

"ACM. SIGMINI SYMPOSIUM ON SMALL SYSTEMS"

New York 2-3 August 1978

Slides to a talk on :

STRUCTURED DESIGN BENEFITS
TO A PROCESS CONTROL SOFTWARE PROJECT

G.P. Benincasa, A. Daneels, P. Heymans, Ch. Serre

Content

1. Overall View of CERN Accelerators
2. Today's Control System
3. Planned Control System → Pilot Project
4. Constraints and Resources for pilot project
5. Design and Implementation of this pilot project

1. OVERALL VIEW OF CERN ACCELERATORS

- machines which accelerate protons, increasing their energy to eventually 400 GeV
- LINAC (50 MeV), BOOSTER (800 MeV), PS (28 GeV), SPS (400 GeV)
- we are concerned with LINAC, BOOSTER, PS + ejection to SPS, ISR and various experiments
- SPS is a separate machine
- protons are produced at the rate of 1 burst per second
- in future this rate will be reduced to 600 msec
- for their controls several 1000 parameters ($\approx 10'000$) are involved

2. TODAY'S CONTROL

- partly centralised computer control system installed gradually since 1967 $\approx$ 5500 parameters
- a few independent computer $\approx$ 2000 parameters
- rest = manual control
- ••hence not very homogeneous ••difficult to - operate &
- maintain

3. THEREFORE NEW SYSTEM

- computer network (see Fig.)
- size of the project = 160 man-years roughly
 - 60 man-years hardware interface
 - 10 man-years system
 - 10 man-years operators consoles
 - 70 to 80 man-year application programs
- budget for hardware 14 MSF
 - consoles
 - standard CAMAC interface
 - computer
- application software 70 to 80 man-years in 5 years
- because of the size of this project also decided to implement a

* PILOT-PROJECT : why ?

so as to be able to

- evaluate some control concepts
- build-up an application software industry

* PILOT-PROJECT : SIZE

consists of small part of process (ejection from PS to SPS)
but sufficiently complex to be significant

- ≈ 100 parameters; evaluated 12 man-years in 12 months
- ≈ 100 programmes (≈ 40'000 instructions)

4. CONSTRAINTS AND RESOURCES for the PILOT PROJECT

Note: most of them are valid for the overall project

(a) Constraints

- process - real-time : every sec several process variables
have to be set and read
- testing - accelerators run 24 h / day
 - a few 3-day shutdowns for test
 - 1 long shutdown ($\approx$ 4 weeks) per year for preventive maintenance and installation of new equipment
 - only 1 operators' console and many interactive programs
 - console and process interface available the last 3 months

(b) Resources

- manpower - large number ($\approx$ 30) people available for programming
but only part-time
- languages - N-PL (intermediate level) for low level software
 - NODAL (interpreter) for high level software
- design - simplified because only conversion of known equipment
- program development facility - $\sim$ 13 consoles

5. OLD STYLE PROGRAMMING AS FROM 1967 ONWARDS AND NEED FOR CHANGE

In general free activity for whoever wanted to implement something

- * advantage
 - high motivation: people felt indispensable (only the author understood)
 - (esoteric art)
- * disadvantage
 - monolithic and often redundant code
 - general absence of any design and implementation methodology
 - no documentation
 - difficult to operate and maintain

For the renewal :

request for about double as many facilities
to be implemented in about half the time

Hence agreed that the project should be managed as any normal engineering project.

6. MANAGEMENT OBJECTIVES

- Systematic objective setting involving the users and ending by formal acceptance of the specifications.
- Creating a general framework for the implementation and future evolution.
- Modularisation so as to ease programmer task assignment, testing, maintenance and future changes.
- Systematic testing procedures and criteria.
- Effective programmer task assignment, instruction and follow-up.
- Programming and documentation standards.
- Progress visibility by documentation all along the project.
- Quantified effort estimation and progress monitoring.

7. HOW THE PILOT PROJECT WAS MANAGED

- A. Structured Design understood as COLLECTION of METHODS
classified in 2 groups

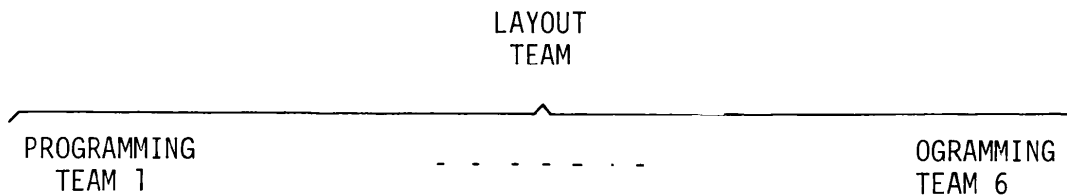
1st group = normal engineering design methods involving

- . objective definition with user
- . design from coarse to fine (stepwise refinement)
- . top-down - works well in such conversion project where a prior design effort has already determined what is possible at the lower levels !
- . modularisation
- . time planning
- . progress monitoring
- . documentation

2nd group = relate essentially to programming style, where top-down design, modularisation is pursued on the level of individual programs.

7. HOW THE PILOT PROJECT WAS MANAGED

B. Software Teams



- * Layout Team
 - all programming team leaders = senior engineers
 - representative of users and suppliers

Layout Team's Responsibility

- analyse the user requirements,
- define the overall software structure in which the application programs were embedded,
- perform the overall design of all application programs and to identify the various modules,
- define standard frameworks for the implementation of similar modules,
- define the interface between modules,
- define the documentation standards,
- provide an implementation planning and allocate resources, coordinate the work of the programming teams and monitor its progress,
- publish the preliminary specification handbook.

- * Programming Teams
 - blend of experienced and less experienced programmers
 - size ≤ 6 persons

* Programming Teams's Responsibility

- detailed design of each application program,
- coding, testing, commissioning and documenting
- updating the specification handbook which thus evolves to a proper documentation of the delivered software packages.

7. HOW THE PILOT PROJECT WAS MANAGED

C. Design and Implementation

* Overall Design : 3 man-years completed in 6 months

- 4 phases :
- learning about environment
 - system
 - language
 - process, etc.
 - detailed analysis of user requirements
 - synthesis and editing of new frameworks
 - publication of PRELIMINARY SPECIFICATIONS presented to users for agreement

- Note
- PRELIMINARY SPECIFICATIONS (500 page document)
 - Content :
 - overall description of control system
 - hardware and system requirements
 - priorities and planning for implementation
 - PSD
 - data structure
 - description of use, displays, frameworks
 - naming convention
 - Frameworks = Software Templates

* Detailed Design and Implementation : 9 man-years completed in 6 months

Input = PRELIMINARY SPECIFICATIONS

- breakdown of every module into smaller ones
- special emphasis on testing by ensuring module INDEPENDENCY

Output

- more detailed PSD
- more detailed Data Structures
- code
- final product

Hence the PRELIMINARY SPECIFICATIONS DOCUMENT
GROWS INTO FULL DOCUMENTATION

7. HOW THE PILOT PROJECT WAS MANAGED

D. Project Control

* Milestones defined by Layout Team

(1) Overall design	20%	<u>Table 1</u>
(2) Detailed design	20%	
(3) Coding	15%	
(4) Off-line testing	15%	
(5) On-line testing	15%	
(6) Documentation	15%	
100%		

Off-line testing comprises 2 things :

- debugging and testing of those modules which do not necessarily need the process,
- simulation testing of the whole program including the modules acting on the process, with the latter switched to the simulation mode.

* Progress Monitoring

- Layout team met every fortnight
- % are rough but sufficiently good
 - however, testing was somewhat underestimated, total is nearer to 40%
 - allowed to predict when a new phase would start in particular ON-LINE Testing

* Modification

- during implementation requests for changes and addition came up
- decided not to depart from original plan
- change and addition considered as separate small project

Result: $\approx$ 3 man-months of change and addition done at the end in 1 additional month.

8. CONCLUSION

- results were very positive
- publication and agreement of Preliminary Specifications committed the user towards the project
- no 90% ready syndrome
- modularity → easy to hand out software
- frameworks → easy to hand out software to less experienced programmers
- improved quality
- improved testing
- good control
- participants had overall view of whole system
- good team spirit

Inspite of initial scepticism, growing interest and conviction of those who actually participated.

COMPUTER TOPOLOGY

