Development of key performance indicators and impact assessment for SHOKs

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Tiivistelmä | Referat | Abstract

This report defines the measurement framework and a set of key performance indicators (KPIs) to measure the performance and impacts of the strategic centres for science, technology and innovation (SHOKs). KPIs were developed for steering purposes. Three fundamental issues addressed by this project were the following: What are the relevant factors to be measured? What indicators are used to measure them? How is the measurement system used to manage and evaluate SHOKs? The focus of this project was on SHOK program level evaluation and, thus, the actual large-scale societal impacts that are expected to occur after five to ten years after each project has ended remain out of the scope of these indicators.

In order to clarify the purpose and needs for measurement, relevant SHOK stakeholders were interviewed first. Current evaluation methods and indicators of five international R&D programs were reviewed and used as a reference point when choosing the measurement approach and KPIs for SHOKs. A working group consisting of SHOK stakeholders as well as the authors was responsible for the process of designing the KPIs and the underlying impact assessment framework. In practice, the design process consisted of iterative discussions by the working group during four half-day workshops. The key success factors were identified based on the SHOKs' strategic goals, SHOK Governing Council's development guidelines, interviews with the stakeholders and discussions during the development workshops. Two working seminars with a wider group of SHOK stakeholders and actors were also organized in order to be able to collect feedback and further development ideas.

As a result, this report proposes an overall evaluation framework for SHOKs and a set of seven KPIs for annual monitoring. The KPIs are intended to be reported to the Ministry of Employment and the Economy and SHOK Governing Council along with qualitative descriptions of progress, key results and future visions. The project proved, once again, that the measurement of the impacts of research, development and innovation activities is very challenging, especially in a networked environment such as in the case of SHOKs. Therefore, it is possible that some of the KPIs seem problematic from the perspective of some SHOK stakeholder. Nevertheless, the project group encourages SHOK actors to actively utilize them. Based on using the KPIs it is possible to learn how they actually work and whether they can function as a valuable tool for monitoring and steering SHOK activities.

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Preface

This report is the result of an intense project carried out during September 2013 – April 2014. It presents the authors' suggestions on the measurement practices of Strategic Centres for Science, Technology and Innovation (SHOKs). The report was produced for Tekes, the Finnish Funding Agency for Technology and Innovation.

Many of the key stakeholders of SHOKs have been involved in the process of identifying and defining the most useful measurement practices (see Appendix 1). In particular, SHOK governing council and the group of individuals participating in measurement design workshops provided significant and relevant support and input for developing the ideas presented in this report. As authors, we are grateful for the insights they have given to the project. Nevertheless, the authors take the full responsibility of the suggestions presented here. In many cases, there have been conflicting views of the best measurement solutions, and in these cases, the authors used their judgment in deciding what to propose in the end.

It is well-known that the measurement of R&D is a challenging theme as such. However, measuring SHOKs (that represent a unique innovation apparatus in Finland and even internationally) proved to be a great challenge. Given the compact nature of this development project, we would like to emphasize the fact that the measurement solutions proposed here should not be considered perfectly valid and reliable scientific instruments for assessing the impacts of SHOKs. Instead, we believe we have been able to create a practically feasible and managerially relevant tool for managing the research and development work carried out by SHOKs. We assume that the systematic use of the indicators proposed here will guide SHOK companies and research programs to focus their efforts on actions which are considered necessary for achieving the ambitious targets related to developing top-level research talents and renewing the Finnish business sectors. Moreover, the proposed indicators can provide a further base for the forthcoming evaluations of the SHOK system as a whole and for evaluating its role and contribution to the Finnish innovation system.

We encourage SHOK stakeholders to view the measurement approaches proposed here critically. Then, after acknowledging both the limitations and the strengths of the indicators, we propose they are taken into use. Experiences of applying the indicators will ultimately determine their value.

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Contents

1 Introduction

1.1 Starting point and goals of the project

In the Finnish context the Strategic Centres for Science, Technology and Innovation (SHOKs) represent a particularly important innovation policy. They were created with high hopes of getting strong impacts from focused and intensive research efforts targeted at six selected areas: energy and environment (CLEEN), ICT/Digital business (DIGILE); Forest industry/Bio economy (FIBIC), metal and engineering (FIMECC), Health and well-being (SalWe) and real estate and construction (RYM). Recently, SHOKs have been criticized for not reaching fully the outcomes that were expected from them (Lähteenmäki-Smith et al., 2013). Moreover, the SHOK evaluation report by Lähteenmäki-Smith et al. (2013) finds that the outcomes cannot be properly judged due to the lack of comparable indicators and measurement practices.

It can be assumed that the criticism towards SHOKs is partly caused by deficient measurement practices: using the currently available measurement information it is not possible to determine whether the SHOKs are underperforming or whether they are succeeding but their outcomes have not been properly captured yet. Due to the challenges related to the measurement of R&D as a phenomenon and to the societal importance of SHOKs, a serious attempt to develop improved measures for SHOKs seems justified.

This project has targeted the following main objective: *to design a measurement framework and a set of key performance indicators (KPIs) to measure the performance and impacts of SHOKs*. Specifically, three fundamental issues are addressed by this project:

- What are the relevant factors to be measured?
- What indicators are used to measure them?
- How is the measurement system used to manage and evaluate SHOKs (in short and long term)?

This project responds to the goal of developing a tailored measurement framework for the Finnish SHOK context, which can be utilized to assess the impacts of 1) SHOK programs, 2) individual SHOKs and 3) all SHOKs collectively at national level.

Since this is not an academic exercise but a project aiming at developing an actual managerial system and related procedures, it is critical that the measurement framework and indicators meet the needs and expectations of key stakeholders. Thus, ascertaining that the key stakeholders understand and accept the logic behind the indicators and that they consider the measures useful is also a key objective of the project. In addition to the key objectives, there are other supporting objectives such as benchmarking global best practices in R&D performance measurement.

1.2 Generic challenges of measuring the impacts of R&D initiatives

Carrying out research, development and innovation (here we use the abbreviation R&D) activities requires significant financial resources to be invested in order to produce desirable impacts. However, uncertainty and risk are typical features of an R&D project. Ambitious projects in particular are quite often characterized by failures in reaching the targeted goals. Nevertheless, the investments in research and development represent a fundamental driver for growth. The competitiveness of companies as well as the economic success of nations is strongly related to the continuous success in R&D efforts. In this prospect, it is of fundamental importance to enhance the efficiency and impact of R&D activities. For this reason a focal position is occupied by the theme of measuring and managing R&D activities as a managerial platform to support and drive the allocation and assessment of investments.

Measuring the impacts of R&D is a particularly interesting and challenging theme. Both the nature of R&D work and the mechanisms related to impacts cause challenges from the measurement point of view. Some key challenges to be addressed are as follows (see e.g., Kerssens-van Drongelen and Bilderbeek, 1999; Leitner and Warden, 2004; Lettice et al., 2006; Lichtenberg, 1990; Martensen et al., 2007; Suomala, 2004; Suomala et al., 2009; Vuolle et al., 2009):

- The impacts of R&D activities are generally manifested only after a certain time lag. Thus, the full implications and impacts of research activities cannot be measured and fully understood right after the completion of an R&D project since they need time to be materialized and appreciated.
- A great range of the impacts are intangible in nature (involving dimension such as learning, socio-cultural consequences, image and reputation, knowledge domain enlargement, stakeholder value, and so on) which are difficult to quantify.
- Each R&D project is unique and affected by cultural and contextual features – producing different kinds of outputs and outcomes. Thus generally a fixed set of measures cannot fully capture the contextually different beneficial outcomes.
- R&D projects tend to produce a wide range of outcomes – including unintended spillover effects – and it is rather difficult to anticipate beforehand all the possible impacts being produced. There is often an element of surprise involved.
- Especially the applied R&D projects take place in the context of real life in which there exist a countless number of factors affecting the same business and technology environment that is being impacted by the R&D initiative; thus, it is challenging to precisely distinguish the actual contribution of the R&D project out of other, sometimes much more intense changes taking place at the same time.
- As R&D is a knowledge-intensive activity a lot of emphasis is often given to the knowledge, skills and experience (more widely the knowledge assets) of

the research team while evaluating the initial potential of a project. However, strong CV does not guarantee success: it is not only about the skills and other resources allocated into the project but how they are transformed into value (i.e., innovative outcomes). For this reason it is important to understand all the factors affecting the mechanisms contributing to successful R&D initiatives.

- Major R&D initiatives are both carried out and exploited by a network of actors rather than a single organization. While majority of existing measurement practices are developed for individual organizations there would be a need for a system (or network) level measurement practices.
- R&D projects produce a multitude of direct and indirect effects that present different nature. The measurement has to take into account the direct and indirect cause-effects mechanisms and map the different forms of value generated through the project in accordance with a stakeholder point of view.

While analyzing the position of the assessment of R&D initiatives, it is important to clarify the reasons of and purposes for the measurement: i.e., why do we want to measure R&D activities and what are the implications of such measurement for improving the processes and impacts of R&D activities? They are not as self-evident questions as they first might seem. Although they require proper reflections, three main purposes for measuring R&D need to be pointed out. The first purpose is the evaluation of new project proposals. Second, measurement information is needed in order to be able to assess ex-post whether the resources invested in R&D have produced adequate impacts – i.e., whether they have been worth the efforts and to what extent. Third, measurements are needed to support the management cycle of R&D initiatives in order to make sure that the right kinds of activities are done in order to reach the expected impacts in the end. These three purposes have implications on dimensions such as 'why', 'what', 'how', 'when', 'who', and 'where' to implement performance measurement system for R&D.

Finally, effective R&D performance measurement process requires – in addition to the indicators – certain measurement-based managerial practices. To put it simply, the measures need to be utilized in order to be of any value. Therefore, the development of "measurement culture" in the Finnish SHOK environment is an additional challenge in addition to the technical measurement issues.

1.3 Methods and main phases of the project

The duration of the first part of the project was altogether 30 working days and it was carried out in September-November 2013. The project was designed to follow the steps described below. The key phases were as follows:

1) Preparatory steps for the measurement design process
   a. Interviewing relevant stakeholders in order to crystallize their needs concerning the measurement information and its using purposes. List of interviewed persons can be found in Appendix 1. During this phase the

existing documentation and knowledge on the measurement of SHOKs (e.g., the goals of SHOKs, existing indicators and any prior work done) was also synthesized as a starting point for the development work.

b. Review of selected international best practices for measuring the impacts of R&D activities (5 benchmark cases were reviewed); identification and critical analysis of the existing measurement practices and indicators adopted for the internal and external evaluation of R&D initiatives.

2) Workshops for designing the measurement system and indicators (4 half-day workshops with 2 facilitators and a group of representatives of key SHOK stakeholder groups) with the following main themes:

a. Starting the design process (based on using the outcomes of phase 1: clarifying objectives, identifying the key measurement challenges, choosing the overall measurement framework)

b. Choosing the factors to be measured

c. Defining key indicators

D. Evaluating the measurement system as a whole and finishing the design phase

3) Feedback and revisions - the draft measurement system was presented in a working seminar in order to inform the relevant parties of the process and to collect feedback for improving the system; the measurement system was revised based on the feedback

4) Examining the practical applicability of the measurement system and fine tuning the indicators; based on pilot testing in one SHOK company.

The steps described above produced the first draft of the measurement system and the report at hand. However, both the SHOK governing council and the SHOK companies found some areas of improvement in the draft version. Thus, the project was continued with a second part.

The second part of the project took place between February and April 2014. In this phase we concentrated on improving and defining the KPI measures based on the feedback and guidance from SHOK governing council and a workshop organized for SHOKs. Two meetings were held with Tekes in order to find consensus between various improvement needs.

Table 1 lists the key activities carried out during the project. The activities and methods as well as the phases listed above are discussed in the following sections of this report.

Table 1. Summary of project activities and methods

Project activities	Methods	Purpose
Interviews	4 Group interviews (N=21) Interviews (N=8)	Crystallizing what and why to measure
International benchmarking	Collecting indicators from international cases (N=5)	Collecting best practices as basis for development
Workshops	4 workshops (N=5-12) 1 working seminar (N=21) 1 workshop for discussing and defining the metrics (N=20)	Developing indicators and the evaluation model; communication Defining and discussing the implementation of metrics
Meetings	3Tekes meeting 3 Project steering group meeting 3 SHOK Governing Council Steering group meetings 1 meeting with Tekes and the Director of SHOK Governing Council 1 FIMECC meeting for evaluating the measurement system	Feedback and guidance Developing and defining the metrics
Review of draft results	Several iterative rounds of reviewing the authors suggestions by email (Project steering group, SHOK Governing Council, other SHOK stakeholders)	Communicating the stakeholders about the work-in-progress plans in order to get detailed feedback for further improving the measurement system and to support the acceptance of the measurement system.

2 Starting point for the development work

2.1 Current measurement practices of SHOKs

Currently, SHOKs produce an annual report to the Ministry of Employment and the Economy (MEE) for monitoring and evaluation purposes, including 32 Key Performance Indicators (KPIs). The monitoring data is gathered each year, processed in the governing council, whose chair gives a report on the progress of the SHOK strategy for Research and Innovation Council (RIC) (Lähteenmäki-Smith, 2013). In various informal discussions at the start of this project, it was commonly criticized that there are too many indicators included and many of them do not focus on relevant aspects of SHOKs performance.

In addition to MEE's annual reports and indicators, Tekes monitors SHOK programs using pre-evaluation of projects, interim, periodic, final and a follow up reports (Tekes, 2013). At the moment, the SHOK programs are funded only by Tekes and, therefore, Tekes funding criteria and program monitoring guides how programs are evaluated and also limits the results that can be achieved during these programs. For example, SHOKs are aimed at carrying out pre-competitive R&D and, thus, SHOK projects should not produce patents (instead, they are expected later on in more commercially oriented spin-off projects). Therefore, the results of this project provide suggestions that could help in developing Tekes' evaluation practices.

Moreover, as SHOK companies are private incorporations, they also have their own measurement systems for internal management purposes and for reporting to their own shareholders. Some of their individual practices seem useful to be utilized more broadly for SHOK system level monitoring, for example, to have a shared and comparative set of statements in SHOK companies' annual stakeholder satisfaction surveys or to have shared best practices for performance measurement and evaluation of programs (see, e.g., DIGILE's international interim review of programs and competence benchmarking framework and levels for programs, such as Recognized global star competence (Lähteenmäki-Smith et al., 2013, p. 256)).

2.2 Interviewing key stakeholders and actors

In order to clarify the purpose and needs for measurement, the relevant stakeholders were interviewed. The participants were identified with the help of the project steering group and SHOK companies. List of interviewed persons can be found in Appendix 1. Table 2 summarizes the key findings concerning the relevant aspects to be covered by the measurement system and some suggestions on carrying out the overall evaluation.

Table 2. Summary of the interview results

Success factor	Dimensions	Proposed methods or measures
Competence platform/ network	Quality, size, focus, openness and flexibility Links between participants, dialogue and collaboration, utilization of results, competence creation, efficiency of activities Quality and credibility of project plan Ambition, high risk level Serendipity	Scenarios Proof-of-Concept –panel Portfolio analysis based on the contents of the program Classifications of participating companies/sectors and research partners/ disciplines Spillovers
Industry relevance	Commitment, realization level of projects Strategic Cross industrial Novelty, renewal Spin-off projects Value added Mobility and recruitments of researchers	The portion of company's funding and personnel to total expenditure on R&D Community Innovation Survey Stakeholder interviews Case studies and success stories KPIs of stakeholder companies SME participation Joint patents
Research excellence	Quality of research Internationality Multi/interdiciplinarity Education	Panel for scientific quality (Joint) international referee journals (quantity & quality), (Jointly supervised) doctoral dissertations, citations, Field of Science and Technology Classification
Internationality	EU-funding, foreign researchers International business Attracting foreign companies and experts	Amount of foreign funding and investments to Finland

Based on the interview results, important success factors were identified and grouped under four dimensions: competence platform/network, industry relevance, research excellence and internationality. During the interviews, it was pointed out that there are higher expectations on outcomes of programs than what is appropriate to achieve under current funding terms and agreements. In addition, the position and goals of SHOKs as a part of the Finnish innovation systems needs to be specified more clearly. The need for systematic and shared indicators was clear but it was questioned if the development of such measures should be linked more to the overall development of SHOK goals, positioning and practices. For example, there is a need to define the SHOK status and how this status is earned or removed.

It was found that the current indicators of MEE are not properly defined and therefore, they are not used systematically or understood in the same way. Therefore, these indicators are not providing comparative information on the performance of SHOKs. In addition, it was pointed that there are too many indicators used for steering purposes at the moment and some of those indicators were not perceived relevant.

2.3 International examples of R&D evaluation practices

Current evaluation methods of R&D programs and international case examples were used as a starting point when choosing the measurement approach for SHOKs. Over 30 evaluation methods and frameworks were identified (and listed as a separate working document) for different purposes and phases of program evaluation. As a result of the review of measurement approaches, three characteristics of measurement emerged as relevant for this project. First, the measurement system should somehow incorporate the idea of the logic of impacts expected. That is, the measurement should cover the different aspects of R&D projects – from inputs through process to outputs and finally to outcomes. Second, these aspects cannot be covered by any single indicator but instead a selection of indicators should be used. Third, as the key aspects of R&D consist of both quantitative and qualitative elements, there is a need for both types of evaluation approaches.

In addition to reviewing different frameworks for R&D measurement, five actual measurement systems used in well-known R&D centers were examined. They were selected in order to benchmark the current practices and indicators in international state-of-the-art R&D units or programs (Table 3). It was considered that although the Finnish SHOK context is somewhat unique there are some similarities in the actual measurement solutions and practices.

Table 3. International case examples (List of indicators in Appendix 2)

Source	Framework	Factors
Australia Co-operative Research Centres (CRC)	Impact Tool for Performance Assessment	Input, Activity, Outputs, Usage, Impact and Benefit
Canada Business-led Networks of Centres of Excellence (BL-NCE Program)	Logic Model and Joint Results-based Management and Accountability Framework and Risk-Based Audit Framework	Outputs, Immediate outcomes, Intermediate outcomes, Ultimate outcomes (Incl. Key performance area/Key Risk, Indicators, Data source/Data collecting method, Responsibility for collection, Timing/ Frequency of measurement)
ECSEL Joint Undertaking	Progress and Performance -Indicators of results and impact	Specific indicators measuring the progress in achieving the objectives and the performance of the ECSEL (Incl. Objectives, KPIs, Metrics)
EIT Knowledge and Innovation Communities (KICs)	EIT Performance monitoring system	6 Key Performance Indicators reflecting the strategic objectives of the EIT and applying to all KIC, 9 additional Performance Indicators for EIT, Individual KPI to be included in Business Plans
The Dutch Leading Technology Institutes (LTIs)	Balanced measurement	Market orientation and (inter)national relevance to industry International position Scientific/academic position Education Governance, organization, finance and efficiency

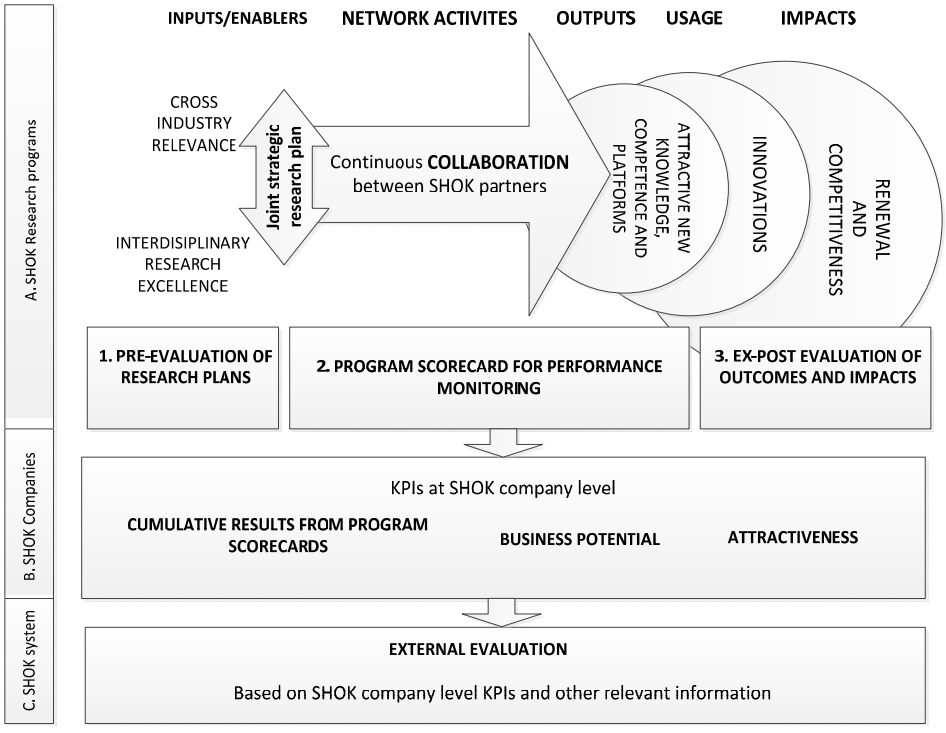
Based on the international benchmarking and review of measurement approaches, we decided to apply the Impact Logic Model for SHOKs to illustrate the factors affecting the impacts (see, e.g., Logic Model Development Guide of W.K. Kellogg Foundation (2004)). In addition, we utilized the Balanced Scorecard method for choosing the Key Performance Indicators for the SHOK programs and SHOK companies. Current international indicators (Appendix 2) were reviewed when selecting KPIs for SHOKs.

3 Designing SHOK evaluation model and the measurement system

3.1 Overview of the SHOK evaluation model

Based on the goals of the project and the needs identified from the interviews, three levels are included in the overall SHOK evaluation model: A) SHOK research program level, B) SHOK cluster/company level and C) SHOK concept/system as a whole (Figure 1). In this project, the main purpose of the evaluation of SHOKs was to provide measurement information to external steering, in order to be able to monitor whether SHOKs are achieving the strategic goals (RIC, 2006), to capture the value of public investments and to justify future investments from government. In addition, related to external steering, the aim is to guide the activities carried out in the SHOK programs by highlighting certain areas by measuring them. The rationale of the evaluation model is described below.

Figure 1. SHOK evaluation model



At **SHOK program level**, it is important to ensure that there is unique vision and best people collaborating in order to be able to create the kind of competence and results that could be exploited broadly and to achieve large scale impacts. The SHOK program level evaluation includes three phases:

1. SHOK Program pre-evaluation for funding applications; at this stage the evaluation focuses on the ability of the planned research program to achieve the desired high level impacts.
2. SHOK Program Scorecard for continuous performance monitoring; at this stage a set of KPIs covering relevant elements of the of the impact logic chain (see Figure 2) guide program execution.
3. SHOK ex-post evaluation of long-term outcomes and impacts; at this stage, i.e., after the research program has ended and the impact have realized, the outcomes are evaluated.

It should be noted that the Program Scorecard is only one of the managerial tools for steering the programs. There are also other methods that are used, such as evaluation of the qualitative descriptions of progress and results as part of the annual reports and meetings between SHOK steering group, Tekes and SHOKs. There are also methods that SHOKs are using by themselves (such as milestone or stage & gate systems, steering and advisory groups) for managing programs.

At **SHOK company level**, the evaluation is focused on the combination of cumulative results from various research programs and total research activities that are carried out in the context of one SHOK cluster. In addition, the stakeholders' views are considered important when evaluating the impacts of SHOK research programs. It should be noted that SHOK company level KPIs are not (necessarily) the same as the SHOK company's own KPIs that are used for reporting on their performance for their own stakeholders. SHOK companies are independent and can measure what they want. Instead, the KPIs discussed here focus on the extent public funding is boosting research activities in collaborative manner under the SHOK status: whether it is achieving the strategic objectives of RIC. There may be also other objectives and important results related to those that are not included in this project.

At **SHOK system level**, the results collected from all SHOKs are assessed by external evaluators in order to have a broader view of how the system is performing as a whole. In addition to the indicators presented in this report, also qualitative data should be gathered, including interviews and surveys, case studies and success stories on innovations that are introduced after participating to SHOK programs.

Based on the discussions with the steering group, most emphasis in this project was put on the program level and the development of max 10 indicators for monitoring the performance of the programs. Although the focus is quite narrow, it was considered the best suitable level for steering public investments because SHOK companies as private entities can pursuit also other kinds of activities. Pre- and post-evaluations are qualitative in nature although some indicators can be used

in these phases as well. These approaches are discussed in Section 3.3. The process for developing the measurement system and the specific indicators for monitoring the performance at program level are described next.

3.2 Iterative workshop process for developing the measurement system

In constructing the measurement system we followed the basic principles of balanced performance measurement (Kaplan and Norton, 1996; Neely et al., 2000; Nudurupati et al., 2011; Bititci et al., 2012) in the sense that the outcome of the project is a measurement system consisting of a set of different indicators (e.g., monetary, non-monetary, tangible, intangible, objective, subjective) covering different aspects related to the impacts and structured against specific defined perspectives. Moreover, strong emphasis was put to make sure that the resulting indicators and the measurement system as a whole meet the criteria of good managerial measures, i.e. validity, reliability, relevance and practicality (Hannula, 1999). In particular, we defined a set of key performance indicators that can significantly inform the assessment of the impacts of SHOK programs. Indicators focus not only on the impacts as such but also other factors that are considered drivers of the desired impacts.

The process of designing a measurement framework follows the generic best practices of the performance measurement literature (e.g., Bourne et al., 2000; Neely et al., 2000; Neely et al., 1997; Lönnqvist et al., 2010). The measures were designed using a group of key actors as experts in defining the issues to be measured, while the authors acted as facilitators of the process. This kind of a facilitated workshop process has proven useful not only in finding useful indicators, but for making the key actors committed to the outcomes of the design process. Other communication actions were also carried out to support the design process in order to obtain feedback for improving draft indicators and to make key actors understand the measures. These are essential steps in developing the measurement culture.

Four half-day workshops for designing the measurement system and indicators were organized during October and November. Participants included 2 facilitators and a group of 5-8 representatives of key SHOK stakeholder groups. The workshops were organized as following:

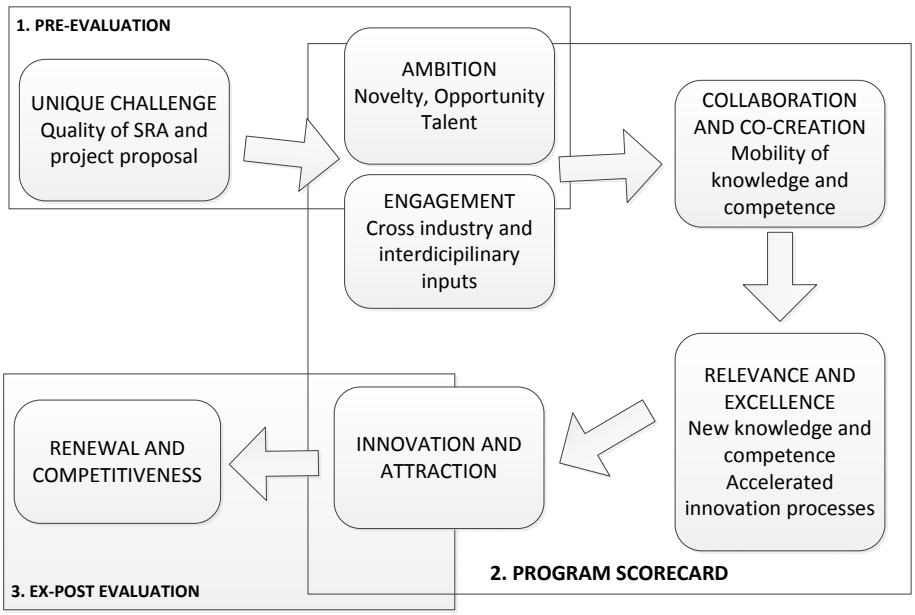
1. Starting the design process (based on using the outcomes of phase 1: clarifying objectives, identifying the key measurement challenges, choosing the overall measurement framework)
2. Choosing the factors to be measured
3. Defining key indicators
4. Evaluating the measurement system as a whole and finishing the design phase (draft version of the measurement framework and indicators was produced as an outcome).

3.2.1 Logic Model: Identifying the impact elements to be measured

Based on the international benchmarking exercise, Logic Model framework was chosen to act as a starting point for the identification of the success factors for research programs[1]. Logic Model provides an effective graphical depiction of the logical relationships between the resources, activities, outputs, outcomes and impacts to be evaluated and helps identifying indicators to apply to each stage. It can be used as the program's road map when planning the expected outcomes and impacts of the program and collaborative activities and outputs that are needed in achieving those. For example, each program could clarify their logic model and define five key strategic outcomes and the impacts expected.

Figure 2 illustrates the Impact Logic Model for SHOKs from inputs to impact; Ambition and Engagement (input), Collaboration (network activities), Industry relevance and Research Excellence (output), Innovation and Attraction (outcome) and Renewal and Competitiveness of Finnish industrial sectors. The three phases of the SHOK program evaluation model are included in Figure 2 to show which elements are emphasized in different evaluations.

Figure 2. SHOK Impact Logic Model



1 Canada Centre of Excellence for Evaluation:http://www.tbs-sct.gc.ca/cee/dpms-esmr/dpms-esmrtb-eng.asp

Canada BL.NCE Logic Model: http://www.nce-rce.gc.ca/ReportsPublications-RapportsPublications/ProgramEvaluations-EvaluationsProgrammes/BLNCE-RCEE/2012-Flowchart_eng.jpg

W.K. Kellogg Foundation Logic Model Development Guide: http://www.wkkf.org/resource-directory/resource/2006/02/wk-kellogg-foundation-logic-model-development-guide

Australian CRC Impact Tool user guide (2012): https://www.crc.gov.au/For-CRCs/Pages/Impact-Tool.aspx

The key success factors (i.e., impact elements) were identified based on the SHOK's strategic goals (RIC, 2006), SHOK steering group's development guidelines[2], interviews with the stakeholders and discussions during the first development workshops. The strategic objectives of SHOKs include the following[3]:

1. Leading companies, universities, research institutes and funding organizations operating in Finland will **commit** to the activities and objectives of SHOKs and **target their resources** in the **long term to strategically selected, high-quality, international-level clusters**.
2. The clusters will engage in **dynamic and interactive** research, development and innovation activities, the results of which will then be **exploited broadly and effectively**. Research activity carried out by the centres will anticipate the needs of society and business life with a time span of 5 to 10 years.
3. **High-quality expertise and a reputation** in science, technology and innovation activities will **attract** innovative companies, global market leaders and international-level top experts to Finland.

These factors and their specific indicators are defined in the next section.

3.2.2 Scorecard: Selecting and designing the indicators for performance monitoring

As mentioned, indicators were designed based on the iterative discussions of the working group. The aim was to identify a set of indicators that would cover the elements of the impact logic model (Figure 2). Some of the indicators are applied at research program level, some at SHOK company level. **It is important to highlight that the indicators do not comprehensively capture all important aspects of SHOKs. Instead, the chosen indicators emphasize the aspects that have been previously identified as areas of improvement (i.e., those criticized by the SHOK evaluation report and those identified by the governing council).**

Purpose: The Key Performance Indicators (KPIs) for ongoing research programs are designed to monitor and evaluate the current performance and growth per indicator annually. The KPIs are reported to the Ministry of Employment and the Economy (MEE) and SHOK steering group.

Evaluation methods: 7 Key Performance Indicators (KPIs) that are reported annually to MEE together with qualitative descriptions of progress, key results and future visions. The first KPI (Global breakthrough targets) is not meant for annual use in every research program but as a mid-term external evaluation. The other KPIs (i.e., 2-7) include traditional quantitative metrics. The target value of the metrics should be discussed and set together with SHOKs and the SHOK governing council in order to take SHOK-specific nature into account.

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2 MEE (2013) http://www.tem.fi/files/36546/SHOK-kehittamislinjaukset_26042013.pdf (in Finnish)
3 RIC (2006), translated from Finnish by Tekes May 2012 for Lähteenmäki-Smith et al. (2013)

In Table 4, the 7 KPIs and specific metrics and data sources for each KPI are presented. Data is collected from program level (KPIs 1-5 included in Program Scorecard) and from SHOK company level (KPIs 6-7).

Table 4. Key Performance Indicators and specific metrics for SHOK Scorecard

KPI	Metrics	Source
1. Global breakthrough targets	1.1 Result of International benchmark/evaluation report	Program Scorecard
2. Engagement of industry	2.1 Total funding from companies (M€)	Program Scorecard
3. Collaboration and mobility	3.1. Annual number of joint publications among science-industry partners 3.2. International research exchange months	Program Scorecard
4. New spin-off development projects	4.1. Total volume of ongoing and finished development and commercialization projects within companies based on the results of the program (M€)	Program Scorecard
5. New knowledge and competence	5.1. The average number of IPR*s of the key industry and academic researchers 5.2. The average h-index** of key academic researchers 5.3 Annual number of publications produced by the program (at least PuFo 1***)	Program Scorecard
6. Business potential	6.1. Business potential of outputs (M€, in 5-10 years)	SHOK company
7. Attractiveness of SHOKs	7.1. Funding to related RDI activities from other national sources (i.e., other than Tekes SHOK program funding) (M€) 7.2. Funding from international sources (M€)	SHOK company

* Including Intellectual property rights, such as patents, trademarks and copyrights in force

** h-index is the largest number h such that h publications have at least h citations (All/in the last 5 years; Google Scholar; Hirsch 2005; Harzing & Wal 2008).

*** The Finnish Publication Forum system is based on quality classification of scientific publication channels - journals, publication series and book publishers - in all research fields. The rating has three levels: 1 = basic, 2 = leading, 3 = top (http://www.tsv.fi/julkaisufoorumi/english.html?lang=en).

Below, each of the key performance indicators and related metrics is defined in detail and the summary of measurement specifications is provided in Table 5.

1. KPI: GLOBAL BREAKTHROUGH TARGETS

MEASURE: 1.1. Result of International benchmark/evaluation report
GOAL: To ensure the ambition level and the progress towards breakthrough targets are significant.
DESCRIPTION: The first KPI is still in the development phase. It is not meant for annual use in every research program but as a mid-term external evaluation that could be organized by SHOKs. It is suggested that current international evaluation practices could be used for reporting ambition level and future development targets

of programs to SHOK steering group. At the moment, at least DIGILE and CLEEN are using external international experts and their experiences and evaluation criteria could be utilized more broadly within other SHOKs as well. More consistent evaluation practice should be further developed together with SHOKs in order to gain commensurable results from the evaluations.

2. KPI: ENGAGEMENT OF INDUSTRY

MEASURE: 2.1. Total funding from companies (M€)
GOAL: To engage industry participants to ensure strategic level long-term research in order to improve competitiveness and renew industries.
DESCRIPTION: This measure is a proxy but a pragmatic indicator of the level of engagement by industry. The basic idea is as follows: if companies invest money in R&D work they are likely to make sure that they have good people working on the project. The more they invest the better skilled resources they are likely to utilize in order to ascertain that they get good results. It is worth to point out that we first planned to measure industry engagement by measuring senior R&D staff working months. However, it turned out to be difficult to distinguish 'senior' from 'normal' industry participant. Measuring the monetary investment seems to be a pragmatic way to describe the same phenomenon. In addition to funding, also in-kind investments and the duration of participation could be measured.

Total funding from businesses could be divided based on more detailed classification of companies and industry sectors in order to ensure the balance between participants. It was also suggested that average company funding could be used to illustrate collective engagement, that is, to better capture the distribution of large and small companies. However, interpreting this metric is a bit more complex than the absolute volume of company funding, and thus, that metric is proposed here. Moreover, the suitability of program consortium should be ensured already while designing it (i.e., this aspect needs to be taken into account in the pre-evaluation phase).

3 KPI: COLLABORATION AND MOBILITY

MEASURES:

- 3.1. Number of months spent abroad and number of months foreign visitors spent in Finland during a year
- 3.2. The number of joint publications among science-industry partners

GOAL: To attract international talents to SHOKs and to promote mobility and knowledge transfer; to capture public-private research linkages and enhance collaboration and learning among science-industry partners.

DESCRIPTION: As SHOKs are aiming to be top level centres of R&D activities, they need to be international. The higher level of internationality was also one criterion in the SHOK's steering group's guidelines. Research exchange during SHOK research programs is an easy way to improve the international aspect of SHOK activities. In addition, it is a way to acquire world class knowledge and competence for the purposes of the research program. In addition to international research mobility, mobility between research organizations and companies could be measured, for example, through placements of universities' researchers and students in companies and vice versa. Collaboration is also measured by the number of joint publications among science-industry partners. Joint publications aim at ensuring the collaboration and learning between participants. It is a concrete manifestation of joint efforts. The publication process is a good practical way to share knowledge between the authors and from each other. It was also suggested that collaboration could be measured in terms of annual number of participation in programs by type, for example, large companies, SMEs and research institutes. The type and amount of participants is currently a part of pre-evaluation of research programs as it is important to evaluate whether there is enough competence and diversity between the partners to provide the best result.

One possible way to measure the quality, links and benefits of research collaboration (including both cross-industry and industry-science collaboration) is to collect data from all participants on the basis of a collaboration survey. Therefore, the use of the survey as a method to collect valuable information is suggested, but acknowledging the need to keep straightforward and compact the measurement system we recommend to use this approach later on once a set of key metrics have been implemented. For this reason, although stressing its relevance, we have not included the collaboration survey among the final set of key metrics for the SHOKs.

4. KPI: NEW SPIN-OFF DEVELOPMENT PROJECTS

MEASURE: 4.1. Total volume of ongoing and finished development and commercialization projects within companies based on the results of the program (M€)

GOAL: To produce results that can be broadly utilized; to ensure the results of the programs are relevant for companies to develop them into new innovations.

DESCRIPTION: As SHOKs carry out precompetitive research they do not produce easily observable business outputs. Instead, they produce new knowledge and ideas that can be further developed into commercial outputs. These further development activities are typically carried out in other R&D projects that are organized as spin-offs in relation to the original SHOK project. Thus, measuring the number of new development projects (e.g., companies´ own R&D projects, pilots, demos, and new joint projects to develop innovations) can be considered an indicator of the commercial potential and value of outputs of SHOK programs.

5. KPI: NEW KNOWLEDGE AND COMPETENCE

MEASURES:

- 5.1 The average number of IPRs of the key industry and academic researchers
- 5.2 The average h-index of key academic researchers
- 5.3 Annual number of publications produced by the program (at least PuFo 1)

GOAL: To raise the talent level of industry and academic staff involved; to lift the ambition of the programs in order to attract top researchers from industry and research institutes; to create new knowledge and competence that is relevant to industries; and to produce high quality research outputs.

DESCRIPTION: In order to attract top researchers and to produce breakthrough results, this KPI aims to illustrate the current talent level of the key industry and academic staff that are participating to the program. Talent needs to be sustained and improved during the project; measuring the number of intellectual property rights and the h-index annually shows the development of talent and reveals if the top researchers are participating or if some are leaving the project. These measures are not used for ranking individual researchers but for describing the level of collective competence of key researchers participating to the project. Key industry and academic researchers are named by SHOKs together with the program participants. In pre-evaluation phase the transdisciplinarity and internationality of research partners need to be ensured. The average number of IPRs is measured from the key industry and academic researchers whereas H-index is measured only from key academic researchers. IPRs include, for example, trademarks, copyrights and patents in force.

The number of IPRs and h-index are not a "perfect" indicators of talent and they can be criticized. However, H-index, for example, is a very pragmatic way to examine whether the participants are researchers who have published articles with impact in terms of citations. In the end, the ability to publish and to get other researchers to notice your work is a key measure of an academic's performance. H-index is calculated automatically by, for example, Publish or Perish software. The calculation of the index can be illustrated with the following example: If a young researcher has published four articles and one of them has been cited ten times, the second five times, the third once and the fourth has not been cited yet, the value of the h-index is 2. If the third paper gets two more citations (three in total), the index value goes up to 3. Later on, when the fourth paper has gained four citations and the other papers at least the same amount, h-index climbs to 4. For a young researcher, h-index value is usually in very small digits. A fresh PHD could have an h-index between 3 to 10, while for a professor the value could be above 10. However, there are differences between disciplines. Nevertheless, for each SHOK, the value of h-index should be growing as a sign of increasing academic talent.

It is important to have young researchers participating in challenging projects, growing to have special and industry relevant skills for the purposes of creating radical innovations and industry renewal. Therefore, in addition to the average of h-index of key academic researchers, also distribution of h-index of all academic researchers could be monitored in order to see that there are both junior and senior researchers. Considering that the educational aspect and competence creation represents an important feature in SHOKs, a further proposed measure was the participation of doctoral students (total working months) from both companies and universities and the number of doctoral dissertations created. In order to boost public-private learning and collaboration, it is suggested that these students can benefit from joint industry-university supervision. Another suggested measure of talent was the number of publications that are ranked at levels 2 and 3 of Publication Forum. However, this may not provide a comprehensive view of participants' talents due to the differences between disciplines. For example, in some well-established disciplines, many of the journals have achieved level 2 or 3 where as in some younger research fields all the most significant journals are still at level 1.

Publications are an important indicator of competence growth as part of SHOK programs and they also improve the level of international visibility. To ensure the quality of publications produced in SHOK research programs, the Publication Forum classification Level 1 is used. It covers the major scientific publication channels (journals, conferences, books, theses) in all disciplines that undergo a full manuscript review. The publication channel ratings can be browsed on the search page of the Publication Forum website. Ratings are meant for the evaluation of large publication volume and capturing progress, not for comparing different disciplines or individual research groups. Also this indicator is not without limitations, but it is a good compromise considering practical measurability, suitability for different fields of research and accuracy.

It was also discussed whether to measure patents or not. Most of the SHOK participants pointed out that the current funding terms and agreements do not support patenting and thus, they cannot be expected and measured as results of SHOK programs. Moreover, patents and patent applications may indicate some kind of technological progress but may not have any market relevance as such[4]. As SHOKs are utilizing open innovation approach, the benefit arises from having the core competence long before competitors and instead of slowing technological development through patents, the idea is to run faster than competitors.

4 Jung, D., Wu, A., & Chow, C. W. (2008). Towards understanding the direct and indirect effects of CEO's transformational leadership on firm innovation. The Leadership Quarterly, 19, 582–594.

6. KPI: BUSINESS POTENTIAL

MEASURE: 6.1 Business potential of outputs (M€, in 5-10 years): Participants' opinion on the business potential of results.
GOAL: To obtain a comparable overview of the business potential of outputs.
DESCRIPTION: As the activities of SHOKs are targeted to renewal and competitiveness of Finnish industrial sectors, the most important success factor is the business potential of research results. Although it may be quite difficult to estimate and will be fuzzy at the beginning of the program, it indicates the level of future value. Data is gathered annually using survey that is sent to all industry participants participating to a SHOK program in order to estimate the business potential (€, in 5-10 years) in terms of

- New business
- Improved market share and
- Improved efficiency and profitability.

Currently, companies may be participating in various research programs and it may be difficult to estimate the business potential of one program. Therefore, it is suggested that the estimation is done at SHOK company level. However, as the programs will be more focused and have more than one SHOK company participating in the future, it may be easier to carry out the assessment at program level. It is suggested that industry participants estimate the business potential for a period of five years. For example, for the measurement point of 2014, the estimated total revenue for the years 2019-2023 would be reported.

7. KPI: ATTRACTIVENESS OF SHOKS

MEASURES:

- 7.1 Funding to related RDI activities from other national sources (i.e., other than Tekes SHOK program funding) (M€)
- 7.2 Funding from international sources (M€)

GOAL: to attract national and international funding to topics relevant to SHOK in order to add volume and impact of SHOK.
DESCRIPTION: In order to gather the critical mass and to create top international-level competence networks to Finland, SHOKs need to attract national and international resources to participate research activities. Attractiveness is measured in terms of funding from national and international sources. It aims at illustrating activities adding value and impact of SHOKs.

National funding refers to other sources than Tekes SHOK program funding, for example, the Academy of Finland and projects funded by ministries in Finland. Academy of Finland is funding research activities related to the topic areas and themes covered by the SHOKs. However, these projects are not currently coordinated by SHOKs and the competence or results are not linked to the activities of SHOKs.

This is the area that should be discussed and new practices created on how to collaborate with these top researchers funded by the Academy in order to increase the benefit to SHOKs and their competence creation. On the other hand, SHOKs provide novel ambitious research topics and ways of doing research that could benefit also the Academy of Finland researchers.

International funding include, for example, EU funding and other competitive research funding which include collaboration and task-sharing initiatives as well as foreign R&D investments (e.g., foreign company or university participation). International funding does not include R&D investment by SHOK companies' foreign business units.

A summary of the metrics, their descriptions, goals as well as data source and frequency of measurement is provided in Table 5.

Table 5. Measurement specification of the metrics of SHOK Performance Scorecard

KPI	Metric	Description	Goal	Data source and frequency
1.	1.1 Result of international benchmark/ evaluation report	The evidence of the ambition level and quality of research programs.	To ensure the ambition level and the progress towards breakthrough targets are significant	International panel evaluations
2.	2.1 Total funding from companies (M€)	The total funding from companies participating in SHOK program	To engage companies to ensure strategic level commitment	Program director reports the total funding; annually
3.	3.1 Number of joint publications among science-industry partners	The publications produced jointly by academic and industry representatives are counted	To capture public-private research linkages and enhance collaboration and learning among science-industry partners	Authors report to program director who sums up the total number; annually
	3.2 International research exchange months	Number of months spent abroad and number of months foreign visitors spent in Finland during a year	To attract international talent to SHOKs and to promote mobility and knowledge transfer	Program director collects the data from project managers; annually
4.	4.1 Total volume of ongoing and finished development and commercialization projects within companies based on the results of the program (M€)	New projects indicates the commercial potential and value of outputs of SHOKs' precompetitive research programs	To ensure the results of the programs are relevant for companies to develop them into new innovations	Program director collects the data from project participants; annually
5.	5.1 The average number of IPR s of the key industry and academic researchers	IPRs, such as trademarks, patents and copyrights, is used as a measure of inventiveness and innovative talent of the key researchers	To engage talented industry and academic researchers and to raise the inventiveness level of staff involved	Program director collects the data from companies and research organizations

	5.2 The average h-index of key researchers	H-index is a quantitative measurement of a researcher's efficiency and the significance of the research work (the track record of key academic staff)	To engage talented academic researchers and to raise the talent level of academic staff involved	Program director collects the data from researcher organizations or using Publish or Perish (Google scholar data); annually
	5.3 Annual number of publications produced by the program (at least PuFo 1)	Publication Forum lists and ranks academic publications; PuFo 1 refers to a minimum quality criteria; same criteria as in MinEdu funding model as of 2015	To create research output with high academic quality	Authors report to program director who sums up the total number; annually
6.	6.1 Business potential of outputs (€, in 5-10 years)	Survey sent to industry participants, including New business, Increased market share and Improved efficiency and profitability; total value of all responses used as an overall result	To obtain a comparable overview of the business potential of outputs	SHOK companies manage the data collection as part of their stakeholder survey; annually
7.	7.1. Funding to related RDI activities from other national sources (i.e., other than Tekes SHOK program funding) (M€)	Activities adding volume and impact of SHOKs. This measure illustrates the attractiveness and viability of SHOKs.	To create critical mass, attract and commit national and international funding organizations to target their resources to topics relevant to SHOKs	SHOK companies manage data collection
	7.2. Funding from international sources (M€)			

During the project many potentially valuable indicators were discussed but in the end left out due to the scope of the resulting measurement system (max 10 key performance indicators). Other discussed indicators included the following:

- Engagement of senior industry managers (total working months); this would indicate the kind of R&D resource used by companies in SHOK project.
- The revenue of new business created in the past 3 years per the key industry participant (M€); this was suggested to measure industry researchers' talent.
- Quality of collaboration (collaboration survey); this would show how the collaboration and co-creation actually works in the SHOK program and provide valuable information on the links between public-private partners.
- Number of new doctoral dissertations
- Total volume (project portfolio size + revenue), Leverage of public funding: Total volume/Tekes funding; this would indicate how much R&D activity can be produced per each euro of Tekes funding.
- International media coverage; this would give an indication of the visibility of the SHOKs internationally (visibility can be regarded an important precondition for being attractive research unit).

3.2.3 Evaluation of the measurement system

Between the third and fourth measurement system development workshops, a working seminar was organized in order to collect feedback and development ideas from a larger group of SHOK stakeholders. The draft versions of the SHOK evaluation model, indicators and measures were presented and discussed in working seminar. Based on the feedback, some indicators were removed and some were merged.

The measurement framework and indicators were also tested in one SHOK program. The evaluation meeting was organized with the CEO of FIMECC and program director of EFFIMA to have feedback on how the indicators would work in practice. Based on this discussion, we were able to clarify the use and description of the indicators in order to define measurement specifications (Table 5).

In the second phase of the project we concentrated on improving and defining the KPI measures. Feedback and guidance were gathered from SHOK governing council and a workshop organized for SHOKs. In addition, two meetings were held with Tekes and final version of indicators and metrics were defined. Moreover, the SHOK companies commented on the draft versions of the proposed measurement system and the authors reviewed SHOKs' existing measurement practices in order to learn about well-functioning existing practices.

3.3 Pre- and Post-evaluations of programs

3.3.1 Pre-evaluation: Unique challenge as a starting point

Purpose: To evaluate SHOK research program plans.
Evaluation criteria: Uniqueness of research program proposal, Industry relevance, Scientific quality, Competence and diversity of network partners, Risk assessment and Impact plan.
Evaluation methods: qualitative evaluation.
In order to have the best prerequisites for potential impacts, the critical point in predicting success is when evaluating SHOK program proposals. The research of SHOK programs focuses on unique and significant challenges that could renew Finnish industrial clusters and improve their competitiveness. This challenge needs to be packed clearly in the project plans that should be evaluated based on these criteria:

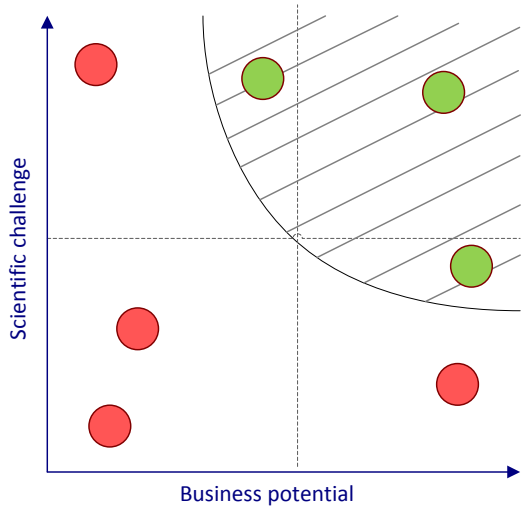
- *Uniqueness of research program plan*, including the value and novelty of business idea and scientific approach (e.g., state of the art report/SRA and the research gap indicated, business idea vision related to product, process, marketing or organizational innovation that is new to company, market, Europe or world).
- *Industry relevance:* Estimation of business potential (e.g., in 5 years after program: to ensure long-term strategic target).

- *Scientific Quality* (e.g., cv and track record of academic researchers (e.g., h-index, amount of PuFo ranked publications, grants and awards, internationality); note, however, that good reputation and enthusiastic attitude of researchers are also important).
- *Competence and diversity of network partners:*
  - Strategic (cross) industry and interdisciplinary participants (e.g., companies participating (funding and investments in person years, number of industry researchers participating) from two or more industries; researchers from two or more disciplines and research organizations). Shared classifications of industry sectors and fields of science and technology should be used to provide more systematic and common way of categorizing participants.
  - Both young and experienced researchers participating (i.e., doctoral students, post-doc researchers and professors as well as junior and senior staff from companies).
- *Risk assessment*[5] (e.g., including network agreements and positioning of program proposals based on their risk level (see Figure 3)).
- *Estimation of impacts:* In order to ensure contextual differences of various SHOKs and their research targets, it could be useful to agree with a specific set of output/impact measures or how to monitor achieving milestones based on the estimated impacts of project proposals. The Impact Logic Model could be useful to guide program planning.

At the moment, SHOK programs (i.e., programs that are coordinated by SHOK company) are funded only by Tekes and therefore, their current funding criteria guide the decision making: quality and relevance, resources and collaboration, and value-added from SHOK model (Tekes, 2013). In this phase, it is suggested that also the risk level should be assessed and to make sure that the scientific quality and ambition of proposal is at good international level. A suggested approach to perform such evaluation is by positioning program proposals based on their uniqueness when compared to scientific challenge and business potential as illustrated in Figure 3. All of the funded programs should reach appropriate level.

5 Canada Risk Assessment and Risk Matrix: http://www.nce-rce.gc.ca/_docs/reports/RMAF-RBAF/BL-NCE_RMAF-RBAF_RCE_TBS_eng.pdf (p.29 >)

Figure 3. Positioning SHOK programs based on their ambition and risk level



There were discussions whether to use outside foreign experts in reviewing funding applications as is done by the Academy of Finland's program proposals. This is, however, considered quite problematic as current practice is not supporting panels; panels could make the decision making process lengthier and it is also perceived risky to give companies' confidential strategic business ideas outside the funding organizations. Nevertheless, it might be useful to experiment with using a panel of academic experts, e.g. in collaboration with the Academy of Finland, to assess the academic quality of the proposals.

3.3.2 Ex-post evaluation of SHOK programs

Purpose: to evaluate short-term and long-term outcomes and impacts of SHOK programs after three years the program has ended.
Evaluation criteria: Competence growth, innovation activities as well as renewal and competitiveness of companies that participated in the SHOK program.
Methods: qualitative evaluation of results and outcomes.
It is suggested that some of the current practices, indicators and statistics (e.g., Community Innovation Survey) could be utilized and analyzed in SHOKs. Those may also provide some comparable measures that could be used for evaluation whether the companies participating in SHOKS are having better the results than companies not participating.

Table 6. Examples of potential indicators that could be used in evaluation:

Objectives	KPI	Metrics
Relevance and Excellence	Accelerated innovation processes New knowledge New competence Recruitment of talent (Inter)national visibility and reputation	1. New tools, techniques, models, simulations, prototypes, demonstration activities, pilots, living labs, competence platforms etc. 2. Reduced time-to-market 3. New strategic partners (number/duration) 4. Number of new university/industry doctorate graduates/ Number of university-industry joint supervised doctorate graduates 5. Number/increase of working years of doctorate graduates within companies (from both universities and companies); % of doctorate graduates of total R&D personnel. 6. Number/Increase of recruitment of highly skilled personnel from Finland/abroad that participated in SHOK program 7. Number of media hits, including international seminar presentations, interviews, newspaper articles and other non-academic publications
Innovation	Usage of results and outcomes Significance of new knowledge	8. Companies introducing product or process innovations in topics related to SHOK 9. Companies introducing marketing or organizational innovations in topics related to SHOK 10. Sales from new to market and new to firm innovations 11. Patent applications submitted/Patents and other IPRs together with research partners from SHOK program
Renewal and competitiveness	Business renewal Spinn-offs	12. Change/renewal of Business revenue structure 13. Number of spin-off companies generated by employees of firms/research partners in topics related to SHOK 14. Replaced outdated products or processes 15. New markets entered 16. Increased market share

3.4 External evaluation of SHOK system

Purpose: To evaluate the performance and impact of SHOK system as a whole (every 5 years)

Criteria: Industry relevance, Research excellence, Collaboration and Effectiveness (renewal and competitiveness)

Methods: An evaluation carried out by an independent panel of experts representing industry and academia. SHOK annual reports and other documents review, analysis of SHOKs performance measures, Interviews of relevant stakeholders and actors in the Finnish innovation system.

The Impact Logic Model of SHOKs and related performance measurement system form the basis for external evaluation: when programs are planned according to the Logic Model, it provides information on the planned outputs and impacts in a more systematic way and it is easier to assess if they have been achieved or not. Similarly, when the shared indicators are clearly defined and understood, implemented

and used in a same way annually, they provide information on the progress of the programs and SHOKs. In order to address the contextual differences between SHOKs, it is important that the expected outcomes of the various SHOK programs and also the timeframe in which the outcomes can be achieved are defined.

The evaluation process is suggested to be carried out using a panel of external experts. Similar approach has been considered to work well in evaluating the quality of research and education in universities (Research Assessment Exercise, RAE[6]; Quality Audits). The panel should include experienced representatives of academia and industry. It might be useful to have specific panels for each SHOK and then an overall panel for making an overall assessment of the SHOK system as a whole. Each SHOK should prepare a self-assessment report of its key activities, results and, most importantly, impacts. These reports would function as the basis of the panel's work. In addition, relevant stakeholders and actors in the Finnish innovation system could be interviewed in order to form a view of the position and impact of SHOKs as part of the national innovation system. It would be important to include both actors who actively participate in SHOK activity and thus know them thoroughly as well as those who are active in other areas of the innovation system but not in SHOKs.

To summarize, the evaluation should cover three key aspects:

1) *Reaching the strategic goals of SHOKs.* The performance of SHOKs should be compared against the strategic goals of SHOKs as defined by RIC (2006) and specified by the Governing Council. To a large extent, these can be examined using the indicators proposed in this report.

2) *Impacts.* As mentioned, the focus of the external evaluation should be on the long-term impacts of SHOKs on the competitiveness and industry renewal of the Finnish business environment (i.e., the top right-hand side of Figure 1, the SHOK evaluation model). Impacts could be judged, for example, based on assessment criteria and four starred levels that could be developed to SHOK context (rf. Overall quality profile: Definitions of starred levels of RAE end REF).

3) *Position is the national innovation system.* It would be the task of the panel to position – ex-post – the programs carried out by the SHOKs in the conceptual model provided in Figure 3 in order to evaluate the extent that the right kinds of projects (i.e., ambitious research challenge, significant business potential and high risk) have been executed by SHOKs.

6 The Research Excellence Framework (REF) will replace RAE in 2014: http://www.ref.ac.uk/

4 Concluding remarks

This report defines the evaluation model and key performance indicators for SHOKs. This short and intense exercise was the first step in creating more systematic measurement culture for SHOKs. However, the focus of this project was narrowed to SHOK program level evaluation and thus, the actual large-scale impacts that are expected to occur after 5 to 10 years after projects remain out of the scope of these indicators. If and when these indicators are implemented, the development in important areas is easier to follow for steering purposes. Next, the SHOK steering group is going to decide whether or not to implement all of some of the indicators as part of annual reporting of SHOKs. After that, the implementation and targets for each indicator should be planned and carried out. The current level and contextual differences between SHOKs needs to be taken into account.

Even though the aim of this project was clearly focused on developing indicators, many of the discussions in workshops and between individuals revolved around fundamental strategic questions concerning the goals of SHOKs. While this topic is outside the scope of this project, it seems useful to communicate some of the lessons learned from this more strategic perspective as well. Moreover, the strategic objectives are strongly linked to key performance indicators and thus, it is difficult to leave them completely out of the discussion either.

A key development area seems to be the clarification of the strategic objectives of SHOKs, including the position and status/license of SHOKs. Based on the discussions during the project, it seems that the fundamental goals of SHOKs are basically clear but somehow there is great variety in how people interpret and understand them. The goals are clear as rough overall targets, but when they are discussed in a more detailed level, the differing interpretations emerge. For example, one of the core ideas of SHOKs is the development of a platform of strategic top level research skill: but what does this mean in practice? Does it refer to high level academic talent? Or is it more important to attract skilled and experienced R&D personnel? If both are preferred, how to find a suitable balance between them?

As a byproduct of designing the measurement system the project at hand provided opportunities for the key SHOK actors to share their views and debate about these fundamental themes. It seems that the awareness of goals was at least to some extent improved during the group discussions. Many of the participants gave positive feedback about the possibility to jointly discuss about these issues. Continuing these kinds of interactive strategic communication activities would likely have a positive impact on the development direction and performance of SHOKs.

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Appendix 1

List of interviewed persons

- Harri Kulmala, FIMECC CEO
- Essi Heinänen, Legal counsel, SHOK Legal Affairs
- Saara Hassinen, SalWe Managing Director
- Reijo Paajanen, Digile CEO
- Kalle Kantola, FIMECC CTO
- Antti Tumelius, CLEEN controller
- Jukka Viitasaari, Director, Electrical and Information Industries, The Federation of Finnish Technology Industries
- Matti Mannonen, Director, Finnish Association of consulting firms SKOL, The Federation of Finnish Technology Industries
- Mervi Karikorpi, Director, Innovation, Research and Education Policy, The Federation of Finnish Technology Industries
- Marko Laiho, Senior Advisor, Enterprise and Innovation Department, Ministry of Employment and the Economy
- Lauri Ala-Opas, Director, Enterprise and Innovation Department, Ministry of Employment and the Economy
- Petri Lehto, Industrial Counsellor, Ministry of Employment and the Economy
- Kirsti Vilén, Ministerial Adviser, Enterprise and Innovation Department, Ministry of Employment and the Economy
- Anne-Christine Ritschkoff, Executive Vice President, Strategic Research , VTT Technical Research Centre of Finland
- Stig Gustavson, Chairman of the Governing council of SHOK
- Kaija Pehu-Lehtonen, Metsä Fibre, SVP, Business Development
- Matti Sommarberg, CTO, Cargotec Corporation
- SHOK Governing Council: Stig Gustavson, Marjo Miettinen, Anne Ritschkoff, Mervi Karikorpi, Teija Lahti-Nuuttila, Marko Laiho, Leila Häkkinen, (Pekka Pesonen)
- Terttu Luukkonen, Chief Research Scientist, ETLA, the Research Institute of the Finnish Economy
- Heikki Mannila, President, Academy of Finland
- Markku Kivikoski, President, Tampere University of Technology
- Tuula Teeri, President, Aalto University

Persons attending the measurement system design workshops

- Ilari Aho, Vice President, New Business Development & CSR, Uponor
- Raimo Vuopionperä, Program Manager (External R&D Collaboration), Ericsson Finland
- Essi Heinänen, Legal counsel, SHOK Legal Affairs
- Tommy Jacobson, CLEEN Oy CEO
- Timo Kolu, Senior Adviser, Academy of Finland
- Prof. Rauno Heinonen, Vice President, Strategic Research, VTT Technical Research Centre of Finland
- Kirsti Vilén, Ministerial Adviser, Enterprise and Innovation Department, Ministry of Employment and the Economy
- Teija Lahti-Nuuttila, Pekka Pesonen, Kimmo Ahola, Tekes
- Prof. Antti Lönnqvist, Maiju Vuolle, TUT

Appendix 2

International benchmarking – indicators

Australia Cooperative Research Centres (CRC):

- https://www.crc.gov.au/
- Impact Tool User Guide: https://www.crc.gov.au/Selection-Rounds/Documents/CRC%20Impact%20Tool%20User%20Guide%20%28Feb%202012%29.pdf
- Performance Assessment of Programs, see Attachment D in CRC Program Guidelines: https://www.crc.gov.au/About-the-program/Documents/CRC-Program-Guidelines-June-2013-v2.pdf

Canada Business-led Networks of Centres of Excellence Program (BL-NCE):

- Logic Model: Canada Centre of Excellence for Evaluation:http://www.tbs-sct.gc.ca/cee/dpms-esmr/dpms-esmrtb-eng.asp
- Canada BL-NCE Logic Model and Performance measurement framework (2007): http://www.nce-rce.gc.ca/_docs/reports/RMAF-RBAF/BL-NCE_RMAF-RBAF_RCE_TBS_eng.pdf
- http://www.nce-rce.gc.ca/_docs/reports/BLNCEEvaluation_eng.pdf
- Program Guide: http://www.nce-rce.gc.ca/_docs/reports/BLNCEProgramGuide-GuideProgrammeRCEE_eng.pdf

The Dutch Leading Technology Institutes (LTIs) – Indicators for the evaluation of LTIs:

- OECD (2004), Public-Private Partnership for research and innovation: An evaluation of the Dutch experience: http://www.oecd.org/netherlands/25717044.pdf

ECSEL Joint Undertaking – Indicators of results and impact (2013):

- http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2013:0501:FIN:en:PDF

Austria: Lähteenmäki-Smith (2013)

EIT's Performance monitoring system, KPIs for Knowledge and Innovation Communities (KICs): Presentation at European RTD Evaluation Network, Brussels, 2013.

Criteria	Indicators	Source
Market orientation and (inter)national relevance to industry	# of industrial partners; % contribution of industry to total budget; # of established or transferred patents; # of licenses sold to 3rd parties: # of spin-off companies: # of institute researchers finding employment elsewhere in the field: Procedures for performance measurement by industrial partners:	LTI
International position	# of EU-projects with participation of the LTI; % EU-funds of total budget: % contribution of international partners to total budget.	LTI
Scientific/academic position	# of TTI-papers in internationally refereed journals.	LTI
Education	# of completed PhDs.	LTI
Governance, organization, finance and efficiency	Ratio indirect costs/total costs; Expenditures for knowledge transfer.	LTI
Human resources (Qualification of scientific offspring)	Number of Master/PhD Theses; Nr. of Post-Docs in Centres Career steps of HR employed at centres and job mobility of employees	Austria
Number of scientific publications (Priority should be given to joint publications)	– publications by single authors – joint publications among science-industry partners – joint publications with international partners	Austria
Network/centre activities	– Number of patents granted (national, international) – Level of third party funding (national, international) – Conferences, workshops and visiting fellows	

		Source
Immediate Outcomes		Canada BL-NCE
High quality post-graduate and post-doctoral training in innovative research	• Number of trainees (graduate students, post-doctorate fellows and other HQP) working on BL-NCE projects – by degree and discipline • Number of trainees receiving salary support for BL-NCE research • Number of specialized training opportunities created by Networks (Strategic plans for HQP) • Number of publications and conferences involving trainees	Canada BL-NCE
Links between researchers and firms	• Number of invitations as guest speakers conferences and congresses with business- user sector • Nature of links between researchers and partners	Canada BL-NCE
Address significant research challenges that meet business needs	• Evidence of participation of industry in decision-making processes for research goals (e.g., private sector representation among members of research planning committees and research projects) • Number and nature of network milestones and objectives achieved	Canada BL-NCE
Outline of a clear path to market or business application for the proposed research	• Number of business applications / proposals identified	Canada BL-NCE

Acceleration of commercialization	• Evidence of research results leading to commercialization • Number of products, goods or services developed/ improved in each priority area	Canada BL-NCE
Intermediate outcomes		Canada BL-NCE
Increased private sector capacity (including among SMEs) and receptivity to the results of R&D	• Changes in number (and type) of employees dedicated to R&D • Changes in R&D expenditures • Opinion of partners regarding changes in capacity and receptivity in their organizations	Canada BL-NCE
Canadian firms positioned in high value segments of production chains	• Number of partners positioned in high value segments of production chain	Canada BL-NCE
Strengthened public-private sector collaboration	• Changes in inventory of industry partners • Number of university-industry links within the network • Opinion of stakeholders	Canada BL-NCE
Benefits spill over to a wide array of firms, sectors and regions of the country	• Number and size of firms, sectors, provinces and regions using results of the network research • Number and nature of policies and practices of the user sector have been influenced by research findings • Evidence of economic impacts	Canada BL-NCE
Ultimate outcomes	Survey of partners, Secondary data analysis, summary reports, case studies, economic impact study	Canada BL-NCE
Increased private sector investment in R&D and advanced technologies	• Trends in R&D investment of partners • Trends in R&D investment in Canada	Canada BL-NCE
Creation and growth of companies in Canada that are able to capture new markets with new innovations	• Number of companies created/ experienced growth using network's results/innovations • Number of jobs created within consortia (all partners)	Canada BL-NCE
Enhanced private sector innovation	• Evidence of impacts of network innovations on existing industries • Evidence of new processes and practices, that enhance private sector innovation	Canada BL-NCE
Economic, social and environmental benefits to Canadians	• Evidence demonstrating the impacts of networks on national, international norms, regulations and policies • Evidence demonstrating the impacts of networks on national, international norms, regulations and policies • Evidence demonstrating the networks' contributions to the health and social well-being of Canadians	Canada BL-NCE

Objectives	KPI	Metrics (measured over period 2014-2024)	the ECSEL Joint Undertaking
the Progress in achieving the objectives of the ECSEL Joint Undertaking:			
Structure and perform excellent multi-disciplinary research	Innovative and State-of-the-Art projects	Quality of results as e.g. measured in number of peer reviewed publications Innovative research and innovation, at least 2 patents per 10 MEUR funding Number and impact of breakthrough technologies	the ECSEL Joint Undertaking
Align strategies	SRIA with priorities	Commitment from all JU members Focus of SRIA commensurate with the available budget	the ECSEL Joint Undertaking
Mobilise and pool resources	Budget execution	Financial commitments by all JU members Contribution towards the 3% target for research and innovation	the ECSEL Joint Undertaking
Maintain and grow manufacturing in EU	Create jobs in electronics industries Increase manufacturing plants in Europe	Number of direct and induced jobs in Europe – progress towards creation of 250.000 induced jobs Number of state-of-the-art fabs in Europe as measured by technology node and wafer size	the ECSEL Joint Undertaking
Leadership in equipment and material (E&M)	Strategic cooperation on E&M issues	Ranking and market share/volume of European E&M suppliers	the ECSEL Joint Undertaking
Support high TRLs	Scale and impact of projects	Number of new/upgraded pilot lines in Europe – at least 3 per year Number of demonstrators of integrated solutions – at least 3 per year Access and use by actors not directly implementing the pilot lines/demonstrators	the ECSEL Joint Undertaking
Availability of electronic components	Take-up of new technologies by European application sectors	European market share/volume for new solutions	the ECSEL Joint Undertaking
Leadership in system engineering	Strategic cooperation on embedded and smart systems issues	Ranking and market share/volume of European electronic systems suppliers	the ECSEL Joint Undertaking
the Performance of the ECSEL Joint Undertaking			
Set strategic research and innovation agenda	SRIA	Adoption of SRIA by all key players Clarity and focus as perceived by the stakeholders	the ECSEL Joint Undertaking
Efficient implementation of programme	JU operations	Time to grants (from call closing to grant signature) < 270 days Time to payment < 90 days Dissemination activities Project results	the ECSEL Joint Undertaking
Synergies for exploitation of results and fostering SMEs growth	Industrial up-take of project results	Number of spin-offs SMEs growth in terms of turnover and employment	the ECSEL Joint Undertaking

Ease participation in projects with strong European dimension	Simplified rules for participation	Industrial and SME participation rate – the latter ≥ 30% Reduction of administrative overhead	the ECSEL Joint Undertaking
Access to design and manufacturing infrastructure	Availability and open access to State-of-the-Art infrastructures	Access and use by SMEs, including system integrators	the ECSEL Joint Undertaking
Cooperation and coordination of stakeholders	Partnerships	Composition of consortia – emergence of strategic alliances	the ECSEL Joint Undertaking
Maintain human skills	Expertise available in Europe	Availability of curricula/courses and effective take-up of professional training in line with industrial needs	the ECSEL Joint Undertaking

Key Performance Indicators for all KICs	Source
Attractiveness of Education Programmes	KICs (EIT)
Number of new graduates	KICs (EIT)
Number of business ideas incubated	KICs (EIT)
Number of start-ups created	KICs (EIT)
Knowledge Transfer/Adoption	KICs (EIT)
New or improved products/services/processes launched	KICs (EIT)

Cooperative Arrangements	Proportion of projects/programs involving more than one participant Number of personnel contributing from each participant Industry contributions as a proportion of total funding Number of joint project/program sharing major facilities Number of project/program involving other CRCs and international collaboration	Australia CRCs
Research and Researchers	Number of publications (papers, presentations, [provisional] patents, etc.) Number and amount of external funding and awards Number of projects in progress	Australia CRCs
Education and Training	Number of higher degree students enrolled and/or completed (theses submitted) Number of participant (non-university) staff contributing to research training and/or teaching Number of courses developed and introduced, and conferences/ symposia/seminars held	Australia CRCs
Application of Research	Number of patent, licenses and royalties applied and/or granted/ received Number of processes and/or projects commercialised Number of consultancies or earnings of consultation Number of new participants and/or associate members Number of promotional articles/research publications on research results and products for users	Australia CRCs
Management and Budget	Proportion of research projects completed or milestones reached (in the planned time and within specified budgets) Total staff (full-time equivalents) including new appointments (CRC-funded) Efficiency and effectiveness of reporting systems including financial reporting system Number/frequency of internal reviews of activities/projects and strategies	Australia CRCs

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SHOKien vaikutusten arviointimallin ja suorituskykyindikaattorien kehittäminen

Tiivistelmä | Referat | Abstract

Tämä raportti kuvaa strategisten huippuosaamisen keskittymiin (SHOK) liittyvän mittausviitekehyksen kehitysprojektin tulokset ja joukon keskeisiä suorituskykyindikaattoreita. Raportin taustalla olleen projektin keskeisiä tehtäviä olivat tunnistaa, mitkä ovat olennaiset mitattavat tekijät, millä indikaattoreilla niitä voidaan mitata ja miten mittausjärjestelmää voisi käyttää SHOKien ohjaamiseen ja arvioimiseen. Projektissa keskityttiin SHOKien tutkimusohjelmien arviointiin, ja koko SHOK-toiminnan pitkän aikavälin yhteiskunnalliset vaikutukset rajattiin pääosin raportin ulkopuolelle.

Mittaamisen tavoitteiden ja tarpeiden selkeyttämistä varten haastateltiin ensin keskeisiä SHOK-toimijoita. Viiden kansainvälisen tutkimusohjelman arviointimenetelmät ja indikaattorit kartoitettiin ja niitä käytettiin eräänä lähtökohtana SHOKien indikaattorien kehittämisessä. Varsinaisesta mittareiden suunnittelusta vastasi SHOK-toimijoista koottu työryhmä. Käytännössä mittausviitekehys ja indikaattorit suunniteltiin neljän keskustelevan työpajan tuloksena. Keskeisten mitattavien tekijöiden tunnistamisessa hyödynnettiin haastattelujen ja työpajojen lisäksi myös SHOKien strategisia tavoitteita sekä SHOK-johtoryhmän asettamia kehityslinjauksia ja tavoitteita. Lisäksi SHOK-toimijoille järjestettiin kaksi laajempaa työseminaaritilaisuutta, joissa kerättiin palautetta ja kehitysideoita.

Projektin lopputuloksena syntyi SHOK-toimintaan räätälöity vaikutustenarviointimalli ja seitsemän suorituskykyindikaattoria käytettäväksi vuosittaiseen tutkimusohjelmien seurantaan. Indikaattorit on suunniteltu raportoitavaksi Työ- ja elinkeinoministeriölle sekä SHOK-johtoryhmälle osana SHOK-toiminnan vuosiraportointia. Tämä projekti osoitti taas kerran tutkimus-, kehitys- ja innovaatiotoiminnan mittaamisen haasteellisuuden. SHOKien kaltainen verkostomainen toimintaympäristö on erityisen hankala. Tästä johtuen osa mittareista saattaa vaikuttaa jonkun sidosryhmän näkökulmasta ongelmallisilta. Kirjoittajat kannustavat kuitenkin indikaattoreiden aktiiviseen hyödyntämiseen, koska vasta käytännön kokemusten perusteella päästään lopulta arvioimaan indikaattoreiden toimivuutta ja hyödyllisyyttä.

Työ- ja elinkeinoministeriön yhdyshenkilö: Elinkeino- ja innovaatio-osasto/Kirsti Vilén, puh. 029 506 4008

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Utveckling av en konsekvensbedömningsmodell och prestationsindikatorer för SHOK

Tiivistelmä | Referat | Abstract

Denna rapport beskriver resultaten av ett projekt för utveckling av en referensram för mätning och en rad centrala prestationsindikatorer för de strategiska centren för vetenskap, teknologi och innovation (SHOK). De centrala uppgifterna för det projekt som ligger bakom rapporten var att identifiera väsentliga mätbara faktorer, med vilka indikatorer de kan mätas och hur mätsystemet ska kunna användas för styrning och utvärdering av centren. Fokus i projektet låg på utvärdering av centrens forskningsprogram. De långsiktiga, samhälleliga konsekvenserna av centrens hela verksamhet lämnades i huvudsak utanför rapporten.

För att klargöra målen för och behoven av mätning intervjuades först relevanta SHOK-aktörer. Utvärderingsmetoderna och indikatorerna i fem internationella forskningsprogram kartlades och de användes som en referenspunkt i utvecklingen av indikatorerna för SHOK. En arbetsgrupp bestående av SHOK-aktörer ansvarade för den egentliga planeringen av mätarna. I praktiken planerades referensramen för mätningen och indikatorerna som resultat av fyra diskuterande workshoppar. Vid identifieringen av centrala mätbara faktorer utnyttjades utöver intervjuer och workshoppar dessutom centrens strategiska mål samt SHOK-ledningsgruppens utvecklingsriktlinjer och de mål som ledningsgruppen satt upp. Dessutom ordnades för SHOK-aktörerna två större arbetsseminarier, där man samlade in respons och utvecklingsidéer.

Som slutresultat av projektet skapades en för SHOK-verksamheten skräddarsydd konsekvensbedömningsmodell och sju prestationsindikatorer, som ska användas för en årlig uppföljning. Indikatorerna ska enligt planerna rapporteras till arbets- och näringsministeriet och SHOK-ledningsgruppen som en del av årsrapporteringen om SHOK-verksamheten. Detta projekt visade igen en gång hur utmanande det är att mäta forsknings-, utvecklings och innovationsverksamhet. En nätverksbaserad verksamhetsmiljö som det i centrens fall är fråga om är speciellt besvärlig. Därför kan en del mätare ur någon intressentgrupps perspektiv verka problematiska. Skribenterna uppmuntrar dock SHOK-aktörerna att aktivt utnyttja indikatorerna, eftersom man först utifrån praktiska erfarenheter till slut kan bedöma hur indikatorerna fungerar och till vilken nytta de är.

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Development of key performance indicators and impact assessment for SHOKs

This report defines the *measurement framework and a set of key performance indicators (KPIs) to measure the performance and impacts of* the strategic centres for science, technology and innovation (SHOKs). KPIs were developed for steering purposes. Three fundamental issues addressed by this project were the following: What are the relevant factors to be measured? What indicators are used to measure them? How is the measurement system used to manage and evaluate SHOKs? The focus of this project was on SHOK program level evaluation and, thus, the actual large-scale societal impacts that are expected to occur after five to ten years after each project has ended remain out of the scope of these indicators.

As a result, this report proposes an overall evaluation framework for SHOKs and a set of seven KPIs for annual monitoring. The KPIs are intended to be reported to the Ministry of Employment and the Economy and SHOK Governing Council along with qualitative descriptions of progress, key results and future visions. The project proved, once again, that the measurement of the impacts of research, development and innovation activities is very challenging, especially in a networked environment such as in the case of SHOKs. Therefore, it is possible that some of the KPIs seem problematic from the perspective of some SHOK stakeholder. Nevertheless, the project group encourages SHOK actors to actively utilize them. Based on using the KPIs it is possible to learn how they actually work and whether they can function as a valuable tool for monitoring and steering SHOK activities.

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