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2

3 SYSTEM AND METHOD FOR MONITORING RISK

4 IN A SYSTEM DEVELOPMENT PROGRAM

5

6 STATEMENT OF THE GOVERNMENT INTEREST

7 The invention described herein may be manufactured and used
8 by or for the Government of the United States of America for
9 Governmental purposes without the payment of any royalties
10 thereon or therefore.

11

12 BACKGROUND OF THE INVENTION

13 (1) Field of the Invention

14 The present invention relates generally to
15 identifying/monitoring risks arising during a development project
16 and, more specifically, to an automated system for determining
17 risk in large development projects such as an expert system for
18 monitoring and tracking ongoing project risk in a large software
19 development project.

20 (2) Description of the Prior Art

21 Due to the level of complexity of multi-million dollar
22 programs such as the design, development, and production of a
23 next generation submarine or weapon, it is a formidable
24 achievement to deliver the product on time, within budget, and
25 with a high degree of quality assurance. In a typical complex
26 military system development program, the cost of software

1 development is a significant cost and often the predominant
2 system cost.

3 It would be desirable to have an automated means for
4 monitoring the risk levels associated with achieving the
5 desirable outcome of the project as per the standards determined
6 for the project. Various projections, baselines, or plans are
7 made prior to project development in order to estimate the time,
8 cost, and quality standards. Currently, the monitoring and
9 identification of risk in achieving the program standards
10 involves collecting data, visually examining the available data,
11 comparing this with the program baseline or plan, and making a
12 subjective estimation of program risk. For example, if program
13 staffing falls substantially below the expected or planned
14 staffing level during a critical phase of the program, as might
15 be determined by other parameters, the project manager might
16 conclude that the risk in product quality or in meeting with the
17 scheduled delivery date is "high". Staffing then becomes a
18 critical program issue and steps can be taken to add personnel as
19 necessary to reduce the perceived risk. However, it would be
20 desirable to have more quantitative information of risk that is
21 less subjective for a particular project. Preferably, it would
22 be desirable to maintain the same staff of experts used in other
23 projects whose experience could be applied to examine and
24 interpret the information, compare it with the planned
25 project/program objectives, and provide a quantitative measure of
26 the risk level involved to aid the project manager in making

1 necessary management adjustments to complete the project. While
2 automated knowledge based systems are well known generally, the
3 solution to the problems involved in ongoing assessment and
4 evaluation of project risks as a management tool are not
5 available in the prior art.

6 U.S. Patent No. 4,783,752, issued November 8, 1988, to
7 Kaplan et al., discloses a knowledge based processor that is
8 callable by an application program to access a knowledge base and
9 to govern the execution or interpretation of the knowledge base
10 to find the values of selected objects or expressions defined in
11 the knowledge base.

12 U.S. Patent No. 4,860,213, issued August 22, 1989, to P.
13 Bonissone, discloses an automated rule-based reasoning with
14 uncertainty system having a three layer structure composed of
15 representation, inference, and control layers.

16 U.S. Patent No. 4,942,527, issued July 17, 1990, to B.G.
17 Schumacher, discloses a computerized management system with two
18 way communication between the computer and an operator for
19 receiving information from the operator during a management
20 emergence stage necessary for developing a plan in machine
21 readable language for an objective, processing the plan through a
22 management convergence stage for generating subdivisional plans
23 for output to the operator and receiving performance information
24 as feedback for reducing the objective to reality, processing the
25 management information and feedback information for generating
26 specifications and quantitative goals for a new version of the

1 objective, and processing the accumulated management data for
2 producing new organizational policy.

3 U.S. Patent No. 5,172,313, issued December 15, 1992 as a
4 continuation-in-part to the above cited U.S. Patent No.
5 4,942,527, to B.G. Schumacher, discloses additional processes
6 related to the above-cited computerized management system such as
7 processing through the emergence and convergence stages to
8 analyze and selectively remove tasks which have exceed planned
9 task time, perform system analysis for directing performance for
10 the next task and calculating the scheduled time for the
11 remaining tasks in the series.

12 U.S. Patent No. 5,189,606, issued February 23, 1993, to
13 Burns et al. discloses an integrated construction cost generator
14 that may be used to project costs for construction projects
15 rather than a method for monitoring ongoing project risk.

16 U.S. Patent No. 5,208,898, issued May 4, 1993, to Funabashi
17 et al. discloses a knowledge processing system in which a grade
18 representing a degree at which an event is satisfied or
19 unsatisfied is obtained depending on a condition part represented
20 in a form of a logical arithmetic expression including an
21 expression of a fuzzy logic and on a grade of satisfaction of the
22 condition part generates rules on assumption of unmeasurable
23 events associated with states of the external field of the system
24 so as to add the rules to the rules related to the unmeasurable
25 events.

1 U.S. Patent No. 5,293,585, issued March 8, 1994, to N.
2 Morita, discloses an industrial expert system for use in
3 designing a plant system or devices thereof and in fault
4 detection, that includes a knowledge base having a rules section
5 for describing deductive inference rules. The system uses a
6 simple construction to efficiently perform detection of fault
7 logic by using specific formula or calculation of parameters
8 representing features of a fault which are to be performed during
9 inference.

10 U.S. Patent No. 5,586,021, issued December 17, 1996, to
11 Fargher et al., discloses a method for planning a production
12 schedule with a factory. A capacity model is determined by
13 determining a plurality of contiguous time intervals,
14 partitioning the factory into a plurality of resource groups, and
15 determining a processing capacity for each of the resource groups
16 for each of the time intervals. For each job to be planned, the
17 job is divided into a plurality of processing segments each of
18 which is represented with a corresponding fuzzy set. A completion
19 date and confidence level can be predicted for each of the jobs
20 so the jobs can be released to the factory and devices fabricated
21 according to the requirements of the jobs.

22 U.S. Patent No. 5,737,727, issued April 7, 1998, to Lehmann
23 et al., discloses a process management system for operating a
24 computer that includes a graphical interface for graphically
25 presenting a process or portion thereof to a user.

1 In summary, while the prior art shows numerous general
2 purpose knowledge based system and various specific purpose
3 systems, there is not shown a system for monitoring and
4 identifying risks associated with large projects such as software
5 development projects. Consequently, there remains a need for a
6 system to quantify various types of ongoing risk that may arise
7 during project development using an objective predetermined
8 basis. It would also be desirable to have means to objectively
9 quantify overall project risk on an ongoing basis. Those skilled
10 in the art will appreciate the present invention that addresses
11 the above and other problems.

12
13 SUMMARY OF THE INVENTION

14 Accordingly, it is an object of the present invention to
15 provide an automated system and method for identifying and
16 monitoring risk associated with a development project.

17 It is another object of the present invention to use a rule
18 based risk assignment system for determining the risk.

19 It is yet another object of the present invention to provide
20 an output in chart form that plots a plurality of risk factors
21 over the duration of the project.

22 It is yet another object of the present invention to provide
23 an overall risk from said rule based risk assignment system.

24 These and other objects, features, and advantages of the
25 present invention will become apparent from the drawings, the
26 descriptions given herein, and the appended claims.

1 In accordance with the present invention, a method for
2 monitoring risk is provided that is related to a successful
3 completion of a development project comprising steps therefore.
4 A plurality of variables are determined relating to the
5 successful completion of the development project. A respective
6 baseline is projected for each of the plurality of variables for
7 the successful completion of the development project. Data
8 values are collected that relate to each of the plurality of
9 variables with respect to time. A data base stores therein rules
10 based on knowledge developed from one or more experts relating to
11 the plurality of variables for interpreting the data values with
12 respect to the respective baseline. The database also stores the
13 data values and the respective baseline for the plurality of
14 variables for determining a plurality of risk levels related to a
15 probability of one or more undesirable events. A visual output
16 is provided that is representative of each of the plurality of
17 risk levels. The method is particularly applicable to
18 development projects that involve development of a quantity of
19 software. In a preferred embodiment, the plurality of risk
20 levels is quantifiably determined and plotted. The visual output
21 representative of the plurality of risk levels may comprise a
22 graph showing each of the plurality of risk levels plotted with
23 respect to time throughout the development project. The risk
24 levels may be determined and plotted at selectable time
25 intervals. Preferably, the data values are converted to metric
26 values. The metric values are used to determine the plurality of

1 risk levels. Each of the plurality of risk levels may be
2 expressed quantitatively such as with a numerical description
3 related to risk or in a non-numerical way such as high, medium,
4 and low risk. In one embodiment of the invention, the data
5 values are collected related to staffing levels, project
6 requirements, and to the number of source lines of code that are
7 required.

8 Thus, the invention comprises an expert system for
9 determining risk in the development project. The expert system
10 may selectively use a first or second plurality of rules for
11 identifying and monitoring the plurality of risk factors. The
12 system has a plurality of inputs related to each of the plurality
13 of risk factors for monitoring during the development project.
14 Each of the plurality of inputs is preferably associated with a
15 quantifiable and weighted value and the database stores the
16 history of each of the plurality of inputs. A computerized
17 program is used for evaluating the plurality of inputs with
18 respect to the quantifiable and weighted value and for comparison
19 with the plurality of projected base levels. From this, the
20 program determines the plurality of outputs related to the
21 plurality of risk factors. The computerized program is operable
22 for producing the historical chart that may show historical
23 values for each of the plurality of risk factors with respect to
24 a time line for the development project. The computerized
25 program may be manipulatable so that each of the plurality of

1 inputs and outputs may be selectively removeable and so that
2 additional inputs and outputs may be added.

3

4 BRIEF DESCRIPTION OF THE DRAWINGS

5 A more complete understanding of the invention and many of
6 the attendant advantages thereto will be readily appreciated as
7 the same becomes better understood by reference to the following
8 detailed description when considered in conjunction with the
9 accompanying drawings wherein corresponding reference characters
10 indicate corresponding parts throughout the several views of the
11 drawings and wherein:

12 FIG. 1 is a block diagram of a rule-based knowledge system
13 in accord with the present invention;

14 FIG. 2 is a chart in accord with the present invention of
15 input data such as source lines of code base line estimates
16 versus actual source lines of code required; and

17 FIG. 3 is a chart in accord with the present invention of
18 output data showing a plurality of risk levels as well as a total
19 risk level with respect to time.

20

21 BRIEF DESCRIPTION OF THE PREFERRED EMBODIMENTS

22 Referring now to the drawings and, more particularly, to
23 FIG. 1 there is shown a high-level block diagram for a knowledge
24 or expert system 10 in accord with the present invention. Expert
25 system 10 includes rule-based risk assignment section 12 that is
26 preferably formulated as a series of rules such as if-then type

1 statements or other logical statements. System 10 may be
2 referred to as an AI (Artificial Intelligence) or expert system.
3 In practice a set of input measurement characteristics 14, 16,
4 18, and/or others will translate into a set of outputs 20, 22, 24
5 and/or others from logical statements, algorithms, and the like,
6 provided by experts who are knowledgeable in analyzing this type
7 of data and determining an output risk level. The expert's
8 rationale is, in effect, captured and stored within the rule-
9 based system. The knowledge, lessons learned, and past
10 experience are used to form the basis of the system. The rules
11 capture the steps that an expert takes in examining and
12 interpreting the measurements, comparing them to the expected
13 measurement behavior that is predicted for a minimal risk that
14 may be referred to as the baseline, plan, or statistical norm,
15 and then determines a measure of the project risk that will be
16 performed by rule-based system 10. The rules of risk assignment
17 module 12 are designed to take into account all possible
18 characteristics of input measurement data such as 14, 16, and 18,
19 and to provide the corresponding outputs 20, 22, and 24 at some
20 points in time during the development project. In one embodiment
21 of the invention, the inputs may vary or be automatically varied
22 in accord with progress of the project. Some inputs may be added
23 or eliminated. The same is true of outputs that may be changed
24 either automatically or by the project manager. In addition,
25 rules module 12 may contain a plurality of rule sets which can be

1 selectively chosen by the project manager depending on the
2 project being monitored.

3 Inputs 14, 16, 18 and/or others may be weighted by weighting
4 levels 26, 28, 30 and/or others and may be stored within database
5 32. Thus, the inputs can be weighted to define the relative
6 importance of the data measurements. If desired, weighting may
7 change during the course of the project by design or by the
8 project manager. Preferably rule-based output 20, 22, 24 and/or
9 others is characterized quantitatively as numbers such as between
10 0 and 1 where 1 is maximum risk and 0 is minimum risk. Other
11 characterizations could also preferably be selectively made so
12 that, for instance, the risk levels could be designated low,
13 medium, and high.

14 The overall program preferably controls input application
15 and will preferably send forms, either paper or computer forms
16 (sent electronically) and the like to those who are responsible
17 for providing the inputs at the appropriate times. A server may
18 be set up for this purpose so that the system may operate on a
19 local network or through the Internet if work is accomplished at
20 numerous locations. The system may be implemented on a PC for
21 use by the project manager, shown as computer 11 in FIG. 1.

22 To provide understanding of the system, a simplified example
23 is given to illustrate operation of the system although it will
24 be understood that in practice the operation is much more
25 complex. We will assume that weighting is equal so that all data
26 is equally relevant. The system is especially suitable for

1 monitoring and identifying risk in the development of a
2 substantial quantity of software as may be used in a typical
3 military system development program. In this example, inputs 14,
4 16, and 18 are collected and entered on a quarterly basis. A
5 cumulative review of input 14 may be represented as shown in FIG.
6 2 that refers to the source lines of code (SLOC) needed for the
7 project. Bars 34 show the base line or projected values for
8 source lines of code required. Squares 36 show a line graph of
9 the actual number of source lines of code as the project is
10 developed. As can be seen there is a substantial change in the
11 source lines of code required for project completion over that
12 planned. Database 32 stores these values. Metric computations
13 are made with the rule based risk assignment, as discussed in
14 more detail subsequently, such that input 14 of SLOC data is
15 computed to a metric or form for use with rule based risk
16 assignment module 12. Risk assignment module 12 then processes
17 the actual and corresponding planned data inputs to compute risk
18 levels according to predetermined criteria. The risk levels are
19 stored in database 32. Historical data chart capability module
20 38 is used to produce a chart showing a plurality of risk levels
21 over time and preferably including an overall or total risk
22 level. A sample output is shown in FIG. 3 where bar 40 is
23 representative of risk levels associated with SLOC data. Other
24 inputs for the simplified example include staffing levels or
25 number of personnel required as input 16 and planned system
26 requirements as compared to actual requirements of the system as

1 input 18. FIG. 2 (showing SLOC data) is representative of the
2 general format for this type of data.

3 FIG. 3 is preferably produced in a form by historical
4 charting module 38 to show all information necessary to the
5 project manager to evaluate risk levels and to make decisions to
6 mitigate risk. Thus, bars 42 in FIG. 3 show the system
7 requirements risk levels associated with input 18 as they change
8 over the course of the software development project.

9 Bars 44 show staffing level risks associated with input 16
10 as they vary during the course of the project. Risk assignment
11 module 12 also preferably produces a total or overall project
12 risk level that is indicated as bars 46 in FIG. 3. As can be
13 seen, overall project risk has reached a maximum probability of
14 failure by September of '99 so that action may be warranted to
15 reduce risk levels. Risk levels were calculated to be in a range
16 between 0 and 1 where 0 represents no apparent risk and 1
17 represents maximum risk, as discussed subsequently.

18 Thus, data inputs 14, 16, 18 and/or others may include the
19 number of system requirements based on the system specification
20 and the actual number of requirements that may often change
21 during the development process; the number of planned personnel
22 for each phase of development (design, coding, and testing) and
23 the actual staffing employed during the product development; and
24 the number of planned or estimated source lines of code (SLOC)
25 upon which the contract was based and the actual amount required.

1 It will be understood that system requirements often change
2 during the development as compared with the original system
3 specification, and therefore generate increased development
4 costs. Therefore it is necessary for risk assignment module 12
5 to compare the actual requirements with the original
6 specification baseline requirements. The metric computed for
7 each input may be for the present case defined as the percentage
8 of requirements (including new ones) that are above the original
9 values. Since staffing is another important parameter which can
10 impact the system delivery schedule, the metric may be computed
11 as defined as the percentage of workers below the base plan
12 staffing level. If this metric is considerably off on the low
13 side, then there may be a schedule impact so that staffing risk
14 is assigned based on this metric. A third metric is computed
15 that may relate the percentage of actual SLOC to the initial SLOC
16 estimate which was the parameter used to bid the project. If
17 during development, the actual code that is developed greatly
18 exceeds the original proposed amount, then the cost may increase
19 prohibitively. SLOC risk is assigned based on this metric. Risk
20 levels are determined by module 12 based on predetermined rules
21 that map software metric values to a quantitative level of risk.

22 In the present example, if-then type rules might consist of
23 the following rules:

- 24 1. If the requirements metric is 0% to 10%, then the risk
25 of additional costs is 0.1. If the requirements metric
26 is 10% to 20%, then the risk of additional costs is

1 0.2. The progression continues to 90% and higher which
2 correspond to an upper risk limit of 1.

3 2. If the staffing metric is 0% to 10%, then the schedule
4 risk is 0.1. If the staffing metric is 10% to 20%,
5 then the schedule risk is 0.2. This progression
6 continues to 90% and higher which correspond to an
7 upper risk level of 1.

8 3. If the SLOC metric is less than 100%, then the risk
9 level is 0. If it's 100% to 110%, then the product
10 quality risk is 0.1. Only when the percentage is
11 greater than 100% does a risk level get assigned. If
12 the metric is 110% to 120%, then the product quality
13 risk is 0.2. This progression continues to 190% and
14 higher which correspond to an upper risk limit of 1.

15
16 As seen in FIG. 2, actual SLOC values exceed the planned
17 values in December 98 and continuing through September 99. This
18 should alert the program manager that there are increasing risks
19 in this area as indicated in FIG. 3. Likewise other risk levels
20 are rising and the overall or total risk level rises
21 dramatically. At this point, the program manager will be alerted
22 to the problem and can take measures to diminish the risk. All
23 information including rule information is preferably available
24 for reference as needed.

25 In this example, each calendar quarter rule-based module 12
26 generates a component risk level and a composite risk level by

1 combining the three components, i.e., requirements, staffing, and
2 SLOC risk levels. Other time intervals may be selected.
3 Weighting or variable weighting may be applied here if one
4 parameter is more important than others.

5 It will be understood that a relatively simple example is
6 given to quickly convey the concepts of the system operation.
7 However, in actuality, such systems designed for large
8 development programs may be extremely sophisticated with
9 substantially more input parameters, substantially more rules and
10 component risk level outputs.

11 In summary, the present invention is operable for using
12 multiple inputs related to risk factors as described in FIG. 1
13 and FIG. 2. The data is stored and operated on with a rule-based
14 expert system to produce a plurality of outputs preferably in
15 chart form as indicated in FIG. 3. Database 32 stores historical
16 values for risk levels, data, baseline projections, and the like
17 as needed to produce the plurality of outputs. Risk projection
18 module 12 provides risk levels based on predetermined standards
19 that are preferably in quantified form. Historical data chart
20 module 38 produces data such as the chart of FIG. 3 in a format
21 that allows the project manager to quickly identify and assess
22 project risks.

23 It will be understood that many additional changes in the
24 details, materials, steps and arrangement of parts, which have
25 been herein described and illustrated in order to explain the
26 nature of the invention, may be made by those skilled in the art

1 within the principle and scope of the invention.

2

SYSTEM AND METHOD FOR MONITORING RISK
IN A SYSTEM DEVELOPMENT PROGRAM

ABSTRACT OF THE DISCLOSURE

A computerized system and method are provided that may be used to project a plurality of risk levels that may develop during the course of a large development project. A plurality of inputs are stored and converted for use to a metric that is used by an expert knowledge rule based system to determine a plurality of risk levels that develops relating to successful completion of a large development program with respect to elements such as cost, time of delivery, and quality. A plurality of outputs are provided in a form that can be used by a program manager to reduce the level of risk that may arise. In a preferred embodiment, the plurality of outputs are provided in a quantified manner that may relate to a probability of failure of one or more aspects of the development program. The rules are based on the knowledge and experience of experts and are predetermined so that risk levels are objectively quantified prior to beginning the project rather than subjectively determined during the course of the project. The system can be implemented on a PC and can be used by a metric analyst or program manager.

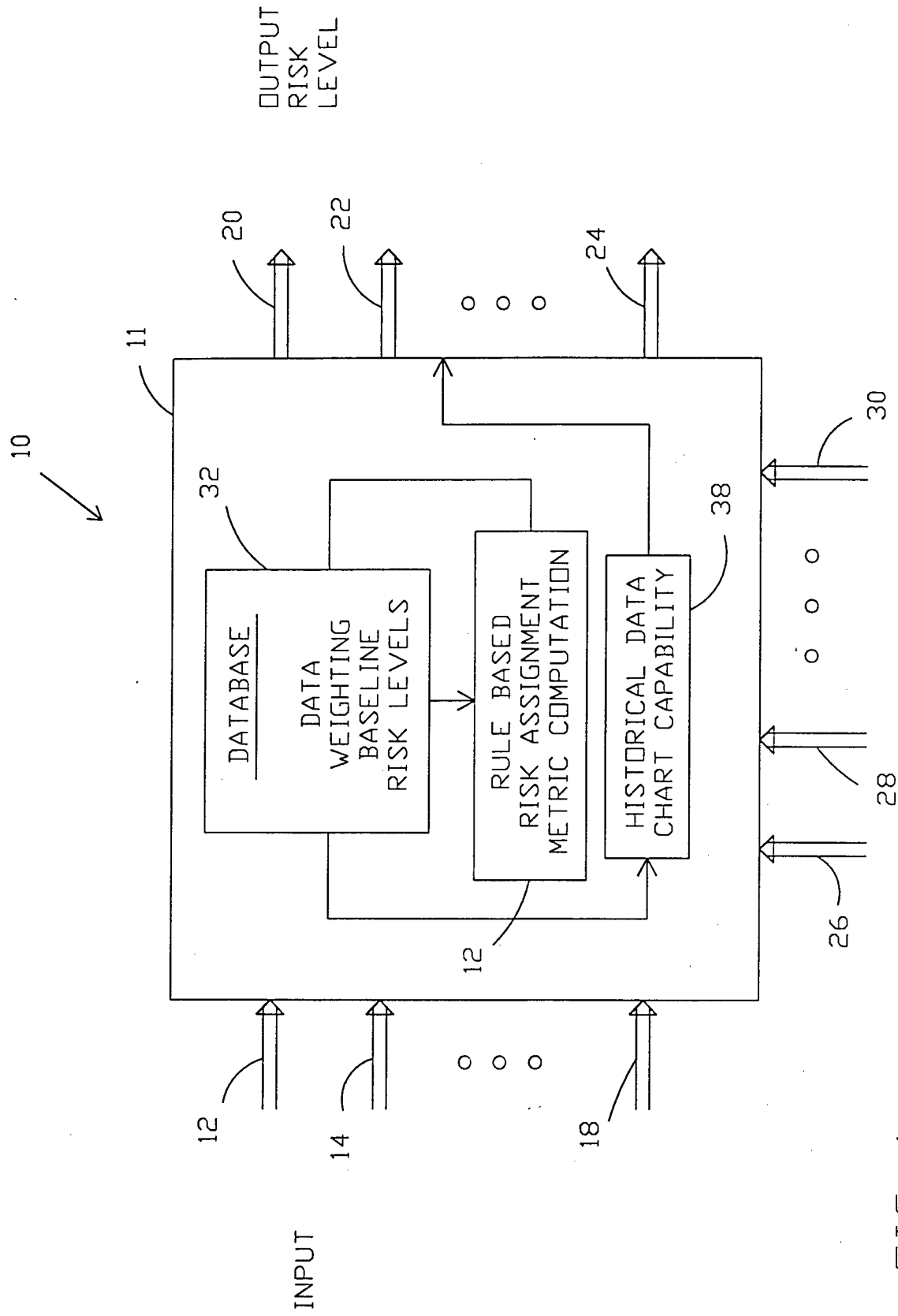


FIG. 1

FIG. 2

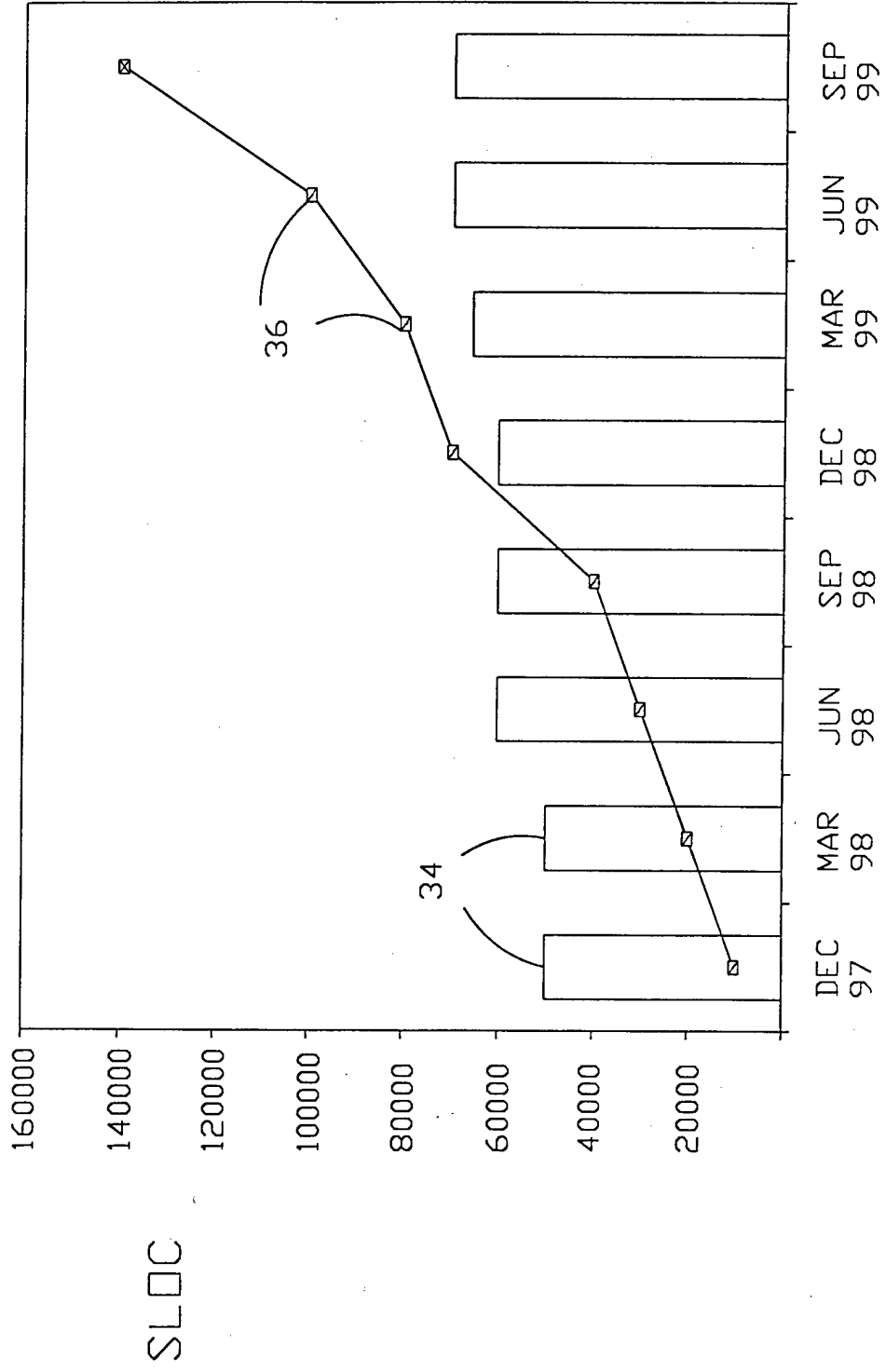
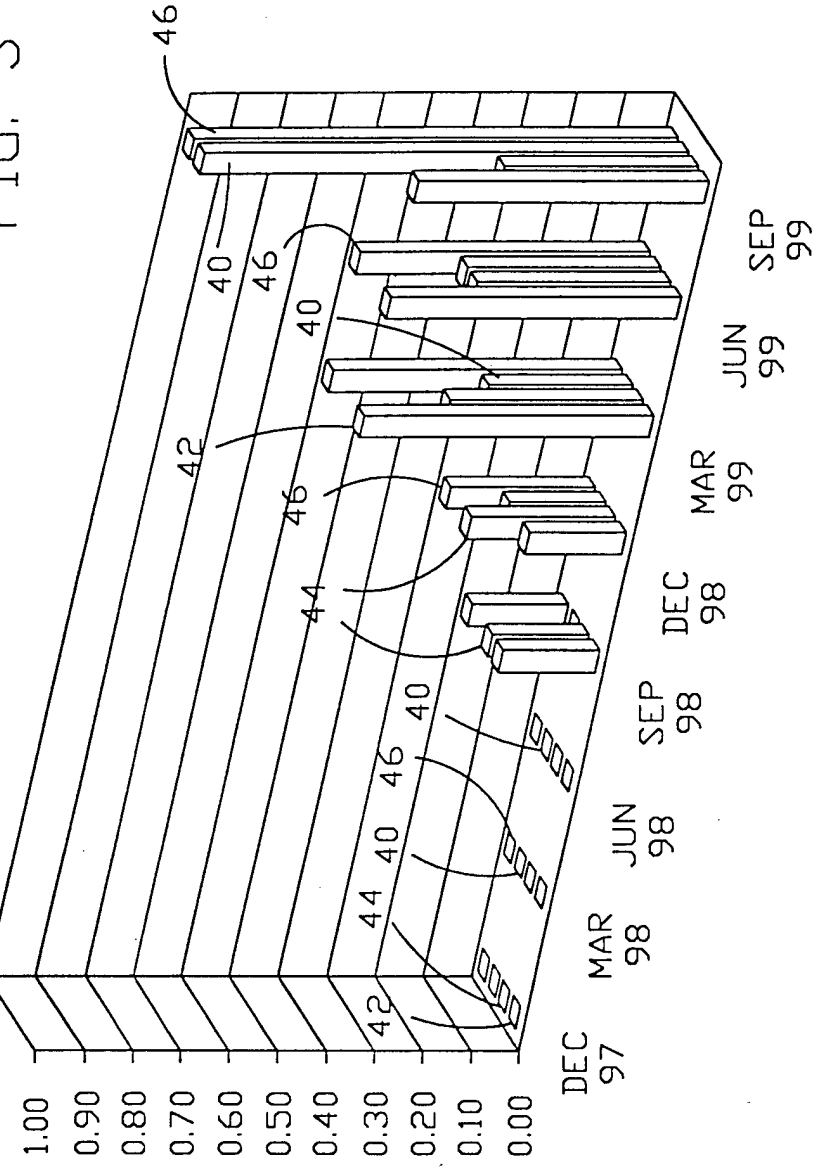


FIG. 3



RISK LEVEL