Design of a Research Performance Measurement System: The Case of NIAB

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At NIAB, a UK based company that provides research, services and information to the agricultural and food sector, a system has been designed that helps to assess and manage the growing research programme of the company. Since the company was 'privatised' four years ago, research activities have increased and moved away from solely applied research to a mix of applied and more fundamental research. Being a key element of the new developed company strategy, research now plays an increasing important role in broadening the scope of the company and keeping current services competitive by driving innovation. All research at NIAB is externally funded. In this paper we report on the process to design NIAB's performance measurement system, for which the Performance measurement system Systematic Design Approach was used. The design process was started with an elaborate structured problem analysis of the research process and its inter and extra-organisational context. Based upon this analysis, firstly a conceptual and secondly a detail design of a performance measurement system was made. To maximise the leverage from research, the system has been designed to optimise the value delivered to the funder as well as the value delivered to internal customers in the form of knowledge that drives innovation.

Introduction

This paper reports on the process of designing a research Performance Measurement System (PMS) at NIAB, a company based in Cambridge (UK). NIAB supplies consultancy, training, information, contract research and technical services to governments, supra-governmental agencies, agribusiness and farmers. Because the research programme within NIAB is of growing importance and size, NIAB management feels the need for a system to support the management of research.

The changing role of government, pressures on the agricultural sector in the UK and the emergence of genetics as a source of knowledge and techniques in the field of agriculture and food have resulted in changes within NIAB. Privatisation (1996), restructuring (1999), and the formulation of a new strategy and mission ('NIAB will achieve a key worldwide role in the development of plant genetic resources through research, technical services and training') (2000) led to a renewed role for research. Research programmes at NIAB traditionally underpinned the statutory and advisory programmes of variety evaluation and seeds testing, enhancing efficiency through the development of new methods and improving the effectiveness of the work and the value of the resulting information (Wellington & Silvey, 1997). In the new strategy, the role of the research programme has broadened. Research must become one of the key activities within the institute, being a business on its own and at the same time driving innovation within the institute through exploring new techniques, creating new knowledge in the field of agriculture and food, thereby creating opportunities for product and process innovation. It is important to mention here that at NIAB, research is funded externally by governmental and non-governmental research funders.

As a part of the implementation of the new strategy, NIAB management felt the need for a system to improve management of the growing and changing research programme by implementing a performance measurement system for research. A research project was initiated together with the University of Twente in the Netherlands. The objective of this research project is to design a Performance Measurement System (PMS), which enables NIAB management and staff to improve control of the research process. The design will be based upon a systematic analysis and diagnosis of the research process within its context.

This paper describes the process of analysing the organisation, defining the purpose and function(s) of the PMS and designing the PMS. We will start with a description of the used theory. Next, the design process is described. The paper will be completed with a reflection on the used design approach, recommendations for further use of this approach and for the design of a research PMS in general.

Design Approach

The first step in the process of designing the PMS for NIAB was to design the process of designing itself. As distinguished by van Aken (1996), a design project not only involves object design (a model of the entity that has to be realised) but also a process design (a model of the design process itself) and a realisation design (how the object design should be produced or implemented). Especially when designing a system that is dependent on the people working with it, the process of design is important for the success of the implementation and institutionalisation of the design.

Interest in performance measurement and management has rocketed during the last few years (Neely & Adams, 2001) and a lot of different frameworks and processes for designing performance measurement systems have been developed. Most of these existing approaches consist of a design approach to derive performance metrics, a framework to present the metrics and an underlying theory. The frameworks 'accommodate' the used metrics. They help to interpret metrics and show interdependence of metrics in different parts of the framework and the relationship between metrics in the same 'frame' of the framework. 'All (existing) frameworks add value because they all provide unique perspectives on performance. The key is to recognise that, despite the claims of some of the proponents of these various frameworks and methodologies, there is no one 'holy grail' or best way to view business performance' (Neely & Adams, 2000). Therefore it is very important to analyse the organisational context, identify reasons for measuring performance and to decompose these into desired functions and subjects of the PMS (see Figure 2), as this enables the design team to determine which 'unique perspective' is most appropriate. Unfortunately, most of the common approaches do not include such a problem analysis phase, so it is not made clear what are, and what are not, required functions of the PMS and whose performance will exactly be the subject of the PMS.

For the design of the PMS at NIAB, the Performance measurement system Systematic Design Approach (PSDA) by Kerssens-van Drongelen (1999) was used. This approach was chosen because, unlike many other design approaches, it is a very complete approach that applies all principles of design (hierarchical decomposition, abstraction, sys-

DEFINITIONS

Metric or performance indicator: a variable, which indicates the effectiveness and/or efficiency of a process, system or part of a system, when compared with a reference value.

Measurement method: a method to assign a value to a metric. Measurement methods can be classified along two dimensions: qualitative/quantitative and objective/subjective methods.

Performance measurement: the process of acquisition and analysis of information about the attainment of objectives and plans and about factors that may influence plan realization.

PMS functions: different ways to use a performance measurement system and its outputs.

PMS subject: the people, or systems of people and resources, whose performance is the subject of the PMS.

Figure 1. Definitions (source: Kerssens-van Drongelen, 1999)

THE MEASUREMENT SYSTEM FUNCTIONS TAXONOMY

1. Provide timely insight into deviations from objectives and environmental factors to support diagnosis by management as to whether and if so which steering measures would be necessary.
2. Fuelling learning about process characteristics, and the influence of external factors and steering measures on these characteristics, and in this way improving the predictive model that may support better decision making in the future.
3. Alignment and communication of objectives, agreements, and rules.
4. Supporting decision making on performance based rewards.
5. Provide timely insight into deviations from objectives and environmental factors to support diagnosis by subordinate(s) as to whether and if so which steering measures would be necessary.
6. Justification of existence, decisions and performance.
7. Motivating people through feedback.

Figure 2. The Measurement System Function Taxonomy (Source: Kerssens-van Drongelen, 1999)

tematic variation, solution selection on the basis of the satisficing principle (Pahl & Beitz, 1996, p. 54-60)). The main advantage in this case was that the PSDA helps to decompose the measurement problem and gives guidelines for building and evaluating conceptual designs (frameworks) before designing the PMS in detail.

The design process therefore consisted, in line with the PSDA, of the following steps: a problem definition phase, including problem diagnosis and decomposition, a conceptual design phase, including systematic variation of conceptual designs, a detail design phase and an implementation phase (see Figure 3).

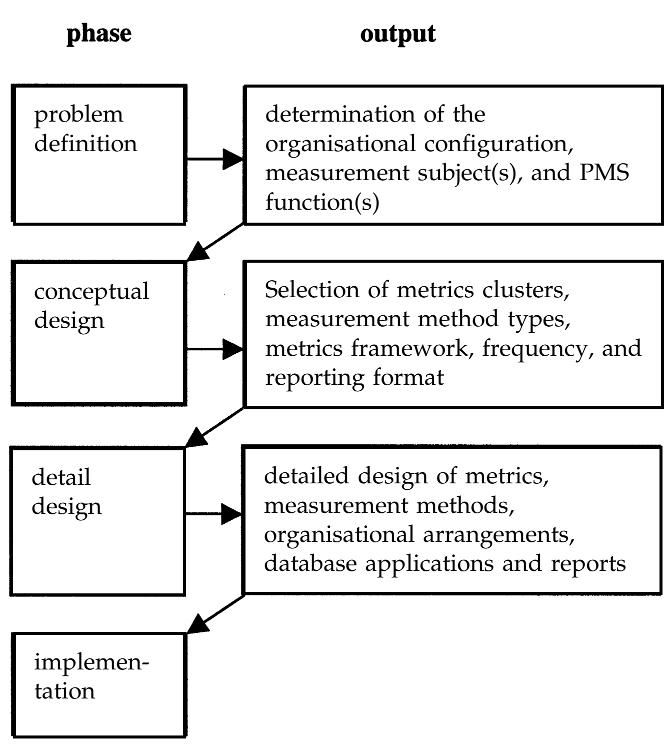

Figure 3. The PMS Design Process and its Outputs

Because, at the beginning of the project, the need for a PMS was not exactly defined, the project was started with an elaborate analysis of the research process and it's inter- and extra organisational context. This analysis enabled us to get a clear overview of the critical function of research, to examine to which extent these critical functions were fulfilled (the current performance) and third to make a link between the current organisational configuration and the current performance. Based on that information, problems were revealed which were the input for the design process.

For analysis and diagnosis, the framework for the description of NDP processes by De Weerd-Nederhof (1998) was used. This framework itself is based on the process-based contingency model for organisations by Boer and Krabbendam, (1993). The framework gives a description of primary-support and management processes, people, organisational arrangements, techniques and tools, the inter organisational context and the extra organisational context.

Methodology

In this single case study, several methods of data gathering were used. To get an overview of the company, a document study was done and the company's directors were interviewed. To reveal the critical functions of research and the extent to which these are fulfilled, a questionnaire was sent to all group heads of NIAB and the research director. Next to that, research group heads and heads of three non–research groups were interviewed. To describe the configuration of the research system, the research director, the key account manager for research, two research group heads and four senior researchers were interviewed. The results of these activities were fed back to and approved by the research director and a complete research group.

After the description and diagnosis, a design team was formed consisting of the research director, a research group head, a non-research group head, the key account manager for research and two senior researchers. This design team was involved in making design choices by individually presenting them alternatives and asking them for their preferences. The research director approved all choices. The first author of this paper acted as facilitator for the design process.

Problem Definition Phase

The problem definition phase was aimed at finding the desired function(s) and subjects of the PMS, and to create a list of requirements, which the system design must apply to.

Problem Analysis and Decomposition

The result of this phase consists of three parts: a list of critical functions of the research process, a list of problems in fulfilling these critical functions and an elaborate description of the current configuration of the research system and it's inter- and extra organisational context (which will not be included in this paper). The causes of the problems are found by looking at the organisational configuration. Four critical functions were identified:

Drive internal innovation: NIAB research must be the driving force of innovation within the company. This means that research must create opportunities for improving products and creating new products in new and existing markets. The other business areas are the most important stakeholders.

Give scientific image: NIAB research must improve the image of NIAB as a research based institute by producing scientific results of good quality and quantity and 'market' these results in the scientific community. This will increase the networking capabilities of NIAB, which are very important in the specific context in which the institute operates. Next, research staff has an interest in the ability of building a personal scientific reputation.

Generate sufficient financial resources: NIAB research needs to meet its financial goals. NIAB as a whole is the most important stakeholder in this perspective.

Satisfy funders: It is important that the funders that pay for the research are satisfied and that the relationship with funders is good.

For the description of the problems in fulfilling these critical functions, a distinction was made into operational effectiveness and strategic flexibility. The identified problems in fulfilling these critical functions and their main causes are:

Operational Effectiveness

1. The quantity of delivered research outputs must rise in order to underpin current business.
2. The financial efficiency of the research process needs improvement of control. If

the contribution margin rises, possibilities for investment increase.
3. The transfer of research to services is not high enough. Alignment of research and services programmes should improve.

Strategic Flexibility

4. The current perception of customers and people within NIAB of NIAB as a research based institute, must improve.
5. The building of new competencies for the future by doing research is not aligned with the future demand of the current customer base and with the core competencies/unique resources of NIAB.
6. Improvement in the effectiveness and efficiency of the research process only takes place through personal experience of researchers. Transfer of knowledge within groups and throughout the organisation is perceived to be low.

The next step was to look in more detail to the underlying causes of the problems and to identify which of these causes could be (partly) taken away by a form of performance measurement. Analysing the earlier made elaborate description of the research system and its inter- and extra organisational context, a total of 24 problem causes were found, of which 13 possibly could be solved by performance measurement.

To determine whether, and if so, what kind of performance measurement system could be useful to solve the identified control problems, for every problem a combination of a measurement system function and a measurement subject was defined, which was most likely to take one of the problem causes (partly) away. This was done with use of a list of all possible measurement subjects within NIAB and with use of the taxonomy of measurement system functions (see Figure 2). The result was a table with many possible function-subject combinations.

Together with NIAB management, two PMS functions where chosen that would help to tackle the most urgent problems:

1. providing insight into deviations from objectives to support diagnosis by management as to whether and if so which steering measures would be necessary
2. communication and alignment of goals.

Both functions are applied on business area level. Other possible functions and subjects were not rejected, but development of performance measures for these functions can be done at a later stage, based upon the PMS that then already exists.

Analysis of Organizational Conditions

In all interviews that were conducted during the problem definition phase, staff was asked for their opinion about the concept of performance measurement in general and their felt need for performance measurement at NIAB. Using this information and a checklist by Kerssens-van Drongelen (1999), it was checked whether the conditions for designing a performance measurement system were favourable. The use of this checklist revealed some points of attention, which were used to improve the design process. The most important improvement was to make extra effort to get staff familiar with performance measurement in general, and with the purpose of, and approach chosen for, this measurement system design project in particular.

Analysis of Contingency Factors

The next step in the process of problem definition was to analyse the contingency factors that influence the design of the PMS. Kerssens van Drongelen (1999) has shown that innovation strategy, company size, the organisational control system, and the technical and commercial uncertainty of research have implications for the design of a research performance measurement system. Analysis of these factors resulted in a set of requirements for the system design.

Formulation of Requirements

The last step in the problem definition phase was to create a list of requirements for the PMS. This list consisted of functional requirements imposed by the chosen measurement system functions, constraints imposed by the contingency factors and additional user demands.

Conceptual Design

The aim of this phase was to obtain a conceptual design of the PMS: a combination of metrics cluster(s), measurement method type(s), a rough indication of the frequency and timing of measurements, a type of reference value and a type of reporting format. This was done by generating a list of alternatives and choosing the best alternative, using the list of requirements, constraints and demands and the preferences of NIAB staff and management.

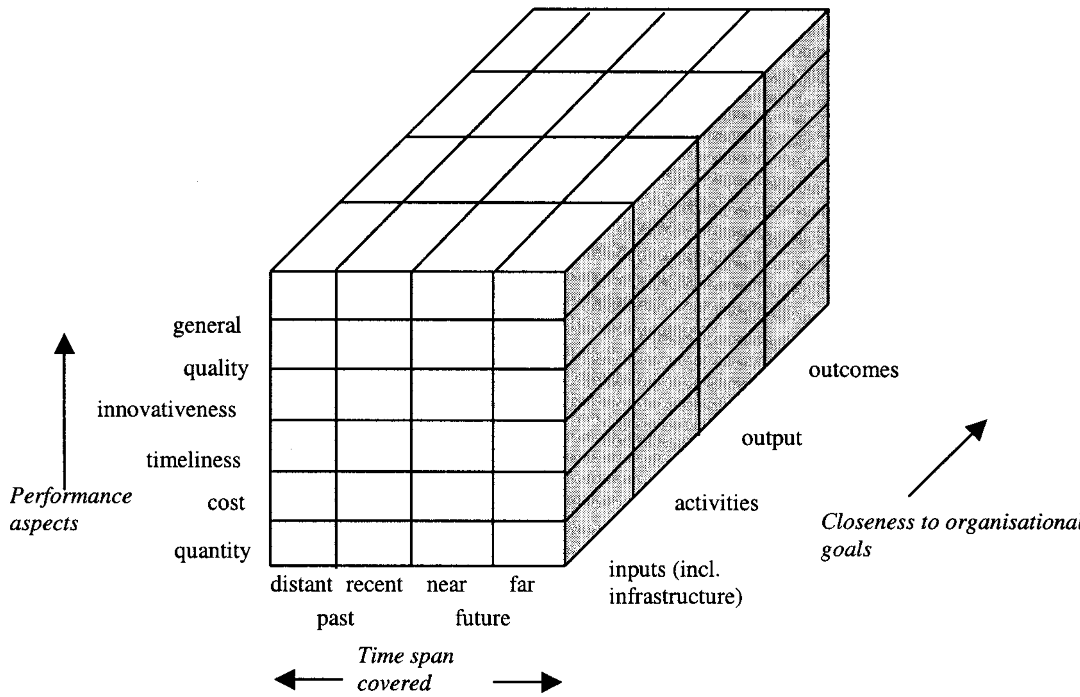

Figure 4. The Metrics Taxonomy

Metrics Clusters

To be able to select metrics on a conceptual level, a taxonomy is needed. For selecting the most appropriate metrics clusters for NIAB research, we used the taxonomy by Kerssens-van Drongelen (1999) that is shown in Figure 4. Next, the guidelines for selecting metrics clusters given in the PSDA proved to be a useful starting point for selection.

Having in mind the goals of the PMS: to support decision making by management and to communicate goals, it was decided to use measures throughout the whole process, (inputs/infrastructure, activities, outputs and outcomes). Because of the long cycle time of the research process, only measuring output would make the feed back time too long to enable management to make decisions at the right moment. The next decision was the time span that has to be covered by the metrics. It was chosen to use mainly recent past and near future metrics. For outcomes, far future metrics were chosen. This should enable NIAB research management to make decisions that have far future effects, based upon information about that far future. This is useful since at the very beginning of a research project, when the proposal is written, the outcomes are already largely determined.

Starting point for the performance aspects that are important was the NIAB strategy. Next, additional insights in useful performance aspects were derived from the different goals that stakeholders of the NIAB research process have. Using the reasoning presented by Anderson and Neely (2000) in their article on the performance prism, for every stakeholder the stakeholder satisfaction (their wants and needs), the strategies, processes and capabilities to attain stakeholder satisfaction and the desired stakeholder contribution was determined.

Measurement Methods

To choose the measurement method to collect data, the PSDA guideline (given the specific context of NIAB research) of emphasis on subjective – qualitative measurements unless otherwise arranged by company wide requirements was accepted. In the detail design phase, the measurement methods per individual metric were chosen by optimising the measurement effort and the informational value of the metric-measurement combination.

Clustering of Metrics

Together with choosing metrics and measurement methods, a framework to present the metrics had to be developed. Four different alternatives were evaluated: the performance prism (Neely & Adams, 2001), the balanced scorecard (Kaplan & Norton, 1996), a clustering directly derived from NIAB strategy and a new constructed clustering.

- **The performance prism**: the performance prism does give the possibility to address all stakeholders goals. The problem is that it proved difficult to derive measures for every category, and even if that had been possible, the number of metrics would become very high (at least 20 to 25). The underlying theory of the performance prism though, proved very useful to make sure that all stakeholders are considered to be involved in measurement.
- **The balanced scorecard**: the balanced scorecard is somewhat more succinct but did not fit well with NIAB research because there is not one single customer group and there are no shareholders (stakeholders with only a financial interest). The business model of NIAB research is considerably different from that for which the balanced scorecard was developed.
- **A clustering derived directly from NIAB strategic goals**: this clustering was somewhat unstructured because the strategy is a mix of desired inputs, outcomes, etc.
- **A self developed clustering, using elements of the three other options (shown in Figure 5)**: the horizontal axis is based on the strategic goals of NIAB research as they were found in the strategic plan of the company, complemented with the outcomes of the reasoning of the performance prism. The vertical axis is based on the clustering by Brown and Svensson (1995) and has a focus on the causal chain leading to the achievement of objectives, as recommended by the PSDA guidelines for the required PMS functions.

After evaluation, the last option was chosen, using the list of requirements and feedback from research staff. The most important advantages of the chosen clustering are the combination of the simplicity of the balanced scorecard, the stakeholder based approach of the performance prism, and the link with the strategic goals of NIAB.

Frequency and Timing

The frequency of measurement is a trade-off between quality (up-to-dateness) of measurement data and time and money involved in measurement. Alternatives of once, twice or more than twice a year were evaluated. Consultation of research staff learned that twice a year was the maximum staff would accept, given the current high work pressure. For the timing of measurement the two main alternatives were to align with individual projects or align with the yearly financial cycle of the institute. Aligning measurement with individual project makes measurement data more appropriate for decision making about individual projects but would involve continuous measurement as projects are continuously started, finished etc. Measuring all projects at once before the yearly budgeting procedure would give an up to date measurement before the decisions about budgets are made.

It was chosen to measure each individual project, before sending the proposal to the funder. The other measurements of projects will be aligned with the measurement of the whole business area. In this way, the number of measurements is minimised and project information will still never be more than 6 months old. The timing of Business Area measurements will be aligned with the

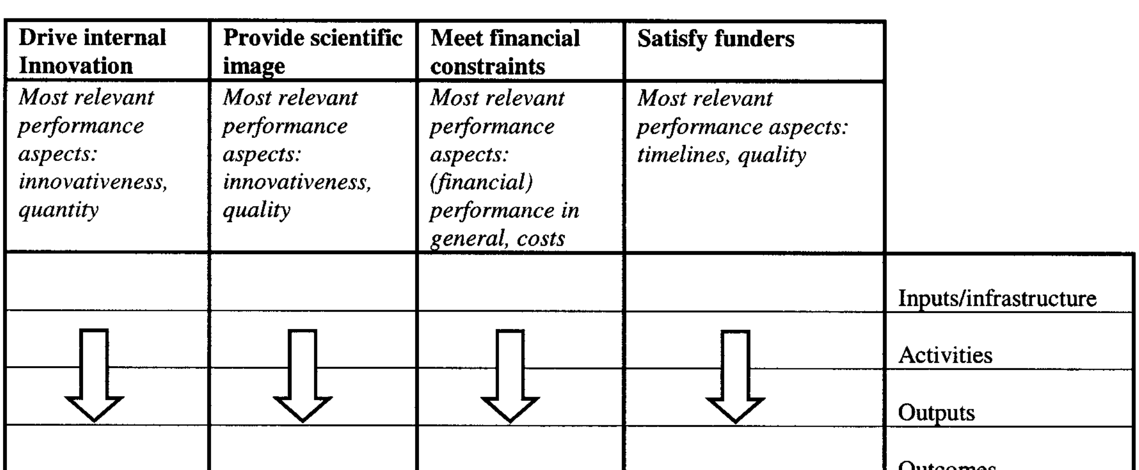

Figure 5. The NIAB Research Performance Measurement Framework

budgeting procedure such that recent information is available when making the budgets but without putting too much time pressure on research management during the actual budgeting procedure.

Reporting Formats

It was chosen to make three different reporting formats: on business area level, on group level and on project level.

Detail Design

In this phase, a list of possible metrics and measurement methods has been created, metrics and measurement methods have been selected, and the organisational arrangements needed for the system to operate have been defined. To facilitate the collection and storing of measurement date and the making of reports, a database application has been built. The result of this phase is a PMS that is ready for implementation.

Choosing Metrics

In the preceding phase, clusters of metrics were selected. The next step was to generate a set of usable metrics. This was done using existing metrics catalogues from Kennerly *et al.* (2001) and from Kerssens-van Drongelen (1999), and metrics mentioned in articles by McGrath (2000), Brown & Svenson (1988), Groen *et al.* (2001) and Tipping *et al.* (1995). This resulted in a list of 82 possible metrics, categorised into the 16 frames of the framework. For each metric, a short description of the measurement method was made. Using 2 rounds of selection, this set was reduced to 18 metrics, which have been used in the first version of the measurement system.

Selection of metrics was done using 2 criteria: measurement effort and informational value. Measurement effort is defined as the time and money involved in the collection of data. Informational value is defined as the extent to which a metric tells something about the attainment of goals: the information richness of the measurement. The metrics and the measurement methods were first ranked (from 1 to n) and categorised (high/medium/low) on their informational value, next they were categorised on measurement effort (little/average/much). For every metric-measurement method, a figure like Figure 6 was made and based upon that, the best metrics were selected. This selection was discussed with several members of research staff and management. Based upon that, the preliminary selection was altered.

The altered selection was compared to the list of demands, constraints and requirements again. The metrics shown in Figure 7 were chosen. To illustrate the balance between operational effectiveness (OE) and strategic flexibility (SF), for each metric it is indicated to which of these forms of organisational performance it relates.

The now obtained framework consists of a list of measures that enables NIAB research management to ensure at all times that the research Business Area is fulfilling its critical functions. A distinction is made between *key* performance measures and additional detailed measures. This is done to support the communication and alignment of goals function as well as the signalling to management function. Communication and alignment re-

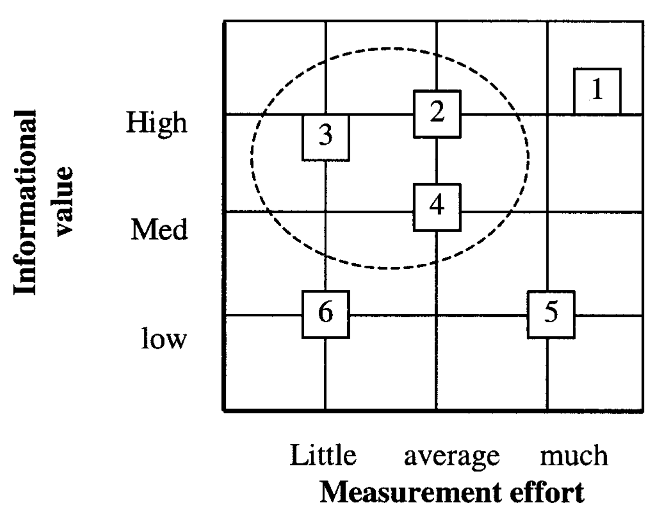

Figure 6. Choosing Metrics

Performance perspective	Key performance measures	Detailed performance measures
Drive internal innovation	Balance in type of outputs of projects (OE/SF)[1)]	Number and source of ideas for research (SF)
		Alignment of outputs with 'internal customer' demand (OE)
		Usefulness of project outputs (OE/SF)
Give scientific image	Quantity of Publications and Talks on conferences (SF)	Span of the scientific network (SF)
		% of state-of-the-art projects (SF)
		Number of competing research institutes with the same capabilities (SF)
Generate sufficient financial resources	Net. Contribution to company overheads (OE)	Proposal success rate (OE)
		Income per no. of staff and per project (OE)
		Average contribution margin (OE)
		Average project cost compliance (OE)
Satisfy funders	Development of funding base (OE/SF)	Time spent in contact with funder (SF)
		Meeting project goals (OE)
		Funder feedback (OE)
		% repeat work (OE)

1) a distinction is made between innovation resulting in: improvement of existing product, making a new product for an existing market, making a new product for a new market, or projects with a low chance of any sort of innovation.

Figure 7. The selected metrics

quires a small set of goals since research on management-by-objectives indicates that if people are given more than six to eight objectives to accomplish, they ignore most of the objectives and concentrate on the two or three they believe are important (Brown & Svenson, 1988). On the other hand, signalling to management whether there are deviations from objectives requires that all objectives are covered and that performance along the causal chain leading to these objectives can be tracked. So for this function monitoring also the detailed metrics will be useful to timely signal deviations.

At the moment, a database application is being built, in which all measurement data can be stored and which can generate reports that show the most recent values of all metrics. Next, storing the metric data makes it easy to monitor the development of all metrics over time.

Conclusions

In this paper we have presented the design process followed so far to develop a Performance Measurement System suiting the specific situation of NIAB research. NIAB's research activities have been analysed and some (control) problems have been found. A performance measurement system has been built that, according to theory, is likely to help NIAB to solve some of those problems. To which extent the performance measurement system will really be a success, can only be proven over time in practice. It will be very interesting to see to what extent the system will fulfil its intended functions and to what extent it can fulfil functions besides that, for which the system has not been specifically designed.

As for the theories used to develop NIAB's PMS, our experiences first of all indicate that research performance measurement in a non-profit organisation where research is externally funded requires a performance measurement framework that is adapted to the business-model of the organisation. This business model is likely to be fundamentally different from that from which many existing frameworks for (research) performance measurement are derived. Hence the common design approaches in which such frameworks are taken as the basis for the PMS design, cannot be applied unconditionally.

Secondly, we conclude that the PSDA has proven a useful method for designing a PMS in such a situation. Using the PSDA, the designed performance measurement system is likely to fulfil the function that it should since the whole design approach is based on that concept. The conceptual design phase is a very useful step but the high level of abstraction in this phase makes it necessary that all involved people understand the used methodology and the used taxonomies. If not, the usability of the PSDA guidelines for this phase is limited and one will probably restrict the generation of alternatives to already existing frameworks like the Balanced Scorecard or the Performance Pyramid. However, even then the conceptual design phase is useful, as at least the framework will be chosen that is most appropriate for the PMS function(s) and subject(s).

Finally, the framework for the description of NDP systems and performance appeared to be suitable for use in the problem analysis phase of the design of a PMS, but it is a very time consuming and elaborate method. Depending on the extent to which the PMS functions are already determined, a more focussed method of analysis will probably be suitable as well. We recommend that the analysis should then be focussed on analysis of the primary process, the management processes, organisational arrangements and critical functions of research. The emphasis placed in De Weerd-Nederhof's (1998) framework on the balance between operational effectiveness and strategic flexibility stimulated the development of a balanced set of critical functions for NIAB research. Since these functions formed one axis of the conceptual design, the set of metrics chosen does also have this balance.

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