Model Based System Engineering applied to IMA with SCADE System

Eric BANTEGNIÉ – President & CEO

François Xavier DORMOY – SCADE System IMA Product Manager
Agenda

- Esterel Technologies & its customers
- SCADE Overview
- IMA Challenges and Esterel Objectives
- SCADE Solutions for IMA
- Customer Example
- Benefits and roadmap
Critical Systems & Software Development Solutions
Esterel Technologies mission

Provide critical system and software developers with model-based development solutions that reduce cost, risk and time-to-certification
# Esterel Technologies highlights

<table>
<thead>
<tr>
<th><strong>Business</strong></th>
<th><strong>Customer Base: 250+</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Model-based development tools for system &amp; Software engineers for safety critical systems</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Presence</strong></th>
<th><strong>End Markets</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Elancourt (near Paris, France)</td>
<td>Aerospace &amp; defense, aircraft engines, industrial machinery, rail &amp; transport, and nuclear</td>
</tr>
<tr>
<td>Direct presence in 7 countries</td>
<td></td>
</tr>
<tr>
<td>Customers in 27 countries</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Certification</strong></th>
<th><strong>Financials</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO 9001:2008 – Certified Company for design and sale of embedded software tools and services</td>
<td>12 years of consistent 20% growth Wholly owned ANSYS Company since August 1, 2012</td>
</tr>
</tbody>
</table>
Our Large Customers..

Aerospace & Defense
- Aeropribor
- Airbus
- Alenia
- AVIC
- Avionika
- BAE SYSTEMS
- BOEING
- Bundeswehr
- (BWB)
- CALT
- CASC / CAST
- CETC
- COMAC
- Crane Aerospace
- DARE
- Dassault Aviation
- Defense
- Singapore
- Diehl Aerospace
- DLR
- EADS CASA
- EADS Astrium
- EADS Cassidian
- ECICT
- Elbit Systems
- Elektroavtomatika
- Embraer
- ELTA
- ELV
- ESA
- ESG
- Eurocopter
- FADACATEC
- GE Aviation
- GE IQ
- Goodrich
- GosNIAS
- HAL
- Hispano-Suiza
- Intecs Systemi
- Intertechnique
- KAL/ADD
- KEEVEN
- Liebherr
- Aerospace
- Lockheed Martin
- Meggitt Safety Systems
- Meggitt Sensors
- Meggitt Avionics
- MIEA
- NASA
- NIIAO
- NKBVS
- Messier-Bugatti
- OAK (UAC)
- ONERA
- Parker
- QinetiQ
- Poliot
- Pratt & Whitney
- Rheinmetall
- Rolls Royce Aero
- Saab Avtronics
- SAIC
- Safran/ Sagem
- Sncma
- Sukhoi
- Turkish Aerospace Ind.
- Tekhpribor
- Thales Avionics
- Thales Training & Sim.
- Toshiba Aerospace
- Turbomeca
- Samsung Thales
- Ultra Electronics
- Ulyanovsk
- US Army Redstone Ars.
- VEGA
- VNIIRA
- Xian Aerospace
- ZODIAC

Rail Transportation
- Alcatel Shanghai Bell
- Alstom Transportation
- Ansaldo
- AREVA TA
- BJTU
- CAF
- CASCO
- Deutche Werke
- Dimetronic
- Engineering AT
- Hollysys
- Hyundai Rotem
- Ikerlan
- INVENSYS Rail
- Istanbul Ulusim
- Kyosan
- Mitsubishi
- NIIAS
- NRIET
- POSCON
- PT LEN
- RATP
- Samsung SDS
- Siemens Rail Transportation
- Systerel
- Thales Rail Signaling Systems
- Union Switch & Signal

Industrial & Automotive
- BMW
- DCNS
- Fuji Heavy
- GE Energy
- IKV
- Liebherr Construction
- Mitsubishi
- Johnson Controls
- NIAT
- Nihon Seiko
- PSA
- Schindler Elevators
- Subaru
- Terex Cranes
- Toyota Automotive
- Toyota Robotics

Energy & Nuclear
- AREVA NP
- BARC
- IGCAR Nuclear Research
- Rolls-Royce Civil Nuclear
- KAERI
- KOPEC
- NPCIL
- NPIC
- Rolls Royce Submarine
- Techenergy
- VNIIA /Rosatom
# Esterel SCADE Customers in Russia

## Aerospace & Defense
- Aeropribor Voskhod
- AVIAPRIBOR
- AVIONIKA MNPK
- ElectroAvtomatika
- GosNIIAS
- IRKUT
- MIEA
- NIIAO
- NKB VS
- NPO NAUKA
- OAK (UAC)
- POLIOT
- STAR (Perm Engine Factory)

## Aerospace & Defense (con’t)
- SUKHOI
- Ulyanovsk Design Bureau (UKBP)
- VEGA
- VNIIRA

## Other Industries
- EngineeringAT (Rail)
- NIIAS (Rail – RZD)
- Rostov State Transportation University (RGUPS)
- VNIIA (RosAtom)
SCADE Aeronautics Applications

- Autopilots
- Anti-icing
- Braking and Landing Gear Systems
- Cabin Pressure and Climate Control
- Cockpit Display Systems
- Doors and Slides
- Electronic Flight Bags
- Engine Control Systems (FADEC)
- Flight Control Systems / High Lift / Slat and Flaps
- Flight Management Systems
- Flight Warning Systems
- Fuel Management
- Heads-up Display
- Hydraulic Controls
- Navigation, Guidance and Inertial Units
- Nacelle Control Systems
- On-Board Airport Navigation Systems
- On-Board Maintenance System
- Oxygen Control units
- Power Management & APU
- Training and Simulation systems
- Thrust Reversers
- Water/Waste
SCADE Usage in Civilian Programs

• **Wide-Bodied**
  - Airbus A318 Elite, A340, A380, A350, A320 Neo
  - Boeing 737 SWA, 737 MAX, 787, 747-8
  - COMAC C919
  - Irkt-OAK MS -21

• **Regional Jets**
  - ARJ-21 (Chinese Regional Jet)
  - ATR 42/72-600
  - Bombardier CRJ 1000, CSeries
  - Mitsubishi MRJ
  - Sukhoi Superjet 100

• **Special Purpose**
  - Beriev-200e

• **Business Jets**
  - Cessna Citation Mustang, Encore+, XLS+
  - Dassault Falcon 7X, Falcon SMS
  - Eclipse 500
  - Embraer Phenom 100/300
  - Gulfstream G250, G500, G650
  - Learjet 85

• **Helicopters**
  - Eurocopter AS 350
  - Eurocopter EC135/145/155/225
  - Sikorsky S76D
  - MHI, KHI, Fuji HI programs

• **Civilian UAV**
  - Watchkeeper (UK)
  - ANKA (Turkey)
  - Skyblade (Singapore)
  - Pipeline surveillance (Russia)
SCADE Product Line

SCADE SYSTEM
Software system design, architecture and simulation

SCADE SUITE
Control software design, prototyping, verification and qualified code generation

SCADE LIFECYCLE
Lifecycle and requirements management certification plans, documentation generation

SCADE DISPLAY
Display software prototyping, design, verification and qualified code generation
SCADE System

System Design

Model Diff

System/Software Sync Up (including I/Os)

INTEGRATE

DESIGN

VERIFY
SCADE Suite for Partition Design

**Prototype & Design**
- Model Checking
- Debug & Simulation
- Model Coverage Analysis

**Verify**
- Formal Verification
- Model Diff
- Time & Stack Analysis

**Generate**
- SCADE Suite KCG
  - C & Ada
- RTOS & PLC Adaptors
- DO-178B
- IEC 61508
- EN 50128
- Certification Kits

**Control Software Design**
- Object Code & Compiler Verification
SCADE Display for Partition Design

Display
Software Design

Model Checking

Simulation

VERIFY

GENERATE

PROTOTYPE & DESIGN (incl. A661)

SCADE Display KCG

DO-178B
IEC 61508
EN 50128
Certification Kits

OpenGL SC
Compliant

OpenGL ES
What is unique about SCADE?

SCADE is developed specifically to be able to address critical system and software applications.

SCADE Suite and Display Code Generators are certified/qualified according to the following international safety standards:

- **DO-178B / DO-178C (2012) qualification up to Level A – Aerospace & Defense**
- **EN 50128 certification up to SIL 3/4 – Rail Transportation**
- **IEC 61508 certification up to SIL 3 – Industrial & Energy**
- **IEC 60880 full compliance – Nuclear Instrumentation & Control**
- **IEC 62304 full compliance – Medical Systems**
- **EN 13849 full compliance – Industrial Machines Safety**
- **ISO 26262 certification up to ASIL D – Automotive (2012)**

Same products qualified at the highest level of safety across 5 market segments by 10 safety authorities, worldwide.
Esterel IMA Strategic Initiative

- Esterel Technologies currently develops SCADE Solutions for IMA
  - Addressing the Avionics Architecture and Software Partition Application layers.
  - Leveraging SCADE System to describe the IMA avionics architecture using standards-based SysML interoperable description
  - Leveraging existing ARINC 653 Adaptor features of SCADE Suite KCG and SCADE Display KCG
  - ... to provide a complete Model-Based solution for IMA systems and applications development
- In close partnership with IMA experts & users, including GosNIIAS
SCADE Solutions for IMA compliant systems

François Xavier DORMOY – SCADE System IMA Product Mgr
IMA Challenges

- Manage complete avionics architecture with DATA dictionaries
- Reduce complexity of system Integration
- Ensure determinism of the system behavior
- Manage System / Software communication and synchronization
- Capability to perform testing early in the process
- Automate IMA configuration tables generation
- Certification according to DO-178B/C and DO-297 (IMA)
The Stakeholders in an IMA Program

- **System Architect Designer and Integrators**
  - Architecture, Integration, Platform Acceptance, System Acceptance

- **Application Suppliers**
  - Application, Application Acceptance

- **IMA Platform Suppliers**
  - Hardware resources and Software drivers

- **ARINC 653 OS Suppliers**
  - Ensure Time and space partitioning
  - Access to hardware resources in an abstracted manner (APEX interfaces standard)

- **Certification Authorities**
  - Certification of Modules, Platform, Apps, System
SCADE Solutions for IMA Compliant Systems
Use model for SCADE Solutions for IMA

- **Full Static description of the IMA avionics architecture model in SCADE System**
  - Supports functional decomposition
  - Supports static architecture decomposition (graphical)
  - Supports allocation of functions to components
  - Management of Interface database for an equipment

- **Partition Design and Code Generation with SCADE Suite & Display**
  - WCET estimation & optimization
  - DO-178B&C Level A qualified code generation & ARINC 653 compliance

- **Methodology and IMA Application LifeCycle Support with SCADE LifeCycle**
  - Synchronization of System architecture and Software Engineering
  - Full Traceability management (with LifeCycle RM Gateway)
  - Entire Documentation Generation (with LifeCycle Reporter)
Summary SCADE IMA workflow

IMA HW Platform
(CPU, I/O, Networks: AFDX, ARINC 429...)

IMA Operating System
A653 API

IMA Configuration Table

IMA Usage Domain
(Platform Constraints)
IMA Platform provider

Manual or legacy Code

Application1 (e.g. FMS)
Partitions

Application2 (e.g. FCS)
Partitions

Application3 (e.g. TCAS)
Partitions

IMA Usage Domain

SCADE Suite

SCADE Display

SCADE System
Customer Example Application

(Presented by Eurocopter at the SCADE User Group Conference)
MFD Example
Architecture design in SCADE System

Equipment communication
Architecture design in SCADE System
Architecture design

Partition design:
External connections
Architecture design in SCADE System

Partition design: internal connections
Architecture design in SCADE System

Definition of types (structures)
Synchronization with SCADE Suite & SCADE Display

- Import from the SCADE System model the datatypes and partitions interface
SCADE Solutions for IMA Benefits

• Management of Avionics Architecture with data dictionary
  – Enabling design of 100% of IMA Application
  – Enabling design of partitions and complete architecture
  – Management of I/O signals

• Reduction of the complexity of system integration
  – Model-Based representation of the system (re-use of legacy)
  – Automated systems consistency checks
  – Early testing and Rapid Prototyping

• Management of System/Software communication and synchronization
  – Early WCET estimation & optimization
  – Built-in Consistency of Software and System activities
  – System and Software semantic Model Diffs
SCADE Solutions for IMA Benefits

• Ensure determinism of system behavior and standards compliance
  – Determinism of generated code
  – Qualified code/table generation capabilities (for DO-178B/C Level A)
  – Conformance to ARINC 653 standard

• Automation of IMA configuration table generation

• Certification according to DO-178B & C
SCADE Solutions for IMA: Roadmap

• Available Now: SCADE Suite & Display A653 Adaptors (current version)
  – WCET estimation & optimization
  – Partition design and certified code generation

• Available Dec 2012: SCADE System 2.0 (beta), GA in March 2013
  – Data dictionary and profiling/annotations capability
  – SCADE System high level API
  – Generic System Checker

• Available H2/2013: SCADE System 2.1 IMA extensions (on top of SCADE System API)
  – IMA Tables generation
  – Specific IMA System Checker
Thank You!

Questions?