule Mode, and Transition Mode, respectively. To avoid duplication, the functions that are available in at least three of the four modes are discussed here.

3.1 Project Start and Finish Period Numbers

The Desired Start Period (abbreviated DS in displays) is the first period during which the user would like activities scheduled. Similarly, the Desired Finish Period (abbreviated DF in displays) is the last period during which the user would like activities to persist. Because of user instructions or activity precedence relationships, it may not be possible to completely observe these Desired Start and Finish Periods. Actual start and finish periods are called the Scheduled Start Period and the Scheduled Finish Period (abbreviated SS and SF in displays).

GITPASE constantly displays both Desired and Scheduled Start and Finish Periods at the top of the Message Window. Color Exhibit 2 shows an example.

Scheduled Start and Finish Periods are computed quantities, but users must specify the Desired values. A Desired Start Period or Desired Finish Period may be supplied or changed at any time by touching its name in the Message Window with the light pen. The system will respond by blinking the touched name and positioning the cursor for the user to TYPE a new value. All activities not specifically assigned a non-conforming start or finish time will be rescheduled so that none starts before the new Desired Start or Finish Period.

3.2 Resource and Time Infeasibility

In all modes, the system displays in the Message Window two measures of schedule quality: the total resource infeasibility (abbreviated RINF), and the total time infeasibility (abbreviated TINF). The total time

infeasibility is the sum of the number of time periods by which precedence constraints are violated, plus the number of time periods by which the Scheduled Start Period is earlier than the Desired Start Period and the Scheduled Finish Period is later than the Desired Finish Period. The total resource infeasibility is the sum of the total infeasibilities of all resources; the total infeasibility of a given resource is the number of time periods that the resource consumption exceeds the resource availability, times the average proportion of the maximum availability by which the consumption exceeds availability.

3.3 Data Set Saving -- the SAV Menu Item

At any stage of processing, GITPASE users may save all present data on the project being analyzed. This feature permits users to preserve work in progress. It is also recommended that SAV be executed periodically to avoid loss of work in the event of a system failure.

Saved data includes inputs such as resource availability data and activity names, as well as information about the present schedule and activity durations. The data set is saved under an up to 7-character, user-specified file name on the PDP 11/70's disk storage. Names must begin with a letter. Users should exercise some care in choosing the name of a SAV data set. If the specified name duplicates an existing one, the new file replaces the old one; old data is lost.

To initiate data saving, the user touches the SAV menu item while TOUCH is displayed in the Message Window. The system then displays the current file name in the Message Window and displays CONFIRM. If the user wishes to save the current schedule and data under the existing file name

(replacing anything currently saved under the same name), the user touches SAV again to confirm; if the user wishes to change the file name, it is necessary to touch the MOD menu item to enter Transition Mode so that a REN (rename) can be executed before the save (see section 3.4).

3.4 Data Set Loading and Mode Changing -- the MOD Menu Item

At any time TOUCH is displayed in the Message Window, the GITPASE user may choose either to switch the processing mode under which he is working on a present data set or to load a different data set. This is accomplished by touching the MOD menu item with the light pen. GITPASE automatically simulates a MOD menu hit as it is signed on.

Immediately upon receiving a MOD menu hit, GITPASE displays in the Lower Window the supplemental menu illustrated in Color Exhibit 1. Touching one of the supplemental menu items with the light pen leads to the following system actions:

- OLD - Erase current project data and request the name of a previously saved data set to be loaded. The request is in the form of the message OLD FILE NAME? After the user types the file name and the user-named data set has been loaded, the supplemental menu will be re-displayed so that the user may choose a processing mode.

- NEW - Erase current project data and prepare to receive a new data set. NEXT FILE NAME? will appear in the Lower Window, as shown in Color Exhibit 1. After the user types the new name, the supplemental menu will be re-displayed so that the user may enter a processing mode.

- ACT - Enter Activity Mode processing of the current data set.

- RES - Enter Resource Mode processing of the current data set.

- SCH - Enter Schedule Mode processing of the current data set.

- END - End execution of the GITPASE system. (See Appendix A for terminal signoff procedures.)

3.5 Cancel

In Activity Mode, Resource Mode, or Schedule Mode, the CNC (cancel) menu item may be touched whenever TOUCH appears in the Message Window. The effect is to cancel all activations of menu items, activities, and resources. For example, if in Schedule Mode the DUR menu item is active, the yellow color code is active, and an activity is activated, then a touch to the CNC menu item will make the DUR menu item inactive (it will cease to throb), make the color code inactive (its menu item will cease to throb, and the resource display in the Lower Window will be erased), and make the currently active activity inactive (its name will go from red to white, and its throbbing end will cease to throb).

4. RESOURCE MODE

To describe a project formally to a planning system like GITPASE a user must supply data about two types of entities -- activities and resources. Activities are the sub-units of work in the project. Resources are the staff, materials and services that are consumed by the activities and subject to limited availability. (See section 1.1 for further introduction to these notions.)

Data are entered and modified in GITPASE by two corresponding data modes. Resource Mode is described mainly in this section, and Activity Mode in section 5. Details of functions available in both modes have already been presented in section 3. For quick reference, all functions available in Resource Mode are summarized in Appendix Exhibit 1.

4.1 The Resource Mode Screen

In section 1, an Army Systems Change Package (SCP) project example was developed and illustrated in Exhibit 1-1. The project has six activities. Resources consumed by various activities would certainly include systems analysts, programmers, and computer test time.

Exhibit 4-1 shows some hypothetical availability data for those three resources. For this example time periods are weeks. The number of units of each resource that are available is shown along with the weeks of availability. For example, 10 hours of Computer Test Time are to be available for the SCP in each of weeks 4 through 5. This availability

RESOURCE NAME		SEGMENT AVAILABILITY			
SYS SYSTEMS ANALYST	FROM	4	6	10	
	TO	5	9	12	
	AMT	12	8	8	
PGR PROGRAMMER	FROM	4	6	8	
	TO	5	7	12	
	AMT	8	22	16	
TTM TEST TIME	FROM	4	6	8	9
	TO	5	7	8	12
	AMT	10	12	16	30

EXHIBIT 4-1: RESOURCE AVAILABILITY DATA FOR EXAMPLE SYSTEMS CHANGE PACKAGE PROJECT

level changes to 12 per week in weeks 6 through 7, to 16 in week 8, and to 30 for the remaining periods.

Color Exhibit 2 illustrates how this same availability information is recorded and displayed when fully entered in GITPASE Resource Mode. Each resource is listed in the Title Window, first by a 3-character identifying code and then by its full name. The schedule of availability for each resource is provided to the right in the Main Window. Resources have been assigned color codes: dark blue for Systems Analysts, green for Programmers, and red for Computer Test Time. Availability information for the activity is written in the assigned color, and the resource's code appears on the menu block for that color. Asterisks in both the Title Window and at the end of each availability schedule reserve locations for adding new data. In this example, a user light pen has already designated the TTM Test Time resource as the active resource. For that reason its title is in red. Also, a plot is provided in the Lower Window of its availability and consumption levels. The dotted line graph reflects the availability sequence detailed in the Main Window. The solid line graph reflects the level of consumption of this resource associated with the present project schedule (the latter is controlled in Activity and Schedule Modes).

4.2 Adding Resource Data

To obtain a full representation of resource data like the one displayed in Color Exhibit 2, resources and resource availability levels

must be entered one at a time. As with all phases of GITPASE, new data is added by touching with the light pen the add asterisk reserving expansion space for the needed data item, and then typing the needed data, as follows. (If the program limit of 16 resources are already in the data set, no others may be added).

To begin, the user touches the add asterisk in the Title Window. When TYPE appears in the Message Window, he types, for the first resource

3-character code (space) full name of resource Return

The carriage return will cause the cursor to move to the add asterisk immediately to the right in the Main Window. When TYPE appears again, the user types the availability information according to the following format:

beginning period number (space) amount available Return

The return causes the asterisk and cursor to move to the next availability segment, where further information can be added. To enter the data for resource SYS SYSM ANAL in Color Exhibit 2, the sequence would be as follows:

4 (space) 12 Return 6 (space) 8 Return Return

The final carriage return terminates the sequence for that particular resource. The asterisk and cursor will now move back to the Title Window, TYPE will appear in the Message Window, and data for the next resource can be entered in the same manner.

When the asterisk and cursor appear in the Title Window after data for the last resource have been added, the user may again hit a carriage return, which will terminate the addition of resources. TOUCH will now appear in the Message Window. At this point the user may, by use of the MOD menu item, move into another mode, or he may stay in Resource Mode and delete, change, or color-code the resource data as follows:

4.3 Deleting Resource Data -- the DEL Menu Item

Either a single resource availability segment (beginning time and amount) or all data for a resource can be deleted in Resource Mode. The user first touches the DEL menu item to activate delete processing and then (when GITPASE again displays TOUCH) touches the item to be deleted. For an availability segment, he touches segment data in the Main Window. For a whole resource, he first touches the resource name in the Title Window, and then, while the resource title and data are blinking and the Message Window displays CONFIRM, he touches the DEL menu item again.

For example, consider again the Resource Mode screen in Color Exhibit 2. If a user first touched the DEL menu item with the light pen, and then touched the Main Window at any point between "6" and "8.00" on the top line, the period 6 availability segment for the systems analyst resource would be eliminated. The prior level of 12 would now apply through period 9. If the user first touched the DEL menu item, then touched "SYS SYSM ANAL" at any point in the Title Window and subsequently confirmed the deletion, both the resource title and its availability data would be deleted.

4.4 Changing Resource Data

Any data item on the Resource Data Screen is easily changed. The user merely touches the item to be changed and then enters the revised data when GITPASE displays TYPE.

Refer again to Color Exhibit 2. If the user first touches "SYS SYSM ANAL" with the light pen and then types the entry

ANL SYSM ANAL Return

the code for the first resource would be changed to ANL. Note that both the code and resource name must be typed together as one entry. If the user does not desire to change either, a carriage return may be typed.

If the user touched any point between "6" and "8.00" on the top line of Color Exhibit 2, the period 6 resource availability segment could be changed. A typed entry of

5 (space) 8 Return

would cause the availability level to begin one period earlier, i.e. in period 5. Notice again that both the beginning time and the available resource amount must be typed, even if only one changes.

4.5 (Re)Assigning Colors to Resources -- the Color Menu

For ease of user recognition, GITPASE color-codes resources. Up to 6 different resources may be assigned colors, with any others being represented in white. No more than 16 total resources are allowed.

Color codes of resources are assigned in Resource Mode. To assign a color, the user merely touches the color's menu block with the light pen while the resource is active (name in red in the Title Window). For example, in Color Exhibit 2, a user would code the PGR PROGRAMR resource green by first touching "PGR PROGRAMR" to make the resource active and then touching the green menu item.

If a color being assigned is already associated with a resource, the previous resource is reassigned and coded white. For example, a user's touching the blue menu item in Color Exhibit 2, while the resource PGR PROGRAMR was active would result in the dark blue color code being transferred to the PGR PROGRAMR resource. The Systems Analyst resource, which was previously coded blue, would thereafter show in white.

4.6 Resource Consumption Tables

The plot of availability and consumption of the active resource shown in the Lower Window can be replaced by a table of consumption of the active resource. When TOUCH is displayed in the Message Window, the user touches anywhere in the Lower Window. The display of consumption is shown in the same format as the availabilities (which are always on display in the Main Window), that is, period numbers followed by consumption levels starting in those periods.

5. ACTIVITY MODE

To describe a project formally to a planning system like GITPASE, a user must supply data about two types of entities -- activities and resources. Activities are the sub-units of work in the project. Resources are the staff, materials and services that are consumed by the activities. (See section 1.1 for further introduction to these notions).

Data are entered and modified in GITPASE by two corresponding data modes. Activity Mode is described mainly in this section, and Resource Mode in Section 4. Details of functions available in both modes were presented in Section 3. For quick reference, all functions available in Activity Mode are summarized in Appendix Exhibit 2.

5.1 The Activity Mode Screen

In section 1, an Army Systems Change Package (SCP) project example was developed and illustrated in Exhibit 1-1. The project has six activities. Resources consumed by the activities are Systems Analysts, Programmers, and Computer Test Time.

Resource availability data for this example were provided in Exhibit 4-1. Exhibit 5-1 shows some corresponding activity data. The planned durations and predecessors of each activity are listed as they are depicted in Exhibit 1-1. The amount of each resource consumed by each activity is also provided. Note that the activity resource consumptions are the total amounts required if the activity is completed within the planned duration. GITPASE assumes each period of the duration uses the same fraction of this total. Thus, for example, it is anticipated that the Programming on

ACTIVITY NAME	NOMINAL DURATION	PREDECESSOR ACTIVITIES	CONSUMPTIONS AT NOMINAL DURATION		
			SYSTEM ANALYSTS	PROGRAMMERS	TEST TIME
1. DESIGN	2	-	20	4	0
2. PROGR-PT A	2	1	0	24	12
3. PROGR-PT B	3	1	6	16	8
4. LVL I TST A	1	2	4	8	16
5. LVL I TST B	2	3	4	12	16
6. LVL II TEST	1	4,5	8	6	8

EXHIBIT 5-1: ACTIVITY DATA FOR EXAMPLE SYSTEMS CHANGE PACKAGE PROJECT

Program B activity will require 16 person-weeks of Programmers if it is completed in the planned three weeks. GITPASE would compute 16/3 = 5.33 person-weeks per project week for this activity.

The input of total requirements in Activity Mode contrasts with the input of resource availability information in Resource Mode, which is supplied in terms of the amount available per period. (See section 4.1).

Color Exhibit 3 illustrates how this activity data is recorded and displayed when fully entered via GITPASE's Activity Mode. Each activity is listed in the Title Window and represented by a color-striped bar in the Main Window. The colors indicate the resources consumed by the activity according to the color menu. Thus, for example, the DESIGN activity has stripes for only the SYS and PGR resources because Exhibit 5-1 shows no Computer Test Time consumption. An add asterisk in the Title Window reserves a space for a new activity. Each activity's Main Window bar has a length equal to the activity's current duration.

The horizontal arrangement of bars in the Main Window shows the present project schedule. For example, the DESIGN activity is scheduled to extend from period 4 through period 5. Its successor PROGR activities both begin in period 6.

Detailed information on the predecessors of an activity and its resource consumptions can be displayed for one activity at a time. In Color Exhibit 4, the PROGR-PT A activity has already been touched by the light pen and designated the "active activity." For that reason its title shows in red. Also, special arrow characters at the right boundary of the

Title Window indicate predecessors of this active activity. Specifically, DESIGN is marked as a predecessor and LVL I TST A is indicated as a successor. Users have specifically entered the predecessors, with successors being computed automatically.

Consumption data for the active activity appears in the Lower Window. Each resource is listed by code along with three alternative consumption values. Only the first, "nominal" consumption is required. It reflects the amount of resource consumed if the activity extends exactly for its nominal duration. Thus, the planned consumption values of Exhibit 5-1 appear in this first column.

The scheduled duration of an activity may be set in Schedule Mode or in Activity Mode to any integer duration within the limits of user-specified minimum and maximum durations. The user is asked to specify nominal (NOM), minimum (MIN), and maximum (MAX) durations of each activity, and estimated resource consumptions for these durations. If the user does not supply MIN and/or MAX durations, GITPASE assumes default values of $\frac{1}{2}$ and 2 times the NOM duration; if the user does not supply resource consumptions for MIN and/or MAX durations, GITPASE assumes default consumptions equal to those for the NOM duration.

The DUR line of the Lower Window display for the active activity shows, from left to right, the NOM duration, the MIN duration, the MAX duration, and (in reverse color) the scheduled (SCH) duration. For example, Color Exhibit 5, in which the activity PROGR-PT A is active, shows a nominal duration of 2, a minimum duration of 1, a maximum duration of 4, and a scheduled duration of 2.

The resource consumption lines of the Lower Window display for the active activity show, in the NOM, MIN, MAX, and SCH columns, the estimates of resource consumptions. The user supplies the estimates for NOM, MIN, and MAX durations, whereas GITPASE calculates interpolated estimates for the SCH duration. For example, Color Exhibit 4 shows the user has estimated 24 person-weeks of the PGR resource will be required if PROGR-PT A has its nominal 2-week duration, but that 32 person-weeks will be required for either the 1-week MIN or 4-week MAX durations; it also shows that the interpolated estimate for consumption of the PGR resource at the scheduled duration is 24 person-weeks.

During the actual execution of Schedule Mode, any integer-valued duration may be selected by the user. The nominal, half-nominal, and twice-nominal values supplied as input merely fix three points. GITPASE automatically estimates other consumption values by fitting a quadratic function through the three specified points. Exhibit 5-2 plots the generated function for the Programmer resource in the Programming on Program A activity.

Up to 104 time periods and 40 activities may be input to GITPASE in one project data set. If more than about 30 activities or more than about 50 time periods are involved, screen resolution may be too poor to permit effective schedule planning in Schedule Mode. Activity Mode permits the user to select a portion of the full activity-time space for enlargement in Schedule Mode. The large white rectangle illustrated in the Main Window of Color Exhibit 4 marks such a Schedule Window. In this example the user has specified that not all time periods should be displayed in Schedule Mode, but only the first five activities.

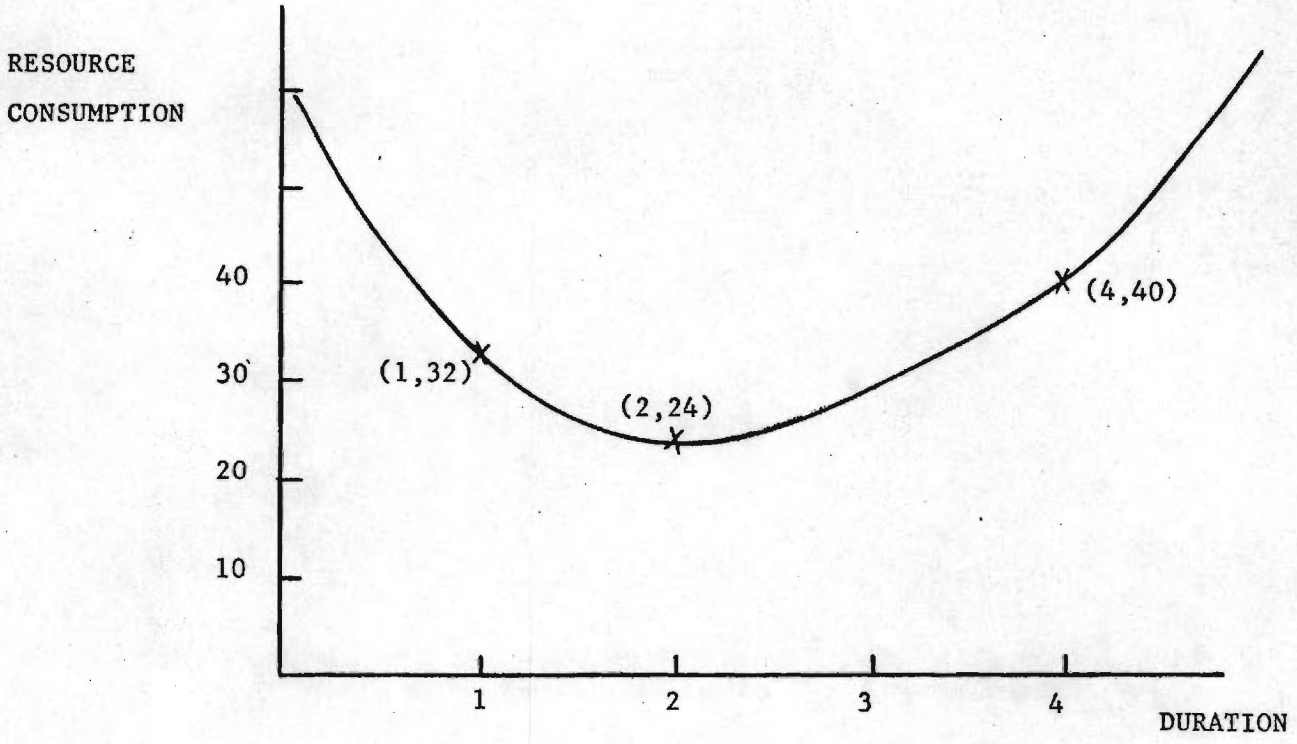


EXHIBIT 5-2 FITTED TIME-DEPENDENT CONSUMPTION FUNCTION FOR EXAMPLE ACTIVITY AND RESOURCE

The default window covers the entire project. Whenever an activity is added, the vertical dimension of the window automatically extends downward to encompass it (and the intervening activities that the user may have excluded from the window previously), so it may sometimes be necessary to redefine the window after adding an activity (see section 5.7). The horizontal dimension of the window never automatically changes.

5.2 Adding Activities

To input activity data to GITPASE activities must be added one at a time. As in all phases of the system, this is accomplished by first touching the add asterisk (provided in the Title Window) with the light pen. As soon as the system positions itself at the add asterisk, the user keys in the new activity's name. GITPASE immediately displays an all zero consumption table in the Lower Window and requests the user to supply a nominal duration for the activity.

Color Exhibit 5 shows a partially complete Activity Data Screen for the data in Exhibit 5-1. To add only the name of the fourth activity, LVL I TST A, a user would first touch the add asterisk with the light pen and then type

LVLI TST A Return

Return

Return

waiting for the TYPE command in the Message Window between each keyed input. (The first carriage return positions the cursor in the Lower Window to solicit resource consumptions for the activity. The second carriage

return stops this solicitation and positions the cursor back in the Title Window to solicit a new activity name. The third carriage return terminates the addition of activity names.

5.3 Deleting an Activity -- the DEL Menu Item

Data for a particular activity is deleted from a project's data set via the DEL menu item. To delete an activity, a user first touches the DEL menu item with the light pen. When GITPASE again displays TOUCH in the Message Window, the name of the activity is touched in the Title Window. GITPASE blinks the activity name and data and displays CONFIRM in the Message Window, and the user touches the DEL menu item again to complete the deletion.

5.4 Changing an Activity Title

Any presently displayed activity title can be changed in GITPASE by touching it twice (once if the activity title is already red) with the light pen and typing a new title. For example, in Color Exhibit 5, if a user twice touched "DESIGN" with the light pen and then typed

DSGN Return

the name of the first activity would be changed to DSGN.

5.5 Precedence Relationships

Precedence relationships between activities specify that the start of one activity cannot come before the end of another. Precedence relationships are input in GITPASE by touching the activity bars in the Main

Window of all predecessors of the activated activity. (To activate an activity, the user touches its title in the Title Window, or its bar in the Main Window if no other activity is currently activated; the title of an activated activity is shown red, in contrast to the other titles in white.) In Color Exhibit 5, for example, touching its title activates the PROGR-PT A activity. Then touching any point on the DESIGN bar tells GITPASE that the DESIGN activity must be completed before PROGR-PT A can begin. GITPASE responds by automatically rescheduling all activities and redrawing those that move; in this case, the activity bar for PROGR-PT A moves to the right (see Color Exhibit 6).

Precedence relationships among activities are deleted by repeating the process that created them. The successor activity is activated; then a touch on any bar that represents a predecessor activity (indicated by the predecessor indicator arrows at the right edge of the Title Window) deletes its predecessor status. In Color Exhibit 6, for example, touching anywhere on its bar activates the PROGR-PT A activity (assuming no other activity is currently active; if another activity were active, it would be necessary to touch the title rather than the bar). Subsequently touching the DESIGN bar deletes the precedence relationship. GITPASE restores the Activity Mode screen to that of Color Exhibit 5.

5.6 Activity Durations and Activity Resource Consumptions

The user inputs duration data for the active activity by first causing the type cursor to appear in the DUR line and then typing one, two, three, or four integers separated by blanks and followed by a carriage return. The last (rightmost) entry is always interpreted as the SCH duration, and

the other entries, if any, are interpreted, in turn, as NOM, MIN, MAX, with omitted entries defaulted. Let the entries be x_1, x_2, x_3, and x_4; the following table shows the interpretations:

Duration Entered	Interpretations			
	NOM	MIN	MAX	SCH
x_1	default	default	default	x_1
x_1 x_2	x_1	default	default	x_2
x_1 x_2 x_3	x_1	x_2	default	x_3
x_1 x_2 x_3 x_4	x_1	x_2	x_3	x_4

For the NOM duration, the default is the existing NOM, or SCH if no durations have previously been supplied by the user. For the MIN duration, the default is the existing MIN, or $\frac{1}{2}$ of NOM if no durations have previously been supplied. For the MAX duration, the default is the existing MAX, or 2 times NOM if no durations have previously been supplied. Thus, for example, if the user had initially entered only a 2 in the DUR line of Color Exhibit 5, the displayed values (2, 1, 4, 2) would have been calculated by GITPASE by applying the defaults; but if the user were now to enter only one number, say a 3, the displayed values would become 2, 1, 4, and 3 (not 3, 1.5, 6, and 3); and if the user were now to enter two numbers, say 3 and 4, the displayed values would become 3, 1, 4, and 4 (NOM would be changed to 3, SCH would be changed to 4, and MIN and MAX would remain unchanged).

When the user has added an activity, the type cursor automatically goes to the DUR line. To enter duration data at an arbitrary time, the user first touches the activity's title in the Title Window to make it the active (red-titled) activity if it is not already the active activity, then touches anywhere within the DUR line. When the cursor appears, the user enters the one to four duration numbers, which are interpreted as explained above.

The user inputs resource consumption data for the active activity by first causing the type cursor to appear in the desired resource consumption line and then typing one, two, or three numbers separated by blanks and followed by a carriage return. The first number is interpreted as the estimated consumption for the NOM duration; the second number, if any, is interpreted as the estimated consumption for the MIN duration; the third number, if any, is interpreted as the estimated consumption for MAX duration. Missing estimates for MIN and MAX durations are defaulted to their existing values, or to those for NOM if no previous consumptions have been supplied. The user cannot input a fourth consumption; GITPASE interpolates the consumption for the SCH duration from the consumptions for NOM, MIN and MAX durations. In Color Exhibit 4, for example, the user could have entered 24 in the PGR consumption line initially, resulting in the displayed values of 24, 24, and 24 for the estimated consumptions at NOM, MIN, and MAX durations and 24 for the interpolated consumption. On the other hand, to get the display (24, 32, 32, 24) on the PGR consumption line of the next color exhibit, Color Exhibit 5, the user would have entered 24, 32, and 32.

Whenever the user changes durations, GITPASE automatically recalculates the interpolated resource consumptions for the SCH duration. Thus, in Color Exhibit 5, if the user changed the scheduled duration of the active activity to 3, the interpolated consumption of the PGR resource, shown in reversed colors in the PGR line, would change to an intermediate value, as would that for TIM.

To skip a resource yet let the cursor go to the next resource, the user can input a comma and carriage return; to skip all further resources, the user can input a carriage return.

In the Lower Window, on the duration line, to the right of the nominal, half-nominal, and twice-nominal durations, the currently scheduled duration is shown for the active activity in black-on-white; on each resource line, to the right of the consumption triplets, the currently scheduled consumption is shown in reversed colors (black on color code).

5.7 Establishing a Schedule Window -- the SEQ and WIN Menu Items

As explained in section 5.1, GITPASE provides for the definition of a Schedule Window in Activity Mode that will be magnified to the full (Main Window) screen in Schedule Mode. The Schedule Window is defined (or redefined) in Activity Mode by first touching the WIN menu item and then touching two opposite corners of the desired area in the Main Window. For example, a light pen hit on the WIN menu item, followed by a hit in the upper left corner of the Main Window and another at the right end of the LVLI TST B bar would establish the Schedule Window outlined in Color Exhibit 4. Repeating the sequence with different points would revise the Schedule Window.

The idea of the Schedule Window is to allow the user to focus Schedule Mode processing on the activities and time periods of greatest concern. However, the activities in the Schedule Window must be vertically adjacent. The SEQ menu item allows activities to be resequenced in Activity Mode so that those of interest are adjacent. Resequencing begins by having or making an activity active, and by touching the SEQ menu item. The user then touches the point in the Title Window where the active activity is to be moved (above the first activity title, between two activity titles, or below the last activity title but above the add asterisk). GITPASE resequences the activities and redraws the Title and Main Windows from the highest changed point downward. For example, in Color Exhibit 4, touching "LVL I TST A" and then touching below "PROGR-PT A" would cause "LVL I TST A" to be moved immediately below "PROGR-PT A."

6. SCHEDULE MODE

Resource Mode and Activity Mode permit the GITPASE user to enter and modify project data sets. All true project planning and scheduling is performed in Schedule Mode, although activity durations can be scheduled in Activity Mode. The data modes were treated in sections 4 and 5, and functions common to all modes were described in section 3. This section presents the functions available only in Schedule Mode. For quick reference, all Schedule Mode functions are summarized in Appendix Exhibit 3.

6.1 The Schedule Mode Screen

Sections 1.1, 4.1, and 5.1 have developed data for a simple Army Systems Change Package project with six activities. In Color Exhibit 4 a Schedule Mode window was selected allowing the first five of these activities and all time periods to be displayed for Schedule Mode processing.

Color Exhibit 7 shows the Schedule Mode screen that would result from correct entry of all the data so far presented. As in Activity Mode, activity names are displayed in the Title Window with corresponding color-striped bars in the Main Window. Of course, only the activities and time periods covered by the Schedule Window are displayed.

Colors indicate the resources consumed by an activity. The color menu at the left provides a key to the color codes. As in Resource Mode, the Lower Window of Color Exhibit 7 plots consumption and availability of a specified resource. The dotted-line plot shows the availability pattern specified in resource data. The solid-line plot shows the actual consumption implied both by the consumption data supplied in Activity Mode and by

the schedule displayed in the Main Window. The resource being displayed is the one blinking in the color menu, in this case TST.

The features unique to Schedule Mode are a series of cues marking needed schedule adjustments and highlighting user opportunities for accomplishing the adjustments. Problems are indicated by broken red lines and by blinking in the Main Window. Broken red lines show "negative slack," that is violations of start and finish and precedence specifications. For example, in Color Exhibit 7, a 1-period red line to the left of the PROGR-PT B activity indicates that the activity should start 1 period earlier if the Desired Start Period (DS), the Desired Finish Period (DF), and all precedence relationships are to be satisfied. In this example, the problem is that DF cannot be achieved while meeting a DS of week 4 and the precedence relationships associated with the Program B path. Either the start time, the finish time or the duration of some activity on the Program B path must be changed.

Blinking in the Main Window signals resource over-utilizations. Whenever the amount of a resource needed in some period is greater than the amount available, all bar stripes of the resource's color will blink in that period. In the Color Exhibit 7, the TST resource in period 8 provides an example. Either the schedule must be revised to eliminate conflicts or Resource Mode must be entered to change availabilities.

When the user has properly resolved a schedule (if it can be resolved), all red lines and blinking in the Main Window should have been eliminated. Of course, if only some activities and time periods are displayed in the Schedule Window others may still be infeasible. As a

final check it is recommended that the user return to Activity Mode and reset the Schedule Window to include all activities and time periods before concluding that a schedule is resolved.

Color Exhibit 11 shows one resolution of the Schedule Window in Color Exhibit 7. Here, the duration of PROGR-PT A has been extended, freeing resources for PROGR-PT B to be expedited. Completing Program B activities earlier allows the project to finish on time.

The GITPASE Schedule Mode Screen has a variety of aids to help users in deciding which such changes should be attempted to resolve a schedule. One cue is the broken white lines shown in the Main Window. These white lines show "positive slack," i.e., opportunities to move activities without violating start time, finish time, or precedence constraints. For example, in Color Exhibit 7, the broken white line to the right of the PROGR-PT A activity indicates that it could start 1 week later without violating schedule constraints. Moving the activity within this slack might eliminate conflicts on over-utilized resources.

The vertical width of stripes in Schedule Mode's activity bars provides additional information. Stripe widths are scaled so that narrow stripes indicate relatively light resource utilization and wide ones show heavy consumption. When resource consumption exceeds availability, activities consuming large amounts of the scarce resource are strong candidates for adjustment.

One final user cue in Schedule Mode appears only for the active activity, i.e., the one titled in red. All precedence relationships involving

that activity are marked along the right margin of the Title Window. A special red left-arrow character denotes a predecessor of the active activity. A red right-arrow character indicates a successor (one having the active activity as its predecessor). This feature is automatically invoked whenever an activity's bar is touched with a light pen in the Main Window. In Color Exhibit 8, the PROGR-PT B activity bar has been touched. Since it is the active activity, its predecessor, DESIGN, and its successor, LVLI TST B, have been tagged in the Title Window.

A light pen touch anywhere in the Lower Window while an activity is active causes the graphic display in the Lower Window to be erased and replaced by the numerical display of durations and consumptions from Activity Mode. A light pen touch anywhere in the Lower Window while this display is showing causes it to be erased and the previous display, if any, to be redrawn. (This allows the user to see the scheduled duration and resource consumptions in numbers rather than interpreting their graphical representations.)

6.2 Selecting the Resource Plotted in the Lower Window -- the Color Menu

Whenever TOUCH shows in the Message Window in Schedule Mode, the user may select a different resource to be plotted in the Lower Window. It is only necessary to touch the color menu item of the selected resource. For example, touching the green menu item in Color Exhibit 7 would cause the Lower Window to display the PGR resource availability and consumption plots. Until another color menu item is chosen, this resource will be the only one plotted. Each modification of the schedule in the Main Window will cause it to be redrawn.

6.3 Fixing Activities in Time -- the FIX Menu Item

Unless otherwise instructed, GITPASE always schedules an activity at the earliest time consistent with the Desired Start Period and precedence relationships among activities. However, the user may wish to fix the schedule of an activity at some other time. Usually the purpose is to eliminate a conflict for an over-utilized resource.

To fix an activity at other than its earliest start time, the user begins by touching the FIX menu item with the light pen. (If the menu item is throbbing, it is already active, and this step can be skipped.) Next the user touches at or near either the left end or the right end of the activity bar of the activity to be fixed. This activates the activity (its name is rewritten in red), and causes the designated end of the bar to throb. Finally, the user touches where he or she wishes the designated end of the bar to go. For example, in Color Exhibit 7, assuming the FIX menu item is active, if the user first touches near the left end of the PROGR-PT A bar and then touches the bar at a point near the beginning of period 7, the PROGR-PT B activity will be fixed to start in period 7 rather than 6, as shown in Color Exhibit 9.

Those activities that are fixed are marked with a green bullet symbol to the left of their names. See section 6.5 for unfixing (freeing) an activity.

6.4 Changing Activity Durations -- the DUR Menu Item

An activity has its nominal duration until and unless the user makes a duration change. Often a duration change changes the activity's resource

consumption (see section 5.6). Usually durations are lengthened to avoid over-utilization of resources, or shortened to speed up the project schedule.

Making duration changes begins by touching the DUR menu item with the light pen. (If the menu item is throbbing, it is already active, and this step can be skipped.)

Next the user touches at or near either the left end or the right end of the activity bar of the activity to be fixed. This activates the activity (its name is rewritten in red), and causes the designated end of the bar to throb. Finally, the user touches where he or she wishes the designated end of the bar to go. For example, in Color Exhibit 7, if the user touches the right end of the PROGR-PT B bar and then a point to its right at the end of period 9, while the DUR menu item is active, the PROGR-PT B activity will be lengthened as shown in Color Exhibit 10.

There are four cases of duration change: shortening or lengthening from the left, and shortening or lengthening from the right. Duration changes from the left, in which the start time is changed and the finish time is not, cause the activity to have a "fixed" status. Duration changes from the right, in which the start time is not changed, do not cause the activity to have a "fixed" status.

6.5 Freeing Activities in Time -- the FRE Menu Item

Once an activity is fixed either by a FIX or a left-end DUR operation, it remains fixed until and unless the user frees it. To free a fixed activity so that GITPASE will again automatically schedule it to start at its

earliest start time, the user first touches the FRE menu item (if it is already throbbing, this step is skipped); then the user touches the activity bar or title (if the activity is already active, as indicated by having its title in red, this step is skipped). When a fixed activity is freed, the green bullet symbol to the left of its name is erased.

6.6 Accepting Heuristic Schedules -- the ACC Menu Item

GITPASE includes a heuristic scheduling procedure that attempts to find a schedule free of resource conflicts by fixing start times but not changing durations. The results of this heuristic are automatically displayed as white "ghost" outline schedule bars showing where the heuristic procedure "recommends" scheduling each activity for which it can find a suitable place. The heuristic is not perfect mathematically, and it sometimes can give a schedule that can be improved in an obvious way. Because it "gives up" on activities that are difficult to schedule, its recommendations do not always make good sense. To accept all of the heuristic procedure's recommendations, the user touches the ACC menu item. This is equivalent to, but much faster than, fixing all the activities' start times at the recommended places. The screen is redrawn with the actual bars where the "ghosts" were.

7. TRANSITION MODE

Transition mode provides three distinct groups of capabilities: (1) Interacting with the data and computer environment (NEW, OLD, REN, SAV, END); (2) handling transitions among modes for a single network (ACT, RES, SCH); and (3) handling the management of networks and subnetworks for hierarchic models of projects in which individual activities can be modeled as networks, whose activities can in turn be modeled as networks, etc.

7.1 The Transition Mode Screen

Transition Mode is invoked by touching the MOD menu item in any one of the other three modes when TOUCH is displayed in the Message Window. The system automatically enters Transition Mode when the user initiates a session. The Lower Window displays several menu items, any one of which the user can touch when the Message Window displays TOUCH:

- NEW The system erases current data and prepares to receive a new data set. The permanent copy of the data set previously active is not destroyed. The name of the new data set is requested.
- OLD The system erases current data and requests the name of a previously saved data set to be loaded.
- REN The system requests the name to which the current data set is to be renamed, and displays the current name in the Message Window. By renaming, the user can save as many different versions and schedules of a project as is desired.
- ACT The system goes to Activity Mode with the current data set.
- RES The system goes to Resource Mode with the current data set.
- SCH The system goes to Schedule Mode with the current data set.
- END The system prepares to end execution of the GITPASE system and asks the user to input Y or YES followed by a carriage return if the user wishes to have the system sign off of the PDP-11/70 system (otherwise, N or NO). See Appendix A for terminal signoff procedures.

The Main Window in Transition Mode can show portions of up to three levels of a hierarchy of networks. A list of the activities in the current network is shown with green diamonds marking which, if any, of the activities are compound, that is, elaborated into a subordinate network. A compound activity at any level can have a white rectangle around its name, indicating that the subactivity names of its subordinate network are shown in the next lower level. The name of an activity may be shown in red, indicating that the (sub)network representing that activity is the currently active network. As detailed in section 7, light pen touches and typed keyboard input in Transition Mode control the data management of a hierarchic set of networks collectively representing a project. The user can brachiate (climb, descend, or move horizontally in the hierarchic tree of networks) by touching activity names, pageup or pagedown menu items, or above the screen. In response to prompts, the user can specify plans -- saved schedules that provide MIN, NOM, or MAX durations of a network, and corresponding resource consumptions, for use at the next higher level where the network represents a single activity. A user can also simplify an activity, that is, cause its subordinate network(s) to be discarded.

7.2 Elaboration of an Activity

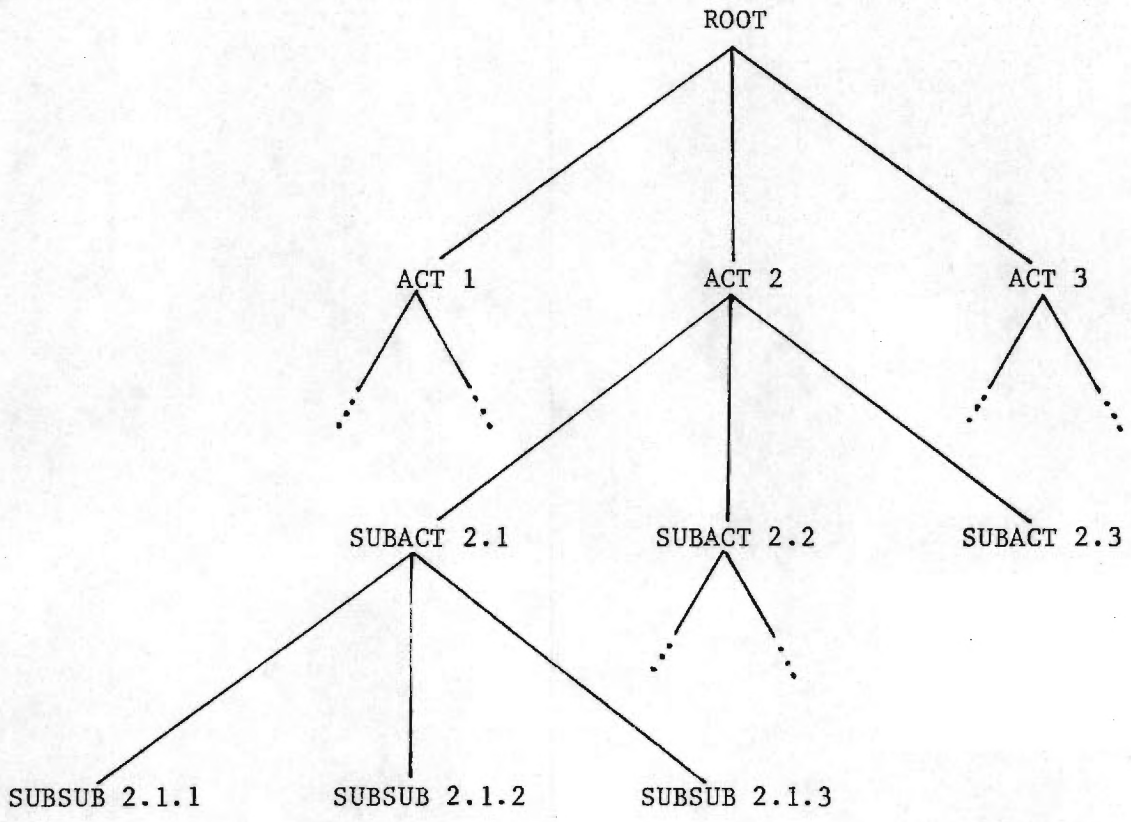
An activity that is itself expressed as a network of subactivities is said to be elaborated and is called a compound activity.

In Transition Mode a light pen touch on an activity name activates that name, causing it to be rewritten in red. Then, if the user touches the ACT, RES, or SCH menu items, the work done there will be on the network that elaborates that activity. When the user returns to Transition Mode, even if no subactivities have been declared, the activity name will be

tagged with a green diamond to its left, indicating that it is a compound activity. The subactivity names, if any, will appear in the next lower slice of the main window. A white rectangle will appear around the name of only one compound activity in each slice of the main window, indicating that the network in the next lower slice elaborates that activity. The Main Window shows up to three levels of a hierarchy of networks, but can show at any one level only one subnetwork. The diagrams in Exhibit 7-1 show how the Main Window in Transition Mode represents parts of a network hierarchy. A partial network diagram is shown at the top: The entire project has three activities; each of these is compound; one of them, ACT2 is elaborated into a network that has three activities; two of those are elaborated, and the activity names are shown for one of them. The way the Main Window presents the same information is indicated on the bottom of the page. The word "ROOT" is shown in parentheses because it does not actually appear; the area above the Main Window represents the unshown next higher level, which here is the "root" or entire project.

To go into SCH mode to work on the schedule of the entire project, the user would touch just above the top of the Main Window and then touch the SCH menu item in the Lower Window. To go into SCH mode to work on the schedule of the subproject ACT2 (consisting of activities SUBACT2.1, etc.), the user would touch the ACT2 name and then touch the SCH menu item. To go into ACT mode to declare activities in a subnetwork elaborating SUBSUB2.1.1, the user would touch the SUBSUB2.1.1 name and then touch the ACT menu item.

If the level of the network that the user wants to see or touch is above or below the three levels displayed in the slices of the Main Window, the pageup (↑) and pagedown (↓) menu items at the left can be touched.



(ROOT)

◇ACT 1	◇ACT 2	◇ ACT 3
◇SUBACT 2.1	◇SUBACT 2.2	SUBACT 2.3
SUBSUB 2.1.1	SUBSUB 2.1.2	SUBSUB 2.1.3

EXHIBIT 7-1: HIERARCHIC NETWORK STRUCTURE

If the user wants to see the activity names for a subnetwork that elaborates a different activity than the one currently shown elaborated, it is necessary to touch the name, go to a different mode, and return to Transition Mode.

7.3 Simplification of an Activity

If it is no longer desired to have an activity elaborated, the SIM menu item is touched with the activity active. The activity names constituting the network about to be discarded begin to blink, and CONFIRM appears in the Message Window. The user can touch any other valid point on the screen, or touch the CNL (cancel) menu item, to abort simplification; otherwise, the user again touches the SIM menu item to confirm that the data is to be discarded.

7.4 Declaration of Plans

As the user goes from one point to another in a network hierarchy, GITPASE needs to be informed whether to store data, throw it away, or overwrite it on previous data. Each network in a project, from the overall network ("root activity") to the lowest-level networks, has up to three declared plans in addition to the current or working plan. The declared plans are designated the MIN, NOM, and MAX plans, and they are fully analogous to the MIN, NOM, and MAX durations of an activity. In fact, when a subproject is scheduled three times and MIN, NOM, and MAX durations for it are declared, the compound activity represented by this subproject automatically acquires the same MIN, NOM, and MAX durations, just as if they had been declared explicitly; and if the activity had been explicitly given nominal durations, these would override them.

To declare a plan that has been scheduled, the user gets into Transition Mode and goes to some other network. A prompt appears in the Lower Window asking whether the last (previous) network's schedule is to be declared as a MIN, NOM, or MAX plan; the user enters 1 to indicate MIN, 2 to indicate NOM, 3 to indicate MAX, or a carriage return to indicate no declaration.

When a user touches (in Transition Mode) the ACT, RES, or SCH menu item after changing the active network, a prompt appears in the Lower Window if the network now being entered is one that has had any plans declared. The prompt asks which plan to load; again 1, 2, and 3 indicate MIN, NOM, and MAX, and a carriage return indicates the working plan. The user's work on the network will then start from whichever schedule has been specified.

7.5 Hierarchic Data Handling

Data automatically pass both up and down the hierarchic tree, and also into and out of the permanent disk files.

In general, durations and resource consumption data pass up the tree, while due dates and resource availabilities pass down the tree.

The nominal planned start time of an activity sets the Desired Start Period for the subproject that elaborates the activity. The Desired Finish Period is the Desired Start Period plus the nominal planned duration.

The resource availabilities for a subproject are those left from those declared at that level or higher, after the resource consumptions of all nominal declared plans for all networks at all levels have been subtracted. (However, the Phase II version of GITPASE does not implement this data passage correctly, so resource usages should be checked.)

A resource may be declared "locally," that is, not at the "root" activity level. Its availabilities affect all networks subservient to the one in which the resource is declared.

Upon declaration of a nominal (or minimum, or maximum) plan for a subproject, its resource consumptions are summed and stored as the nominal (or minimum, or maximum) duration resource consumptions for the activity that is elaborated by the subproject. These consumptions overwrite those estimated at the higher level. (However, the Phase II version of GITPASE does not implement this data passage correctly, so resource consumptions should be checked.)

After a SAVe has been executed at least once during a GITPASE session, the user should be careful that any work he desires to preserve must be declared as MIN, NOM, or MAX plans, and that any work he desires not to be preserved must not be so declared. The original schedule and data set with which the session was entered is not automatically preserved, although it may be available on the PDP disk system under a previous version number of the same file name declared for the project, and thus could be recovered by a user who can use the PDP operating system.

To ensure that a data set is not lost, a user can do a REName immediately upon entering Transition Mode at the beginning of a session.

APPENDIX A

Hardware and Software

GITPASE Phase II is implemented on the PDP 11/70 system at AIRMICS, O'Keefe Building, Georgia Tech, Atlanta, Georgia 30332. For access information, contact the appropriate person in the Management Information Sciences Division of AIRMICS, 404-894-3107. The host program, written in FORTRAN, is maintained on the PDP 11/70 computer by AIRMICS personnel. There are also two terminal programs, written in BASIC, kept on a diskette by AIRMICS personnel. In this Appendix the name of the BASIC program to be loaded is assumed to be HASPDP1; this program chains to another program assumed to be named HASPDP2. AIRMICS personnel can supply the diskette and any changes to the instructions given below that may be caused by software enhancements or hardware upgrades.

Documentation on the PDP 11/70 system is available at AIRMICS.

The smart terminal required for running this system is a Chromatics CG1999, manufactured by Chromatics, Inc., Norcross, Georgia, with the following options: 64K memory, light pen, 19" screen with 512 x 512 dot matrix, hardware vector generator, second serial port, diskette drive. AIRMICS has acquired four of these units, which reside in various locations. Documentation on the Chromatics units is available at AIRMICS.

Also required is a 1200-baud modem or acoustic coupler for telephone-line communication from the Chromatics unit to the AIRMICS PDP 11/70 system.

At the time of writing, it is also possible to communicate at 300 baud, using the telephone number extensions 3117 or 3118 instead of those given below, and using a 2 instead of a 7 in step 2 below; it is also necessary to make a small change in the BASIC program. AIRMICS maintains an alternative program to HASPDP1 for use at 300 baud.

Signon and Signoff Procedures for GITPASE Phase II

Signon

1. Turn on Chromatics and floppy disk drive, make sure 1200-baud acoustic coupler is hooked up, and load floppy disk in drive.

2. Type the following key sequence on the Chromatics (no carriage return at at end and no blanks as separators):

   reset boot CRTOS esc R 0 7 esc F

3. Make sure acoustic coupler is on, call 404-894-3100 (or 3121), and cradle receiver.

4. In response to the prompt, type (using blanks as separators and with carriage return at end):

   LOGIN/N USERNAME PASSWORD (Use assigned username and password)

5. In response to the prompt, type (using blanks as separators and with carriage return at end):

   @SETCOM

6. Press the BASIC Key on the Chromatics.

7. In response to Chromatics prompt, type 48000 followed by carriage return.

8. In response to Chromatics prompt, type (using blanks as separators and with carriage return at end):

   DOS"LOAD HASPDP1"

9. In response to Chromatics prompt, type RUN followed by carriage return.

Signoff

1. Touch END menu item with light pen.

2. Type the following key sequence on the Chromatics (no carriage return at end and no blanks as separators):

   CRTOS esc R 0 7 esc F esc H

3. Type carriage return to get prompt, and type LOGO followed by carriage return to release host computer.

APPENDIX EXHIBIT 1: FUNCTIONS AVAILABLE IN RESOURCE MODE

Function	Input Sequence to Accomplish
Change modes or load a new or different different project (Section 3.4)	1. Touch MOD menu item 2. Touch appropriate item in supplemental menu
Save the current project's data and schedule (Section 3.3)	1. Touch SAV menu item 2. Touch SAV again to confirm
Reset the Desired Start Period (Section 3.1)	1. Touch DS in the Message Window 2. Enter the new Desired Start Period number
Reset the Desired Finish Period (Section 3.1)	1. Touch DF in the Message Window 2. Enter the new Desired Finish Period number
Add a resource (Section 4.2)	1. Touch the add asterisk in the Title Window 2. Type in the 3-letter code, a space, and the resource's name
Delete a resource (Section 4.3)	1. Touch the DEL menu 2. Touch the resource's name in the Title Window 3. Touch DEL again to confirm
Change a resource's code and name (Section 4.4)	1. Touch the resource's name (twice if the resource is not active [name in red]) 2. Type the new 3-letter code, a space, and the resource's name
Assign a color to a resource (Section 4.5)	1. Make the resource active (touch its name in the Title Window if it is not) 2. Touch the color menu of the desired color

Function	Input Sequence to Accomplish
Add a resource availability segment (Section 4.2)	1. Touch the add asterisk for that resource in the Main Window (if cursor not already there) 2. Type the beginning period of the availability, a space, and the amount available 3. Repeat for additional segments, or type a carriage return
Delete a resource availability segment (Section 4.3)	1. Touch the DEL menu 2. Touch the segment to be deleted
Modify a resource availability (Section 4.4)	1. Touch the segment in the Main Window 2. Type the new beginning period, a space, and the new availability level
Request consumption table for an active resource (in lieu of graph in Lower Window)	1. Make the resource active (touch its name in the Title Window if it is not) 2. Touch anywhere in the Lower Window
Abort an input sequence	1. If TOUCH is blinking in the Message Window, touch the CNL ('cancel') menu item 2. If TYPE or RETYPE is blinking in the Message Window, type carriage returns until TOUCH appears

APPENDIX EXHIBIT 2: FUNCTIONS AVAILABLE IN ACTIVITY MODE

Function	Input Sequence to Accomplish
Change modes or load a new or different project (Section 3.4)	1. Touch MOD menu item 2. Touch appropriate block in supplemental menu
Save the current project's data and schedule (Section 3-3)	1. Touch SAV menu item 2. Touch SAV again to confirm
Reset the Desired Start Period (Section 3.1)	1. Touch DS in the Message Window 2. Enter the new Desired Start Period number
Reset the Desired Finish Period (Section 3.1)	1. Touch DF in the Message Window 2. Enter the new Desired Finish Period number
Add an activity (Section 5.2)	1. Touch the add asterisk in the Title Window 2. Type the added activity's name 3. Type activity's nominal duration 4. Type resource consumption data for the activity (see below), or carriage return to exit this sequence
Delete an activity (Section 5.3)	1. Touch the DEL menu 2. Touch the name of the activity in the Title Window if it is not already active [name in red] 3. Touch DEL again to confirm
Change an activity's name (Section 5.4)	1. Touch the activity's name (twice if the activity is not active [name in red]) 2. Type the new name

Function	Input Sequence to Accomplish
Modify resource consumption data for an activity (Section 5.6)	1. Touch the name of the activity if it is not already active [name in red] 2. Touch the resource consumption data to be modified 3. Type from two to four numbers; the first is at NOM, the second is at MIN, the third is at MAX 4. If the cursor goes to the consumption data for the next resource, repeat step 3 for the new resource, or type a carriage return to exit the sequence, or type a comma and a carriage return to skip to the next resource
Designate a predecessor for an activity (Section 5.5)	1. Touch the name of the activity which is to have a predecessor designated for it, if it is not already active [name in red] 2. Touch the predecessor's bar in the Main Window
Delete the predecessor for an activity (Section 5.5)	1. Touch the name of the activity which is no longer to have a predecessor, if it is not already active [name in red] 2. Touch the predecessor's bar in the Main Window
See which activities are predecessors of an activity (Section 5.1)	1. If it is not already active [name in red], touch the name of the activity 2. Note red arrows in the Title Window pointing to names of predecessors
Specify the activity/period window for schedule mode (Section 5.7)	1. Touch the WIN menu 2. Touch one corner of the new window in the Main Window 3. Touch the opposite corner of the new window in the Main Window

FUNCTION	Input Sequence to Accomplish
Abort an input sequence	1. If TOUCH is blinking in the Message Window, touch the CNL ('cancel') menu 2. If TYPE or RETYPE is blinking in the Message Window, type carriage returns until TOUCH appears
Change the sequence of activities (Section 5.7)	1. Touch the name of the activity to be moved if not already active [name in red] 2. Touch the SEQ menu 3. Touch at or slightly below the name of the activity which will be above the one to be moved
Modify the scheduled duration for an activity (Section 5.6)	1. Touch the name of the activity if it is not already active [name in red] 2. Touch the DUR line in the Lower Window 3. Type the new scheduled duration
Modify nominal durations for an activity (Section 5.6)	1. Touch the name of the activity if it is not already active [name in red] 2. Touch the DUR line in the Lower Window 3. Type from two to four numbers. The last is SCH. Of the other three, #1 is NOM, #2 is MIN, #3 is MAX

APPENDIX EXHIBIT 3: FUNCTIONS AVAILABLE IN SCHEDULE MODE

Function	Input Sequence to Accomplish
Change modes or load a new or different project (Section 3.4)	1. Touch MOD menu item 2. Touch appropriate block in supplemental menu
Save the current project's data and schedule (Section 3.3)	1. Touch SAV menu item 2. Type SAV again to confirm
Reset the Desired Start Period (Section 3.1)	1. Touch DS in the Message Window 2. Enter the new Desired Start Period number
Reset the Desired Finish Period (Section 3.1)	1. Touch DF in the Message Window 2. Enter the new Desired Finish Period number
Designate or change the resource plotted in the Lower Window (Section 6.2)	1. Touch the color menu for the designated resource
Fix the scheduled time for an activity at other than its early start time (Section 6.3)	1. Touch the FIX menu item, if it is not already active [throbbing] 2. Touch one end of the activity's bar 3. Touch the location where the same end should now appear
Free a fixed activity to allow it to be scheduled automatically at its early start time (Section 6.5)	1. Touch the FRE menu time 2. Touch anywhere on the activity's bar or title
Change the duration of an activity (Section 6.4)	1. Touch the DUR menu if it is not already active [throbbing] 2. Touch the end of the activity's bar that is to be moved 3. Touch the location where the same end should now appear

Function	Input Sequence to Accomplish
See which activities are predecessors and successors of a given activity (Section 6.1)	1. Touch the name or bar of the given activity if it is not already active [name in red] 2. Note the left-pointing red arrows in the Title Window pointing to names of predecessors, and the right-pointing red arrows pointing to names of successors
Cause the Lower Window to display numerical duration and resource consumption data for the active activity (Section 6.1)	1. Touch the name or bar of the activity if it is not already active [name in red] 2. Touch anywhere in the Lower Window
Accept the entire set of heuristic schedule recommendations displayed by "ghost" bars in the Main Window	1. Touch the ACC menu item
Abort an input sequence	1. If TOUCH is blinking in the Message Window, touch the CNL ('cancel') menu 2. If TYPE or RETYPE is blinking in the Message Window, type carriage returns until TOUCH appears

COLOR EXHIBIT CAPTIONS

Color Exhibit 1. Transition Mode. When GITPASE comes up, or when the user touches MOD from one of the other modes, the Transition Mode display appears, with menu items OLD, NEW, REN, ACT, RES, SCH and END in the Lower Window, the name of the current file (or 'NONE') in the Message Window, and the menu items CNL and SAV at the left. Here the user has touched either OLD, NEW, or REN(ame), and the system awaits typing of the next filename. If OLD was touched, the current in-core data will be discarded and the system will be ready for the user to create data which, if SAVed later, will be saved under the designated filename; if REN was touched, the current in-core data will remain, and, if SAVed later, will be saved under the designated filename.

Color Exhibit 2. Resource Mode with Lower Window Graph. The three resources have been assigned colors; note their codes showing in the color menu items. The dotted graph in the Lower Window displays the active (red title) resource's availability data graphically, and the solid graph displays the current schedule's consumption of the resource (TIM).

Color Exhibit 3. Complete Activity Data for Example Project. Six activities and their nominal durations and resource consumptions have been entered. No activity is active. Although the user has done no scheduling, the system is currently assuming the earliest schedule allowable with nominal durations and the precedences that have been entered. The TINF and RINF numbers in the Message Window imply that this schedule has a time conflict (in this case the scheduled finish period is later than the desired finish period) and a resource conflict (the schedule consumes more resource than is available, for at least one resource in at least one period).

Color Exhibit 4. Activity Data Mode with Window. The window shown within the Main Window excludes the last activity and the last time period. If the user goes into Schedule Mode, the entire Main Window will be filled with this subset of the project.

Color Exhibit 5. Activity Mode with Partial Data. The third activity (PROGR-PT B) has its bar shown in white, indicating the user has not yet entered its consumption data for any of the color-coded resources. The second activity (PROGR-PT A) is active, and its duration and consumption data appear in the Lower Window.

Color Exhibit 6. Activity Mode After Precedence Designation. The user has made the first activity (DESIGN) a predecessor of the second (PROGR-PT A), and the system has responded by rescheduling accordingly.

Color Exhibit 7. Schedule Mode with Initial Schedule. Note that this Main Window shows only the subset of the project which is within the window designated in Color Exhibit 4. The user has touched the red TIM menu item, causing the Lower Window to show the resource graph. Note that in period 8 the TIM resource is scheduled at greater consumption than its availability. This can be seen not only in the Lower Window graph, but also in the Main Window; the camera has caught the red portion of the activity bar for the third activity in period 8 in the process of throbbing. The red dotted lines extending to the left of the third and fifth activities indicate a time conflict, which in this case is caused by the Scheduled Finish being later than the Desired Finish. (note DF= 10 and SF= 11 in the Message Window).

Color Exhibit 8. Start of FIX Operation. The user has touched the FIX menu (the camera has caught this menu item in the small phase of its throbbing) and has touched the left end of the third activity bar as the first of two touches which will fix its start time one period later. This first touch has activated the activity, causing its name to appear in red and causing arrows to appear in the Title Window showing that the first activity is a predecessor and the fifth activity is a successor.

Color Exhibit 9. Result of FIX Operation. The third activity has been fixed to start one period later. Note the green fix symbol at the left of its name.

Color Exhibit 10. Result of a DUR Operation. Refer back to Color Exhibit 7. If the user had touched the DUR menu item and then touched the third activity bar at its right end and then one period to the right of its right end, this would have been the result.

Color Exhibit 11. Feasible Schedule. This shows a feasible schedule for the example project, which was obtained by shortening the duration of the third activity and letting the fourth and fifth activities be accomplished at the same time (as is allowed by the increased availability of the TIM resource starting in period 9). The entire project is shown, so the user must have returned to Activity Mode and enlarged the window.