---- 9th EUROPEAN TRIGA USERS CONFERENCE ----
Roma, 7-9 Ottobre 1986

"APPLICATION OF SYSTEM-PROCESS-GOAL APPROACH FOR DESCRIPTION OF TRIGA RC-1 SYSTEM"

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ABSTRACT

The new methodology of the goal oriented description of an artificial system is presented.
In the SPG approach (System-Process-Goal) it is assumed that the knowledge necessary for achiving the goal is available but it is not ordered or ordered for other purposes.
The aim of SPG is to give the description of the analyzed system in form of network by decomposition of goal-system relationships using uniform and mathematical formalism.
The SPG approach is useful to build a reactor operator aid system.
This paper presents the conception of the application of the SPG approach to the decomposition of TRIGA RC-1 dynamics and for designing of TRIGA diagnostic algorithms.

Material on

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The aim of SPG is to give the description of the analyzed system in form of network by decomposition of goal-system relationships using uniform and mathematical formalism.
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1. Introduction

The description or the model of an artificial complex dynamic system /ADYS/ such as ,for example, a nuclear plant ,is never completed and the choice of system elements ,functions , assumptions depends strongly on

- goal of description, which is more or less fuzzy, and normally changes , in some frames , during the construction of the description
- common environment of observer/designer (o/d) and ADYS object , being a source of assumptions not dependent on o/d ; environment conditions set
- the o/d assumptions about:
  - .the environment influence on the ADYS,
  - .a possible goal properties,

  which determine the description goal; goal assumptions. Goal assumptions depend on the o/d knowledge which is frequently not verbalized.

It is easy to note that many existing descriptions of ,for example, TRIGA reactor system [1] are extremaly different and when prepared for one goal are not useful for some others ones or include big redundancy of knowledge, relatively to an assumed goal .

The problem of proper goal oriented description of an ADYS is not as important in engineering or scientific papers as in a computer knowledge base where the size, access time and uniqueness play sometimes an essential role.

One of the relatively difficult tasks which has been attacked in different ways is the description of a reactor system for the construction of the diagnostic and supervisory system giving to the operator staff a support during the reactor control.

Some results of those approches are presented in the reports collected in Tab.1.[2] .

One can see that different reaserch directions are being independently developed to construct a reactor operator aid system. We can select the following approches:

- events cause-consequence analysis goal oriented approach ,
- critical safety functions identification,
- system-variable monitoring,
- process-models early fault detection,
- goal-function-equipment presentation methodology.

However , in none of those publications it is possible to find a sufficiently precise description of the operator aid system and a sufficient motivation of the approach accepted.

For the reason that every operator aid system must increase the safety of reactor exploitation, the choice of the domain of the system applicability in its space ,is of particulare importance and a description of the reactor system is the basic goal assumption for the operator aid system.

Our problem was to construct the description of the TRIGA RC-1 reactor system destined to the TRIGA Supervisory System /TSS/ and it has been developed in the Applied Informatics Laboratory in C.R.E.Casaccia, ENEA.

2. System-Process-Goal approach /SPG/ - theory

2.1.Aims of SPG

The SPG approach is a knowledge ordering methodology destined for :

A. Goal oriented description of an artificial dynamic system /ADYS/

B. Designing an ADYS .

The basic assumption of the SPG is that the knowledge necessary for the problem solving exists but is not ordered or is ordered for other purposes.

The aim A includes the situations when the goal of the description of an ADYS system A is to present its selected processes or proprieties which are necessary for designing another system B being connected by some relations with the system A.

In the above case we should distinguish the following goals:

- G_B , goal of the designed system B
- G_A , goal of the existing system A

- G_{dA} , goal of the description of the system A.

Let, G_X [P1,P2,P3] be our first approach to a goal formalization where : X denotes the system , P1 is a goal given in form of text expression, P2 is an environment conditions set, P3 is a goal assumptions set.

Now we can write a raugh example of the situation mentioned:

G_B [PB1= Control of A , PB2, PB3],

G_{dA} [PdA1= Presentation of controlable elements,processes, functions and subsystems of A , PdA2, PdA3],

G_A [PA1= Safety and economic production of a product C, PA2 , PA3].

In order to design the system B ,the system dA must be constructed. The conditions and assumptions: PdA2,PdA3 depend on G_B and also on the available knowledge about the system A .

This complex hierarchical conditions exist during the designing of every supervisory, control or, more generally, every A support system.

The System-Process-Goal methodology is an attempt to connect, formalize and generalize the approches mentioned earier in a form which could be useful for the computer aid designing or for the identification of an ADYS . The specific features desired for the final description should be : its completness and uniqueness which enable one to includ it into a computer knowledge base , for example, of the system B, and to reduce the propability of the appearance of unexpected proprieties of the designed system.

2.2. Main concept of SPG

The SPG approach profits from the generally known mathematical theories as well as from recently developed ideas in problem solving theories , artificial intelligence domain or in identification methods. As only an example,let us mention the following papers being the present ' background ' of the SPG [3] - [10]. Particulary important steps on the way leading to the SPG approach was the previous Gadomski's papers concerning modeling and identification problems of reactor dynamic processes [16],[17],[18], as well as the set of M.Lind's reports [11],[12],[13] about the Multilevel Flow Modelling which represent the concept of hierarchical description of a power plant in terms of goals, functions and equipments for mass and energy flows.

The MFM approach has been used by Lind for a functional decomposition of the termodynamic part of a nuclear power plant and has been examined in INFO Lab. by Businaro at al.[14],[15].

In spite of the fact that the final description of a system in the MFM is formalized in form of graphic symbols , the rules for their construction are not already sufficiently clear and give to a designer a relatively big freedom in the choice of the description of a system.

The SPG approach bases on the idea of the goal oriented decomposition of a relationship between the ADYS and its functional goal in form of graph with distinguished layers, such as : - goal net,

- function net,
- process net,
- system net.

Dependently on our purposes, the links between the net elements are defined as : cause/consequence , syntesis/decomposition or carrier relations, which will be explained later.

In Fig.1 an example of this decomposition is presented.

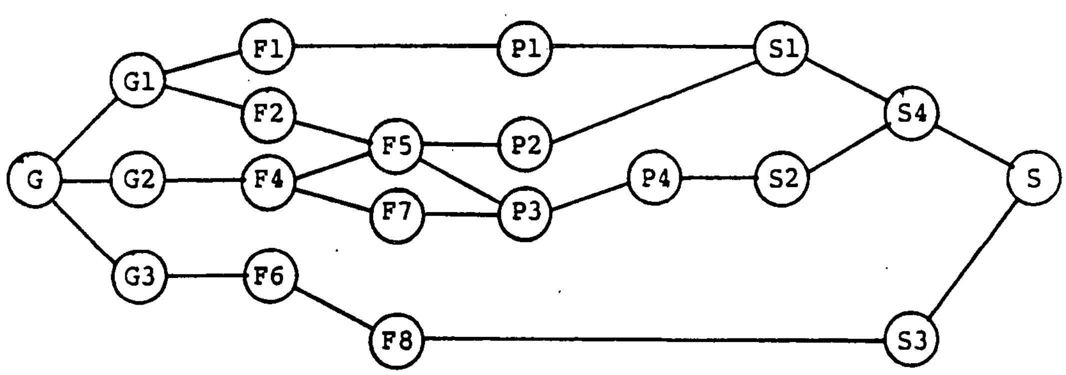
The formal decomposition of the goal-system relation in the terms previously mentioned needs a set of basic definitions.

For this, the SPG contains mathematical and graphical formalisation of objects , relations and rules .

The basic term of the SPG theory is the arbitrary introduced concept of an object with its attributes and values.

a) basic interrelation between a system S and its goal G

b) decomposition on the layers



c) the layer decompositions

Fig. 1. General idea of the decomposition of a G-S relation.

2.3. Objects

In frame of the SPG , an object is defined as a name which can be described (by us) , by some set of another names or values on an assumed time intervale.

The object name < N > is a text expression and the set of the names which directly describes an object is called the attribute set denoted by A.

Every attribute $a \in A$ of any object N is a text expression and can be connected with attribute value ,w.

The attribute value is an element of the attribute space, W.

In the SPG the following classes of attribut spaces are now selected :

WO . set of objects

WN . set of ordered names ; relatively to some transitive relation,

WT . set of mathematical functions

WD . set of areas in defined numerical space

WR . numerical space .

The above assumptions enable to construct an infinite , hierarchical object structure .

Three classes of objects are assumed:

. <u>formal objects</u> are the terms of the SPG approach,

. <u>real objects</u> are the identified elements or propriety of real world

. abstract objects represent approximations/descriptions of real objects in the SPG formalism.

According to the introduced definitions , an operation, act, state, system, process, function, goal, variable or paramerer are the formal objects of the SPG approach.

As an illustration,the definition of elementary object will be now presented.

Definition

Q is an elementary object /E-object/ iff it is described by the triple [A, AW, T] , where A is attribute set and AW is the set of attribute values over the time interval T = (t1, t2).

E-object is a quantitative if every element $w \in AW$ is the element of WD- or WR-class space or

E-object is qualitative if w is element of WO- or WN- or WT-class space.

Introducing the new features of the formal objects we are obtaining the definitions of the SPG concepts, which is schematically illustrated in Fig.2.

Basic formal objects of the SPG are : goal, function, process, system, variable, parameter and model.

Omitting in this paper the exact definition we can assume as follows

System is an object which is identificable by a subset of its invariant attributes , called parameters.

Process is an object described by input and output time dependent variables.

- Any process can be formally presented as known or unknown operator expresion:

$$y(t) = P\,x(t)\ ,\ \text{for } t \in (t1,t2)$$

where y(t) - time dependent output variables vector,

x(t) - time dependent input variables vector,

P - operator of process which depends on parameters of the system S, and $P \in S$.

/ symbol $\in$, see 2.4 /

Goal oriented proprietes of process P we call dynamic function, Fd , and $Fd \in P$.

Goal oriented proprietes of system S we call static function, Fs, and $Fs \in S$.

For example, hermeticness of the reactor cooling system is its static function respect to its goal, but cooling of the reactor core is the dynamic function of the energy transport process and of course, of the reactor cooling system.

A function of system S is described by attribute status. The value domain of 'status' attribute has the following values:

value	1	2	3
availability	yes	yes	no
activity	yes	no	no

In the text form it means that

1. function is active
2. function is available but not active
3. function is not available => no active

For many goals , for example 'maintain system in normal operational status' is desired that some subset of functions in moment t have value of status index only 1 or only 2.
The function status can depend on the reactor operator action but in this case the goal must concern the system which also includes the reactor operator.
A proper function status is identificable by <u>performance index</u> which has two value domain:

YES or 1 indicates that function is performed
NO or 0 indicates that function is not performed.

Other attribute of a function is <u>quality index</u> concerning the carrier process or system. For example, the quality index is

1 if the carrier process is going according to designer assumptions,

0 if the values of some carrier process variables are over the designed limits and the function is not maintained.

If quality index is 0 then performance index is 0 .

<u>Effectivity index</u> describes the goal-function relation and is important if some values of goal attributes (requirements) are in WD space.

Example:

GB, goal of system B = ' to maintain the temperature of system A into fixed intervale'

GB attributes: a1 = 'optimal temp. level [C degree]'

a2 = 'accepted temp. intervale'

a3 = 'environment conditions set'

a4 = 'quality distribution function'

a5 = 'goal assumptions set'

a6 = 'goal performance index'

a7 = 'goal quality index'

.
.
.

Fd, dynamic function of system B = 'energy production'

Fd attributes: i1 = 'performance index'

i2 = 'quality index'

i3 = 'effectivity index'

.
.
.

If the cause/consequence relation is represented by the following sentence:

IFF Fd THEN ONLY GB.

then the domain of argument of quality distribution function is domain of Fd effectivity index .

At the end of this paragraph is necessary to add that the functional description of a system is reasonable and useful for realy complex systems, especially for design, so called,man-machine interface for a plant control . However, this complexity is also achived when the application of process description desires to the operator /or system users/ to much decision steps in to short time intervale.

2.4. Relations

Decomposition of the goal-system interrelation needs the formalization of relations between the basic objects.

.One of the most important relations is the carrier relation.

This relation exist between : system, process, function and state.

For example

$P \in S$ - relates that system S is the carrier of process P,

$F \in P \in S$ - here, the carrier of the function F is process P

The carrier relation is transitive but not symetric.

Graphical illustration of carrier relation is presented in Fig.3.

.Cause an consequence relations (c/c) are represented in the SPG as interrelations between formal objects.

The c/c are collected in the Table.2 .

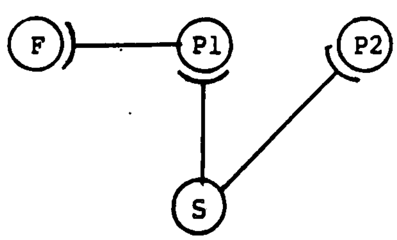


Fig. 3. Graphic representation of carrier relation.

.The third group of the relations concerns the same type of the formal objects on the same herarchical level.

They are the following :

functional connection,

process connection,

structural connection.

Systems S1 and S2 have a <u>functional connection</u>, F-relation iff exists

Fa(Si) , Fb(Sj) and Fa is a cause of Fb

for (i,j)=(1,2) or (2,1),

where Fx(Sy) means that Sy is the carrier of function Fx, Fx $\in$ Sy .

System S1 and S2 have a <u>process connection</u>; P-relation iff exist

Pa(Si) and Pb(Sj) , and Pa ,Pb have variable connection, where (i,j)=(1,2) or (2,1).

The mentioned above and decomposition and syntesis connections are illustrated in graphical form in Fig.4.

.Other, but not least relation in the SPG formalism is the <u>variable-process</u> relation, v-p relation /see Fig.6./.

The introduced definitions enable to construct four important types of <u>nets</u>.

1. G-S decomposition net /heterogeneous net/, presented in Fig.4.1.

2. Homogeneous net obtained by herarchical decomposition of anyone element of G-S net,
3. Variable-process net / Fig.6/.
4. Cause or consequence net / homogeneous/.

Extention of v-p net is variable-process-pararmeter net /v-p-p/.

The v-p and v-p-p nets are useful for decomposition of dynamic processes for diagnostic purposis.For example, on this base has been elaborated by Bessenyei and Gadomski [2] so called Process-Support Process /PSP/ graphical method destinated for presentation to the reactor operator a current state of reactor processes.

2.5. Rules

First group of rules in the SPG are identification rules, they concern :

- goal identification
- system identification

and after, the identification of other real objects in terms of the SPG approach.

Second group of rules includes net building rules concerning hierarchical and level decompositions.

Third one is called driving rules.

The driving rules are goal oriented. The goal of a description of the ADYS 'S' can be the presentation of some features of S which are necessary for:

. designing of S

. control of S

. diagnosis of S

or for performing another function by an assumed system S2. In this paper we are intrested in the description of the TRIGA RC-1 system for diagnostics purposis.

An example of the half-heuristic main driving list adequated for this goal is presented below:

1.goal identification and decomposition

2.system identification and hierarchical decomposition

3.identification of parameters of subsystems

4.process identification

- hierarchical decomposition
- variabie-process net building
- proces-support process net building

5. cause of an abnormal status identification ; construction of a cause net through decomposition of system-parameter-process relations

6. consequence identification through decomposition of process-function relations

7. reduction of information redundancy in S-G decomposition.

or

8. verification of goal attributes.

All these steps are performed by the detailed lists of IF..THEN .. rules.

3. TRIGA RC-1 Supervisory System

The goal of the description of TRIGA RC-1 System /TRS/ presented here is to be useful for the construction of the TRIGA RC-1 Supervisory System /TSS/.

For this reason the identification of the goal of TSS must be preliminary performed.

TSS GOAL = ' Increasing exploitation safety and economy of the TRS'

The TSS GOAL is achived if the following functions are performed by TSS :

FS1 = ' Continuous information production concerned dynamic status of the previously defined TRS
processes; p-set,
subsystems; s-set,
functions; f-set
under the assumed time conditions'

FS2 = ' Presentation the produced information in form useful and easy accepted by the reactor operator'

The FS1 function must be performed under the envirnment conditions:

a. normal TRS conditions

b. abnormal TRS conditions

Realization of the FS1 depends on the TRS conditions status, it means that the adequated function is necessary.

The FS1 is decomposed in the following way

FS1 : F11 + F12 + F13 + F14 + F15 ,

where: F11 is registration of measured variables and parameters,

F12 is process flow simulation,

F13 is detection of abnormal process /failure detection/,

F14 is identification of subsystems status /diagnosis/

F15 is identification of functions performance /consequence searching/.

The above functions require the identification of measured variables, parameters and the descriptions of the p-,s-,and f-sets .

The identification of status of the processes and measured parameters must be sufficient for diagnosis and for functional consequence assesment.

It means that the description must be unique and complet with regard to accepted TRS divisions and approximations.

The diagnostics information must be hierarchical and includes

- monitoring level; on the base of safety margins,
- model level; comparising the submodel variables with adequated measured variables,
- cause level; where an abnormal status of the system elements is identified,
- consequence level; which gives to the opertator direct information necessary for his decision process.

Important parameters of the TRS ,from the diagnostic point of view are importance of the reactor system functions and time constants of the carrier processes.

The TSS diagnostics domain not includes the processes where some variable can achived the safety margin in time shorter than the time necessary for the fault detection and the operator reaction.

4.Description of the TRIGA RC-1 Reactor System

The goal of TRS description /GRd/ is in cause relation with the goal of TSS /GTs/ :

and includes requrements list /goal attributes/ as for example, the list of functions and equipments which should be monitored and ordered relatively to their importance attributes.

Final description of the TRS depends on the GRd environment conditions /= goal constrains/ and will enable to calculate the GRd quality index.

Some goal constrains can be unknown before finishing of the description but then they must be identified if the quality index is not accepted by the TSS designer.

For example, a maximal variable list realy available to registration can be, in particular cases, not necessary and not established .

The TSS system is now under developing and not all diagnostic functions are alredy completed, for this reason, the description presented below concerns only the selected subsystems of the TRS.

1.Assumption - Main subsystem which will be diagnosed:

S1 = 'Reactor core system'

S2 = 'Reactor thermo-hydraulic system'

2.Assumption - Variabies and parameter list which can be available /=registrated in real time with sufficient precision and accuracy/.

3.Assumption - Approximations in the process models

The assumptions 2 and 3 enable to decompose the systems S1,S2. In Fig.4 the variable net is shown.
The obtained process-variable net is illustrated in Fig.5.
Fig. 6 presents the system decomposition/ structure.
Last decomposition level is composed with the subsystems or equipments which can be considered as the elementary diagnosed subsystems / s-set/.

4.Assumption - The main functions :

F1 = ' Energy production by S1 '

F2 = ' Heat removing by S2 from S1 to TRS physical environment '

5.Assumption - Hierarchical decomposition of the main functions up to f-set level.

For the TRS , the functional decomposition is closely related to the system decomposition /see Fig.7/.

Finally , the complete description of the TRS enables realization of the following sequence of the supervisory functional procedures :

a. variable registration

b. variable simulation

c. identification of the status of the real process

if this status is abnormal then

d. searching of male subsystem/ equipment;

cause searching

e. searching of a function(s) which will be perturbed;

consequense searching.

The idea of this TSS main functions is presented in Fig.9.

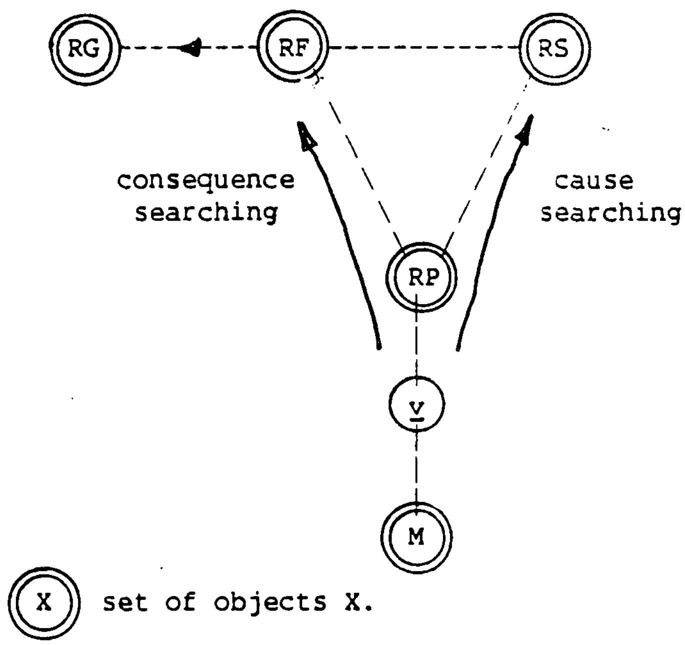


Fig. 9. Idea of the main supervisory functions of the TSS.

RG - TRS goal, RP - TRS process

RF - TRS function, v - TRS measured variables

RS - TRS subsystem, M - TRS subprocess model .

The SPG approach has been used for elaboration the Process-Support Process /PSP/method designated for the graphical presentation of a status of the reactor processes.

The main process of the plant is decomposed and every subprocess is presented in form of the variable-process net with selected input control variables.

Every abnormal state of the main process is a consequence of either control error /human error/ or process parameter perturbations. The process paramerers can be two types:

i.dependent only on system invariant attributes / structure parameters/

ii.dependent on static process /support process variables/, for example, mass flow rate.

The concept of hierarchical presentation of a reactor system status using PSP method is shown in Fig.10.

Any perturbation of structure parameters, directly responsible for equipments status, changes the character of support process ,from static to dynamic and finally perturbes the monitored main process variables.

Fig.11. illustrates the application of the PSP for presentation of the main process in the TRS.

According to the PSP rules, the decomposition of the TRS has been preliminary performed.

5. Conclusions

The presented paper is only the information about goals , properties and the possible applications of the SPG approach .
Complete description of the SPG is now under preparation.
Up to now, the SPG is a half heuristic approach to designing of a complex dynamic system and the tool for better understanding the complexity of a system-goal interrelations.

The SPG with the generalized formal object theory should enable to constract the designer support system ,for example, using the LISP languague.

For the reason, that present theoretical and experimental results seems to be sufficiently interesting and fruitfull, the SPG approach will be also used for the elaboration of the TRIGA Supervisory System .

References

[1]. L.Di Palo at al.

Reacttore RC-1 1MW Progetto definitivo e Rapporto di Sicurezza,

Report of CSN Casaccia, CNEN, (1960).

[2]. Z.Bessenyei,

Multilevel flow modelling and other candidates with respect to the TRIGA Supervisory System,

Summary report for IAEA, CRE Casaccia, ENEA,TIB-ISP-INFO (1986).

[3]. S.Niizuma, T.Kitahasaski,

A Problem- Decomposition Method using differences or equivalence relations between states,

Artificial Intelligence 25 (1985),117-151.

[4]. Yo Ishizuka, K.Shimizu,

Necessary and sufficient conditions for the efficient solutions of nondifferentiable multiobjective problems,

IEEE Trans. of System,Men and Cybernetics, 4 (1984),625.

[5]. R.E.Korf,

Macro-Operators: A Weak Method for Learning,

Artificial Intelligence 26 (1985),35-77.

[6].Z.Pawlak,

Classification of objects by means of attributes,

Polish Academy of Science, ICS PAS report no.429(1981).

[7]. A.K.Hajdasinski et al.

The choice and use of different model sets for system identification,

Proc. of IFAC Identification and System Parameter Estimation ,1982, Washington D.C. USA (1982).

[8]. R.E.Stepp, R.S.Michalski,

Conceptual clustering of structured objects:

A Goal-Oriented Approach,

Artificial Intelligence 28 (1986),43-69.

[9]. J.de Kleer,

An assumption-based TMS,

Artificial Intelligence 28 (1986),127-162.

[10]. Materiales of the International Seminar on Artificial

Intelligence and Diagnostics Application in Industry,

Roma,June 3 (1986).

[11]. M.Lind,

Multilevel Flow Modelling of process plant for

diagnostics and control,

RISO National Lab., RISO-M-2357(1982).

[12]. M.Lind,

A system modelling framework for the design of

integrated process control system,

RISO National Lab., RISO-M-2409(1983).

[13]. M.Lind,

Informational interface for process plant diagnostics,

RISO National Lab., RISO-M-2417(1984).

[14]. T.Businaro et al.,

An application of Multilevel Flow Modelling method

for nuclear plant state identification,

ENEA report, RT:TIB:85;31,(1985).

[15]. T.Businaro et al.,

Preliminary report on:

A high risk complex plant supervisory system,

19th Informal Meeting on Reactor Nose,Rome,June (1986).

[16]. A.M.Gadomski,

Problems of real time nuclear reactor caslculations,

Int.report IBJ, 0-251/XII/82 (1982) /in Polish/.

[17]. A.M.Gadomski,

Application of Singular Perturbation Method in nuclear reactor dynamics,/ in Polish/,

University of Warsaw,Math.Dep.,Warsaw,Poland(1984).

[18}. A.M.Gadomski,

Basic assumptions of TRIGA dynamic model for operator aid expert system, /Primo rapporto d'attivita/,

TIB-ISP-INFO,ENEA,C.R.E. Casaccia,(1985).

[19]. A.M.Gadomski,

Information about System-Process-Goal approach to diagnostics and supervisory of nuclear reactor system,

19th Informal Meeting on Reactor Nose,Rome,June (1986).

TABLE 1. Review of the different supervisory systems [2].

No	Autors	Title and source	Year	Name of the system	APT	Place of appl	Fundamental method	Description of cf	dm	im	sw	hw	ev	EXP	Notes
01	P.Gemst, P.Waessman:	Post accident diagnostic system IAEA SM 265/76	1982	PAOS	A	Ringhalsl & Forsmarkl	CFS	-		-	+	-	+	O	
02	H.Yoshitosi et al:	Development of Computerised Operator support system IAEA SM 265/75	1982	NUPOMAS/ COSS	P		CCT	+		-	+	-	+	S	
03	T.Masui et al:	Diagnostic Technologies for the PWR Plants In Japan IAEA SM 265/34	1982		P		CCT	+	-	-	+	+	+	S	
04	F. Dworzak et al:	Design and IMpl of a Computerised system for evaluating of Plant Status IAEA SM 265/95	1982		P	Forsmarkl	mixed	-	-	-	-	-	-	N	
05	A.J.Spugin et al:	Decision Making Aid for Op Crews (satua of DASS) IAEA SM 265/83	1982	DASS	A/T		CCT		-	-	-	-	-	N	
06	R.R.Shah L.M.Watkins:	Failure detection and Recovery in Disturbed Sytems SM 265/7	1982	REDNET	A	Chalk River Nucl Labs	mixed	-	-	-	+	+	-	N	
07	D.Schriefer et al:	Design and Constr a Reliable /uP Based ..... IAEA SM 265/21	1982		T			-	-	-	-	+	-	N	
08	K.Yoshioka K.Fukunishi:	Failure Diagn Proedures for large TOKAMAK Mchines J. Nucl Sci and Techn. vol20. no9.sept	1983		A/T		CCT	+	+	+		+	+	S	
09	D.N.Wormely et al:	Math Modelling of Fossil Fuelled Steam Power Plants (part I) Knoxwill/6	1983		T			-	-	-	-	-	-	N	
10	C.M.Smith F.J.Sweeney:	Demonstration of an Automated Online Surveillance System at a Commercial NPP Knoxwill/31	1983		A	Sequoyahl	noise	-	+	-	-	+	+	O	
11	G.Hoffmann et al:	Transfer of Expert Knowledge to the Consulting Core Surveillance System COCOSS at KNK II. Knoxwill/27	1983	COCOSS	A	KNK II.									
12	M.Kitamura:	Use of Analytic Redundancy for Surveillance and Diagnosis of Nuclear Power Plants Knoxwill/33	1983		T		model ref	-	+	+	+	-	+	O	
13	C.M.Smith J.March-Leuba:	Development of an Automated Diagn System for BWR stability Measurements SMORN IV 1.3.	1984		T/A		noise	-	+	-	-	-	+	S	
14	W.R.Cocoran et al:	The Operators Role and Stafety Functions Comb. Eeng. TIS 6655A	1980	CFMS	T		CSF	+		-	-	-	-	N	

No	Autors	Title and source	Year	Name of the system	APT	Place of appl	Fundamental method	cf	dm	im	sw	nw	ev	Exp	Notes
17	P.J.Gaudio:	Improved On-line Operational Support Using Success Path Monitoring (Enlarged Halden Project Meeting Gothenburg) Comb. Eng. TIS 7732	1985	SPMS	T		SPM	+	+	-	+	-	+	S	
18	M.Lind:	MFM Handbook (draft)	1985		T		MFM	+	-	-	-	-	-	N	
19	S.Yoshimura et al:	Man-machine Interface Using MFM OEC Halden Project HWR 96	1983		T/A		MFM	+	+	-	-	+	+	S	
20	O.Berg et al:	Early Fault Detection Using Process Models and Improvad Presantation Techniques OEC Halden Project HWR 141	1985		T		process model	-	+	+	-	-	+	S	see: 12
21	E.Hollnagel et al:	Report from the Pilot Experiment on MFM Displ Using the GNP Simulator OEC Halden Project HWR 114	1984		T		MFM	+	-	-	-	-	+	S	
22	G.Dahll et all:	Proposal for a Computerised Procedure System OEC Halden Project HWR 143	1985		T			+	-	-	+	-	-	N	
23	R.Isermann:	Prosecc Fault Detection Based on Modelling and Estimation Methods - A Survey Automatica vol20 no4 pp 387-404	1984		T			+	+	-	-	-	-	N	referred in 20
24	E.Hollnagel:	A Survey of Man-machine System Evaluation Methods OECD Halden Project HWR 148	1985		T			+	-	-	-	-	-	N	
25	T.Businaro et al:	An Application of Multilevel Flow Modelling Method for Nuclear Plant State Identification ENEA Internal Report	1985		A	PEC	MFM	+	-	-	-	+	+	S	

TABLE .1. (continued)

Legend for Tab. 1 [2].

- APT applied/planned/theory; these letters show whether the report describes a really applied or a planned supervisory or diagnostic system, or only some type of theoretical approach is given.
- In the column 'description of' the + and - signs mean whether the topics listed below are detailed or not:

  + cf: characteristic function of the system
  + dm: diagnostic method
  + im: failure identification method
  + sw: software description
  + hw: hardware description
  + ev: evaluation or verification of the method

- In the column EXP, the O/N/S letters mean that the method was experimentally tested, or not.

  + O: on-line test was done
  + S: test on simulator
  + N: any test was not done

- In the 'fundamental method' column the abbreviations are:

  + CFS: critical safety functions
  + CCT: cause-consequence tree
  + SPM: success path monitoring
  + MFM: multilevel flow modelling .

TABLE 2. Cause and consequence relations

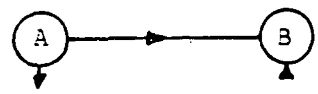
——▶—— indicates cause; ——▷—— indicates consequence.

Examples :

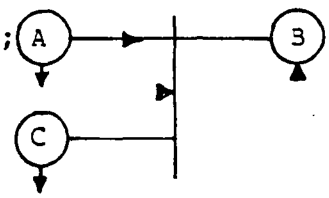
1. iff A then only B ;

2. iff A then B ;

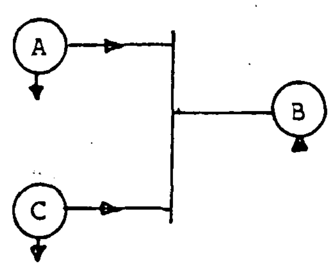
3. if A then B ;



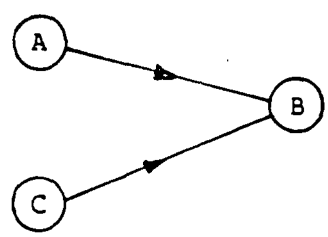
4. if C then A is necessary for B;



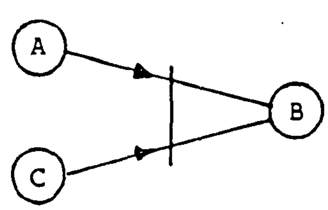
5. if A and C then B ;



6. iff A or C then only B ;



7. iff A or C or (A and C) then only B ;



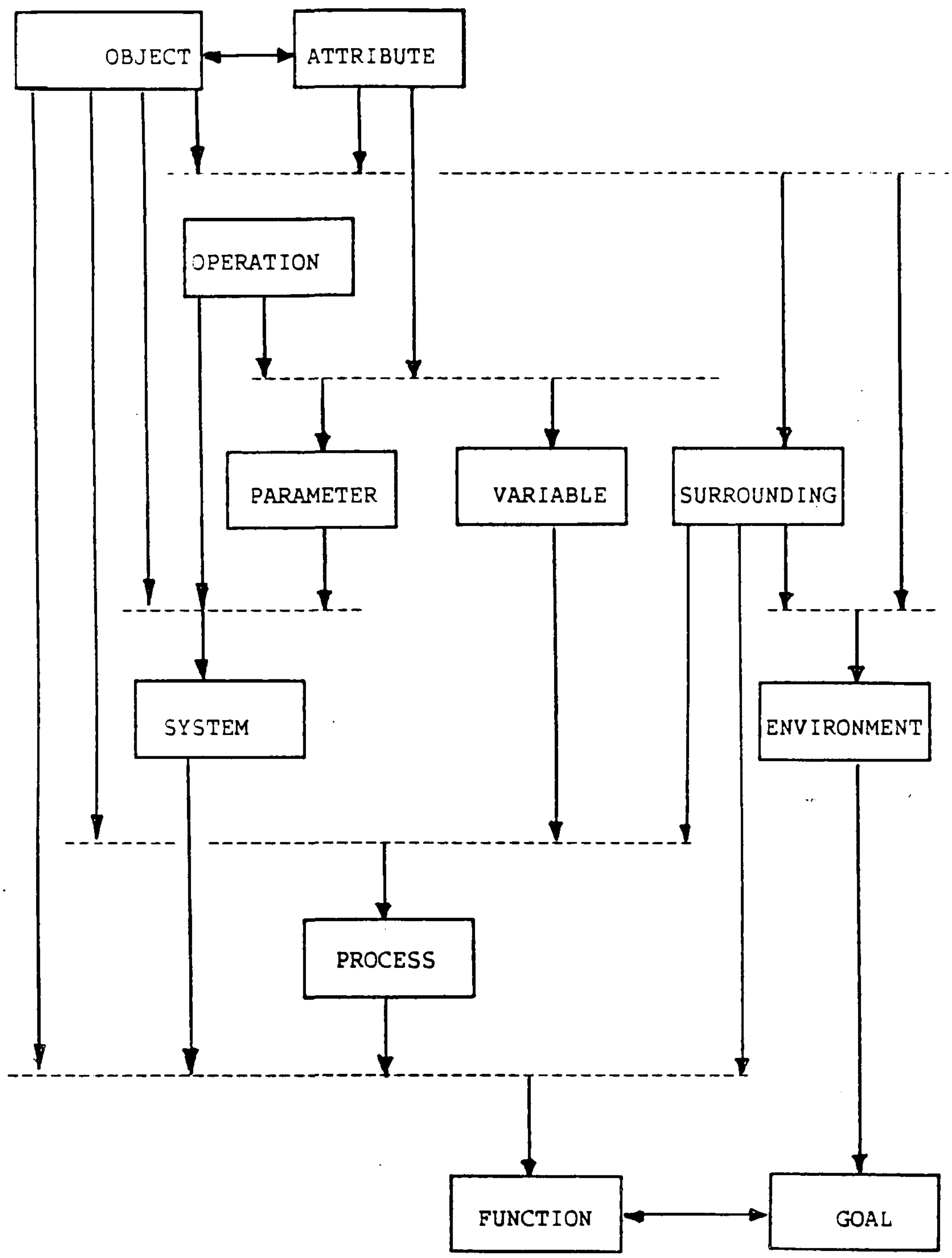
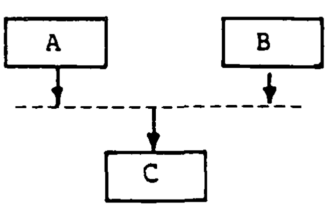


Fig.2. Net of some basic definition sequences in the SPG approach,



means that def. A and B are used directly in def.C.

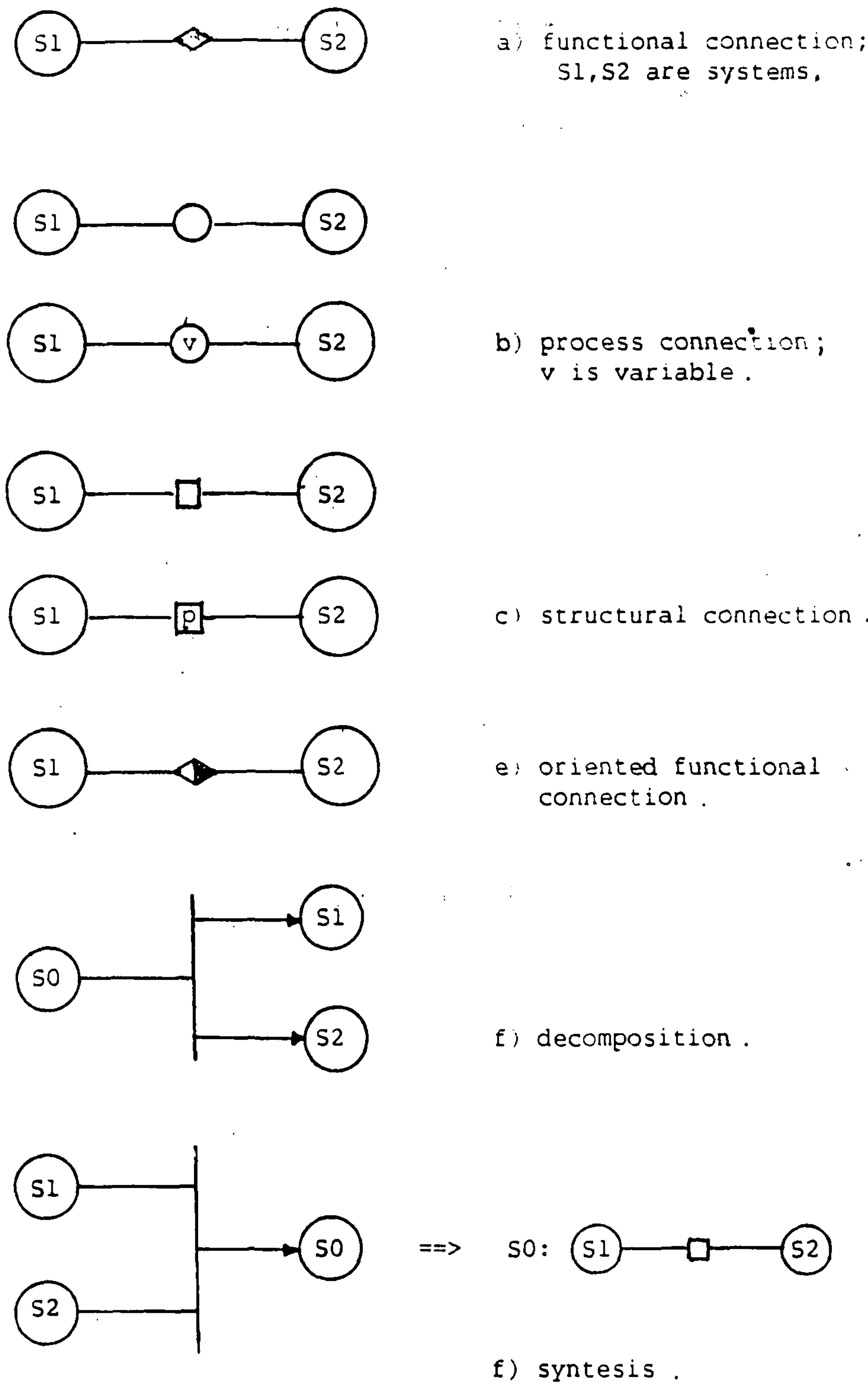


Fig.4. Functional, process and system relations,
- example of homogeneous interrelations /connections/
in the SPG .

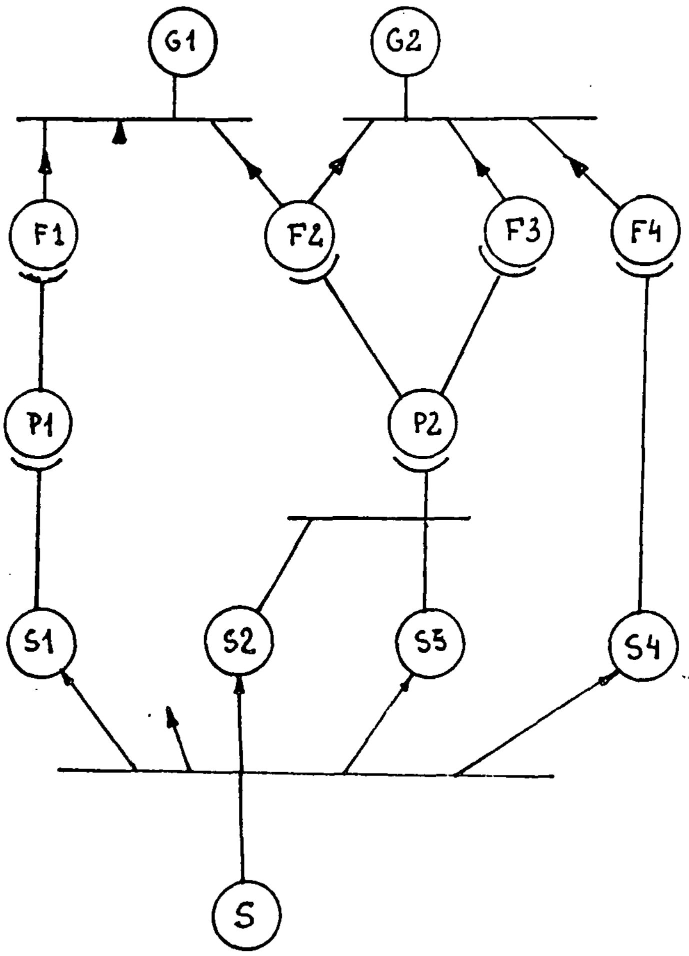


Fig4.1. Goal-System heterogeneous net.

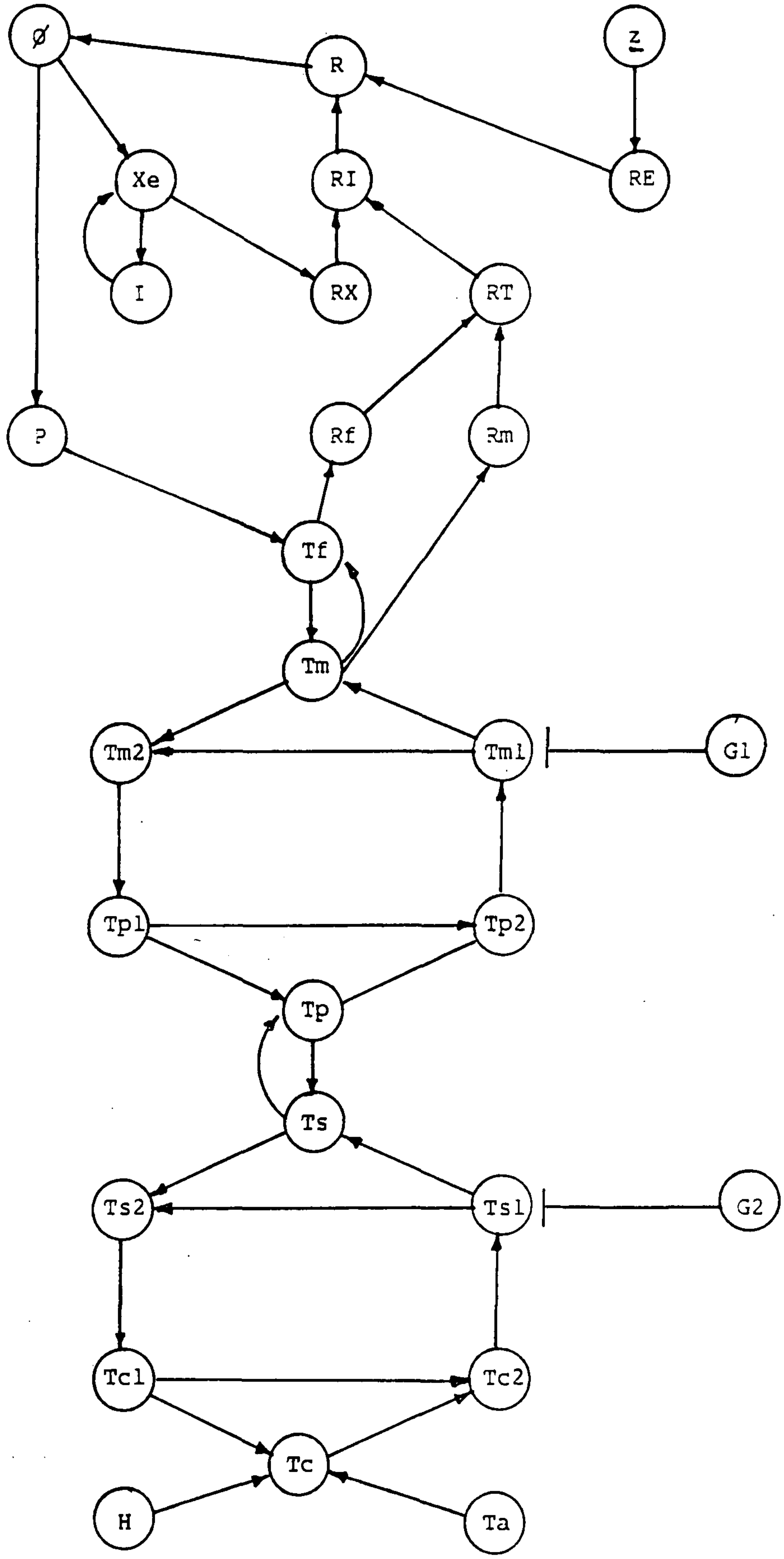


Fig.5. Variables net in the TRIGA main process model
/variables list in Appendix/.

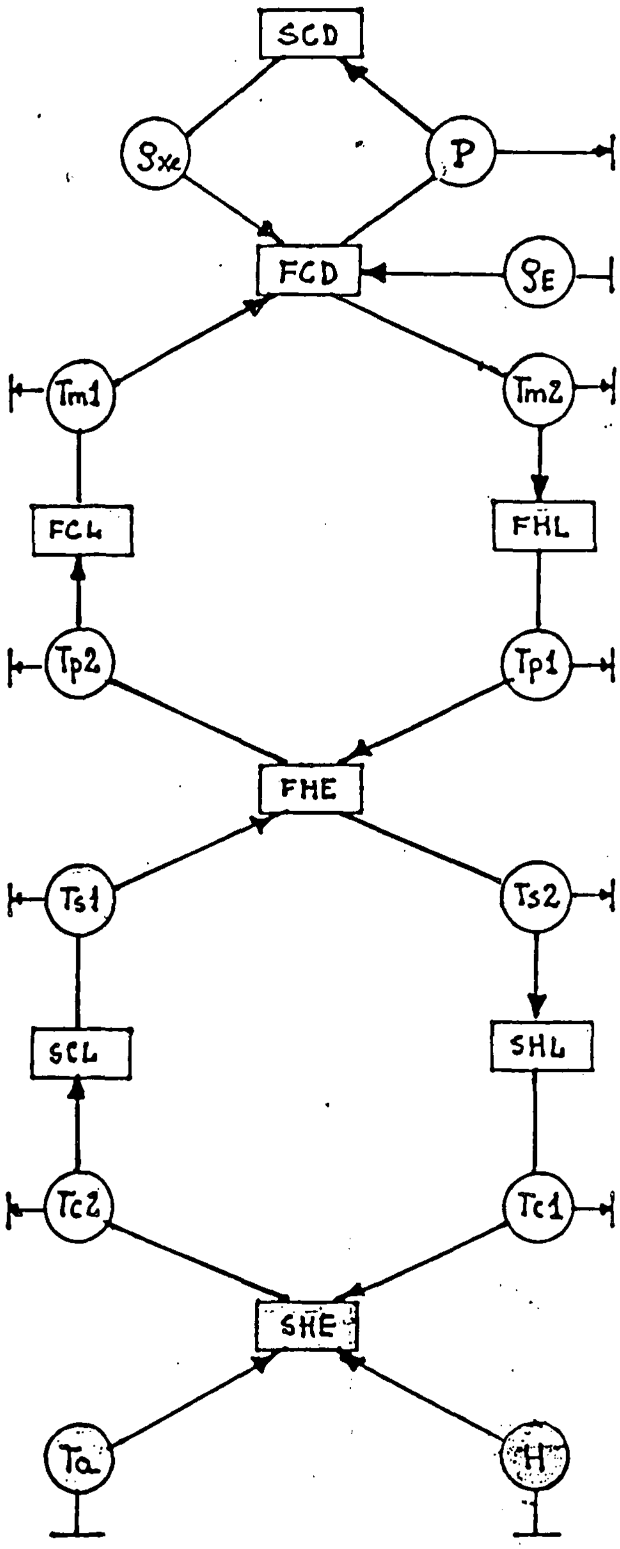
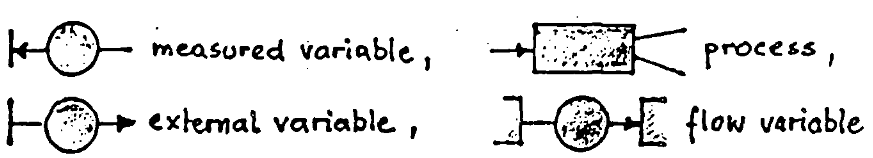


Fig. 6. Process-variable net representing the TDM modular structure.



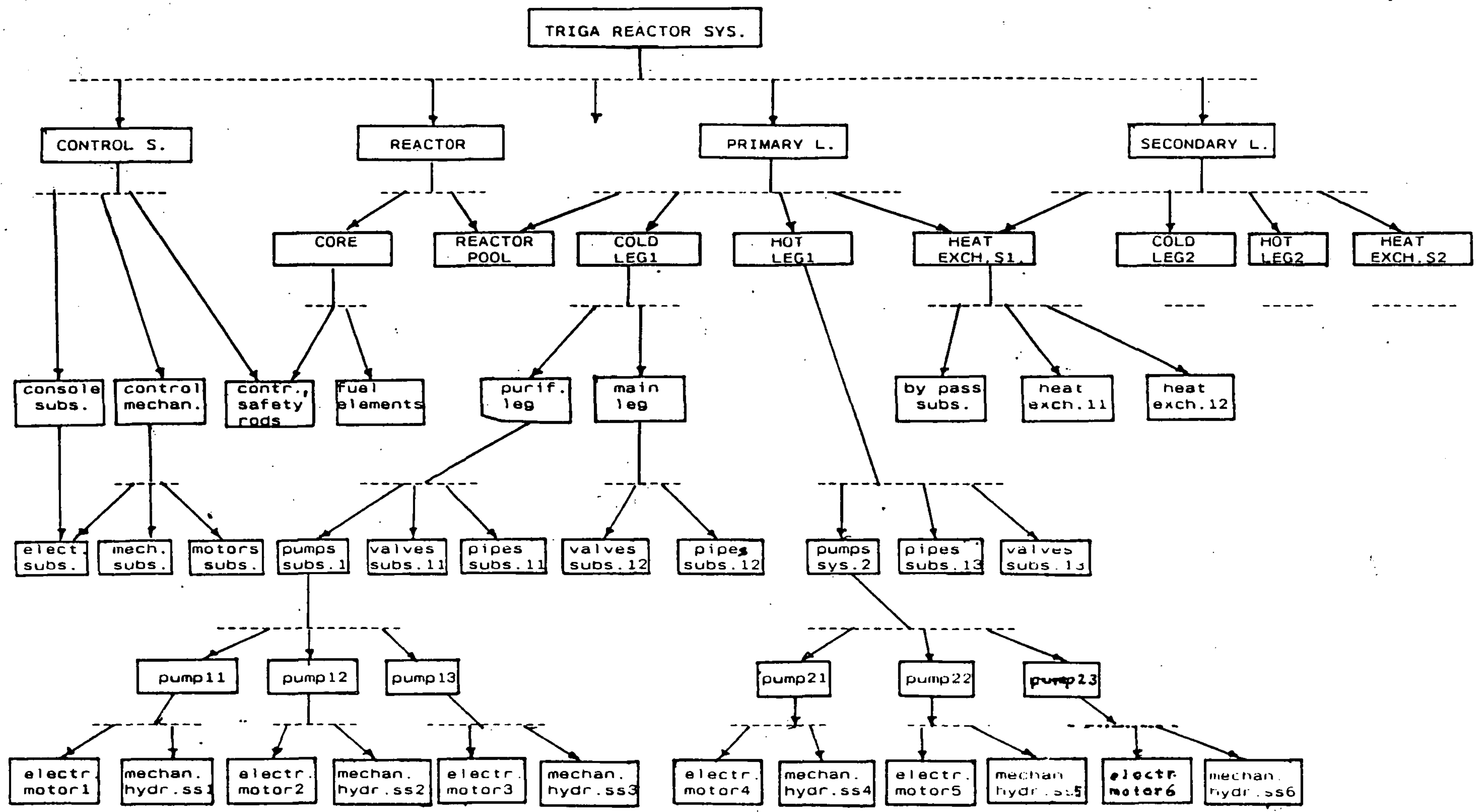


Fig.7. Example of the TRS structural decomposition ; 6 levels. The second level is the carrier of the main TRS processes.
The next levels are dedicated for diagnostic purposis.

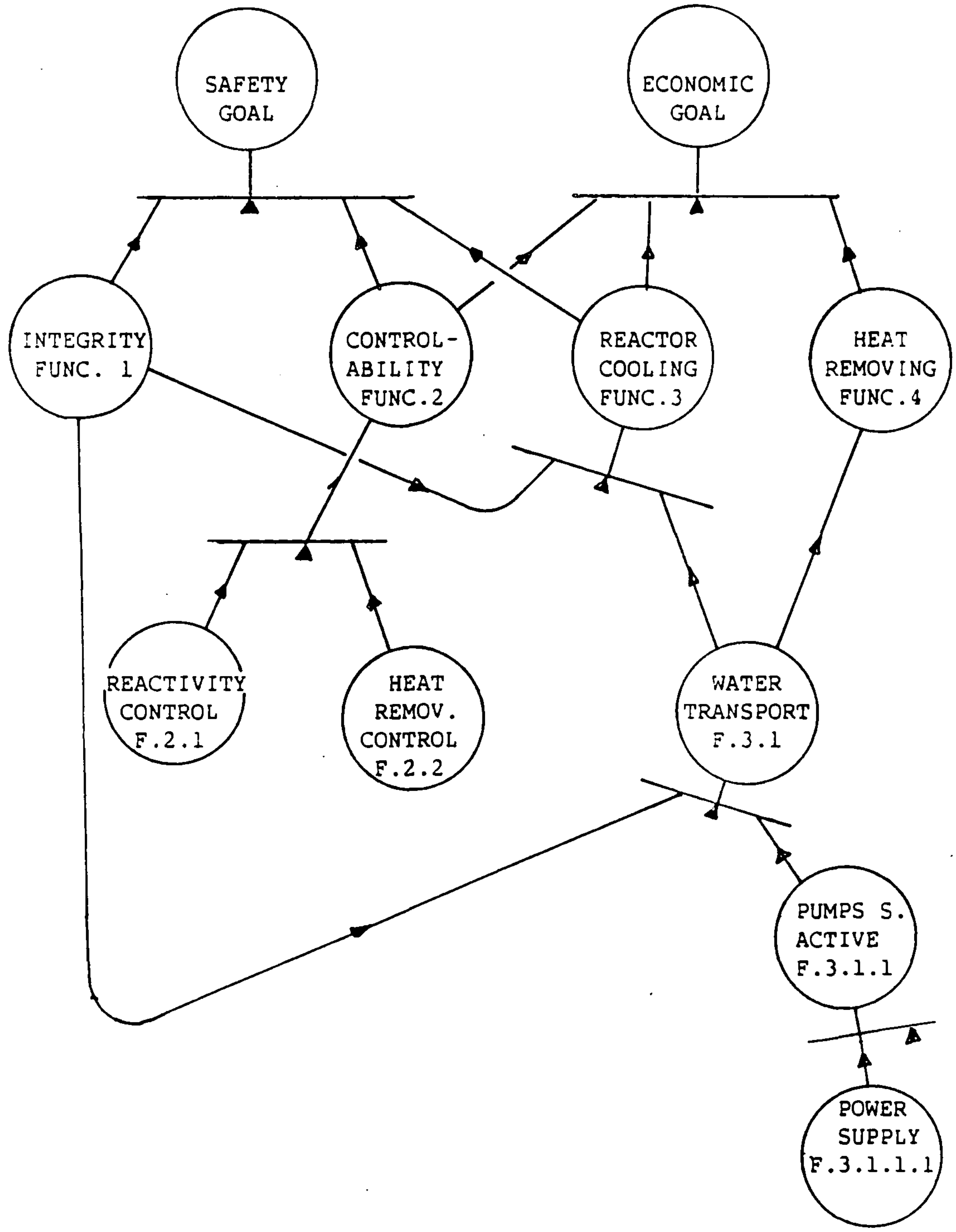


Fig.8. Interrelations between the main TRS functions.

FUNC.1 - Integrity of the TRS,
FUNC.2 - Controlability of the TRS
FUNC.4 - Heat removing from the reactor vesel to atmosphere
FUNC.3.1 - Water circulation in the primary and secondary.

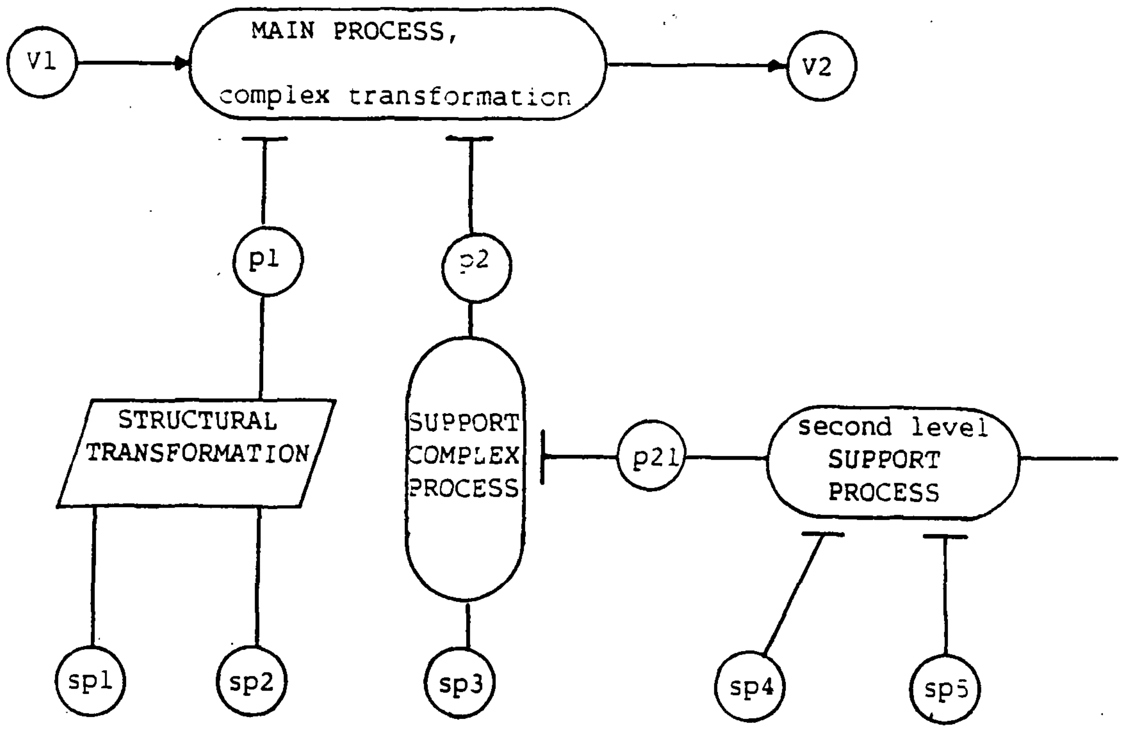
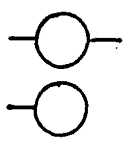
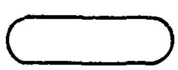
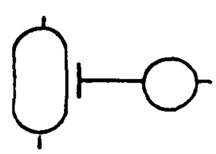


Fig. 10. Concept of hierarchical presentation of an ADYS using Process-Support Process method.

 - variable or parameter vector

 - complex transformation

 - process-parameter relation

V1,V2 - input and output the main process variables vector

p1,p2 - vector of the main process parameters
p2 also is output variable vector of support process.

sp1 - sp5 are structure parameters.

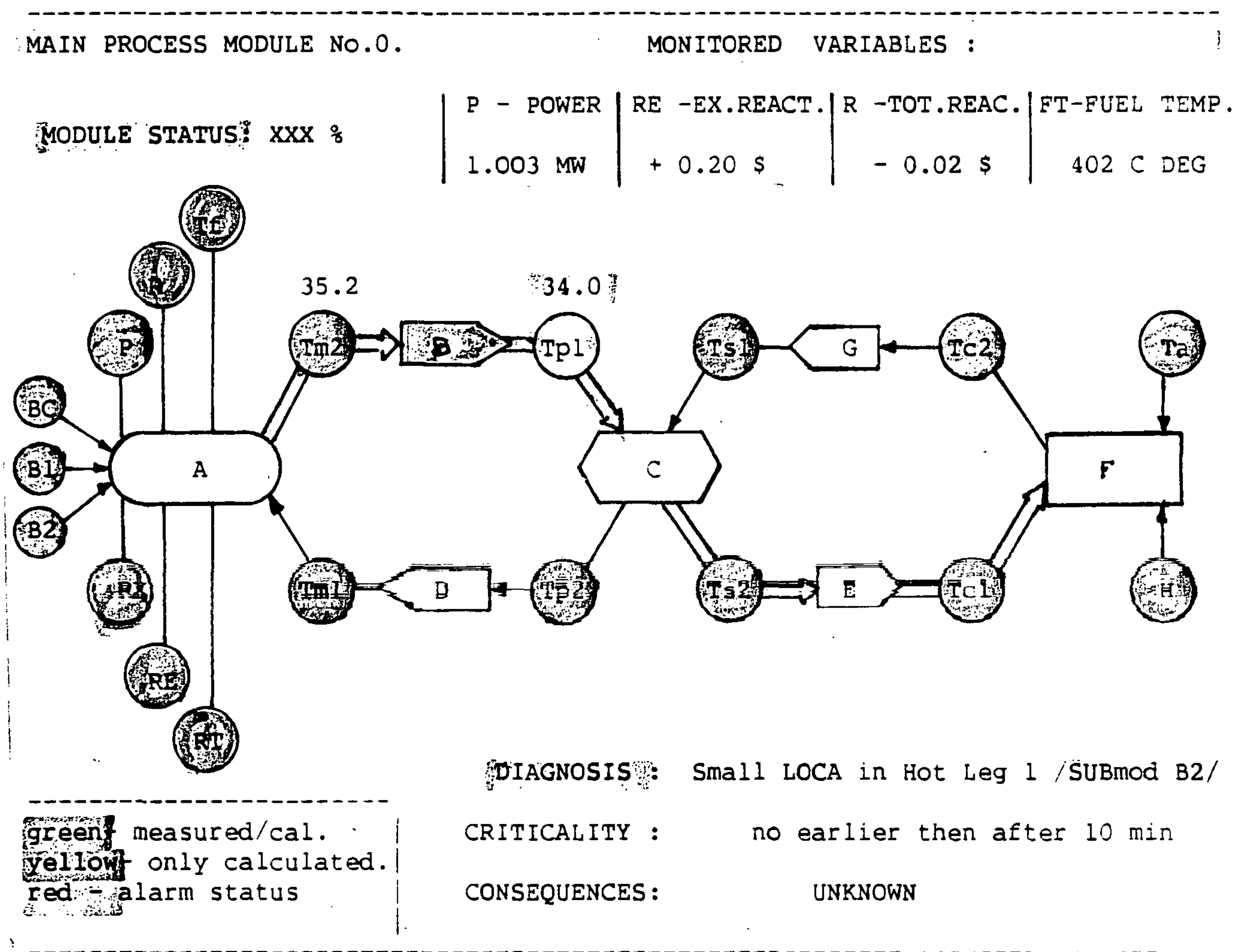


Fig.11. Main process in TRIGA RC-1 reactor system presented using the Process-Support Process method / explaination, see Appendix 3 /.

The value of variable/parameter (v/p) can be presented on the request by touching of the screen in place where this v/p is visualized
or automaticaly, if this v/p has an abnormal value.

Appendix

A1. List of variables and process parameters in the TRIGA dynamics model /Fig.5./.

- z - vector of the positions of the regulating elements
- P - power proportional to neutron flux
- Tm1 - core inlet temperature
- Tm2 - core outlet temperature
- Tp1 - first heat exchanger system (FHE) inlet temperature in primary loop (PL)
- Tp2 - FHE outlet temperature in PL
- Ts1 - FHE inlet temperature in secondary loop (SL)
- Ts2 - FHE outlet temperature in SL
- Tc1 - second heat exchanger (SHE) inlet temperature in SL
- Tc2 - SHE outlet temperature in SL
- Ta - air temperature
- H - air humidity
- G1 - mass flow rate in primary
- G2 - mass flow rate in secondary.

A2. List of modules in the TRIGA dynamics model /see Fig. 6/.

1. Fast core dynamics, FCD
2. Slow core dynamics, SCD
3. First heat exchanger system, FHE
4. First loop hot leg, FHL
5. First loop cold leg, FCL
6. Second heat exchanger system, SHE
7. Second loop hot leg, SHL
8. Second loop cold leg, SCL.

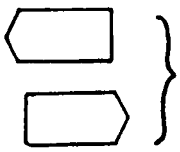
A3. Short comments on the PSP presentation method

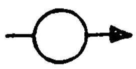
List of the graphic symbols

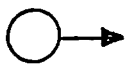
 - main transformation, or whole main or support process

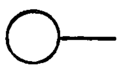
 - homogeneous transformation; for example, temperature A ⟶ temperature B

 - heterogeneous transformation; for example, power ⟶ xenon reactivity

 - artmethic, with time delay ,homogeneous transformations

 - flow variable or parameter vector

 - input variable

 - variable or parameter , for presentation only.

The hierarchical structure of the PSP modules

Level 0. Main process

Level 1. Subprocesses /after decomposition/ conditioned by parameters

Level 2. Support processes /if not decomposed then conditioned/ or structural transformations

⋮

Level n. ...

Three screens are desired for the PSP:

- .the first is for the main process module
- .the second is for monitored variables transients
- .the thirt is for selected submodule and in abnormal reactor status , for critical variable transient.