IEEE Recommended Practice for Distributed Interactive Simulation—Verification, Validation, and Accreditation

1278.4™

IEEE Computer Society

Sponsored by the
Distributed Interactive Simulation Committee

IEEE
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Distributed Interactive Simulation Committee
of the
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Abstract: Guidelines are established for the verification, validation, and accreditation (VV&A) of distributed interactive simulation (DIS) exercises. “How-to” procedures for planning and conducting DIS exercise VV&A are provided. Intended for use in conjunction with IEEE Std 1278.3-1996, this recommended practice presents data flow and connectivity for all proposed verification and validation activities and provides rationale and justification for each step. VV&A guidance is provided to exercise users/sponsors and developers.
Keywords: accreditation; certification; Distributed Interactive Simulation; simulation; validation; verification; warfare simulation; wargames

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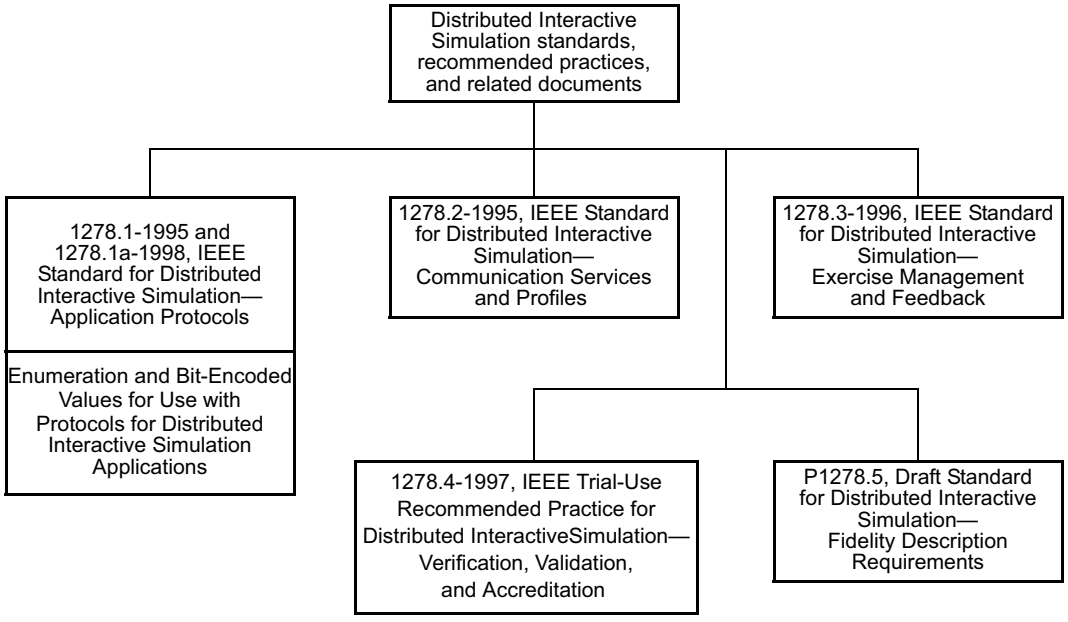
Introduction

(This introduction is not part of IEEE Std 1278.4-1997 (Reaff 2010), IEEE Recommended Practice for Distributed Interactive Simulation—Verification, Validation, and Accreditation.)

Distributed Interactive Simulation (DIS) is a government/industry initiative to define an infrastructure for linking simulations of various types at multiple locations to create realistic, complex, virtual "worlds" for the simulation of highly interactive activities. This infrastructure brings together systems built for separate purposes, technologies from different eras, products from various vendors, and platforms from various services and permits them to interoperate. DIS exercises are intended to support a mixture of virtual entities with computer-controlled behavior (computer-generated forces), virtual entities with live operators (human in-the-loop simulators), live entities (operational platforms and test and evaluation systems), and constructive entities (wargames and other automated simulations). DIS draws heavily on experience derived from the Simulator Networking (SIMNET) program developed by the Advanced Research Projects Agency (ARPA), adopting many of SIMNET's basic concepts and heeding lessons learned.

In order for DIS to take advantage of currently installed and future simulations developed by different organizations, a means had to be found for assuring interoperability between dissimilar simulations. These means were developed in the form of industry consensus standards. The open forum (including government, industry, and academia) chosen for developing these standards was a series of semi-annual workshops on standards for the interoperability of distributed simulations, which began in 1989. The results of the workshops have been several IEEE standards along with supporting documentation. These standards provide application protocol and communication services and profile standards to support DIS interoperability. In addition, an IEEE recommended practice for exercise management and feedback provides user guidelines for setting up and conducting a DIS exercise.

The relationship between the component documents constituting the set of IEEE DIS documents is shown in the figure below. Used together, these standards and recommended practices will help to ensure an interoperable simulated environment.



Documentation relationships

The interoperability components addressed by these standards and recommended practices are as follows:

a) Application protocols;
b) Communication services and profiles;
c) Exercise management and feedback;
d) Validation, verification, and accreditation; and
e) Fidelity description requirements.

IEEE Std 1278.1-1995, *IEEE Standard for Distributed Interactive Simulation—Applications Protocols*, and IEEE Std 1278.1a-1998 (Supplement to IEEE Std 1278.1-1995) define the format and semantics of data messages, also known as protocol data units (PDUs), that are exchanged between simulation applications and simulation management. The PDUs provide information concerning simulated entity states, the type of entity interactions that take place in a DIS exercise, and data for management and control of a DIS exercise, simulated environment states, aggregation of entities, and the transfer of control entities. IEEE Std 1278.1a-1998 also specifies the communciation services to be used with each of the PDUs.

An additional, non-IEEE document is required for use with IEEE Std 1278.1-1995 and IEEE Std 1278.1a-1998. This document is entitled *Enumeration and Bit-Encoded Values for Use with Protocols for Distributed Interactive Simulation Applications* and is available from the Defense Modeling, Simulation and Tactical Technology Information Analysis Center.[1]

IEEE Std 1278.2-1995, *IEEE Standard for Distributed Interactive Simulation—Communication Services and Profiles*, defines the communication services required to support the message exchange described in IEEE Std 1278.1-1995 and IEEE Std 1278.1a-1998. In addition, IEEE Std 1278.2-1995 provides several communication profiles that meet the specified communications requirements.

Taken together, IEEE Std 1278.1-1995, IEEE Std 1278.1a-1998, and IEEE Std 1278.2-1995 provide the necessary information exchange for the communications element of DIS.

IEEE Std 1278.3-1996, *IEEE Recommended Practice for Distributed Interactive Simulation—Exercise Management and Feedback*, provides guidelines for establishing a DIS exercise, managing the exercise, and providing proper feedback. This recommended practice is used in conjunction with IEEE Std 1278.1-1995, IEEE Std 1278.1a-1998, and IEEE Std 1278.2-1995.

IEEE Std 1278.4-1997, *IEEE Recommended Practice for Distributed Interactive Simulation—Verification, Validation, and Accreditation*, provides guidelines for verifying, validating, and accrediting a DIS exercise. This recommended practice, used in conjunction with IEEE Std 1278.3-1996, presents data flow and connectivity for all proposed verification and validation activities and provides rationale and justification for each step.

IEEE P1278.5, *Draft Standard for Distributed Interactive Simulation—Fidelity Description Requirements*, provides a taxonomy of fidelity characteristics with a consistent and uniform language to describe fidelity at six levels: resource, fidelity domain, capability, implementation, characteristic, and descriptor.

[1]For information about the Defense Modeling, Simulation and Tactical Technology Information Analysis Center, see their Web site at http://dmsttiac.hq.iitri.com/.

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During the development cycle of this recommended practice, the DIS Verification, Validation, and Accreditation Subgroup had the following membership:

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Contents

IEEE Recommended Practice for Distributed Interactive Simulation—Verification, Validation, and Accreditation

1. Overview

1.1 Scope

This recommended practice establishes guidelines for the verification, validation, and accreditation (VV&A) of Distributed Interactive Simulation (DIS) exercises. It provides "how-to" procedures for planning and conducting DIS exercise VV&A.

1.2 Application

This recommended practice is intended for use by persons responsible for or participating in DIS exercise VV&A activities (e.g., VV&A agents, VV&A teams, exercise managers, exercise architects). It provides VV&A guidance to exercise users/sponsors and developers. It does not specify who can or cannot participate in a DIS exercise or in the VV&A process.

DIS exercises are conducted for a variety of reasons (e.g., technical demonstration, training, requirements definition, concept definition, acquisition, analysis, test, and evaluation). Because each objective has different requirements, this recommended practice offers latitude in defining and applying the principles of DIS exercise VV&A to suit the needs of the exercise user/sponsor and the accreditation agent. Depending upon the exercise objectives and the allocated time and assets, the procedures involved and the degree to which they should be followed can vary significantly.

2. References

This recommended practice shall be used in conjunction with the following publications. When the following standards are superseded by an approved revision, the revision should apply.

IEEE Std 1278.1-1995*,* IEEE Standard for Distributed Interactive Simulation—Application Protocols.[1]

[1]IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

IEEE Std 1278.2-1995, IEEE Standard for Distributed Interactive Simulation—Communication Services and Profiles.

IEEE Std 1278.3-1996, IEEE Recommended Practice for Distributed Interactive Simulation—Exercise Management and Feedback.

IEEE P1278.5, Draft Standard for Distributed Interactive Simulation: Fidelity Description Requirements.[2]

IST-CF-97-23, Enumeration and Bit-Encoded Values for Use with Protocols for Distributed Interactive Simulation Applications.[3]

3. Definitions and list of acronyms and abbreviations

3.1 Definitions

For purposes of this recommended practice, the following terms and definitions apply:

3.1.1 acceptability criteria: A set of standards, established by the modeling and simulation (M&S) application sponsor or accreditation authority, that a particular model or simulation must meet to be accredited for a given use. The criteria will be unique to each problem and will give key insights to potential solutions.

3.1.2 accreditation: (1) Distributed simulation accreditation is the official certification that a distributed simulation is acceptable for use for a specific purpose. (2) Model/simulation accreditation is the official certification that a model or simulation is acceptable for use for a specific purpose.

3.1.3 compatible/DIS compatible: Two or more simulations/simulators that are Distributed Interactive Simulation (DIS) compliant and whose models and data that send and interpret protocol data units (PDUs) support the realization of a common operational environment among the systems (i.e., they are coherent in time and space).

3.1.4 compliant/DIS compliant: A simulation/simulator that can send or receive protocol data units (PDUs) in accordance with IEEE Std 1278.1-1995[4] and IEEE Std 1278.2-1995. A specific statement must be made regarding the qualifications of each PDU.

3.1.5 component: A model, simulation, or database used or considered for use in a Distributed Interactive Simulation (DIS) exercise.

3.1.6 conceptual model: A simulation implementation-independent representation of the exercise architect's understanding of the exercise objectives, requirements, and environment. The model includes logic and algori thms and explicitly recognizes assumptions and limitations.

3.1.7 data: A representation of facts, concepts, or instructions in a formalized manner suitable for communication, interpretation, or processing by humans or by automatic means.

3.1.8 database (DB): A collection of interrelated data, often with controlled redundancy, organized according to a schema to serve one or more applications; the data are stored so that they can be used by different

[2]IEEE P1278.5 was an authorized standards project at the time this standard was balloted; however, as this standard goes to press plans are under way to withdraw the draft. The IEEE Standards Department will maintain a copy of the last edition of this draft for reference.

[3]For information on this and other projects under way at the Defense Modeling, Simulation and Tactical Technology Information Analysis Center, check their web site at http://dmsttiac.hq.iitri.com/.

[4]Information on references can be found in Clause 2.

programs without concern for the data structure or organization. A common approach is used to add new data and to modify and retrieve existing data.

3.1.9 data verification, validation, and certification (VV&C): The process of verifying the internal consistency and correctness of data, validating that it represents real-world entities appropriate for its intended purpose or expected range of purposes, and certifying it as having a specified level of quality or as being appropriate for a specified use, type of use, or range of uses. The process is conducted from two perspectives: (1) the data producer ensures the data produced satisfy the appropriate standards and (2) each data user ensures the data selected are appropriate for the specific application.

3.1.10 Distributed Interactive Simulation (DIS): A time-and-space-coherent synthetic representation of world environments designed for linking the interactive, free play activities of people in operational exercises. The synthetic environment is created through real-time exchange of data units between distributed, computationally autonomous simulation applications in the form of simulations, simulators, and instrumented equipment interconnected through standard computer communicative services. The computational simulation entities may be present in one location or may be distributed geographically.

3.1.11 exercise/DIS exercise: (1) One or more sessions involving two or more interacting simulation applications with a common objective and accreditation. Participating simulations share a common identifying number called the exercise identifier and use correlated representations of the synthetic environment in which they operate. (2) The total process of designing, assembling, testing, conducting, evaluating, and reporting on an activity.

3.1.12 interoperable/DIS interoperable: Two or more simulations/simulators that, for a given exercise, are Distributed Interactive Simulation (DIS) compliant and DIS compatible and whose performance characteristics support the fidelity required for the exercise.

3.1.13 measure of effectiveness (MOE): Measure of how the system/individual performs its functions in a given environment. Used to evaluate whether alternative approaches meet functional objectives and mission needs.

3.1.14 measure of performance (MOP): Measure of how the system/individual performs its functions in a given environment. It is closely related to inherent parameters (physical and structural), but measures system/individual behavior.

3.1.15 protocol data unit (PDU): A Distributed Interactive Simulation (DIS) data message that is passed on a network between simulation applications according to a defined protocol.

3.1.16 session: A portion of an exercise that is contiguous in wall clock (sidereal) time and is initialized by a session database that includes network, entity, and environment initialization and control data.

3.1.17 validation: The process of determining the degree to which a distributed simulation is an accurate representation of the real world from the perspective of the intended use(s) as defined by the requirements. Validation also refers to the process of determining the confidence that should be placed on this assessment.

3.1.18 verification: The process of determining that an implementation of a distributed simulation accurately represents the developer's conceptual description and specifications.

3.2 List of acronyms and abbreviations

ARPA Advanced Research Projects Agency
ATM asynchronous transfer mode
CASE computer-aided software engineering

DB	database
DIS	Distributed Interactive Simulation
DMSO	Defense Modeling and Simulation Office
DoD	Department of Defense
DSI	Defense Simulation Internet
EMF	exercise management and feedback
IDEF0	Integrated Computer-Aided Manufacturing Definition process modeling technique
IST	Institute for Simulation and Training
M&S	modeling and simulation; model and/or simulation, models and/or simulations
MOE	measure of effectiveness
MOP	measure of performance
MSRR	Model and Simulation Resource Repository
PDU	protocol data unit
SAF	semiautomated forces
SME	subject matter expert
V&V	verification and validation
VV&A	verification, validation, and accreditation
VV&C	verification, validation, and certification (of data)

4. Factors relating to the implementation of exercise VV&A

This clause describes some of the considerations of exercise development and VV&A activities that impact the relationship between the exercise life cycle and the VV&A process.

4.1 Factors relating to the exercise

4.1.1 Credibility/risk

Credibility is essential for the acceptance of results of any model or simulation. DIS exercises are no exception. Users must have assurance that models and simulations will perform as expected, are capable of being integrated into the planned DIS exercise, and can adequately support the intended purpose of the exercise. VV&A activities can assist in lowering development and integration risk while greatly enhancing the credibility of distributed simulations. Such considerations drive the need for a formal, systematic, disciplined approach to the VV&A of distributed simulation exercises.

4.1.2 Reuse

Reuse of existing components is a cost-effective method for building a DIS exercise. Reuse is encouraged and supported by thorough and consistent record keeping and configuration management. The extent of the VV&A effort necessary for an exercise is determined in part by the availability and completeness of the VV&A histories of the components. When an exercise configuration uses a well-documented preexisting architecture or when the configuration comprises individual components with detailed VV&A histories, fewer and less intense verification and validation (V&V) activities are needed than when the configuration is new or when records and VV&A histories are nonexistent or incomplete. The maintenance of detailed records of model versions, deficiencies, remedial actions performed, and resources assigned and consumed on each task also contributes to the continuous improvement and refinement of VV&A procedures and assists in the calibration of VV&A cost models.

4.1.3 Communication requirements

Communication linkage between models and simulations is the backbone of any distributed exercise. Systems currently used to support DIS exercises include the Defense Simulation Internet (DSI) and dedicated

telephone lines. Future transmission schemes, such as the asynchronous transfer mode (ATM) and the Defense and Engineering Network (the next phase of DSI), may offer expanded bandwidth and better balance among data, video, and voice requirements and will undoubtedly affect the communications architectures and interfaces used in a DIS exercise. A major part of the VV&A effort should involve evaluation of the linkage to ensure that it allows appropriate and timely interactions and accurate transmissions between the proper components.

4.1.4 Aggregation/deaggregation requirements

Objects or entities are often aggregated or deaggregated in constructive modeling to reduce network traffic or to provide the views of entities that are appropriate for the various situations. An exercise may employ varying levels of resolution. If a simulation is used to examine the behavior of single entities inside an aggregated unit, special interface adapters may be required to deaggregate the unit, allowing interactions between entities on a one-on-one basis. In addition, aggregation and deaggregation can affect the fidelity of the objects being represented. Deaggregated assets are often viewed and modeled at a higher level of fidelity than aggregated assets. The exercise VV&A effort will involve testing the effectiveness of the interface adapters as well as evaluating the appropriateness of the levels of fidelity represented.

4.2 Factors relating to VV&A

4.2.1 Component-level VV&A

A DIS exercise is formed by electronically linking individual components (e.g., constructive models, virtual reality simulations, simulators, instrumented field exercises). Component V&V done previously for a similar application can serve as a foundation for the exercise VV&A effort. However, if a component's VV&A history is inadequate or inappropriate, the exercise sponsor decides if additional component-level VV&A is needed to ensure that the component can meet the compliance, compatibility, and interoperability criteria appropriate for the particular DIS exercise being planned.

4.2.2 Effectiveness and efficiency

Factors affecting the efficiency and effectiveness of a DIS exercise VV&A effort include

a) Early V&V involvement in the exercise planning and development process;
b) Thorough knowledge of external interfaces, environment, phenomenology, and opposing forces;
c) Access to previously accredited models and simulations, certified data sources, and interfaces to live play;
d) Thorough knowledge of the specific domains, such as weapons, communications, sensors, information systems, forces, and materiel;
e) Access to historical VV&A information to evaluate candidate models, simulations, and test objects;
f) Effective use of independent test and evaluation assets at the developmental and operational levels;
g) Close ties with testing and data communities; and
h) Careful tailoring of the process.

4.2.3 VV&A tailoring

An exercise VV&A effort must be cost-effective, responsive, and sufficient if it is to succeed. To maintain a balance between exercise needs and real-world constraints, the VV&A process should be tailored to address the particular concerns of the exercise domain and simulation types involved within the constraints of available resources. Tailoring, the selection of specific V&V tasks based on exercise requirements and resource availability, is done as a part of the VV&A planning process to determine the most appropriate and cost-effective ways to address the exercise requirements and acceptability criteria. Tailoring and costing are more fully discussed in Annex D.

5. Exercise development and VV&A

This clause describes the relationship between the exercise life cycle and the VV&A process, including the exercise organization and management systems involved, the exercise life cycle, and fundamental concepts inherent in exercise VV&A.

5.1 Functional roles and responsibilities

IEEE Std 1278.3-1996 describes the roles and responsibilities of the personnel, agencies, and systems involved throughout the exercise management and feedback (EMF) process. The entities most closely associated with the VV&A process are identified in the following subclauses.

5.1.1 Exercise user/sponsor

The person, agency, or organization that determines the need for and scope of a DIS exercise and/or establishes the funding and other resources for the exercise. The user/sponsor also determines the exercise participants, objectives, requirements, and specifications and appoints the exercise manager and VV&A agent.

5.1.2 Exercise manager

The person responsible for creating the exercise, executing the exercise, and conducting the post-exercise activities. The exercise manager coordinates with the VV&A agent during these tasks and reports the results of the exercise to the user/sponsor. The exercise manager serves as the primary coordinator between the exercise user/sponsor and the VV&A team.

5.1.3 Exercise architect

The person or organization responsible for designing, integrating, and testing the exercise as directed by the exercise manager.

5.1.4 Network manager

The person or agency responsible for maintaining and operating a network capable of providing the DIS link between two or more sites. For a given exercise, the exercise manager selects the network manager.

5.1.5 Model/tool provider

A person or agency responsible for developing, stocking, storing, maintaining, and issuing simulation assets. The model/tool provider also maintains historical records of utilization and VV&A.

5.1.6 Database provider

A person or agency responsible for developing and/or providing data for the exercise. Responsibilities include producer verification, validation, and certification (VV&C) of the data and configuration management of the data and its associated metadata.

5.1.7 VV&A agent

The person, agency, or organization appointed by the exercise user/sponsor to measure, verify, and report on the validity of the exercise and to provide data allowing the user/sponsor to accredit the results. The VV&A agent may be part of the exercise development team or may be an independent evaluator.

5.1.8 VV&A team

The persons designated by the VV&A agent to plan and conduct the VV&A activities for an exercise. Team size and composition should be tailored to address the needs of the particular exercise and should be formed according to organization and/or service involvement. The team should include one or more members with current knowledge and understanding of the following:

a) Specific behaviors required of the exercise;
b) Individual modeling and simulation (M&S) components of the exercise;
c) Types of data to be used in the exercise;
d) Appropriate V&V policies and procedures;
e) Appropriate VV&C policies and procedures; and
f) Appropriate accreditation policies and procedures.

5.2 Exercise life cycle

IEEE Std 1278.3-1996 describes the EMF process shown in Figure 1. A summary of the five phases of this process is provided in Figure 1.

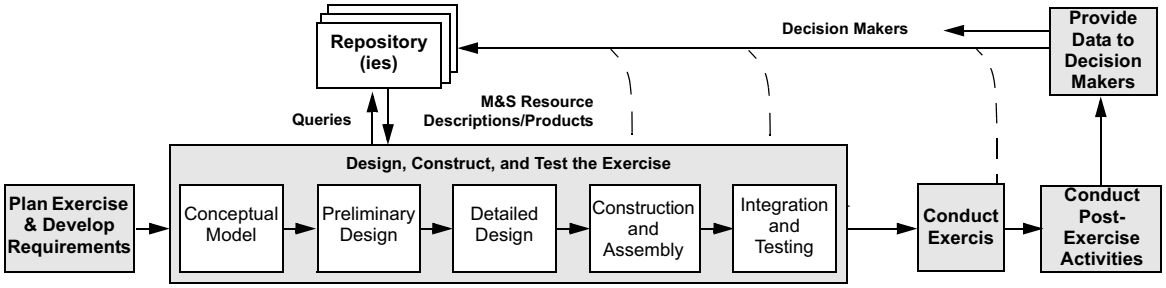

Figure 1—Exercise life cycle

5.2.1 Plan exercise and develop requirements

This phase includes a number of functions that support proper planning, such as

a) Select measures of effectiveness (MOEs) and measures of performance (MOPs) applicable to the exercise;
b) Develop support plans (e.g., VV&A, data development, VV&C, testing);
c) Define exercise simulated natural environment (e.g., weather, climate, electromagnetic, oceanographic);
d) Determine mix of simulation forces among live, virtual, and constructive categories;
e) Identify available simulation resources;
f) Determine technical and exercise support personnel requirements; and
g) Develop functional requirements and interface specifications.

These functions also support the development of VV&A plans.

5.2.2 Design, construct, and test the exercise

During this phase, the exercise is developed to meet the requirements specified during the planning phase. This phase consists of five steps: *Conceptual Model, Preliminary Design, Detailed Design, Construction and Assembly,* and *Integration and Testing.*

V&V activities are conducted during and following each step. Accreditation activities are conducted following *Integration and Testing.* Results of these VV&A activities must be accepted by the exercise manager before proceeding.

5.2.2.1 Conceptual model

The exercise architect develops the conceptual model and high-level architecture for the exercise that show the participating components, interfaces, behaviors, and control structure.

5.2.2.2 Preliminary design

The exercise architect translates the requirements into a preliminary exercise design by developing scenarios, mission plans, and databases; by designing communication networks and tests; and by planning for training and rehearsals.

5.2.2.3 Detailed design

The exercise architect and exercise manager expand the design model and architecture to support and complete the definition of all required functions, behaviors, and data flow, specifically including communication data rate requirements and data latency limitation requirements.

5.2.2.4 Construction and assembly

The exercise manager and model/tool providers assemble existing components and develop new components to meet all exercise and security requirements.

5.2.2.5 Integration and testing

The exercise manager and exercise architect work this step as an incremental process, starting with a minimum number of components and connectivity and adding and building until operational status is achieved. Testing is done concurrently to determine whether requirements and performance criteria are met and support personnel are trained and rehearsed.

5.2.3 Conduct exercise

The exercise manager conducts the exercise using resources developed during the design, construct, and test phase to satisfy objectives established during the planning phase.

5.2.4 Conduct post-exercise activity

The exercise manager oversees the collection and processing of output data, analysis of results, after-action review, and preparation of exercise documentation.

5.2.5 Provide results to decision makers

The exercise manager reports exercise results to designated user/sponsors and other audiences according to the reporting requirements of the exercise. These results may include such factors as exercise credibility, cause-and-effect relationships, detail and aggregation, analysis, and exercise improvement.

5.3 Exercise VV&A fundamentals

Figure 2 maps the VV&A process to the exercise life cycle. The exercise life cycle from Figure 1 is shown in the shaded area. The nine basic VV&A activities are depicted as numbered, shadowed boxes. Small

arrows represent the normal information flow between VV&A activities and the exercise life cycle. Wide arrows represent the collection of evidence that occurs throughout the VV&A process and culminates in a set of VV&A documents.

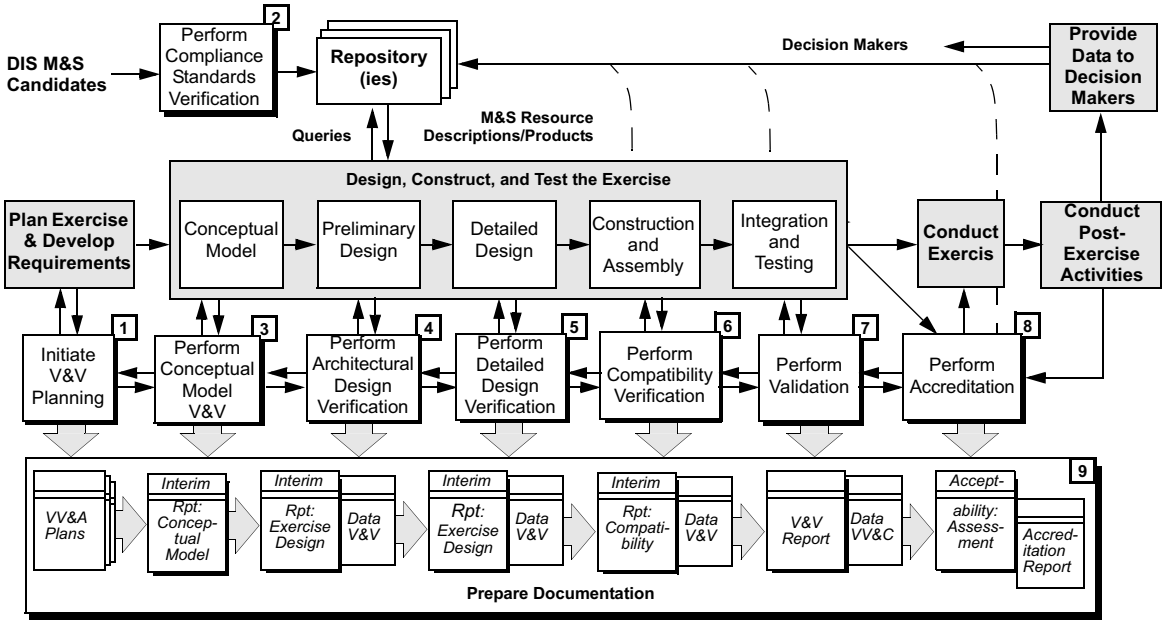

Figure 2—Exercise life cycle and VV&A

5.3.1 Evolution of exercise VV&A

The VV&A process diagram in Figure 2 illustrates the synergetic relationship between the exercise life cycle and the VV&A process. Although the process appears to be linear, a considerable amount of iteration occurs between steps. Individual VV&A activities are performed interactively with and in response to specific exercise life cycle activities. Results of each VV&A activity, risk assessments, and recommendations are reported to the exercise manager and, as necessary, to the exercise architect, network manager, and appropriate model and data providers. Critical issues are reported immediately to avoid costly delays and to facilitate a timely recovery. The exercise manager reviews VV&A results and coordinates with the exercise sponsor to determine the course of action.

5.3.2 Basic VV&A tools and techniques

The VV&A team needs a computing environment appropriate for the various analytic applications involved and word processing capability to support briefing and document production. In addition, the VV&A team may need access to the data and tools used during the design, development, and testing of the exercise. Tools and techniques typically used during specific VV&A activities are identified throughout Clause 6. These tools and techniques are examples only and should not be construed as all-inclusive or as requirements.

5.3.3 VV&A products

Information resulting from VV&A activities is vital for reuse and long-term maintenance of the DIS exercise and participating components. Information collected throughout the process is used for decision making and to prepare the final reports for storing in appropriate M&S repositories and component archives. Additional information about VV&A products is provided in 6.9 and Annex B.

6. Exercise VV&A process

This clause provides procedures and guidelines for planning and conducting exercise VV&A by discussing individually the nine basic activities constituting the VV&A process. Each activity addresses specific objectives and fulfills a unique function in the overall VV&A process. The VV&A process diagram in Figure 3 has been modified to show a number of the techniques normally associated with individual activities. Although an individual exercise VV&A effort should include all nine activities, the individual tasks involved and techniques selected to perform those tasks should depend on the requirements of the exercise and the availability of resources.

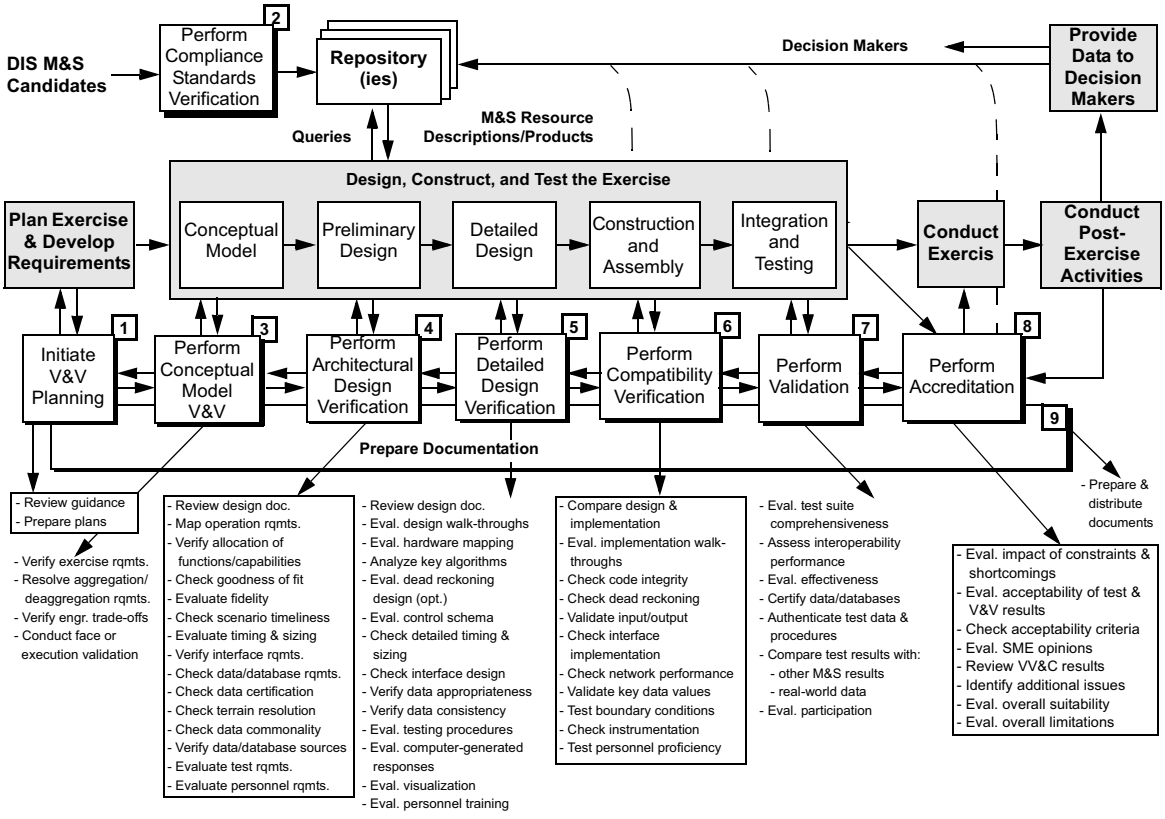

Figure 3—Exercise VV&A process

6.1 Activity: Initiate VV&A planning

Figure 4 depicts the basic interactions between exercise and VV&A activities and *Initiate VV&A Planning*. Arrow annotation provides examples of the types of information exchanged and products produced.

6.1.1 Objective

The objective of this activity is to develop plans for executing exercise V&V, data VV&C, and exercise accreditation in support of exercise requirements and development.

6.1.2 Overview

Although it is possible to develop one comprehensive plan to address V&V, VV&C, and accreditation, it is generally more convenient to create individual plans for each area. The VV&A team should develop the

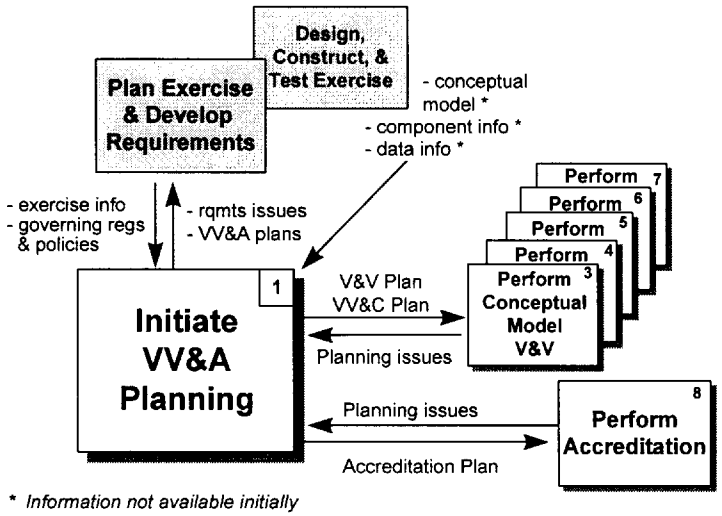

Figure 4—Planning in the VV&A process

plan(s) by identifying the tasks required in a manner that matches and complements the exercise development plan, exercise requirements, test plans, component requirements, available resources, and timelines. The VV&A team should ensure that the plan(s) address the requirements and associated acceptability criteria and map to the available resources. The plan(s) should be flexible allowing for adjustment and refinement as required throughout the exercise development process.

Initially, all plans should be working documents that are expected to evolve as the exercise takes shape. When new information is available or changes occur, the VV&A team should update the plans and submit them to the exercise manager for approval.

6.1.3 Recommended resources

6.1.3.1 Information

The accreditation process is governed by a number of constraints (e.g., accreditation policies, regulations, and directives of the participating organizations, services, agencies) that should be taken into consideration when developing the plan(s). Table 1 lists examples of references used during the VV&A planning process and their normal sources. Additional information is provided in Annex B.

Table 1—VV&A planning information

Information	Source
Regulations, directives, instructions, policies Standards, recommended practices	Exercise user/sponsor M&S respiratory, Modeling and Simulation Resource Repository (MSRR)
Exercise requirements Exercise environment Acceptability criteria Exercise plan, schedule VV&A resources	*Plan Exercise and Develop Requirements* (5.2.1) Exercise manager
Validated conceptual model[a] M&S and data component information[a]	*Design, Construct, and Test Exercise* (5.2.2) Exercise architect

[a]Not available during initial planning phase.

6.1.3.2 Functional responsibilities

Individual V&V, VV&C, and accreditation plans should be developed by qualified members of the VV&A team:

- V&V planners should include experts in the specific behaviors required in the exercise and analysts with V&V experience;
- VV&C planners should include data experts and data analysts; and
- Accreditation planners should include developmental and operational test and evaluation personnel, independent evaluators, and/or appropriate subject matter experts (SMEs).

6.1.4 Procedure

V&V, VV&C, and accreditation planning can each be accomplished using the following approach: *Obtain Planning Guidance, Review Requirements, Select Approach,* and *Prepare Plan.*

The V&V, VV&C, and accreditation plans should serve as primary controls throughout the entire exercise VV&A process. In particular,

- The V&V plan should establish a process for collecting evidence to evaluate the acceptability and to support decisions on the sufficiency of the exercise configuration;
- The VV&C plan should identify the data V&V issues and measures to be used to evaluate the appropriateness of the data; and
- The accreditation plan should elaborate the accreditation issues and acceptability criteria.

Working drafts of each plan should be submitted to the exercise manager for review and comment. When all necessary information has been obtained and no additional changes are expected, the (final) plans should be submitted to the exercise user/sponsor for approval.

6.1.4.1 Obtain planning guidance

Policies, regulations, guidelines, standards, and directives pertinent to the administration and execution of VV&A activities are collected and reviewed to determine the constraints under which the V&V, VV&C, and accreditation efforts should operate.

6.1.4.2 Review requirements

Exercise requirements and acceptability criteria are reviewed; the exercise environment is examined; and appropriate V&V, VV&C, and accreditation issues and metrics are identified. Once candidate M&S and database components have been identified by the exercise manager, VV&A and VV&C histories should be reviewed to ascertain what additional V&V tasks are required to achieve a suitable level of acceptability or risk.

6.1.4.3 Select approach

The basic approach and the methods and techniques to be used should be selected based on exercise requirements and priorities, policy constraints, and availability of resources.

6.1.4.4 Prepare plan

Each plan should document the issues, priorities, techniques used, resources assigned, problem areas, and potential risks (when identified). Individual tasks should be scheduled to coincide with appropriate exercise activities and each other. Draft plans should be revisited throughout the VV&A process to ensure their integ-

rity. Whenever changes are made, plans should be updated and submitted to the exercise manager for approval.

6.1.5 Expected results

This activity should result in the products listed in Table 2.

Table 2—Major planning products

Plans
Exercise V&V plan Exercise VV&C plan Exercise accreditation plan

6.2 Activity: Perform compliance standards verification

Figure 5 illustrates the two phases involved in compliance standards verification. The shaded portion of the figure shows the initial process that is performed independently by the M&S provider. The remainder of the figure depicts the basic interactions between exercise and VV&A activities and *Perform Compliance Standards Verification*. Arrow annotation provides examples of the types of information exchanged and products produced.

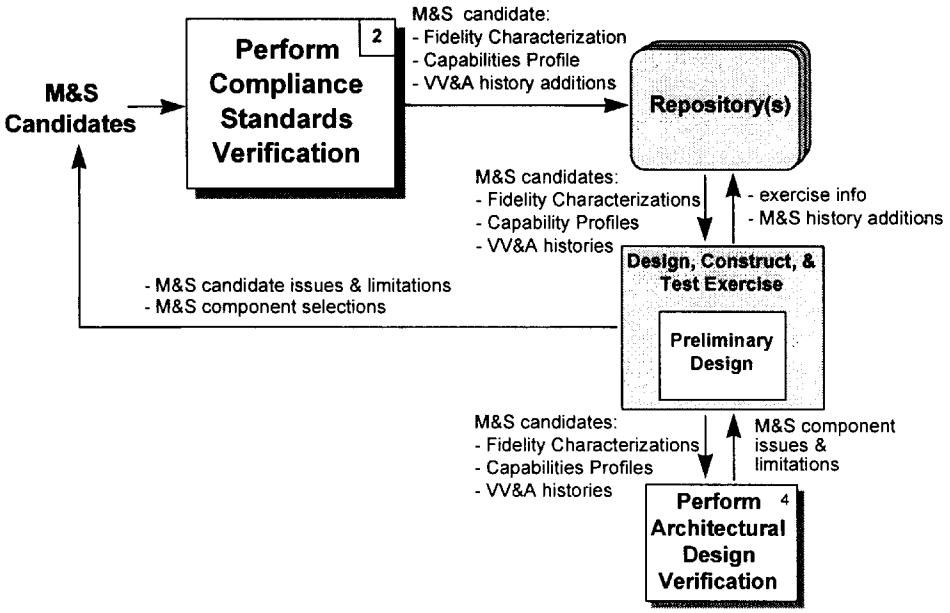

Figure 5—Compliance standards verification

6.2.1 Objective

The objective of this activity is to verify that a model, simulation, or simulator complies with the appropriate protocol standards as specified in IEEE Std 1278.1-1995 and IEEE Std 1278.1a-1998.

6.2.2 Overview

DIS protocol data units (PDUs) and their associated enumerations were developed as a method of communication to support the interactions that take place between entities during a DIS exercise (e.g., passive detection, weapons fire, logistics support, collisions, radio/tactical communications, active emissions). To evaluate heterogeneous systems that simulate or represent diverse sets of operational systems, the capabilities of each system should be described sufficiently to allow evaluation criteria to be developed.

Compliance implies that a model or simulation can communicate using a specified compliance profile (e.g., a PDU configuration and its corresponding enumerations) and will interact with the connecting environment without corrupting the network. Initial compliance testing may be independent of a specific exercise. An M&S provider with the need or desire to be DIS compliant should

a) Complete a capabilities statement describing the operational capabilities (e.g., move, shoot, repair) of each system, sensor, entity and/or object to be supported by DIS PDUs and enumerations;
b) Download the appropriate DIS test system from the DIS Service Center; and
c) Conduct the tests.

The resulting compliance profile, including the capabilities statement and test results, should be archived in a M&S repository (e.g., MSRR) and made available to exercise managers and exercise architects to use when selecting participants for their exercise configuration.

6.2.3 Recommended resources

Tools are being developed in the government and commercial sectors to support the compliance testing process. Typical resources used to perform compliance verification are shown in Table 3.

Table 3—Compliance testing resources

Information
Specified versions of IEEE Std 1278.1-1995 and IEEE Std 1278.1a-1998 and associated enumeration documents IEEE P1278.5 DIS test system Test simulated natural environment data and visual models Compliance test procedures for DIS application protocols Capabilities statement form

6.2.4 Procedure

Two primary tasks are involved: *Conduct Compliance Tests* and *Develop Fidelity Characterization.*

6.2.4.1 Conduct compliance tests

Compliance tests are conducted to evaluate the consistency and correctness of PDU interpretation and utilization by an M&S. Compliance test procedures are based on the “shall” statements in IEEE Std 1278.1-1995 and IEEE Std 1278.1a-1998 and are organized into reception and transmission tests for each PDU type.

a) Reception tests are conducted to ensure the M&S under test can respond to the PDUs identified as meaningful in the capabilities statement.
b) Transmission tests are conducted to ensure the M&S can transmit the PDUs required to support the interactions described in its capabilities statement. Transmission test procedures that verify appro-

priate format, proper protocol usage, and correct application of enumerations are available for each PDU type.

As additional PDUs are developed and current PDUs are changed, supplementary tests will be required.

A requirements database developed by members of the government, commercial, and academic communities traces each requirement in IEEE Std 1278.1-1995 to a capabilities statement template and associated test procedures. An M&S provider interested in becoming DIS compliant uses the template to prepare a capability statement that, in turn, is used in the selection of appropriate test procedures. The capabilities statement and test results are then used to develop a capabilities profile that provides information about the operational capabilities supported by the M&S.

6.2.4.2 Develop fidelity characterization

A fidelity characterization is a tool for comparing disparate M&S by standardizing the metrics for enumerating capabilities and organizing the data for entry into the M&S repository. The model provider should build a fidelity characterization based upon the fidelity taxonomy defined in IEEE P1278.5. This standard does not prescribe any minimum level of fidelity for M&S components to participate in DIS applications, but serves as a common language to be used by exercise managers and architects in the selection of M&S components and the design and development of exercise configurations.

6.2.5 Expected results

The compliance test phase can give an excellent indication of an M&S candidate's utility throughout a range of applications. Specific products are listed in Table 4. When stored in the M&S repository, these products should provide useful information for comparing various candidate systems against exercise requirements.

Table 4—Major compliance testing products

M&S component assessments
Capabilities profile Fidelity characterization M&S VV&A history additions

6.2.6 Transition to exercise VV&A

Initial compliance standards verification is conducted independent of an exercise by the M&S provider and can occur at any time. To be considered for inclusion in a particular exercise, a simulation should be tested for compliance to the exercise-specific enumeration prior to the exercise *Preliminary Design* step (5.2.2.2). The exercise manager normally identifies the specific protocols and enumerations (i.e., data collection requirements) needed for the exercise during the *Conceptual Model* step (5.2.2.1). During the *Preliminary Design* step, the exercise architect searches the M&S repository for potential M&S components. Candidates should be selected based on their functional capability and DIS compliance.

Once M&S candidates have been selected, the VV&A team should review their capability profiles and fidelity characterizations to ensure compliance with the specific exercise PDU and representational requirements. If the initial compliance verification is insufficient, the exercise manager may request additional testing by the M&S provider.

6.3 Activity: Perform conceptual model V&V

Figure 6 depicts the basic interactions between exercise and VV&A activities and *Perform Conceptual Model V&V*. Arrow annotation provides examples of the types of information exchanged and products produced.

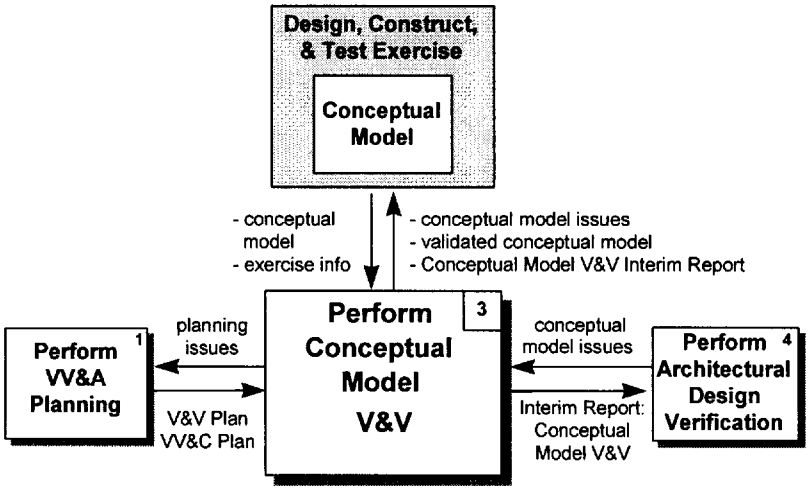

Figure 6—Conceptual model V&V

6.3.1 Objective

The objective of this activity is to establish validity of the conceptual model as a suitable specification for simulation design of the exercise requirements in terms of

a) Essential environments and scenarios;

b) Requisite number and types of entities;

c) Necessary entity behaviors, characteristics, attributes;

d) Fundamental interactions between entities;

e) The logical context of required processes; and

f) Degree of fidelity involved.

6.3.2 Overview

The conceptual model is a simulation implementation-independent representation of the exercise architect's understanding of the exercise objectives, requirements, and environment. It serves as a vehicle for transforming requirements into functional and behavioral capabilities and provides a crucial traceability link between the exercise requirements and the design implementation. The validated conceptual model can be used as the structural basis for the overall design and development of the exercise configuration.

During this activity, the VV&A team evaluates the conceptual model's completeness, correctness, and appropriateness in terms of end-to-end context, performance objectives, and behavioral needs. The team should ensure that a mapping exists between the exercise and operational requirements and the conceptual model and evaluate the mapping for reasonableness, completeness, and an appropriate level of fidelity.

6.3.3 Recommended resources

6.3.3.1 Information

Table 5 lists examples of the information used during conceptual model V&V.

Table 5—Information examples

Information	Source
Exercise requirements Exercise environment Planning factors Operational behaviors Scenario Available resources	V&V, VV&C, and accreditation plans Exercise manager
Conceptual model	Exercise architect

6.3.3.2 Functional responsibilities

The VV&A team performs the tasks necessary to complete this activity and reports issues and results to the exercise manager and exercise architect for resolution. SMEs can be used to assist in areas requiring special expertise, such as specific functional areas or particular behaviors.

6.3.3.3 Tools and techniques

The VV&A team should obtain the conceptual model from the exercise architect. If automated tools, such as those listed in Table 6, were used during the development of the conceptual model, they should also be used during the validation process. Note that

a) High-level modeling tools that can be used to explore different aspects of the conceptual model may be limited in their ability to define the overall behavior and exercise objectives.
b) Using a fidelity taxonomy (e.g., IEEE P1278.5) to define the conceptual model in terms of the fidelity desired for each requirement
    1) Provides a common language;
    2) Helps articulate the fidelity requirements in terms of measurable metrics;
    3) Provides a fidelity characterization of the exercise; and
    4) Can simplify the task of evaluating the capabilities of M&S candidates during the exercise *Preliminary Design* step (5.2.2.2).
c) Other modeling approaches can offer similar capabilities.

6.3.4 Procedure

This activity involves three basic tasks: *Verify Conceptual Model, Evaluate Logical Design,* and *Validate Conceptual Model*.

6.3.4.1 Verify conceptual model

a) The VV&A team and selected SMEs should first compare the conceptual model with the exercise requirements to determine that all
    1) Required processes and their relationships have been adequately described;

Table 6—Typical conceptual model V&V tools

Tools and techniques	Purpose
Structured analysis/design Computer-aided software engineering (CASE) tools Prototyping tools that can execute the model Object-oriented analysis tools Face validation	Execute conceptual model Evaluate for completeness Evaluate for consistence Evaluate for correctness Trace requirements Verify mapping Diagram execution order
Fidelity taxonomy (IEEE P1278.5)	Identify fidelity required Map requirements
Analytic tools	Calculate fidelity parameters

2) Entity requirements have been defined to include required attributes and components and both dynamic interactions and static relationships with other objects;
3) Input data requirements and authoritative sources have been identified; and
4) Fidelity requirements have been specified.

b) The VV&A team should then evaluate the fidelity of the conceptual model in terms of
1) Application effectiveness, to measure how well a simulation concept supports the exercise objectives;
2) User acceptance, to measure how well a simulation concept supports the user requirements; and
3) Use as a bounding mechanism to determine the scope of the V&V effort.

6.3.4.2 Evaluate logical design

The VV&A team should trace the underlying logic of the conceptual design to identify dynamic issues relating to the physical (e.g., communications, processing, performance) and behavioral representations. In particular, requirements for aggregation and deaggregation should be evaluated for appropriateness and sensibility.

6.3.4.3 Validate conceptual model

The VV&A team and selected SMEs should examine the conceptual model to ensure that it adequately specifies both the physical and behavioral aspects of the exercise problem domain. In particular, they should review the allocation of functions from the exercise requirements into the functional specification (or its equivalent) and ensure that operational requirements are traceable in the emerging exercise architecture.

6.3.5 Expected results

The VV&A team documents results, deficiencies, and potential risks in a V&V report. This report is submitted to the exercise manager and exercise architect. At the direction of the exercise manager, the exercise architect will address model limitations identified in the V&V report. An iterative discussion will take place between the exercise manager, exercise architect, and the VV&A agent until all outstanding issues are resolved. Once the conceptual model has been accepted by the exercise manager, the exercise architect can begin development of the preliminary exercise design. Table 7 lists the major products of this V&V activity.

Table 7—Conceptual model V&V products

Interim reports
Conceptual model V&V report Validated conceptual model

6.4 Activity: Perform architectural design verification

Figure 7 depicts the basic interactions between *Perform Architectural Design Verification* and other VV&A and exercise life cycle activities. Arrow annotation provides examples of the types of information exchanged and products produced.

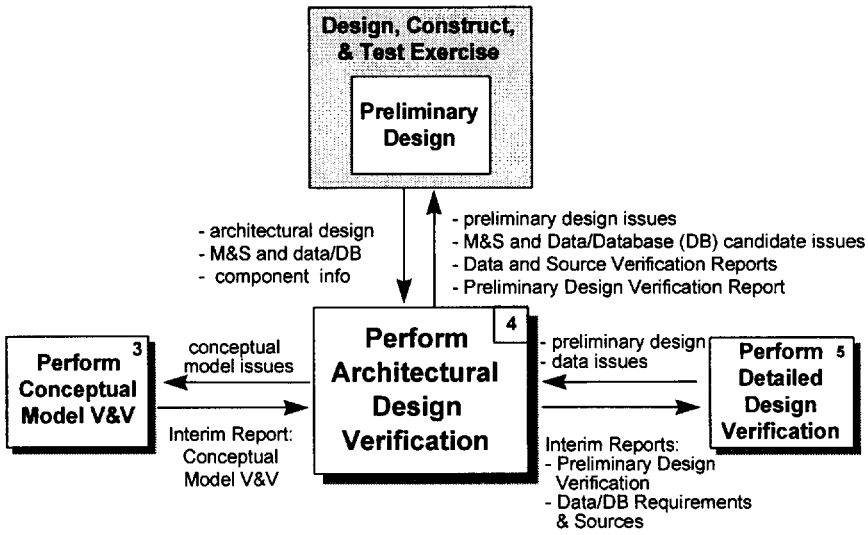

Figure 7—Architectural design verification

6.4.1 Objective

The objective of this activity is to ensure that the developing architecture accurately reflects the exercise requirements as described in the conceptual model.

6.4.2 Overview

Verification of the preliminary design should involve

a) Evaluating the appropriateness of the allocation of functions and capabilities to individual components;
b) Evaluating the consistency of the mapping between exercise, data, and interface requirements and the preliminary design;
c) Evaluating the sufficiency of representations of the simulated natural environment (e.g., weather, phenomenology, terrain);
d) Determining exercise requirements and standards for common resources and databases (e.g., earth model, coordinate systems, terrain, weather, phenomena, man-made and natural objects);
e) Identifying authoritative data sources; and
f) Establishing compatibility and appropriateness of candidate M&S.

To evaluate M&S candidates, the VV&A team should examine such factors as their ability to represent the levels of fidelity, accuracy, and aggregation needed by the proposed exercise configuration. To verify the appropriateness of the preliminary architecture, the VV&A team should assess overall behavior and performance of the exercise by estimating timing, sizing, and scenario timelines and benchmarking hardware platforms. Care should be taken to consider underlying exercise assumptions as well as exercise requirements.

Different verification methods can be applied to different aspects of the design. For example,

— Static parts of the DIS exercise model can be evaluated by tracing requirements and tracking function allocation (i.e., requirements and capabilities) to ensure consistency, correctness, and completeness;

— Dynamic parts (e.g., instantaneous and time-variant behavioral issues) can be assessed through face validation or execution of the model; and

— The reasonableness of the requirements mapping to potential simulated and live components can be confirmed by feasibility checks.

The VV&A team can also use these verification elements to review the exercise test requirements and to design validation tests for use later in the VV&A process.

6.4.3 Recommended resources

6.4.3.1 Information

In addition to the documents collected previously (see 6.1.3.1 and 6.3.3.1), VV&A team should obtain and review the information listed in Table 8. Additional suggestions are listed in Annex B. If information is not available, the exercise manager determines whether the information should be produced by the responsible party, alternative measures should be taken, or the VV&A team should work around the problem.

Table 8—Information used in architectural design verification

Information	Sources
M&S candidate compliance profiles M&S candidate fidelity characterizations M&S candidate model documentation M&S candidate VV&A histories	M&S repository (MSRR) M&S providers
Network specifications Bandwidths Formats	Network managers
Interface specifications	Exercise architect
Exercise data Enumeration protocols and PDUs Testing and personnel requirements	Exercise manager
Authoritative data sources Candidate databases (data, metadata, VV&C documentation)	DoD Authoritative Data Sources Repository Data producers

6.4.3.2 Functional responsibilities

The VV&A team should work closely with the exercise architect, exercise manager, network managers, test team, and M&S component providers. One task, *Verify Data Requirements and Sources* (see 6.4.4.3), is a VV&C activity and should be conducted by team members with knowledge of the various types of data involved as well as the standards and policies governing their production, application, and accessibility (see Annex C for additional information).

6.4.3.3 Tools and techniques

Tools and techniques appropriate for use during this activity are listed in Table 9.

Table 9—Typical tools used to evaluate architectural design

Tools and techniques	Purpose
Checklists, spreadsheets, evaluation matrices	Track /locate necessary information Document results
Diagramming tool to delineate entities, interfaces, network characteristics, connectivity, and data flow Data exchange model or exercise data model	Evaluate architectural model Depict complex data relationships among components
Requirements-tracing database or tool Functional allocation decomposition method CASE tool control flow diagram	Prohibit corruption of requirements Evaluate completeness, consistency, and correctness of function allocation Assess operational requirements mapping
M&S candidate compliance profiles M&S candidate fidelity characterizations	Evaluate M&S candidates
Conceptual model Structured, object-oriented design or prototyping tools to execute the model	Conduct goodness-of-fit analysis
Fidelity taxonomy	Characterize exercise fidelity
Event-sequence diagram, scheduling/timing template, exercise architect's timelines	Verify scenario timeline
Network analysis tool Spreadsheet	Evaluate interface specifications Summarize performance data Analyze individual nodes and links
Database management system	Track and control data sources, output data
Database inspection tool Metadata	Evaluate source-to-input correlation
Database/manual technique for data collection	Estimate timing and sizing

6.4.3.4 M&S preparation

Exercise M&S candidates should have well-documented VV&A histories, compatibility profiles, and fidelity characterizations. However, if M&S documentation is unavailable or insufficient, the M&S provider

should carry out compliance testing (see 6.2) and meet with the VV&A team, exercise manager, and exercise architect to develop a suitable plan to address V&V deficiencies.

6.4.4 Procedure

This activity consists of five major tasks: *Evaluate Architectural Design, Evaluate Interface Requirements, Verify Data Requirements and Sources, Evaluate Preliminary V&V Test Requirements and Plans,* and *Verify Operator Requirements*.

6.4.4.1 Evaluate architectural design

This task verifies the preliminary design with respect to the exercise requirements and conceptual model and assesses the ability of the M&S candidates to meet the needs of the exercise.

Appropriate functions include

a) Evaluating the allocation of functions from the exercise system-level specification (i.e., exercise requirements) into a functional specification;
b) Concurrently, mapping the operational requirements into the emerging exercise architecture;
c) Conducting goodness-of-fit analyses to evaluate individual M&S candidate suitability;
d) Performing consistency analyses between M&S candidates to determine the best combinations of components for the exercise;
e) Reviewing scenario timelines and estimates of exercise sequencing; and
f) Conducting analyses to address hardware or software modifications as needed.

6.4.4.2 Evaluate interface requirements

This task assesses the adequacy of the preliminary network configuration by

a) Evaluating the ability of the network configuration to satisfy the components in terms of arrival times, arrival rates, accuracy, latency, and traffic saturation; and
b) Confirming each network element can recognize the message traffic it requires and disregard the rest.

Appropriate functions include

— Developing an independent estimate by translating the load estimates (node and total) provided by the exercise network manager into network capacity requirements; and
— Evaluating latency in message and data traffic by examining the hardware and long haul carriers selected to handle the transmissions.

6.4.4.3 Verify data requirements and sources

This task ensures that appropriate valid (and certified) data are available and data voids and deficiencies are identified in a timely manner. It should be performed in conjunction with *Evaluate Architectural Design* (6.4.4.1) and *Evaluate Interface Requirements* (6.4.4.2) so data requirements can be assessed as part of the M&S candidate evaluation. When possible, it should be conducted as part of an overall data VV&C process (see Annex C).

The types of data normally involved in an exercise include

a) Common databases (e.g., simulated natural environment, man-made obstacles, weather) shared by all or most components that require a high degree of correlation;

b) Data created expressly for the exercise (e.g., testing, scenario, threat generation) that require verification and validation for both the individual components and the overall exercise;
c) Data required by individual M&S components (when the data are key to exercise interactions); and
d) Data pertaining to the execution of the exercise (e.g., data collection).

Appropriate data evaluation techniques include

— Verifying candidate data and database sources are the appropriate sources for the data required by the exercise by checking the Authoritative Data Sources Repository, a DoD information source that lists certified data sources;
— Reviewing the exercise data requirements and candidate data and database documentation to verify the availability of appropriate data and identify data voids and inconsistencies;
— Assessing the correspondence between source metadata and M&S component input data specifications to ensure appropriate data usage; and
— Examining data created explicitly for the exercise to ensure that appropriate certified data are not attainable and to assess the risks involved in their use.

6.4.4.4 Evaluate preliminary V&V test requirements and plans

The primary objective of this task is to identify appropriate tests to address the V&V test requirements. Because an exercise is usually integrated and tested incrementally, individual components may develop their own test plans. These individual test plans are then used to create an integrated exercise test plan containing a series of global tests that are responsive to the overall exercise scenario and examine compatibility and interoperability issues.

The VV&A team should review exercise test requirements and plans as they evolve to ensure the tests are comprehensive and doable and satisfy V&V test requirements. If the planned tests do not address all the V&V test needs, the VV&A team should coordinate with the exercise manager regarding possible modifications or additions. The VV&A team should also examine test histories and requirements for individual M&S components.

6.4.4.5 Verify operator requirements

Exercise operators and players (e.g., simulator operators) need to be both familiar with the equipment and able to perform the functions necessary to support the exercise. Because their performance can impact the testing process and the validity of the exercise, the VV&A team should review operator and player requirements to identify expected qualifications (e.g., skill levels, certification), potential training prerequisites, and scheduling concerns. Frequently, this review is performed at the component level and results are rolled up to the exercise level.

6.4.5 Expected results

This activity should demonstrate that the architectural design is sufficient to address the exercise requirements, the M&S components are suitable for their assigned functions, and appropriate data and database sources have been identified. Design deficiencies, potential risks, and recommendations are reported to the exercise manager and exercise architect. When the exercise manager has accepted the preliminary design, the exercise architect can begin the process of evolving the detailed design. Primary products are listed in Table 10.

Table 10—Typical design verification interim reports

Interim reports
Exercise V&V information Preliminary design verification report Interface assessment V&V testing assessment Personnel assessment
M&S component assessments Exercise compliance profile Exercise fidelity assessment
Data/database assessments Data requirements & source reports

6.5 Activity: Perform detailed design verification

Figure 8 depicts the basic interactions between *Perform Detailed Design Verification* and other VV&A and exercise life cycle activities. Arrow annotation provides examples of the types of information exchanged and products produced.

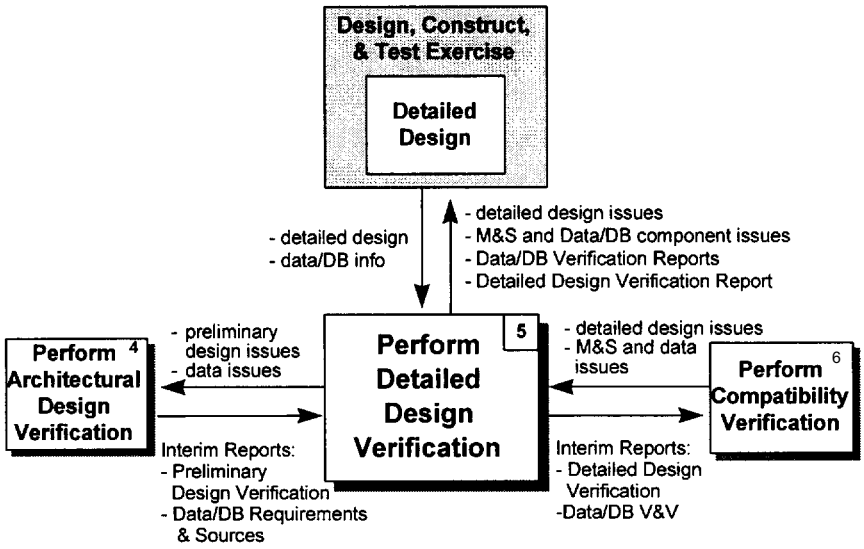

Figure 8—Detailed design verification

6.5.1 Objectives

The objective of this activity is to ensure that the exercise design continues to accurately reflect exercise requirements and is adequate to support the anticipated activities.

6.5.2 Overview

The exercise configuration is incrementally designed by mapping the components to the functions identified in the architectural design and identifying the means by which component interactions should occur. Typical functions include

— Evaluating the compatibility of the M&S components and their ability to support the exercise;
— Determining the appropriateness and sufficiency of the prospective network traffic and facilities;
— Assessing the completeness and accuracy of timing estimates of the control schema;
— Checking boundary conditions to ensure stable exercise execution; and
— Verifying data and database.

As the detailed design evolves, the VV&A team should

a) Review M&S component documentation and, if necessary, source code to determine components' ability to perform their assigned functions;
b) Execute key algorithms to ensure they function appropriately to address the exercise requirements;
c) Assess the logic of the proposed interconnections of the components by evaluating the proposed interchange of PDUs; and,
d) Analyze the exercise design for its rigor.

Members of the team conducting data verification and validation should evaluate the appropriateness and sufficiency of the input data selected for use in the exercise.

6.5.3 Recommended resources

6.5.3.1 Information

In addition to the documentation acquired previously (see 6.1.3.1, 6.3.3.1, and 6.4.3.1), the VV&A team may need to obtain and review more detailed information regarding the M&S and data components (e.g., model specifications, database metadata, source code, executables, VV&A histories, functional specifications, component documentation). Additional information suggestions are listed in Annex B.

If key information is not available, the VV&A team should notify the exercise manager, specifying the risks involved. The exercise manager will decide whether to have the information produced or have the VV&A team work around the problem.

6.5.3.2 Functional responsibilities

The VV&A team should work closely with the exercise architect, exercise manager, network managers, test teams and M&S component providers. To maintain continuity, some members should have participated in the *Perform Architectural Design Verification* activity (6.4) and some should participate in the *Perform Validation* activity (6.7). One task, *Verify Data and Databases* (6.5.4.3), is a VV&C activity and should be conducted by members of the team with data and data testing expertise.

6.5.3.3 Tools and techniques

Tools and techniques used during *Perform Architectural Design Verification* (6.4) and those used by the exercise architect during the development of the detailed design should be used during this activity. Examples are listed in Table 11. Whenever possible, the VV&A team should also participate in exercise design reviews, walk-throughs, and technical interchange meetings.

Table 11—Typical tools used to evaluate detailed design

Tools and techniques	Purpose
Requirements tracing database or tool Data exchange model or exercise data model	Map requirements Examine M&S component capabilities Evaluate key data
Structured or object-oriented design tools to execute model Diagramming tools to delineate entities, interfaces, network characteristics, connectivity, and data flow	Test network control schema
Network analysis tool Spreadsheet/calculator	Evaluate interface specifications Conduct individual node/link analyses
M&S component compliance profiles	Evaluate M&S components
Event-sequence diagram Exercise architect's timeline	Evaluate scenario
Database inspection tool Database or manual technique for data collection	Verify timing, sizing, boundary conditions Assess dead reckoning and coordinate conversion algorithms

6.5.4 Procedure

This activity involves five major tasks: *Evaluate Detailed Design, Evaluate Interface Design, Verify Data and Databases, Evaluate V&V Test Plans,* and *Evaluate Training Requirements.*

6.5.4.1 Evaluate detailed design

This task determines if the design is sufficient to ensure that

— The individual M&S components are capable of representing the exercise phenomenology at appropriate levels of resolution; and
— The underlying network assets can support the exchange of data between the components at the necessary levels of fidelity.

Appropriate functions include

a) Evaluating the mapping of requirements to hardware and software;
b) Conducting detailed assessments of key algorithms, dead reckoning designs, and coordinate conversions;
c) Characterizing the network resources by evaluating detailed timing and sizing and control schema; and
d) Analyzing risks based on the intended M&S component applications.

6.5.4.2 Evaluate interface design

This task evaluates the ability of the individual M&S components to interoperate with each other and with the network by

a) Determining that interfaces between components and interfaces with the synthetic environment are sufficient to allow consistency in the level of details, data fidelity, data sources, and sufficient modes of operation;
b) Ensuring that user interfaces for input and output can pass information to accomplish efficient scenario construction, component execution, network management, and report generation; and
c) Evaluating the impact of network factors such as latency produced, network loading, and filtering requirements.

The VV&A team should first partition the network analysis so the requirements and capabilities of each node can be examined, calculated, and evaluated separately. As nodes are added to the network, the team can use an iterative process to examine the ability of the main trunks to carry the expected traffic. When the assembly process is complete, the VV&A team should collect and assess the results of individual analyses for consistency, correctness, and completeness.

6.5.4.3 Verify data and databases

This task assesses the sufficiency and usability of the input data and databases. It should be accomplished in conjunction with *Evaluate Detailed Design* (6.5.4.1) and *Evaluate Interface Design* (6.5.4.2) to ensure that the data required by the M&S components and the DIS exercise will provide appropriate, consistent, accurate, and timely results during execution. When possible, this task should be conducted as part of an overall data VV&C process (see Annex C).

Appropriate functions include

a) Evaluating the ability of shared data (e.g., simulated natural environment, force structure, environmental data) to address the operational requirements and produce an appropriate synthetic environment;
b) Comparing M&S component and exercise data applications to ensure a high degree of consistency in the data exchanged;
c) Assessing key data elements for appropriate use and for accurate and consistent valuation;
d) Ensuring data transfers and manipulations do not violate exercise security policies; and
e) Reviewing the suitability of special data requirements resulting from the testing and data collection.

6.5.4.4 Evaluate V&V test plans

This task is a continuation of *Evaluate Preliminary V&V Test Requirements and Plans* (6.4.4.4) to ensure V&V test plans are adequate and complete.

The VV&A team continues to examine M&S component and exercise test plans to determine if they can accommodate the V&V testing requirements. If the plans are inadequate, the VV&A team should work with the exercise manager and M&S component providers to develop tests that can accommodate the V&V testing requirements.

6.5.4.5 Evaluate training requirements

Once the exercise operators and players have been identified by the exercise manager, the VV&A team should review training requirements, assess the ability of training plans to address the requirements, and recommend appropriate tests for evaluating the success of the training.

6.5.5 Expected results

This activity should ensure the detailed design is comprehensive, continues to accurately reflect exercise requirements, and is adequate to support the anticipated activities. Design deficiencies, potential risks, and recommendations are reported to the exercise manager and exercise architect. When the exercise manager

has accepted the design, the exercise architect can implement the exercise. Typical products resulting from this activity are listed in Table 12.

Table 12—Typical design verification reports

Interim reports
Exercise V&V information Detailed design verification report Interface assessment V&V testing assessment Personnel assessment
M&S component assessments Exercise compliance and compatibility
Data/database assessments Data/database verification

6.6 Activity: Perform compatibility verification

Figure 9 depicts the basic interactions between *Perform Compatibility Verification* and other VV&A and exercise life cycle activities. Arrow annotation provides examples of the types of information exchanged and products produced.

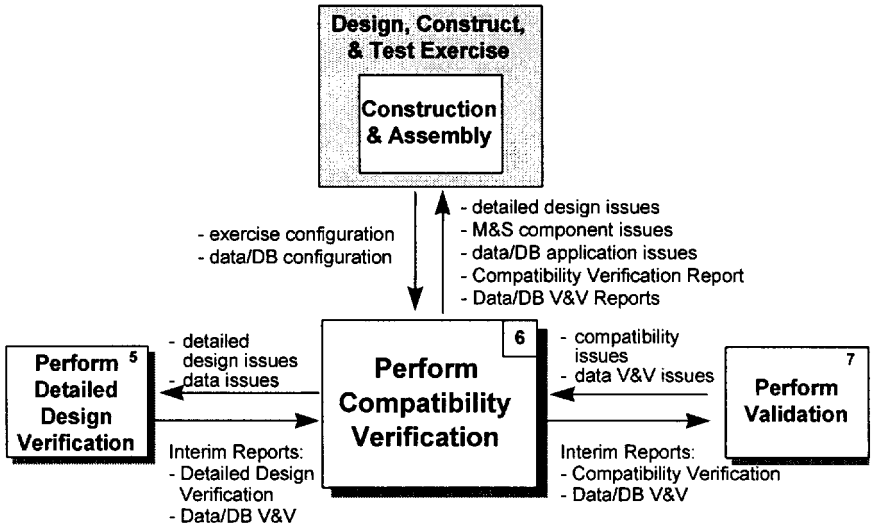

Figure 9—Compatibility verification

6.6.1 Objectives

The objective of this activity is to complete the verification process by ensuring that

a) M&S components exchange data and interact appropriately with each other;
b) Individual components correctly use the common data (e.g., terrain, weather) to generate their portion of the synthetic environment; and
c) The overall implementation is adequate to address the exercise requirements.

6.6.2 Overview

This activity should be coordinated with the exercise *Construction and Assembly* phase to take advantage of testing opportunities during the assembly process. Major considerations are entity fidelity, flexibility, and the ability of the configuration to satisfy mission objectives. The VV&A team should

a) Evaluate the hardware/software implementation of the detailed design;
b) Verify the applications of key functions (e.g., dead reckoning algorithms, line-of-sight calculations, coordinate transformations);
c) Test the interfaces and network to ensure loading and latency are within acceptable bounds; and
d) Test the M&S components' ability to use the associated data resources and validate the data.

In addition, when system simulators are being used as part of the exercise structure, the VV&A team should examine the results of operator training to assess the proficiency of the operators.

6.6.3 Recommended resources

6.6.3.1 Information

This activity uses information collected previously (see 6.1.3.1, 6.3.3.1, 6.4.3.1, and 6.5.3.1) that

a) Describes the conceptual model and traces requirements;
b) Defines the exercise design, message flows, control flow, and data; and
c) Specifies the overall design characteristics of each M&S component (e.g., compliance test profiles, fidelity characterizations, VV&A histories) with respect to behavior and performance in the context of the exercise application.

Additional documentation pertaining to the internal detailed design of an M&S component may be needed if it becomes necessary to determine the component's precise performance capabilities.

6.6.3.2 Functional responsibilities

To maintain continuity, some VV&A team members should have participated in *Perform Conceptual Model V&V* activity (6.3), *Perform Architectural Design Verification* activity (6.4), and *Perform Detailed Design Verification* activity (6.5) and should participate in the *Perform Validation* activity (6.7). In addition, the VV&A team requires the assistance of the SMEs to help fine tune and evaluate entity behaviors and characterizations, and the exercise developers (e.g., exercise architect and the site managers, component experts and operators, and software engineers) involved in assembling the exercise. One task, *Verify Data and Databases* (6.5.4.3), is a VV&C activity and should be conducted by members of the team with data testing expertise.

6.6.3.3 Tools and techniques

The VV&A team will need access to exercise instrumentation, network analysis tools to evaluate compatibility, probes to determine traffic flow, and techniques to measure and verify M&S component behavior on the network (e.g., DIS compliance tests, individual M&S component test suites). Any automated tools used during construction and assembly of the exercise should be used during algorithm testing and data validation.

6.6.4 Procedure

This activity includes five major tasks: *Evaluate Design vs. Implementation, Evaluate Compatibility, Evaluate Interface Implementation, Assess Instrumentation Requirements,* and *Evaluate Impact of Operator Proficiency.*

6.6.4.1 Evaluate design vs. implementation

The purpose of this task is to determine the adequacy of the overall implementation by comparing the design as documented (e.g., conceptual model, component compliance profiles, fidelity characterizations) and the exercise configuration. The VV&A team should participate in exercise development walk-throughs and apply a series of checks to compare the physical configuration to the documented design.

6.6.4.2 Evaluate compatibility

The purpose of this task is to determine whether the individual components

a) Represent system performance as required for the exercise;
b) Transfer information to and from the network without corruption;
c) Share common perspectives of the virtual reality produced by the exercise; and
d) Employ database elements, shared models, and support systems appropriately.

The VV&A team should conduct a comprehensive evaluation of exercise entities to ensure correct interpretations of positions on the virtual battlefield and realistic representations of movements and behavior and to identify anomalies in behavior (e.g., violations of physical laws). The members of the VV&A team conducting VV&C should concurrently assess the components' ability to use data resources, evaluate data integrity in data aggregation situations, and validate the data. When possible, the last task should be conducted as part of an overall data VV&C process (see Annex C).

6.6.4.3 Evaluate interface implementation

This task focuses on network performance needs, interface implementation issues, and identification of changes in the exercise configuration that could impact operation of the network. The VV&A team typically inspects the hardware configuration and reviews data collection and transfer (e.g., PDUs) between components to determine that the interface implementation is in accordance with interface specifications. The VV&A team should also evaluate the results of network loading and latency tests for possible impacts on simulation results.

6.6.4.4 Assess instrumentation requirements

The exercise architect installs equipment (e.g., data loggers) to support testing and data collection. This instrumentation can be used to

a) Measure, establish, and debug baseline performance;
b) Log data at designated points in the exercise;
c) Dynamically monitor critical nodes and links; and
d) Perform analysis and after-action review.

The VV&A team should evaluate the adequacy of the instrumentation requirements for V&V purposes.

6.6.4.5 Evaluate impact of operator proficiency

The VV&A team, with identified SMEs, should observe and evaluate the performance of operators to determine if they possess the appropriate skill level to perform the functions required for the exercise.

6.6.5 Expected results

Compatibility verification establishes that components appropriately interact with the synthetic environment and each other and lays the groundwork for interoperability and exercise validation. Incompatibilities, potential risks, and recommendations are reported to the exercise manager and exercise architect. Once the exercise manager has accepted the assembly, the exercise architect begins integrating and testing the configuration. Typical products are listed in Table 13.

Table 13—Typical compatibility reports

Interim reports
Exercise V&V information Compatibility verification report Exercise data/database reports Interface assessment Personnel assessment
M&S component assessments Exercise compatibility results
Data/database assessments Data/database V&V reports

6.7 Activity: Perform validation

Figure 10 depicts the basic interactions between *Perform Validation* and other VV&A and exercise life cycle activities. Arrow annotation provides examples of the types of information exchanged and products produced.

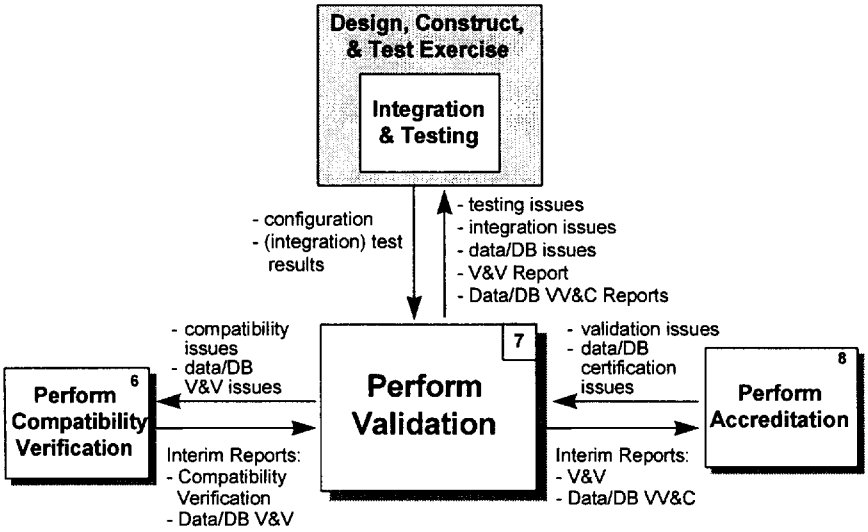

Figure 10—Validation

6.7.1 Objective

The objective of this activity is to ensure that the integrated simulation is adequate to satisfy exercise and representational requirements so that

a) Exercise behaviors and performance map sufficiently and appropriately to real-world counterparts for the specific application;
b) Performances and representations of the simulated entities are sufficient to support the intended application; and
c) Acceptance criteria have been appropriately addressed by testing.

The degree to which these issues can be resolved affirmatively is indicative of the degree of validity that can be achieved.

6.7.2 Overview

The preceding verification activities concentrated on the functional integrity of the exercise. This validation activity focuses on evaluation of operational aspects (e.g., behavioral representations, interoperability, real-time interactions, fidelity of the terrain and environmental representation). The VV&A team and SMEs should assess how well the component and the integrated exercise performances match real-world behaviors, performances, fidelity, and interoperability requirements for the specified application by reviewing the results of preceding phases, evaluating results of exercise tests, and executing validation tests (i.e., functional, performance, interoperability, regression tests).

Appropriate functions include

a) Analyzing the completeness and structural soundness of the exercise and the realism of its results in terms of the exercise requirements;
b) Determining whether exercise output behavior has the accuracy required for its intended use within the specified application domain; and
c) Evaluating the acceptability of each M&S component in the context of its operation and contribution to the complete exercise.

6.7.3 Recommended resources

6.7.3.1 Information

This activity requires access to all documentation pertaining to the exercise (e.g., requirements, plans, test results) and the VV&A process to date (see 6.9).

6.7.3.2 Functional responsibilities

The VV&A team works closely with the exercise manager, exercise test team, data providers, and M&S providers. In addition, SMEs should assist the VV&A team in areas requiring special expertise (e.g., representations of functional areas and behaviors).

6.7.3.3 Tools and techniques

6.7.3.3.1 Tools

In addition to the tools and equipment used during preceding activities, the VV&A team may require access to the exercise infrastructure and available test beds and equipment (e.g., test ranges, battle labs, research centers) to set up and run realistic tests and evaluate data. They may also require access to equivalent models and simulations and real-world examples for comparison of exercise behaviors and outcomes.

6.7.3.3.2 Techniques

Four basic types of testing are involved:

a) *Unit tests* occur at the component level and are normally accomplished before and/or during the verification phase. Unit tests include
   1) Functional tests that ensure correctness of all of the basic functional capabilities for the entity represented; and
   2) Performance tests that are scenario-driven and reflect aspects of component performance (e.g., timing, detections, behavior, fire rates, motion, speed, realism, accuracy) to evaluate how well the component generates data needed to satisfy acceptability criteria.

b) *Integration tests* verify the components work together effectively. Integration tests include
   1) Functional tests to ensure correctness of all of the basic functional capabilities for the entity represented;
   2) Performance tests that are scenario-driven and reflect aspects of exercise performance and component interoperability (e.g., timing, detections, behavior, fire rates, motion, speed, realism, accuracy) to evaluate how well the exercise generates data needed to satisfy the acceptability criteria; and
   3) Interoperability tests to examine the realism of entity interactions as required for the specific application. Such testing focuses on the identification of effects that may degrade or distort exercise data used to calculate and analyze acceptability criteria.

c) *Stress tests* examine exercise performance under boundary conditions (e.g., network loads).

d) *Regression tests* serve as the baseline for systems performance and interoperability. As components are added to the exercise, regression tests provide a mechanism for determining the impact of the additions on previously tested and validated elements.

6.7.4 Procedure

This activity consists of five basic tasks: *Establish Context for Validation Activities, Evaluate Configuration Interoperability, Perform Effectiveness Evaluation, Evaluate Test Results,* and *Evaluate Operator Performance*.

6.7.4.1 Establish context for validation activities

The purpose of this task is to confirm the appropriateness of the validation effort, affirm the availability of correct data, and lay the foundation for the exercise validation report. The VV&A team should determine that the scope of the validation effort is adequate, the acceptability criteria are sufficient, and potential shortcomings and limitations are identified.

6.7.4.2 Evaluate configuration interoperability

The purpose of this task is to verify the mapping of individual components to the detailed design. As problem areas are identified during testing, the exercise architect and the VV&A team can use this mapping as an interoperability blueprint for exercise integration and implementation (see 6.4 and 6.5) to pinpoint potential sources of difficulty.

6.7.4.3 Perform effectiveness evaluation

The purpose of this task is to assess the ability of the different parts of the exercise architecture, including live and computer-generated forces, to generate the data needed to address the acceptability criteria. This task should involve

a) Tracing exercise performance data to the acceptability criteria;
b) Evaluating the data for accuracy, sufficiency, and appropriateness; and
c) Testing the algorithms used to collect, aggregate, or summarize the exercise data to ensure the resulting values are accurate.

6.7.4.4 Evaluate test results

The VV&A team and SMEs work in concert with the exercise testers during testing to ensure validation tests are conducted. During the V&V planning process (6.1), the VV&A team selects techniques and allocates resources to address each validation issue. In many instances, these techniques include comparisons of testing results to the results of baseline models and simulations, to real world data, or to a review of testing results by SMEs (face validation). When conducting comparisons, the VV&A team should consider underlying assumptions, differences in fidelity, and other constraints and limitations in their evaluation. Typical issues to address include

a) Correspondence between exercise performance and real-world behavior and appearance of the represented systems and forces (to the degree required);
b) Suitability of the correlation of fidelity among the components;
c) Adequacy of the environmental representation; and
d) Correlation of live and synthetic targets.

If test results differ widely from the expected values, the exercise testers and the VV&A team should identify the causes and report them to the exercise manager and appropriate M&S providers for resolution.

6.7.4.5 Evaluate operator performance

The VV&A team should compare operator performance throughout the test period to real world performance requirements and report any deficiencies that may impact the validity of the exercise to the exercise manager.

6.7.5 Expected results

This activity should result in validation of the exercise configuration. The VV&A team presents its results and recommendations to the exercise manager, exercise architect, and associated component providers. Once the exercise manager has accepted the validation effort and the validated configuration, the VV&A team completes the Exercise V&V Report and begins the accreditation process. Typical products of this activity are listed in Table 14.

Table 14—Typical products

Interim reports
Exercise V&V information Exercise validation report Interface assessment V&V testing assessment Personnel assessment
M&S component assessments Exercise test results
Data/database assessments Data/database certifications
Formal reports
Exercise V&V report Exercise VV&C report

6.8 Activity: Perform accreditation

Figure 11 depicts the basic interactions between *Perform Accreditation* and other VV&A and exercise life cycle activities. Arrow annotation provides examples of the types of information exchanged and products produced.

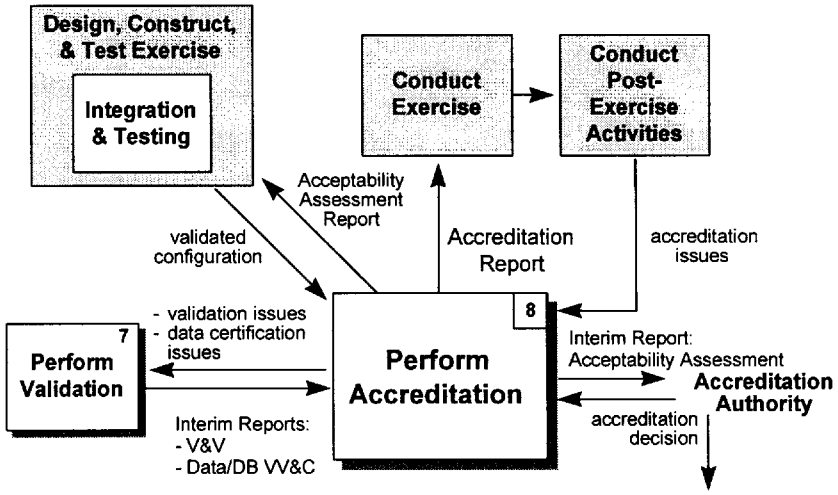

Figure 11—Accreditation

6.8.1 Objective

The objective of this activity is to determine whether the configuration is sufficient to satisfy the exercise user/sponsor's requirements.

6.8.2 Overview

The accreditation process can employ both subjective (i.e., SME) evaluations and objective information (e.g., validation results) to determine whether exercise requirements have been addressed and acceptability criteria have been met. Examples of appropriate techniques include

a) SME review of exercise and V&V documentation;
b) Evaluation of validation and test results with respect to the exercise requirements and acceptability criteria;
c) Identification of inadequacies and disparities;
d) Consideration of ancillary factors (e.g., acceptability of data, availability of resources, costs, time-lines, alternative courses of action).

6.8.3 Recommended resources

6.8.3.1 Information

The VV&A team requires access to all documentation pertaining to the exercise configuration and the VV&A process to date. Examples are shown in Table 15.

Table 15—Information used in accreditation

Exercise information
Exercise plan and requirements Acceptability criteria Exercise V&V information (e.g., compliance profile, fidelity characterization) Hardware configuration Software release data
Data information
Data/databases Data/database metadata and VV&C histories Data/database assessments
M&S component information
M&S component compliance profiles M&S component fidelity characterizations M&S component VV&A histories
V&V information
V&V, VV&C, accreditation plans Exercise V&V report Exercise VV&C report

6.8.3.2 Functional responsibilities

The VV&A team in cooperation with the sponsor should establish SME review boards as needed for review of systems, behaviors, and functional representations.

6.8.4 Procedure

This activity consists of three main tasks: *Compare V&V Results and Acceptability Criteria, Identify Risks,* and *Prepare Acceptability Assessment Report.*

6.8.4.1 Compare V&V results and acceptability criteria

The VV&A team and SME review boards should compare the results of the V&V effort to the acceptability criteria to determine whether the exercise configuration is acceptable. Limitations and deficiencies identified during V&V activities should be reviewed to determine whether appropriate resolution has occurred or whether additional development, testing, and/or data are still needed.

6.8.4.2 Identify risks

The VV&A team should identify additional factors (e.g., availability of resources, alternative data sources) and evaluate their impact on exercise acceptability.

6.8.4.3 Prepare acceptability assessment report

The VV&A team should document their results and prepare a recommendation for the exercise accreditation authority. Potential recommendations include

a) Accredit the exercise for the specified use;
b) Accredit the exercise with limitations;
c) Conduct additional verification or validation and resubmit for consideration;
d) Modify components and/or exercise configuration, conduct additional V&V, and resubmit for consideration; or
e) Reject the exercise configuration and use a different approach.

6.8.5 Expected results

This activity results in the assessment of the exercise configuration and the preparation of the Acceptability Assessment Report for submission to the exercise accreditation authority. Once the accreditation authority has accredited the configuration, the VV&A team prepares the Exercise Accreditation Report and the exercise manager prepares to conduct the exercise. Products of this activity are listed in Table 16.

Table 16—Typical accreditation products

Interim report
Acceptability assessment report
Formal report
Exercise accreditation report

6.9 Activity: Prepare documentation

In Figure 12, the exercise VV&A process diagram is shown with *Prepare Documentation* expanded to include the principal documents produced during each activity.

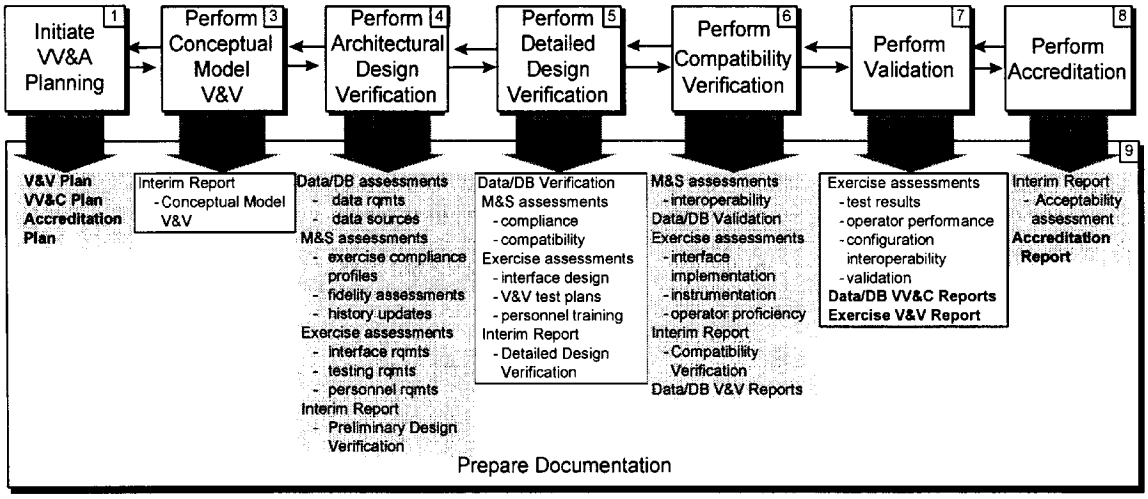

Figure 12—VV&A documentation

6.9.1 Objective

The objective of this activity is to document the VV&A activities to satisfy the planning needs of the exercise manager, to facilitate the flow of information during the ongoing exercise development activities, and to address the information requirements of future exercises.

6.9.2 Overview

VV&A documentation can be facilitated by visualizing it as the result of a process that begins with the initial development of the plans and ends only when the records of the procedures and results have been properly archived. Every VV&A activity involves the collection and evaluation of information. The VV&A team reports results and recommendations to the exercise manager and associated decision makers (e.g., affected M&S and database providers) whenever major problems arise and at the culmination of each task. These "interim reports" should provide the majority of the information required to conduct the final analyses and prepare the final reports. When the VV&A process has been completed, the information should be archived in the M&S repository. To make this transition as efficient as possible, the VV&A team should establish a standard method for collection and documentation to ensure the interim reports contain the necessary information and are formatted appropriately.

6.9.3 Recommended resources

6.9.3.1 Information

During the initial planning phase, the VV&A team should identify the types of information to be produced and collected throughout the process for preparation of the necessary reports and archives.

6.9.3.2 Tools and techniques

Members of the team should have access to compatible word processing equipment. Ideally, this system would include a database management system or template formatted to facilitate information sharing and storage.

6.9.4 Expected results

This activity occurs in conjunction with all VV&A activities and serves to record the procedures and results of each activity. It culminates in the production of the final reports and transference of exercise VV&A records to the appropriate archives. Typical products are listed in Table 17.

Table 17—Typical VV&A products

Plans	Interim Reports	Formal Reports
V&V plan VV&C plan Accreditation plan	Exercise V&V information Conceptual model V&V Exercise design verification Compatibility verification Exercise validation Interface assessment V&V testing assessment Personnel assessment Acceptability assessment M&S component assessments Exercise compliance profiles Fidelity assessments Exercise test results Individual V&V histories Data/database assessments Data requirements and sources Data/database V&V reports	Exercise V&V report Data/Database report Data/Database accreditation report

Annex A

(informative)

Bibliography

The most recent editions of the following texts and papers are recommended as guides on various aspects of DIS VV&A:

[B1] Air Force Instruction 16-1001, *Verification, Validation, and Accreditation Policies and Procedures*.

[B2] American Management Systems, Inc., *Automated Data Element Finder (ADEF) User's Guide,* Arlington, Va.

[B3] Ballistic Missile Defense Organization Directive No. 5002, *Test and Evaluation Verification, Validation, and Accreditation Policy for Ballistic Missile Defense Organization.*

[B4] Blechinger, P. I., "Verification, validation, and accreditation of distributed simulations," *Proceedings of the XXXIII Army Operations Research Symposium (AORS),* Ft. Lee, Va., Oct. 1994.

[B5] Bufkin, B.,"Network monitoring and characterization for defense interactive simulation (DIS) protocols," *11th Workshop on Standards for the Interoperability of Distributed Simulations*, Orlando, Fla., Sept. 1994.

[B6] Coe, G. Q., "Conceptual model for verification, validation and accreditation (VV&A) of distributed interactive simulations (DIS) applications," *10th Workshop on Standards for the Interoperability of Distributed Simulations,* Orlando, Fla., Mar. 1994.

[B7] Davis, P. K., "Generalizing concepts and methods of verification, validation and accreditation (VV&A) for military simulations."

[B8] Defense Model and Simulation Office (DMSO), *DoD Verification, Validation and Accreditation (VV&A) Recommended Practices Guide,* Nov. 1996.

[B9] "DoD glossary of M&S terms (draft)," Aug. 1995.

[B10] Department of Defense Directive (DoDD) 5000.59, *DOD Modeling and Simulation (M&S) Management*, Jan. 1994.

[B11] Department of the Army Pamphlet 5-11, *Verification, Validation, and Accreditation of Army Models and Simulation*.

[B12] Department of the Army Regulation 5-11, *The Army Model and Simulation Management Program*.

[B13] Department of the Army Regulation 25-9, *The Army Data Management and Standards Program*.

[B14] DoD 5000.59-P, "DOD Modeling and Simulation (M&S) Master Plan," Oct. 1995.

[B15] DoDD 5010.19, *DoD Configuration Management Program*.

[B16] DoDD 8320.1-M, *DoD Data Administration Procedures*, Mar. 1994.

[B17] DoD Instruction 5000.61, "DoD modeling and simulation (M&S) verification, validation, and accreditation (VV&A)," Apr. 1996.

[B18] Gravitz, P. D., and Jordan, W., "Utilizing IDEF0 for examination of the individual activities of the DIS VV&A process model," *11th Workshop on Standards for the Interoperability of Distributed Simulations*, Orlando, Fla., Sept. 1994.

[B19] Gravitz, P. D., et al., "DIS exercise management and feedback—An IDEF0 model," Huntsville, Ala., 1995.

[B20] IEEE Std 1012-1998, IEEE Standard for Software Verification and Validation.

[B21] IST-SP-94-01, "The DIS vision, a map to the future of distributed simulation," May 1994.

[B22] JSI 8104.01, *Verification, Validation, and Accreditation of Joint Models and Simulations*.

[B23] Jamison, R. S., Jordan, W. E., Jr., and Lewis, R. O., "A systematic methodology for verification, validation, and accreditation (VV&A) of models and simulations used in distributed interactive environments," *XXXII Army Operations Research Symposium (AORS) Proceedings*, Ft. Lee, N.J.

[B24] Kameny, I., et al., "DIS need for DoD data standards."

[B25] Lewis, R. O., "A paradigm for verification, validation, and accreditation (VV&A) of models and simulations used in distributed interactive simulation (DIS) environments," *9th Workshop on Standards for the Interoperability of Distributed Simulations*, Orlando, Fla., Sept. 1993.

[B26] ———, "Defining a multi-use taxonomy for algorithms, data modeling, and fidelity," *Interim Working Group Meeting of VV&A Group,* Ft. Leavenworth, Kans., June 1994.

[B27] ———, *Independent Verification and Validation: A Life Cycle Engineering Process for Quality Software*. New York: John Wiley & Sons. ISBN 0-471-57011-7.

[B28] ———, *Verification, Validation, and Accreditation (VV&A) Pilot Program Report—Study No. 1: Patriot Demonstration Model and Simulation for the 15th I/ITSEC.* Report no. CR-650-2025, USASSDC, Huntsville, Ala.

[B29] ———, "Verification, validation, and accreditation (VV&A) process for distributed interactive simulations," *10th Workshop on Standards for the Interoperability of Defense Simulations*, Orlando, Fla., Mar. 1994.

[B30] MIL-STD-498, *Software Development and Documentation*, AMSC no. N7069, Dec. 1994.

[B31] Navy Interim Policy Guidance, *Verification, Validation, and Accreditation (VVA) Policies, Procedures, and Guidelines*.

[B32] Office of the Assistant Secretary of Defense (Command, Control, Communications, and Intelligence), DoDD 8320.1-M-x, *DoD Data Model Development, Approval and Maintenance Procedures* (draft).

[B33] Rothenberg, J., "A discussion of data quality for verification, validation, and certification (VV&C) of data to be used in modeling (draft)," RAND Report no. DRR-1025-DMSO, Apr. 1995.

[B34] Rothenberg, J., and Kameny, I., "Data verification, validation, and certification to improve the quality of data used in modeling," *Proceedings of the 1994 Society for Computer Simulation (SCS) Summer Computer Simulation Conference (SCSC'94),* 1994.

[B35] Sargent, R., "An overview of verification and validation of simulation models," *Proceedings of the 1987 Winter Simulation Conference*, Society for Computer Simulation, 1987.

[B36] Secretary of the Navy Instruction, DRAFT 5200.XX.

[B37] Solick, S. D., "Harmonization of Army standard data elements (ASDE) and distributed interactive simulations (DIS) protocol data units (PDUs)," *1994 DMSO Verification, Validation and Accreditation of Distributed Simulations Project Report*, Ft. Leavenworth, Kans., Sept. 1994.

[B38] ———, "The relationship between the DIS data verification, validation and certification (VV&C), process, other major DIS processes and the generic VV&C process," *14th Workshop on Standards for the Interoperability of Distributed Simulations*, Orlando, Fla., Mar. 1996.

[B39] ———, "Verification, validation, and accreditation of distributed simulations," *Proceedings of the XXXIV Army Operations Research Symposium (AORS)*, Ft. Lee, Va., Oct. 1995.

[B40] ———, "VV&A of distributed simulations: Database consistency." *1994 DMSO Verification, Validation and Accreditation of Distributed Simulations Project Report*, Ft. Leavenworth, Kans., Sept. 1994.

[B41] ———, "Interaction between data VV&C and V&V activities of the DIS exercise VV&A process model," *12th Workshop on Standards for the Interoperability of Distributed Simulations*, Orlando, Fla., Mar. 1995.

[B42] U. S. Army TRADOC Analysis Center (TRAC), et al., "Conduct VV&A of DIS exercise: IDEF0 model specification for verification, validation, and accreditation for distributed interactive simulations, *1994 DMSO VV&A of Distributed Simulations Project,* Huntsville, Ala., Sept. 1994.

[B43] Workshop on Standards for the Interoperability of Distributed Simulations, *Distributed Interactive Simulation Testing System Operational Concept Description* (draft).

[B44] ———*, Distributed Interactive Simulation Testing Program Plan* (draft).

[B45] ———*, Standard for Distributed Interactive Simulation—Application Protocols Rationale* (draft).

[B46] Wright, R. H., "Data collection for the close combat tactical trainer: Lessons learned," *10th Workshop on Standards for the Interoperability of Distributed Simulations*, Orlando, Fla., Mar. 1994.

[B47] Wright, R. H., and Browning, J., "Verification, validation and accreditation of the close combat tactical trainer: A practical application of the VV&A process," *Military Operations Research Society Conference*, Ft. Leavenworth, Kans., June 1996.

Annex B

(normative)

VV&A information requirements

B.1 Purpose

The purpose of this annex is to discuss the types and sources of information used during VV&A process.

B.2 Overview

Information regarding the exercise, exercise sponsors, M&S components, data, and data sources is crucial to the exercise VV&A process. The ability to obtain appropriate information at the appropriate time impacts the success of the individual V&V activities, the level of credibility achieved, and the cost of the overall effort. Information comes from

a) External sources (e.g., policies, M&S component histories and technical documentation, database metadata, DIS exercise histories);
b) Current exercise design and development phases (via the exercise manager or exercise architect);
c) Exercise support activities (e.g., testing); and
d) VV&A activities and tasks (see 6.9).

Information obtained from external sources is used primarily in planning and calibrating the VV&A effort. The availability, appropriateness, and accuracy of this information helps determine the types of V&V activities required.

Information associated with the current exercise and VV&A activities connects the exercise development process and the VV&A process and provides an appropriate means by which to chronicle the VV&A effort. (See 6.9 for additional information on preparing documentation.)

B.3 Information from external sources

Externally developed information shapes the exercise by

a) Ensuring the exercise and VV&A procedures adhere to the regulations, policies, and wishes of the sponsoring and participating organizations;
b) Providing historical information on similar exercises;
c) Providing background information on participants; and
d) Providing information on data and data sources.

Table B.1 lists types of information that can be obtained from different external sources. The first column provides examples and sources. The second column identifies (by number) in which VV&A activities the information is typically used:

a) *Initiate VV&A Planning;*
b) *Perform Compliance Standards Verification;*
c) *Perform Conceptual Model V&V;*
d) *Perform Architectural Design Verification;*

e) *Perform Detailed Design Verification;*
f) *Perform Compatibility Verification;*
g) *Perform Validation;* and
h) *Perform Accreditation.*

Because the ninth activity, *Prepare Documentation,* involves all information used during the other eight, it is not listed separately on the table.

The first half of the table focuses on typical policies and general requirement and operational concerns. Such information is generally obtained as early as possible because it is used during exercise and VV&A planning. The second half of the table provides examples of the types of information about individual databases and M&S components typically used in the development and V&V of an exercise. The exercise manager selects M&S and data candidates based upon their ability to accommodate the requirements of the exercise. Because much of the information used during V&V is also used during exercise planning and development, the VV&A team should be able to obtain it from the exercise manager rather than from the originating sources. However, the V&V effort may require more detailed information than the exercise manager is able to provide.

B.4 Information from the exercise

Table B.2 lists information about the exercise typically used during the VV&A process. Because this information evolves throughout the design and development of the exercise, it is subject to change and care should be taken to obtain it in its most updated form.

B.5 Information from the VV&A process

The VV&A process is designed to interact with the exercise design and development process. Success of this interaction depends on the efficiency and accuracy of the information flow between the exercise development processes and the VV&A activities. The information passed back and forth is used by the exercise manager and VV&A agent to decide courses of action. The same information is used during validation and accreditation, in the preparation of final reports, and for cataloging the exercise in the M&S repository. Additional details are given in 6.9, *Prepare Documentation*.

Table B.1—Information obtained from external sources

M&S community: M&S repository, MSRR, DIS service center	Used during VV&A activity number 1	2	3	4	5	6	7	8
IEEE Std 1278.4-1997, IEEE Std 1278.3-1996	X	—	X	X	X	X	X	X
IEEE Std 1278.1-1995, IEEE Std 1278.1a-1998	—	X	—	X	—	X	—	—
IEEE Std 1278.2-1995	—	—	X	X	X	X	X	—
IEEE P1278.5	—	X	X	—	X	—	—	—
Industry security, sensitivity, proprietary standards and policies	X	—	—	X	—	X	X	—
Testing guidance	—	—	—	—	—	—	—	—
Compliance tests (component level)	—	X	—	X	—	X	—	—
Exercise testing program plan	X	X	—	X	—	—	—	—
Test scenarios	X	—	X	X	—	X	X	—
Test procedures from similar exercises	X	—	X	X	X	X	X	—
VV&A & VV&C histories and shared data sources of similar exercises	—	—	—	X	—	—	—	—
Government: Individual services and agencies, M&S repository, MSRR	**Used during VV&A activity number 1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Government security, sensitivity, proprietary policies & regulations	X	X	X	X	X	X	X	X
Service/component data policies and regulations	X	—	—	X	X	—	—	—
VV&A regulations, directives, instructions, guidance, policies	X	—	—	—	—	—	—	X
DoD Directive 5000.59, DoD 5000.59-P								
DoD Instruction 5000.61								
DoD VV&A Recommended Practice Guide								
Army Regulation 5-11, Army Regulation 25-9, Army Pamphlet 5-11								
Department of Army M&S Master Plan								
Air Force Instruction 16-1001								
Secretary of the Navy Instruction (DRAFT 5200.XX)								
Data: DoD Authoritative Data Sources Repository, Data providers, MSRR	**Used during VV&A activity number 1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Authoritative data sources	X	X	X	X	—	—	X	X
Data and database standards	X	—	X	X	—	X	—	X
Data and database metadata	—	—	—	X	X	X	—	—
Database structures, data control and entry mechanisms								
Data generation techniques, data collection techniques								
Data quality assessments, data fidelity								
Data, data VV&C histories, and data models (if available)	—	—	—	X	X	—	—	—
M&S candidate data VV&C documentation	—	—	—	X	X	—	—	—
M&S Components: Exercise manager, M&S providers, MSRR	**Used during VV&A activity number 1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Design characteristics	X	X	—	X	X	X	X	X
Histories: integration, input data needs, VV&A	—	—	X	—	—	—	—	—
Compliance profiles, performance capabilities	—	X	X	X	X	X	—	—
Fidelity characterizations	—	X	X	X	X	X	—	—
Behavior and performance characteristics	—	X	—	X	X	X	—	—
Key algorithm descriptions	—	X	—	X	—	—	—	—
Network specifications and capabilities	—	X	X	X	X	X	—	—
Data, VV&C, and data sources	—	X	X	X	X	X	—	—
Component-level personnel/semiautomated forces (SAF) requirements	—	X	X	—	—	—	—	—
Source code, executables, detailed design documentation	—	—	—	X	X	X	—	—

Table B.2—Typical exercise information requirements and sources

Exercise manager	Used during VV&A activity number 1	2	3	4	5	6	7	8
Exercise mission, requirements, objectives, acceptability criteria, planning factors, schedule, plan	X	—	X	X	X	X	X	X
Environment: political environment, scenario, initial conditions, maps, indigenous factors, simulated natural environment, special effects, forces	X	—	X	X	X	X	X	X
Operational behaviors: operational objectives, missions, rules of engagement, intelligence	X	—	X	X	X	X	X	—
Live elements, simulation types, external interfaces	X	—	—	X	X	X	X	—
Participants: organization, staffing, and training plans and requirements	X	—	—	X	X	X	X	—
MOP, MOE, M&S memoranda of agreement	X	—	—	X	X	—	X	—
SAF scripts, man-machine trade-off analyses	—	—	—	—	X	X	X	—
Event-sequence diagrams	—	—	X	X	X	X	X	—
Performance specifications (scenario timeline)	—	—	—	X	X	X	X	—
Data collection requirements: selected PDUs and corresponding enumerations, corresponding test suites	—	X	—	X	X	X	X	—
Data requirements, exercise data model (opt)	X	—	—	X	—	—	—	—
Data sources, candidate databases	X	—	X	—	X	—	—	—
V&V, VV&C, accreditation, testing, and training resources	X	—	—	—	—	—	—	—
Decisions and rationale to VV&A task reports	X	—	—	X	X	X	X	X
Exercise architect	**Used during VV&A activity number 1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Conceptual model	X	X	X	X	X	X	X	X
M&S candidate information	—	—	—	X	—	—	—	—
Requirements specifications	—	—	—	X	X	X	X	—
Preliminary design (functional) specifications	—	—	—	X	X	X	X	—
Detailed design specifications: data flow, data definitions, control flow and/or state transition diagrams	—	—	—	—	X	X	X	—
Exercise testing requirements and plan	X	—	—	X	X	X	X	—
Output data collection requirements	—	—	—	X	X	X	X	—
M&S component, data information	—	—	—	X	X	X	—	—
Test cases and procedures	—	—	X	—	—	X	X	—
Exercise hardware configuration and software release data	—	—	—	—	—	X	X	—
Network manager	**Used during VV&A activity number 1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Network/communications specifications and capabilities	X	X	—	X	X	X	X	X
Interface design documents and interface requirements specification	—	—	—	X	X	X	X	—
Types of links (e.g., radio frequency), bandwidths, formats	—	—	—	—	X	X	—	—
Protocols and PDUs	—	—	—	X	X	X	—	—
Hardware configuration	—	—	—	X	X	X	X	—

Annex C

(normative)

Data verification, validation, and certification

C.1 Introduction

This annex discusses the data VV&C process that interacts with and supplements the exercise VV&A process. Figure C.1 shows the exercise VV&A process diagram expanded to include VV&C activities. Small arrows represent the normal information flow between VV&C activities and the VV&A process. Wide arrows represent the collection of evidence that occurs and culminates in a set of VV&A and VV&C documents.

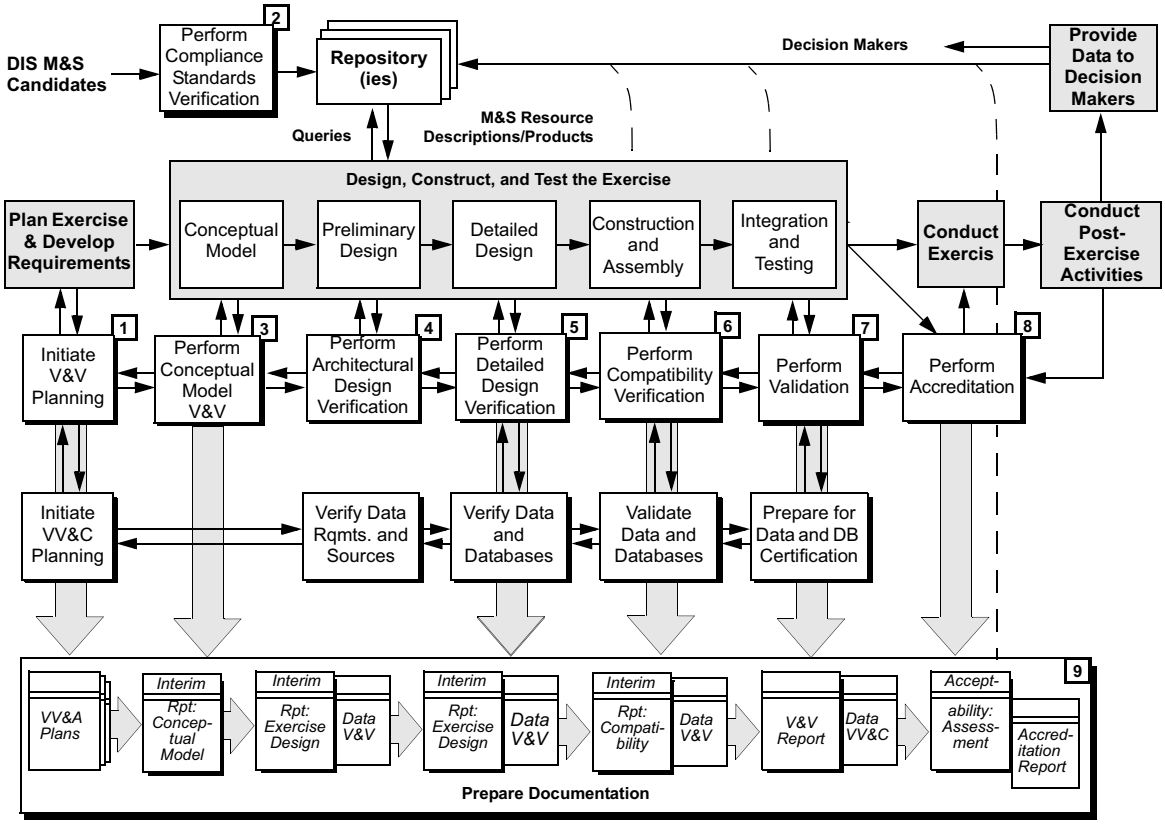

Figure C.1—VV&C, VV&A, and the exercise life cycle

C.1.1 Exercise data requirements

C.1.1.1 Types of data involved

A DIS exercise uses a complex combination of data to develop, execute, and evaluate an exercise, including

a) Common databases (e.g., simulated natural environment, man-made obstacles);
b) Databases created expressly for use in the exercise (e.g., scenario, threat);

c) Data created to fill data voids in available databases;
d) Data required by individual M&S components (when the data are key to exercise interactions);
e) Data pertaining to the execution of the exercise (e.g., aggregation, collection); and
f) Data created to support exercise testing.

Data shared among the components require a high degree of correlation. Although such data may have previously been certified for use by individual components, their use at the exercise level should be evaluated. New data created for the exercise may require V&V at both the individual component and overall exercise levels.

C.1.1.2 Exercise data sources

Data are externally supplied, preexisting data; data created specifically for the exercise; or data generated during the design and development.

a) Preexisting data include shared data (e.g., simulated natural environment, force structure) that are used by all or most of the M&S components as well as input data specific to each component. Ideally, most preexisting data exist in databases certified by authoritative data sources.
b) Data and databases developed for the DIS exercise are generally based on the specific requirements of the exercise (e.g., geographic features, special force assets, mission requirements for deployment, objectives, scenarios). Such data are usually derived from pre-existing certified databases and tailored by the exercise manager to address the needs of the exercise.
c) Data are generated during exercise development by the exercise architect and network managers to facilitate exercise execution and configuration management.

C.1.2 Exercise-level VV&C

C.1.2.1 Purpose

Data VV&C is necessary at the exercise level to ensure the data selected and created for use in the exercise are usable by the exercise components and are appropriate for the designated exercise application. Although individual M&S proponents are responsible for conducting user VV&C on any data used by their M&S, an exercise-level VV&C effort is needed to ensure that

a) The selected data and databases have been obtained from the most appropriate sources;
b) Each of the components has been certified to use the data in the designated applications,
c) The data selected are accurate to the degree required by the exercise; and
d) The data selected are the most appropriate for use with the configuration of M&S in the exercise.

C.1.2.2 Definitions

a) *Data verification, validation, and certification (VV&C):* The process of verifying the internal consistency and correctness of data, validating that it represents characteristics of real world entities appropriate for its intended purpose or an expected range of purposes, and certifying it as having a specified level of quality or as being appropriate for a specified use, type of use, or range of uses. The process has two perspectives: producer and user process.
b) *Data verification:* Data producer verification is the use of techniques and procedures to ensure that data meets constraints defined by data standards and business rules derived from process and data modeling. Data user verification is the use of techniques and procedures to ensure that data meets user specified constraints defined by data standards and business rules derived from process and data modeling, and that data are transformed and formatted properly.
c) *Data validation:* The documented assessment of data by subject area experts and its comparison to known or best-estimate values. Data user validation is an assessment as appropriate for use in an intended model. Data producer validation is an assessment within stated criteria and assumptions.

d) *Data certification:* Data user certification is the determination by the application sponsor or designated agent that data have been verified and validated as appropriate for the specific M&S usage. Data producer certification is the determination by the data producer that data have been verified and validated against documented standards or criteria.

C.1.2.3 Assumptions and limitations

a) DIS exercises are unique. Regardless of the number of components and databases that have been used together before, some VV&C efforts will be necessary;
b) The amount of VV&C required for a DIS exercise will depend on the requirements and mission of the exercise and the quality of the history available on each of the components and databases;
c) Data and database validation must precede exercise validation;
d) The majority of the databases under consideration for the exercise have already been verified, validated, and certified by their respective producers;
e) The majority of the M&S components under consideration for the exercise will have already undergone VV&A as independent models, simulations, and simulators;
f) Not all databases under consideration will have complete VV&C records for the given application;
g) Not all M&S candidates will have complete VV&A records for the given application;
h) The "best" data for a given component might not be the "best" data for the exercise;
i) New data will have to be generated, verified, validated, and certified; and
j) Although individual data elements are examined during a V&V process, it is the database that receives the certification.

C.1.2.4 Functional roles and responsibilities

Although individual M&S proponents are responsible for conducting user VV&C on any data used by their M&S, the overall VV&C effort should be coordinated at the exercise level. If no independent VV&C team has been appointed by the exercise sponsor, the exercise VV&C process should be led by the VV&A team and conducted as part of the VV&A effort. This "VV&C team" should include one or more members of the VV&A team with current knowledge and understanding of types of data to be used in the exercise and appropriate VV&C policies and procedures. The VV&C team should be responsible for planning, conducting, and documenting the user data V&V effort and producing the certification report for the DIS exercise. In addition, SMEs associated with the individual databases and M&S components used in the exercise should assist with different tasks.

C.1.2.5 Recommended resources

The types of information required to plan and conduct VV&C are discussed in Annex B and examples of documents commonly used are listed in Tables B.1 and B.2. Table C.1 gives examples of the types of tools and techniques used in the evaluation of data. In addition, any specific tools or techniques used in the development or characterization of the data should be available for use during the VV&C process.

Table C.1—Typical tools used in VV&C

Tools and techniques	Purpose
VV&A, VV&C process models	Develop plans
DoD Authoritative Data Sources Repository	Verify data sources
Database management system	Track sources
Data exchange model Data flow diagramming tool Exercise data model	Depict complex data relationships among components
Data flow diagramming tool Data dictionary	Evaluate exercise data model (optional)
Database inspection tools Data dictionary Database metadata	Evaluate source-data-to-input-data correlation
Data production tools and techniques Data manipulation tools and techniques	Verify and validate data
Data assessment checklists	Trace and record results

C.2 Exercise VV&C process

The exercise VV&C process consists of five basic activities: *Initiate VV&C Planning, Verify Data Requirements and Sources, Verify Data and Databases, Validate Data and Databases,* and *Prepare for Data/Database Certification.*

C.2.1 Initiate VV&C planning

C.2.1.1 Objective

The objective of this activity is to create a plan that serves as the major control mechanism for ensuring that appropriate criteria and evaluation techniques are used and sufficient resources are allocated for each individual effort.

C.2.1.2 Scope

Initiate VV&C Planning should be done in conjunction with exercise planning and VV&A planning (see 6.1). Because each individual database or data set is considered for certification separately, individual plans may need to be developed and included in the overall VV&C plan.

C.2.1.3 Procedure

Initiate VV&C Planning consists of the same basic tasks as *Initiate VV&A Planning* (see 6.1): *Obtain (VV&C) Planning Guidance, Review (VV&C) Requirements, Select (VV&C) Approach,* and *Prepare (VV&C) Plan.*

The VV&C team should gather as much information about the exercise and its individual components (both M&S and data) as possible (see Table B.1). In coordination with the exercise manager, the VV&C team should begin identifying and prioritizing key data elements (i.e., data elements whose availability and accuracy will have significant impact on the overall exercise) based on exercise requirements and key exercise functions. The team should select the techniques and identify the tools needed to verify, validate, and certify the data and coordinate with exercise planners to establish timelines.

Because much of the necessary information is not available at the beginning of the exercise (e.g., individual databases, M&S components), the VV&C plan should be considered a working document that evolves when new information is obtained or when changes in exercise requirements, plans, or resources result in corresponding changes in VV&C activities. Each iteration of the plan should be submitted to the exercise manager for approval. Ideally, the completed plan provides detailed information such as that listed in Table C.2.

Table C.2—Possible contents of a VV&C plan

Planning elements

Exercise data requirements
Data V&V issues and priorities
Data certification criteria
Problem areas, potential risks
Tailored VV&C tasks (per data set)
  Task leaders
  Recommended tools, techniques
  Data V&V criteria
  Timelines
  Costs
  Report requirements (format, points of contact)
Required resources

C.2.1.4 Expected results

Detailed planning is extremely important because of the complexities involved in developing and executing a DIS exercise. The VV&C plan serves as the blueprint for the VV&C effort and is an integral part of the final documentation. Products resulting from this activity include the VV&C plan and prioritized key data list.

C.2.2 Verify data requirements and sources

C.2.2.1 Objective

The objective of this activity is to ensure that appropriate data (valid, certified) are available and that data voids and deficiencies are identified in a timely manner.

C.2.2.2 Scope

This activity should be performed during *Perform Architectural Design Verification* (6.4) in conjunction with the evaluation of the preliminary design and M&S components [*Evaluate Architectural Design* (6.4.4.1) and *Evaluate Interface Requirements* (6.4.4.2)] so data requirements can be assessed as part of the M&S candidate evaluation.

C.2.2.3 Procedure

This activity addresses a variety of issues regarding the origin and application of the data being considered for use in the exercise (see Table C.3 for examples). Four basic tasks are involved: *Verify Data and Database Sources, Verify Data and Database Application, Evaluate Need for New Data,* and *Evaluate Data Control.*

Table C.3—Typical issues when verifying data requirements and source

Data requirements
Assess completeness of exercise data specifications Identify key data Identify authoritative data sources Identify M&S component data requirements
Preexisting data
Determine databases are certified and sources are authorized Locate required documentation (database and component VV&C) Determine databases are approved for use by components Determine extent and appropriateness of previous use by M&S components Ensure commonality of shared data Correlate input data and sources
Key data generated specifically for the exercise
Verify need Evaluate appropriateness of data generation technique Evaluate credibility of data produced Assess risks
Data control
Check data transfer capability Review input data collection methods Examine data controls

C.2.2.3.1 Verify data and database sources

To ensure that the data and database sources selected by the exercise manager are the most appropriate available, the VV&C team should check the DoD Authoritative Data Sources Repository, which provides information on certified data sources. If the candidate sources are not certified for the types of data involved, the VV&C team should identify alternative sources or outline steps to be taken to correct the data source deficiencies.

C.2.2.3.2 Verify data and database application

The VV&C team should review individual database VV&C and M&S component VV&A histories and review data and database metadata (see Table B.2) to

a) Ensure the individual M&S components have been certified to use the data in similar applications and are capable of using it appropriately;

b) Identify administrative and legal restrictions (e.g., security classification, proprietary policies), data inconsistencies (e.g., format, fidelity), and data voids;
c) Ensure M&S components are capable of sharing common databases; and
d) Verify correlation between key data source definitions and M&S component input data specifications.

If an exercise data model was constructed by the exercise manager, the VV&C, team should verify it against the exercise data requirements.

C.2.2.3.3 Evaluate need for new data

If data are generated specifically for an exercise (e.g., data voids, new systems), the VV&C team should verify the appropriateness of their development, evaluate the credibility of the data produced, and assess the risks (to the exercise) versus the need for the data.

C.2.2.3.4 Evaluate data control

To evaluate the ability of the exercise to generate, transfer, and collect data, the VV&C team should

a) Check components' abilities to exchange data via standard protocols and realistic message formats;
b) Evaluate appropriateness of the data control and generation methods;
c) Examine the classification and sensitivity of data produced and collected with respect to the policies governing the exercise; and
d) Conduct risk assessments on discrepancies and inconsistencies and document the results.

C.2.2.4 Expected result

This activity should result in verification of the appropriateness of data sources and the data-handling infrastructure. The VV&C team should report all data inconsistencies and insufficiencies and the associated risks and recommendations to the exercise manager who determines if changes are necessary. The main product resulting from this activity is the Data Requirements and Sources Assessment. In addition, assessments of the individual data and databases should be provided to the data producers and M&S component providers.

C.2.3 Verify data and databases

C.2.3.1 Objective

The objective of this activity is to assess the adequacy of the input data and databases to address the needs of the exercise and the appropriateness of their use by components of the exercise.

C.2.3.2 Scope

This activity should be performed during *Perform Detailed Design Verification* (6.5) in conjunction with the *Evaluate Detailed Design* (6.5.4.1) and *Evaluate Interface Design* (6.5.4.2) tasks.

C.2.3.3 Procedure

Verify Data and Databases involves four basic tasks: *Verify Source Data, Evaluate Correspondence Between Source and Input Data, Evaluate Data Correlation Between Components,* and *Evaluate Data Control.*

C.2.3.3.1 Verify source data

The VV&C team should examine the data and associated metadata provided by the data producers and compare them to exercise requirements to ensure the data selected are the data desired. The VV&C team should assess the quality of key data elements by evaluating them in terms of characteristics such as those listed in Table C.4.

Table C.4—Data quality

Data characteristics	
Reliability	Sensitivity
Fidelity	Consistency
Integrity	Aggregation
Appropriateness	Adequacy
Sufficiency	Compatibility
Completeness	Availability

C.2.3.3.2 Evaluate correspondence between source and input data

The VV&C team should compare key source data and metadata to component input values and specifications to verify values assigned and identify differences in format (e.g., type, size, units, field definition) or content (e.g., value, precision, range). Such discrepancies are assessed in terms of their impact on exercise execution and output. In addition, the VV&C team should trace key data from their application to source to create an audit trail for use during validation.

C.2.3.3.3 Evaluate data correlation between components

The VV&C team should examine the use of common or shared key data by

a) Evaluating the appropriateness of the methods used by individual components for data manipulation and reduction;
b) Verifying and validating algorithms used by individual components to transform data for use; and
c) Assessing the impact of differences in data values, formats, resolution, or precision on exercise execution and output.

C.2.3.3.4 Evaluate data control

The VV&C team should review exercise test plans, evaluation criteria (MOEs, MOPs, acceptability criteria), and output data production and collection designs to ensure

a) Suitability of collection methods (e.g., time-step, event-driven);
b) Appropriateness of aggregation levels and techniques; and
c) Adequacy of the data produced.

The VV&C team should also evaluate the appropriateness of data analysis techniques and examine data storage designs to assess the appropriateness and accuracy of data conversions and to ensure they are adequate for the expected volume of output.

C.2.3.4 Expected results

This activity should demonstrate the adequacy and appropriateness of the data and databases for exercise use. The VV&C team should report all data inconsistencies and insufficiencies and the associated risks and recommendations to the exercise manager who determines if data or source changes are necessary. The main product resulting from this activity is the Data and Database Verification Assessment. In addition, individual data and database assessments should be provided to data producers and M&S component providers where appropriate.

C.2.4 Validate data and databases

C.2.4.1 Objective

The objective of this activity is to ensure that the data and databases used in the exercise will provide appropriate, consistent, and timely results during testing, execution, and evaluation.

C.2.4.2 Scope

This activity should be performed during *Perform Compatibility Verification* (6.6) in conjunction with the *Construction and Assembly* (5.2.2.4) phase of the exercise life cycle.

C.2.4.3 Procedure

Data applications are tested to ensure data are interpreted and used correctly, initial values are acceptable, and results are realistic. Testing should be conducted during exercise construction and assembly to take advantage of ongoing component compatibility tests. While the individual M&S components are being connected and tested, the VV&C team can evaluate their use of data within the exercise framework by analyzing the results of the compatibility tests and by executing specific functions, modules, or simulations as needed. The VV&C team, assisted by SMEs, should

a) Establish audit trails that trace outputs through functions and transformations back to original inputs to ensure initial data have appropriate values and are handled consistently;
b) Check for consistency and accuracy in data transfers (aggregation/deaggregation situations) and reasonableness in results to evaluate shared data applications;
c) Compare test results to standard independent sources (e.g., physical tests, technical manuals, resulting outputs of the M&S in the exercise configuration vs. outputs of the independent M&S) to ensure results are realistic and appropriate for the application; and
d) Conduct sensitivity analyses to assess the impact of data variations and transformations.

C.2.4.4 Expected results

This task should result in the validation of the data and databases for exercise use. Validation results, data deficiencies, risks, and recommendations are reported to the exercise manager who evaluates the results and determines if data changes are necessary. The main product resulting from this activity is the Data and Database Validation Assessment. In addition, individual data and database assessments should be provided to data producers and M&S component providers where appropriate.

C.2.5 Prepare for data/database certification

C.2.5.1 Objective

The objective of this activity is to prepare the individual data and database V&V assessments for submission to the certification authority.

C.2.5.2 Scope

Because data certification pertains to individual databases and data sets, individual certification assessments may need to be prepared for each of the databases and data sets involved.

C.2.5.3 Procedure

The VV&C team and appropriate SMEs analyze the data V&V results, identify data strengths and weaknesses, assess risks, and prepare a certification assessment for each database and data set.

C.2.5.4 Expected results

The VV&C team submits the individual database certification assessments to the designated certification authority who evaluates the assessment, examines alternatives, and makes a decision regarding the certification of each database. If certification is withheld for one or more databases, the results and recommendations are reported to the exercise sponsor for appropriate action and decisions. Certification rationale should be documented and incorporated into the Exercise VV&C Report. Individual database VV&C reports should be presented to data producers for inclusion in their VV&C histories.

Annex D

(normative)

Tailoring VV&A to the application

D.1 Introduction

This annex presents a methodology for tailoring and costing VV&A programs using a consistent, quantitative, repeatable frame of reference.

D.1.1 Objective

The objective of this activity is to describe a comprehensive method to plan, optimize, and cost VV&A programs for M&S.

D.1.2 Scope

Although the method described is appropriate for all M&S programs, this discussion is limited to distributed simulation applications or exercises.

D.1.3 Purpose

The goal of the tailoring process is to optimize, not maximize, the VV&A program. Tailoring is done for a variety of reasons:

a) To accommodate different applications: training, analysis, acquisition;
b) To accommodate different types of M&S: live, constructive, virtual;
c) To address the needs of the specific exercise in terms of
    1) Exercise development approach,
    2) Budget and resource limitations,
    3) Exercise requirements,
    4) Exercise standards: MOPs, MOEs, acceptability criteria, and
    5) Scheduling and technical constraints;
d) To ensure fairness and accuracy in employment and interaction of components and simulated forces;
e) To take advantage of qualifying factors, such as
    1) VV&A histories of M&S components and the exercise configuration,
    2) New processes, tools, and technologies, and
    3) Available testing resources (e.g., government organic and contractor test beds); and
f) For economics, to ensure that only what needs to be done is done.

D.1.4 Overview

To be cost-effective, a V&V effort must be tailored to balance program needs and real-world constraints. The determination of which V&V activities to perform and the level of effort dedicated to each should depend on program particulars, defined needs, known problem areas, identified risks, and availability of resources (e.g., tools, people, facilities, funding). To effectively tailor the V&V effort, the VV&A agent should

a) Understand the proposed development paradigm;
b) Determine levels of uncertainty and technical needs based on the requirements of the program;
c) Select V&V activities and assign levels of intensity (e.g., weights) for each based on the levels of uncertainty and technical needs involved;
d) Compute an estimated V&V cost based on the proposed, weighted set of V&V activities; and
e) Evaluate proposed cost estimates against real-world cost constraints.

Because of the numerous uncertainties and co-dependencies involved, these steps may need to be revisited a number of times before optimization is achieved. If done correctly, tailored V&V is a "value-added" process, providing more benefits than it costs.

D.2 VV&A tailoring process

Figure D.1 depicts the overall tailoring process.

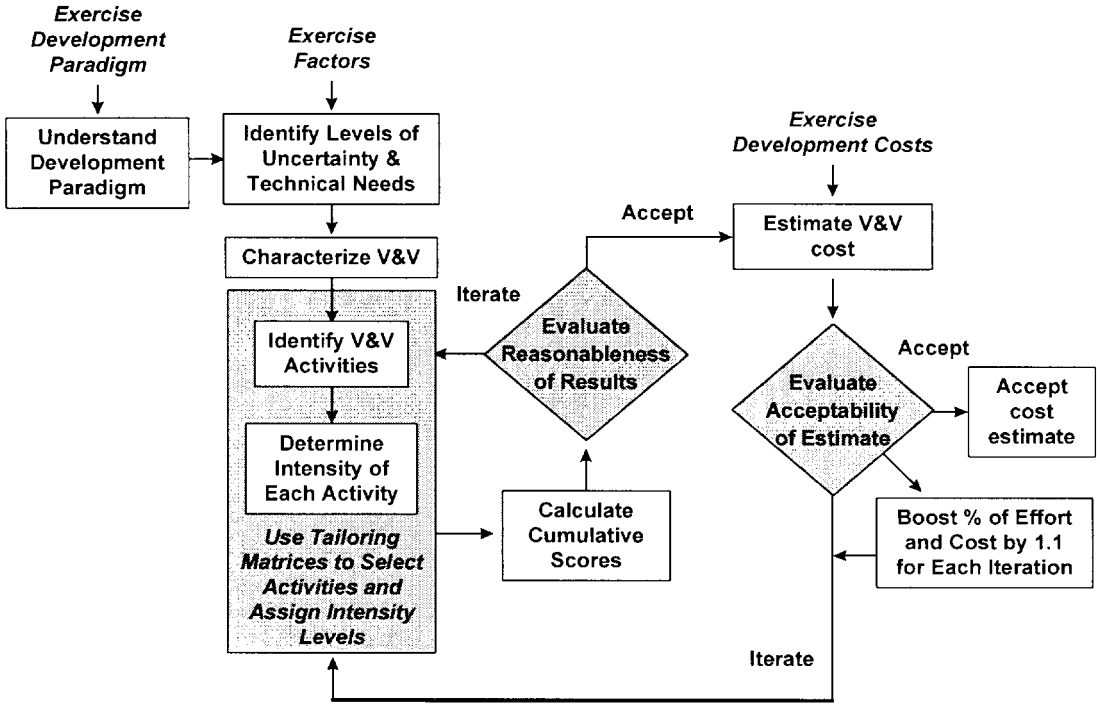

Figure D.1—VV&A tailoring process

D.2.1 Understand the exercise development paradigm

D.2.1.1 Development paradigms

To develop a distributed simulation, the exercise architect selects a paradigm that optimizes exercise development by capturing the unique set of circumstances, constraints, and requirements of the program and by reflecting the degree of certainty associated with the amount of information known. Selection of the development paradigm will have a major effect on VV&A planning and implementation. Typical development paradigms include

a) *Waterfall process:* Used when both requirements and design are stable, predictable, and certain. Appropriate when the exercise includes reused and previously accredited M&S components and/or

configurations; predictable performance expectations; preexisting and certified data; experienced, knowledgeable participants; and sufficient appropriate documentation.

b) *Design iteration process:* Used when exercise requirements are well known but the design is uncertain to ensure adequate design through iteration and analysis. Appropriate when the exercise involves a new configuration, a new application of a preexisting configuration, or new components in the configuration.

c) *Requirements and design iteration process:* Used when both requirements and design are moderately uncertain. Appropriate when a new exercise involves a known network and combinations of known and unknown components and of certified and uncertified data.

d) *Incremental build process:* Used when incremental releases of an application are required and focus is on design-code-test of each build. Requirements are relatively well-defined for all builds but there is greater stability in the early builds. Appropriate either when extensive reuse is involved or when new M&S are produced for the builds.

e) *Evolutionary process:* Used when requirements cannot be completely defined initially and must evolve during development. Appropriate when part of the system or exercise must be built and tested to define additional requirements. The development process iterates until the exercise sponsor is satisfied. Difficult to plan, schedule, and budget.

f) *Rapid prototyping:* Highly adaptive and flexible.
   1) Used for identifying high-risk or unknown parts and to improve, refine, and further develop a system or exercise. Appropriate for building individual executable pieces that can quickly and efficiently provide feedback on specific concepts or operational objectives.
   2) Used for building deliverable end products through a maturation process (similar to the evolutionary model). Appropriate for developing and evaluating requirements, proving early design concepts, demonstrating the graphical user interfaces and human interaction, proving critical algorithms, evaluating the environment and infrastructure, etc.

During longer programs, development paradigms can be deliberately shifted or combined to optimize development. For example, rapid prototyping can be used with any of the other development paradigms and employed at different points in the development cycle to address technical problems.

D.2.1.2 VV&A planning

To identify appropriate V&V activities, VV&A planning should begin with a thorough understanding of the exercise development paradigm, program objectives, requirements, and constraints. The V&V activities selected should address the requirements of the program at appropriate levels of confidence and should be mapped to the development paradigm to ensure effective execution. Figures D.2a and D.2b illustrate how the VV&A process can be overlaid on each of the six defined paradigms.

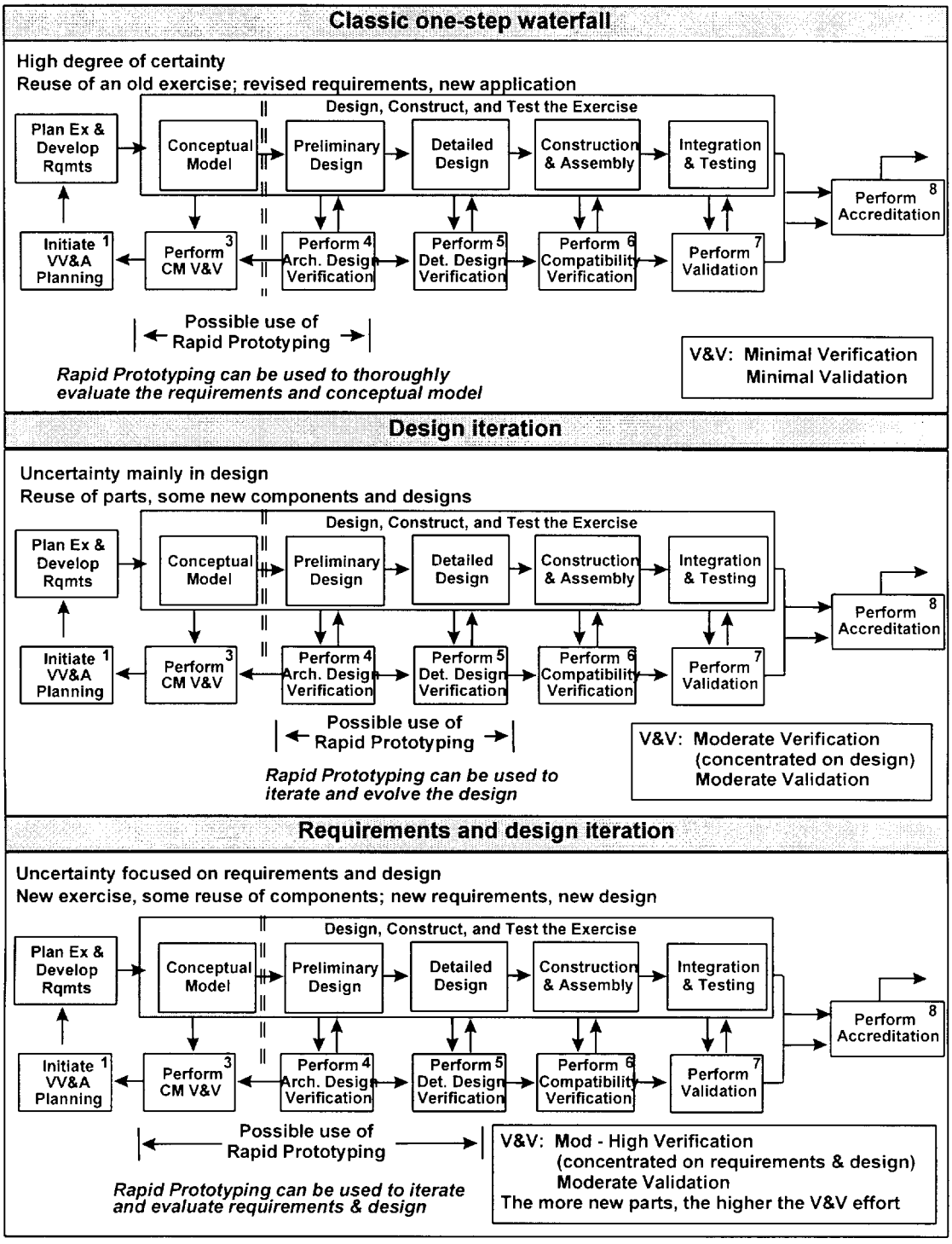

Figure D.2a—Popular development paradigms

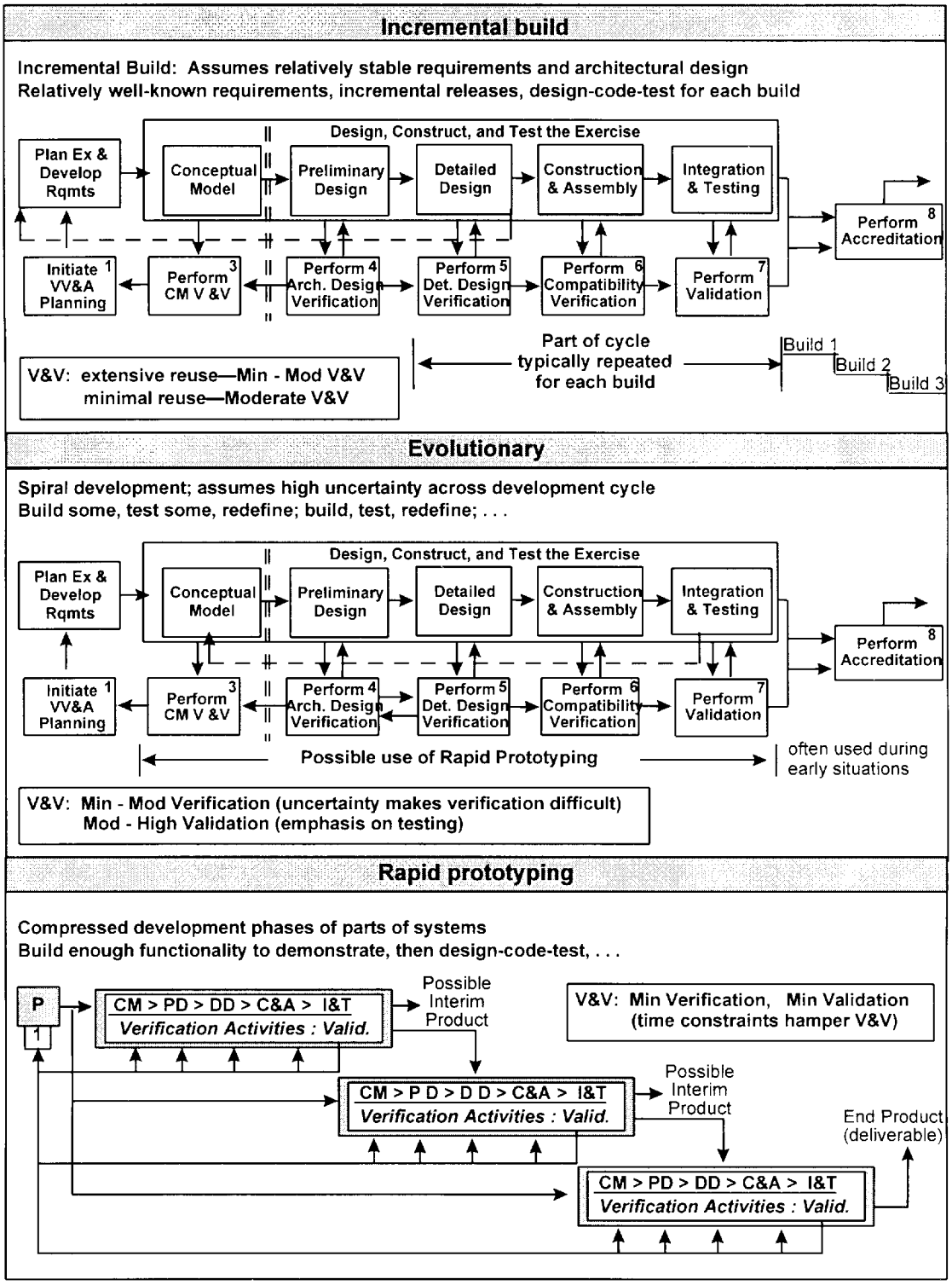

Figure D.2b—Popular development paradigms (*continued*)

D.2.2 Identify levels of uncertainty and technical needs

Factors that have a major impact on exercise development also affect which V&V activities are selected and the degree to which each should be pursued. Such factors include

a) Maturity of technologies;
b) Availability of tools and resources;
c) Clarity of requirements; and
d) Stability of design.

The exercise developers and the VV&A agent should identify factors affecting the development process and assess the level of uncertainty associated with each. Table D.1 shows a certainty versus uncertainty continuum that indicates the degree to which identified factors impact both the development paradigm selection and the level of effort associated with V&V activities. The level of certainty versus uncertainty drives which development paradigm is selected and the amount of V&V needed. In general, higher levels of uncertainty in the development paradigm require higher levels of VV&A. For low-level and, to a lesser extent, moderate-level V&V efforts, the VV&A agent must decide whether to remain comprehensive with reduced analysis or to concentrate on high-risk areas and ignore other areas entirely.

Table D.1—Certainty-uncertainty continuum

High certainty factors	<<<<----------->>>>	**High uncertainty factors**
Known technologies	<<<<----------->>>>	Unproved technologies
Known, stable requirements	<<<<----------->>>>	Unstable requirements
Reused parts with VV&A history	<<<<----------->>>>	Mostly new, untried parts
Stable design	<<<<----------->>>>	Fluid design
Known communication and networking	<<<<----------->>>>	Undecided communication and networking
Predictable performance	<<<<----------->>>>	Unknown performance
Strong tool base	<<<<----------->>>>	Sporadic tool application
Certified data sources	<<<<----------->>>>	Indefinite data sources
Known operational objectives	<<<<----------->>>>	Vague operational objectives
Trained participants	<<<<----------->>>>	Nondedicated participants
Developmental paradigms		
Waterfall Design iteration	Requirements and design iteration Increment build	Evolutionary Rapid prototyping
Level of V&V effort		
Minimum required<<<<<<<<<<<<<<<	<<<<Moderate<<<<<	<<<<<<<<<<<<<<<<<<Maximum required

D.2.3 Characterize the V&V effort

D.2.3.1 Tailoring the process

Once the development paradigm has been selected, the nine-step VV&A process, described in Clause 6, should be tailored to address key issues and performance expectations of the exercise. Figure D.3 provides a list of VV&A activities associated with each of the nine steps. Tailoring is accomplished by selecting the most effective activities and determining appropriate levels of effort for each:

a) High-level efforts attempt to accomplish all or most of the possible activities in great detail;
b) Moderate-level efforts reduce both the intensity and number of specific activities planned, selecting those that are most important to the success of the exercise; and
c) Low-level efforts typically focus on only essential activities.

Tailoring a V&V effort to address the needs of the exercise is an iterative process. Throughout the exercise-planning and requirements definition phase of the exercise life cycle, the VV&A agent accumulates the necessary information. A tailoring matrix can be used to help identify the most effective combination of V&V activities.

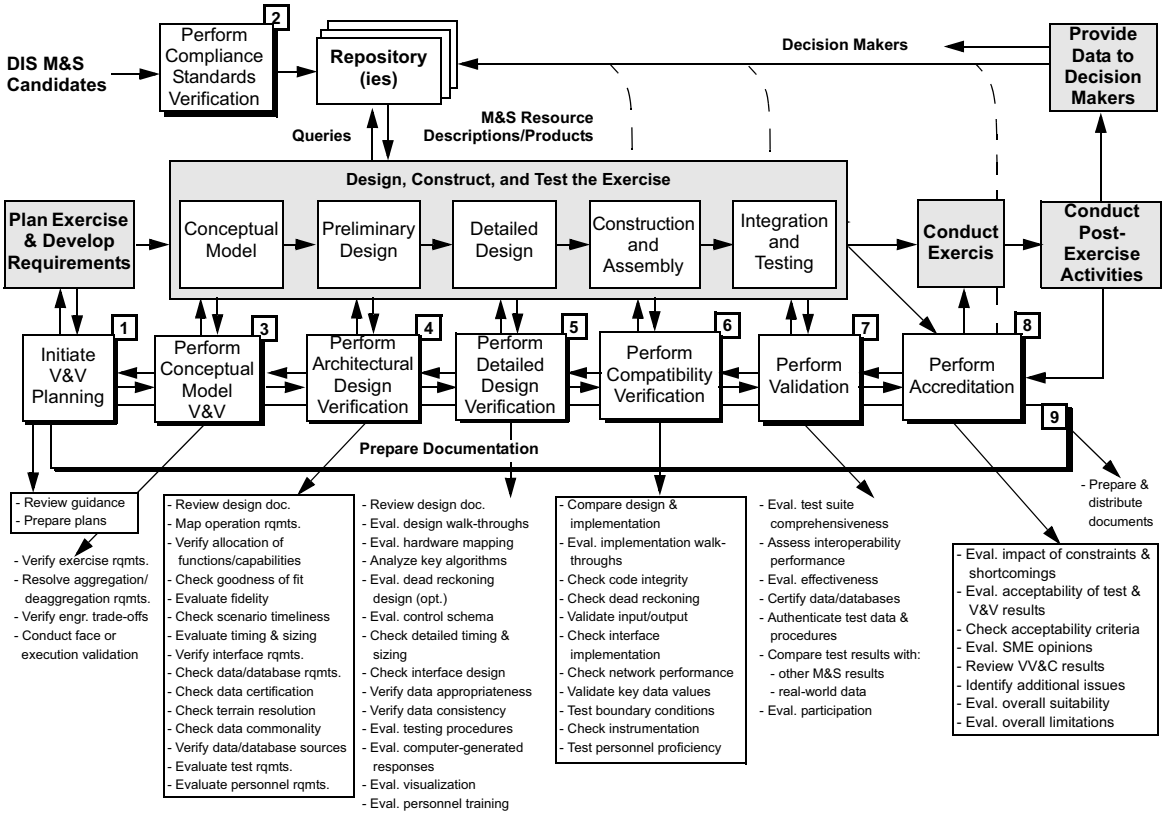

Figure D.3—VV&A process and associated activities

D.2.3.2 VV&A tailoring matrix

The VV&A tailoring matrix is a tool that helps the VV&A agent

a) Select V&V activities to be performed;
b) Weight those activities by their importance; and
c) Develop a cumulative score to use in estimating costs.

The matrix used in the tailoring process is presented in Tables D.2a, D.2b, and D.2c. This multidimensional matrix allows the VV&A agent to explore different options during planning. The first column lists the activities shown as bullets in Figure D.3. Columns 2 through 4 indicate the intensity associated with high, moderate, and low levels of effort for each activity.

Table D.2a—VV&A tailoring matrix for activities 1 through 4

VV&A activity	High-level	Moderate	Low-level
1. *Initiate VV&A Planning*			
Review VV&A planning guidance	X[a]	Y[b]	Z[c]
Prepare plans			
V&V plan	X	Y	Z
VV&C plan	X	Y	
Accreditation plan	X	Y	Z
Subtotal Step 1:	14.00	9.00	3.00
2. *Perform Compliance Standards Verification*			
Check compliance profile	X	X	Y
Check fidelity	X	Y	
Evaluate M&S documentation	X	Y	Z
Evaluate VV&A history	X	Y	Y
Subtotal Step 2:	14.00	10.25	5.50
3. *Perform Conceptual Model V&V*			
Verify exercise requirements	X	X	Y
Verify engineering trade-off analyses	Y	Z	
Resolve aggregation/deaggregation issues	X	Y	Z
Conduct face validation/model execution	X	Y	Y
Subtotal Step 3:	12.75	9.00	5.50
4. *Perform Architectural Design Verification*			
Review preliminary design documentation	X	Y	Z
Map operational requirements	X	Y	Y
Verify allocation of functions/capabilities	X	Y	—
Check goodness of fit	X	Y	Z
Evaluate fidelity	X	Y	—
Check scenario timelines	X	Y	Y
Evaluate timing and sizing	Y	—	—
Verify interface requirements (int. and ext.)	X	Y	Z
Check data/database requirements	Z	—	—
Check data certification	Y	Z	—
Check terrain resolution	X	Y	Z
Check data commonality	Y	Z	—
Verify data/database sources	X	Y	Z
Evaluate test requirements	Y	Y	Z
Evaluate personnel requirements	Y	—	—
Subtotal Step 4:	46.25	24.50	10.50

[a]X=3.5 points
[b]Y=2.25 points
[c]Z= 1 point

NOTE—The allocations presented above represent nominal cases. Additional tailoring should be based on program particulars.

Table D.2b—VV&A tailoring matrix for activities 5 through 7

VV&A activity	High-level	Moderate	Low-level
5. *Perform Detailed Design Verification*			
Review detailed design documentation	Y[a]	Z[c]	Z
Evaluate design walk-throughs	X[b]	Y	Z
Evaluate hardware mapping	X	Y	—
Analyze key algorithm/function	X	Y	Z
Evaluate dead reckoning designs (opt.)	X	Z	—
Evaluate overall control schema	X	Y	Z
Check detailed timing and sizing	X	Z	—
Check interface design (ext. and int.)	X	Y	Z
Verify data appropriateness	X	Y	—
Verify data consistency	X	Y	Y
Evaluate test procedures	X	Y	Z
Evaluate computer-generated responses	X	Y	Z
Evaluate visualization	Y	Z	Z
Evaluate personnel training	Y	—	—
Subtotal Step 5:	45.25	24.25	10.25
6. *Perform Compatibility Verification*			
Compare design and implementation	X	X	Z
Evaluate implementation walk-throughs	X	Y	—
Check code integrity	X	Y	Y
Check dead reckoning (opt)	X	Y	—
Validate input/output data	X	Z	Z
Check interface implementation	Y	Y	Y
Check network performance	X	Y	Z
Validate key data values	X	Z	Z
Test boundary conditions	X	Y	Z
Check instrumentation	Y	Y	—
Test personnel proficiency	Y	Z	—
Subtotal Step 6:	35.75	22.25	9.50
7. *Perform Exercise Validation*			
Certify data/databases	X	Y	Z
Evaluate test suite comprehensiveness	X	Y	Z
Assess interoperability performance	X	X	Z
Evaluate effectiveness	X	X	Z
Authenticate test data and procedures	Y	Y	—
Compare results with baseline M&S results or real-world data	X	Y	Y
Evaluate participation	Y	Y	Z
Subtotal Step 7:	22.00	18.25	7.25

[a]Y=2.25 points
[b]X=3.5 points
[c]Z=1 point

NOTE—The allocations presented above represent nominal cases. Additional tailoring should be based on program particulars.

Table D.2c—VV&A tailoring matrix for activities 8 and 9

VV&A activity	High-level	Moderate	Low-level
8. *Perform Accreditation*			
Evaluate impact of limitations and constraints	X[a]	X	Z[c]
Evaluate acceptability of test and V&V results	X	Y[b]	Z
Check acceptability criteria	X	Y	Z
Analyze SME opinions	X	Y	Z
Review VV&C results	X	Y	Z
Identify additional considerations	X	Y	Z
Evaluate overall exercise suitability	X	X	Y
Evaluate overall exercise limitations	X	X	Y
Subtotal Step 8:	28.00	21.75	10.50
9. *Prepare Documentation*			
Prepare and distribute interim assessments	X	Y	Z
Prepare and distribute documents			
Verification and Validation report	X	Y	Z
VV&C Report	X	Y	Z
Acceptability Assessment	X	Y	Z
Accreditation Report	X	Y	Z
Subtotal Step 9:	17.50	11.25	5.00
Cumulative score:	235.50	150.50	67.00

[a]X=3.5 points
[b]Y=2.25 points
[c]Z=1 point

NOTE—The allocations presented above represent nominal cases. Additional tailoring should be based on program particulars.

D.2.3.3 Levels of intensity

The data used to calibrate the intensities were derived from historical data. The VV&A programs from over fifty historical sources were reviewed and classified as high-, moderate-, or low-level efforts; and average cost percentages, in terms of the percentage of development costs, were calculated for each level. For a high level of effort, average VV&A costs were 17.5% of the development costs; for a moderate level, 11.25%; and for a low-level effort, 5%. Intensity points were derived by normalization:

Intensity Point Value = Average VV&A Cost % / Smallest Average VV&A Cost %

resulting in the values shown in Table D.3.

Table D.3—Levels of intensity

VV&A level	Average V&V cost % (% development cost)	Intensity point value
High	17.50%	3.5
Moderate	11.25%	2.25
Low	5.00%	1

In Tables D.2a, D.2b, and D.2c, the letters X, Y, and Z are used to indicate the normalized intensity values associated with each level of effort. The allocations used in the tables represent "ideal" selections for each level of effort. Because V&V tailoring efforts should be based on individual program particulars, every VV&A effort is expected to vary from the nominal cases shown.

D.2.4 Compute V&V costs

D.2.4.1 Real-world impacts

An optimal VV&A program should accomplish its objectives at a reasonable cost. Cost estimation is done to obtain the best-value balance between program needs and real-world constraints. If the cost of the V&V activities identified during the tailoring process exceeds the budget, trade-offs are made by prioritizing the selected activities based on their ability to instill and confirm confidence in the exercise and their return on investment. Final decisions on the VV&A activities should be driven by program particulars (e.g., discrete requirements, defined needs, known problem areas, high-risk and critical items, availability of tools, methods, key staff) to maximize V&V effectiveness and minimize costs.

D.2.4.2 V&V cost factor

A common cost factor has been developed for use in all programs. By dividing the cumulative scores derived from the nominal VV&A tailoring matrix (Tables D.2a, D.2b, and D.2c) by the average V&V cost percentages based on historic evidence (D.2.3.3), a V&V cost factor of 13.4 is produced (see Table D.4).

Table D.4—V&V cost factor

V&V level	Cumulative score	V&V cost % (% development cost)	V&V cost factor
High	235.25	17.50%	13.4
Moderate	150.50	11.25%	13.4
Low	67.00	5.00%	13.4

D.2.4.3 Costing process

V&V cost calculation is based on the cumulative score derived from the V&V tailoring matrix and the V&V cost factor. The VV&A agent completes the tailoring matrix for the agent's specific application and computes a cumulative score. This score is then divided by the V&V cost factor (13.4) to produce the V&V cost percentage (i.e., % development cost). The V&V cost percentage is multiplied by the exercise development cost estimate to obtain the V&V cost estimate:

V&V Cost % = V&V Cumulative Score × V&V Cost Factor
V&V Cost Estimate = Exercise Development Cost Estimate × V&V Cost %

D.3 Additional considerations

a) Because VV&A program requirements are not compared to the available budget until the end of the process, an optimal VV&A program plan (i.e., one tailored to address the needs of the exercise) is produced without budgetary biases and pressures. This approach allows the VV&A agent to present an optimal plan to the exercise sponsor and negotiate the funding and/or scope of the effort. When the budget is appreciably lower than the resulting estimate, adjustments should be made in the plan, or the sponsor will have to seek additional funding.

b) Programs that involve more than one major VV&A cycle (e.g., incremental development, interim products, incremental accreditation) may require additional special costing consideration. When additional validation is required for accreditation, for example, an adjustment can be made to the intensity values assigned to the activities associated with *Perform Accreditation* (see Table D-2c).

c) Because repetition of similar activities can result in savings, an iteration factor of 10% can be used to determine the additional costs for each iteration beyond the initial procedure. For example, if an exercise or program involves three increments and the initial V&V cost figure is 10.4% of the development costs, the iteration factor could increase the VV&A budget as follows:

10.4% (V&V cost %) × 1.20 (10% per additional iteration) = 12.5% (revised V&V cost)

If this factor is ignored, the VV&A effort will tend to run low on resources toward the end of the program and will not be able to perform in an optimal manner.

D.4 Conclusion

a) Tailoring the VV&A process requires careful analysis of the exercise requirements, an understanding of the development paradigm, knowledge of the problem areas and technologies, knowledge of and access to the various certified data sources, and understanding of the exercise environment and infrastructure. The level of uncertainty involved in the exercise development governs the amount of VV&A involved: Moderate uncertainty calls for a moderate VV&A effort; low uncertainty requires less VV&A and reduces cost; a high level of uncertainty requires greater VV&A effort and increases cost.

b) A VV&A program can be planned, tailored, and executed in an affordable manner for virtually any DIS application. A conscientious VV&A effort can actually add value to the development of the exercise. Its cost can be completely absorbed by the savings involved in using a valid conceptual model, reducing rework, detecting defects early, stabilizing the architecture and network, improving usability, correlating results, ensuring compatibility, and participating in test and evaluation. When budgetary constraints are involved, the tailoring matrix can also be used to select the most significant activities as well as those that have the highest return on investment to build an austere, yet effective program (e.g., minimize labor-intensive activities and retain those that are based on automated tools), select most critical functions and algorithms and perform off-line analysis techniques to assess and plot their behavior.

c) The VV&A process is a highly adaptable, versatile, and cost-effective process that augments much of the work done by the exercise developer. When correctly planned and executed, it is nonadversarial, cooperative, and workload-sharing. It is invariably worth at least as much as it costs.