Experience with Validation by Simulation,

Automated Code Generation and Integration

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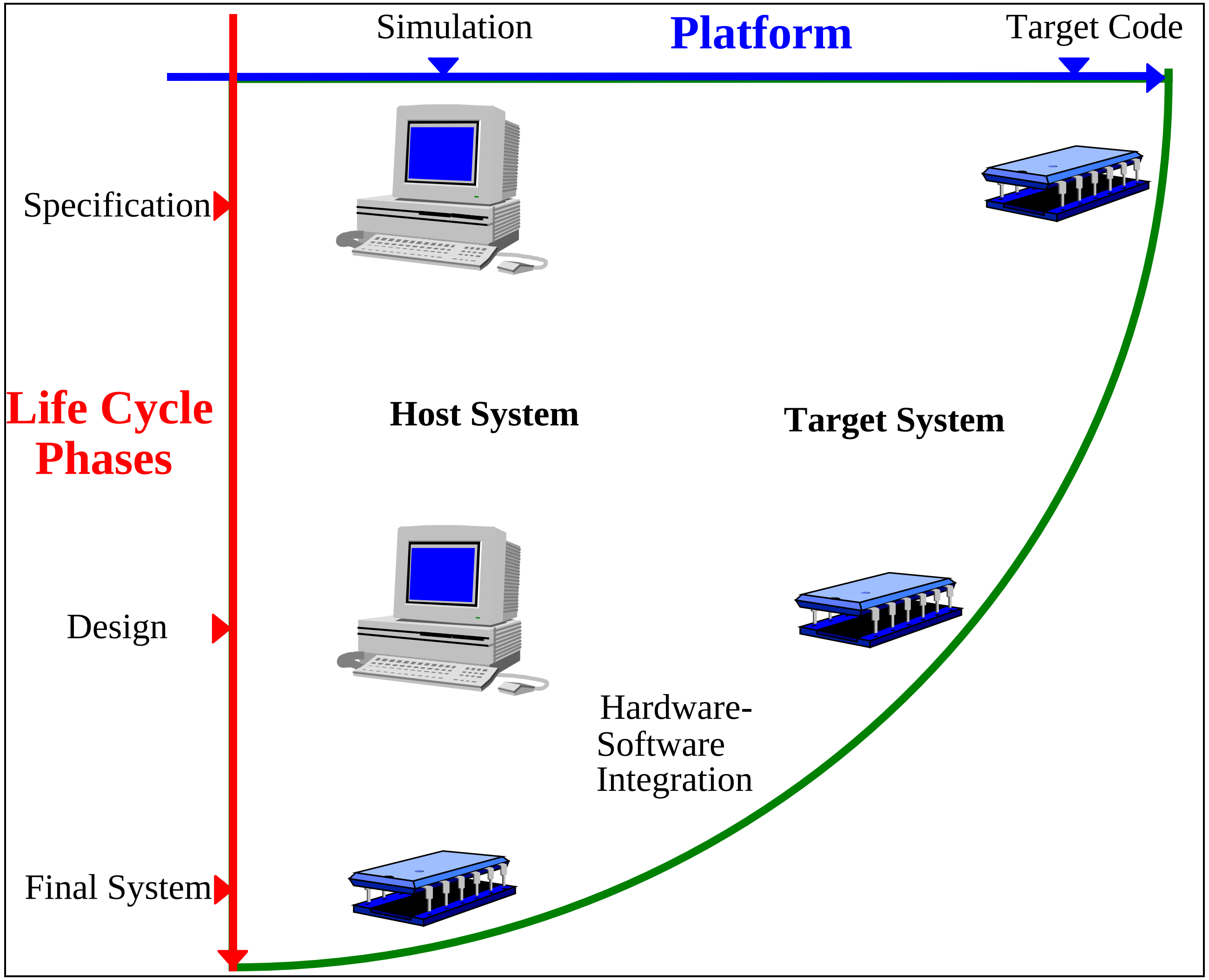
Computer-Integrated Validation

- **through the platforms: validation support**
  - simulation on host
  - execution on host
  - execution on target
- **through the life cycle: coherent transitions**
  - specification - design
  - design - coding
  - coding - module testing
  - module testing - integration
  - integration - acceptance
- **through the application types**
  - embedded (real-time) systems
  - MMI
  - databases
  - algorithms

The 2-Dimensional Life Cycle



Experience

❐ validation support and coherent transitions

- very efficient after re-organisation and automation
- from step to step (verification and validation)
- from platform to platform
- on-line walk-through during second half of this presentation

❐ application types

- careful consideration neeed
- methods and tools do not cover every application type
- strong in one area, weak in another area
- when trying to apply a method / tool to the whole scope of the application: one may loose everything $\rightarrow$ no advantage at all

Example: SDL

- **very strong and very efficient for behaviour and distributed systems**
  - verification and validation
  - automation of verification and code generation

- **problems with verification when large data structures are processed**

  but only in case of verification by exhaustive simulation,

  no constraints / problems in other cases
  - behavioural verification does not terminate:

    values of data are added to system space: explosion of system state space
  - advantage of automated verification of behaviour is lost
  - remark: filtering does not help here

- **considered solution: EaSySim II + future evolution**
  - partition the problem (system) into application types
  - define interfaces between the partitions
  - apply the best method / tool to each application type

Executed Steps (1)

❒ export data processing to C

- use the SDL-C interface
- define data types in SDL, take them in C
- do not allocate memory for (large) data in C
- do only declare such data in SDL which impact behaviour

❒ compress range of data which are used in SDL

- consider out-of-range condition for x (real, integer): $[X_L, X_U]$
- if we only need the decision: x is out-of-limit: true/false

  introduce an operator:

  xOutOfLimit: $\rightarrow$ Boolean "extern C";

  instead of implementing (pseudo-code, not SDL code)

  x Real;

  if $(x>X_U$ OR $x<X_L)$ then ....

Executed Steps (2)

❒ export to C

- verification means are lost
- disadvantage

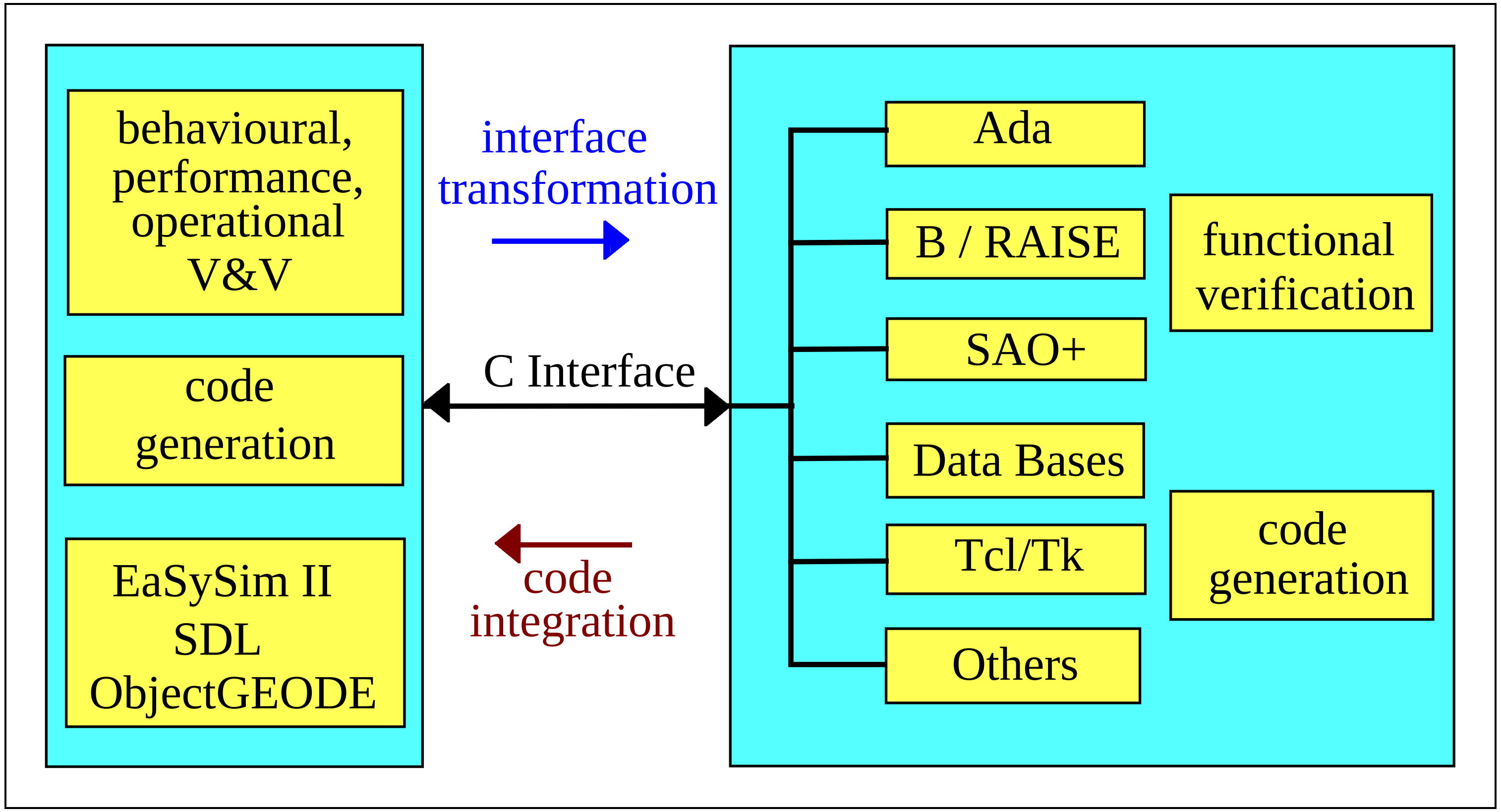
❒ consequence:

- apply appropriate verification method (formal method) to the exported part
- **"export via C interface"** instead of "export to C"
- do implementation in the best environment for each part of the system
- import results via C interface: generated code
- use generated code in SDL part for simulation and code generation phase

❒ optimisation of partitioning approach:

- use the interfaces to provide test drivers for the exported parts
- gives a better coverage of simulation for behavioural verification

Complementary Verification and Validation



Efficient Walk through the Platforms

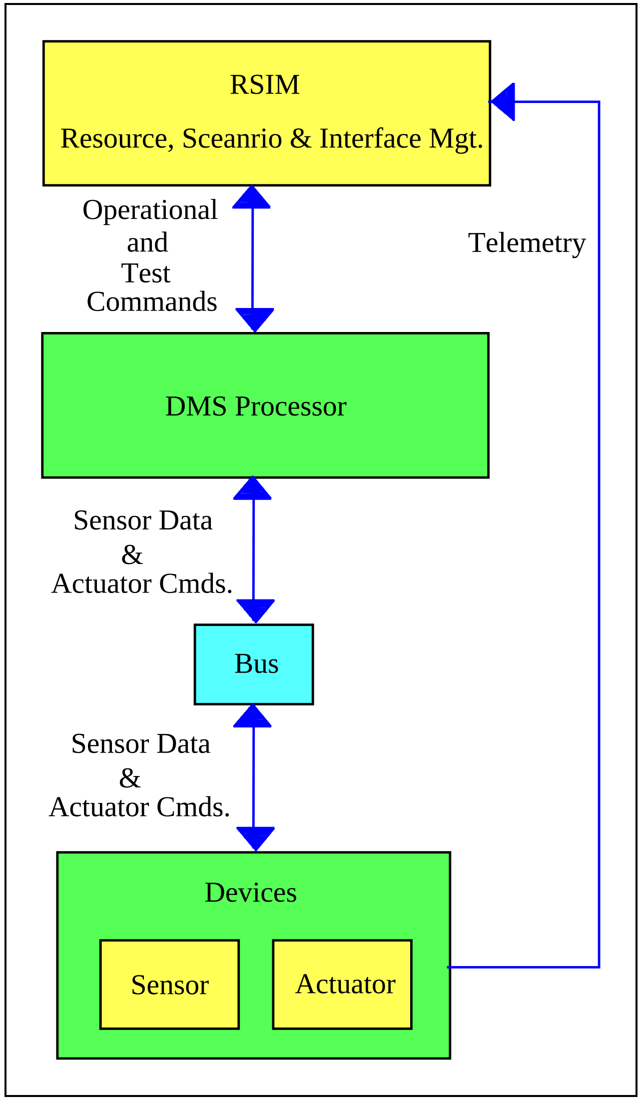
❐ on-line demo: walk from simulation to target

- example: data management system
  processor, bus, sensor, actuator

❐ no need to wait for the very end of life cycle to move to target

- due to automated code generation capabilities of SDL / ObjectGEODE for different platforms
- however: appropriate organisation needed

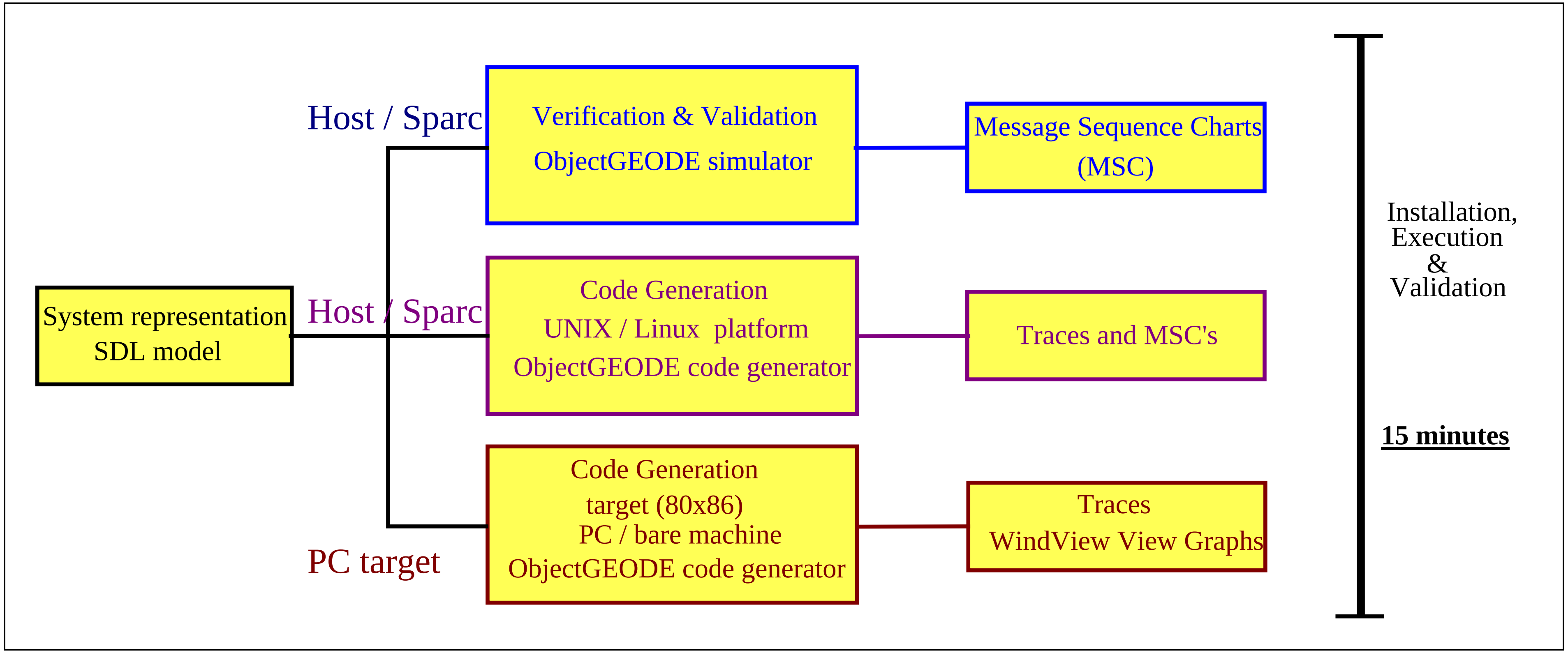
Application: On-Board Data Management System



The Demo Steps

- **simulator (on Sparc)**
  - installation
  - simulation in batch
  - random simulation
  - generation of MSC
  - exhaustive simulation
- **execution on host (Sparc UNIX)**
  - installation
  - code generation
  - execution and tracing
- **execution on target (PC bare machine, VxWorks, WindView)**
  - installation
  - code generation
  - execution, tracing and recording of task status

From Verification & Validation to Code Execution

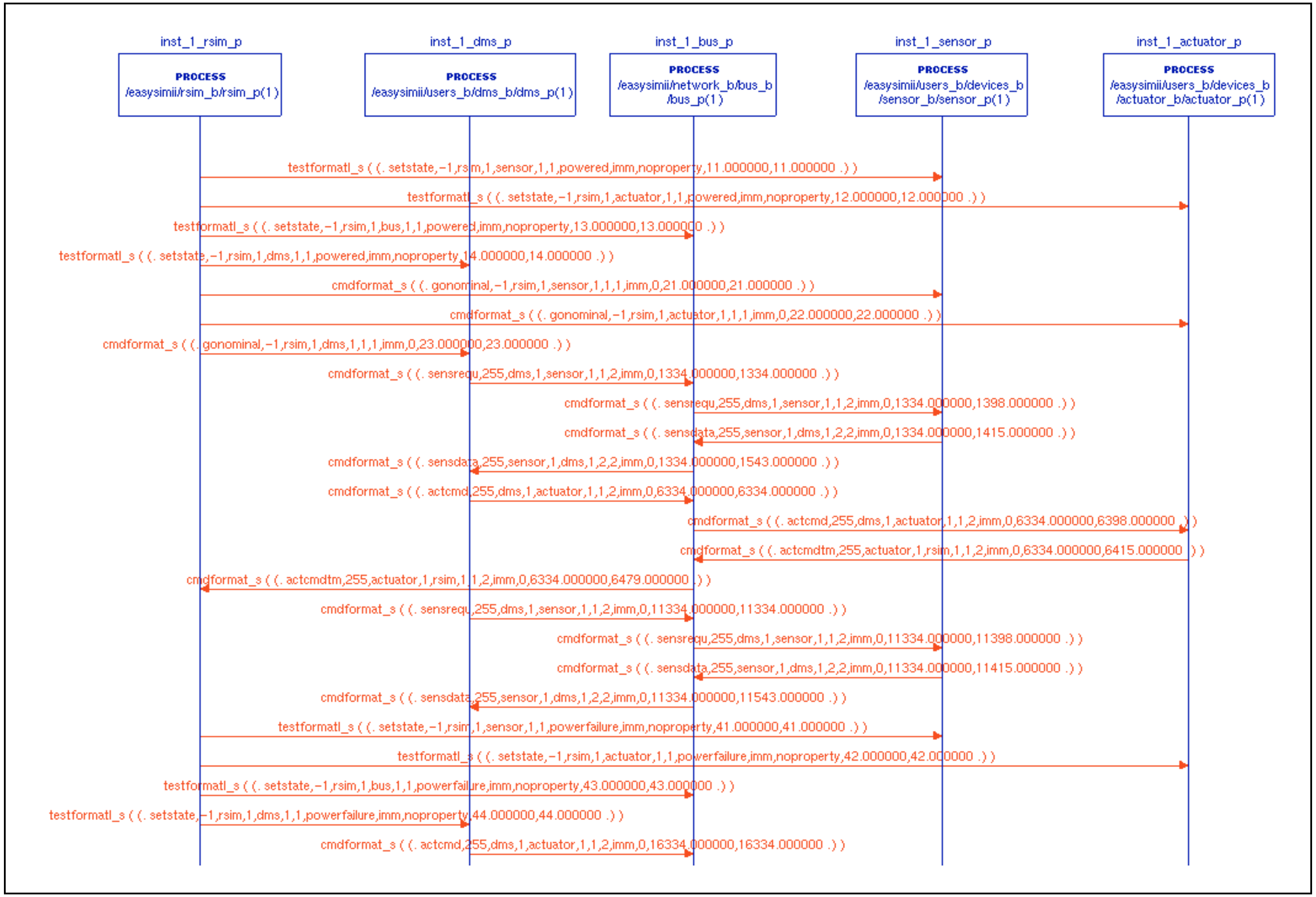


Performance Evaluation

- **resource consumption / Message Sequence Chart**
  - all devices consume independent resources
  - time stamps
    - start time of data acquisition
    - actual time when leaving a device
  - modelling bug is still included, is visualised by time stamps

- **recording on target system**
  - task activities are visible
  - bug detected for cyclic processing
    when measuring the time intervals between the cycles

Message Sequence Chart



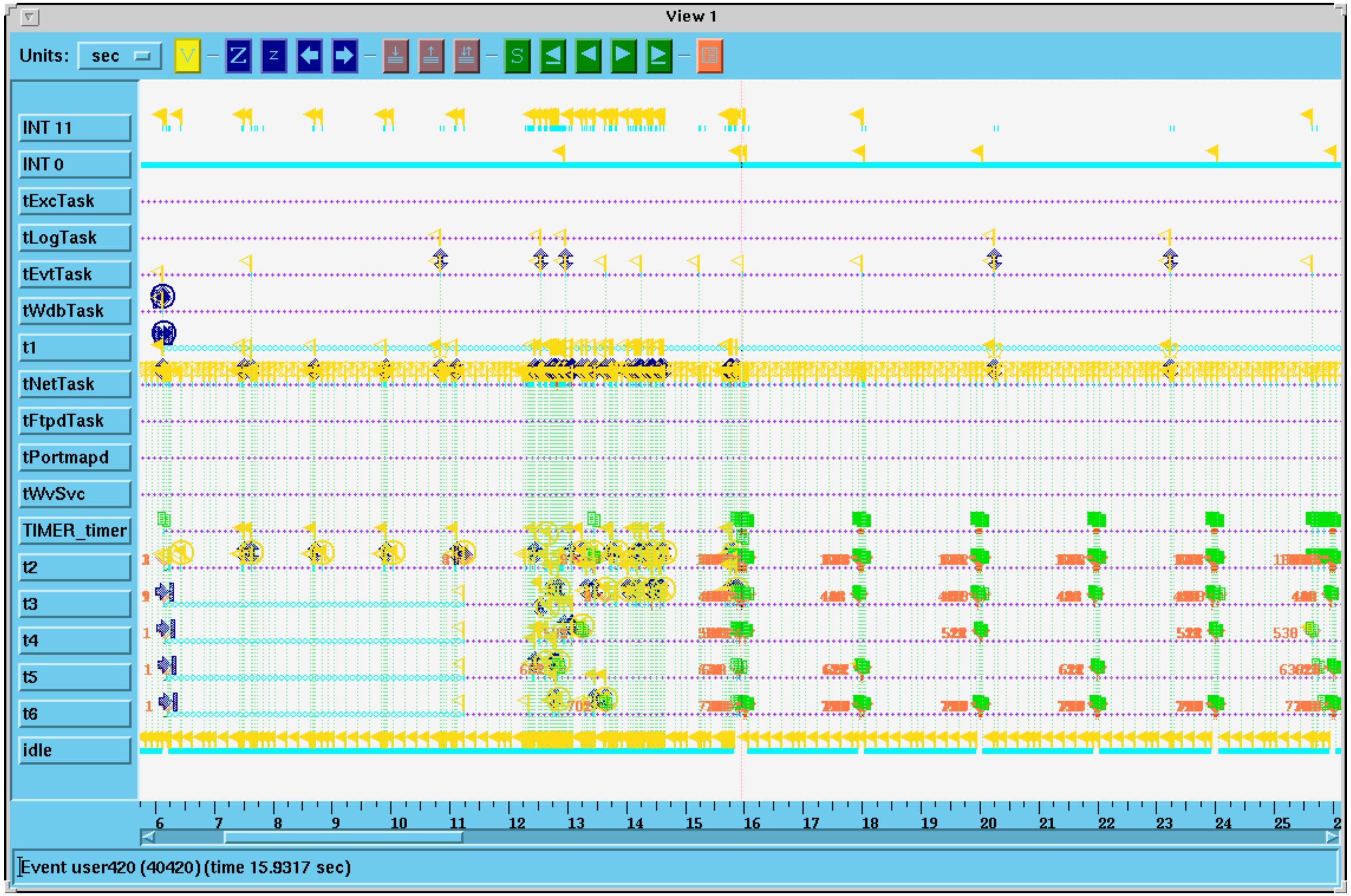
Recording of Target System Execution

DMS processor

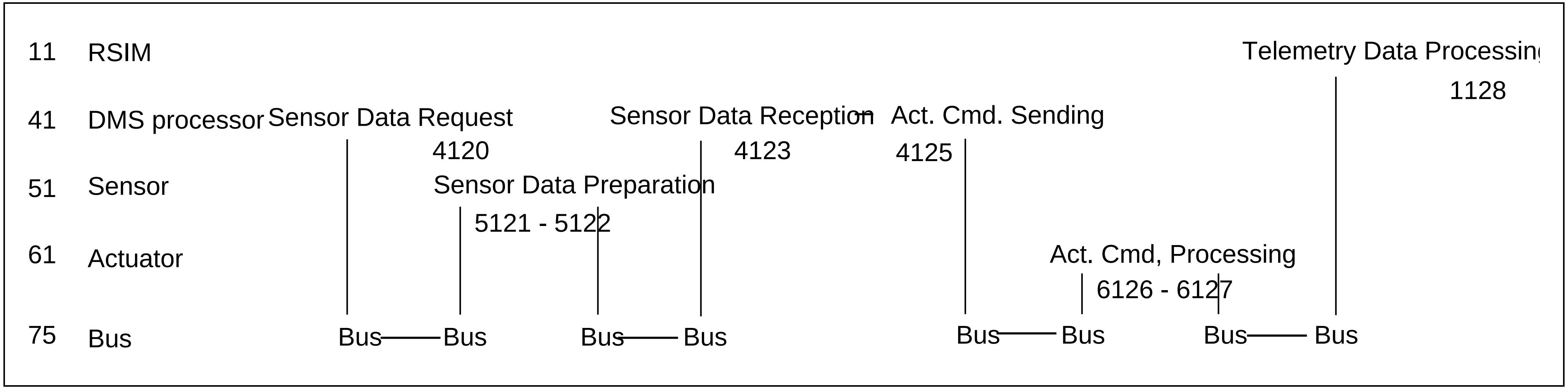
sensor

actuator

bus



Data Flow


11 RSIM
41 DMS processor
51 Sensor
61 Actuator
75 Bus
Telemetry Data Processing
1128
Sensor Data Request
4120
Sensor Data Reception
4123
Act. Cmd. Sending
4125
Sensor Data Preparation
5121 - 5122
Act. Cmd, Processing
6126 - 6127
Bus
Bus
Bus
Bus
Bus
Bus
Bus
Bus

Conclusions

- **partitioning of system development and validation needed**
  - best method and tool for a certain application type: separated verification
  - integration of system partitions in SDL
  - complete or advanced system validation in SDL
  - through all platforms

- **partitioning ensures success of validation of a broader class of applications**

- **efficient walk through the platforms**
  - after optimisation of organisation

- **for detailed questions:**
  - time for detailed walk-through