

## 5.1 Basic Technical Challenges

The producibility vision is achievable by competent practitioners with current developmental capabilities. Although techniques and supporting technology used have been significantly improved over the years, further improvements in development practices and operational capabilities would enhance both productivity and software-based product quality.

*{advances needed to enhance effectiveness of producibility as practiced; correlate to Producibility paper topics for research and transition into practice}*

### Developmental Practices

Opportunities to improve developmental practices used in building software-based products or a product family:

- Software methods that foster engineering discipline (e.g., for each of the facets of the software project model defined in chapter 2 and as subsumed and extended for the DsE program model in chapter 3)
  - Maintaining a coherent focus by programs and projects on business objectives that align to institutional capabilities and needs of targeted customers or market as a whole, avoiding redundant or divergent efforts.
  - Adopting a development approach that entails continuous iteration to address uncertainty, diversity, and change in and among all products
  - Instituting applicable developmental quality criteria, actively managed to improve productivity and minimize variation in practices across programs and projects
  - Adopting methods that align to practitioner competence, with recurring training and assistance for continuous improvement
  - Leveraging methods through optimal automation of practices

- Techniques and tools that support recurring analyses of problem-solution properties and tradeoffs based on product quality factors and potential for change
  - Identifying alternatives and tradeoffs with rationale across all elements throughout a product's lifecycle
  - Recognizing product behavioral quality factors as first-class development concerns
  - Tracing the relationship between customer and engineering decisions and tradeoffs in customer quality factor criteria
- Improved capabilities for disciplined pre-deployment product evaluation
  - Systematic directed reviews, supported by quantitative and qualitative analytic and empirical verifications, of specifications and realizations
  - Evaluating whole-product consistency and completeness, adjusting for engineering and manufacturing variations
  - Monitoring dynamic behavior of a product in its actual/approximated or virtualized environment with the means to initialize data and inject faults and to observe and trace externally non-observable behavior
  - Simulating an enterprise-defined operational process and users/systems/devices performing product-relevant activities within that process
  - Emulating hardware devices, for use in behavioral specification or empirical product evaluation with unavailable or defective devices, or where feasible, for operational use as facsimiles of enhanced, inaccessible, or inoperative devices
- Enhanced methods and tools to enable building alternative versions or variants of a product or multiple similar products
  - Deriving multiple versions of a product corresponding to different problem-solution alternatives

- Analyzing product models to comparatively evaluate capabilities and properties of alternate versions of a product or element
- Identifying and choosing among approximate-fit alternatives to a valid but currently unbuildable product (possibly requiring relaxation of customer acceptance criteria)
- Verifying a derived (deployable or exemplar) instance against its defining product model, distinguishing family and instance-specific properties
- Verifying the properties of a product family in aggregate (i.e., an intensionally-defined set [see section 5.2])
- Collectively revising a set of similar or multi-version deployed products for both capability enhancement and defect remediation, accounting for problem-solution differences, customer-specified configurations, and user-determined preferences

## Operational Capabilities

Opportunities for advances (e.g., in data reliability, timeliness, and accuracy) that would enable developers in building products with systematically-enhanced operational capabilities:

- Mitigating hardware faults and failures
  - Software enhancement of hardware diagnostics and prognostics to detect, diagnose, and mitigate hardware faults and failures
  - Selective use of alternative or remote resources or emulation to approximate results of unavailable devices
  - Product self-monitoring and introspection-based explanations of product behaviors with causal rationale
  - Recognizing and adjusting for flawed or missing data
  - Detecting unspecified / unexpected behavior with diagnostic logging for root cause analyses, while recognizing and avoiding detrimental effects

- Suspending or deferring less critical behavior when needed resources exceed availability
- Accounting for temporality in defining behavior (e.g., local / universal time, transience / persistence: time varies with location and distance; strategic tasking can be across time but tactical actions must be local; even “hard real-time” must account for latency and semi-concurrent events ordering; account for inherent fixed / variant delay / latency to approximate zero-delay / “instantaneous” communications)
- Mitigating information and communications overload with prioritization and data filtering (when is data relevant / needed with how much delay, e.g., for immediate action, for timely planning of action, for tracking non-critical occasionally changing information, for historic / retrospective insight, evaluation, or learning; processing / filtering / aggregation / retention of continuous enviro-sensor data streams; spatial-temporal granularity of retained data)
- Translating program-standard developmental and operational terminology to conform to each customer’s enterprise preferences
- Efficiently accommodating evolving data representations, accounting for tradeoffs in information integrity, security, and accessibility, storage and access efficiency, representational diversity, and distribution / replication of content