Supervisory Control Language

Applying Tcl To The Realtime Arena

by

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Background

CPU's Mission

Computerized Processes Unlimited, Incorporated is an independent control system integrator serving domestic and international Oil and Gas Energy and other process industries with highly competent consulting services, project management and customized problem solving software.

Primary Projects

- the design and implementation of systems to monitor and control processes
- realtime data integration with corporate databases
- network integration

Platforms (client driven)

- Hewlett-Packard 9000/7xx running HP-UX
- Digital VAX
- PC's

Foundation requirements

A stable, extensible software foundation to build custom solutions for our clients.

Supervisory Control and Data Acquisition (SCADA)

Purpose

- Collect data from field devices and present the data in meaningful form to operators.
- Provide methods for operators to issue commands to field located controllers.
- Operator must be able to:
  - determine the state of the process easily
  - control the process instinctively

Current State of the Industry

- Current SCADA systems place extreme importance on the interactive operator display to help the operator process data from many sources and respond correctly to changes in the process.

- Small to moderate size systems are now PC based and are user configurable. Unfortunately, configuration is rigid and extensibility is limited.

- UNIX and VMS based systems are used for larger applications. These make use of the multitasking, and operator interface features. Custom integration is still required and can be complex.

Hewlett-Packard's Realtime Application Platform (RTAP)

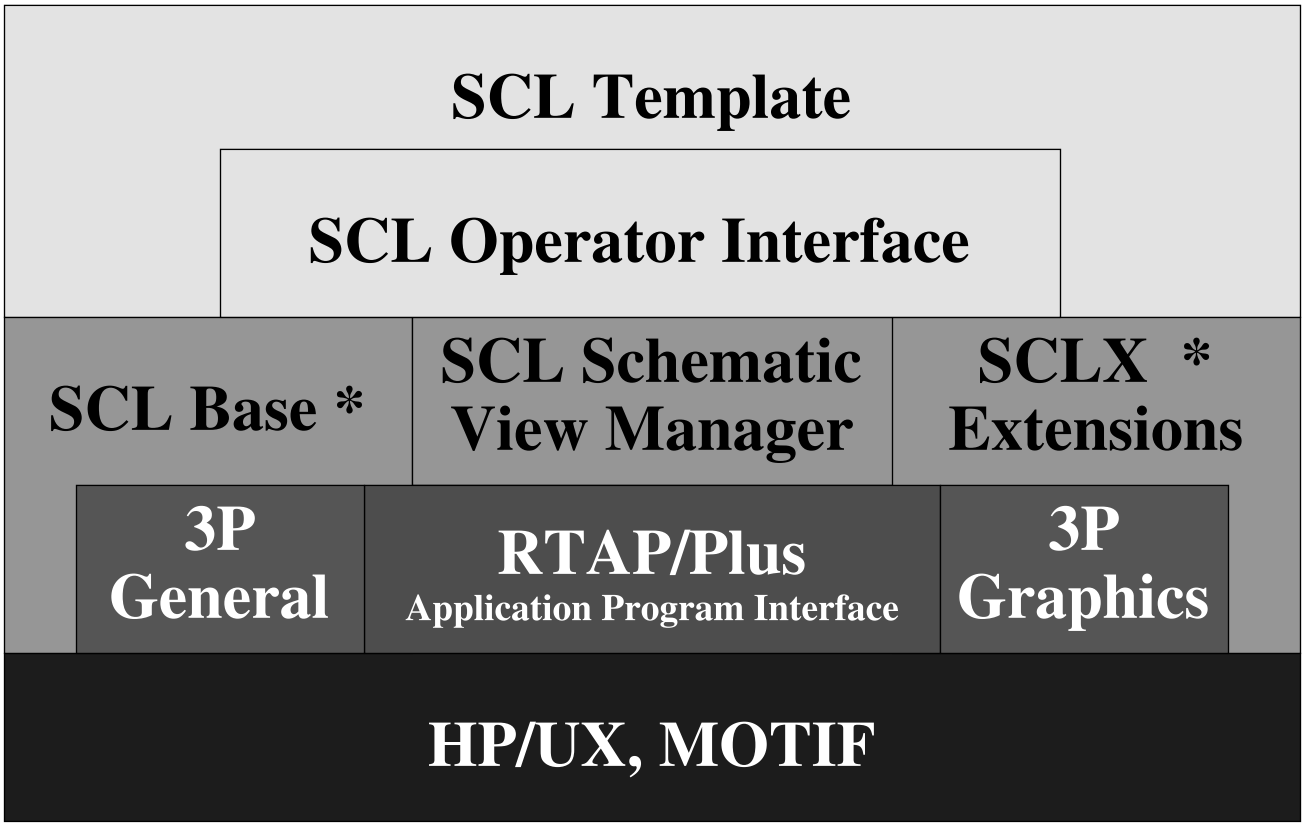
- **Provides a toolkit for building SCADA applications. Configuration is a combination of using interactive tools and C programming.**
- **Major components are:**
    - realtime database with calculation engine
    - data historian to maintain data for longer times
    - time keeper and event manager to support event processing
    - environment configuration and monitoring
    - scan system for acquiring data and issuing commands to and gathering data from remote devices
    - alarm detection, reaction, and display
    - report system for producing hard copy summary reports
    - user interface tools to support the creation and display of interactive schematics

Goals of the SCL Project

- **Develop a product that would allow CPU to become more effective at system integration**
- **Provide complete development and configuration environment**
  - Support custom configuration/application by engineer/technician
- **Leverage work done by others**
  - RTAP/Plus
  - Other third party products
  - Public domain products
- **Extensible by:**
  - CPU
  - Third parties
  - Users
- **Provide appropriate interface for different levels of users**

The SCL Family

A Layer Diagram



Peer Type Extensibility

SCL(X) Interpreter

PARSER

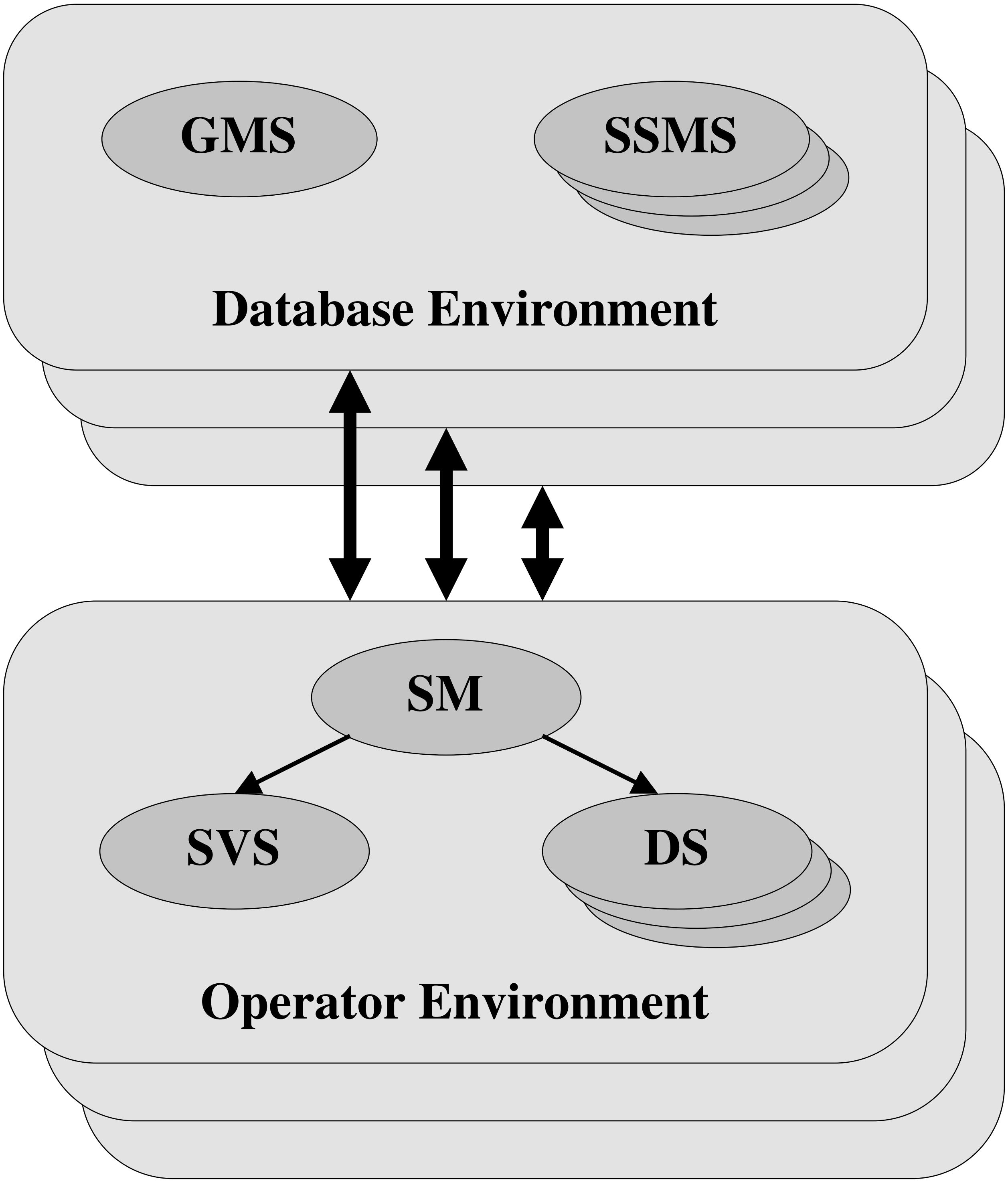
Extensions Made in "C"

SCL Base	*RTAP/Plus*	*X Windows*	*SVM (UIP)*	*Other CPU*	*Third Party*
File Access Lists Keyed Lists Math Strings Unix XPG/3	Alarms Database Data Historian Event Manager Environment Plot Display Scan System Time Keeper Watchdog	Buttons Labels Menus Graphics Icons Entry etc.	Schematics Symbols X-events Menus Messages	Dialogs Widgets TBD	SYBASE Plotting Widgets TBD

Extensions Made in SCL

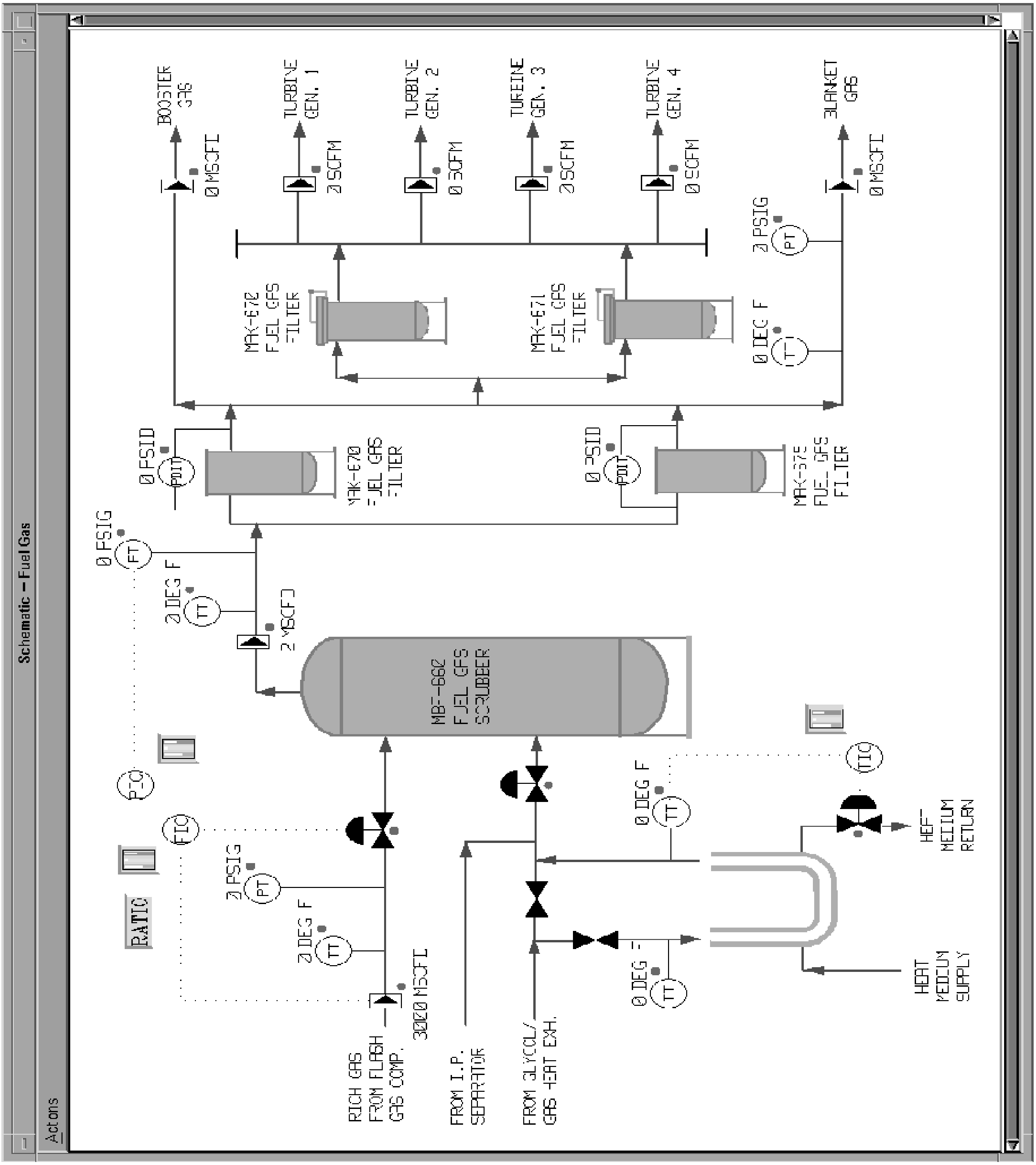
Option Parsing	Point Read	Gauge Vector Levelmeter	Config Macros	Point Methods	TBD

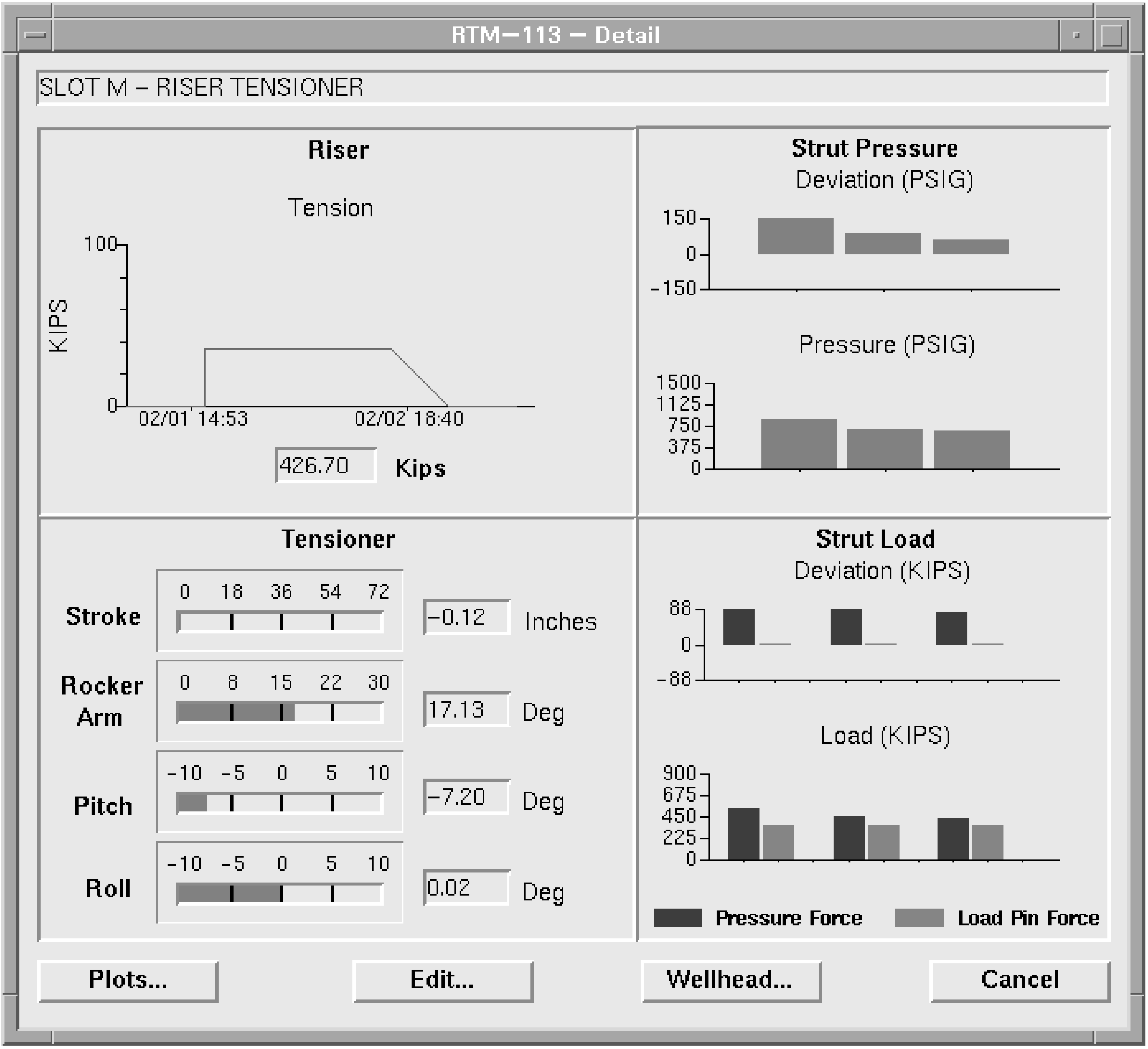
SCL Plus Process Model



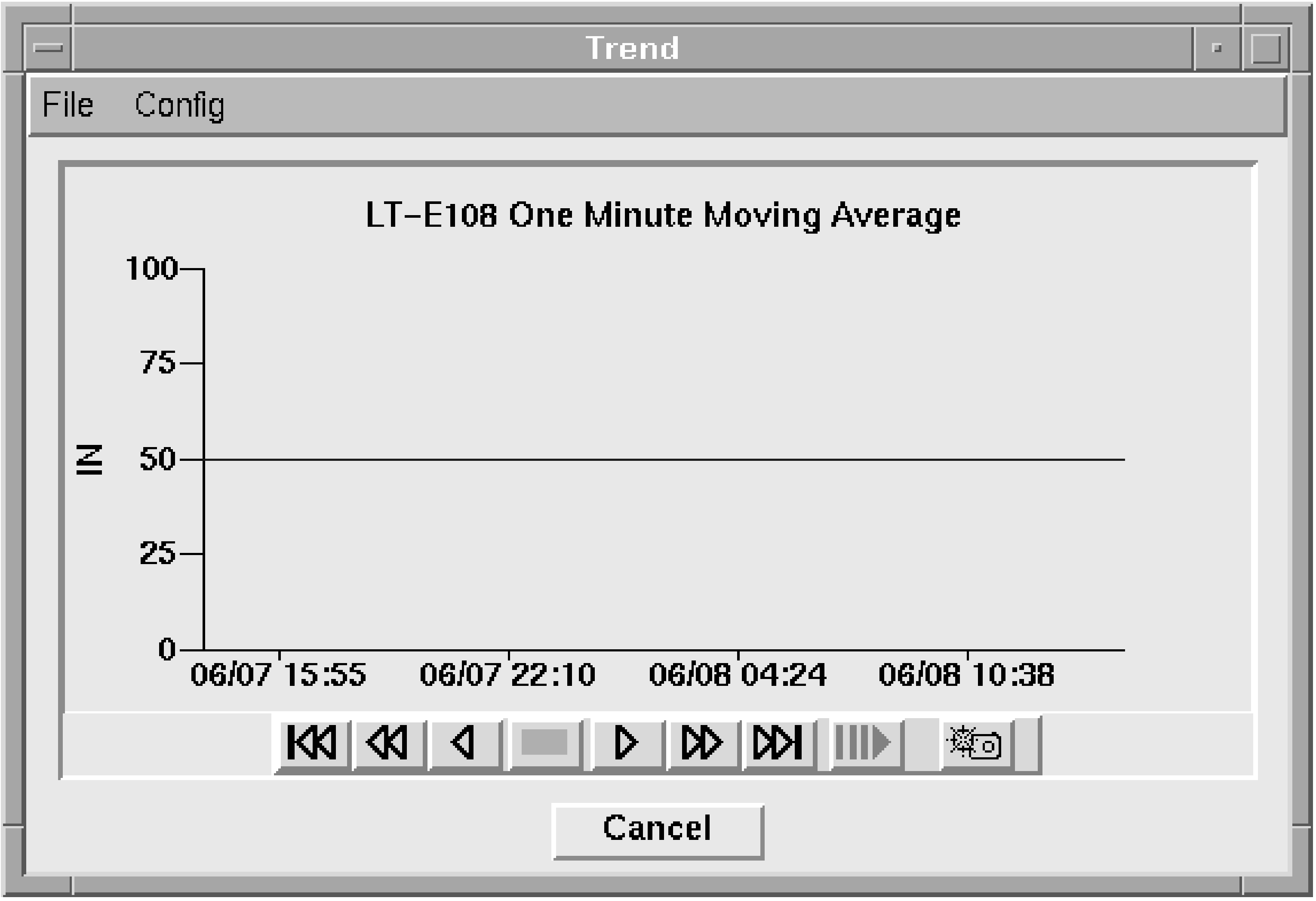
Typical Screens

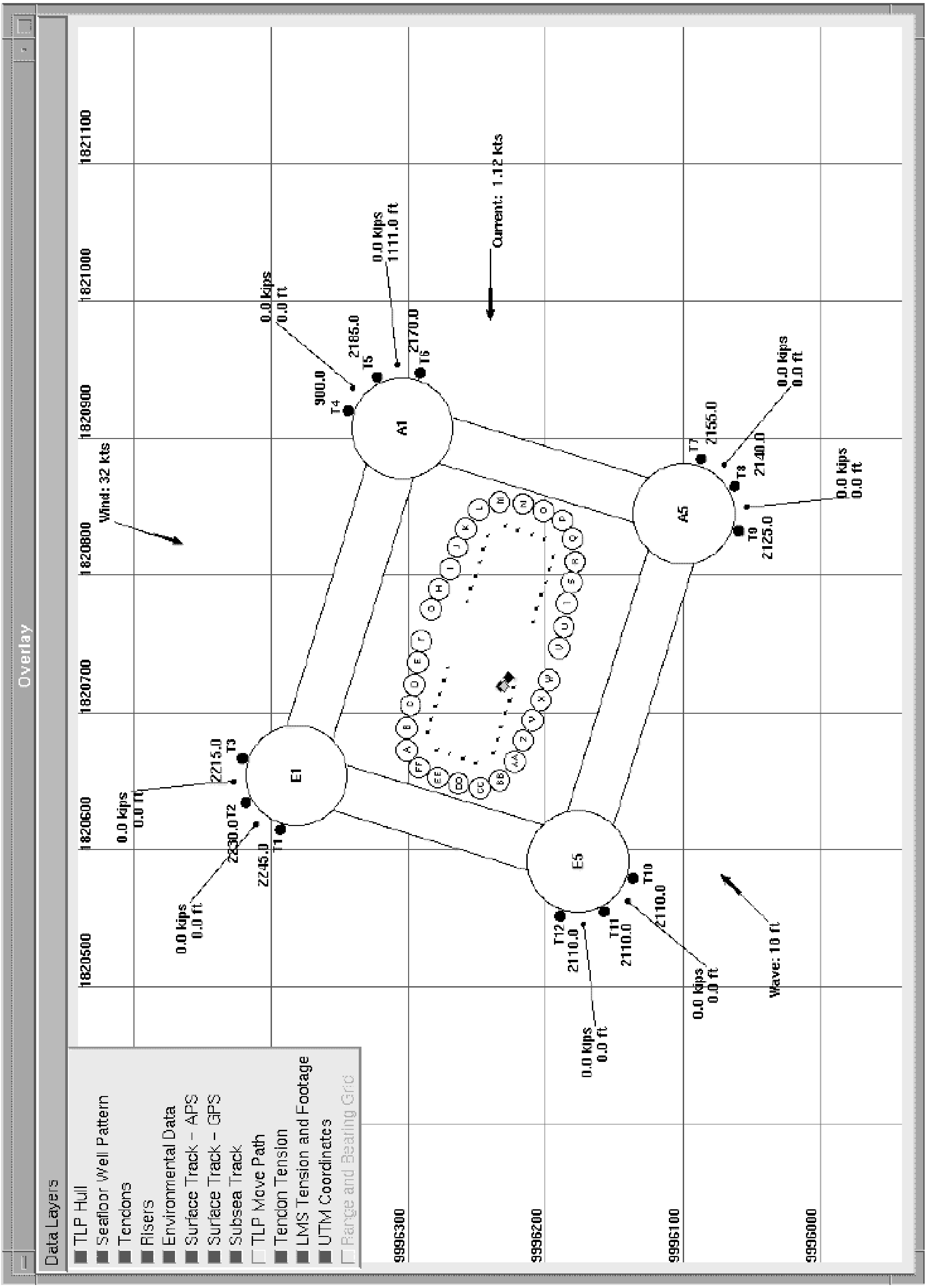
- **Process schematic**
- **Detail panel**
- **Plot panel**
- **"Layered" detail panel**


Schematic – Fuel Gas
Actions
BOOSTER GAS
TURBINE GEN. 1
TURBINE GEN. 2
TURBINE GEN. 3
TURBINE GEN. 4
BLANKET GAS
FUEL GAS FILTER
FUEL GAS SCRUBBER
RATIO
FIC
PIC
TIC
HEAT MEDIUM SUPPLY
HEAT MEDIUM RETURN
RICH GAS FROM FLASH GAS COMP.
FROM I.P. SEPARATOR
FROM GLYCOL/ GAS HEAT EXH.



RTM–113 – Detail
SLOT M – RISER TENSIONER
Riser
Tension
KIPS
100
0
02/01 14:53
02/02 18:40
426.70
Kips
Strut Pressure
Deviation (PSIG)
150
0
-150
Pressure (PSIG)
1500
1125
750
375
0
Tensioner
Stroke
0 18 36 54 72
-0.12
Inches
Rocker Arm
0 8 15 22 30
17.13
Deg
Pitch
-10 -5 0 5 10
-7.20
Deg
Roll
-10 -5 0 5 10
0.02
Deg
Strut Load
Deviation (KIPS)
88
0
-88
Load (KIPS)
900
675
450
225
0
Pressure Force
Load Pin Force
Plots...
Edit...
Wellhead...
Cancel


Trend
File
Config
LT–E108 One Minute Moving Average
100
75
50
25
0
IN
06/07 15:55
06/07 22:10
06/08 04:24
06/08 10:38
Cancel


Overlay
Data Layers
TLP Hull
Seafloor Well Pattern
Tendons
Risers
Environmental Data
Surface Track – APS
Surface Track – GPS
Subsea Track
TLP Move Path
Tendon Tension
LMS Tension and Footage
UTM Coordinates
Range and Bearing Grid
1820500
1820600
1820700
1820800
1820900
1821000
1821100
9996300
9996200
9996100
9996000
Wind: 32 kts
Current: 1.12 kts
Wave: 10 ft
A1
A5
E1
E5
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12
0.0 kips
0.0 ft
0.0 kips
1111.0 ft
2185.0
2170.0
900.0
2155.0
2140.0
2125.0
2215.0
2230.0
2245.0
2110.0
2110.0
2110.0

CPU's TCL Activity

C Code:

27,000 lines

Tcl/Tk Code:

120,000 lines

Conclusion

- **SCL has allowed CPU to become more effective at integrating systems.**
  - drastically reduced development time by:
    - almost eliminating C code programming
    - eliminating linking and compiling
    - reducing the need for the script writer to be concerned with memory allocation and other operating system "baggage"
  - greater reusability of applications since libraries are easier to build and maintain
  - debugging and testing is made simpler by the interactive interface
  - all of the above results in a substantially reduced turnaround time

Desired Future Directions for Tcl/Tk

- **Better support for multiple interpreters**
    - Multiple interpreter support for Tk
    - Standard method of resolving signals when using multiple interpreters
- **Further development of canvas**
    - partial fill of objects
    - drawing tool for creating objects and defining bindings
- **Compiler**
- **Windows NT**
- **Continued unencumbered license (no Copy Left)**

Appendix A

SCL RTAP Extensions

Alarm System

rrtas_alarm_ac
rtas_close
rtas_config_connection
rtas_open
rtas_update_msg

Database

rtdb_close
rtdb_config *item*
    ADD_NULL_PT, ADD_SCALAR, ADD_TABLE,
    ADD_VECTOR, ALIAS, ATTR_NAME,
    CATEGORIES, COPY_ATTR, COPY_BRANCH,
    COPY_POINT, DEFINITION, DEL_ATTR,
    DEL_BRANCH, DEL_BR_CHK, EXP_ORDER,
    GROUPS, MOVE_POINT, PT_CLASS, PT_NAME,
    RESIDENCE, SET_RECORD_CNT
rtdb_control *item*
    CE_ORDER, DISABLE_SNAPS, ENABLE_SNAPS,
    LOCK_PT, REL_CFI, RUN_CE, SET_CFI,
    SET_CWP, SET_USAGE, SNAPSHOT,
    UNLOCK_PT, XFER_LOCK_PT
rtdb_match_pts
rtdb_multi_read,
rtdb_multi_write
rtdb_open
rtdb_query *item*
    ALIAS, ALPHA_ATTRS, ATTRIBUTE, ATTR_ACCESS,
    ATTR_CNT, ATTR_NAMES, ATTR_ORDER,
    CATEGORIES, CATEG_NAMES, CE_DEP_REF,
    CE_DEP_UPD, CE_OPER, CONN_INFO, DEFINITION,
    DE_TYPE, DIRECT, DIRECT_ATTR, EVENT,
    EXPR_ORDER, FIELD_NAMES, FIRST_CHILD,
    GROUPS, GROUP_NAMES, LRL, NEXT_SIBLING,
    PARENT, PTS_IN_CLASS, PT_CLASS, RESIDENCE,
    SYM_ABS, SYM_ALIAS, SYM_REL, USAGE

Database (cont.)

rtdb_read
rtdb_set
rtdb_write
rtdb_unit_write

Historian

rtdh_close
rtdh_config *item*
AUTOREARM, COPY_ABS_POINT, COPY_REL_POINT, DELETE_TABLE_POINT, RECORD_DATA, TABLE_NAME, TABLE_RESIDENCE, TABLE_SIZE
rtdh_control *item*
ARM_TABLE, AUTOARM_DISABLE, AUTOARM_ENABLE, CLEAR_TABLE, DATAWRAP_DISABLE, DATAWRAP_ENABLE, DISABLE_TABLE, DISARM_TABLE, ENABLE_TABLE, ONESHOT_TABLE
rtdh_open
rtdh_query *item*
AUTOARM, AUTOREAM, DATAWRAP, OUTPUT_TRIGGER, RECORD_DATA, TABLE_CONN_PLIN, TABLE_LIST, TABLE_LIST_CNT, TABLE_NAME, TABLE_RESIDENCE, TABLE_SIZE, TABLE_STATE
rtdh_read
rtdh_set

Event Manager

rtem_attach_event
rtem_change_event
rtem_detach_event

Environment System

rtenv_bind_msg_handler
rtenv_break_dispatch
rtenv_dispatch_msg
rtenv_get_env_dir
rtenv_get_error
rtenv_get_my_name
rtenv_ get_option *item*
    DEBUG, PRECISION, READ_BUFFER, READ_WRITE_STAT
rtenv_get_proc_name
rtenv_get_proc_num
rtenv_get_unix_pid
rtenv_log_error
rtenv_msg_recv
rtenv_msg_send
rtenv_print_error
rtenv_query_msg_handler
rtenv_sched_process
rtenv_set_my_name
rtenv_set_option *item*
    DEBUG, PRECISION, READ_BUFFER, READ_WRITE_STAT

Plot System

rtpd_control *item*

CLOSE_VIEW, CONFIGURE_PLOT, COPY_PLOT, COPY_PLOT_UNDER, DELETE_PLOT, HOUR_GLASS_OFF, HOUR_GLASS_ON, ICONIFY, ICONIFY_VIEW, OPEN_VIEW, OPEN_VIEW_AT, PRINT_PLOT, PRINT_PLOT_TO, REFRESH, SET_LIST_BY_PARENT, SET_LIST_BY_SIBLING, SWITCH_VIEW, UNICONIFY, UNICONIFY_VIEW

rtdp_query *item*

GET_CONTEXT, GET_VIEW_STATUS

Scan System

rtss_close
rtss_control *item*

COLD_RTS_DEVICE, COMM_PORT_MODE, DISABLE_SS, DISABLE_CP, DISABLE_SD_SI, DISABLE_SD_SI_PT, DISABLE_SD_SO, DISABLE_SD_SO_PT, ENABLE_SS, ENABLE_CP, ENABLE_SD_SI, ENABLE_SD_SI_PT, ENABLE_SD_SO, DENABLE_SD_SO_PT, FORCE_POLL, FORCE_POLL_TYPE, FORCE_PRBX, FORCE_PRBX_TYPE, POLL_PERIOD, POLL_TYPE, PRBX_PERIOD, PRBX_TYPE, SET_TIME, SNAP, SNAP_WITH_VERIFY, WARM_RST_DEVICE

rtss_open
rtss_query *item*

SYSTEM_STATE, TASK_STATE

rtss_read
rtss_set
rtss_write

SCL Initialization

scl_init

Time Keeper System

rttk_cancel_timer
rttk_delay
rttk_start_timer

Watchdog

rtwd_cancel_monitor
rtwdcontrol_server
rtwd_report_condition
rtwd_start_monitor

Appendix B

SVM Extensions

Schematic View Manager

- svm_bind
- svm_control item
  - POLL
  - REFRESH
  - RUN
  - STOP
- svm_config_menu
- svm_config_menu_item
- svm_config_sch
- svm_config_sym
- svm_control
- svm_create_menu
- svm_create_sch
- svm_destroy_sch
- svm_message
- svm_query
- svm_query_sch
- svm_query_sym
- svm_set