romments, which must be solved through a combination of inventing better notations and abstracting operations. Finally, the ability to demonstrate correctness does not mean that it is appropriate to do so in all cases; better guidelines for applying the varying degrees of rigor possible in the methodology must be developed.

REFERENCE


EXPERIENCE WITH THE IPAD SOFTWARE DEVELOPMENT METHODOLOGY—Susan Voigt

NASA is sponsoring the development of a computer-aided design system for use by the aerospace industry. The system, denoted IPAD, is being designed and implemented by Boeing Commercial Airplane Company and Boeing Computer Services. IPAD is a software system to enhance the computer complexes of aerospace companies to improve speed, efficiency and reliability of the design process for complex aerospace vehicles. The contract calls for application of an effective software engineering approach to minimize programming and software design errors, as well as to produce highly portable software.

THE TECHNIQUE

NASA established general guidelines for phases of the development and release of software in stages, to allow early user testing and experience. The development phases are:

1. Definition of the Problem (namely the Aerospace design process)
2. Requirements Definition (integrated information processing and functional requirements)
3. Development of IPAD System Specifications
4. Preliminary Design
5. Detailed Design, Code, and Test for each incremental release
6. Acceptance Test and Demonstration with sample problems for each release
7. User Training and feedback
8. Software maintenance during remainder of development contract

Several plans and specific documents were called for in order to encourage a systematic approach and a well-documented product:

1. Management and Technical Plans to describe general approach
2. Configuration Control Plan to control and track all changes to requirements, design, code and documents
3. User Involvement Plan to insure the system developed is satisfactory to the users
4. Test Plans to establish systematic procedures for development and acceptance testing
5. Software Standards Handbook
6. Requirements and Preliminary Design Documents
7. Preliminary User's Manual written during design so early user feedback can be obtained
8. User and Demonstration Manuals
9. Installation and Maintenance Manuals

As the basis for the IPAD software engineering methodology, the Boeing IPAD Development Team selected the Boeing Computer Services "Systematic Software Development and Maintenance (SSDM)" approach. SSDM is basically a set of general guidelines for all phases of the software life cycle, and it corresponds well with the NASA requirements.

An Industry Technical Advisory Board (ITAB) was established at the start of the contract to closely involve the prospective user community. They have helped review and critique the requirements definition and software design phases. Subsequently, they will have the opportunity to install and test the software at their own computing facilities.

EXPERIENCE AND EVALUATION

At the time of this writing, the development is in phase 4, Preliminary Design. The techniques used to date and an assessment of their usefulness in the software development process is described below.

In phase 1, a reference aircraft design process was documented in flow diagrams indicating activities and decision points, with accompanying discussions. Also communications between various disciplinary groups participating in an aircraft design project were diagrammed to illustrate the complex network of interfaces. Separate volumes were written to document the interactions between designers and the manufacturing organization and the activities in managing a product development. These three volumes written by engineers representing potential users defined the problem to be addressed with the IPAD system.

The requirements were defined by the engineers in phase 2. The BCS technique SAMM (Systematic Activity Modeling Method) (Reference 1) was used to chart the inputs and outputs (description and quantity) for each activity in the flow-charts of phase 1. The user's view of his requirements for computer-aided support in the aerospace design process was also documented.

The results of phases 1 and 2 represent a very thorough definition of the aerospace design process and CAD users' needs. These were well-received by the user community and have provided guidelines for their own analyses within their respective companies. The flow diagrams of the design process and the SAMM charts of the data flow are well correlated and provide a very systematic look at the problem.
Phase 3 was done by the software team, assisted by the engineers. They developed a concise set of IPAD requirements based upon the engineering documents and NASA requirements for the IPAD system. A formal analysis checked that each requirement was complete, correct, unambiguous, precise, consistent, relevant, testable, traceable, free of unwarranted detail, and manageable. The engineering team developed criteria for acceptance testing for each requirement. Each test criteria was summarized in a paragraph which accompanies the requirement statement in the IPAD Requirements Document. The requirements were reviewed carefully by both NASA and ITAB, with considerable feedback and revision resulting. A set of IPAD system specifications were not produced, per se; the IPAD Requirements became the baseline for further development.

The formal analysis of requirements was not successful. Ambiguities, inconsistencies, and redundancies were very difficult to eliminate, especially between similar requirements. These arose from using secondary sources in developing the IPAD requirements and giving them weight equal to the primary source, the engineering definition of the problem. A satisfactory set of requirements was obtained through careful reorganization and joint review by software and engineering team members and NASA. The inclusion of the summary for acceptance test was very helpful in clarifying the intent of a requirement, as well as setting the stage for later testing. It also forced the engineering and software teams to collaborate, and is highly recommended for future projects.

In Preliminary Design, phase 4, a user interface model was developed using state transition diagrams (Reference 2). This included a set of user functions correlated to the IPAD requirements. These state diagrams have been used to walk through “user scenarios” to illustrate the functioning of IPAD from a user point of view in performing a specified set of tasks. The other major components of IPAD are: the executive, the information processor, and the other systems interface and are currently undergoing design by separate subteams. Coordination among the various subteams in producing an integrated design has been difficult.

While the approach used has been successful in achieving a good set of requirements, IPAD is not yet developed and the design methodology is unproven. The basic concepts appear to be an effective approach and further assessments can be made when the software is developed.

REFERENCES
