Small Business Innovation Research (SBIR) Program

Proposal Cover Sheet

Proposal Number: B041-020-0641 Agency: MDA DUNS: 102385056
Topic Number: MDA04-020 CAGE:
Proposal Title:

Multivariate Statistical Analysis Techniques for Arbitrary Bit Stream Pattern Recognition

Firm:
Firm Name: RBI
Mail Address: 9511 W. Waneta Lake Rd.
Hammondsport, NY 14840-9511
Website Address: linkny.com/edrice4/engnr
Proposed Cost: 87327 Phase: I Duration: 6 Months
Business Certification: (Check all that apply)
Are you a small business as described in paragraph 2.2 (note: wholly owned subsidiaries are not eligible)? YES
Number of employees including all affiliates (average for preceding 12 months): 1
Are you a socially or economically disadvantaged business as defined in paragraph 2.3 ? NO
Are you a woman-owned small business as described in paragraph 2.4 ? NO
Are you a certified HUBZone small business concern as described in paragraph 2.9 ? NO
Are you a service-disabled veteran-owned small business as described in paragraph 2.11 ? NO
Are you a veteran-owned small business as described in paragraph 2.12 ? YES
Are you proposing to use a Federal facility or FFRDC? NO
Has a proposal for essentially equivalent work been submitted to other US government agencies or DoD components? NO
If yes, list the name(s) of the agency, DoD component or other SBIR office and Topic Number in the space below.

Project Manager/Principal Investigator Corporate Official (Business)
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Title: Principal Engineer Title: Sole Proprietor
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Signature of Principal Investigator Date Signature of Corporate Business Official Date

Technical Abstract

(Limit your abstract to 200 words with no classified or proprietary information)

The proposed effort entitled "Multivariate Statistical Analysis Techniques For Arbitrary Bit Stream Pattern Recognition" will exploit little used multivariate statistical analysis techniques to develop an automated signal grouping/identification capability. These multivariate techniques have had rapid development in the processing rich environment of the past few years, but their power has not been exploited in any engineering disciplines. The statisticians use these powerful techniques to perform factor analysis on a myriad of data found in the proliferation of survey information. The system engineer can use these powerful techniques to perform correlation, clustering and factor analysis on a myriad of technical parameters used in signal, voice and threat ID. The challenge of arbitrary bit stream classification will be used to develop and advance a multivariate statistical analysis toolbox. These techniques have already been able to separate scrambled data form nonscrambled data and even to detect the scrambler algorithm used on the digital data. With the introduction of frequency parameters as factors of discrimination and multivariate statistical analysis techniques to optimize and calculate probabilities, high fidelity

signal identification will be accomplished. An automated signal ID capability and the multivariate tools developed will be put in an open architecture which will be prototyped and tested in a Phase II development.

Anticipated Benefits/Potential Commercial Applications of the Research or Development.

(No classified or proprietary information)

The commercialization of the multivariate statistical methods is pending the open architecture development of powerful data analysis modules. RBI expects to drive this R&D to that end. The tools used by the statistician to perform the correlations, factor analysis and clustering of diverse data require expert handling and understanding. The less diverse data used in the engineering environments enable the honing of these statistical methodologies into automated data processing modules which perform specific correlations and factor analysis to enable powerful understandings of raw data. These modules can be interconnected to perform multiple functions in the same way that business modules are interconnected in the open architecture of Java Beans. Thereby the engineer can use these statistical methods to do whatever he wants with myriad's of data.

RBI expects to use this multivariate statistical methodology to 1) find powerful solutions to voice and signal identification challenges, 2) to perform geopositioning, tracking and fusion applications in the missile defense arena , 3) to perform data correlations and factor analysis for homeland defense functions and 4) to perform level 2+ data fusion advancements. As a new start company operating in a recession RBI has no material resources to invest in these four development areas. However, RBI has found an ample human resource of engineers operating out of their areas of expertise who are eager to invest their talents in the possibilities found in this vision. The opportunity for patents and sales of specific modules is expected to result from the Phase II development. The synergism from the addition of programmers and talented system engineers for a Phase II development will generate more opportunities for spin-offs of this technology. These diverse applications of such a powerful set of modules is expected to reap financial benefits within two years of their availability. The advancements to be retrofit into the modules for even more diverse applications will generate more benefits as well as advanced R&D investments

List a maximum of 8 Key Words or phrases, separated by commas, that describe the Project.

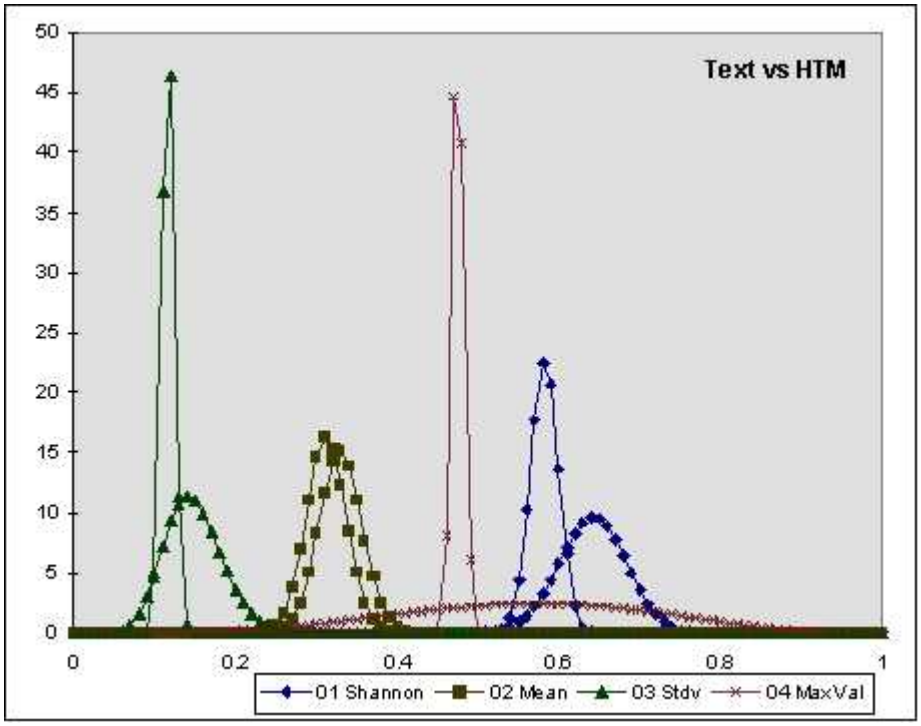
Missile Defence, Innovation, Multivariate Statistics, Signal Identification, Factor Analysis, Cluster Analysis, Multidimentional, Bit Stream ID Last Updated on: 1/8/2004 11:35:33 PM

2. IDENTIFICATION & SIGNIFICANCE OF THE OPPORTUNITY

There have been tremendous advances in how statistical analysis of data is accomplished with the modern powerful computer processors. These advanced statistical processing tools are used extensively by statisticians in masters programs and statisticians working in social, psychology, medical, marketing and political fields. These powerful correlation and factor analysis tools have not been used nor even understood in many of the engineering fields. The correlation , fusion and identification disciplines in the engineering environment would be greatly enhanced by the cluster analysis techniques that use Euclidean distances and /or Eigen Vector methods. The objective of this proposal is to introduce multivariate statistical methods into the engineering field of signal identification. The advantages of these multivariate methods will enable the automated grouping and identification of arbitrary bit streams. The exploration of these multivariate methods will automate the data correlation and fusion efforts currently stalemated in the R&D arena.

In times past the statistician used dichotomous information as independent variables used to validate a hypothesized value of a single dependent variable. This dependent reasoning used simple correlation techniques and cluster analysis methods to perform linear regression type predictions. With the advent of powerful processing tools the statistician found they could handle multiple dependent variables and innumerable independent variables. These multivariate statistical methods of factor analysis have exploded into the marketing , social, psychology, and political science fields with some very powerful data correlation's giving insightful conclusions. The departure from the single dependent variable arena requires new multivariate statistical methods and multidimensional thinking. This challenge has been largely undertaken by statisticians in master programs. The results have been phenomenal. The powerful multivariate statistical methods and the multidimensional thinking is equally available and equally promising to an engineer holding advanced mathematical backgrounds and doing advanced R&D work involving vast amounts of data. The arbitrary bit stream identification challenge provides an ideal environment to develop these multivariate statistical analysis tools for the engineering discipline.

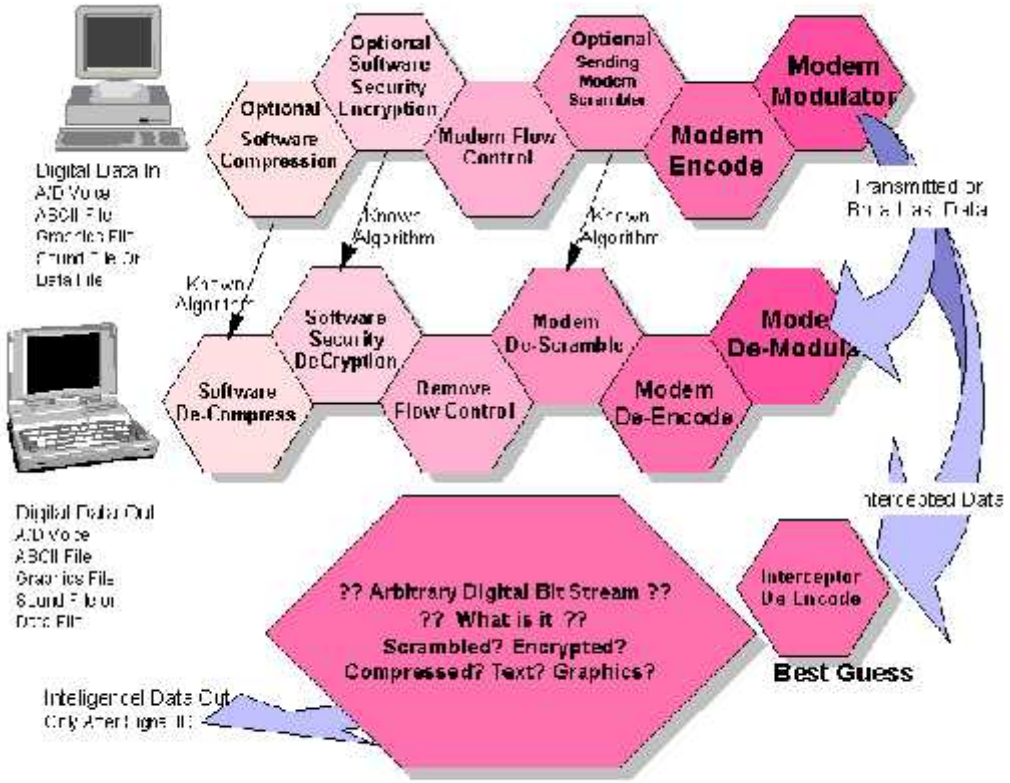
The ability to extract powerful signal grouping/identification characteristics is illustrated in the figure below.



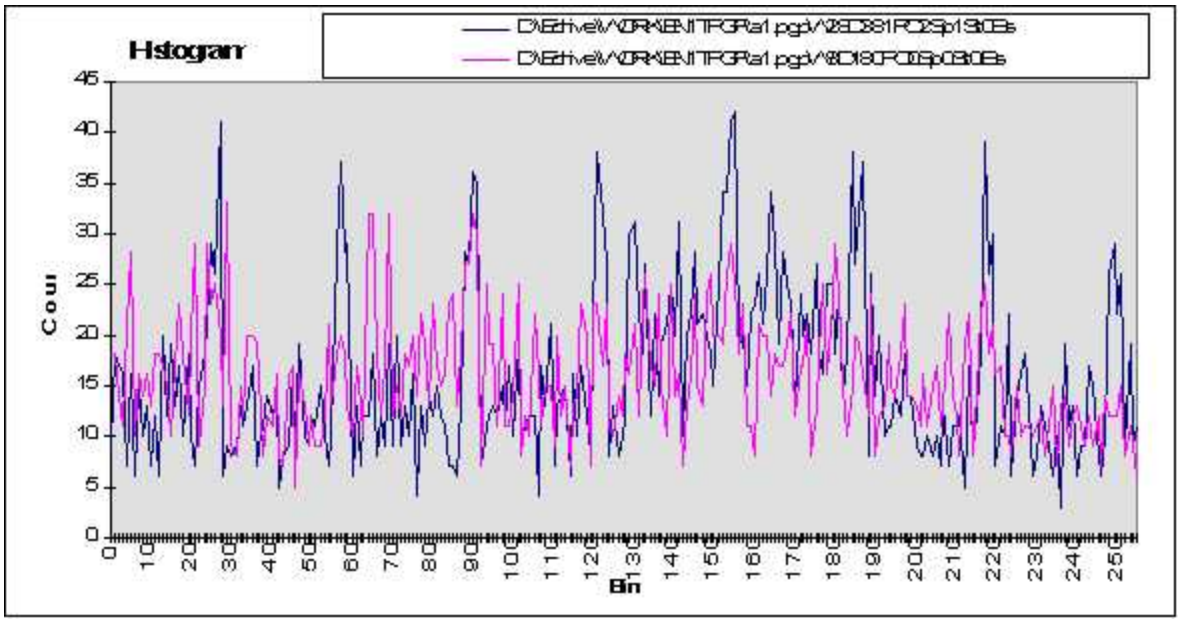
The multivariate statistical methods are used here to calculate distribution curves for parameters of several arbitrary bit streams. The area shared beneath the two distribution curves for the Shannon entropy variable indicate the probability that an entropy measurement could not be categorized into either group with certainty. Likewise for the other three distributions. With the use of Bayes theorem of probabilities one can use information of all four of these distribution to group a sampled bit stream into either text, htm, or neither with very high probability. A single parameter cannot perform this classification, but multiple parameters, even when some are dependent variables, can add a powerful synergism to signal grouping/identification methods. This multivariate statistical method of grouping/identification of signals with very high fidelity is only the beginning of the multivariate methods now found available to a statistician, and multivariate statistics is relatively untapped by the engineers doing signal identification.

This effort will use these multivariate statistical methods to explore their direct application to engineering disciplines. The classification of arbitrary bit streams is ideally suited as the catalyst for this development of multivariate statistical modules which will find direct application in several engineering applications. Applications which include signal ID, voice ID, geopositioning, tracking, data correlation and data fusion disciplines.

2.1 Background Arbitrary Bit Stream ID. An Arbitrary Digital Bit Stream is encountered when an intelligence intercept of digital data has been demodulated. Such a scenario is pictured in the figure below.



Notice from this figure that an arbitrary bit stream may be text, voice, graphics, or other data that may be compressed or not, encrypted or not, and scrambled or not. Before useful intelligence can be obtained from the intercept it is essential that the signal be categorized as to the previous processes which acted upon it. The arbitrary bit stream classifiers currently in use rely on only one or two parameters for grouping. Shannon entropy measures have been reasonably effective at separating encrypted data from the rest, however using multivariate statistical techniques has given promise to higher fidelity classifications. Notice the differences in the histograms of formatted encrypted data, and unformated encrypted data in the figure below:



If the naked eye can detect differences in data then the multivariate statistical methods can discriminate the difference with far greater exactness. With these multivariate methods RBI has been able to differentiate scrambled datas to even tell which type of scrambler algorithm was employed. This was accomplished using only entropy and histogram characteristics. By employing the frequency characteristics, now being pursued as additional factors,

and the power of multivariate statistics to perform factor analysis and Eigen Vector clustering, high fidelity ID of all signal types is imminent and insights into the compression, scrambling and encryption algorithms which were employed are assured. It is promising that even the encryption password length can be detected for most of the encryption algorithms employed today.

An advantage of using arbitrary bit stream classification for the development of multivariate statistical modules is the plethora of data available in unclassified media. Any home computer can, and does, quickly generate text, graphic, htm, voice, sound, and other digital data. This data may then be compressed, or not, scrambled or not and encrypted or not right on the host machine using any number of algorithms available on the market or easily coded with the published basic algorithms. It is an easy task to then dip into the middle of this generated file and extract an arbitrary bit stream of any desired frame length or format. Thus with a minimum of resources a myriad of realistic bit stream test information is available for analysis purposes. With the myriad of data samples comes a myriad squared number of parameters generated and thus the necessity and great promise of multivariate statistics to wade through all the factors and aggregate the most optimal insights for signal discrimination and identification. The multivariate statistical tools then contained in these open architecture Java modules will empower a number of similar ID, correlation and fusion efforts.

2.2 Multivariate Statistics Background. Multivariate statistics are used extensively to :

1) develop taxonomies (or system of classifications.)
2) to investigate useful ways to conceptualize or group items.
3) to generate hypothesis, and
4) to test hypothesis.

Many mathematical and statistical computer tools are available to accomplish theses purposes. The massive computer power unleashed with multivariate analysis tools is revolutionizing the analysis capability of marketers, politicians, sociologists and graduate statistics students. These powerful tools unleash faster analysis methods, multidimensional scaling techniques and cluster analysis advances to look at and understand interrelationships among multiple variables. Politicians, Sociologists, and Business Marketers are on the leading edge of this technology breakthrough. Engineers doing signal analysis, geopositioning, target ID and level 1 fusion are on the trailing edge when it comes to utilizing these powerful multivariate analysis techniques.

Multivariate statistics can do two major functions to edify the fusion or signal processing tasks of the systems engineer. First it looks at multiple variables related to the task and through the use of correlation's and Eigen vector analysis it determines the interdependence of the various variables. One method of revealing the interdependence of variables is through multidimensional scaling (MDS). We can define MDS as "a set of multivariate statistical methods for estimating the parameters in and assessing the fit of various spatial distance models for proximity data" (cf. Davison, M.L. (1992)) The more powerful tool for this interdependence is with factor analysis. (cf. Kim, J., and Mueller, Charles W. (1978)) When making threshold decisions in either signal processing or in data fusion the interrelationship of the factors in the decision process provide vital information. With a clear understanding of the interrelationships the key factors for a particular decision may be separated from the myriad of data and be used to clarify and validate the decision.

Secondly the multivariate statistical analysis enables groupings of data into categories of similarities. These groupings can be as wide or as narrow as desired. The categorization can use the fidelity of multiple variables to single out an individual entry and even perform ID or fingerprint type classifications. This type of grouping is done via cluster analysis (Aldenderfer, M.S., and Blashenfield, R.K. (1984)) or MDS methods previously mentioned. Previous statistical analysis used dependence methods whereby multiple regression and analysis of variance used several

variables but one dependent variable was predicted by means of several independent variables (Hair, J.F. et al. (1992)). These multivariate statistical methods allow examination of interrelationships among variables thereby enabling powerful new abilities to enhance signal processing, identifications or 'fingerprinting' of signals or data sources, and the fusion of related data into situational awareness. Multivariate statistics has powerful applications being utilized by statisticians yet still untapped by system developers.

3. PHASE I TECHNICAL OBJECTIVES

The phase I objectives are to re-evaluate the parameters used in arbitrary bit stream ID and optimize an automated ID capability using multivariate statistics. The parameters will be evaluated using the correlations, cluster analysis and factor analysis tools of the multivariate statistics trade. The interrelationships of the factors will enable the optimization of a set of parameters to perform effective bit stream ID. These optimized parameters and the measure of their effectiveness will then be used to advance an automated bit stream ID prototype which can be coded and tested in an open architecture environment during Phase II of the effort.

4. PHASE I - WORK PLAN

The Phase I work will 1) re-evaluate the parameters of arbitrary bit streams applicable to data ID, 2) evaluate the multiple variables with multivariate statistic tools to correlate and group the parameters or factors, 3) investigate the interrelations of the bit-stream parameters and 4) optimize an automated ID capability.

The Phase I work plan will include the following tasks for achieving the stated objectives:

4.1 Task I - Investigate and/or Develop Parameters (100 hr.)

The data parameters necessary to perform bit-stream ID will be explored in this task. Several parameters have already demonstrated powerful metrics for grouping data, but a diverse set of parameters will be explored in the time and frequency domain. Multiple parameters, even if they are interrelated, can be optimized and analyzed with the multivariate statistics tools. The key in this task is to capture every conceivable parameter that might add weight to the grouping/ID fidelity of an automated process.

4.2 Task II - Multivariate Analysis Methods (300 hr.)

Multivariate statistical analysis tools are generally made to analyze dichotomous data from survey or polling inputs. These tools are robust and powerful but are not automated nor versatile. The data to be input to these statistic methodologies in this effort will in general be continuous. Most of the data will fit a normal statistical distribution but many times the data will better fit a Beta distribution. The tools will need to be modified or developed to efficiently handle both distributions of continuous data. The Eigen vector and correlation analysis tools will likewise need some modification to handle these diverse data requirements. The power of the multivariate statistics methods will be defined/refined and developed in Java in this task.

4.3 Task III - Investigate Parameter Interrelations (150 hr.)

The power of the multivariate statistics analysis methods will be unleashed in this task. The parameters/factors which provide the best fidelity for the groupings and ID will be selected and isolated in this task. The tools of this trade include the ability to 'rotate' data into independent variables. These data transformations must be done without loss of valuable discriminating information. The evaluation of parameter interrelationships and the transformations into independent variables done in this task will preserve optimized information for automating an ID process.

4.4 Task IV - Optimize Multivariate Automated ID (200 hr.)

In this task the multivariate statistics output will be optimized to architecture an automated signal ID. Multiple signal ID scenarios will be performed manually to fully understand the complete transition from raw data to identified

signal. This ID process will then be broken into modules which can be interconnected in a versatile open architecture which can be implemented into a Java prototype in Phase II.

4.5 Reporting. (50 hr.)

A. Bimonthly Progress reports: In addition to day-to-day informal contacts with the program monitor, technical progress reports will be submitted every two months.

B. A Final Report will be generated. A final report detailing all of the development and evaluations will be generated at the end of Phase I.

The Phase I work would follow the tentative schedule below:

Task	Days	Hrs	Start	Stop
SBIR Phase I MVSAT for Bit Streams	186	800	03/01/2004	09/03/2004
Task 4.1 Investigate Parameters	24	100	03/01/2004	03/25/2004
Task 4.2 Multivariate Analysis Methods	70	300	03/25/2004	06/03/2004
Task 4.3 Investigate Interrelations	35	150	06/03/2004	07/08/2004
Task 4.4 Optimize Automation	46	200	07/08/2004	08/23/2004
Task 4.5 Reporting	11	50	08/23/2004	09/03/2004

Waterfall Chart of Tasks

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SBIR Phase I          ...A.....M.....J.....J.....A.....S....
4.1 Invst Paramrs     XXXX.................................
4.2 MVA Methods       ....XXXXXXXXXXXXX.....................
4.3 Interrelations.................XXXXXX..............
4.4 Optimize Automa......................XXXXXXXX.......
4.5 Reporting          ..............................XXX....
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5. RELATED WORK

The Principal Investigator is the sole proprietor of RBI and has been involved in pursuing categorizing arbitrary bit streams for the past several years. While in the USAF he was responsible for the programs that enhance the performance of numerous intelligence collection platforms. With minimal funding and resources RBI is staying abreast of the current technologies and intelligence mission requirements. RBI has used multivariate statistical analysis methods to perform classifications and identification of arbitrary bit streams. The multivariate methods as used in that task will have direct application to several system engineering challenges found in the military intelligence R&D incentives. RBI maintains connections with both DOD military intelligence R&D efforts and multivariate statistics R&D advancements to stay on the leading edge of this breaking technology.

6. Relationship With Future Research Or R&D

The successful use of multivariate statistics methods in the signal ID and data fusion arena will open doors of opportunity for signal ID, level 2+ data fusion and for this powerful factor analysis methodology. If these statistical methods mark notable improvements for signal ID in Phase 1, the follow on phases of prototyping will field open architecture Java modules which will find application in multiple fields of both fusion and digital processing. RBI will advance it's system engineering arm to lead in other R&D efforts which will exploit these little used methodologies in areas of military intelligence collections, missile defense missions of geoposition and tracking, homeland security intelligence collections and level 2+ data fusion areas that are currently stalemated without adequate correlation and clustering techniques to sort through their myriad of mitigating factors.

7. Commercialization Strategy

The commercialization of the multivariate statistical methods is pending the open architecture development of powerful data analysis modules. RBI expects to drive this R&D to that end. Multivariate statistics is currently in vogue and application in college, in social/political polling and in marketing positions. The tools used by the statistician to perform the correlations, factor analysis and clustering of diverse data require expert handling and understanding. Thereby the statistician can make the statistics say whatever he wants. The less diverse data used in the engineering environments enable the honing of these statistical methodologies into automated data processing modules which perform specific correlations and factor analysis to enable powerful understandings of raw data. These modules can be interconnected to perform multiple functions in the same way that business modules are interconnected in the open architecture of Java Beans. Thereby the engineer can use these statistical methods to do whatever he wants with myriad's of data.

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8. KEY PERSONNEL

Edward G. Rice, Senior Engineer

EDUCATION:

M.S., Electrical Engineering, Air Force Institute of Technology, Wright Patterson AFB Ohio, March 1992.

B.S. Electrical Engineering, Ohio State University, Columbus Ohio, March 1982.

CURRENT POSITION AND RESEARCH:

Edward Rice is a retired USAF officer and the Sole Proprietor of RBI. He has more than 18 years of experience in USAF intelligence systems. RELEVANT EXPERIENCE: Prior to starting RBI Ed Rice was the consultant that developed and tested the basic Euclidean Distance Vector Fitting Technique for Categorizing Arbitrary Bit Streams. From 1989 to 1995 he was assigned to Rome Laboratories where he managed numerous intelligence collection technology initiatives. From 1984 to 1989 as a USAF Electrical Engineer he worked with numerous data collection and weapon delivery systems furthering and rounding out his background in intelligence systems. He is currently Pastoring a Baptist Church and teaching high school math and science part-time, while pursuing a M.Div. Degree. He is available to work on RBI efforts up to 40 hours per week.

9. FACILITIES/EQUIPMENT

Due to cutbacks and limited resources RBI currently has no facilities and minimal equipment. The economic recession in the New York area makes available ample office space and computer resources which can be in place with minimal investment and time. Currently algorithm development and statistical analysis is performed on a home

computer in an office in the basement of my home. A Java development environment , Excel Spreadsheets utilizing Visual Basic, tools in Microsoft Office and Lotus Millennium have proven very adequate on a PC to perform research and module developments. Should RBI be funded for a multivariate statistical development ample facilities and equipment could be in place within 30 days.

10. CONSULTANTS

Several engineers with backgrounds in statistics, intelligence and computers are available to act as consultants for this effort. RBI is close to Cornell University, Rochester and Syracuse NY where unemployed engineers await a call and opportunity to get involved in a visionary development for RBI. Additionally the internett makes available a world of such expertise which can be utilized to perform this multivariate statistical development. Any consultants utilized by RBI for this effort will be paid by RBI, are not reflected in the cost proposal and shall not alter the cost proposal of this effort.

11. PRIOR, CURRENT OR PENDING SUPPORT

RBI has 3 SBIR proposals submitted which utilize the powerful advantages of multivariate statistical analysis techniques. There is great potential in any one of these proposals, if two or three of them are initiated the synergism between them will benefit all. RBI can pull together the resources necessary to perform all three of these efforts simultaneously with advantage to each participant. The three proposals are titled as follows:

Multivariate Statistical Analysis Techniques For Data Fusion 2 +

SBIR Topic Num: AF04-115
SBIR Title: Innovative Approaches to Fusion 2 +
SBIR Research & Technical Areas: Information Systems
SBIR Topic Author: Michael Hinman,
Phone: (315) 330-3175 Fax: (315) 330-4380
Email: hinmanm@rl.af.mil

Multivariate Statistical Analysis Techniques For Arbitrary Bit Stream Pattern Recognition

SBIR Topic Num: MDA04-020
SBIR Title: Innovative Techniques for Missile Defense
SBIR Research & Technical Areas: Weapons
SBIR Topic Author:Mr. Vincent Nguyen
Phone: (703) 695-0285 Fax: (703) 695-6222
Email: Vincent. Nguyen@mda.osd.mil

Multivariate Statistical Analysis Techniques For Automatic Speech Identification

SBIR Topic Num: AF04-062
SBIR Title: Expanded Speech Recognition to Include Foreign Accents
SBIR Research & Technical Areas: Human Systems
SBIR Topic Author: Mr. David Williamson
Phone: (937) 255-7593
Email: david.williamson@wpafb.af.mil

12. COMPANY COMMERCIALIZATION REPORT (SEE ADDITIONAL ELECTRONIC SUBMITTAL)

13. COST PROPOSAL (SEE ADDITIONAL ELECTRONIC SUBMITTAL) (See Last Page)

14. REFERENCES and FOOTNOTES

Aldenderfer, M.S., and Blashenfield, R.K. (1984)
Cluster analysis. Newbury Park, CA: Sage Publications.

Davison, M.L. (1992)
Multidimensional scaling. Malabar, Fl, CA: Krieger Publishing.

Hair, J.F. et al. (1992)
Multivariate data analysis (3rd ed.). New York: Macmillan.

Kim, J., and Mueller, Charles W. (1978)
Introduction to factor analysis: What it is and how to do it. Newbury Park, CA: Sage Publications.

Romesburg, H.C. (1984)
Cluster analysis for researchers. Belmont, CA: Lifetime Learning Publications.

Rummel, R.J. (1984)
Applied factor analysis. Evanston, IL: Northwestern University Press.

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RBI Cost Proposal

RBI 9511 W.Waneta Lake Rd, Hammondsport NY 14840

Date: **1-Jan-04**

Phone: **(607) 292-6639** CAGE Code: _____

Title: **Multivariate Statistical Analysis for Arbitrary Bit Stream Pattern Recognition**

Topic: **MDA04-020 Innovative Techniques for Missile Defense**

Total Proposal Amount **$87,327.39**

Direct Labor	EST MM	RATE/HR	EST COST	TOTAL
(1728 MH/MY)	20	hr/wk		
Principle Engineer	803	45	□36,135	
Jr Engineer	0	24	□0	
Programmer	0	24	□0	
Publications	0	13	□0	
TOTAL DIRECT LABOR	5.58	0.93	ENGRS	□36,135
LABOR OVERHEAD	OH RATE	XBASE	EST COST	
a. IN PLANT	0.7	36,135	□25,295	
b. ON SITE	0.55	0	□0	
TOTAL LABOR OVERHEAD	.	.	.	□25,295
SPECIAL TESTING	.	.	.	□0
SPECIAL E□UIPMENT	.	.	.	□0
TRAVEL	EA	RATE	EST COST	
a. TRANSPORTATION	3	979	□2,937	
b. PERDIEM	10	85	□850	
c. LOCAL TRANSPORTATION	10	32	□320	
TOTAL TRAVEL	.	.	.	□4,107
CONSULTANT	Hrs	Rate	Cost	
	0	75	□0	
TOTAL CONSULTANT	.	.	.	□0
OTHER DIRECT COST	.	.	.	□0
TOTAL DIRECT COST AND OVERHEAD		.	.	□65,537
GENERAL ADMIN EXPENCE	0.25	OF COST	.	□16,384
COST OF MONEY	0	OF COST	.	□0
TOTAL ESTIMATED COST	.	.	.	□81,921
FEE OR PROFIT	0.07	OF COST	.	□5,407
□	□	□	□	□
TOTAL ESTIMATE AND FEE OR PROFIT		.	.	□87,327.39