

# Biostratigraphy Integration and Interpretation Workspace Proposal

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## **Executive Summary**

With the advances in the geological sciences and information technology, geoscientists are processing ever-greater amounts of geologic data/information (*e.g.*, petrophysics, geophysics, biostratigraphy). In order to better constrain drilling risk, all disciplines are expected to improve the precision and accuracy of their results. To help meet these needs in biostratigraphy TACS has focused on a fit for purpose strategy of developing rigorous, multivariate analytical methods (*e.g.*, BioSlot and Fuzzy *c*-means (FCM)), tailored to the specific needs of industrial biostratigraphy, and these methods are already having positive impact in biostratigraphical analyses.

The feedback from the biostratigraphers within the companies sponsoring TACS research is that they want TACS to continue to work on methods that will help them to get as much useful information as possible out of their biostratigraphical data. More specifically, they requested methods to get the maximum information available from a single well, as well as tools to assist in the analysis of large numbers of wells. Although TACS does not have the resources to simultaneously develop the capabilities to meet both requests, the single-well application is a logical precursor to the multi-well application. As such, TACS is proposing a research program for 2005 that focuses on development of a Integration and Interpretation Workspace application, with concomitant research on potential methods to address multi-well problems.

For 2005, we propose to develop new methods for the interpretation of the results from existing TACS multivariate analytical methods, as well as integration of those results with other biostratigraphical data (*e.g.*, total abundances, diversity, paleobathymetry, etc.), and geological data (*e.g.*, petrophysics). These new functionalities, which will be part of the TACSWorks application, are:

1. Interactive Range Chart
2. Single-Well Interpretation Workspace
3. Work Session Management Tools

These functions serve an immediate need to solve single-well interpretation problems, and provide the capabilities necessary to generate the reference wells that can later be used for the analysis/interpretation of larger numbers of wells using supervised classification methods. The above functions are explained in detail in the body of this proposal. Concurrent with these software application development tasks, the 2005 scope of work will also include background research into (1) methods for the interpretation of large data sets, (2) correlation and chronostratigraphy, and (3) geospatial visualization of biostratigraphical data/information. More information on these research topics is contained in Appendix A for TACS sponsor feedback.

This “Biostratigraphy Integration and Interpretation Workspace” proposal is for one year (the 2005 calendar year), the sponsorship fee is \$22,500 and a minimum of six sponsors are desired to complete the scope of work as presented.

## ***Maximizing the Value of Biostratigraphical Data***

As oil and gas exploration pursues increasingly complex plays (typically in areas requiring large investments for resource extraction) petroleum geology disciplines are necessarily asked to provide greater precision and accuracy in their results, in order to better constrain risk. Biostratigraphy for example, has aggressively pursued the development of new methods to provide correlations between the traditional biostratigraphic markers. To help biostratigraphy achieve these goals, TACS has focused on the development of rigorous, multivariate analytical methods (*e.g.*, BioSlot and FCM) tailored to the specific needs of industrial biostratigraphy. As a result, the biostratigraphers that have used these methods have demonstrated that there is a considerable amount of valuable information remaining to be exploited in biostratigraphical data.

Up until now, new algorithms and methods developed by TACS have been in response to specific needs for numerical tools and algorithms. The resultant tools have targeted problems specific to the exploration and development of hydrocarbons, such as the correlation of sections in the absence of markers (BioSlot), the recognition of faunal assemblages (biofacies) and their relative proportions in samples (fuzzy-*c*-means, FCM). The BioSlot and FCM methods are being used by many TACS sponsors, and have already proven to be important contributors to sequence stratigraphical interpretations and directional drilling programs. These technologies have been successful in mature areas such as the North Sea, as well as frontier areas, including sub-salt Gulf of Mexico and offshore northwest Africa. Continuing with this research objective (maximizing information from biostratigraphical data) TACS is currently developing the Fuzzy Inference System (FIS) for quantifying descriptive geological models. The FIS module will be completed later this year.

While these new tools have produced new biostratigraphical information and insights, biostratigraphers have, as a result recognized new needs. For example, to get the greatest value from multivariate methods, the data often (usually) needs to be properly “prepared” (*e.g.*, transformations, treatment of missing values, data reduction, derivation of new attributes, etc.). This has resulted in the development of the TACSWorks Data Preprocessor, which will be released to sponsors as a beta version in 3Q 2004. This proposal marks a subtle, but important expansion in the scope of TACS research and development to include not just analytical procedures, but also interpretation and visualization tools. In other words, TACSWorks is maturing from a “toolbox” to a “workbench”. The workbench is not only new tools, but it provides a framework to support the necessary workflow to exhaustively and efficiently bring multiple data analysis and interpretation tools to bear on a biostratigraphical project.

The TACS research/development initiative outlined in this proposal (the “Integration and Interpretation Workspace”) will be designed to help the biostratigrapher fully and efficiently analyze and interpret their data, and build a workflow to ultimately allow the analysis/interpretation of larger data sets.

## ***Industrial Biostratigraphy: Future Technology Needs***

Biostratigraphers’ increasing use of large databases is producing larger volumes of numerical information/data that needs to be interpreted. The results from new multivariate methods (*i.e.*, TACSWorks) can further add to this information/data management deluge, especially if multiple analyses with different conditions (*e.g.*, different numbers of fuzzy clusters; different taxa subsets)

are performed, which is not uncommon. Therefore, a number of company representatives have requested that TACS develop the capabilities to help them easily compare and interpret these multivariate results, and integrate them with more conventional biostratigraphical and petrophysical data from which they can make integrated interpretations.

Requests from TACS sponsor biostratigraphers tend to one of two categories:

1. Biostratigraphers that work primarily frontier areas have said that they need the capability to exhaustively analyze and evaluate the full potential of their data, even though that data may be limited. As one sponsor put it, even with limited data from frontier areas (indeed *because* the data are so limited) it is crucial that we “leave no stone unturned”.
2. Other biostratigraphers working in more mature areas have expressed their need the capabilities to work with larger numbers (10s) of wells. Their needs range from basic correlation and chronostratigraphy to extending the BioSlot algorithm to more than three wells and ultimately, the ability to analyze very large number of wells (*i.e.*, tens or hundreds) for regional studies. Existing biostratigraphical applications are not designed to efficiently process these large amounts of quantitative information/data, and the general geological software available from vendors such as Landmark and Geoquest aren’t capable of effectively handling the unique and varied data types typical of biostratigraphy. Therefore, these biostratigraphers have asked TACS whether there are techniques that can be developed to assist in the integrated analysis and visualization of biostratigraphical information/data for many wells.

Interestingly, some of the biostratigraphers expressing the need for interpreting large volumes of data from many wells are from the same companies as some of those saying they need the capability to exhaustively analyze a few wells. There is no real inconsistency here. Rather, this just reflects the extremes of the spectrum of exploration strategies being employed by the industry, from frontier areas where limited data exists and any bit of new information can be critical, to the reevaluation of mature areas in search of overlooked opportunities where a quick, more expansive “look” is the objective. It is important that the TACSWorks application ultimately be able to accommodate the greatest range of needs among industrial biostratigraphers, in order to limit the inefficiencies of moving data between different applications and ensure that the appropriate interpretation tools are available.

Fortunately, from a technology development perspective, the desires of these two groups of biostratigraphers are compatible. While large, multi-well data sets present unique challenges in terms of analysis and interpretation techniques, and data visualization, it shares a workflow prerequisite that is identical to that of the single-well problem, and that is, before extending an interpretation to very large numbers of wells it is necessary to fully analyze/interpret/validate a subset of “anchor” or “reference” wells. As such, the capability to analyze and interpret data from a single well can and should be designed with a clear path towards its eventual use in the interpretation and visualization of data from large numbers of wells. Therefore, the “Integration and Interpretation Workspace” (an application to fully interrogate the data/information for individual wells) is proposed below for 2005.

## ***The “Integration and Interpretation Workspace” Scope of Work: 2005***

The proposed new Integration and Interpretation functionality will allow the biostratigrapher to exhaustively analyze and interpret wells in a TACSWorks session and ultimately, prepare a set of reference wells for geospatial visualization and for subsequent regional analysis. The three primary new functions are listed below, and are outlined in detail in the sections that follow:

1. Interactive Range Chart
2. Single-well Interpretation Workspace
3. Work Session Management Tools

### **Interactive Range Chart**

The range chart is the fundamental tool for biostratigraphers to perform their interpretations, but the commonly available range chart software is either not capable of effectively handling multivariate results produced by TACSWorks or, because of the iterative procedure typical of the multivariate analytical workflow, it is too disruptive to frequently transfer results between TACSWorks and other applications. Therefore, we propose to develop a digital range chart functionality within TACSWorks (*e.g.*, linked to the Preprocessor, BioSlot, FCM and FIS applications) so that the biostratigrapher can easily move between performing range chart-based interpretations and multivariate analysis, and allow easy and rapid transfer of results between all TACSWorks applications. As well as interactive functionality, the range chart will link to and reflect the data changes resulting from use of the Preprocessor module, and will produce a resolution independent vector image that will load directly into Adobe Illustrator. Note that this image capture capability is intended as a method to quickly produce analytical results graphics. It will not have the full charting capabilities of a product such as StrataBugs.

### **Single-Well Interpretation Workspace**

In addition to the range chart, a new functionality will be a flexible interpretation workspace that can display any multivariate results produced by TACSWorks (*e.g.*, BioSlot, FCM and FIS), as well as the raw abundances or percentages of any taxon in the well, and ancillary data, such as petrophysical data and synthetic seismic. The display of multivariate data will not be static curves however; they will be directly linked to the TACSWorks multivariate applications, so that samples or taxa selected in the range chart are, where appropriate, selected in the other applications.

The term “Single-Well Interpretation Workspace” is a bit of a misnomer, because the Workspace will be designed so that the biostratigrapher can cycle among the wells in a session and build a comprehensive, integrated solution using the Work Session Management Tools discussed below. The biostratigrapher will have the capability to annotate and define horizons and intervals within the Interpretation Workspace. A unique feature is that the horizon and interval definitions will be dynamic. After the depths are selected the biostratigrapher can specify the outputs that define the horizon or interval (*e.g.*, abundance of particular taxa, membership to a particular biofacies, etc.) and the system calculates statistics to allow it to find samples with similar multivariate signals using the Work Session Management Tools discussed below.

### **Work Session Management Tools.**

The ultimate power of the Interpretation Workspace will come from the Work Session Management Tools that will enable the biostratigrapher to iterate, document and composite the results among all the wells within a session. These tools will provide the biostratigrapher with basic analysis functions, such as creating ratios, as well as larger data functions, including the ability to add a new well to an existing *tac* file, build and use global synonymy tables, and locate matches to previously interpreted samples. After horizons and intervals are interpreted for one well, the biostratigrapher can look for the reoccurrence of the previously defined biofacies in other wells and decide whether they are truly comparable to that previously defined or not. At the judgment of the biostratigrapher the samples can be assigned to the existing biofacies definition, the biofacies definition can be modified, a new biofacies definition can be created or the match can be ignored. This function will not only assist the biostratigrapher in building a comprehensive, dynamic catalog of biofacies definitions for a particular set of wells, but ultimately, these horizons and biofacies definitions will be the basis for extending TACSWorks interpretation capabilities to larger data sets. All definitions and interpretations will be automatically documented in a pdf file for reference.

### **Research Methods for the Interpretation and Analysis of Larger Datasets - Visualization, and Recognition of Biofacies and Correlation/Chronostratigraphy**

In preparation for expanding the analytical and interpretation capabilities of TACSWorks to correlation and chronostratigraphy, the interpretation of large numbers (*i.e.*, tens or hundreds) of wells for regional studies and geospatial visualization, we will perform basic research into potential technology and methods. These results will be presented to the TACS sponsors in June/July 2005 for discussion as to their merits and the needs of the sponsors. Based on that feedback TACS will produce a proposal for future biostratigraphy technology development.

### **Schedule for Deliverables**

March 2005	Initiate development of interactive range chart, single-well interpretation workspace and work session management tools.
March 2005	Initiate basic research into methods for correlation/chronostratigraphy, interpretation of large numbers of wells and geospatial visualization.
June/July 2005	Present recommendations based on basic research and a progress report on the development of new TACSWorks functions.
October/September 2005	Deliver beta-version of TACSWorks with new functions.
March 2006	Deliver final version of TACSWorks with new functions.

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**Biostratigraphy Integration and Interpretation Workspace Project**

EGI Salaries	\$125,225
Other Costs	\$9,774
<b>Total Budget</b>	<b>\$134,999</b>
Number of sponsors	6
Budget per sponsors	\$22,500