I simulatori real time realizzati da ENEL dedicati allo studio della dinamica degli impianti di produzione di energia elettrica.

Seminario illustrativo delle esperienze di modellistica dinamica di processi industriali complessi.

Bologna 13/05/1999

MODELING EXPERIENCES AT ENEL

- The first activities in this field date back to the mid '60s
- From the beginning, all the models have been developed using the principles of physics (equations of mass, momentum and energy conservation)
- Cultural intercourse with EDF in the field of modelization was very significant
- Types of plant taken into account:
  - fossil fuel plants
  - nuclear plants
  - solar plants
- All the models were oriented to mechanical components and control systems verifications for real time simulation

Role of dynamic models in mechanical and automation systems design verification

- Dimensioning of mechanical components in dynamic conditions
- Mechanical and thermal stress analysis for life consumption evaluation
- Control systems project:
  - process stimulation response
  - regulation loops planning and testing
  - logical and protections systems planning

- Verification of manoeuvre procedures
- Functional control system testing in factory

REAL TIME SIMULATORS AT ENEL

- From long experience on reference and simplified models, ENEL has taken the skill in developing simulators

- The ENEL approach to the construction of thermal power plants simulators:
  - characteristics drawn from reference
  - implicit numerical methods to solve the differential system

- Result: robust and reliable models in a wide functioning range

COMPACT SIMULATORS

- limited number of simulated systems
- no replication of control panels but use of animated synoptics
- single workstation or PC
- operator interface using one or more monitors, keyboard, mouse, etc
  - cheap an flexible
  - reduced hardware costs
  - useful for control system design and testing
  - concept-oriented training

Some projects involving compact simulators

Year	Project	Plant Type
1994/95	SERENE (FIAT-AVIO)	12 units , 50Mw each, combined cycle
1994/95	Montalto di Castro	4 units , 900Mw each, combining 660Mw of a supercritical once-through with 2 TG (240Mw)+HRB
1994/95	Turbigo	2 units , 450Mw each, combining 330Mw of a drum boiler with 1 TG (110Mw)+HRB
1994/95	Rossano	4 units , 450Mw each, combining 330Mw of a drum boiler with 1 TG (110Mw)+HRB
1994/95	Brindisi Nord	once through boiler with 1 TG (120Mw)+HRB
1994/95	Trino Vercellese	2 units , 330Mw each, combined cycle
1992/93	Vado Ligure	2 units, 320Mw each, coal fired
1989/90	Brindisi Sud	2 units, 660Mw each, supercritical once-through

TRAINING SIMULATORS

- **FULL-SCOPE REPLICA**
  - complete replica of a fossil power plant control room
  - represents all plant systems
  - generally implemented on main-frame or mini-computers
    - » very costly, can be used only in a training center
- **PART TASK TRAINER**
  - training on a particular task in which it can be considered as a full replica
    - » requires a training center and provides a limited set of maneuvres
- **GENERIC SIMULATOR**
  - non-plant-specific in models and/or operator interfaces
    - » requires a training center and could be deceiving on unexperienced personnel

Some projects involving full scope simulators

Year	Project	Plant Type
1992/94	Priolo Gargallo	320Mw fossil fired drum boiler
1984/89	La Casella	320Mw fossil fired once-through
1996/1998	Puertollano	340 MW combined cycle plant with gassifier

STEPS IN SIMULATORS CONSTRUCTION

- Process modeling definition (choice of systems which are interesting for dynamic analysis)
- Model definition (choice of the elementary mathematical models and construction of the topological scheme)
- Control system simulation by graphic construction
- Synoptics and MMI construction for control system operation

SW / HW TOOLS FOR SIMULATORS DEVELOPMENT

- **ALTERLEGO is the software used to build a simulator**
  - modular code: LEGO
  - model builder: LEGOCAD
  - regulation subsystems builder: REGOMMI
  - MMI developing environment: LEGOMMI
  - real time simulation environment: LEGORT
  - alarm handling : SCADA
- **Hardware for developing and running simulators:**
  - one or more workstations:
    - » Digital ALPHA with UNIX O.S.
    - » Digital VAX 4000/90 with VMS O.S.
    - » PC pentium with LINUX
    - » PC pentium with Windows NT (in progress)

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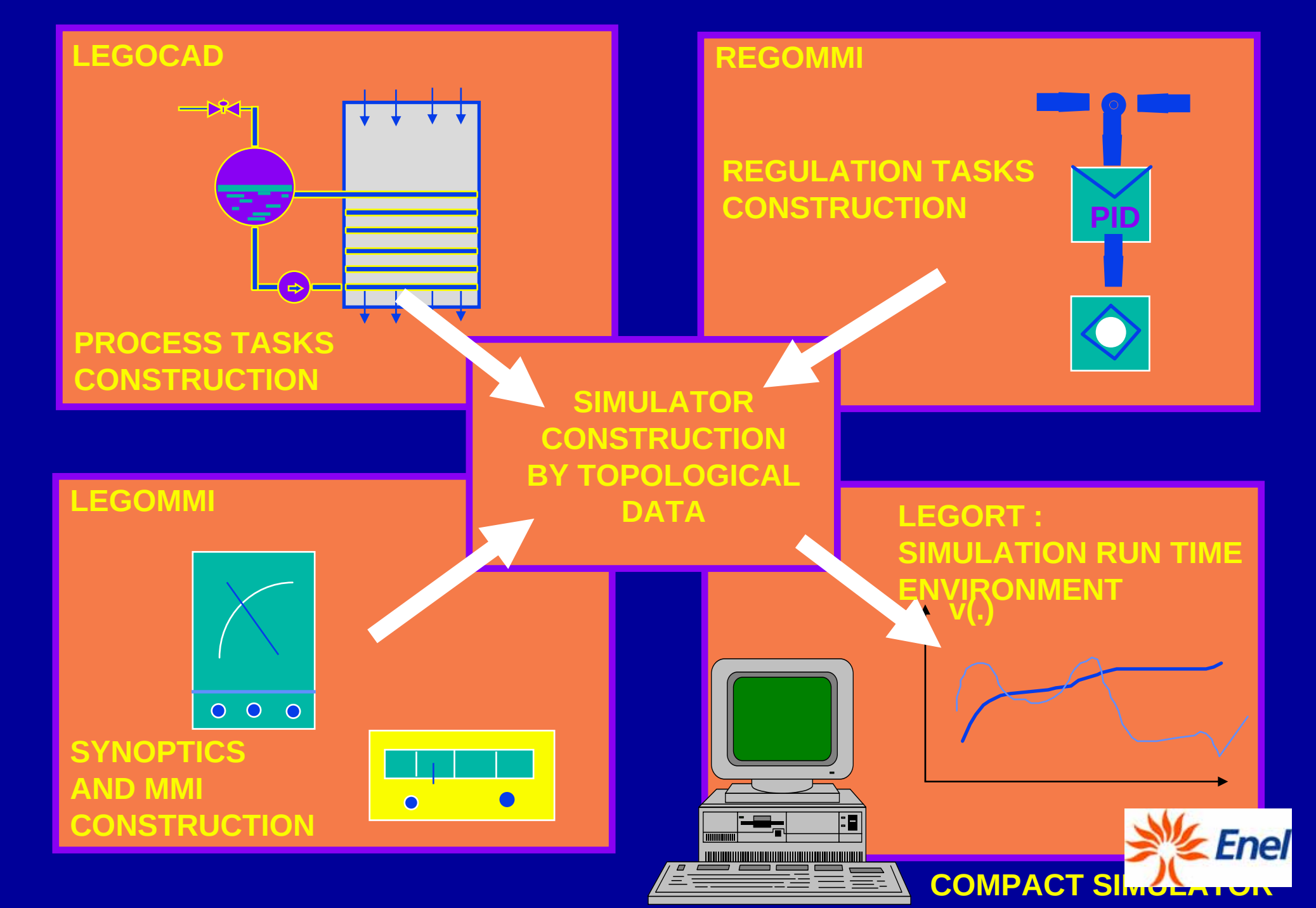
Services provided by compact simulators

- Thermo-mechanical process verification (stress analysis)
- control system design and verification
- Control system apparatus testing
- Manoeuvres procedures simulation
- Training of the personnel devoted to plant start-up

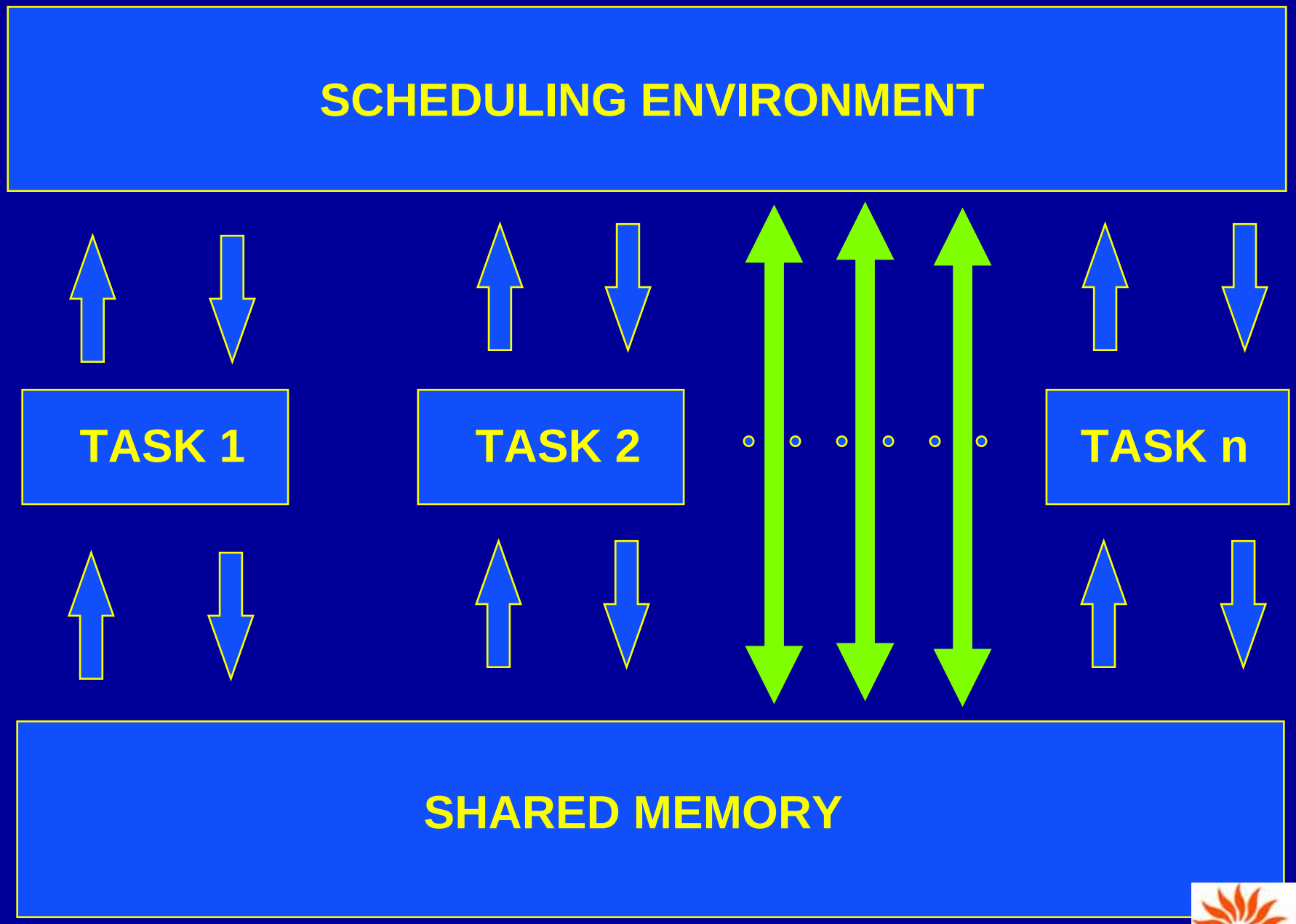

LEGOCAD
PROCESS TASKS
CONSTRUCTION
REGOMMI
REGULATION TASKS
CONSTRUCTION
PID
SIMULATOR
CONSTRUCTION
BY TOPOLOGICAL
DATA
LEGOMMI
SYNOPTICS
AND MMI
CONSTRUCTION
LEGORT :
SIMULATION RUN TIME
ENVIRONMENT
V(.)
COMPACT SIMULATOR
Enel

Documents for models construction

- process fluograms
- data sheets
- heat balance sheets
- components characteristic curves (pumps, valves)

DECOUPLING A PLANT IN TASKS

- The whole plant is splitted in several subsystems
- The tasks are solved independently one from another and see exchanged variables with a time of delay
- The exchanged variables form a shared data area, placed in a shared memory
- A scheduling real time environment runs the single tasks in turn and coordinates data exchanges via shared memory


SCHEDULING ENVIRONMENT
TASK 1
TASK 2
TASK n
SHARED MEMORY

Typical plant tasks

- combustion chamber and boiler
- air and flue gas
- circuit air- recirculating gas path and recirculating gas system
- feed water system
- condensate system
- turbines and generator system
- boiler control system
- balance of plant control system
- turbine control system
- air-gas path control systems

LEGO and LEGOCAD

- LEGOCAD is the environment allowing an easy assisted process model construction

- LEGO is the numerical problem solver, managing data acquisition and the library modules (components) defined the model

REGOMMI: control system builder

- The control system is made up of a set of tasks
- It is an environment designed to provide an easy way for creating and testing control tasks
- The user writes the FORTRAN code of a module (that is: a regulation scheme) by placing in a drawing simple blocks (such as PIDs or adders or auto-man stations)
- REGOMMI transforms this information in calls to the subprograms corresponding to the inserted simple blocks and forms the LEGO module of the regulation scheme
- More regulation modules can be placed in a regulation task, which is run, together with the other process and regulation tasks by the scheduler
- REGOMMI gives also the possibility to execute steady state and transient calculations on one single task to test it stand-alone

The scheduler : LEGORT

- Allows tasks sincronization
- Provides standard simulation functions:
  - start / stop
  - freeze / restart
  - snapshot / backtrack
  - simulation speed
  - CPU statistics
  - inputs perturbations
  - results display

LEGOMMI

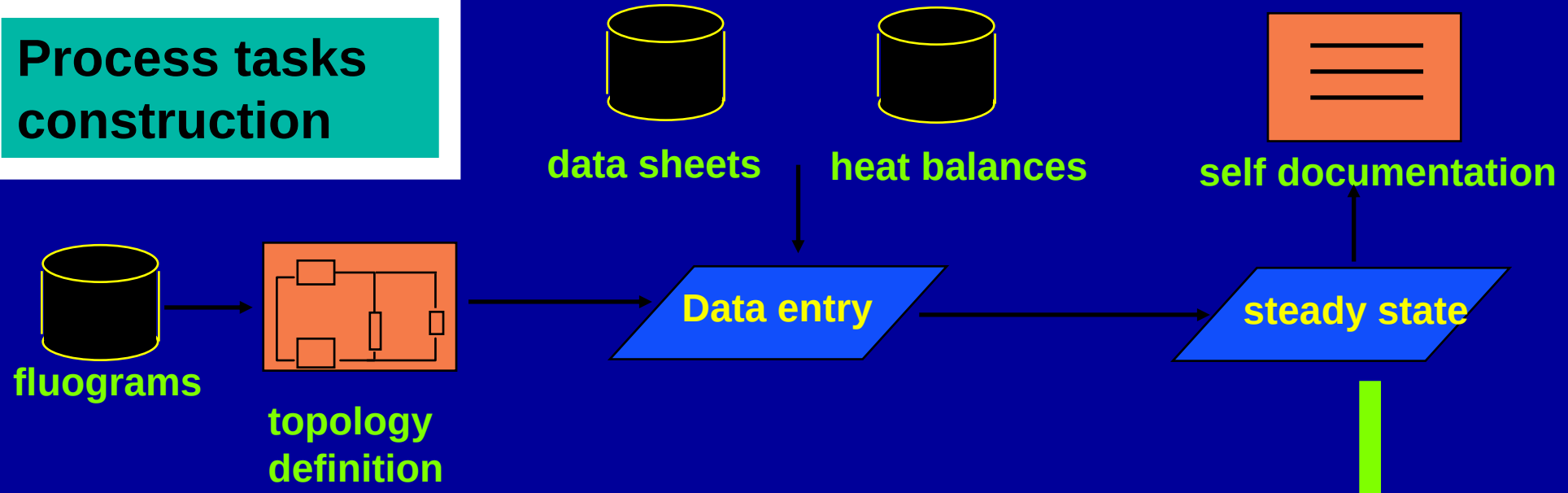
- allows easy building of mimic synoptics associated with LEGO models

- A synoptic is composed of:
  - MOTIF graphic objects, each of which is associated with LEGO blocks
  - a set of simulation variables, shown during the simulation

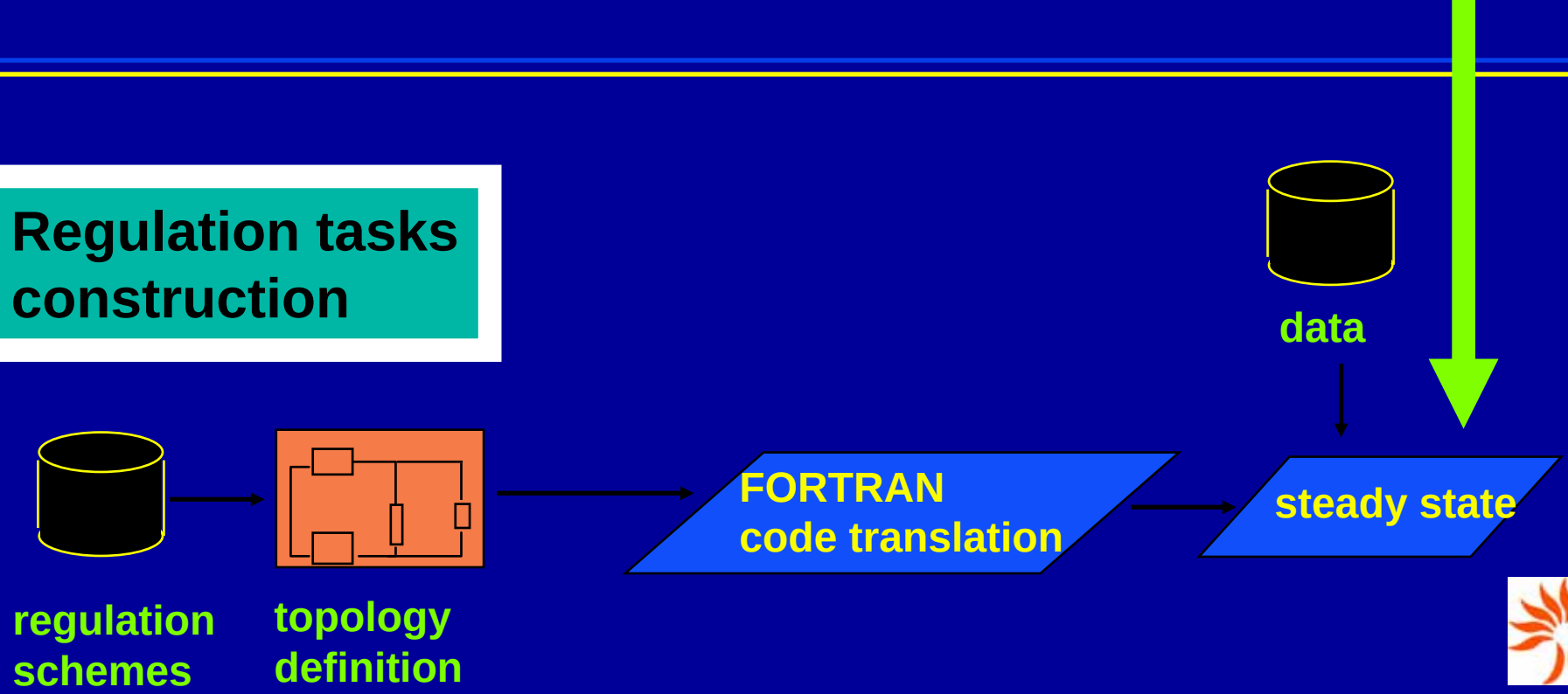
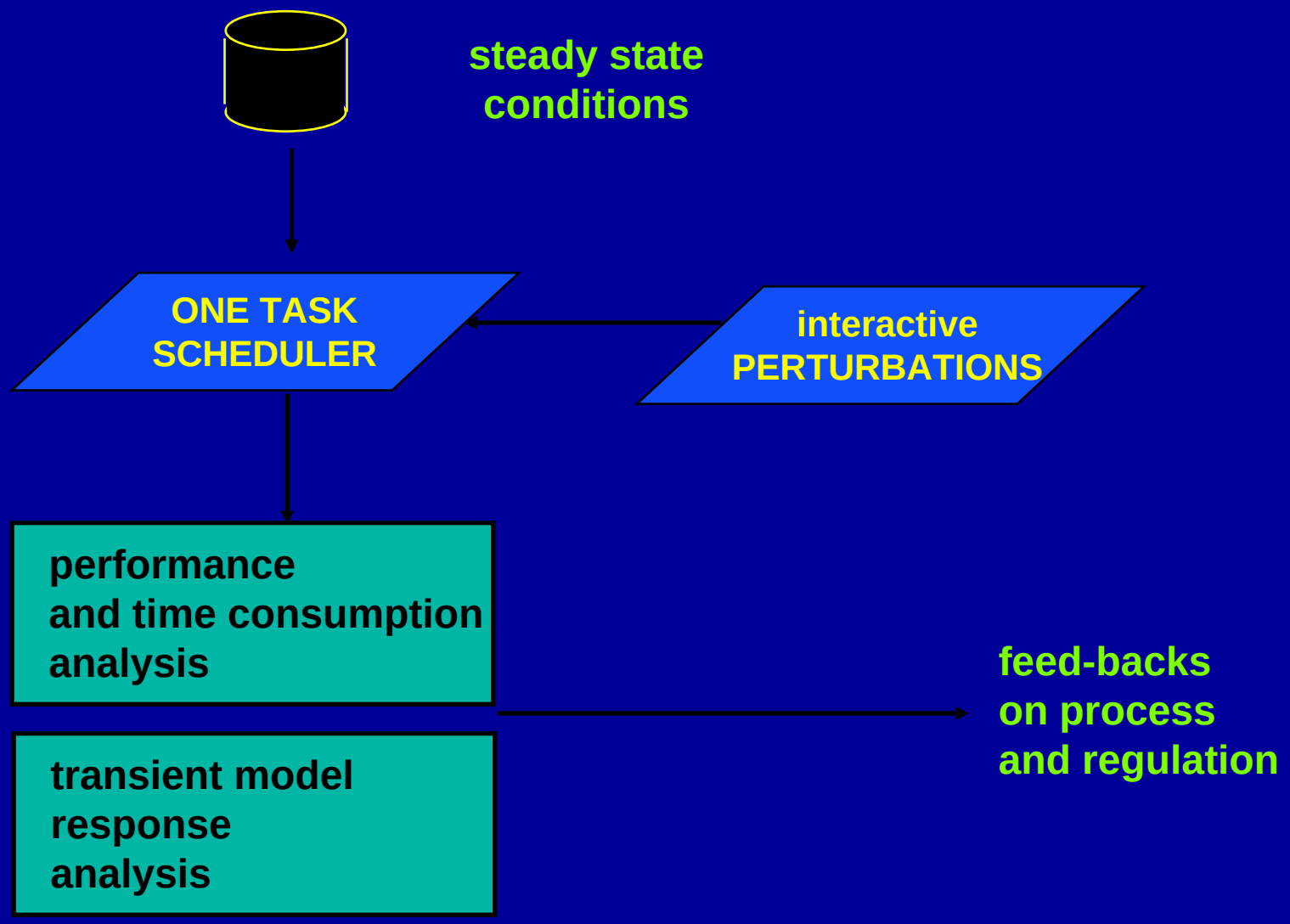
- Icons are animated to track critical conditions

- Active graphic elements are associated to LEGO blocks and variables by a menu-driven procedure

Process tasks construction



Regulation tasks construction



LEGOCAD transient
for consistency verifications