

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

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

Revised Version of July 1988

By

Robert A. Crovelli and Richard H. Balay

Open-File Report
87-414A

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 the U.S. Geological Survey editorial standards.

Denver, Colorado
July, 1988

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ABSTRACT

FASPUM and FASPAG (version 88.7) by Robert A. Crovelli and Richard H. Balay are programs for the IBM PC and compatible microcomputers to assess and aggregate the hydrocarbon potential in a set of geologic plays.

Requirements: IBM PC or compatible; minimum 256 K RAM; monochrome or color monitor; 2 diskette drives or hard disk; 8087 or compatible coprocessor; 132 column printer; DOS 2.0 or later.

OF87-414A, Documentation, 14 p., paper copy;
OF87-414B, Executable diskette, 5.25 inch.

1. INTRODUCTION

FASPUM 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).

The FASPUM package described here is a revision of an earlier release of the same information. The computer program has been modified to present a simpler and more intuitive interface to the user, and the documentation below has been changed accordingly; but the underlying methodology is the same as before. This new version is compatible with the computer data files created by the earlier FASPUM release.

FASPUM 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. FASPUM means Fast Appraisal System for Petroleum - Universal Metric 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.

The petroleum resource appraisal system 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. Metric units are used in this version.

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

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

An IBM-PC compatible diskette containing the executable programs and documentation files for FASPUM is distributed in association with this Open-File Report. The diskette is a separate Open-File Report, number 87-414B. The program files on the diskette are:

FASPUM.COM NEWED.CHN FASPRE.CHN FASPAG.COM

The function and usage of these four program files are described in the remainder of this report. The information file on the diskette is

FASPUM.DOC

This file reproduces the essential content of the present Open-File Report. The diskette also includes a few short utility files needed to install and run the system.

2. COMPUTER REQUIREMENTS

The computer requirements for running FASPUM 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, 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. There may be compatibility problems in running FASPUM on some other display hardware, or with some older versions of the DOS operating system. The development system was MS-DOS 3.1.

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 (Km ²)							
	Reservoir Thickness/vertical closure (meters)							
	Effective Porosity %							
	Trap Fill (%)							
	Reservoir Depth (m)							
	HC Saturation (%)							
No. of drillable prospects (a play characteristic)								

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 (meters)
- 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 (Bars)
- T: Reservoir Temperature (Deg K)
- Rs: Gas-oil Ratio (m^3/Ton)
- Bo: Oil Formation Volume Factor (no units)
- Z: Gas Compressibility Factor (no units)

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

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

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

3. FASPUM INSTALLATION GUIDE

FASPUM consists of several modules, performing three main functions:

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

The first two functions are combined under the supervision of the shell program FASPUM.COM. When FASPUM.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 FASPUM.COM and enter information requested by the program; loading and execution of the other modules is done by FASPUM.COM.

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

3.1 Installation for a Diskette System

To install FASPUM on a PC with two diskettes:

1. Format a new diskette, and include the DOS operating system on it. Label this diskette "FASPUM SYSTEM DISK."
2. Insert this new FASPUM system disk into drive A. Insert the FASPUM issue diskette which was shipped to you into drive B. Now run the FASPUM installation program for two diskettes by typing

B:INSTAL2D

This command takes care of creating the needed directories on your new system diskette and copying the necessary files.

3. Make a backup copy of the system diskette, and keep it in a secure place for recovery of the system in case your working system disk meets with accident and becomes unusable.
4. Format another diskette to use as a FASPUM data disk. It is possible to put your data files on the same disk with the system, but the system occupies most of its disk and there will not be space for much data. As FASPUM runs, it will generate additional files which will be placed on the same disk with the data.
5. When running FASPUM, always have your system disk as the default disk. You cannot run FASPUM if you are logged onto a disk different from the one where FASPUM resides.

3.2 Installation for a Hard Disk System

To install FASPUM on a PC with a hard disk and one diskette, use the following procedures. NOTE: the FASPUM installation program will create a new directory on your hard disk, named \FASPUM. In the unlikely case that you already have such a directory, the installation may fail. You should eliminate the existing \FASPUM directory before running the installation procedure.

1. Insert the FASPUM issue diskette which was shipped to you into diskette drive A.
2. Run the FASPUM 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 FASPUM (one of C: D: E: F:), and be sure to include the colon after the drive letter.

3. Use an ASCII text editor to modify the PATH command in the AUTOEXEC.BAT file in the root directory of your startup disk. At the end of the PATH command, add the text

; disk \FASPUM

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

;C:\FASPUM

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

PATH disk \FASPUM

An example of this is PATH C:\FASPUM.

If your 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 your changes in AUTOEXEC.BAT take effect, reboot your system by keying CTRL-ALT-DEL. This makes it possible to use FASPUM immediately. From this point on, the modifications in AUTOEXEC.BAT will take effect automatically every time you turn on the computer.
5. It is possible to put your data files in the same directory with the system, but you may prefer to package the data files in a different directory. If you want to do this, make a new directory on the hard disk for this purpose. You can also keep your data on a diskette instead of on the hard disk, but this is not so convenient.
6. When running FASPUM, always have the hard disk containing FASPUM 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 your data files, and run FASPUM from there. FASPUM will generate a number of new files while processing your data, and these files will be put in the same directory with the data file.

4. FASPUM USER'S OPERATION GUIDE

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

Before running FASPUM, 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, you can proceed with the operation of the system, described below.

In most respects, operation of FASPUM 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 up:

4.1 Starting FASPUM - Diskette Computers

1. Put the FASPUM system disk in drive A and a formatted data disk in drive B.
2. Be sure your default (logged) drive is A.
3. After the DOS prompt A>, type

A> FASPUM

4. When FASPUM asks for a file name, type something like

B:datafile.DAT

where in place of "datafile" you will substitute the name you have chosen for your own file. Your "datafile" 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 you prefer, but you must avoid the suffixes .REL, .AGG, and .AGL as FASPUM uses these suffixes for its own output files. FASPUM 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 FASPUM - Hard Disk Computers

1. Log into whichever disk contains FASPUM. Go into whatever directory you want for your data files, or stay in the root directory if you don't want a separate one.
2. Assuming your default disk is C, type after the DOS prompt:

C> FASPUM

3. When FASPUM asks for a file name, type something like

datafile.DAT

where instead of "datafile" you will substitute the name of your own file. Your "datafile" 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 you prefer, but you must avoid the suffixes .REL, .AGG, and .AGL as FASPUM uses these suffixes for its own output files.

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

4.3 Operation of FASPUM - Both Diskette and Hard Disk Computers

After loading FASPUM 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 you have specified a new file, FASPUM will load the data entry module so you can proceed to enter new data. The details of working with the data input editor are described below.

If you have specified an old data file name, then FASPUM gives you the options of editing the file or passing the file directly to the FASPUM assessment program. The details of this are given later.

4.4 Operation of the Data entry Editor - New Files

This version 88.7 of FASPUM 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 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 you are 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 you are 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 you are already on the last cell on the current line, the cursor will jump to the first cell on the next line below. But if you are 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 you are 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 you are already on screen 1, there is no effect.
PgDn key	This key will jump to the next screen. But if you are already on screen 9, there is no effect.
ESC key	This key can be pressed from any cell on any screen to escape from the data entry function. You then have 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, FASPUM will have already entered dummy data into some of the cells. You will 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 you completely fill a cell with characters, the editor will jump to the next cell.

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

Numeric entries. If the parameter is a number, you can type the number 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 in fixed point form 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 monotone nondecreasing order. If they are not, an error message is given. The fractiles for Depth on this screen must be strictly monotone 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 FASPUM assessment: reservoir pressure (Pe), reservoir temperature (T), gas/oil ratio (Rs), oil formation volume factor (Bo), 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 variable, one of the function types will be highlighted; and this is the function type currently selected. You can 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. You can 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 monotone increasing, else an error will result.

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

Do what with this file?

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

Press the letter key corresponding to the action you want to take. Either upper or lower case letters are accepted. If you type X, FASPUM will save your data file in the file directory and return you to DOS. If you type Q, the system will terminate without saving the newly created (or edited) file; you might use this option if you realize your current edits are useless and you don't want to save this version of the data. If you type S, then FASPUM will pipe the data file directly to the FASPUM assessment module. If you type E, then FASPUM 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 FASPUM data file when first entering FASPUM, the system will show a DO WHAT menu similar to the one in the paragraph above. Suppose you want to edit the file before sending it on to the FASPUM assessment program, so you press the E key.

Then FASPUM 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 you are satisfied with the edited data, press ESC to return to the DO WHAT menu.

5. COMPUTING THE ASSESSMENT

Whenever you see the DO WHAT menu on the screen, you have the option to send the current data file to the FASPUM assessment module. To do this, press the S key. The FASPUM 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 FASPUM. The summary listing file is named by FASPUM to agree with your data file name, but having the file

name suffix .REL. The aggregation data file is named by FASPUM to agree with your data file name, but with the suffix .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, FASPUM asks if you want to include computations of fractiles for the number of hydrocarbon accumulations in the play. This computation is potentially the most time consuming part of the FASPUM method. Its computing time depends on a complex interaction between the number of prospects fractiles and several other parameters. Since its effect is unpredictable, it is optional. You probably should include it 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 you find the program is running too long, you must abort FASPUM 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 computation, and the program should finish in a short time. In this case, FASPUM will print a row of dashes on the summary output file for number of accumulations to show that this computation was bypassed.

Finally, FASPUM asks you to give a run number parameter. This is intended to help you 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 FASPUM 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 FASPUM is finished, it will return you 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 FASPUM 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 you gave to your data file when it was originally created through the FASPUM editor. The output file is printed on two pages.

The other file output by FASPUM, 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 FASPUM AGGREGATION MODULE

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

To run FASPAG, type the command

```
A> FASPAG  (on diskette systems)
or
C> FASPAG  (on hard disk systems)
```

When FASPAG starts, it will ask you 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 title line you want.

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. 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 your default disk, include a drive prefix with the file name. FASPAG does not check the legality of your file name, so if you specify an illegal one, the program will abort with an "I/O Error F1." FASPAG will use your output file name to generate the aggregation file name: this will have the same first name as your .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 your 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 FASPUM or FASPAG. After you have typed 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 you to DOS.

To print the summary output file, use the DOS command

```
PRINT  aggdata.AGL
```

where "aggdata" is the name you gave above for your aggregation output listing file.

8. REFERENCES

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