

appendix D

A SDF-Derived Curriculum

This appendix outlines a framework for a System Design and Management Curriculum with suggested course content based upon the SDF. As discussed in the preceding chapters, all technical activities of the SDF can be organized into one of the basic categories: Requirements Development, Synthesis (Design, Analysis, Integration, and Verification) and Trade Analysis. This suggests a curriculum whose core technical subjects include these key topics. Managerial activities include topics such as: risk management, configuration management, subcontracts management, program planning, man-power planning, metrics definition and implementation, business development, customer interface, etc. This suggests a set of core System and Project Management courses that cover these topics in some detail. This curriculum is focused on the system development phase for complex system development.

Section 1

SDF-Derived Curriculum — Technical

I. Overall System Development Framework

Integrate into Requirements Development and Synthesis Courses

A. Time Domain View

B. Logical Domain View

C. Survey existing Standards

II. Requirements Development — Full Semester Course

B. Work Generation Activities

1. Derive Context Requirements

- QFD
- Requirements traceability
- Requirements traceability tools (doors, RTM, etc.)
- Requirements/specification writing
- Operations concept
- Program timeline
- Mission phases, modes, and states
- External interfaces

2. Generate Functional Description

- Function identification and diagramming
- Function interaction/interfaces

- Simulation of functional description
- Tools

C. Rework Discovery Activities

1. Analyze Requirements

- Implementation of Configuration Management activities
- Identification of all “To Be Determined” (TBD) holes in the requirements with a closure plan
- Identification of conflicting or inconsistent requirements with a closure plan
- Interpretation of vague or ambiguous requirements in order to review with the customer and gain his/her consensus
- Determination of the verification method (test, analysis, demonstration, simulation, inspection) that will be used for each requirement
- Determination of where in the system build-up each requirement will be verified

2. Analyze Functional Description

- Determine if the specification(s) is (are) complete and self-consistent
- Identify all functional requirements flowing out of imposed and derived requirements
- Determine performance requirements of each function and the relationships (interfaces, interdependencies, etc.) between functions
- Validated specification(s)
- Functional models (block diagrams, flow diagrams, behavior diagrams, simulations)

III. Synthesis — Full Semester Course

A. Work Generation Activities

1. Design

- Design space definition — parametric methods
- Partitioning — DSM
- New technology development
- CAE, CAD, CAM tools

2. Allocation

- Margin and contingency rules (e.g., NASA and DOD guidelines)
- Technical budget development and management

- Schedule development and management
- Cost estimation and management
- Technical performance measures, metrics

3. *Analysis*

- Form and function
- Partitioning — DSM techniques
- Lower level specification development
- Tools (RDD-100, etc.)

4. *Functional Decomposition*

5. *Inter-Tier Interaction*

- Data quality and control of information flow down
- Interface control/management

6. *Design Integration*

- Interface identification and characterization
 - Data (buses, discrete, serial, parallel, protocols)
 - Power (primary, secondary, RF, optical, etc.)
- Risk, configuration, and subcontract management (system and project management course)

B. *Rework Discovery Activities*

1. *Design Phase Test Activities*

- a. Test planning
- b. Analyses
- c. Testing engineering test models (ETM), breadboards, etc.

2. *Testability, Producibility, Specialty Engineering Analyses*

3. *Optimization*

- Linear, non-linear, integer programming techniques (system optimization course)
- Other techniques

IV. *Trade Analyses*

Discuss the various trade-off methodologies in the literature (cf. Footnote 57, page 85, where four sources are identified).

Section 2

SDF-Derived Curriculum — Managerial

I. Content of System Development Management Courses

A. Developing the Program Structure

Part of System and Project Management Course

- Partitioning
- Interaction control logic

B. Program Management

Part of System and Project Management Course

- Risk management
- Configuration management
- Cost development and management
- Schedule development and management
- Roles and responsibilities definition
- Reviews and audits
- Subcontracts management
- Customer interface
- Senior management interface

C. General Managerial Skills — Core Courses

1. Business development and marketing

- Proposal development and management
- Red team reviews
- Business plan development

- New technology development and management
- Short and long-term business strategy
- Technical presentations
- Marketing and customer strategy

2. *Accounting and Finance*

3. *System Dynamics*

4. *Engineering Risk Benefit Analysis*

D. Functional Management

Part of Organizational Processes Course

- Team dynamics
- Hiring practices
- Benefits, compensation, incentives
- Performance appraisals

II. Manufacturing, Production, and Distribution

Operations Management Course

Notional SDF-Based Assignments

I. Develop Requirements

Activities

- Collect and analyze imposed requirements
- Derive requirements through mission analysis, functional analysis, design, allocation, and decomposition
- Manage requirements derived during the development process
- Communicate requirements and requirements changes
- Determine and track how and where in the system build-up the requirements will be verified
- Maintain traceability of requirements
- Change impact analysis

A. Inputs

Collect Inputs

- Immediate customer
- Subcontractors
- Heritage designs
- The department
- The division
- Procuring organization
- New technology
- Competitors
- Business development
- The corporation
- User community

B. Work Generation Activities

1. Derive Context Requirements

Activities/Assignments:

Identify all mission phases, modes, and states
Identify and characterize all external interfaces, by mission phase
Define the environments to which the system will be subjected, by mission phase
Identify critical issues by mission phase (events, technologies, etc.)
Develop the concept of operations

Output

- Specification(s)
- Operations concept
- Context diagram(s)
- Entity relation diagram(s)
- Event list(s)
- External ICDs
- FMECA

2. Generate Functional Description

Activities/Assignments:

Identify all functional requirements flowing out of imposed and derived requirements
Develop the specification(s)
Determine performance requirements of each function and the relationships (interfaces, interdependencies, etc.) between functions

Output

Specification(s)
Functional models (block diagrams, flow diagrams, behavior diagrams, simulations)

C. Rework Discovery Activities

1. Analyze Requirements

Activities/Assignments:

Outline implementation of Configuration Management activity

- Identify all of “To Be Determined” (TBD) holes in the requirements with a closure plan
- Identify conflicting or inconsistent requirements with a closure plan
- Interpret vague or ambiguous requirements in order to review with the customer and gain consensus
- Determine the verification method (test, analysis, demonstration, simulation, inspection) that will be used for each requirement
- Determine where in the system build-up each requirement will be verified

2. *Analyze Functional Description*

Activities/Assignments:

- Determine if the specification(s) is (are) complete and self-consistent
- Identify all functional requirements flowing out of imposed and derived requirements
- Determine performance requirements of each function and the relationships (interfaces, interdependencies, etc.) between functions

Output

Validated specification(s)

Functional models (block diagrams, flow diagrams, behavior diagrams, simulations)

Output → Functional Description

Customer Consensus — Gain Instructor Consensus

II. Synthesis

A. Work Generation Activities

1. Design

Activities/Assignments:

- Quantify Design Space (H/W & S/W)
 - Parametric Analyses
 - New technologies and heritage designs are surveyed for applicability
- Generate Preliminary Design
 - Block diagrams, Schematics, Drawings, etc.
 - Internal ICDs
- Risk Management → Identify and Assess Risk
 - Technical performance, cost, schedule
 - Preliminary mitigation approaches
- Configuration Management of all design documentation

Output → H/W & S/W concept(s) and/or design(s), Risk assessment

2. Allocation

Activities/Assignments:

- Allocate functionality, performance, constraints to H/W and S/W elements
- Define budgets
 - Technical: mass, power, throughput, memory, RF links, etc.
 - Reliability, Contamination, etc.
 - Margin and Contingency Rules
- Performance Monitoring — Metrics Development — Define/Refine TPMs
- Cost and Schedule Management

Output → Budgets, Technical Performance Measures

3. Analysis

Activities/Assignments: Perform the following as appropriate:

- Mission, system, electrical, digital, analog, RF, mechanical, etc.
- Simulations
- FMECA (Failure Modes Effects and Criticality Analysis)

4. Functional Decomposition

Activities/Assignments:

- Decompose the implementation into subfunctions
- Identify the interfaces between the subfunctions
- Generate the functional model and verify the functional definition
- Generate the specification(s) and ICDs

Output → Lower-level validated specifications and ICD(s), lower-level simulation

5. Integration

Activities/Assignments:

- Identify and characterize interfaces
- Update Specifications, ICDs, Databases, Etc.
- Update Design Definition

- Update Mission Timeline and Operations Concept
- Develop Block diagrams, schematics, Drawings, layouts
- Management Activities
 - Performance Measurement — Budgets, etc.
 - Subcontract Management
 - Risk Management — Identification, assessment, and mitigation approaches
 - Configuration Management — Configuration Control Board (CCB)

Output → Integrated design that includes the data generated above

B. Rework Discovery Activities

Activities/Assignments:

1. Analysis, Development Testing, and Test Planning

- Analysis — Perform those analyses aimed at determining “how well” the current design meets its requirements. This is in contrast to those analyses aimed at defining design space which are performed as described above in the design activity.
- Perform development testing as appropriate (e.g., ETMs, prototypes, breadboards)
- Develop product test plans (e.g., test requirements, test flow, resource planning, etc.)

2. Producibility, Testability, and Other Specialty Engineering Activities

These activities assess those areas of the design commonly called “specialty engineering” concerns.

- Assess testability within resource and time constraints
- Assess producibility within resource and time constraints
- Assess acceptability with respect to EMI/EMC, reliability, maintainability, affordability, supportability, etc. parameters

3. Optimization

Discuss various optimization approaches. Perform appropriate optimization analyses.

Output → The output of the Design Verification activity is a design that has been assessed as to how well it meets all the requirements.

III. Trade Analysis

Discuss the pros and cons of the various trade methodologies found in the literature. Perform a trade study commensurate with customer requirements, program need, and other criteria as determined by the development team.

Highlight the classic trade-off that occurs in most any system development activity: cost, schedule, and technical performance. Also include issues relating to risk, robustness, safety, cost, schedule, and technical performance.