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FASPUE English Version: Analytic Petroleum Resource Appraisal
Microcomputer Programs for Play Analysis Using a
Reservoir-Engineering Model

By

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Open-File Report
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DISCLAIMER

Although program tests have been made, no guarantee (expressed or implied) is made by the authors or the U.S. Geological Survey regarding program correctness, accuracy, or proper execution on all computer systems.

This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards.

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1. INTRODUCTION

FASPUE is an extensive modification of another program (FASP) which was used in the USGS assessment of the petroleum resource potential in the Arctic National Wildlife Refuge of Alaska (Croveli, 1988).

FASPUE is a prototype package of programs for IBM PC/XT/AT (and compatible) microcomputers to assess the resource potential of undiscovered oil and gas resources using a play analysis method. Play analysis is a general term for various geologic models and probabilistic methods of analyzing a geologic play for petroleum potential. FASPUE means Fast Appraisal System for Petroleum - Universal English version.

The geologic model used in this study is a universal type of reservoir engineering model. The model is a generalization of the site-specific geologic model that was developed by the U.S. Department of the Interior and applied by the U.S. Geological Survey in petroleum assessments of the National Petroleum Reserve in Alaska and the Arctic National Wildlife Refuge (U.S. Department of the Interior, 1979; White, 1979). The probabilistic methodology used in those two assessments was a Monte Carlo simulation method.

FASPUE is based upon an analytic method using probability theory, rather than a Monte Carlo simulation method. Conditional probability theory is applied, along with many laws of expectation and variance. The risk structure considers both the uncertainty of the presence of the assessed petroleum resource and its amount if present.

The geostochastic system can be applied in explored as well as frontier areas. Separate programs exist for assessing individual plays and for aggregating a set of plays. The programs produce resource estimates of crude oil, nonassociated gas, dissolved gas, and total gas for a geologic play and an aggregation in terms of probability distributions. English units are used in this version. For a metric version the reader should see Croveli and Balay (1987).

The reader should refer to Croveli and Balay (in press) for a description of the reservoir engineering model and the analytic probabilistic methodology. Other useful references are Croveli (1985, 1987a, 1987b) and Croveli and Balay (1986).

All of the geologic play data required by this model are entered on an oil and gas appraisal data form, and later transcribed to computer data files for processing by the FASPUE software. The primary data form is reproduced in Figure 1, and an addendum data form is shown in Figure 2.

Oil and Gas Appraisal Data Form

Evaluator : _____

Play Name _____

Date Evaluated: _____

Attribute		Probability of Favorable or Present								Comments
Play Attributes	Hydrocarbon Source									
	Timing									
	Migration									
	Potential Reservoir Facies									
	Marginal Play Probability									
Prospect Attributes	Trapping Mechanism									
	Effective Porosity (>3%)									
	Hydrocarbon Accumulation									
	Conditional Deposit Probability									
Hydrocarbon Volume Parameters	Reservoir Lithology	Sand								
		Carbonate								
	Hydrocarbon	Gas								
		Oil								
	<div>Fractiles</div> <div>Attribute</div>	Probability of equal to or greater than								
		100	95	75	50	25	5	0		
	Area of Closure (x10 ³ Acres)									
	Reservoir Thickness/vertical closure (Ft)									
	Effective Porosity %									
	Trap Fill (%)									
	Reservoir Depth (x10 ³ Ft)									
	HC Saturation (%)									
No. of drillable prospects (a play characteristic)										
Proved Reserves (x10 ⁶ Bbl; TCF)										

Figure 1.--Oil and gas appraisal data form. (Modified from U.S. Department of Interior, 1979.)

Geological Variables

Four Types of Mathematical Functions

1. Zones Linear Function: $A * \text{Depth} + B$
Maximum of 4 zones with 3 transition depths (feet)
2. Exponential Function: $A * \exp(B * \text{Depth})$
3. Power Function: $A * \text{Depth} ** B$
4. Logarithmic Function: $A * \ln(B * \text{Depth})$

For each of the five geological variables below, select one type of function and assign values for the parameters A and B.

- Pe: Original Reservoir Pressure (PSI)
 T: Reservoir Temperature (Deg Rankine)
 Rs: Gas-oil Ratio (Thousand CuFt/BBL)
 Bo: Oil Formation Volume Factor (no units)
 Z: Gas Compressibility Factor (no units)

Variable	Function	Parameters									
		A	B	D	A	B	D	A	B	D	B
Pe											
T											
Rs											
Bo											
Z											

- Oil Floor Depth (feet): _____
 Oil Recovery Factor (percent): _____
 Gas Recovery Factor (percent): _____

Figure 2.--Oil and gas appraisal addendum data form.

An IBM-PC compatible 5.25" diskette containing the executable programs and documentation files for FASPUE is distributed in association with this Open-File Report. The diskette is a separate Open-File Report, number 89-1B. The files on the diskette are:

FASPUE.COM	The main system program;
NEWED.CHN	The data entry editor module;
FASPRE.CHN	The resource assessment module;
FASPAG.COM	The aggregation program;
FASPUE.DOC	The system documentation file;
INSTAL2D.BAT	The automatic installation script for a 2-diskette computer (5.25" diskette);
INSTALHD.BAT	The automatic installation script for a hard disk computer;
TEST.DAT	A file of hypothetical sample data for test-running the FASPUE system.

The TEST.DAT file contains most of the present Open-File Report. It can be copied out onto a printer using the DOS command

```
PRINT disk:FASPUE.DOC
```

where disk should be replaced by the drive letter of the disk drive containing the FASPUE system disk; for example, if the system disk is in disk drive B, the command would be PRINT B:FASPUE.DOC.

2. COMPUTER REQUIREMENTS

The computer requirements for running FASPUE are the following:

- IBM PC/XT/AT or compatible machine of other manufacture
- IBM compatible video driver
- Monochrome or color monitor
- 8087 Math Coprocessor
- 2 diskette drives (5.25"), or 1 diskette and a hard disk
- 256 K memory
- Printer able to print 132 characters on a line

The program does not require a graphics adapter, although it will run correctly with CGA and Hercules graphics boards and on hardware compatible with these standards. It has not been tested on machines having EGA or VGA adapters, but there should be no problem with them. There may be compatibility problems in running FASPUE on some other display hardware, or with some older versions of the DOS operating system. The development system was MS-DOS 3.1.

3. FASPUE INSTALLATION GUIDE

FASPUE consists of several modules, performing three main functions:

Function -----	Module(s) involved -----
Data entry and editing	FASPUE.COM NEWED.CHN
Resource assessment	FASPUE.COM FASPRE.CHN
Aggregation of assessments	FASPAG.COM

The first two functions are combined under the supervision of the shell program FASPUE.COM. When FASPUE.COM runs, it requests a data file name and allows the user to pass this file into either NEWED.CHN for data entry and editing, or into FASPRE.CHN for processing of the data in the file. The user needs only run FASPUE.COM and enter information requested by the program; loading and execution of the other modules is done by FASPUE.COM.

This section covers the installation of the necessary executable files to generate a FASPUE working system on either a dual 5.25" diskette computer or a computer with a diskette and a hard disk. Information on running the FASPUE system after it is installed appears in the next section.

In all the instructions that follow, underlining is used to mark a part of a command which you must replace with a phrase that fits your application.

3.1 Installation for a Diskette System

To install FASPUE on a PC with two 5.25" diskette drives:

1. Format a new diskette, using the standard form of the `FORMAT` command to include the DOS operating system on the new diskette. For help in doing this, refer to the MS-DOS or PC-DOS manual for your machine. Label this diskette "FASPUE SYSTEM DISK."
2. Insert this new FASPUE system disk into drive A. Insert the FASPUE program diskette which was shipped to you into drive B. Now run the FASPUE installation program for two diskettes by typing

`B:INSTAL2D`

This command takes care of creating the needed directory, named `\FASPUE`, on the new system diskette and copying the necessary files into it.

3. Make a backup copy of the system diskette, and keep it in a secure place for recovery of the system in case the working system disk is damaged and becomes unusable. Refer to the MS-DOS or PC-DOS manual for your machine for help in copying a diskette.
4. Format another diskette to use as a FASPUE data disk. As FASPUE runs, it will generate additional files which will be placed on the same disk with the data. It is not advisable to put the data files on the same disk with the system, as the system disk has little free space.
5. When running FASPUE, always have the system disk as the default disk. You cannot run FASPUE if you are logged onto a disk different from the one where FASPUE resides.

3.2 Installation for a Hard Disk System

To install FASPUE on a PC with a hard disk and one diskette drive, use the following procedures. NOTE: the FASPUE installation program will create a new directory on the hard disk, named \FASPUE. In the unlikely case there is already such a directory on the hard disk, the installation may fail. You should eliminate the existing \FASPUE directory (refer to your MS-DOS or PC-DOS manual) before running the installation procedure.

1. Insert the FASPUE program diskette which was shipped to you into diskette drive A.
2. Run the FASPUE installation program for hard disk systems by typing

A:INSTALHD disk:

In place of disk substitute the drive letter of the hard disk where you want to install FASPUE (one of C, D, E, F), and be sure to include the colon after the drive letter. An example of the install command is
A:INSTALHD C:

3. Use an ASCII text editor (such as EDLIN, Sidekick, or a word processor) to modify the PATH command in the AUTOEXEC.BAT file in the root directory of the startup disk. At the end of the PATH command, add the text

;disk:\FASPUE

where disk is the same as in the preceding paragraph. For example, if you are installing to disk C, append to the PATH command the phrase

;C:\FASPUE

If the AUTOEXEC.BAT file doesn't have a PATH command in it, add a line at the end of the file which says

PATH disk:\FASPUE

An example of this is PATH C:\FASPUE.

If the startup disk doesn't have an AUTOEXEC.BAT file, use an ASCII text editor to create one, and put the above PATH command in it.

4. To make the changes in AUTOEXEC.BAT take effect before running FASPUE for the first time, reboot the system by keying CTRL-ALT-DEL. This makes it possible to use FASPUE immediately. From this point on, the modifications in AUTOEXEC.BAT will take effect automatically every time the computer is turned on.
5. It is possible to put the data files in the same directory with the system, but you may prefer to package the data files in a different directory. You can also keep the data on a diskette instead of on the hard disk, but this is not so convenient.
6. When running FASPUE, always have the hard disk containing FASPUE as the default disk; it will not run from any other default disk. However you can change to any desired directory on the hard disk for the data files, and run FASPUE from there. FASPUE will generate a number of new files while processing the data, and these files will be put in the same directory and on the same disk as the data file.

4. FASPUE USER'S OPERATION GUIDE

This is an orientation guide for new users of the FASPUE oil and gas resource appraisal program.

Before running FASPUE, it must be correctly installed on your PC. If this has not been done, you will have to run through the installation procedure described above. After installation is complete, proceed with the operation of the system, described below.

In most respects, operation of FASPUE is the same whether you are using a dual diskette system or a hard disk system. There are a few differences in the ways these two installations are started; both cases are covered separately below.

4.1 Starting FASPUE - Diskette Computers (two diskette drives)

1. Put the FASPUE system disk in drive A and a formatted data disk in drive B.
2. Be sure the default (logged) drive is A.

3. After the DOS prompt A>, type

FASPUE

4. When FASPUE asks for a file name, type a name of the form

B:datafile.DAT

where B: is the disk drive designator, and in place of datafile you must substitute the name chosen for your own file. For example, you might give the file name B:FILE5.DAT. The data file name must be 8 or fewer letters or digits, not counting the .DAT suffix. The .DAT is not required as part of the name, but it is recommended. You can use another suffix if preferred, but you must avoid the suffixes .REL, .AGG, and .AGL as FASPUE uses these suffixes for its own output files. FASPUE doesn't check the legality of the file name, so if you enter an illegal one, the program will abort with a cryptic "I/O Error F1."

4.2 Starting FASPUE - Hard Disk Computers

1. Log into the disk in your computer which contains FASPUE. Change to a different directory where you plan to keep data files, or stay in the root directory if you don't want a separate one.
2. Assuming the default disk is C, type after the DOS prompt:

FASPUE

3. When FASPUE asks for a file name, type a name of the form

datafile.DAT

where in place of datafile you must substitute the name of your own file. For example, you might give the file name SOUTH.DAT. The data file name must be 8 or fewer letters or digits. The suffix .DAT is not required, but it is recommended. You can use another suffix if preferred, but you must avoid the suffixes .REL, .AGG, and .AGL as FASPUE uses these suffixes for its own output files.

The file name may include a directory path prefix if needed, for example \MYDATA\TESTRUN.DAT. FASPUE doesn't check the legality of the file name, so if you enter an illegal one, the program will abort with an "I/O Error F1."

4.3 Operation of FASPUE – Both Diskette and Hard Disk Computers

After loading FASPUE and specifying a data file name, both diskette and hard disk systems work the same way. A diskette system will work a bit slower.

If the named file does not already exist, FASPUE will ask if you want to create a new file with that name. Answer Y or N. The N response is provided as an escape in case you really wanted an existing file but typed its name incorrectly. FASPUE will load the data entry module so you can proceed to enter new data.

The first data entry screen will appear. It includes a bar at the top of the screen with the name of the file being edited, and a bar at the bottom showing a menu of the control keys: the arrow keys, the RETURN and TAB keys, PgUp and PgDn. The details of working with the data input editor are described below.

If the named file is an old one, then FASPUE gives the options of editing the file or sending the file directly to the FASPUE assessment program. The details of this are given later.

4.4 Operation of the Data entry Editor – New Files

FASPUE has a random access data entry module. The program accepts keyboard entry of input data parameters through a series of 9 display screens. Each screen contains cells for entry of a group of parameters. You can step sequentially through the cells on a screen by striking the RETURN key after entering each value. The right arrow key and the TAB key have the same function as RETURN.

But by using the cursor keypad and other control keys you also can browse randomly through the cells on the visible screen, and through the adjacent screens, until you come to the cell where you want to enter or edit data. These are the cursor controls:

- | | |
|-----------------|---|
| Up arrow key | This key will jump the cursor to the next line above the current line. But if the cursor is already on the first line of the screen, there is no effect. |
| Down arrow key | This key will jump the cursor to the next line below the current line. But if the cursor is already on the last line of the screen, there is no effect. |
| Right arrow key | This key will jump the cursor to the next cell to the right of the current cell. If the cursor is already on the last cell on the current line, the cursor will jump to the first cell on the next line below. But if the cursor is already on the last cell of the screen, there is no effect. |

Left arrow key	This key will jump the cursor to the next cell to the left of the current cell. But if the cursor is already on the leftmost cell of the current line, there is no effect.
RETURN key	This has the same effect as the right arrow key.
TAB key	This also has the same effect as the right arrow key.
PgUp key	This key will jump to the previous screen. But if the cursor is already on screen 1, FASPUE will say "No previous screen."
PgDn key	This key will jump to the next screen. But if the cursor is already on the last data screen (screen 9), FASPUE will say "No following screen."
ESC key	This key can be pressed from any cell on any screen to escape from the data entry function. FASPUE then gives the option to send the data to the resource assessment module, to return for more editing on the data, or to quit.

For a new file, FASPUE will have already entered dummy data into some of the cells. You can step through the cells and substitute actual values for your application.

The size of each cell limits the amount of space for that entry. If a cell is completely filled with characters, the editor will jump to the next cell.

As values are entered, FASPUE monitors the entries for correctness. If an entry has an error in it, FASPUE will display an error message on the screen and wait for you to retype correctly. However if you realize there is a typing error in the current cell, you can backspace over the bad characters and then retype.

Numeric entries. If the parameter is a number, it can be entered in any reasonable form: real numbers can be in fixed point notation (like 3.1416) or in floating point scientific notation (like 2.386E+3). Where real numbers are requested, integers are also acceptable. When integers are implied (as in the number of geologic prospects), these must be typed without a decimal point (like 34, never as 34.0).

Probability entries. If the entry being requested is a probability, it must be entered as a real number in the range 0.0 to 1.0. A probability which is out of range will cause an error message.

Percent entries. If the entry being requested is a percent, it must be entered as a real number in the range 0 to 100. If it is out of range, an error message is given.

Fractile entries. The lists of fractiles on screen #3 must be in nondecreasing order. If they are not, an error message is given. The fractiles for Depth on this screen must be strictly increasing; if any two of the fractiles are equal, an error results.

Geologic variable screens. The data on screens 4 through 8 specify the parameters for the five geologic variables in the FASPUE assessment: reservoir pressure (P_e), reservoir temperature (T), gas/oil ratio (R_s), oil formation volume factor (B_o), and gas compressibility factor (Z). Each of these variables can be specified as one of four function types: (a) zoned linear: a set of from 1 to 4 linear functions of depth, with transition depths to separate the zones; (b) exponential function of depth; (c) power function of depth; and (d) logarithmic function of depth.

For each of the geologic variables, one of the function types will be highlighted; and this is the function type currently selected. Use the left/right cursor keys to highlight one of the other function types, and the mathematical form of the function will change on the screen to show the current selected formula.

If the selected function type is zoned linear, a line will appear on the display to show the number of zones (1 to 4), and one of these will be highlighted to show the current selection. Use the left/right cursor keys to highlight one of the other numbers, and the mathematical form of the function will change on the screen to show the current selected formula and number of zones. If 3 or more zones are being used, the entries in the cells for transition depths must be strictly increasing, else an error will result.

When you have entered all the data on the nine screens, press the ESC key. FASPUE will print the DO WHAT menu:

Do what with this file?

- E Return to editing
- S Send the file to the FASPUE assessment program
- X Exit and save file
- Q Quit without saving.

Press the letter key corresponding to the action wanted. Either upper or lower case letters are accepted. If you type X, FASPUE will save the data file in the file directory and return to DOS; only the new version of the file is kept, and it replaces the old version, if any. If you type Q, the system will terminate without saving the newly created (or edited) file; this option is used if you realize the current edits are useless and you don't want to save this version of the data. If you type S, FASPUE will save the file in the directory, then send the data directly to the FASPUE assessment module. If you type E, then FASPUE will re-enter the data entry module for further review and editing. This is the same as editing an old file, and this process is described next.

4.5 Operation of the Data entry Editor - Old Files

If you specify the name of an already existing FASPUE data file when first entering FASPUE, the system will show a DO WHAT menu similar to the one in the paragraph above. If the file needs to be edited before sending it on to the FASPUE assessment program, press the E key.

Then FASPUE will run through the data entry screens as before, but now showing the cells already filled with the parameters in the existing file. If the existing values for any screen are correct, press PgUp or PgDn to review the other screens. If the content of a cell needs to be changed, move the cursor to that cell and type the new entry to replace the old. When the edited file is correct, press ESC while any data input screen is visible to return to the DO WHAT menu.

5. COMPUTING THE RESOURCE ASSESSMENT

Whenever the DO WHAT menu appears on the screen, you have the option to send the current data file to the FASPUE assessment module. To do this, press the S key. The FASPUE assessor will read the input data file, perform the assessment of resources, and produce two output files: a listing which summarizes the input data and displays an estimate of resources in the play; and a file of parameters which can be fed into the aggregator program to combine estimates of several plays after they are processed by FASPUE.

The summary listing file is named by FASPUE to agree with the data file name, but having the file name suffix .REL. The aggregation data file is named by FASPUE to agree with the data file name, but with the suffix .AGG. For example, if the original data file name is TEST.DAT, then FASPUE generates new files with names TEST.REL and TEST.AGG.

When the assessment program starts, it will ask you to enter today's date and the current time. These are character string entries, so date and time can be entered in any desired form.

Next, FASPUE asks if you want to include computations of fractiles for the number of resource type accumulations in the play. These computations are potentially the most time consuming part of the FASPUE method. Including them is optional because their effect on running time depends on a complex interaction between the number of prospects fractiles and several other parameters. They probably should be included for a first run (type y or Y in response to the query) because for most data sets the computing time is acceptably low. If the program is running too long, you must abort FASPUE by entering CTRL-C, then restart it on the same data file. This time, enter n or N when asked if you want to include the number-of-accumulations computations, and the program should finish in a short time. In this case, FASPUE will print a row of dashes on the summary output file for number of accumulations to show that this computation was bypassed.

Finally, FASPUE asks for a run number. It must be given as an integer. This is intended to help keep track of the results when several different runs of the same play are made with slight changes in the data on each run. The run number is printed at the top of the .REL output listing.

Now FASPUE will run its assessment. It may take from 10 seconds to several minutes to complete, depending on the content of the data file and on whether you have elected the option to compute number of accumulations. When FASPUE is finished, it will return to DOS. The .REL and .AGG output files, as well as the source data file, are left in the file directory.

6. PRINTING THE OUTPUT

The printer used to print the file resulting from a FASPUE assessment run should be able to print 132 columns across a page. Scroll the paper in the printer until the print head is positioned about 3 lines below the tear-off perforations.

Now enter the standard DOS command:

```
PRINT playdata.REL
```

where playdata is replaced by whatever name was given to the data file when it was originally created through the FASPUE editor. Examples of this command are PRINT TEST3.REL and PRINT B:WESTERN.REL. The output file is printed on two pages.

The other file output by FASPUE, the one with the .AGG suffix, is also printable, but it is intended to be read by another program, not by people.

7. RUNNING THE FASPAG AGGREGATION MODULE

FASPAG is a program which will combine the resource assessments from the previous runs of FASPUE on two or more plays. FASPAG will aggregate the plays and produce two new output files: (1) a summary listing file showing input values and output estimates; and (2) another .AGG file which can later participate in a higher level aggregation.

To run FASPAG, type the command

```
FASPAG
```

When FASPAG starts, it will ask you to enter today's date and the current time. These are character string entries, so they can be given in any desired format.

Next FASPAG will request a title line for this aggregation. This is the title which will be printed across the top of the summary output file, and is for documentation purposes. Type any desired title line.

Now FASPAG will ask for the name of a file on which to write the output listing. This must be a legal DOS file name consisting of a first name of 8 or fewer letters or digits and a suffix .AGL. An example of an output file name is ALLUSA.AGL. If you use a different suffix, FASPAG will change it to .AGL. If

you want the output listing file to go onto a disk different from the default disk, include a disk drive or directory prefix with the file name, as in B:ALLUSA.AGL or \PROJECTX\ALLUSA.AGL. FASPAG does not check the legality of the file name, so if you specify an illegal one, the program will abort with an "I/O Error F1." FASPAG will use the output file name to generate the aggregation file name: this will have the same first name as the .AGL file, but the suffix will be .AGG.

Then FASPAG will ask you to enter a degree of dependency between the plays to be aggregated. This must be a real number between 0.0 and 1.0 inclusive. If the entry is out of bounds, FASPAG will wait for you to re-enter it.

Finally, FASPAG goes into a mode which allows you to type any number of aggregation file names to join in the aggregation. These must be files with type suffixes of .AGG which were generated by earlier runs of FASPUE or FASPAG. After typing the names of all the aggregation files which are to participate in the aggregation, just press RETURN to exit. FASPAG will complete the assessment, save the output files and return to DOS.

There is a possibility that FASPAG will encounter computational problems with certain aggregation data files having unusually small unconditional play probabilities. This problem is unpredictable, as the computation is a complex interaction between these probabilities and several other parameters of the aggregation. If this happens, FASPAG will output a message like "arithmetic fault in nonassociated gas," and it will enter rows of dashes on the output summary file to indicate the bypassed fractile computations. However, a valid aggregation output file is still produced, and this .AGG file can participate in further aggregations.

To print the summary output file, use the DOS command

```
PRINT aggdata.AGL
```

where aggdata must be replaced by the name given above for the aggregation output listing file.

8. REFERENCES

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