Information Sciences

Root Source Analysis / ValuStream™ — a Methodology for Identifying and Managing Risks

Root sources of uncertainty are taken into account in a rigorous, systematic way.

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Root Source Analysis (RoSA) is a systems-engineering methodology that has been developed at NASA over the past five years. It is designed to reduce costs, schedule, and technical risks by systematically examining critical assumptions and the state of the knowledge needed to bring to fruition the products that satisfy mission-driven requirements, as defined for each element of the Work (or Product) Breakdown Structure (WBS or PBS). This methodology is sometimes referred to as the ValuStream method, as inherent in the process is the linking and prioritizing of uncertainties arising from knowledge shortfalls directly to the customer's mission driven requirements. RoSA and ValuStream are synonymous terms.

RoSA is not simply an alternate or improved method for identifying risks. It represents a paradigm shift. The emphasis is placed on identifying very specific knowledge shortfalls and assumptions that are the root sources of the risk (the "why"), rather than on assessing the WBS product(s) themselves (the "what"). In so doing RoSA looks forward to anticipate, identify, and prioritize knowledge shortfalls and assumptions that are likely to create significant uncertainties / risks (as compared to Root Cause Analysis, which is most often used to look back to discover what was not known, or was assumed, that caused the failure). Experience indicates that RoSA, with its primary focus on assumptions and the state of the underlying knowledge needed to define, design, build, verify, and operate the products, can identify critical risks that historically have been missed by the usual approaches (i.e., design review process and classical risk identification methods). Further, the methodology answers four critical questions for decision makers and risk managers:

1. What's been included?
2. What's been left out?
3. How has it been validated?
4. Has the real source of the uncertainty / risk been identified, i.e., is the perceived problem the real problem?

Users of the RoSA methodology have characterized it as a true "bottoms up" risk assessment. The insights gained regarding specific shortfalls (risks) in the underlying knowledge base are particularly important to decision makers in determining the readiness to proceed at major decisional milestones in the lifecycle of a program.

With RoSA the granularity of the assessment is taken to the level where one can see and assess the *driving assumptions and state of the knowledge* on which the program management and engineering rests, relative to specific customer-driven requirements. The methodology uses a knowledge matrix or grid.

The left side of the matrix is the program / project WBS (or PBS), which is the hierarchy of products, created by the designers, that are needed to satisfy mission requirements. The top of the matrix is a Capability Breakdown Structure (CBS), which is a hierarchy of the programmatic and / or technical disciplines, filled by engineers / scientists (termed Functional Discipline Specialists, FDS's), that provide the underlying knowledge needed to bring the product to fruition. The cells of the matrix are the individual knowledge elements needed for mission success. The FDS's assess the current state of the knowledge for each element and identify knowledge shortfalls that could significantly affect attainment of a customer's goals and requirements. These root sources of uncertainties are characterized as specific, *actionable* shortfalls in the analytical tools and databases, and fabrication verification and operations capabilities needed to provide the products that fulfill the customer's expectations. In the process, critical assumptions are also assessed, and standardized, discipline-unique capability readiness level (CRL) scales are used to quantify the readiness levels and to insure consistency. Once identified, these shortfalls and critical assumptions are analyzed in an interactive, multidisciplinary process that yields prioritized lists of risks and recommended mitigating actions.

Results from a RoSA assessment constitute a basic input into risk-management plans and technology plans and metrics. A part of the process is an interactive session involving both the FDS's (who tend to be technologically conservative) and the designers (who tend to be optimistic). This interaction between the two different perspectives significantly increases the validity of information.

RoSA is useful for identifying risks at any stage of the life cycle of a program or project. It has shown itself to be effective in validating the achievability of requirements and in identifying and prioritizing root sources of uncertainties / risks (i.e., the root sources of unreliability) in hardware / software from definition through design, as well as in fabrication, verification, and operations processes. It offers a truly independent validation of the technology readiness level (TRL) estimates, whether considering heritage hardware, commercial off-the-shelf (COTS), modified off-the-shelf (MOTS), or insertion of a new technology, by comparing TRL estimates made by the designers with the related capability readiness level (CRL) assessments made by the FDS's for the various WBS products. (The TRL cannot be higher than the underlying CRL of the knowledge elements on which the product depends.) Further, it is effective for planning technology programs and managing the associated risks, assessing technology maturation progress and readiness for deployment and for validating the programmatic and technical readiness of organizational capabilities to execute a program or project.

This work was done by Richard Lee Brown (self-employed consultant) for Marshall Space Flight Center. Inquiries concerning rights for the commercial use of this invention should be addressed to Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-32316-1.