BSSE System and Software Engineering

Avoiding Malfunctions Due To Software Failures by Automation of Software Production and Test

Pannen wegen Software-Fehlern vermeiden durch Automatisierung von Software-Produktion und Test

ESA Colloquium
„Technology Exchange between Space and Automotive Industry“

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Facts and Issues

- Wirtschaftswoche summer / autumn 2002
  - increasing number of malfunctions in high-tech vehicles
  - major part by software malfunctions
- VDI-Nachrichten September 2002
  - Charles Simonyi, co-founder of Microsoft

  „today we can design and control production of jumbo-jets, but programming still remains a handcrafted task“
- Trend in automotive industry: more software
  - e.g. 11. Aachener Kolloqium „Fahrzeug- und Motorentechnik“
  - high quality software becomes a big challenge

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Looking on Car Mass Production

- well-defined production process
  - high productivity
  - high quality
  - pre-condition for quality assurance
  - saving company know-how
  - continuous process improvement
- automated software production becomes "the" issue
  - scalable approach needed to cover a broad range

BSSE's Automation Approach ASaP

History

- 1992 ESA project on performance and FDIR validation (HRDMS)
  FDIR = Fault Identification and Recovery
- 1993 ESA project on behavioural validation (OMBSIM)
- 1995 ESA project on sysem fault tolerance (DDV)
- 1996 BSSE project on ATC protocol validation (OPAL)
- 1997 BSSE project on distributed fault-tolerant system (CADIS)
  turn-key system
- 1998 BSSE project on distributed critical control system (CRISYS)

ASaP milestones

- 1999 first version of fully automated environment (MSL / ISS)
- 2000 final delivery of automatically generated software package

ASaP Improvements

- State-Of-The-Art

• Productivity:	1 man-hour	0.1 .. 10 LOC
• Bug Rate	typical:	10^{-2}/ LOC
	very good:	10^{-3}/ LOC

N.E.Fenton, 2000

- Automated Software Production and Test (ASaP)

• Productivity	1 PC-hour	16,000 .. 320,000 LOC
		1 .. 20 man-years (my)
		1600 mh/my 10 LOC / mh
• Bug Rate		$\approx 0 .. 10^{-5}$ / LOC

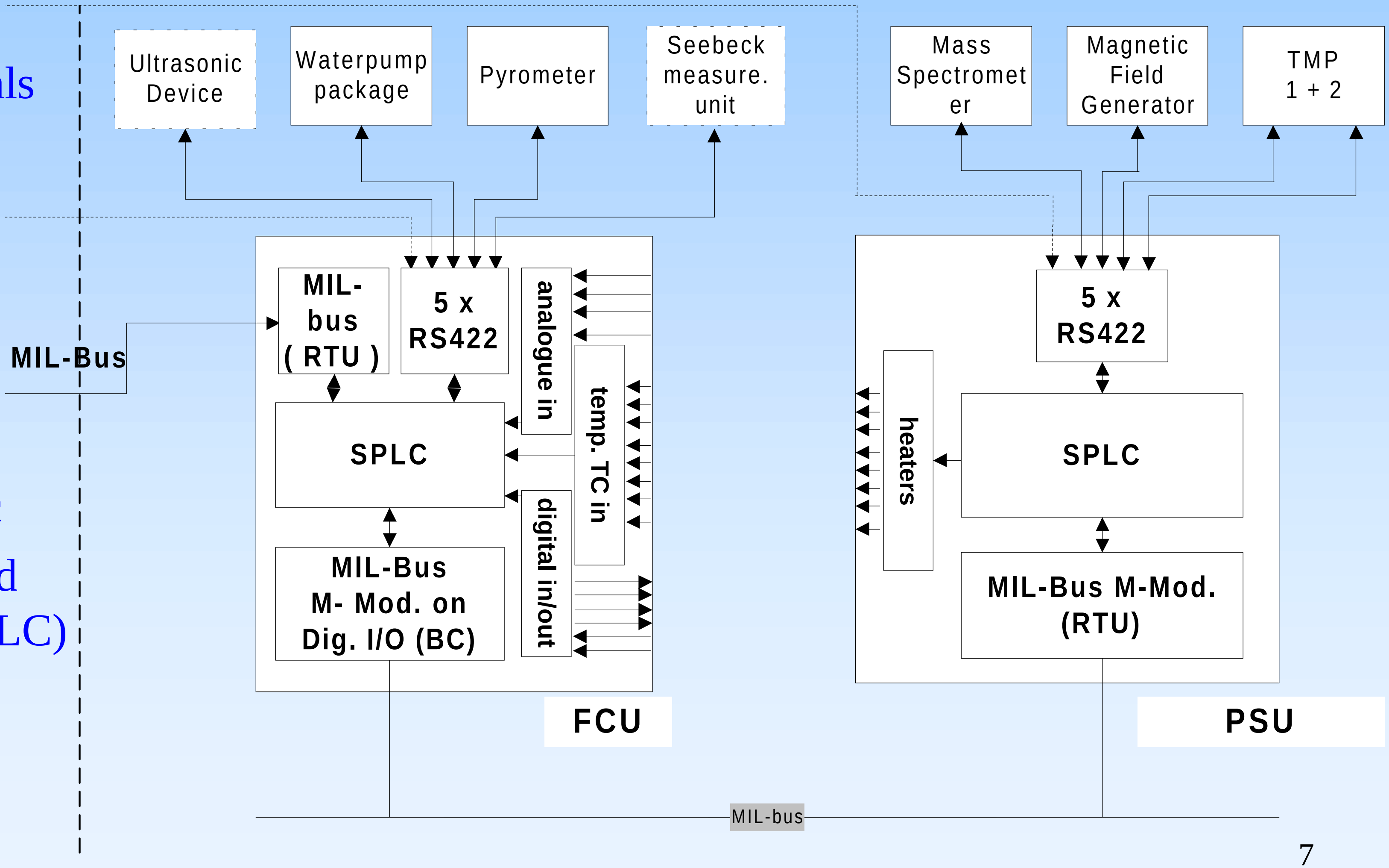
Quality is not expensive

if a new technology is applied

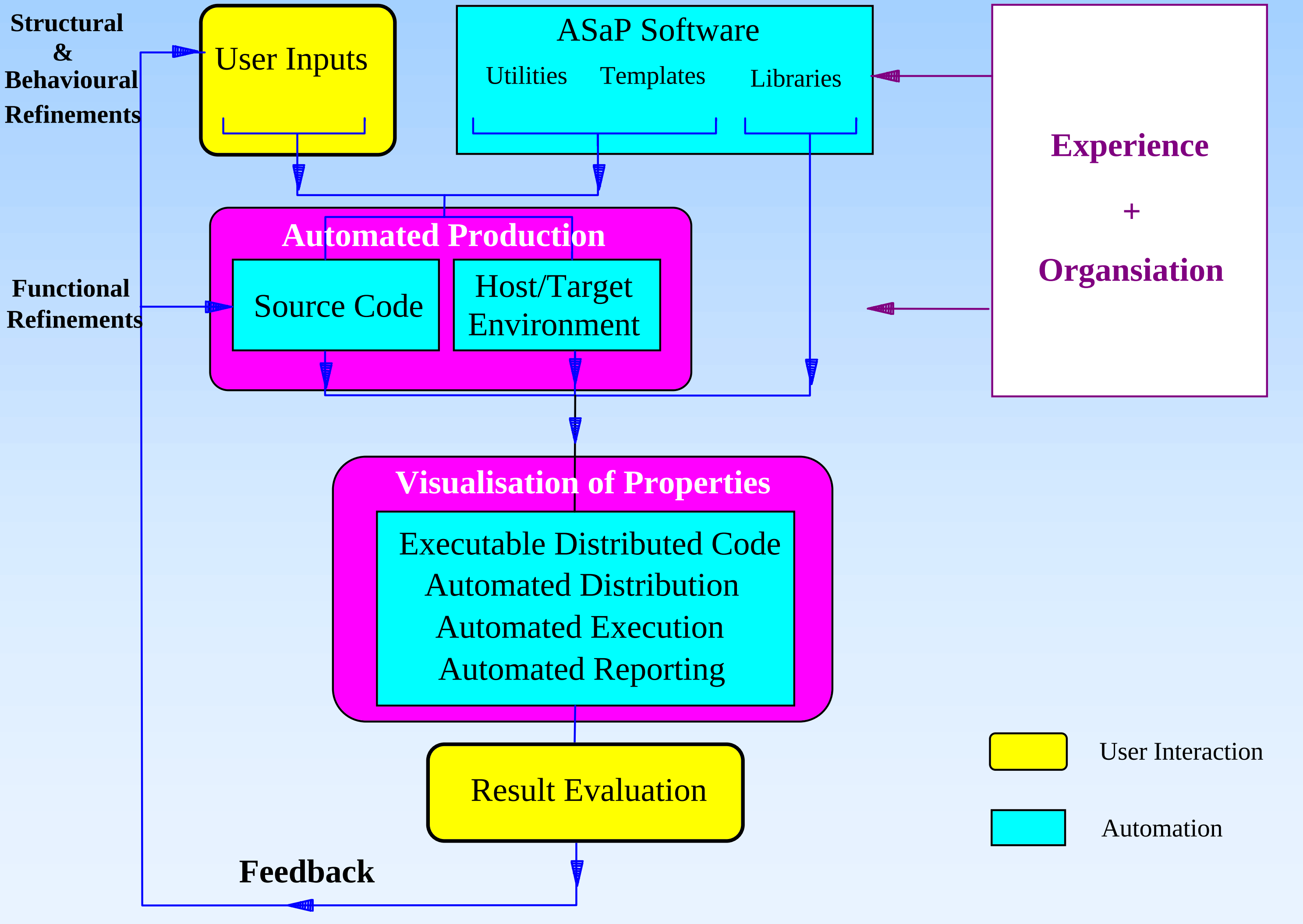
Example: Distributed Real-Time System (MSL / ISS)

Peripherals

2 x Sparc embedded (ESA SPLC)



Incremental Generic Development Cycle of ASaP



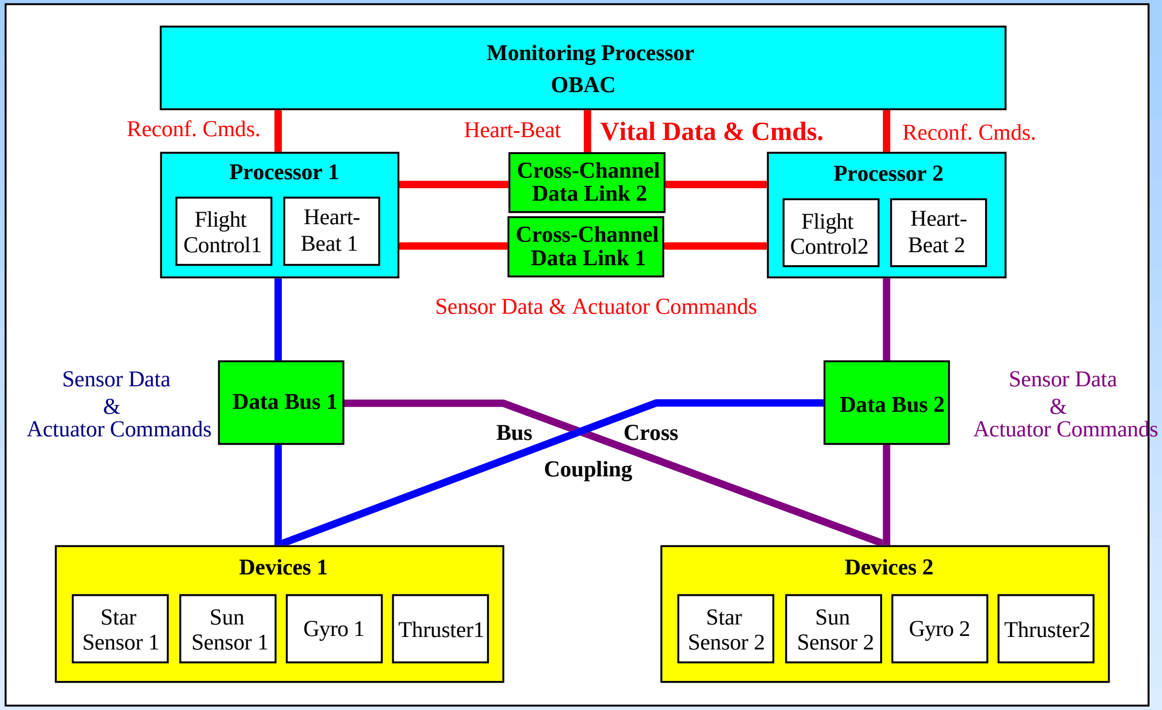
Benefits by ASaP

- flexibility for changes and refinements
  - generic approach
  - compact user inputs
- shorter development cycle
  - short generation time
  - incremental refinements
- higher dependability
  - fault prevention by intensive checks of user inputs
  - fault identification by built-in assertions and visualisation
  - fault tolerance by coverage of exceptions, built-in mechanisms
- higher usability
  - fast feedback from real system
  - little effort to optimise the user interface

Potential Application Areas in Automotive Industry

- Vehicle
  - system management
  - subsystem / unit software
- User Interface / Infotainment
  - user operation
  - unit manangement
  - unit software
- Vehicle Manufacturing
  - automated verification of manually coded robot programs vs. CAD
  - automated generation of robot programs from CAD data
- Project and Contractor Management
  - integration of COTS and sub-contractor software
  - quality checks and evaluation of software

Fault-Tolerant Systems and Risks



ESA Project DDV

validation of the exception handling of a fault-tolerant system

Sporadic System Failure

- computer C1 fails
- computer C2 takes over control
- C1 issues an actuator command before it fails
- C2 does not get this information
- C2 issues the same command
- !! the system fails !!

Risk Reduction by Automation

- Can such problems be identified in advance?

- Answer by automated software production: YES
  - framework implies problem classification
  - less time needed for implementation,
    more time available for system engineering
  - better visualisation of properties

Inputs in User Notation and Derived Output (MSL Database)

Name of Signal	Data Type	Input Range	Physical Range	Acqui. Rate	HW Module	Calibration Type
CFDdrive_pot	REAL32	0 - 10V	0 - 200 mm	100	ASM F1	FctASM1_Std
CFDrot_pot1	REAL32	0 - 10V	0 - 360 °	100	ASM F1	FctASM1_Std
CFDrot_pot2	REAL32	0 - 10V	0 - 360 °	100	ASM F1	FctASM1_Std
CF_reg_v_pot	REAL32	0 - 10V	0 - 270 °	10	ASM F1	FctASM1_Std
GS_press_low	REAL32	0 - 10 V	0 - 2 bar abs.	10	ASM F1	FctASM1_Std
CFVpenn_chamb	REAL32	0 - 10 V	1.e-7 - 1000 mbar	1	ASM F1	FctASM1_Pressure
VGSpenning_ms	REAL32	0 - 10 V	1.e-7 - 1000 mbar	1	ASM F1	FctASM1_Pressure

```
T_database_entry MSL_db_desc[]={
                                        {
/* address in DB            */                    (int*)&MSL_db.LRT_HK_A1.CFDdrive_pot,
/* offset  in DB            */                    (int)CFDdrive_potDBoff,
/* #samples                 */                    100,
/* size of data type        */                    sizeof(REAL32),
/* id of type               */                    7,
/* copy DB data             */                    0,
/* calibration function     */                    {(int*)FctASM1_Std_CFDdrive_pot,
/* supervision structure    */                              {
/*   SV function            */                                        (int*)&limChckREAL32,
/*   limit definitions      */                                        CFDdrive_pot_suarr,
                                                            }
                                                  },
/* post-processing function */                    {(int*)NULL}
                                        },
```

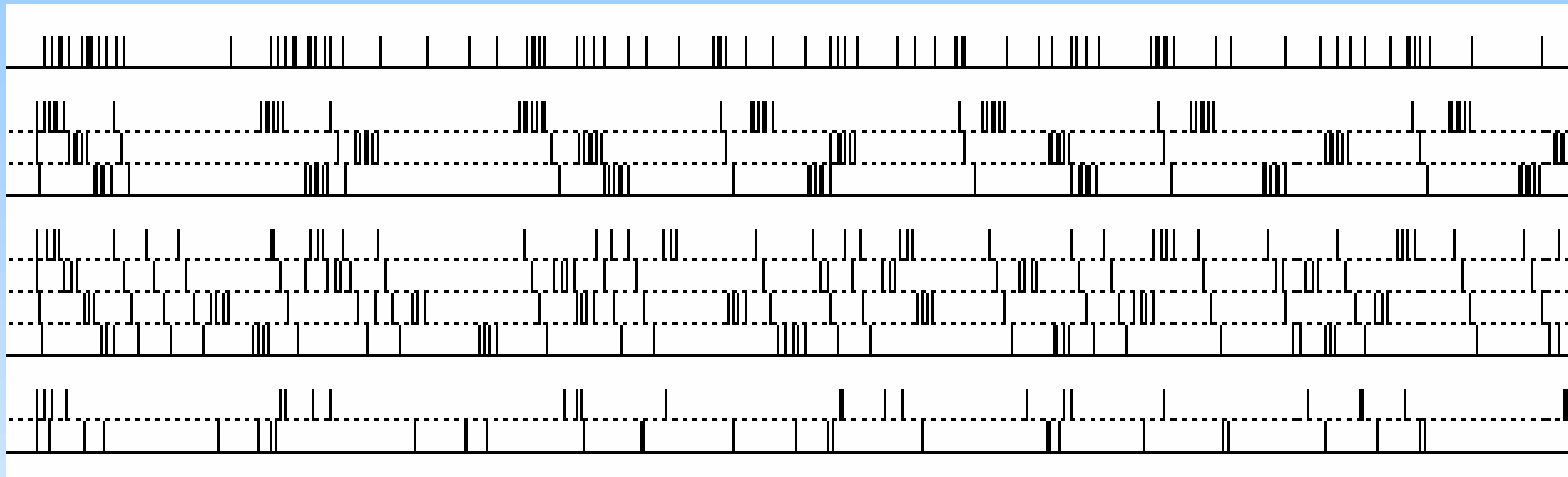
More Derived Files (Subset Only)

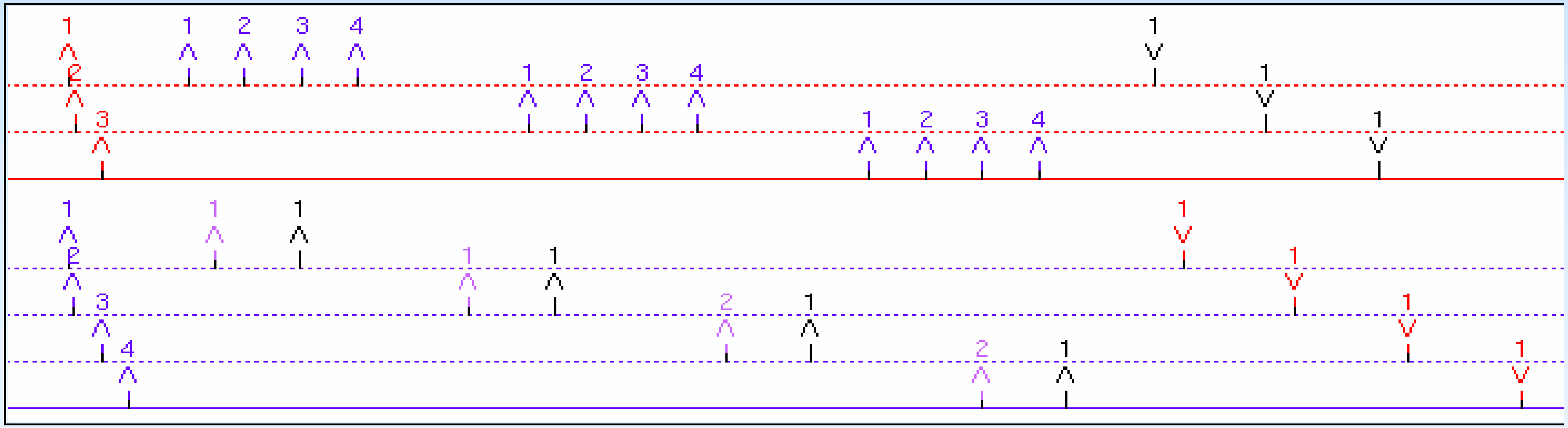
```
REAL32 FctASM1_Std_CFDdrive_pot(UINT16 Data)
{
          REAL32 buffer;
          INT32  value;

/* ADC correction (including amplifier correction) */
          buffer = (Data - ADCCorrASM1[0][0].Offset) * ADCCorrASM1[0][0].Gain;

/* conversion to physical units */
          value = (REAL32) ((REAL32)0) + ((REAL32) 200  - (REAL32) ((REAL32)0)) /
                    ( (REAL32) ((1<<12) - 1) ) * buffer;
          return value;
}
```

```
#include "frametypesDB.h"


/* MSL database */
TyDatabase MSL_db;

/* Recording of database updates */
int updateDBcnt=0;
int DBupdate[TOT_DATABASE_ITEMS];

/* # of instances of telemetry frames */
#define TM_BUFF_INST 2
```

```
int LRT_HS_framePtr=0;
int LRT_HS_frameInd=0;
TyTMbuffer_LRT_HS LRT_HSArr[TM_BUFF_INST];

/* Array pointing to TM frame instances */
TyTMbufferArr TMbufferArr[]=
{
          {LRT_HK_A1_ID,      (int*)&LRT_HK_A1Arr},
          {LRT_HK_D1_ID,      (int*)&LRT_HK_D1Arr},
          {LRT_HK_D2_ID,      (int*)&LRT_HK_D2Arr},
          {LRT_HS_ID,         (int*)&LRT_HSArr}
};
#define TM_BUFFER_ARR_SIZE
          sizeof(TMbufferArr)/sizeof(TyTMbufferArr)
```

Visualisation of Properties: Timing and Communication





Reports available after 15 minutes starting by delivery of user's spreadsheet inputs

Achievements

- distributed real-time system
  - within 30 minutes equivalent of about 5 man-years (my)
  - 80,000 LOC (environment: 200,000 LOC)
- distributed, synchronised database
  - within 30 minutes equivalent of about 1 my
  - 16,000 LOC and more
- operations on data types, interfaces etc.
  - within 1 minute equivalent of about 2 my

We give warranty!

"accepted user inputs are automatically transformed into correct and immediately executable software when applying an automated production process established by us"

How and Where Can ASaP be Applied?

- Use of existing products
  - distributed critical real-time and control systems
  - data processing, distributed databases, GUIs
  - test case generation
  - integration and subcontractor management
  - user support possible
- Customised ASaP approach
  - know-how transfer
  - definition of an appropriate approach
  - building of the needed environment

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Customising ASaP

- Analysis of current manual procedures
  - similar to „REFA“ in case of hardware
  - identification of the most generic approach
    maximum coverage of application area
- Definition of the user interface
  - identification of driving parameters
    minimum set of user inputs
  - re-use of current environment (if any)
    building of an interface to the user‘s world
- continuous optimisation of ASaP procedures
  - provision of analysis tools
  - continuous benchmarking to check productivity and quality
  - continuous process improvement

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This was a very short introduction, but ...

we are available today

- for further discussions
- to show more details
- to give a demo on

„Instantaneous System and Software Generation“ (ISG)

15 minutes from user's spreadsheet inputs to reports

- **10 minutes generation time**
- **3 minutes system execution**
- **2 minutes report generation**