1.1 Introduction

This text is a systemic reconception of the engineering and manufacture of software-based products. A software-based product is an article created and employed to induce or change the capabilities, properties, or behavior of a system of interest so as to improve the degree to which that system supports particular objectives of an enterprise.

The approach presented here is a generalized response to Dijkstra's admonition[1] to regard every software program as a member of a *family* of related programs, "as alternative programs for the same task or as similar programs for similar tasks". He asserts that it is not enough to just build an initially acceptable product: one must be able to argue that the resulting solution is "a deliberate choice out of a possible set of things you could have done", reconsidering that choice when changed circumstances require a modified solution.

Six precepts characterize the nature of building modern software-based products:

- *A product is conceived to serve a well-defined purpose.* It provides capabilities that enable a customer enterprise to operate effectively toward perceived objectives. A well-conceived product lacks nothing essential and includes nothing extraneous to its intended purpose. It must conform to or induce changes in how a customer enterprise operates.
- *A product operates according to its purpose to influence the behavior of an ecosystem*. A product is built to observe and induce changes in an ecosystem (i.e., entities interacting within a shared environment) based on an understanding of the nature and natural behavior of the environment and associated entities, the product's purpose and agency, and the mechanisms available to observe and influence behavior.
- *The effective ability of an enterprise to build products relies on coherent focus, continuity of purpose, a shared discipline of practice, and effective competence.*

[1] E.W.Dijkstra, "On Program Families" in *Structured Programming* (Academic Press, 1972) p 39-41 (from Dijkstra manuscript #249 (Aug 1969) p 50-52 < https://www.cs.utexas.edu/~EWD/ewd02xx/EWD249.PDF >.)

  - Coherent focus is the alignment of enterprise objectives, focusing the purpose for which the enterprise has been established, with a well-defined market focus.
  - Continuity of purpose is a commitment to maintaining the established purpose of the enterprise as the rationale for all past, current, and future endeavors of the enterprise. This enables viewing past products as retained capital assets, an investment to be leveraged in building future products having similar capabilities. Elements have residual value in avoiding repeated effort for building subsequent products or in providing insights on resolving recurrent engineering tradeoffs.
  - A shared discipline of practice is a commitment to the maturity, suitability, and compatibility of disciplined management and technical practices that are appropriate to the type of problems and potential range of solutions to be realized in products.
  - Effective competence is the alignment of collective developer problem-solution *competence*—knowledge, experience, and expertise—with enterprise development efforts. In particular, developers with experience building similar products require less effort to identify and resolve problem-solution uncertainties and tradeoffs in building an acceptable product.

- *Every well-defined problem has many potential solutions.* Each such solution must satisfy the criteria and constraints that characterize the problem but will differ from others in both essential and incidental aspects. Incidental differences, which arise due to different techniques, terminology, or conventions but result in products that exhibit equivalent behavior, can be reduced through use of disciplined practices. Conversely, essential differences between potential solutions represent different resolutions of critical tradeoffs among functionality, quality factors, and total lifecycle costs that must be weighed. Focusing prematurely on a particular solution can result in a product that is costly to build, an inferior fit to the customer's needs, and difficult to modify over time.

- *A problem must be properly understood to be properly solved.* The initial conception of a problem is often an incomplete, inaccurate, or poorly communicated understanding of needed capabilities. Perceptions of the problem may differ due to uncertainties, unknown or undisclosed information, differing assumptions, and conflicting opinions that should not be arbitrarily or prematurely resolved. Further, the actual problem changes over time as needs, circumstances, or enabling technology change. Understanding of a problem tends to change due to insights gained both during development and during use of a product. An effective development approach will support changing the solution as problem understanding changes.
- *Every constructible product is similar, in varying degrees and aspects, to other products, past, present, and future.* Similarity describes the change that would be required to cause a product to have behavior equivalent to that of a different product. This implicitly includes the similarity that exists between different versions of a single product.

These precepts are the foundation for an industrial approach for systematically building software-based products. Recognizing that similar problems are amenable to similar solutions is the basis for leveraging effort needed to build similar products. Customers needing substantially similar capabilities may be satisfied with a single ("one-size-fits-all") product but may need customized solutions if their essential needs differ by too much. Customized solutions may be custom ("one-of-a-kind") products or instances of a jointly managed set of products for customers that have reasonably similar needs. As traditional approaches poorly account for uncertainty, change, and diversity and treat software as a recurring cost rather than as an investment in future capability, a different approach can better support the predictable and cost-effective building of either singular changing products or sets of similar changing products.