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S&T Analysis and Management of Innovation Activity IV (STAMINA IV)

Benefit Statements, Benefit-Cost-Risk Analysis, and Integration of Key Performance Indicators (KPIs) and Indicators of Success (IoS) into the S&T Business Process Flow (BPF)

Appendix B: Task 3 - Framework, Methodology, and Guide for Evaluating Key Performance Parameters (KPIs) and Indicators of Success (IoS) of R&D Transition Products

FY24 Annual Report
For Period September 29, 2023, to September 28, 2024

September 28, 2024

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Executive Summary

The S&T Analysis and Management of Innovation Activity IV (STAMINA IV) project consists of a Base Period from September 29, 2023, to September 28, 2024, and a 12-month Extension. This Appendix provides additional details on performance measurement of R&D projects in support of Task 3, Framework, Methodology, and Guide for Evaluating Key Performance Parameters (KPIs) and Indicators of Success (IoS) of R&D Transition Products.

S&T's R&D program responds to a broad range of homeland security threats and risks across a broad range of operational domains. The evaluation of R&D performance is generally challenging due to the many interrelated factors affecting stakeholders' perspectives on the expected outcomes and impacts of the R&D outputs. This inherent diversity presents a specific challenge in conveying the operational impact and value of transition product uptake benefits of S&T's R&D program to its diverse stakeholders, especially non-technical stakeholders.

To clarify these factors, this Appendix provides additional details on the performance measurement of R&D projects using Key Performance Indicators (KPIs) and Indicators of Success (IoS). Based on the KPIs and IoS literature review and analysis, as supported by the expanded descriptions and details here and in Appendices E, combined with the logic model representation for the S&T R&D lifecycle, we arrive at the classification of KPIs and IoS specific for S&T R&D performance assessment shown in Table ES-1.

Table ES-1 Classification of KPIs and IoS for R&D Performance Assessment.

The classification of KPIs and IoS in the framework of Table ES-1 enables an approach for identifying,

- KPIs at the **Research Level**: The research level KPIs play a pivotal role in assessing and measuring progress of the project. Researchers and leadership utilize a combination of both qualitative and quantitative metrics as KPIs, including factors such as publication impact, user satisfaction, and data accuracy, among others.

- KPIs and IoS at the **Transition Level**: At the transition level, KPIs and IoS explore the impact of transition on the intended end-users. Here, KPIs and IoS reflect the operational impact and implications on the users. The goal is to ensure the project's R&D research level KPIs align with the user requirements and address the problem they seek to solve.

- KPIs at the **Financial Level**: The financial level delves into the economic and commercialization benefits of implementing R&D results in an HSE domain. For this purpose, KPIs shift to metrics that assess and convey financial interests, such as the feasibility and profitability of translating the R&D results into commercial products or services. KPIs may include market demand, scalability, and cost-effectiveness. This classification recognizes and accommodates the importance of economic and commercialization benefits in achieving the overall R&D transition product benefits.

The integration of the classification of KPIs and IoS in Table ES-1 with the S&T R&D lifecycle leads to the overlay of KPIs and IoS in the context of the S&T R&D lifecycle of Figure ES-1.

Figure ES-1. Classification of KPIs and IoS Along R&D Lifecycle from BPF to NDAA Transition Reporting.

The flowchart is partitioned into multiple sections, such as inputs, outputs (or throughputs), outcomes, etc., with the basic premise of the section listed along with descriptions of the KPIs and IoS. Assessing R&D's long-term success is challenging as the impacts often emerge long after the initial R&D phases, making them delayed or difficult to measure. To address this issue, it is recommended that some KPIs address this challenge, such as an innovation metric, as applicable. This structure makes it possible to determine R&D project alignment with success from the outset.

The flowchart also displays the interconnectedness of R&D inputs with the project's outputs/throughputs and outcomes. This framework enables correlation analyses, which, for example, can show that the input of R&D expenditure or secured funding can yield the output of greater product counts, which can, in turn, lead to the outcome of technical advancements and product improvements.

Figure ES-1 provides a comprehensive set of KPIs and IoS applicable to various stages along the R&D lifecycle. The data for the assessment of these KPIs and IoS, along with the operational baseline, is then collected as an integrated activity in the BPF to enable scorecards and dashboards for tracking and monitoring both the R&D project's R&D and transition-related progress and enabling the resulting transition products' benefits to be assessed in terms of uptake outcomes, operational impact and HSE value.

The data for the operational baseline and assessment of these KPIs and IoS is then collected as an integrated activity in the BPF to enable scorecards and dashboards for tracking and monitoring the R&D project transition-related progress, and the resulting transition products and their benefits in terms of uptake outcomes, operational impact and HSE value.

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Appendix B: Framework, Methodology, and Guide for Evaluating Key Performance Parameters (KPIs) and Indicators of Success (IoS) of R&D Transition Products

B1. Performance Measurement of R&D Projects

B1.1. The Challenge of R&D Performance Assessment

The evaluation of Research and Development (R&D) performance is challenging due to the breath of factors characterizing both the definition of R&D itself and the measurement of its performance. Among these factors are the,

- **R&D Phase** – The spectrum of the driving nature and purpose of the R&D, ranging across,
  - Fundamental/Theoretical search for knowledge and understanding principles
  - Applied R&D, examining extensions or applications of early-stage/fundamental knowledge
  - Product development of new goods and commercial profit
- **R&D Motivation** – The varied motivations for the R&D and thus the primary areas of importance and perspectives on its end products, including,
  - Academic – knowledge discovery and dissemination of results
  - Commercial – new products to consumers, market penetration and percentage share, and profit margins
  - Government-sponsored – both of the above motivations for the public good
- **R&D Performer** – The range of the R&D's performers and their reward systems for performance, including,
  - Academic institutions
  - Federal/National/government laboratories
  - Federally Funded Research and Development Centers (FFRDCs)
  - Non-profit research institutions/centers (other than FFRDCs)
  - For-profit, private sector/industrial/commercial entities
- **R&D Domain and Stakeholder** – The multiple homeland security threats and risks across the broad range of operational domains of interest to DHS and their corresponding operational components, some examples of which include,
  - Borders and maritime domains of interest to CBP, TSA and USCG
  - Cybersecurity and critical infrastructure protection domains of interest to CISA
  - Natural disaster preparedness, resilience, and response domains, which are of interest to FEMA
  - Weapons of mass destruction potential, such as biological and nuclear threats, of interest to the CWMD program
- **R&D Indicators of Performance** – The multiple potential connotational interpretations and applicabilities of the R&D's results descriptors, all linguistically and associatively valid but which thereby lead to the R&D's performance measurement understanding challenges, using such terms as,
  - Inputs
  - Solutions
  - Outputs
  - Outcomes
  - Benefits
  - Impact
  - Value
  - Return-on-Investment

B1.2. KPIs Versus IoS

The terms "Key Performance Indicators (KPIs)" and "Indicators of Success (IoS)" are often used interchangeably, but there are subtle differences between them. While both KPIs and IoS help assess progress towards goals, the key differences between them include,

Focus:

- KPIs focus on measuring specific, quantifiable activities, measurable actions, and outputs directly linked to achieving strategic and tactical project-specific goals. KPIs are typically quantitative and time-bound, allowing for close monitoring and evaluation.
- IoS focus on achieving goals and objectives that represent the overall success of an organization, initiative, or project. IoS focus on impact, value, and satisfaction, representing the ultimate operational metrics of R&D transition success.

Timeframe:

- KPIs are measured over shorter timeframes, such as weekly, monthly, or quarterly, enabling rapid identification of areas needing improvement and course correction.
- IoS are measured over longer timeframes, like annually or even over several years, reflecting the longer-term impact and achievement of the overall R&D transition goal.

Relationship between KPIs and IoS:

- KPIs are building blocks that contribute to success in achieving IoS. By tracking, improving, and achieving individual performance targets reflected in KPIs, organizations move closer to achieving the desired IoS.
- KPIs should feed into IoS. Data gathered from KPIs can be used to assess the overall effectiveness of strategies and initiatives. IoS guide the selection and definition of KPIs, as the overall goals and desired outcomes should inform which specific actions and metrics are tracked through KPIs.
- Balance is critical as KPIs and IoS are both essential for a comprehensive understanding of progress and performance.

In summary, KPIs are specific, quantifiable metrics used to track R&D performance against predefined targets, while IoS provide a broader, more holistic view of overall R&D transition success and operational impact. KPIs focus on specific R&D performance aspects, while IoS encompass the factors contributing to achieving HSE value from the R&D's transition products. KPIs and IoS are essential in evaluating and measuring "success," but serve different purposes in assessing R&D transition performance.

B1.3. Classification of KPIs and IoS

R&D performance quantification typically relies on industry-, domain-, and project-specific KPIs and IoS. KPIs and IoS have similarities and differences, as discussed in more detail in Section D1.2, and both work together to present an overarching perspective of the overall, complete embodiment of R&D performance. KPIs are typically identified with the "front-end" of R&D in conjunction with the use of the S.M.A.R.T. guidelines (Doran 1981) for describing milestones towards achieving goals and objectives. They are selected to provide the measurable quantitative insight and feedback on the R&D project's technical and project management progress towards the milestones.

As described below, KPIs are also valuable in the ”middle/intermediate/in-between” stages of the R&D lifecycle to provide quantitative guidance on intermediate productivity measures indicative of future expected performance. KPIs are the preferred tracking techniques in the industrial/commercial/financial domain, in close coordination with scorecards and dashboards.

IoS typically work on the “back-end” of R&D, quantifying the importance of the R&D to the ultimate beneficiary of the R&D results. IoS focus on the benefits of the transition product uptake outcomes, and the outcomes then resulting in operational impact, which then translate into HSE value. These uptake benefits can be quantified with the Benefit-Cost Analysis (BCA) methodology, models, and categories of von Winterfeldt and John (references).

It is important to note that the focus of this effort and the accompanying discussions of KPIs and IoS is not in the traditional project management (PM) context, though important in its own right, referring to the traditional triple constraint, typically encompassing monitoring, measuring and tracking progress towards achieving 1) technical milestones and specifications, 2) budget expenditures, and 3) meeting schedule; or even the advanced PM metrics associated with Earned Value Management (EVM), risk registers, reserves and buy-downs, or quality. The focus of this effort is specifically on developing a methodology for identifying KPIs and IoS measuring R&D transition performance after the R&D has been conducted and concluded and its results have been delivered as a transition product to a receiving entity, perhaps possibly the first of several downstream receiving entities and transitions leading to operational uptake.

Furthermore, historically, KPIs and IoS have had traditional associations with metrics that gauge the R&D’s performance in a manner that implicitly associates the specific relationships embedded among the above-mentioned interpretations and the stakeholder parties. For example, the National Science Foundation (NSF, 2023) tracks R&D output indicators typically associated with government-sponsored R&D performed by academic institutions, and reflecting educational and societal benefits accruing from R&D such as the KPIs of,

- Science, Engineering, and Health Doctorates Conferred per 1,000 Employed Science, Engineering, and Health Doctorate Holders
- Academic Science and Engineering Article Output per 1,000 Science, Engineering, and Health Doctorate Holders in Academia
- Academic Science and Engineering Article Output per $1 Million of Academic S&E R&D
- Academic Patents Awarded per 1,000 Science, Engineering, and Health Doctorate Holders in Academia
- Patents Awarded per 1,000 Individuals in Science and Engineering Occupations

As a second example, Federal government agencies that operate Federal laboratories or conduct activities subject to the protection of federally owned inventions must file an annual performance report quantifying metrics with KPIs that include,

- Invention disclosures
- Non-provisional patent applications filed
- Patents issued
- Invention licenses
- Elapsed time for granting invention licenses

- Invention license income
- Total earned royalty income
- Number of Cooperative Research and Development Agreements (CRADAs) or similar

As a third example, Table B-1 provides a representative set of industrial/commercial KPIs used to determine the performance of R&D departments in the context of business and financial interests (extracted from Someka 2023). The breadth of these KPIs is procedurally broad, covering the spectrum from commercial project execution to finance. Yet, it is narrowly focused on metrics related to the major private industry concerns related to commercial success and financial return on investment (ROI).

Table B-1. Representative set of industrial/commercial KPIs used to determine the performance of R&D projects in a business/commercial context (extracted from Someka 2023)

- Project Execution
  - Proposal Success Rate
  - Ideas turned into experiments
  - Projects completed
  - Time-to-market
  - Time for the experiments
  - Deviation from Schedule
  - Portfolio in existing products
- Cost
  - R&D costs / Total costs
  - License costs / Total R&D cost
  - R&D Costs / Sales
  - Product improvements / R&D cost
  - Cost Savings Attributable to R&D
- Pipeline Management
  - Total Patents Filed
  - Ideas in the Pipeline
  - Projects that meet planned targets
  - Products launched on time
  - Number of products released
- Finance
  - Income from New products
  - Budget Variance / Cost Variance (CV)
  - Return on Innovation Investment (ROI)
  - Products launched on budget
  - R&D Effectiveness Index (RDEI)
- R&D Department
  - Total R&D Headcount
  - Portfolio in Core and Growth Projects
  - R&D Budget

B2. S&T R&D Lifecycle Logic Model

B2.1. Introduction and Background on Logic Models

To clarify and further the discussion of KPIs and IoS and their use to quantify transition-related performance, it is useful to introduce the “R&D laboratory as a system” (see Figure B-1, reproduced from the original article), a key concept from Brown and Svenson (1998) that structures the link between R&D and performance measurement (Bican 2020). The diagram introduces the concept of a logic diagram for R&D, correlating inputs, activities, outputs, outcomes, and measurement and feedback mechanisms.

Furthermore, studies evaluating R&D projects have often focused on only one performance aspect, such as the inputs. However, by considering both intermediate outputs (like patents and publications) and final outcomes (like enhanced products, processes, and sales) in addition to standard input indicators, a more comprehensive assessment of R&D success can be formed. For example, alternative metrics or 'altmetrics' can be used to overcome the limitations of typical bibliometric indicators (which track research impact from scholar to scholar) by instead tracking research impact to non-academic audiences through indicators such as social media mentions, downloads, and views, or online discussions.

A more comprehensive assessment framework is provided in Figure B-2, a second logic model representation of the R&D lifecycle from Landree and Silberglitt (2018). The additional insight provided by the figure from this article is the links among the individual elements of the model (i.e., inputs, activities, outputs, and outcomes) and to the operational mission and goals.

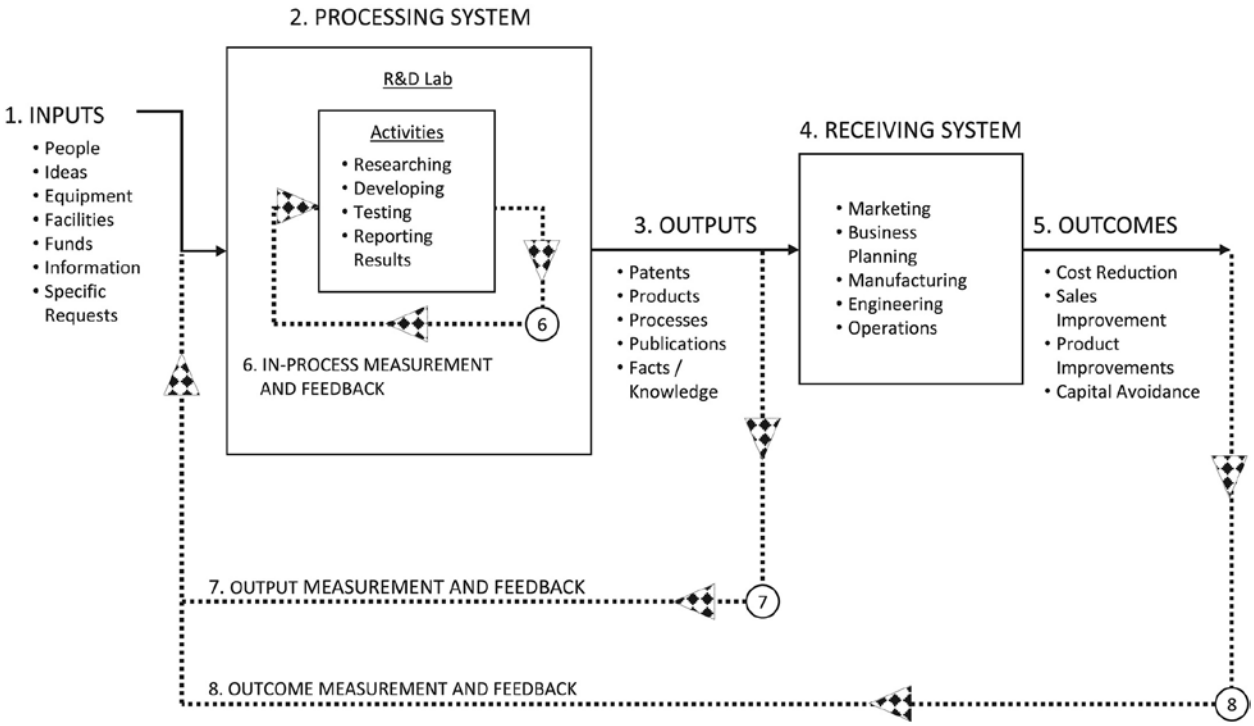

Figure B-1. From Bican 2020, R&D laboratory as a system. Source: Brown and Svenson 1998 (p. 106). Managing innovation performance: Results from an industry-spanning explorative study on R&D key measures, Creat Innov Manage, Volume: 29, Issue: 2, Pages: 268-291, First published: 07 May 2020, DOI: (10.1111/caim.12370).

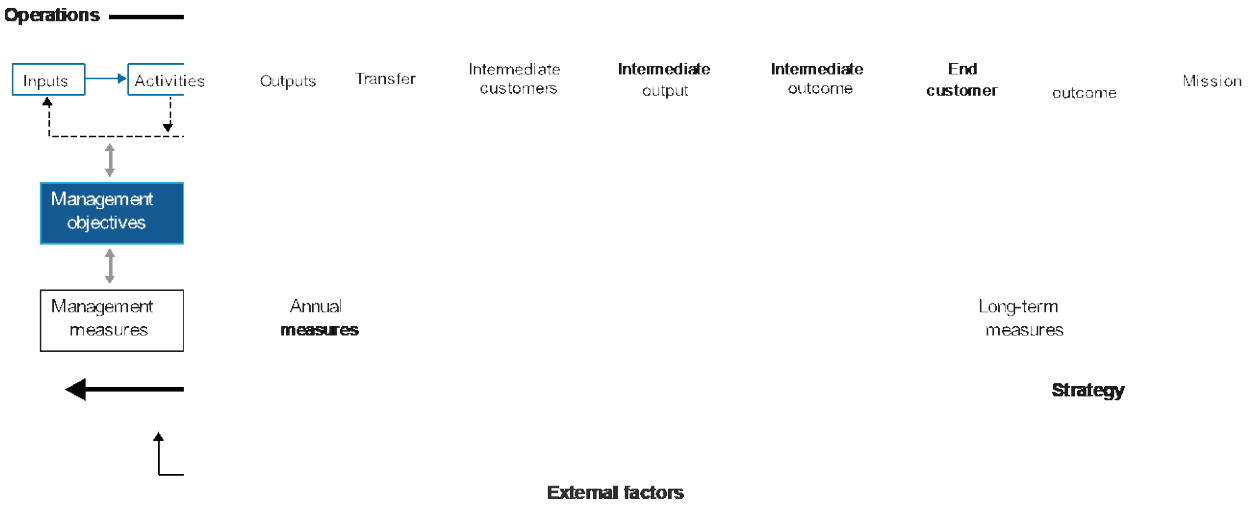

Figure B-2. From Landree and Silberglitt 2018, Figure 5. Depiction of Alignment of Program Operations with Goals and Measures. Source: Adapted from Greenfield, Williams, and Eisman, 2006.

Continuing with the expansion of examples, input indicators may include budget spent on applied research, budget spent on basic research, hours spent on project vs. total hours R&D, innovation level and degree of creativity, and project progress/projects completed to indicate performance; but supplementing with output indicators such as transfer rate of new knowledge and technology into product development, % of projects abandoned after partial completion, degree of anticipative ness to internal customer needs, % of new tech content in new products, planning accuracy, etc., provide a richer understanding of the R&D's performance.

Other examples of inputs to an R&D program, which would include the inputs to overarching management of the entirety of the R&D program, include the following,

- Money
- People (an input that can be converted to an equivalent money value, assuming capability and supply are reflected in labor cost)
    - By labor categories, e.g., executive level
    - Managerial level
    - Supervisory
    - Senior Researchers, Scientists, Engineers (RSE)
    - Entry-level RSE
    - Technicians
    - Assembly workers
- Facilities (all of which can be converted to an equivalent money value, assuming capabilities and supply are reflected in the facility utilization cost)
    - By type, e.g., national laboratory
    - Federally Funded Research and Development Center (FFRDC)
    - Academia
    - Industry
        - By type, e.g., specialized laboratory

    - Manufacturing
- Materials/Other Physical Resources (all of which can be converted to an equivalent money value, assuming supply chain and scarcity are reflected in the materials/resources cost)
- Information and Data (a more challenging endeavor to assign a monetary value to information/data, or developing an equivalence to data subscription services)

Other example logic model representations of the R&D lifecycle are provided in Appendix E, providing additional insights on the links among the individual elements of the model (i.e., inputs, activities, outputs, and outcomes) and operational missions and goals. The adaptation of the generic R&D lifecycle logic model specifically to the S&T BPF and the methodology developed herein is provided in Sections D2.2 and D2.3.

B2.2. R&D Lifecycle Logic Model

It is useful to introduce a specific form of the logic model diagram to meet the challenge in developing KPIs and IoS for quantifying S&T's R&D transition performance in the specific context of transition product operational impact and value for NDAA17 tracking and reporting. Following the logic model framework in the previous section, the generic logic model and glossary of terms for the R&D lifecycle are presented in Figure B-3 and Table B-2.

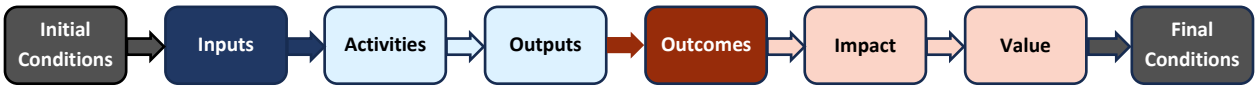

Figure B-3. Generic Logic Model for an R&D Project

Table B-2. Logic Model-Related Glossary of Terms for an R&D Project

Initial Condition	The operational baseline at the start of a project that the R&D aims to change
Inputs	The resources available to the R&D project, including human, material, and financial
Activities	The series of actions that will be taken to carry out the R&D and achieve its objectives
Outputs	Analogous to R&D results, these are the immediate achievements of the R&D project
Outcomes	The direct effect of the uptake of the **Outputs** of the R&D project by a receiving entity, which can be near/short-term, intermediate, or long-term
Impact	The change in operational performance metrics and measures resulting from the **Outcomes**
Value	The risk, economic/financial and human equivalents of the operational change resulting from the **Impact**
Final Conditions	The operational baseline after acquisition and implementation uptake of the **Outputs**

R&D activity is difficult to measure and assign a tangible output and value, which is why measurement systems have typically used R&D input or qualitative output evaluation. Overall, expanding the focus to include outputs, outcomes, impact and value, as defined by the sources cited in Appendix C of the comprehensive annual report, lead to more broadly useable indicators than solely using input indicators.

B2.3. Logic Model for S&T R&D Lifecycle

The underlying logic model concepts in these earlier efforts were developed and adapted to the DHS S&T R&D lifecycle process (Maya, Blancas, & Young 2023) and updated, as shown in Figure B-3. This model provides the framework for the methodology for quantification of R&D performance integrating both KPIs and IoS. It improves on previous models, expanding the R&D's downstream transition uptake-related components of Outcomes, Operational Impact, and HSE Value. This depiction thus more clearly identifies and highlights the importance of transition of R&D results to the intended operational users, focusing on measuring the operational impact of the transition product uptake and the value to the HSE.

Figure B-3. Logic Model for S&T R&D Lifecycle from BPF to NDAA transition reporting, focusing on transition product uptake impact and value.

Based on the KPIs and IoS discussion of Section D1, combined with the logic model representation for the S&T R&D lifecycle, we arrive at the classification of KPIs and IoS specific for S&T R&D performance assessment shown in Table B-4.

Table B-4. Classification of KPIs and IoS for R&D Performance Assessment.

The classification of KPIs and IoS in the framework of Table B-4 enables an approach for identification of,

- KPIs at the **Research Level**: The research level KPIs play a pivotal role in assessing and measuring progress of the project. Researchers and leadership utilize a combination of both qualitative and quantitative metrics as KPIs, including factors such as publication impact, user satisfaction, and data accuracy, among others. Thus, when quantifying success for research, indicators could include the extent to which, for example,
    - Research findings are used by stakeholders to make decisions
    - Research findings lead to change in policy or practice
    - Research findings contribute to a better understanding of the topic
    - Research findings contribute to the development of new technologies or solutions

- KPIs and IoS at the **Transition Level**: At the transition level, KPIs and IoS explore the impact of transition on the intended end-users. Here, KPIs and IoS reflect the operational implications for the users. The goal is to ensure the project's R&D research level KPIs align with the user requirements and address the problem they seek to solve.

- KPIs at the **Financial Level**: The financial level delves into the economic and commercialization benefits of implementing R&D results in an HSE domain. For this purpose, KPIs shift to metrics that assess and convey financial interests, such as the feasibility and profitability of translating the R&D results into commercial products or services. KPIs may include market demand, scalability, and cost-effectiveness. This classification recognizes and accommodates the importance of economic and commercialization benefits in achieving the overall R&D transition product benefits.

The integration of the classification of KPIs and IoS in Table B-4 with the S&T R&D lifecycle of Figure B-3 leads to the overlay of KPIs and IoS in the context of the S&T R&D lifecycle of Figure B-4.

Figure B-4. Logic Model Framework for Methodology for Identifying, Selecting, and Quantifying KPIs and IoS for S&T R&D projects and their transition products' uptake outcomes, operational impact, and HSE value.

The flowchart is partitioned into multiple sections, such as inputs, outputs (or throughputs), outcomes, etc., with the basic premise of the section listed along with descriptions of the KPIs and IoS. Assessing R&D's long-term success is challenging as the impacts often emerge long after the initial R&D phases, making them delayed or difficult to measure. To address this challenge, it is recommended that some KPIs address this characteristic, such as an innovation metric, as applicable. This structure makes it possible to determine R&D project alignment with success from the outset.

R&D input KPIs encompass the resources initially invested in an R&D project, spanning people, ideas, equipment, funds, and information. While financial inputs like R&D expenditure are commonly used as proxies for innovation, additional inputs such as project scope and technical complexity should also be considered. Examples include,

- R&D Expenditures/Funding Secured
- R&D Staffing/Human Resources
- Innovation Level and Degree of Creativity
- Project Scope and Complexity
- Project Progress and Milestones Completed

R&D outputs/throughputs represent the more immediate results arising from a project, with intermediate KPIs covering patents, products, processes, publications, and knowledge acquired during the R&D project.

Lastly, outcomes represent the more long-term effects of the project, indicating that the ultimate results of R&D were actually utilized and were impactful. Indicators include measures such as cost or risk reduction, sales improvements, and the introduction of new or enhanced products. Financial output indicators, such as return on investment, are commonly used. At the same time, integration metrics like time to market or the adoption of research findings offer additional insights into the utilization of the results of R&D.

The flowchart also displays the interconnectedness of R&D inputs with the project's outputs/throughputs and outcomes. This framework enables correlation analyses, which, for example, can show that the input of R&D expenditure or secured funding can yield the output of greater product counts, leading to the outcome of technical advancements and product improvements.

Figure B-5 provides a comprehensive set of KPIs and IoS applicable to various stages along the R&D lifecycle. The data for the assessment of these KPIs and IoS, along with the operational baseline, is then collected as an integrated activity in the BPF to enable scorecards and dashboards for tracking and monitoring both the R&D project's R&D and transition-related progress and enabling the resulting transition products' benefits to be assessed in terms of uptake outcomes, operational impact, and HSE value.

Figure B-5. Classification and Integration of KPIs and IoS along R&D Lifecycle from BPF to NDAA Transition Reporting.

The data for the operational baseline and assessment of these KPIs and IoS is then collected as an integrated activity in the BPF to enable scorecards and dashboards for tracking and monitoring the R&D project transition-related progress and the resulting transition products and their benefits in terms of uptake outcomes, operational impact, and HSE value. The IoS for transition product uptake operational impact and HSE value can be quantified with the Benefit-Cost Analysis (BCA) methodology, models, and categories of von Winterfeldt and John (reference), shown in the main report as Table 4-1, and reproduced herein for convenience as Table B-5.

Table B-5. BCA Benefit Categories and Calculational Models [Rx-y].

Monetized Benefit Categories and Models	Non-Monetized Benefits
1. CS: Reduced cost of operations without reducing performance; BCA Model 1	1. Filling gaps in an integrated technology system
2. PI: Increased performance without increasing cost; BCA Model 1	2. Satisfying legislative or regulatory requirements
3. RR(T): Reduction of threats; BCA Model 2	3. Responding to Congressional inquiries
4. RR(V): Reduction of vulnerabilities; BCA Model 2	4. Supporting appropriations requests
5. RR(C): Reduction of consequences; BCA Model 2	5. Supporting prioritization of DHS activities
6. SDT(D): Increased detection rates; BCA Model 3	6. Improving emergency management
7. SDT(F): Reduced false alarm rates; BCA Model 3	7. Improving coordination between agencies
8. VOI: Value of information to reduce uncertainty; BCA Model 4	
9. VOI: Value of Information to improve operations and decision making; BCA Model 4	
10. VoT: Value of Education & Training; BCA Model 5	

As an S&T R&D project proceeds along the BPF, shown in Figure B-6, R&D- and transition-related activities are conducted in parallel that lead to the coordinated development of a

knowledge and technology product transition plan (KTTP) based on the S&T Technology Transition Plan Template [R9], documenting the pathway for optimum transition of the project's expected technology and knowledge products to the intended operational component and/or other HSE customers and end-users. The KTTP documents the understanding between S&T and the intended end-users regarding the key considerations to address in maximizing the success of transition of the technology and knowledge products of the R&D.

Figure B-6. S&T's Business Process Flow (BPF) [ESR2]

The coordination among the participants in transition KPI and IoS planning and tracking along the BPF for the specific transition-related engagements is shown in Table B-6. Table B-7 provides additional granularity correlating the transition-related KPI and IoS development and tracking activities within the contextual domains of the transition-related activities along the BPF.

Following D-5, identifying and selecting an S&T R&D project's transition product operational benefit categories and developing a clear uptake benefit impact and value statement should occur at BPF1, the Customer Needs Scoping process. The benefit category or categories should be selected from a deliberatively comprehensive list in Table B-5, developed from the BCA references [R5-8]. It is perfectly acceptable to have more than one benefit category associated with an R&D project, in which case, all should be identified. A benefit of using the list in Table B-5 is that each benefit category is associated with a BCA calculational model that will enable the subsequent quantification of transition product uptake benefits. As this process matures, additional benefit categories may be identified. New calculational models may be developed to ensure the list is sufficiently comprehensive to meet the needs across the broad range of threats and risks associated with S&T's R&D operational domains in the HSE.

Table B-6. Transition-Related KPI and IoS Development Integration with the S&T BPF.

BPF Phase	Transition-Related KPI and IoS Development Integration with BPF
BPF1 Customer Needs Scoping	Identification and selection of transition product operational benefit categories, and development of clear uptake benefit impact and value statement
BPF 2 Decomposition	Identification of transition-related Key Performance Indicators (KPIs), Indicators of Success (IoS) matching benefits, data needs, and baseline quantification
BPF 3 Solutions Approaches	Initial quantification of transition product uptake Benefit-Cost-Risk-Analysis (BCRA)
BPF 4 Business Case Analysis	N/A
BPF 5 Project Pitch	Finalize transition product operational uptake benefit impact statement and transition-related KPIs, IoS, and BCRA
BPF 6 TR Kick-Off	N/A
BPF 7 TR Planning & Execution	N/A
BPF 8 Delivery	Determine final KPIs, IoS, & BCRA
BPF 9 Close-out/Post-Transition	Determine effort to collect data and conduct ongoing BCRA vs expected benefits for the required 3-year NDAA period to provide recommendations on "to the extent feasible"

Table B-7. Contextual Domain-Specific Transition-Related KPI and IoS Development Activities Along the BPF

Contextual Domain	BPF1	BPF2	BPF3	BPF5	BPF8	BPF9/Post-Transition
Benefit Category(ies)	Identify and Select		Review and Update	Finalize	Document Lessons Learned in benefit category selection	
Operational Baseline	Quantify		Review and Update	Finalize	Document Lessons Learned in obtaining baseline data	
Benefit / Impact Statement	Develop		Review and Update	Finalize	Document Lessons Learned in writing benefit impact statement	
KPIs and IoS		Identify & Quantify	Review and Update	Finalize	Determine final KPIs, IoS, & BCRA; Document Lessons Learned in identification, selection, and quantification of KPIs, IoS & risk	Report Transition-related IoS per NDAA
Transition Risks		Identify & Quantify	Review and Update	Finalize		
BCRA			Conduct	Finalize	Conduct update with Actuals/Achieved	Determine effort to collect data and conduct BCRA vs communication benefits for the required 3-year NDAA period to provide recommendation on "to the extent feasible"
Data	Specify	Specify	Review and Update	Finalize	Confirm Transition recipient support per NDAA needs	

The process of identifying and selecting the appropriate benefit category(ies) in BPF 1 then provides clarity and guidance on identifying and selecting the project's corresponding transition KPIs and IoS in BPF 2 Decomposition. The transition KPIs and IoS matching the benefits then lead directly to the identification of the corresponding data to be obtained from the operational component to enable quantification of the baseline intended to be improved by the R&D project's results implementation in the operational domain and their target and threshold values representing the value of the transition product uptake.

The initial quantification of transition product uptake risk, enabling Benefit-Cost-Risk-Analysis (BCRA), is conducted in BPF3, Solutions Approaches. In this step, the considerations of the risks and uncertainties for transition success of the R&D output are examined. Once the current Technology Readiness Level (TRL) is determined, the BCRA includes assessments of the likelihood that the technology will proceed successfully to each subsequent TRL required for transition. In addition, uncertainties related to funding, regulatory and legal challenges, and organizational and cultural barriers that would impact deployment and utilization are identified and assessed at this step. Finally, uncertainties related to changes in threat level and technology advances that could attenuate the expected lifespan usage of the technology are identified and assessed.

The transition product operational uptake benefit impact statement and transition-related KPIs, IoS, and BCRA are finalized and updated as an integral part of BPF 5 Project Pitch. Then, if, at any time during BPF 7 Execution, there is a material change to the projected technical performance at the project end, the transition-related KPIs, IoS, and BCRA should be updated.

Finally, given the actual results of the R&D project, the actual transition product operational uptake benefit impact statement and transition-related KPIs, IoS, and BCRA are finalized and updated as part of BPF 8 Delivery.

During BPF 9 Close-out/Post-Transition, the effort to collect data and conduct ongoing BCRA is evaluated versus the expected benefits for the required 3-year NDAA period to provide recommendations on "to the extent feasible" for each Transition Product. The methodology for determining this "on-ramping" of R&D project transition products into the 3-year requirement is provided in Section 4-6 in the main document.

B2.4. Examples of Key Performance Indicators (KPIs) and Indicators of Success (IoS) for S&T R&D Projects

This effort demonstrated the application of a methodology for analyzing articles of R&D projects similar to S&T R&D projects to identify and extract the articles' KPIs and IoS, then classifying them at the research level, the transition and user level, and the financial/commercialization level. The objective was to develop a detailed understanding of KPIs and IoS across the various types of R&D, the R&D lifecycle phase, and across multiple domains. We first reviewed the list of S&T R&D projects approved for STAMINA IV, and selected a subset on which to demonstrate the process. To provide continuity across the tasks, we selected the same projects used in Task 1. We then conducted literature reviews to find articles on similar R&D projects, which were then reviewed to extract KPIs and IoS.

The research was iterative, progressing through increasing refinements, expansions, and clarifications of the KPIs and IoS. In the first pass, general KPIs and IoS were extracted from the similar projects identified. As more articles were reviewed, increased understanding of the domain-relevant KPIs and IoS resulted. Then, a subsequent pass of the literature enabled deeper analysis to categorize the KPIs and IoS into specific categories, including PM KPIs (Cost, Resource, Schedule, Risk, Quality), R&D Performance KPIs, Transition KPIs, Operational IoS, and Financial/Commercial KPIS/ROI. A final pass of the literature was then performed to ensure all relevant KPIs and IoS had been categorized accurately, to add any additional KPIs and IoS, as applicable, and to ensure KPIs and IoS were clearly defined and appropriately categorized for better clarity and usability. Data on the KPIs and IoS were captured in Excel files, and an example segment of a typical table extracting KPIs and IoS from the articles is shown in Table B-3. The results of this effort for all the articles reviewed and refined are provided in the tables of KPIs and IoS, shown in Tables D-4 through D-7, systematically categorized across similar projects, providing a clear framework to identify the most relevant KPI and IoS categories. Details of the process are provided in Appendix D.

Data on the KPIs and IoS were captured in Excel files, systematically categorized across similar projects, providing a clear framework to identify the most relevant KPI and IoS categories. The categorization used provided a framework for accommodating and understanding the diverse breath of metrics used to measure R&D success across the S&T domain. The framework in turn enabled the analysis to focus on the KPIs and IoS of specific interest to this study, namely, R&D Performance KPIs, Operational/User-Level IoS, and Financial KPIs/ROI. By analyzing a range of similar projects, it was possible to identify prevalent KPIs and IoS across multiple articles, highlighting consistent KPI and IoS categories. This consistency suggests that common categories may simplify the effective identification and selection of KPIs and IoS in new S&T

R&D projects. Furthermore, this approach ensured that the KPIs and IoS were not only identified but also categorized in a manner that would facilitate easy reference and application in future evaluations. The results for the Detection Canine Program are shown in Table ES-6.

Table ES-6. Operational KPIs and IoS from Canine Articles.

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