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ACUS RESEARCH & DEVELOPMENT

ACUS Software Engineering Tools (ASSETs)

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Abstract

ACUS has an accelerated R&D programme to implement a complete set of software engineering tools by 1 January 1990. The goals are to increase software development productivity and quality over the whole range of Unisys machines. ACUS is a unique Unisys development centre which provides strategic Unisys Open Systems and advanced language products for porting to all Unisys computer families (2200, A, B, U, V series and PCs). The parallel porting to disparate computer architectures and operating systems presents a unique challenge for the ACUS Software Engineering Tools (ASSETs). The ASSETs approach supports the cooperative development of a number of key projects with other Unisys development centres and joint system test and integration. ASSETs is built by loosely coupling a number of mainly new Unisys configuration management and software testing tools with third party CASE products. ASSETs covers

* project management, metrics and cost estimation
* configuration management
* software testing
* OSI Conformance testing
* CASE

Introduction

The paper "Towards a Common Software Engineering Environment" [1] presents a typical multi-year effort in the design and development of an integrated software engineering environment. Unisys corporate philosophy is to reduce product development cycles to less than a year. This constraint and the rapidly changing working environment made an entirely new approach to software engineering tools necessary. The ASSETs approach is a rapid, incremental and loose integration of software engineering tools, and their immediate application to ACUS development projects. ASSETs has to comply with the following CONSTRAINTS:

ACUS Software Engineering Tools (ASSETs)

1: The tools have to run on existing Unisys systems. Basically, ACUS software engineers have the choice between PCs and BTOS machines networked together and via emulators to 2200-series, A and U series machines. ACUS has 130 software engineers and the number will grow to 250 by 1992. Ideas about each software engineer having an advanced workstation running integrated CASE solutions had to be abandoned partly due to cost and partly due to the need to be as compatible as possible with the end-user Unisys environment.

2: The tools have to be available NOW and have to be fairly mature. Most of our projects have schedules too tight to enable any debugging of experimental software tools.

3: The acquisition and implementation of tools have to be accomplished over a one year period. A large integrated environment requiring change in development methodologies could not be adopted even if available for our environment.

4: The acquisition budget for ASSETs has to be minimal. We are talking about a direct investment of less than $1,000 per software engineer. This contrasts with the $100,000 acquisition needed for some of the high end AI workstations with an integrated software engineering environment.

5: ACUS software engineers currently do not extensively use (semi)formal software engineering methodologies. The only positive experiences have been the application of object oriented design and programming using C++ [2] for systems and communications software development, and the emerging corporate Linc Systems Approach LSA methodology [3] to use the Linc System Generation Language for rapid prototyping and not just as a Lower CASE 4GL Cobol generator. Against this background, the process of selection CASE tools has to be conservative. Tools that require massive training in (semi)formal methodologies are not practical for ACUS at this stage.

6: Budgeting is very tight: There are no slush funds for developing tools or for engaging in research not directly related to product development. The software acquisition budgets are limited and acquisition is approved only if the tools can immediately be applied to the benefit of current software development projects.

7: The working environment is democratic: people are not required to use software engineering tools. Everything has to be based on creating enthusiasm and motivation. An initial attempt was made to use the SPS Software Products & Services, Inc. EPOS CASE product. There was a poor match between the object oriented design methodology and EPOS, and EPOS as a tool was still immature. A lot of the resentment, however, was due to the non-democratic management decision that developers MUST use EPOS.

Snapshot at 31 March 1989

ACUS was established on 1 September 1987 as part of the Unisys Corporate Citizenship Agreement with the Commonwealth of Australia. ACUS grew from a few employees to 100 during its first year. The success of ACUS receiving Unisys Open Systems, Advance Language and Line of Business development projects has made the R&D and export requirements of the Corporate Citizenship Agreement a byproduct of the ACUS R&D goals.

The phenomenal growth of ACUS presented a management challenge. The first action item was careful learning of corporate Unisys phase review, release management and support processes to ensure that ACUS interacts smoothly with Corporate Program Management, Corporate Software & Publication Operations (CSPO) and Customer Support Centres. This learning process has been documented in the ACUS Standards and Procedures Manual. This manual represents our best efforts to combine the strengths of IEEE Software Engineering Standards, Corporate Phase Review process, Unisys Software Development Methodology, and Corporate Engineering Information Release (EIR) process. The ACUS Standards and Procedures Manual has been sent to Corporate Standards Office for evaluation as a voluntary guideline for the 43 Unisys software development centres. The standards are in media form (BTOS OFIS Designer) and can be easily tailored by individual development centres. The strongest area of the ACUS standards is management planning of development, quality assurance, testing, phase reviews and configuration management. The weakest area is the lack of a (semi)formal specification and design methodology. The standards do not extensively address this issue.

Object oriented design, as previously mentioned, has emerged as the preferred methodology for system and network software development. The Linc Systems Approach (LSA) for rapid prototyping of Line of Business Applications is the second emerging methodology. These methodologies require strong CASE tools support.

ACUS had implemented the following software engineering tools prior to 31 March 1989:

1 - Project Manager Workbench PMW [4] as a planning tool;
2 - Project Observation Workbench and Evaluation Reporter POWER [5] for audits;
3 - Engineering PRIMUS Application System EPAS [6] for configuration and support management;
4 - C++ to support object oriented design and programming;
5 - Linc used as a prototype and 4GL Cobol applications generator;
6 - Unix SCCS and Make tools as Unix project configuration management tools;
7 - Polytron PVCS and PolyMake as Unix SCCS and Make improvements for MS-DOS.

Also, ACUS made limited favourable evaluations of the CA-Estimacs [7] for cost, staffing and risk estimation, and the Index Technology Excelerator [8] CASE tool. Evaluation results of a second CASE tool, the SPS EPOS [9], were negative.

Unisys software development practices and tools used were surveyed during the author's trip to Charlotte CDC, Blue Bell, CSPO, Roseville, Eagan, Lake Forest and Mission Viejo, 23 January - 7 February. Information was available from Camarillo, ULDC and the Paoli Research Centre, too.

The results of this survey are:

1 - Configuration management tools will be available across the whole range of Unisys computer systems by the end of 1989. Most of these tools have been developed by Unisys.

2 - Rapid advances have been made in testing tools covering functional, system and autoregression testing. The testing tools cover most Unisys computer systems. Some of the testing tools will mature only by the end of 1989.

3 - Very little work seems to have been done in implementing CASE tools. A number of research efforts are listed in [10].

The author was appointed as the ACUS Quality Research Manager with the objective of having a complete set of software engineering (CASE, Configuration Management and Testing) tools in place by 1 January 1990.

Project Planning Tools

The first tools acquired were word processors, spreadsheet packages, and electronic mail (corporate B-mail and E-mail). After these basics, ACUS evaluated a number of project management packages and decided to implement the Hoskyns Group Project Management Workbench. PMW [4] supports four views of a project:

* Gantt Chart
* Resource Spreadsheet
* Dependency Definition Diagram
* CPM Network

PMW has been used from April 1988 by most ACUS projects. The next phase will be to interface the Estimacs [7] cost estimation tool with PMW via the Planmacs utility. The chain Estimacs --> Planmacs --> PMW is via the file system. There is no reversed chain from PMW back to Estimacs. Estimacs has been used for cost estimation of the ACUS Line of Business projects. With Estimacs, you can explore the scope of the effort, staffing, costs, hardware needs, and risks involved. Estimacs implements Function Point Analysis based on A. Albrecht's work at IBM in the mid 1970s. Estimacs seems suitable for our Line of Business projects. The risk estimation module of Estimacs has wider applicability for ACUS projects. The COCOMO [11] model has been used manually to estimate network product development cost, and a tool based on COCOMO might be acquired.

Project Observation Workbench and Evaluation Reporter POWER [5] automates and standardizes the collection and evaluation of software project status information. POWER uses a series of over 600 structured questions to evaluate the state of a project during the six Phases of project development. The questions have been weighted by POWER according to the size of the software under development, its complexity, and whether the program is real time or non-real time. You can modify the POWER question set to meet your particular needs. POWER has been used to evaluate the ACUS ODA/SFO project. Its use is regarded as tedious.

Configuration Management Tools

The primary system for ACUS configuration management is the Roseville Engineering PRIMUS Application System. EPAS [6] is used to report and track problems and new feature suggestions from phase 4 qualification onwards. Phase 5 customer support is based on the User Communication Form (UCF) [12] and CONTACT processing [13]. EPAS is used as a configuration management database for status accounting and as a means for communicating with customer support centres and as a means for distributing changes electronically. ACUS fulfils the corporate customer serviceability objectives [14] by using EPAS. The logistics of accessing EPAS over the UNIDATS network from ACUS BTOS and PCs emulating UTS terminals were completed by January 1989, EPAS training is complete in April 1989, and the process of opening Product Validation Profiles for each ACUS product before phase 4 qualification has started. EPAS will be used by ACUS not only for customer support but also as a development phase configuration management database. In particular, the OS1100 projects environment will use a local PRIMUS node for change control with integrated changes (CHGs) harvested to EPAS. EPAS document types [6] currently used are UCF, PLE, CHG, CONTACT and PVP. Future use will expand to include Test Product Profiles and System Test Activities [6,15] to support OS1100 product system test preparation for Devon and Roseville.

A Series change control is based on the PatchManager [16] used by Tredyffrin, Devon, Orange and ACUS to develop and maintain patches to Unisys A Series software and documentation. Tredyffrin will implement by June 1989 an interface [17] for uploading PatchManager patches into EPAS CHGs. Currently, the PatchManager is used by only one ACUS project, the A Series Message Handling System. Orange County Release Management is developing an additional tool, the Product Definition System PDS which interfaces with PatchManager and the CSPO Engineering Information Release (EIR) system.

Release Management, and Configuration Management in general, are handled by the ACUS Support/CM Group. A number of corporate Mapper based systems (CORMAP, ADMAP, DISMAP and PM) provide vital information and data entry programs to drive the CSPO Engineering Information Release and Ship Authorize processes. In particular, the PM Reltrak and ADMAP ASAP [18] programs are important. CSPO is in the process of enabling electronic transfer of software. A lead system is the Roseville Series 1100/2200 TXFR Tape Transfer Utility [19] which enables the transfer of System Base Releases from Roseville to CSPO and back for verification as a fully automated one day cycle.

2200 Series Configuration Management will be based on the Clear Lake Software Productivity Workbench. SPW represents perhaps the most ambitious Unisys software engineering tools effort and has the following features [20]:

* Provides mainframe and workstation configuration management facilities

* Automatically determines the effective change (delta) from one version to the next version of a program's source

* Conserves mass storage and isolates a programmer's activity from the rest of the project

* Supports concurrent updating of multiple programs by multiple programmers

* Promotes reusability of software by supporting the development and maintenance of program libraries

* Manages changes to non-symbolic type programs

* Administers product integration and enhanced product generation facilities

* Provides a configurable interface to Unisys, user-supplied, and third party development tools

* Records and audits all changes made to a product

* Prevents accidental modification of products by security mechanisms

* Provides utilities to aid in the setup and migration of existing Unisys products to the SPW environment

* Delivers graphical workstation interfaces

* Integrates Unisys tools supporting test generation, execution, and verification; terminal and network simulation; symbolic debugging; performance measurement; symbolic cross-referencing; code metrics; code coverage, and software usability

SPW shall be the central component for the ACUS OS1100 environment described below.

U Series Configuration Management is based on the standard Unix Source Code Control System SCCS and Make utilities. There will be a gradual shift to more user friendly and integrated third party products with essentially the same capabilities as those of SCCS and Make. The Polytron PowerPak [21] seems to be the most promising product, and is gradually being ported to Unix systems. PowerPak is currently available for Sun.

Polytron Powerpak (consists of Polytron Version Control System, PolyMake and PolyLibrarian) passed ACUS evaluation as the preferred configuration management package to support LAN networked PCs.

The only missing link is BTOS version control. A third party version control utility is being ported onto BTOS by the Unisys Camarillo plant.

Initially, ACUS planned to use a networked configuration management solution under Unix with file transfers between a U Series machine and all other Unisys machines. This proved to be an impractical solution, and it was decided that each Unisys system must have native mode configuration management tools at least for version control and product build. The reasons behind this decision were primarily administrative. It was felt that file transfers between the different systems would not be manageable.

Also, 2200 and A Series source control and release mechanisms present technical problems that cannot be easily resolved by using a central tool under U series. The third party Unix vendors do not offer configuration management tools that can be easily applied to the Unisys environment. The only integrated configuration management mechanism is the EPAS as mentioned previously.

The primary unsolved version control problem is the 4GL Linc development. Configuration management functions have to be built in the next Linc 15.0 core product to be released by mid 1990.

Testing Tools

The greatest Unisys software engineering breakthroughs are in the field of software testing tools. Unisys has a number of in-house software testing tools that cover functional, system and autoregression testing: TAC 1100 and CLU 1100 for 2200 Series, APT for A Series, and LAST for A, V, U and 2200 Series. Also, a third party tool, AutoTester, is under ACUS evaluation. Brief product descriptions follow.

Test Activity Controller TAC 1100 [22] main features are:

"A single execution of TAC can be directed to control terminal simulators, schedule scripts and runstreams, and automatically vary batch, demand, and transaction activity simultaneously and without human interaction. TAC is able to generate reports on all aspects of a test session.

TAC provides function-testing capability in addition to its system-test capability. TAC runs test packages, compares results, and provides test status reports.

TAC offloads massive regression tests into weekend and night runs."

ACUS OS1100 projects have three options for System Test:

1) Carry out complete system test in-house;

2) Participate in the Roseville/Devon System Test;

3) Let Roseville/Devon carry out the testing process.

The second option was chosen by ACUS; Implementation of TAC 1100 is the first step in setting up a compatible Integrated Test Environment ITE. A number of logistics issues are under study: TAC requires the CS1100 product which in turn may require dedicated DCP hardware. It is possible to use the new CS1100 versions just as another DCP application. The testing system and tested system could be the same. It is then possible to support both demand and transaction terminal simulation. TAC 1100 as a stand-alone product is limited to simulating up to four demand mode terminals. The above problems are typical for several plants trying to set up compatible testing and integration environments. These problems are becoming more frequent as Unisys is slowly abandoning the lead plant "integrator" approach in favour of parallel development, test and integration.

Conversation Logging Utility (CLU) 1100 [23] enables to record and replay demand mode conversations with OS1100 and programs executing under OS1100. CLU supports conversations with full-screen programs. A conversation is defined as system and program output messages to terminal, and input messages transmitted. Replay and record modes may be suspended and resumed dynamically to intermix both live and prerecorded conversations. Recorded scripts may be converted for execution under TAC 1100. Recorded scripts may be used to simulate production environment when replayed on multiple terminals via CS1100 Remote Terminal Simulator and TAC 1100.

The combination of TAC 1100 and CLU 1100 provides a complete OS1100 functional, system and autoregression test environment.

The A Series Automated Program Tester (APT) [24] was developed by Tata Unisys for Mission Viejo. The ACUS MHS project has an identical development environment and ACUS is evaluating the APT, too. APT is a tool to conduct functional testing of A-series software with minimal operator intervention. APT offers facilities to define test specifications, execute tests, store test history and generate reports. APT is capable of setting up the test environment and executing the steps that comprise the test procedure. APT records the test run as pass/fail based on user-given criteria. Functional testing has five tasks:

1 - Analyse the functional specifications to be tested.

2 - Design the tests.

3 - Write the tests

4 - Execute the tests

5 - Analyse the results

APT supports tasks 3-5. APT is ideal for network and system software functional testing but seems less capable for testing Line of Business applications with a sophisticated user interface. APT does not capture keystrokes. APT requires output definition which may be tedious for screen based applications.

Autoregression tools LAST and AutoTester may be viewed as complementary to APT and independently for Line of Business and other user interface oriented applications. Linc Automatic Script Tester LAST [25] was developed by Unisys Linc Development Centre ULDC. The name choice does not reflect the LAST capability as a general purpose autoregression test tool. LAST supports Unisys A, V, 2200 and U series hosts. LAST uses PC or BTOS as a workstation and has terminal emulation for the Unisys hosts. LAST records keystrokes and host responses. During playback all host responses are checked with the expected results. Another use for LAST is creation of canned demonstrations that can be replayed without being connected to the host. LAST is still in its infancy. The product is tightly coupled with Infoview. Each release of Infoview requires regeneration of LAST by ULDC which is a problem with the frequent Infoview updates. Also, the LAST BTOS B25 version 4.01 had quite a few problems including the need to run the old BTOS 8 operating under BTOS II. The PC version of LAST is more stable, and the user interface is good. LAST user documentation, however, is still in a development draft form.

AutoTester [26] is a third party autoregression tool by Software Recording Corporation. AutoTester is a Capture/Playback system which automates not just keystrokes, but also the documentation, management, administration, and reporting of the testing process. AutoTester enables use of Input/Output Variables reducing the human effort in recording and maintaining scripts and deciding what should be reported and when.

The unique aspect of AutoTester is the Outliner component that performs three functions:

- documents the unit tests in plain English (raw keystroke scripts are difficult to understand).

- acts as a blueprint of the sequence and relationship of unit test scripts.

- combines unit tests into regression, stress and volume tests.

The Recorder, Script Editor, Playback and Match (including masking of don't care characters) are standard features of all the three autoregression systems under ACUS evaluation (CLU 1100, LAST and AutoTester). CLU 1100 is the preferred product for ACUS OS1100 System Base Release products OSS and OEUF. CareSys Line of Business product has a preference for LAST being a Linc application. The A Series Message Handling System may use either LAST or AutoTester (to supplement APT). SGE, Directory Services, ODA/SFO and the ISDN demonstrator could use either LAST or AutoTester. AutoTester is in a more mature and commercial stage than LAST. However, the emulation of the various Unisys machine types may present a major interface problem with LAST. A number of Unisys Blue Bell SDG plants are evaluating AutoTester. Our inclination is to favour LAST as a free and gratis product. The possibility of using the AutoTester Outliner as a separate front end to test planning needs to be studied. There is a strong need for such a product.

ACUS Conformance Test Laboratory

A special test environment is being set up by ACUS to test whether Open Systems Interconnection (OSI) protocols have been implemented in accordance with agreed upon specifications [28]; Test tools used include NCC and DANET test suites for the ACUS OSI projects MHS and ODA/SFO. ACUS Conformance Test Laboratory is being documented and not covered by this paper. However, this effort should be regarded as a major building block in the future ACUS software engineering environment for network software product development.

OS1100 Environment

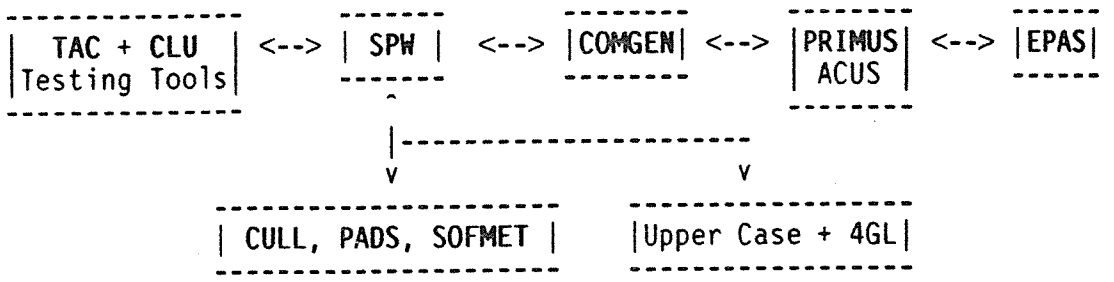
ASSETs implementation for OS1100 will be a complete environment, and serves as a model for other environments to be implemented across all Unisys systems. The main component of the planned OS1100 software development and support environment is the Software Productivity Workbench (SPW) developed in Clear Lake. The SPW comes with the COMGEN system generation and installation utility that gradually over a period of 2-3 years will replace COMUS. The transition for new OS1100 products should start early 1990.

Change control will be based on PCR under PRIMUS [26]. Initially, ACUS started with the old PCR system. The old PCR databases will be gradually phased out and the development centres will be provided with PRIMUS 5R3 with the Change Document type as the only document type available (development centre PRIMUS nodes could have a richer set of PRIMUS document types such as PVPs, PLEs and UCFs but this is not a technical issue). Integrated changes will be harvested nightly from the ACUS PRIMUS node to EPAS.

Functional, system and autoregression testing tools, the TAC 1100 and CLU 1100 are provided by the Roseville System Test Organization.

Currently, ACUS is using DSP*WORK which is a partial prototype for the coming SPW. The time frame for the implementation of the complete OS1100 environment is July - October 1989 and depends on Roseville and Clear Lake.

The complete environment planned:



Interfacing of 4GL and Upper Case with SPW will not be available for the first release. Initially only terminal user interface will be available. The interface is a pure command interface that does not query for any information. SPW will initially run under the IPF environment. The planned workstation front-end together with the open architecture of SPW provides the future opportunity to migrate the SPW environment to other architectures including Unisys A Series and Unix architectures.

CULL and PADS serve symbolic cross-referencing and debugging. SOFTMET [27] is a software metrics tool that produces Halstead, Lines of Code, McCabe and implementation weight/corrected volume metrics for OS1100 design and programming languages (Structured Design Language SDL, SSG, PLUS, FORTRAN, MASM/ASM, COBOL, C and INLINE).

CASE

Computer Aided Software Engineering CASE pose the biggest problem for Unisys software development centres. The available tools are from third party sources, very difficult to integrate with existing Unisys software development tools, cost anywhere from a few hundred dollars to several hundred thousand dollars, and suffer from "vaporware" of unmet expectations. A number of major CASE solutions are being evaluated by Unisys development centres including the Index Technology Excelerator, IDE Software Through Pictures, Yourdon Software Engineering Workbench and CADRE TeamWork. Also, a number of Unisys projects are slowly evolving including the Camarillo SEWB [29] and the Paoli CSEE [1].

ACUS Software Engineering Tools (ASSETs)

ACUS needs an upper CASE solution to support product specification and design. Unisys 4GL/SGL (Linc, Mapper and Ally) are used as lower CASE tools and have to interface with the upper CASE tool chosen for Line of Business applications. Eventually, the 4GL/SGL core solutions will be expanded to include upper CASE functions but this will take at least two years. ACUS SGE and network products upper CASE solution has to support object oriented design and enable smooth transition via C++ to C programming.

Currently, the only Unisys agreement with a CASE vendor is with Index Technology Corporation. The agreement covers over 300 copies of the Excelerator product. ACUS has decided to adopt the Excelerator as the only affordable solution. Care Manager specification and design by Excelerator has started. This 20 man year Linc Line of Business application is worth perhaps 100 man years of Cobol programming. The results of applying Excelerator will be most significant for ACUS. A parallel attempt to use Excelerator Real Time System for a network or SGE software development project is being planned.

Upper CASE tools should support:

* Object Oriented Design
* Entity-Relationship Diagrams
* Structured Analysis
* Combined Data and Control Flow Diagrams
* Process Specifications
* Integrated Data Dictionary
* Consistency Checking & Diagram Balancing
* Project Documentation Generation
* Built-in Configuration Management
* Project Library Database
* Run under Local Area Networked PCs

The primary problem is to train our software engineers in the methodologies. Unisys Professional Services have ready courseware.

Summary

ACUS Software Engineering Tools ASSETs is an evolutionary and incremental approach constrained by low acquisition budgets and no funds for experimentation. The idea is to make the most out of existing Unisys solutions for configuration management and testing. The primary constraint is to have ASSETs implemented by January 1990 across all Unisys systems. This and the budgetary constraints precludes any attempt for an integrated software engineering environment as a total solution. Also, no attempt is possible to introduce an AI/software engineering workstation environment. The success of ASSETs will be determined by the extent of its use. The greatest risk is in the training process of modern software engineering methods, the application of Upper CASE and the interfacing of this with the rest.

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Note: Organizational contact information of all OS1100 products listed in this paper are available via Product Validation Profiles for EPAS users.