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An American National Standard

Standard Practice for Modeling in Health Informatics¹

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1. Scope

1.1 Information models appropriately are used for analysis, design, and sharing a common understanding in health and healthcare information engineering, in healthcare process improvement, in building information systems, and in health informatics standards development.

1.2 The purpose of this practice is to identify best practices for the creation, use, and assessment of information models in the health and healthcare domain.

1.3 Included in this practice are recommended organizational policies and procedures, where modeling is best used in healthcare, and recommended modeling methods, best practices and evaluation criteria.

1.4 Excluded from this practice are detailed specifications of modeling techniques that are specified or described in other sources.

2. Referenced Documents

2.1 ASTM Standards:

E 1239 Guide for Description of Reservation/Registration-Admission, Discharge, Transfer (R-ADT) Systems for Automated Patient Care Information Systems²

E 1384 Guide for Content and Structure of the Electronic Health Record (EHR)²

E 1639 Guide for Functional Requirements of Clinical Laboratory Information Management Systems²

E 1715 Practice for Object-Oriented Model for Registration, Admitting, Discharge and Transfer (RADT) Functions in Computer-Based Patient Record Systems²

2.2 ANSI Standards:³

ANSI X3.172-1990 Dictionary for Information Systems

IEEE 1320.1-1998 Standard for Functional Modeling Language—Syntax and Semantics for IDEF0

IEEE 1320.2-1998 Standard for Functional Modeling Language—Syntax and Semantics for IDEF1X (Object 97)

2.3 ISO Standards:³

ISO 8601-88 Data Elements and Interchange Formats—Representation of Dates and Times

ISO/IEC 1087 Terminology Work—Vocabulary-Part 1: Theory and Application

ISO/IEC 11179 Information Technology—Specification and Standardization of Data Elements, Parts 1-6

ISO/IEC 2382 Information Processing Systems—Vocabulary

2.4 FIPS Standards:⁴

Information Modeling (IDEF1X) Federal Information Processing Standard 184. Gaithersburg, MD: National Institute of Standards and Technology. December 21, 1993. See also: IEEE 1320.2

Integration Definitions for Functional Modeling (IDEF0) Federal Information Processing Standard 183. Gaithersburg, MD: National Institute of Standards and Technology. December 21, 1993. See also: IEEE 1320.1

3. Terminology

3.1 The following sections present terms, definitions, and acronyms found in this practice and in various modeling activities.

3.2 Definitions:

3.2.1 *activity, n*—a group of logically related tasks performed for a purpose.

3.2.2 *alternate key attribute, n*—any candidate key of an entity other than the primary key.

3.2.3 *attribute, n*—a characteristic of an object or entity (see **ISO/IEC 11179**).

3.2.4 *attribute value, n*—a representation of an instance of an attribute (see **ISO/IEC 11179**).

3.2.5 *behavior column, n*—a column is a physical data model and relational database structure that is analogous to the attribute of a logical data model.

3.2.6 *concept, n*—a unit of thought constituted through abstraction on the basis of characteristics common to a set of objects, (see **ISO/IEC 1087**).

3.2.7 *concept activity model, n*—the activity component of the Concept Model.

3.2.8 *concept data model, n*—the data component of the Concept Model.

¹ This practice is under the jurisdiction of ASTM Committee E31 on Health Informatics and is the direct responsibility of Subcommittee E31.25 on Healthcare Management, Security, Confidentiality, and Privacy.

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² *Annual Book of ASTM Standards*, Vol 14.01.

³ Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036. <http://www.ansi.org>.

⁴ Available from National Technical Information Service (NTIS), U.S. Dept. of Commerce, 5285 Port Royal Road, Springfield, VA 22161. <http://www.fedworld.gov>.

3.2.9 *concept model*, *n*—also known as a conceptual schema from the ANSI/X3/SPARC Study Group for Database Management Systems.

3.2.10 *context*, *n*—a designation or description of the application environment or discipline in which a name is applied or from which it originates (see [ISO/IEC 11179](#)).

3.2.11 *data*, *n*—a representation of facts, concepts, or instructions in a formalized manner, suitable for communication, interpretation, or processing by humans or automatic means (see [ISO/IEC 11179](#)).

3.2.12 *data dictionary*, *n*—a database used for data that refers to the use and structure of other data; that is, a database for the storage of metadata (see [ANSI X3, 172-1990](#)).

3.2.13 *data element*, *n*—a unit of data for which the definition, identification, representation and permissible values are specified by means of a set of attributes (see [ISO/IEC 11179](#)).

3.2.14 *data model*, *n*—a description of the organization of data in a manner that reflects an information structure (see [ISO/IEC 11179](#)).

3.2.15 *data steward*, *n*—a person or organization delegated the responsibility for managing a specific set of data resources, (see [ISO/IEC 11179](#)).

3.2.16 *dependent entity*, *n*—an entity that inherits one or more identifying attributes from another entity.

3.2.17 *domain*, *n*—the set of possible data values of an attribute (see [ISO/IEC 2382](#)).

3.2.18 *entity*, *n*—any concrete or abstract thin of interest, including associations among things (see [ISO/IEC 2382](#)).

3.2.19 *external schema*, *n*—an external schema is the representation of data at the system architecture presentation layer as viewed by the user when interacting or communicating with the information system.⁵

3.2.20 *foreign key attribute*, *n*—an attribute or combination of attributes of a child or category entity whose values match those in a primary key of a related or generic entity instance.

3.2.21 *function*, *n*—an activity, process or transformation identified by a verb that describes what would be accomplished.

3.2.22 *independent entity*, *n*—an entity that does not inherit identifying attributes from another entity.

3.2.23 *internal schema*, *n*—a schema of the ANSI X3/SPARC Three Schema⁵ architecture in which views of the information are representations of data structure at the system architecture data layer.

3.2.24 *key attribute*, *n*—an attribute used to identify an instance of an entity.

3.2.25 *key inheritance*, *n*—the transmission of a key attribute from a parent or independent entity to a child or dependent entity.

3.2.26 *lexical*, *n*—pertaining to words or the vocabulary of a language as distinguished from its grammar and construction (see [ISO/IEC 11179](#)).

3.2.27 *logical data model*, *n*—a data model that presents a logical organization of data in the form of entities, attributes and relationships, especially where these components are normalized.

3.2.28 *metadata*, *n*—data that describes other data (see [ISO/IEC 11179](#)).

3.2.29 *non-key attribute*, *n*—an attribute that is not the primary or part of a composite primary key of an entity.

3.2.30 *object*, *n*—any part of a conceivable or perceivable world (see [ISO 1087](#)).

3.2.31 *object class*, *n*—a set of objects, ideas, abstractions, or things in the real world that can be identified with explicit boundaries and meaning and whose properties and behavior follow the same rules (see [ISO/IEC 11179](#)).

3.2.32 *object-oriented methodology*, *n*—any of several modeling and information management methods and techniques that employ objects rather than entities or tables.

3.2.33 *physical data model*, *n*—a data model that presents an organization of data in the form of tables, columns, and relationships.

3.2.34 *primary key attribute*, *n*—the candidate key selected as the unique identifier of an entity.

3.2.35 *property*, *n*—a peculiarity common to all members of an object class (see [ISO/IEC 11179](#)).

3.2.36 *relational data methodology*, *n*—any of several modeling and information management methods and techniques that employ structured relationships among entities or tables.

3.2.37 *row*, *n*—a row is a physical data model and relational database structure that contains an instance of data in a column.

3.2.38 *subject area*, *n*—a subject area is a portion of an entire data model which is created to facilitate understanding of a specific functional area or component task.

3.2.39 *table*, *n*—a physical data model and relational database structure that is analogous to the entity of a data model.

3.2.40 *transformational data model*, *n*—a data model that is optimized for performance on a specific technology.

3.2.41 *view (such as clinical)*, *n*—a collection of entities and assigned attributes (domain) assigned for some purpose.

3.3 Acronyms:

3.3.1 *ANSI*—American National Standards Institute.

3.3.2 *ASTM*—American Society for Testing and Materials.

3.3.3 *CODASYL*—Conference on Data Systems and Languages.

3.3.4 *ICOM*—Input, Control, Output and Mechanisms of IDEF activity modeling.

3.3.5 *ICT*—Information and Communications Technology.

3.3.6 *IDEF*—Integrated Definition Language.

3.3.7 *IDEF0*—The IDEF activity modeling language.

3.3.8 *IDEFIX*—The IDEF data modeling language.

3.3.9 *IDO*—Integrated Delivery Organization.

3.3.10 *IE*—Information Engineering diagramming methodologies.

3.3.11 *IEC*—International Electrotechnical Commission.

3.3.12 *ISO*—International Organization for Standardization.

3.3.13 *ISA*—Information Systems Architecture.

3.3.14 *UML*—Unified Modeling Language.

3.3.15 *DFD*—Data Flow Diagram.

3.3.16 *SML*—Standardized Modeling Language.

⁵ ANSI Standards Planning and Requirements Committee—a layered model of database architecture comprising a physical schema, a conceptual schema, and user views.

3.3.17 *NIST*—National Institute of Standards and Technology.

3.3.18 *SQL*—Structured Query Language.

3.3.19 *CRC*—Class, Responsibility and Collaboration Approach.

3.3.20 *RDB*—Relational Database.

3.3.21 *RDBMS*—Relational Database Management System.

3.3.22 *CORBA*—Common Object Request Broker Architecture.

4. Summary of Practice

4.1 This practice describes policies and procedures, best practices for the creation, use, and assessment of health information models, and typical applications of information modeling in the health and healthcare domain.

4.2 The foundation for best practices in health information modeling may be derived from structure, process and outcome quality constructs (1).⁶

4.2.1 *Quality Construct*—Information Modeling Area Supported.

4.2.2 *Structure*:

4.2.2.1 The organization component where modeling activities occur.

4.2.2.2 The composition of the modeling method or tool, its language and syntax.

4.2.3 *Process*:

4.2.3.1 Appropriate use of modeling.

4.2.3.2 Effective use of modeling methods.

4.2.3.3 Correct employment of the modeling technique.

4.2.4 *Outcome*—A quality health informatics model that provides a meaningful representation of past, present, or future reality.

4.3 The five dimensions (2) of model quality that derive from these quality constructs are as follows:

4.3.1 *Conceptual Correctness*—The model accurately reflects health or business concepts.

4.3.2 *Conceptual Completeness*—The model contains sufficient objects to describe the full scope of the target health or business domain.

4.3.3 *Syntactic Correctness*—The objects in the model do not violate syntactic rules of the modeling language.

4.3.4 *Syntactic Completeness*—All health or business concepts are captured at appropriate points in the modeling process.

4.3.5 *Enterprise Awareness*—The model depicts the entire enterprise or can be seamlessly integrated with other models across the entire organization.

4.4 *Enterprise Awareness*:

4.4.1 The foundation of a quality information model is the ability to describe the entire organization, either by itself or when combined with other comparable models.

4.4.2 Multiple models must seamlessly integrate across the entire organization and their descriptions must rationally flow from one model to another.

4.4.3 The Zachman Information Systems Architecture (3) is an effective tool to describe the totality of an organization from an informatics viewpoint. The Zachman ISA, therefore, is a suitable framework for identifying models that represent the informatics structure and processes of the organization.

4.5 *Conceptual Correctness*:

4.5.1 All models are representations of real objects or concepts.

4.5.2 The model must accurately describe the intended real organizational structures or processes, or both, and effectively communicate this description to anyone who understands the modeling method and syntax.

4.6 *Conceptual Completeness*:

4.6.1 Models describe the full scope or an element of the structures or processes, or both, of an organization or concept.

4.6.2 The model must contain sufficient objects to describe the full scope of the intended health or business domain.

4.7 *Syntactic Correctness*:

4.7.1 Each modeling method has a predefined language typically consisting of visual structures and symbols. Rules govern the manner in which these structures and symbols are assembled and interpreted.

4.7.2 The modeling method must use a recognized and preferably standardized set of rules (4).

4.7.3 The model must adhere to the syntax of the modeling methodology.

4.8 *Syntactic Completeness*:

4.8.1 A modeling method may use different objects, symbols or structures at different times in the modeling process.

4.8.2 The model must employ the appropriate structures and symbols at the appropriate place in the model and at the appropriate time in the modeling process.

4.9 *Additional Technical Considerations*:

4.9.1 In addition to the dimensions of quality, several technical considerations impact the quality of an informatics model (4).

4.9.1.1 *Nonredundancy*—A fact must be represented at only one point in the model.

4.9.1.2 *Business Rules Enforcement*—The model accurately reflects organizational, health, or business processes.

4.9.1.3 *Reuseability*—The content of the model is accessible to other than the originally intended users.

4.9.1.4 *Stability*—The model accepts changing health or business requirements without significant alteration in the structure of the model.

4.9.1.5 *Flexibility*—The model is capable of supporting change in health concepts or business processes.

4.9.1.6 *Simplicity*—The model is easily understandable and well presented.

4.9.1.7 *Implementable*—The model may be readily and economically used in analysis, design, development, or operation.

4.9.1.8 *Communicability*—The model readily conveys meaning to its users and readers.

4.10 *Assessing the Modeling Process and Model Quality*:

4.10.1 The dimensions of model quality that are derived from structure, process, and outcome quality constructs lead to best practices in the following areas:

⁶ The boldface numbers in parentheses refer to the list of references at the end of this standard.

4.10.1.1 *Structure*—The organization desiring to employ modeling creates and maintains an environment conducive to the creation, evaluation, communication and use of quality information models.

4.10.1.2 *Process*—Modeling methods are appropriately selected and applied through effective use of modeling language and adherence to syntax to provide a meaningful, comprehensive, and balanced representation of real world health or business concepts.

4.10.1.3 *Outcome*—The resulting model(s) exhibit a high degree of excellence and wholeness are identified by author, participants, technique and approach, perspective, view and subject areas, and may include test data for evaluation purposes.

4.10.2 **Annex A1** of this practice provides checklists for assessing the quality of models and modeling activities in terms of structure, process, and outcome.

5. Significance and Use

5.1 Modeling is increasingly used in the healthcare industry to develop a common understanding of processes, functions, activities, and supporting data. Typical users of such models are healthcare systems developers, health, and healthcare operations researchers and analysts, educators, and executives.

5.2 Information models are regarded widely as beneficial by saving the cost through risk reduction and elimination of redundancy. Information models convey ideas and facilitate analysis and understanding of complex processes and structures. These models form the basis for software engineering practices that build databases, redefine organizational processes, and develop standards.

5.3 This practice provides a practical means for developers and users of health information models to employ appropriate modeling methods and to objectively determine model quality.

5.4 Background:

5.4.1 Models are representations of past, existing, or contemplated reality. Models may assist in the explanation or analysis of complex structures and processes that may exceed human capacity for direct visualization or understanding. Models enable a focus on the key elements of a process or structure while ignoring confounding or irrelevant elements. As such, models make an explicit statement of the meaning of the reality being modeled.

5.4.2 Integrated information engineering models provide a coherent view of the activities and data of an organization or enterprise (5). Activity models identify the fundamental tasks performed in a function. Process models accurately describe the detailed collection of activities within an organization. Data models are derived from and support the functions described in activity models. Object models collectively characterize the processes and data required to understand the operation of an organization and to construct information systems that support that operation. Models may be textual, graphic, or mixed graphic and text forms, including, flowcharts, state diagrams, data flow diagrams, entity-relationship diagrams, and related techniques develop an understanding of business processes and the transformation of data through these processes (6).

5.5 Frameworks for Relating Models to Systems:

5.5.1 Since proposed by Zachman in 1987 (3), the Information System Architecture (ISA) has become an accepted means to view and to blueprint information systems within an entire organization, designing business practices, and changing enterprise strategies. Zachman developed this ISA as a “framework” to describe and interrelate the components of an information system to the entire organization. The Zachman ISA has been adapted for the Healthcare sector: **Table 1** presents the ISA as a framework of healthcare related informatics standards that may apply in a given healthcare enterprise.

5.6 Principles and Approaches to Modeling:

5.6.1 Modeling activities have been prevalent throughout the history of the engineering disciplines. This rich history indicates four basic principles (7), as:

5.6.1.1 The choice of what models to create has a profound influence on how a problem is attacked and how a solution is shaped.

5.6.1.2 Every model may be expressed at different levels of precision.

5.6.1.3 The best models are connected to reality.

5.6.1.4 No single model is sufficient; every nontrivial system is best approached through a small set of nearly independent models.

5.6.2 The three approaches to information modeling are characterized as top-down, bottom-up, and inside-out (8).

5.6.2.1 The “top-down” approach follows a progression of activities that first analyzes and understands functionality of the domain-of-interest and only then progresses to model preparation. The top-down paradigm typically consists of preparing a high level conceptual model, consisting of activity model and an entity-relationship data model. Logical data models may be constructed as appropriate for the standard and healthcare domain. The strength of this approach is it provides a broadly-based and comprehensive set of rationally derived models that are generally appropriate across the spectrum of healthcare activities. This paradigm saves time and resources in development.

5.6.2.2 The “bottom-up” approach reflects the experience of subject matter experts in a variety of specialized subdomains. These panels of experts prepare small models that are subsequently integrated. The strength of this approach is that it addresses detail that can be easily converted to a specific application, and may be tuned or optimized for a segment of the healthcare environment. Often, it is used when the entire domain is not well understood or in the absence of a business model foundation. The bottom-up paradigm produces narrowly focused model components requiring extensive effort for component integration.

6. Determining the Need for Information Modeling

6.1 In health informatics, these principles may be applied to modeling for content, modeling in information systems development, modeling in standards development.

6.1.1 *When and Where to Use Modeling Techniques for Content*—The complexity and extensiveness of current health information and health care information systems preclude a comprehensive understanding to the depth of detail required



TABLE 1 The Zachman Information Systems Architecture

	Why	When	Who	What	How	Where
Scope (contextual)	Goals (motivation) 1. Personal/Public Healthcare delivery business case	Events (time) 2. Identification of significant care/care delivery events	Vision [Guidelines] Stakeholders (People) 3. Essential health service organizations and functions	Values (content) 4. Description of important healthcare service and care delivery information	Processes (function) 5. Important healthcare and care delivery services	Locations (Network) 6. Identification and description of organization and individual locations
Enterprise model (Conceptual)	Objectives 7. Personal health benefit and care delivery business objectives	Timeline 8. Sequence and timelines of healthcare services	Design [Standards] Organization 9. Healthcare information workflow	E-R Data Model 10. Semantic description of healthcare processes	Process Model 11. Conceptual activity model of healthcare delivery	Interface Architecture 12. Structure and interrelationship of healthcare facilities
System model (Logical design)	Requirements 13. System Functional Requirements	Phases 14. Healthcare event phases and process components	Hierarchies 15. Healthcare information system human-system interface architecture	Logical Data Model 16. Logical data model for healthcare information	Data Flow 17. Application architecture with function and user views	Network Model 18. Connectivity and distributed system architecture
Technology model (Physical design)	Knowledge Design 19. System Operational Requirements	Control Structure 20. Healthcare information system control structures	Implementation [Standards] Human-Technology Architecture 21. Healthcare information system human system interface description	Physical Data Model 22. Physical data model for healthcare information	Structure Chart 23. System Design, language specification and structure charts	System Architecture 24. Health system information network detailed architecture
Components (Modules and subsystems)	Knowledge Definition 25. Technical Requirements	Timing Definition 26. Healthcare Information System component timing descriptions	Security Architecture 27. System Security Architecture and Operations	Data Dictionary 28. Healthcare Information Metadata and DBMS scripts	Program Description 29. Code Statements, Control blocks, DBMS stored procedures	Network Architecture 30. Physical data network components, addresses and communication protocols
Functioning system	Strategy 31. Technology Operational Requirements	Schedule 32. Healthcare information system operation schedules	Operation [Standards] Organization 33. IS participant description	Data 34. Functioning database, knowledgebase	Function 35. User procedural system and documentation	Network 36. Operating health system communication network

required. Formal methods are needed to facilitate the development and sharing of a common understanding about such information and systems. The following sections suggest where and how a given modeling method or technique may be appropriately used to model content, to develop systems, and to develop standards. These sections also outline how to recognize where and how to select a particular modeling technique for application to a specific problem and enterprise, and how to document the representation health information and healthcare systems concepts.

6.1.2 Integrated Delivery Organizations (IDO)—Almost all Integrated Delivery Organizations (IDOs) will have facilities and settings of care that range across the familiar resident (inpatient) and nonresident (ambulatory) facilities and settings. Historically, these have been treated differently, but in Guide E 1239, the concept of a common structure for the care record applicable to all settings of care is introduced and is carried forward into Guide E 1384. That concept is applicable to all of the information subdomains and healthcare professional specialty views of the underlying data structures and representations. In order to achieve composable component models from

which to build an entire enterprise model, common underlying concepts must be consistently used in each subdomain of an integrated composed domain information model. These common concepts applied to the familiar ancillary services and activities are dealt with below. The application of modeling techniques to an IDO should only proceed as part of a defined project within the Life Cycle Processes for a system if the range of participants needed to model an organization of this scale are to be systematically engaged in a manner that will lead to a useful outcome.

6.1.3 Resident Healthcare Facilities—The most familiar resident facility is the hospital, which has a number of specialty configurations, many of which are described in Guide E 1384 and each configuration has different patterns of specialty participation. Using the methods, techniques and tools in Sections 6 and 7, the facility must be dissected into its constituent specialty views and the information subdomains identified.

6.1.4 Population/Public Health—The ability to assess population and public health care is critical to any health care information system. Modeling of these domains is the

ensure the development of an inclusive health Domain Information Model. In addition, population and public health care needs may have significant architectural impact on the information system. Modeling of these partitions will identify those essential information subdomain components that must be addressed through the development process.

6.1.5 Ambulatory Care Facilities—Ambulatory care facilities serve the widest variety of settings and enterprise arrangements, many of which require interoperation of the facility informatics domain with inpatient facilities. Understanding the information architecture which best serves each practice setting requires careful modeling in order to understand the information, the data structures, the data representations, the information services and system responsibilities and constraints. Part of this architecture can be built upon common frame works that are documented in the healthcare informatics standards, such as ADA 1000 Series, Guide E 1384, Practice E 1715, Health Level 7, and used as a core for a set of enterprise models that document how the individual enterprise operates and interacts with the external world. Careful consideration of the Zachman ISA Framework (see 4.5) helps document the modeling steps that may be needed.

6.1.6 Home Healthcare Facilities—In the emerging healthcare arrangements, care at home by visiting practitioners is increasing. The information that documents care by family members or other residents in a patient's home, in addition to that rendered by visiting practitioners will be part of the health Domain Information Model that must be represented. Both content concepts and implementation technology must be represented for this setting of care so that both clinical care and resource management concepts are included.

6.1.7 Laboratory Components—Modeling of not only the information architecture internal to the clinical laboratory of the but also the other enterprise environments it serves is also appropriate. Guide E 1639 deals with the clinical laboratory enterprise environment and the internal requirements of the of the clinical laboratory information domain. This standard depicts the modeling methods that help the clinical laboratorian understand the internal structures and activities and how to relates these to the practitioner customers that they serve. Guide E 1239 and Practice E 1715 depict the key foundation data structures for registration admitting, discharge functions that are common to both the clinical laboratory and to the EHR information domain of the practitioner.

6.1.8 Pharmacy Components—Pharmaceutical care, in all settings, is becoming recognized as a contributing information subdomain that is a component of clinical views of the patient care record. In addition to the attributes recorded for the care record, additional resource management attributes within the pharmacy itself and its relationship with the financing subdo-

main, must be modeled accurately in order to reflect the obligations, responsibilities and constraints of the information services involving this pharmaceutical care Subdomain.

6.2 When and Where to Use Models for System Development:

6.2.1 At a high level, all development methodologies employed in software engineering share a sequence of four essential activities from project inception to implementation (9) as illustrated in Fig. 1.

6.2.2 Why Use Modeling in System Development:

6.2.2.1 Software engineering is heavily dependent upon modeling activities.

6.2.2.2 System development models may consist of elementary structures like an organizational chart to detailed structural representation of a software package. Models typically are employed in the planning and analysis phase of software development, in system and software design, and in the coding process.

6.2.2.3 Booch, et. al. (7), state that the single fundamental reason for modeling a system is to better understand the system being developed, achieving four aims:

- (a) To visualize an existing or desired system;
- (b) To specify the structure and behavior of a system;
- (c) To provide a guiding template for system construction; and,
- (d) To document the decisions made in system development.

6.2.2.4 Pressman notes three additional reasons for modeling (10) in system development:

- (a) The business problem and solution can be approached incrementally, thus reducing the probability that a major feature will be misinterpreted or overlooked;
- (b) The customer or user can more easily review the analysis and design, to help preclude or eliminate areas of ambiguity and misunderstanding; and,
- (c) The development proceeds in a logical, efficient and more readily manageable manner through the migration of models from analysis through design and development.

6.2.2.5 Most importantly, models greatly enhance quality in system development. Models enable the developer to proactively build-in quality during design rather than reactively assess quality during development. As models are transformed from analysis through physical software, sets of quality criteria can be created for each modeling step, with the models reviewed against these criteria incrementally. Errors in requirements definition, design, and development can be uncovered easily and corrected at the earliest possible time with less effort and delay than if corrected during module or integration testing.

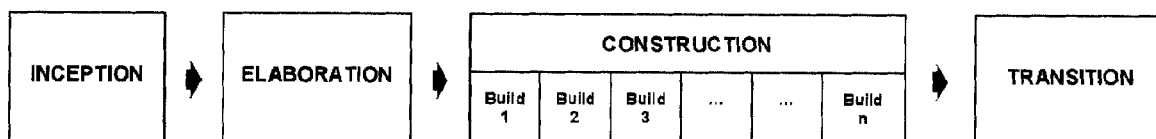


FIG. 1 High Level View of Software Development Steps