A M&S Process to Achieve Reusability and Interoperability

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ABSTRACT

This paper presents a modelling and simulation process based on state-of-the-art software engineering concepts, tools and best practices. It aims at guiding modellers in the development of extensible, reusable and interoperable models to be used in integrated simulations. Although this process has a very broad reach, it is incubated in a project for weapon system engagement simulation in order to better focus its application. The first iteration of the process development, which is reported here, is aimed at assessing the validity of the proposed concept. It was observed that despite the availability of tools and guidelines, no successful and cost-effective simulation is possible without teamwork, communication, common infrastructure, agreement, education, constraints and integration.

1.0 INTRODUCTION

In the context of defence related research and development, Modelling and Simulation (M&S) is often used as a tool to obtain precise answers to very specific questions. Due to time, resource and expertise constraints, several models or simulations are commonly developed in an executable format, with few customisable elements, to satisfy very specific requirements. Consequently, a more or less significant model rework is required for even slightly different applications. Another common weakness is the lack of rigorous, common and enforced modelling method, which often produces non-reusable and non-interoperable models.

The actual quest for a global synthetic environment is a catalyst to increase the span of M&S benefit. In this new vision, the real world is represented as a virtual environment where autonomous entities, behaviours, terrain, environment and information interact dynamically. A specific simulation only observes a subset of the entire environment. This conceptual approach may lead to some solutions to the M&S reusability and interoperability problem. However, the demanding system integration needs to be supported by effective teamwork and large-scale software development methods applied to the M&S domain.

From this point of view, new requirements for successful and cost-effective M&S include reusability, extensibility, portability, modularity and interoperability. Recently, the software engineering domain has tackled these problems with success. Therefore, since M&S relies on software applications, these novel M&S requirements could be fulfilled using state-of-the-art software engineering concepts, tools and best practices.

Paper presented at the RTO NMSG Conference on "NATO-PfP/Industry/National Modelling and Simulation Partnerships", held in Paris, France, 24-25 October 2002, and published in RTO-MP-094.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
00 NOV 2003	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
A M&S Process to Achieve Reusability and Interoperability	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Electro-optical Warfare Section Precision Weapon Section Defence R&D Canada Valcartier 2459, boul. Pie-XI Nord Val-Bélair, Québec, G3J 1X5 CANADA**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM001655., The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**UU**	**52**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

This paper proposes an integrated M&S process to guide the modellers in the development of reusable and interoperable models to be used inside extensible simulation frameworks. The proposed process has been initiated by modellers from the engineering and engagement levels, at the bottom of the M&S levels pyramid (Figure 1). The team adopted a vertical approach and focussed on the modelling process. Model engineering [1] is essential to create models for high-fidelity sub-system simulations as well as for a higher-level synthetic environment. Emphasize was then on potential uses for the models instead of specific deliverables, which implied that modellers had to understand the different contexts in which their models may be useful.

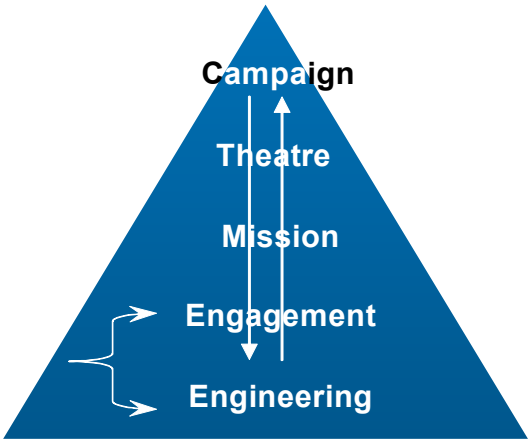

Figure 1: The M&S Levels of Detail Pyramid [2].

However, since modellers are rarely software engineers, an integration specialist is required. To foster the application of the proposed process, this person must understand the physics and the software aspects of the problem. It stresses the point that, to maximize reusability and interoperability, the bottom of the pyramid must understand the top and the top understand the bottom. For instance, the modellers must accept to be constrained, to some extent, to ensure that their models will be reusable and interoperable. The process must allow the modellers to focus on what they are good at, the modelling of physics.

This paper first describes the proposed M&S process and, afterwards, its practical implementation using specific software tools. The results section explains the incubating project surrounding the development of this process. Finally, the concluding remarks presents the lessons learned from the development and application of the proposed M&S process.

2.0 THE PROPOSED M&S PROCESS

As shown on Figure 2, the typical phases of any simulation are: modelling, execution and analysis [1]. The proposed process takes place to complement the M&S development theory in guiding the M&S teams in its concrete application. It essentially relies on software engineering concepts, tools and best practices applied to the M&S domain.

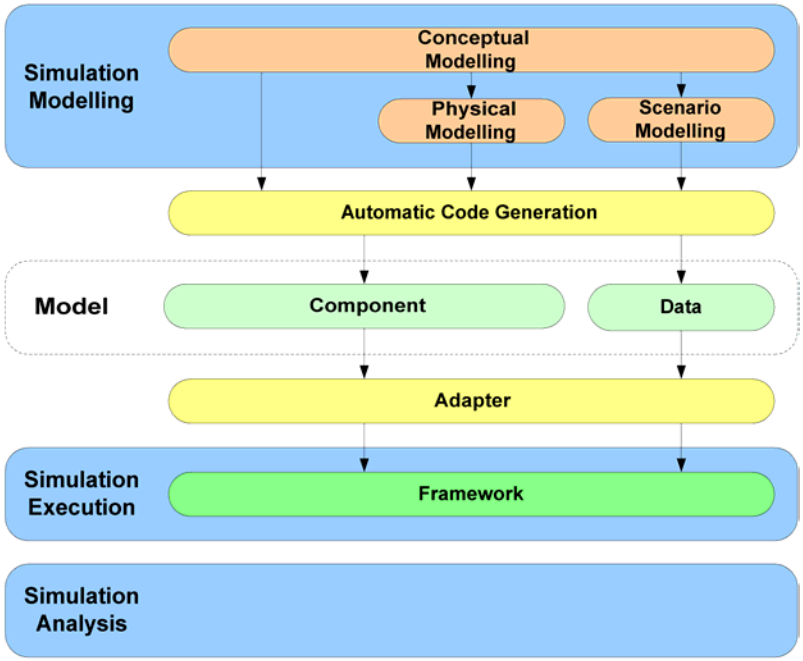

Figure 2: The Proposed M&S Process.

This is also an iterative process in the sense that the top-down integration can be restarted at any time in the development of a simulation and be completed within a few minutes time scale. In the software engineering domain, it is often called a micro-process spiral life cycle [3]. The automated steps standardize and speed up the model development process.

2.1 Simulation Modelling

The simulation modelling includes three main activities: 1) the conceptual modelling of the elements to be simulated; 2) the modelling of the physical behaviour of each element; and 3) the modelling of the scenarios describing the interaction between the various elements.

2.1.1 Conceptual Modelling

Conceptual modelling [1] is the first step of any structured M&S process. It is the abstraction of the entities, properties, behaviours and interactions to be simulated. In the proposed M&S process, the conceptual modelling is the reference of design. It means that modellers shall always go back at this level to make any changes. From a very high level perspective, representing the simulation requirements, it is possible to progress toward a model closer to the implementation.

In a software engineering approach to M&S, modularity and reusability can be expressed using the object-oriented (OO) paradigm and the component-oriented approach. As a standard for representing these concepts, the Unified Modelling Language (UML) [4] was selected to support the conceptual modelling. Therefore, applications of the simulation are described using “use case” diagrams while the static and dynamic aspects of the simulated system are represented using “class” and “sequence” diagrams, respectively. Finally, the implementation of the system is conceptualized using “component” diagrams. A consequence of this

approach is the fact that modellers must be educated on UML and object-oriented programming to agree on a common conceptual model.

Design patterns [5] and domain specific standards, such as the Real-Time Platform Reference Federation Object Model (RPR-FOM) [6] in defence M&S, are also introduced at this level to synthesize reproducible and globally accepted concepts.

A simulation developed with the proposed process gains its extensibility from the incremental additions at the conceptual model level. This process fosters reusability by inviting the modellers to extract the commonality of their models. It also promotes interoperability by forcing them to agree on standard concepts and interfaces.

2.1.2 Physical Modelling

Physically based modelling [7] is the mathematical representation of the real world behaviour. In order to remain at a manageable complexity level, the physical models are tailored to satisfy specific use cases. Various physical models may then be necessary for different applications, which is also called multi-modelling [1][8]. This concept is essential for bottom/up and top/down reusability of models in the M&S pyramid (Figure 1).

Once the stakeholders agree on requirements and the modellers agree on concepts (entities and interactions), each specialist can model the physics that is under its responsibility. Stand-alone work is possible at the condition of strictly respecting the conceptual model or updating it appropriately if a modification is required.

At the final stage of the physical modelling, the model is implemented into a software format. The software model can be directly written in an object-oriented programming language or encapsulated into a class if it is a legacy model. However, since modellers are not necessarily programmers, it is often impossible to require structured and standardized code from them. On the other hand, they can be assisted by automatic code generation tools providing a standardized code skeleton limiting the code to be written. Visual programming and simulation tools are also favoured for physical modelling without specific programming skills. Indeed, these tools were especially created for specific domain engineering-level rapid prototyping, test and validation. They often allow the reuse of functionalities through common libraries and the interoperability with other specialists. The only constraint is then to design physical models compliant with the OO and component-oriented conceptual model and to break the functionalities into discrete, more or less fine-grained, modules. The main challenge resides in switching from block and wire to object thinking and to manage the time steps synchronization between the integration schemes.

2.1.3 Scenario Modelling

The execution of a simulation requires the prior modelling of the scenario. In the OO approach, conceptual and physical modelling are dealing with generic objects while scenario modelling refers to instances of these objects. It typically includes the specification of model parameters, initial conditions for the state variables, the dynamic assembling of sub-models composing higher-level models, the recording of output results and the instantiation of objects composing a simulation scenario.

Scenario modelling generates the data characterizing the simulation. By scripting, in opposition to hard coding, these elements, it is possible to reuse parameters and initial conditions, to select the output to be logged and to dynamically compose, at run-time, the parts of a model or the entities of a scenario. A standard and flexible data format, such as the eXtensible Markup Language (XML) [9], can significantly fosters the exchange, the modularity and the portability of these data.

2.2 Automatic Code Generation

To automate and speed up the M&S process, software tools can generate the code of the model components and data. This practice promotes software quality and model consistency. The model code generation can be done directly from the conceptual model. This option involves a manual intervention of the modeller to include, in the skeleton, his physical model written in the appropriate programming language.

Alternatively, the modeller can use a visual programming tool to develop his physical model and, afterwards, automatically generate the model code including all the behaviours. This option allows reusing the visual prototype to produce the final model components. Similarly, a tool associated to scenario modelling can automatically generates the model data.

2.3 Model

The outcome of the modelling phase is a software model that includes a component and its associated data. The component is the generic software implementation of a model while the data contains the features of each instance. For example, the simulation of two different instances of a model can be achieved by using the same model component with different data files.

To maximize the model modularity and reusability, the components must encapsulate fine-grained generic code modules. Moreover, in order to optimize the modeller's efforts, the components shall contain physical model code independent of any simulation framework. In practice, components are generally compiled in a library that can be dynamically instantiated and linked at run-time.

Model data specify what is left generic in the model components, each component having customizable parameters and initial conditions. Parameters are the model data that remain constant over the simulation while initial conditions change over time.

Entities are container models that can be dynamically composed of part models using configuration files. Similarly, simulation scenarios are composed of entity models with their respective configuration files.

2.4 Adapter

To maximize reusability, the generic models and data files are adapted (from the "Adapter" design pattern [4]) to specific simulation frameworks. The adapter relationship with the simulation framework and the model component is shown on Figure 3. An instance of the adapter is required for each instance of a model entity.

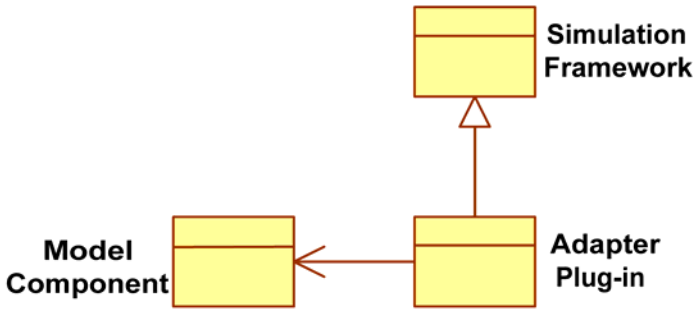

Figure 3: The "Adapter" Concept to Integrate a Model with a Framework.

Theoretically, the adaptation is possible with any OO and component-based simulation framework. However, a different adapter must be built to fit each specific framework. For a particular framework, the anchoring points can be limited to one or a few adapters depending on its extensibility and the compliance of the concepts between the custom models and the framework. Depending on the architecture and the complexity of the interaction, a variable level of effort may be required to benefit from the various built-in functionalities of a framework.

Practically, a model adapter is programmed using the Application Programming Interface (API) of the selected simulation framework and inserted into it as a plug-in. It acts as a dynamic model component interface with the simulation framework. The association of the model with the framework then does not require any recompilation and, depending on the framework, it may be run-time selectable. Scenario data file adapters can take the form of import/export capabilities.

Adapters have the advantage of reducing the dependence on a particular software product or environment. They contribute to improve the reusability of generic models, the modularity of the dependence to simulation execution and the extensibility of the simulation framework.

2.5 Simulation Execution

In the proposed process, the simulation execution is delegated to an existing commercial-of-the-shelf (COTS) framework that provides functionalities such as scenario creation, execution control, doctrines, trajectory, viewers, etc. Some frameworks may even include built-in model components and data. This approach originates from the fact that the expertise of the process initiators mainly resides in simulation modelling not in time management, distributed simulation, terrain database, visualization, etc.

The use of a recognized simulation framework contributes to the interoperability between the modellers by providing a common infrastructure. Within the defence community, such interoperability may also be improved if the chosen framework is compliant with the High-Level Architecture (HLA) [10].

2.6 Source Control and Web Page

The proposed M&S development process needs to be supported by version control, ownership tracking and exchange functionalities to ensure the integrity of the information. This can be achieved using, for instance, a shared database and a project web page. This practice shall be applied through the entire M&S process including: the conceptual model; the visual prototypes; the source code; the model components; the data files; and the documentation.

3.0 THE M&S PROCESS SUITE OF TOOLS

Practically, several software engineering tools are required to support and automate the proposed M&S process. An option analysis was carried out to determine the most appropriate suite of tools to demonstrate the proposed process. Some are COTS solutions and others are custom tools especially developed to be as generic as possible. It should be noted that these tools are not a unique solution but represent the best compromise when the option analysis was conducted. The automatic integration of these tools prevents subjective manual operations, promotes the iterative refinement and accelerates the process. Figure 4 shows the software tools associated to the M&S process while Figure 5 presents screen snapshots of the different tools.

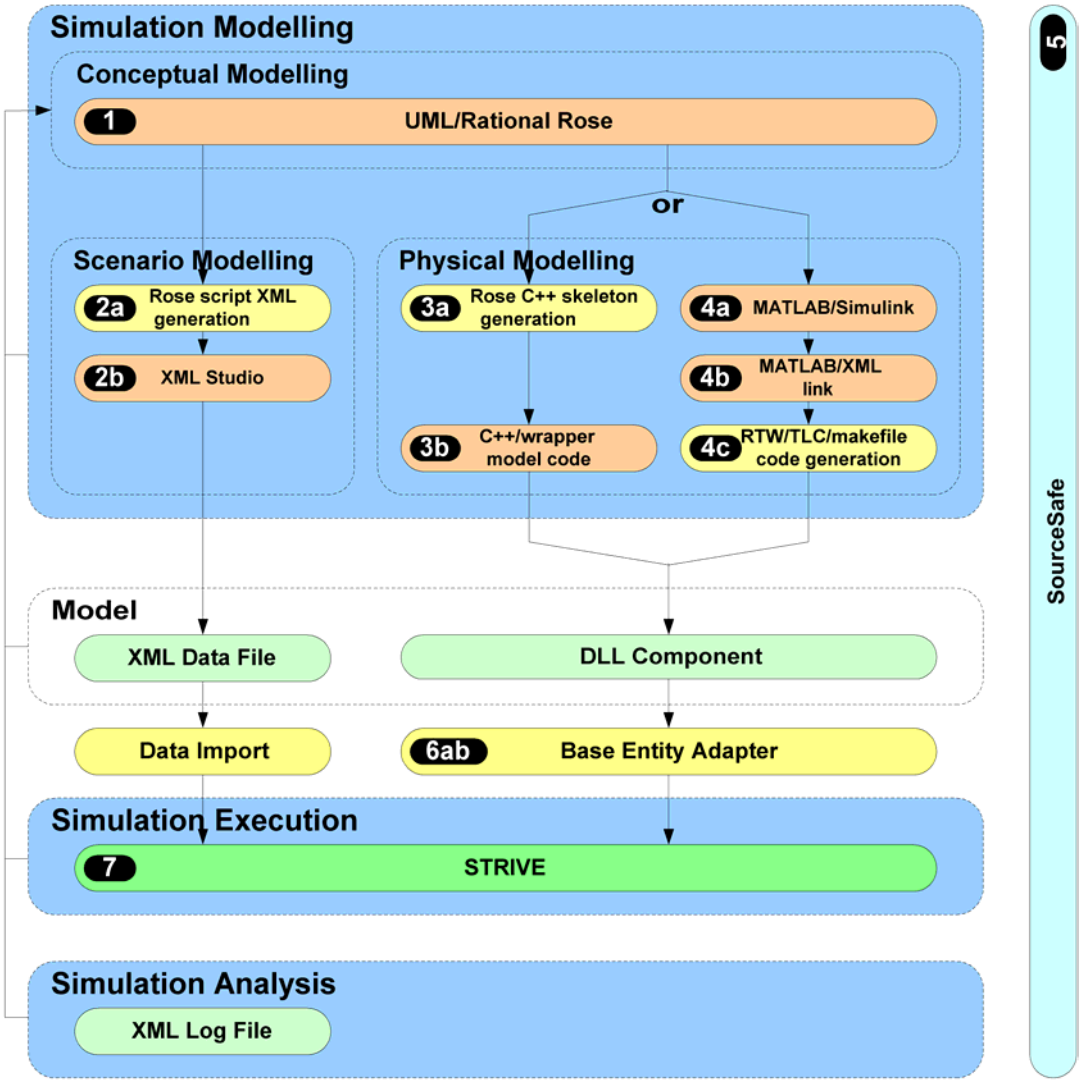

Figure 4: The Concrete Steps Implementing the Proposed M&S Process.

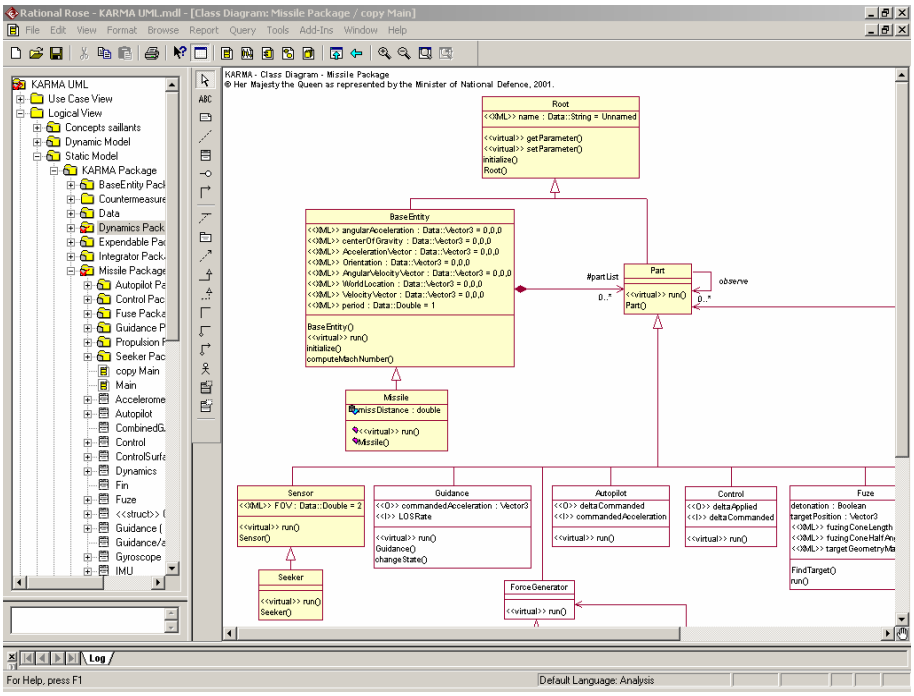

Figure 5a: Step 1 – Agreement on a Conceptual Model in UML with Rational Rose®.

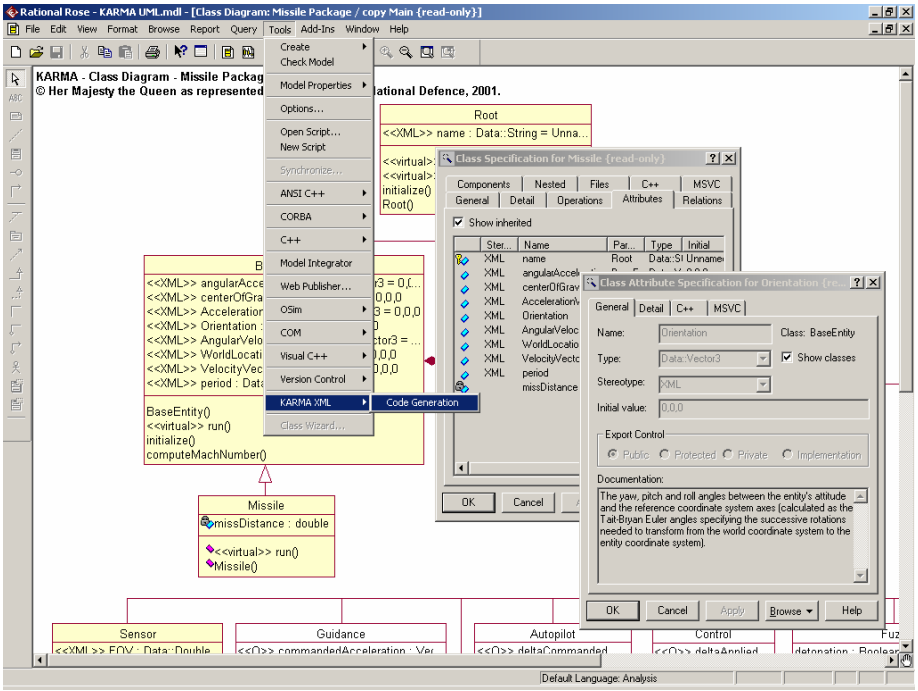

Figure 5b: Step 2a – Generation of XML Default Parameters Files from Rational Rose®.

Figure 5: Screen Snapshots of the Tools Supporting the M&S Process.

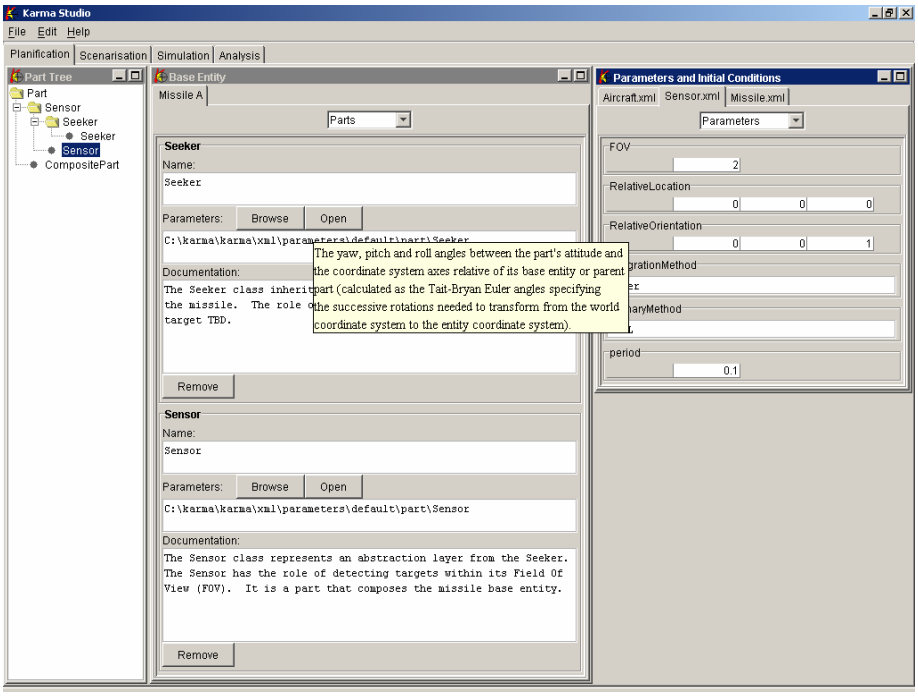

Figure 5c: Step 2b – Edition of the XML Scenario, Parts and Parameters Files in the Adaptive Java Studio.

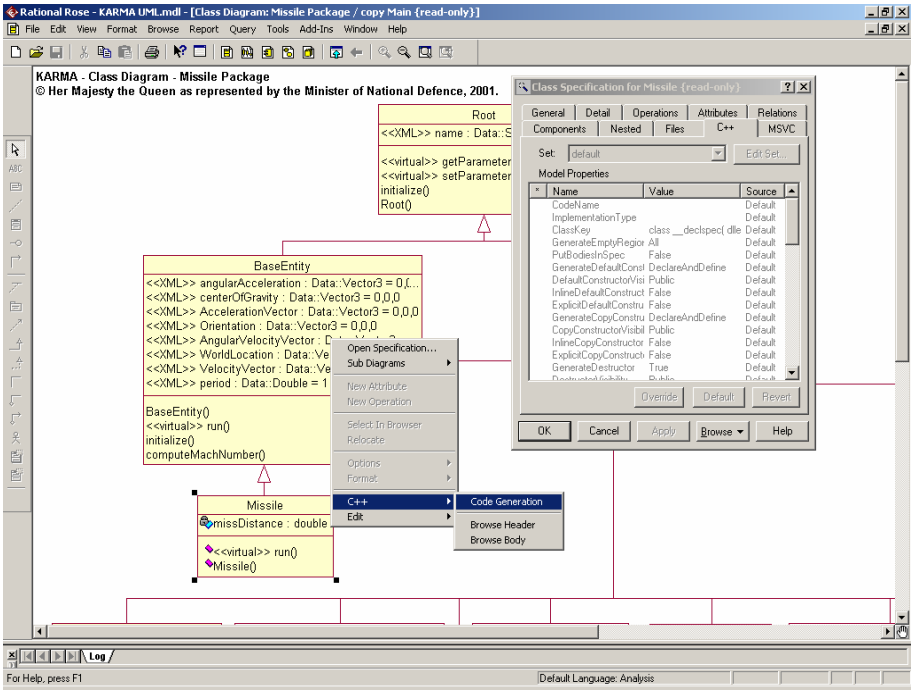

Figure 5d: Step 3a – Generation of a C++ Skeleton from the UML Conceptual Model with Rational Rose®.

Figure 5 cont'd: Screen Snapshots of the Tools Supporting the M&S Process.

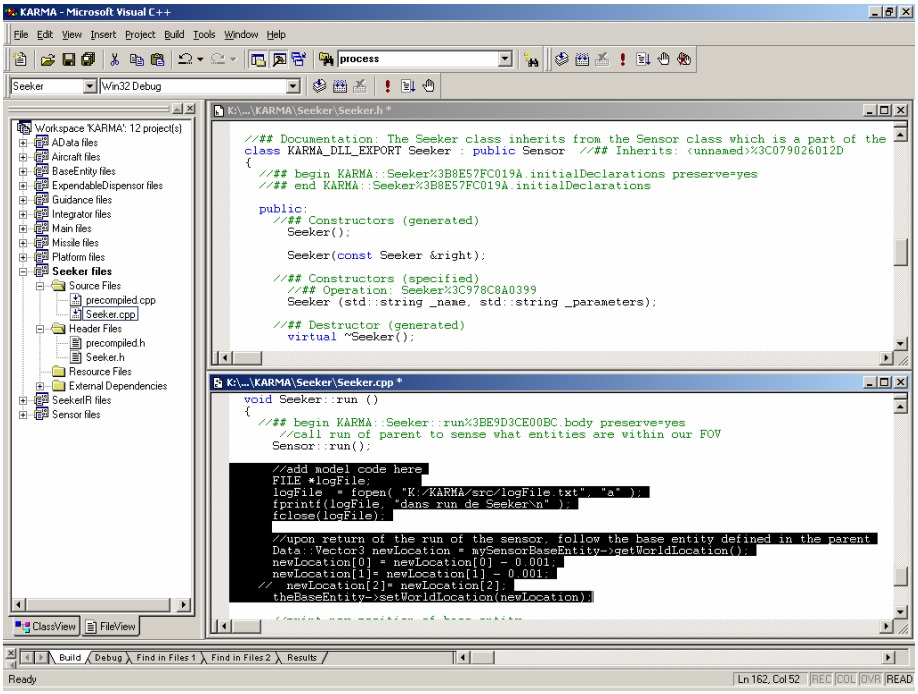

Figure 5e: Step 3b – Filling the C++ Skeleton with a Physical Model in C++ or Wrap a Legacy Model.

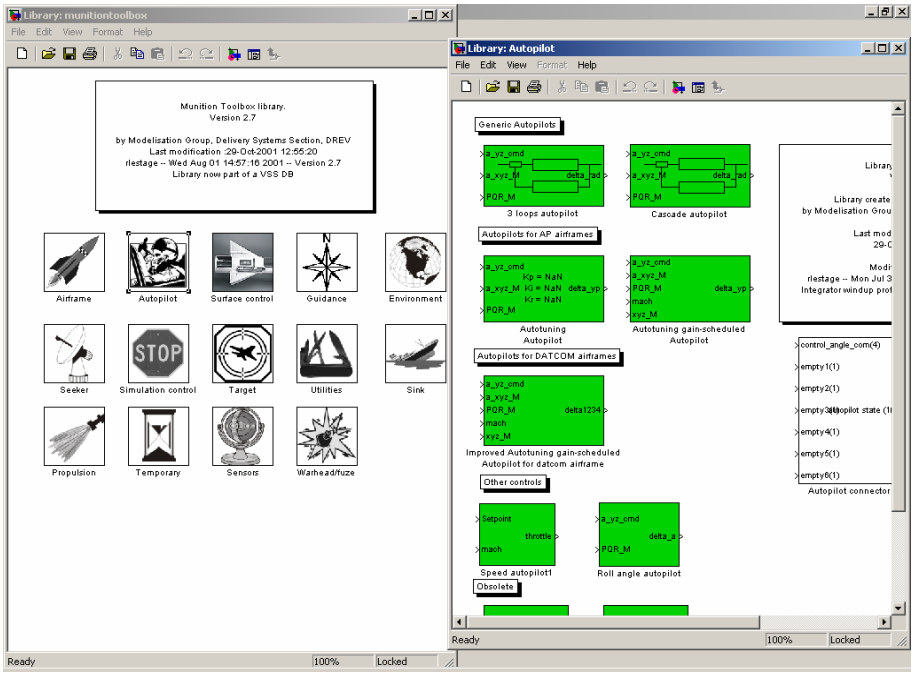

Figure 5f: Step 4a – Prototyping the Physical Model in MATLAB/SIMULINK®.

Figure 5 cont'd: Screen Snapshots of the Tools Supporting the M&S Process.

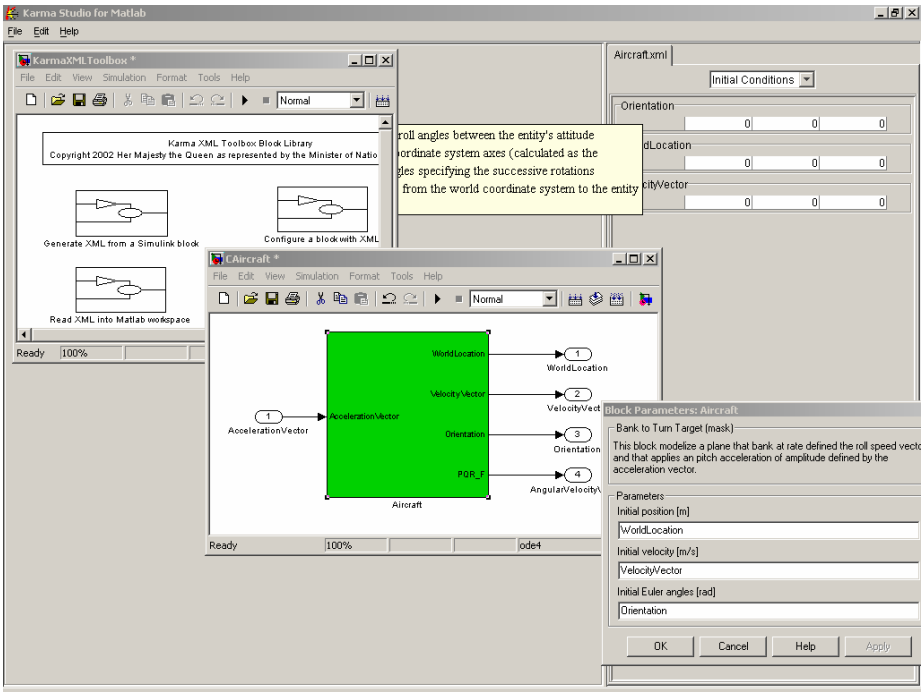

Figure 5g: Step 4b – Associating the SIMULINK® Model with XML Data Files Using the XML Toolbox.

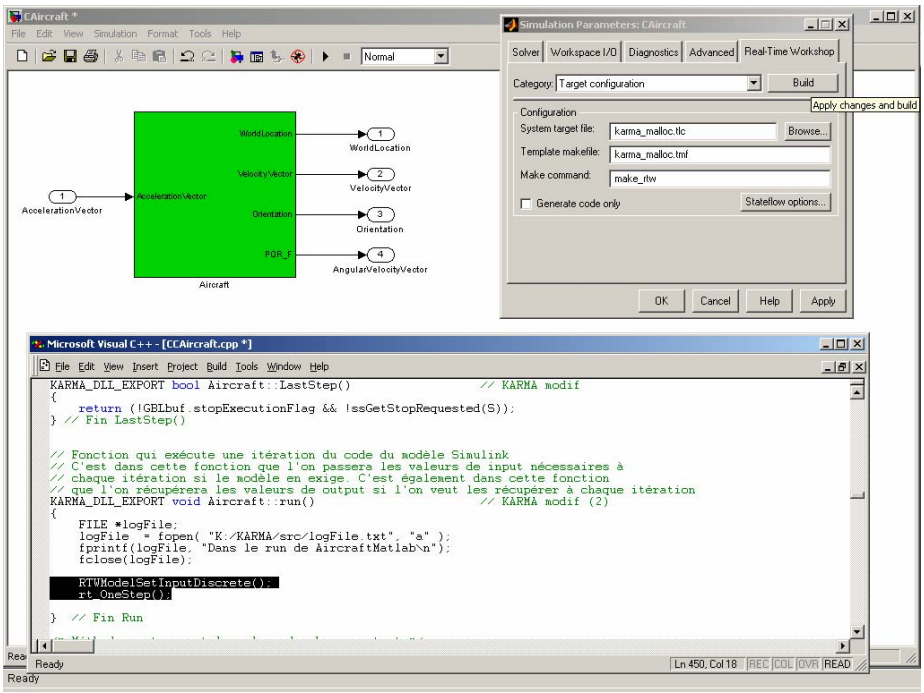

Figure 5h: Step 4c – Generating the DLL Using RTW®, TLC® Custom Script and Makefile.

Figure 5 cont'd: Screen Snapshots of the Tools Supporting the M&S Process.

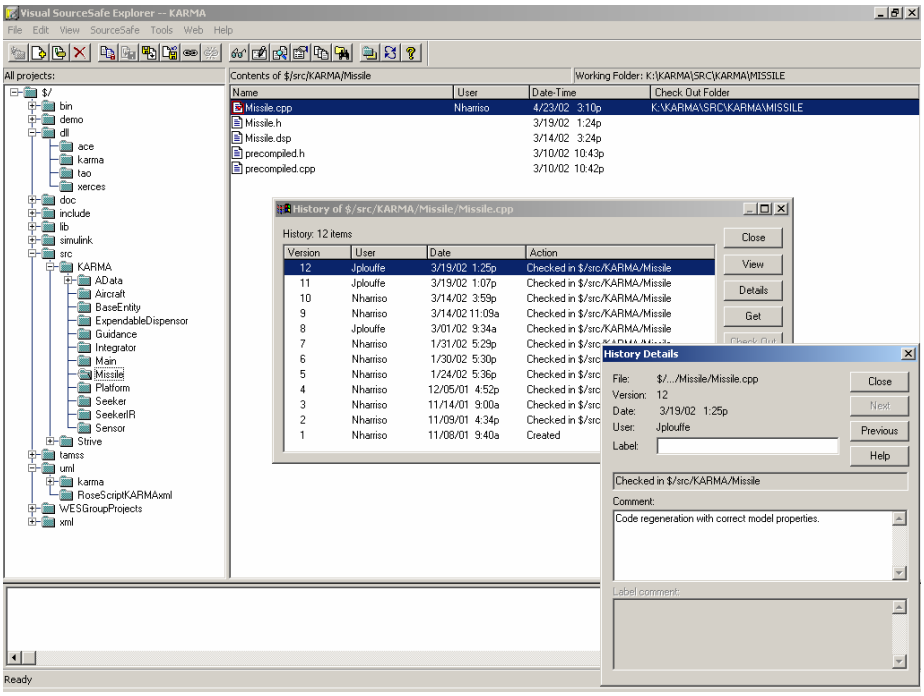

Figure 5i: Step 5 – Controlling the Versions and Sharing the Project Files with Sourcesafe®.

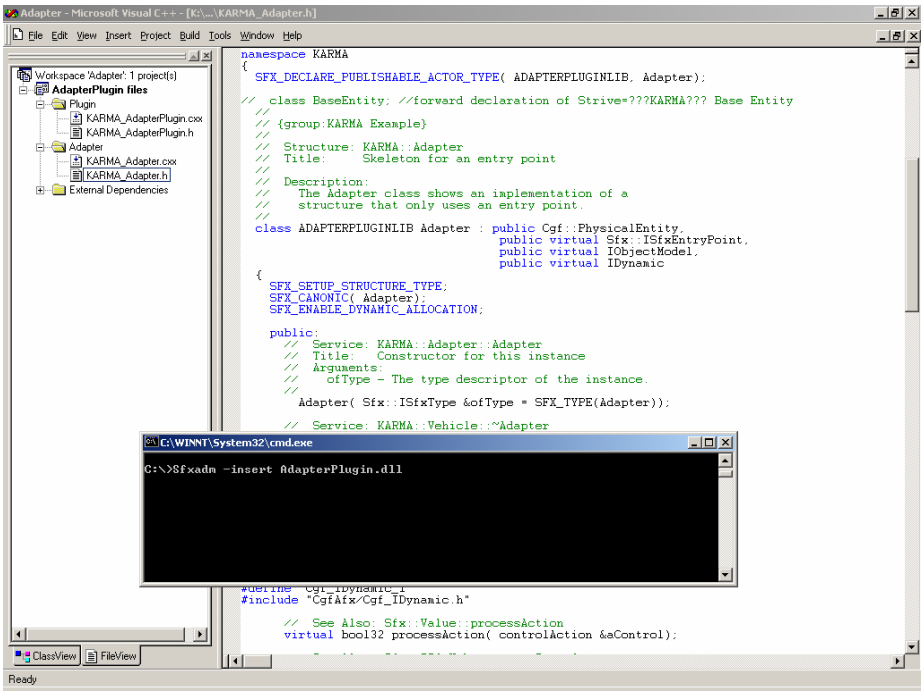

Figure 5j: Step 6a – Developing a STRIVE® Adapter in Microsoft Visual C++® and Inserting the Plug-In into the SFX.

Figure 5 cont'd: Screen Snapshots of the Tools Supporting the M&S Process.

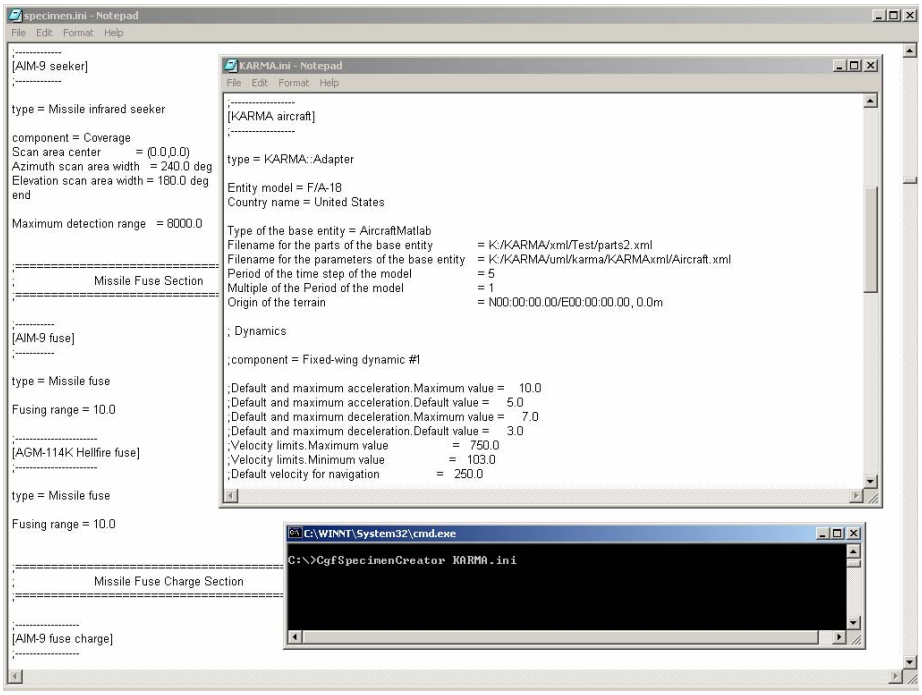

Figure 5k: Step 6b – Adapting the Data Files using a Custom STRIVE® specimen.ini File.

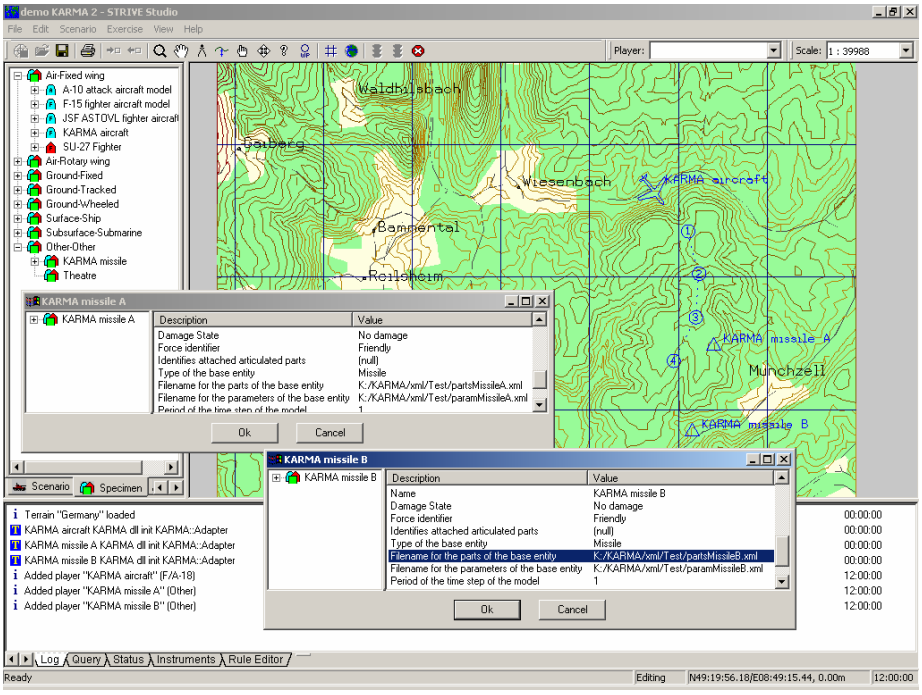

Figure 5l: Step 7 – Executing the Simulation in STRIVE®.

Figure 5 cont'd: Screen Snapshots of the Tools Supporting the M&S Process.

3.1 Simulation Modelling

Simulation modelling includes a series of tools to support the conceptual, scenario and physical modelling. Their link with each step of the proposed process is shown on Figure 4.

3.1.1 Conceptual Modelling

The process starts (Figure 4, Step 1 and Figure 5a) by agreeing on a conceptual model in UML using the Rational Rose® visual modelling tool [11]. It is a COTS product implementing the UML design standard and supporting OO and component-oriented conceptual modelling. The typical elements of the UML notation (use cases, class, sequence, component diagrams) are used to represent the conceptual model. The class attributes (parameters or initial conditions), methods, interaction and documentation are also systematically included in the UML class diagram.

3.1.2 Scenario Modelling

The second step of the proposed process (Figure 4, Step 2a and Figure 5b) consists in generating the XML parameter and initial condition files from the UML conceptual model using an automated functionality integrated into Rational Rose®. Practically, this is done in stereotyping, with the tag <<XML>>, the classes that require a parameter file. All class attributes that need to be configurable, either as a parameter or as an initial condition, are also tagged. Then, a custom script, integrated into the Rational Rose® tools menu, automatically generates default XML parameter files with the corresponding parameter names, data types, initial values and documentation. The practice of properly documenting the conceptual model and automatically generating the data insures the quality of the parameters data files.

Afterwards, the creation and the edition of the XML data files can also be done using a custom Java interface called the Studio (Figure 4, Step 2b and Figure 5c). This interface automatically adapts the Graphical User Interface (GUI) to the number and the name of the parameters defined into one model. It also dynamically represents the parameters according to their type. The data type entered by the user is validated and the minimum and maximum ranges permitted for each parameter are verified. Units and documentation are also displayed. The drag-and-drop capability of the GUI allows composing scenarios from entity models and entities from part models. The Xerces C++ and Java XML parsers [12] allow reusing the XML files at the scenario graphical modelling level, at the visual programming level and at the simulation framework level.

3.1.3 Physical Modelling

Based on the conceptual model, a C++ skeleton of the physical model can be automatically generated with Rational Rose® (Figure 4, Step 3a and Figure 5d). Moreover, Rational Rose® is integrated with the Microsoft Visual C++® development environment. The practice of systematically referring to the UML model to make any change on the skeleton and redo the automatic code generation ensures that the conceptual model always reflects the state of the implementation. It also improves the quality and the uniformity of the documentation and the code.

The modeller can then add the physical model directly in the reserved area of the C++ skeleton (Figure 4, Step 3b and Figure 5e) using Microsoft Visual C++® or any other appropriate development environment. At this stage, the modeller also has the possibility of wrapping a legacy model into the C++ skeleton of the class.

Alternatively, the modeller has the opportunity to use the MATLAB/SIMULINK® [13] visual programming tool for prototyping the physical model (Figure 4, Step 4a and Figure 5f). However, the SIMULINK® model should be consistent with the OO conceptual model to ensure the compliance between the SIMULINK® and the skeleton generated code.

When using MATLAB/SIMULINK®, the modeller shall associate the visual model with a XML data file (Figure 4, Step 4b and Figure 5g) to be consistent within the process. Custom tools were developed to use the XML data files with MATLAB/SIMULINK®: 1) XML files for SIMULINK® models are automatically generated using a m-file export program called MATLAB2XML; 2) parameters defined in XML can be imported in the MATLAB® workspace using the XML2MATLAB m-file program; and 3) the SIMULINK® blocks can be automatically associated with the XML Studio using an automatic configuration m-file.

If the modeller uses the MATLAB/SIMULINK® environment to develop the physical model, the proposed process allows to automatically generate a model component compiled as a Dynamic Link Library (DLL). The component is produced using the Real-Time Workshop® (RTW®) and the Target Language Compiler® (TLC®) COTS products (Figure 4, Step 4c and Figure 5h). RTW® is integrated within SIMULINK® and automatically generates portable and executable C code from the block model. Using the TLC®, included with RTW®, it is possible to customize the generated code and, for instance, wrap the produced C code into a C++ class compliant with the conceptual model. The interface of the resulting class is identical to the one automatically generated from the conceptual model with Rational Rose®. In addition, this code contains the calls to the MATLAB/SIMULINK® functions responsible for the mathematical modelling and the numerical integration. Finally, a custom makefile automatically compiles the generated code into a DLL to produce a stand-alone component.

3.2 Source Control

The modelling process produces model data for parameters, entity parts and scenarios in XML file format and model components in DLL file format. The different versions of these files are tracked using Microsoft Visual SourceSafe® COTS product (Figure 4, Step 5 and Figure 5i). SourceSafe® is integrated with the other modelling tools (Microsoft Visual C++®, Rational Rose® and MATLAB®) to optimize file management. Practically, it automates the sharing and the version control of the UML conceptual model, the C++ source code and the SIMULINK models.

3.3 Adapter

STRIVE® from CAE (Montreal, Canada) [14] is the simulation framework selected to demonstrate the process. It is an HLA-native framework that internally uses publish and subscribe as interaction mechanism. It implements distributed simulation using the Run-Time Infrastructure (RTI) [10] and supports an extended RPR-FOM. Its architecture is divided into two main elements: 1) a simulation framework, called SFX and 2) a Computer Generated Forces (CGF). It allows adding custom models that only use the SFX or use also the behaviours provided by the CGF.

Custom models are added into STRIVE® as plug-in components in DLL file format. To avoid coding the physical models using framework-dependent API, the proposed M&S process uses an adapter between the generic model DLLs and the STRIVE® SFX. The adapter can be initialized from a library template automatically installed by STRIVE® into Microsoft Visual C++® (Figure4, Step 6a and Figure 5j). In a single command line, the plug-in is inserted into the STRIVE® framework.

Similarly, the XML data files shall be adapted through a STRIVE® specimen initialization file (Figure 4, Step 6b and Figure 5k). This step represents the minimal effort required so that custom models could be recognized within the STRIVE® CGF.

3.4 Simulation Execution

Finally, the simulation is executed in STRIVE® (Figure 4, Step 7 and Figure 5l) to benefit from its built-in functionalities i.e., HLA compliance, distributed capabilities, visual scenario and doctrine creation tools, trajectory waypoints, 2D and 3D viewers, etc. Nevertheless, the custom model remains responsible for initializing dynamically its parameters from the XML files and the simulation results are always logged into XML files to maximize their portability.

4.0 THE INCUBATING PROJECT FOR THE M&S PROCESS DEVELOPMENT

This M&S process has been demonstrated in the context of an R&D project aiming at developing a weapon system engagement simulation environment. Typical requirements for such engagement simulations are, for example, to simulate a specific threat X, with the parameters Y, engaging a target Z that could counteract in specific ways. Implemented using a classical approach, this would have resulted in narrow simulation capabilities. With the use of the proposed M&S process, it has been demonstrated that various configurable subparts developed by several specialists can be connected and interchanged dynamically in the STRIVE® simulation framework.

The conceptual modelling allowed to devise and properly structure the main concepts of the simulation i.e., autonomous “Base Entities”, composed of “Parts” equipments, are detecting each other within the “Environment” of the simulation “Theatre”. Standardized terms from the RPR-FOM (such as “BaseEntity”, “WorldLocation”, “VelocityVector”, etc.) were adopted to describe similar concepts. In order to meet the engagement simulation requirements, the base entity concept was specialized, for example, in “Aircraft” or “Weapon” and the part concept, in “Airframe”, “Sensor” or “Propulsion”. The conceptual model proved to be independent of the number and the assembly of instances.

The physical models of the parts used in the simulation were exported to DLL components from an existing MATLAB/SIMULINK® weapons library. All parameter, initial condition, base entity parts composition, scenario and log files were associated to XML files for universal use across the entire M&S process.

The execution of the simulation in STRIVE® allowed to play different scenarios by dynamically instantiating “Aircraft” instances composed of interchangeable parts, each with all configurable parameters. Through STRIVE®, the models also became HLA compliant.

The main objective of the incubating project was to establish a solid architecture and good teamwork practices such as information sharing and documentation. The experimentation of the process showed that such methodology and tools greatly improve the quality of the end product while easing further developments.

5.0 CONCLUSION

This paper proposed an automated iterative process, supported by a suite of software engineering tools and best practices, to guide modellers in the development of reusable and interoperable models. The application of this process brought to light the following advantages:

- the reusability of component models independent of any simulation framework;
- the interoperability improvement from an agreement at the conceptual level;
- the modularity of the models XML data and DLL components;
- the extensibility of the conceptual model and the simulation framework;
- the portability of the simulation data in XML format; and
- the quality and consistency of the outcome due to many automated steps.

On the other hand, the application of the process also showed some noticeable disadvantages like:

- the maintenance of custom tools developed to support the process;
- the uncertainty of being at the mercy of COTS tools providers;
- the significant integration work requiring specific skills;
- the learning curve of the modellers for the conceptual modelling; and
- the rigorous information (database) management required.

Through the experience of the incubating project, the following lessons were learned:

- despite the availability of tools and guidelines, no successful and cost-effective M&S could be achieved without a major change of mind about teamwork in the defence R&D community;
- transparent and efficient information sharing and appropriate communication and documentation must be established within the team;
- reusability and interoperability only occurs with an agreement at the conceptual model level;
- modellers must be left to do what they are the best at, the mathematical modelling of physical behaviours, while conforming to a rigorous method to maximize reusability and interoperability;
- modellers shall be properly educated on subjects such as the UML and the object-oriented paradigm – it is believed that these initial investments would lead to long-term payoff; and
- someone must be responsible for the integration in order to maximize the process efficiency.

Finally, the proposed M&S process only fosters model reusability and interoperability in providing guidelines to modeller teams. However, the object-oriented paradigm does not guarantee reusability and interoperability of the concepts. In order to achieve these requirements to a higher level, some constraints on the abstraction of entities, properties and interactions must be imposed [15].

6.0 REFERENCES

[1] Fishwick, P.A., "*Simulation Model Design and Execution: Building Digital Worlds*", Prentice Hall, New Jersey, 1995.

[2] "*Creating and Improving Intellectual and Technological Infrastructure for M&S*", Chapter 6, Technology for the United States Navy Corps, 2000-2035: Becoming a 21st-Century Force, National Academy of Sciences, 1997. (http://www.nap.edu/html/tech_21st/msindex.htm#Contents)

[3] Booch, G., "*Object-Oriented Analysis and Design with Applications*", The Benjamin/Cummings Publ. Comp. Inc., 1994.

[4] The Unified Modeling Language (UML) Web Site: http://www.uml.org.

[5] Gamma, E., Helm, R., Johnson, R. and Vlissides, J., "*Design Patterns: Elements of Reusable Object-Oriented Software*", Addison-Wesley, 1995.

[6] The RPR-FOM Standards Development Group Web Site: http://www.sisostds.org/stdsdev/rpr-fom.

[7] Witkin, A. and Baraff, D., "*Physically Based Modeling: Principles and Practice*", Course notes, SIGGRAPH, 1997.

[8] Davis, P.K. and Zeigler B., "*Multi-Resolution Modeling and Integrated Families of Models*", Appendix E, Chapter 6, Technology for the United States Navy Corps, 2000-2035: Becoming a 21st-Century Force, National Academy of Sciences, 1997.

[9] The eXtensible Markup Language (XML) Web Site: http://www.w3.org/XML.

[10] The HLA Web Site: https://www.dmso.mil/public/transition/hla.

[11] The Rational Rose Web Site: http://www.rational.com/products/rose.

[12] The Xerces Open-Source XML Parser from Apache Web Site: http://xml.apache.org.

[13] The MathWorks Web Site: http://www.mathworks.com.

[14] The STRIVE Web Site: http://www.cae.com/en/military/software/strive.shtml.

[15] Bernier, F., Poussart, D., Laurendeau, D. and Simoneau, M., "*Interaction-Centric Modelling for Interactive Virtual Worlds: the APIA Approach*", Proceedings of the 16th ICPR conference, Quebec, Canada, 2002, pp. 1007-1010.


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R&D
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A M&S Process to Achieve Reusability and Interoperability

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C. Lalancette, R. Lestage and A. Morin

October 25th, 2002

Defence Research and Development Canada
Recherche et développement pour la défense Canada
Canada

Outline

- Problem
- Solution
- Proposed M&S process
- Suite of tools
- Incubating project
- Advantages
- Disadvantages
- Lessons learned
- Way ahead

1. Problem

Feature driven M&S

Non-reusable and non-interoperable M&S

Architecture driven M&S

How do we engineer models in order to build reusable, interoperable, extensible, modular and portable M&S applications?

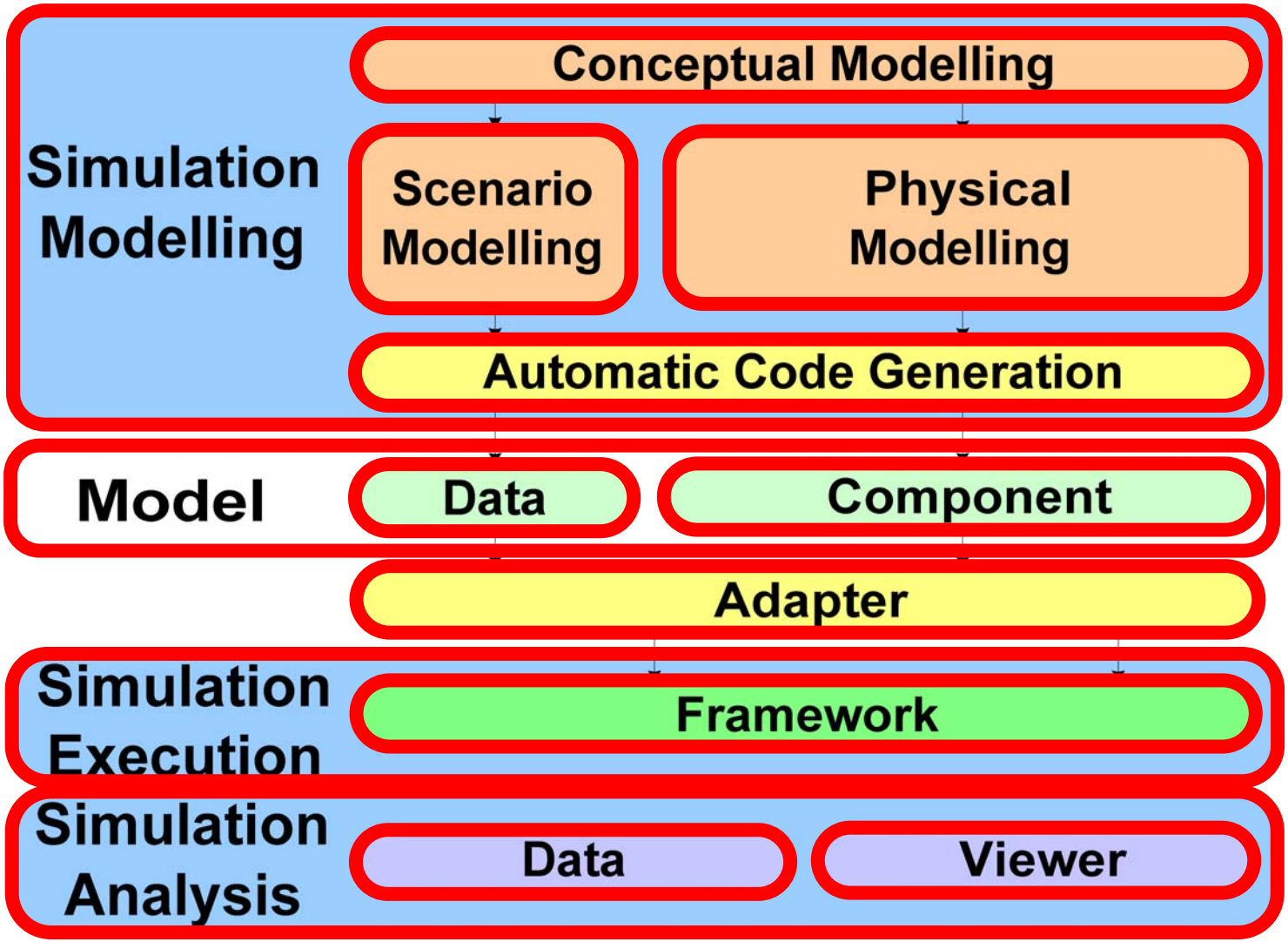
2. Solution

Apply software engineering to M&S

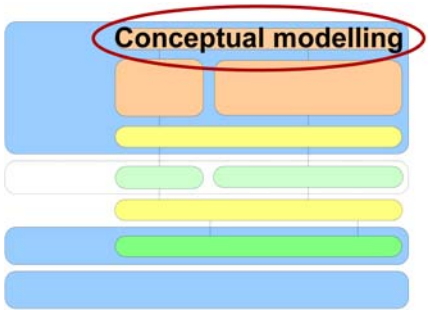
M&S Process

- Based on software engineering concepts, tools and best practices
- To guide the modellers
- Reusable and interoperable models
- Extensible simulation framework

3. The M&S Process

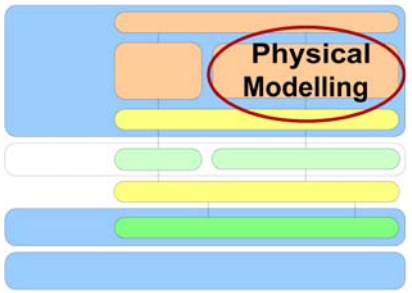


3.1 Conceptual Modelling



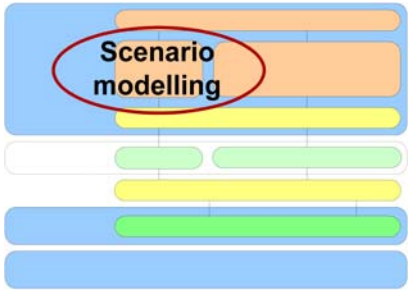
- Aim
  - Abstraction of the relationship between entities, properties, behaviours and interactions to be simulated
- Concepts
  - Object-oriented and component-oriented
  - Unified Modeling Language (UML)
  - Design Patterns and domain-specific standards
- Approach
  - Reference of design
- Benefits
  - Modularity, reusability, interoperability, extensibility

3.2 Physical Modelling



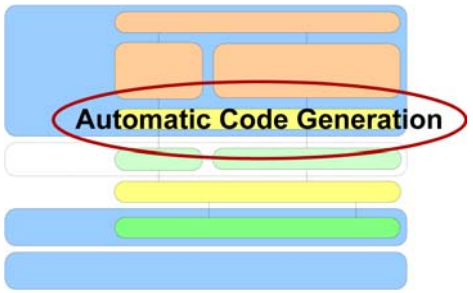
- Aim
  - Mathematical representation of entities, properties, behaviours and interactions to be simulated
- Concepts
  - Software programming
- Approach
  - Specialist modellers
  - Consistency with the conceptual model
  - Object-oriented programming or wrapping
  - Visual programming
- Benefits
  - Quality, consistency, interoperability, reusability

3.3 Scenario Modelling



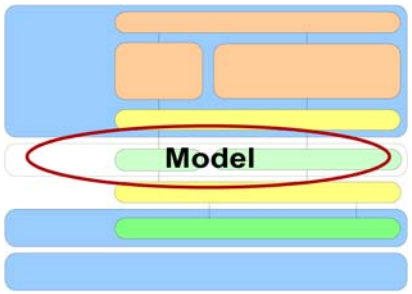
- Aim
  - Configuration of simulation instances
- Concepts
  - Data representation standard
  - eXtensible Markup Language (XML)
- Approach
  - XML schemas
    - Parameters and initial conditions
    - Parts
    - Scenario
    - Log
- Benefits
  - Modularity, reusability, portability, dynamism

3.4 Code Generation



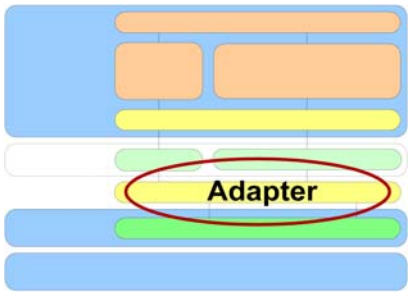
- Aim
  - Automatic software representation for the model components and data
- Concepts
  - Software integration and automation
- Approach
  - Speed up and standardize the end product
- Benefits
  - Quality, consistency, uniformity

3.5 Model Component / Data

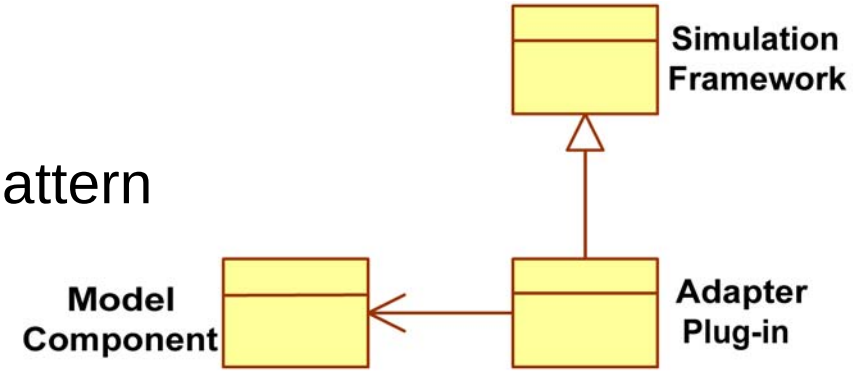


- Aim
  - Outcome of the modelling phase
- Concepts
  - Model = Component + Data
  - Component = generic object, dynamic, DLL
  - Data = specific instance, configuration, XML
- Approach
  - Pure model independent of the simulation framework
- Benefits
  - Modularity, reusability, dynamism

3.6 Adapter



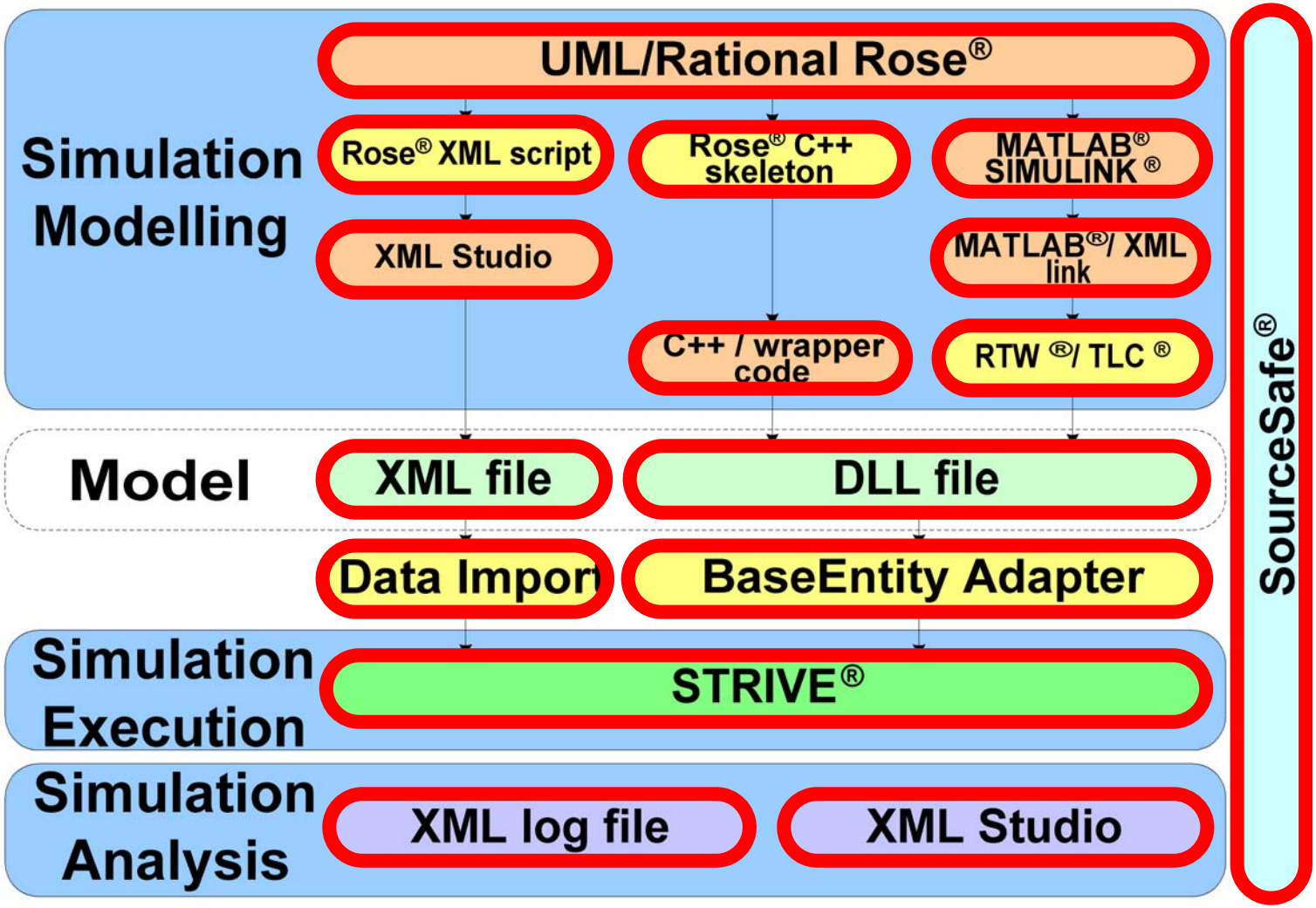
- Aim
  - Adapt pure models to specific simulation frameworks
- Concepts
  - “Adapter” design pattern
  - Framework API
- Approach
  - Run-time selection of the model to be instantiated
  - Component plug-in
  - Scenario data import
- Benefits
  - Modularity, reusability, extensibility



3.7 Simulation Framework

- Aim
  - Simulation and time management are left to a simulation framework
- Concepts
  - Common infrastructure
  - Object-oriented and component-oriented framework
- Approach
  - Take advantage of built-in functionalities like execution control, scheduling, visual scenario and doctrine creation, HLA compliance, distribution, trajectory waypoints, 2D and 3D viewers, etc.
- Benefits
  - Reusability, interoperability, extensibility

4. The Suite of Tools



5. The Incubating Project

- R&D project for weapon engagement simulation
  - to connect and interchange dynamically configurable subpart models developed by several specialists
- Conceptual model
  - Entities, Parts, Theatre and Environment
  - Standard: RPR-FOM (BaseEntity, WorldLocation, etc.)
- Physical Models
  - MATLAB/SIMULINK® weapons library
- Simulation Execution
  - Dynamic instantiation of configurable entities in STRIVE®

6. Advantages

- Interoperability
  - Agreement at the conceptual level and common framework infrastructure
- Modularity
  - XML data separated from DLL components
- Reusability
  - Modular models independent of any simulation framework
- Extensibility
  - Upgrade the conceptual model and add functionalities to the simulation framework
- Portability
  - Simulation data in XML format
- Quality
  - Consistency and uniformity preserved by automated steps

7. Disadvantages

- Maintenance of custom tools
- Rigorous information management
- Being at the mercy of COTS tools
- Learning curve
- Significant integration work

8. Lessons Learned

- Change of mind
- Transparent and efficient information sharing, appropriate communication and documentation
- Agreement at the conceptual model level
- Modellers must do what they are the best at, while conforming to a rigorous method
- Training is an initial investment that leads to long-term payoff
- Someone must be “responsible” for the integration

9. Way Ahead

- From fostering …
  - The proposed process only fosters reusability and interoperability by providing tools and guidelines to modellers
  - Object-oriented paradigm does not guarantee reusability and interoperability
- To achieving…
  - Constraints must be imposed on the conceptual abstraction of entities, properties and interactions
  - Meta-model to allow interaction between models without prior knowledge of each other

Leader en sciences et

technologie de la défense,

la Direction de la recherche

et du développement pour

la défense contribue

à maintenir et à

accroître les compétences

du Canada dans

ce domaine.

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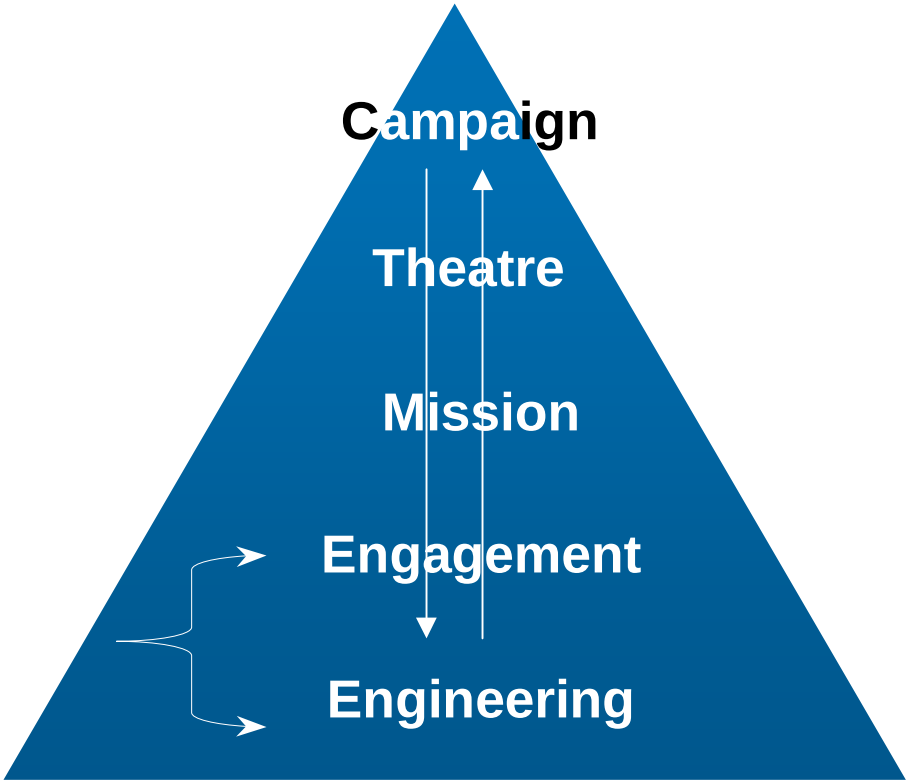
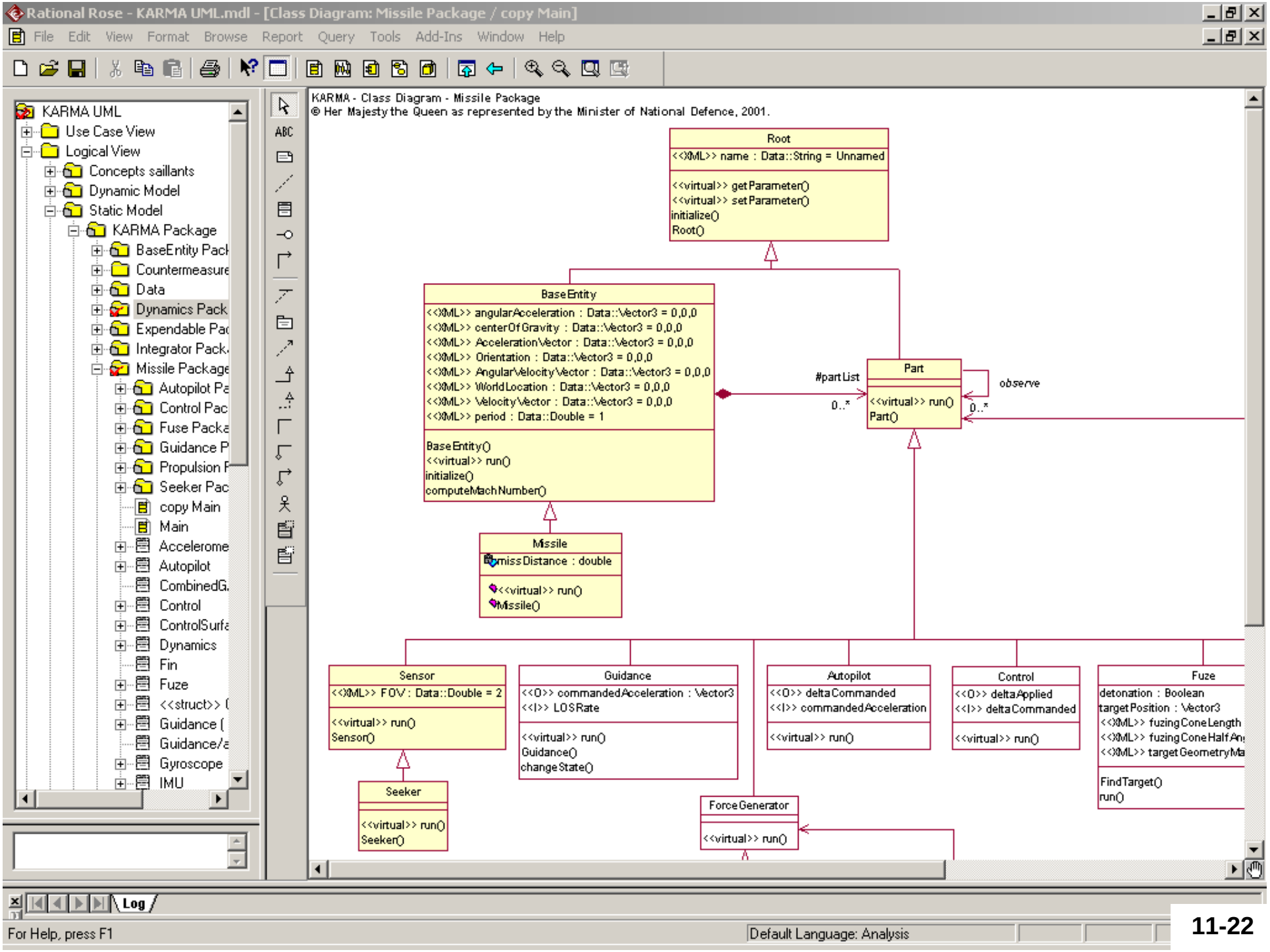
The M&S Pyramid

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KARMA UML
Use Case View
Logical View
Concepts saillants
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Static Model
KARMA Package
BaseEntity Pack
Countermeasure
Data
Dynamics Pack
Expendable Pac
Integrator Pack
Missile Package
Autopilot Pa
Control Pac
Fuse Packa
Guidance P
Propulsion F
Seeker Pac
copy Main
Main
Accelerome
Autopilot
CombinedG
Control
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Dynamics
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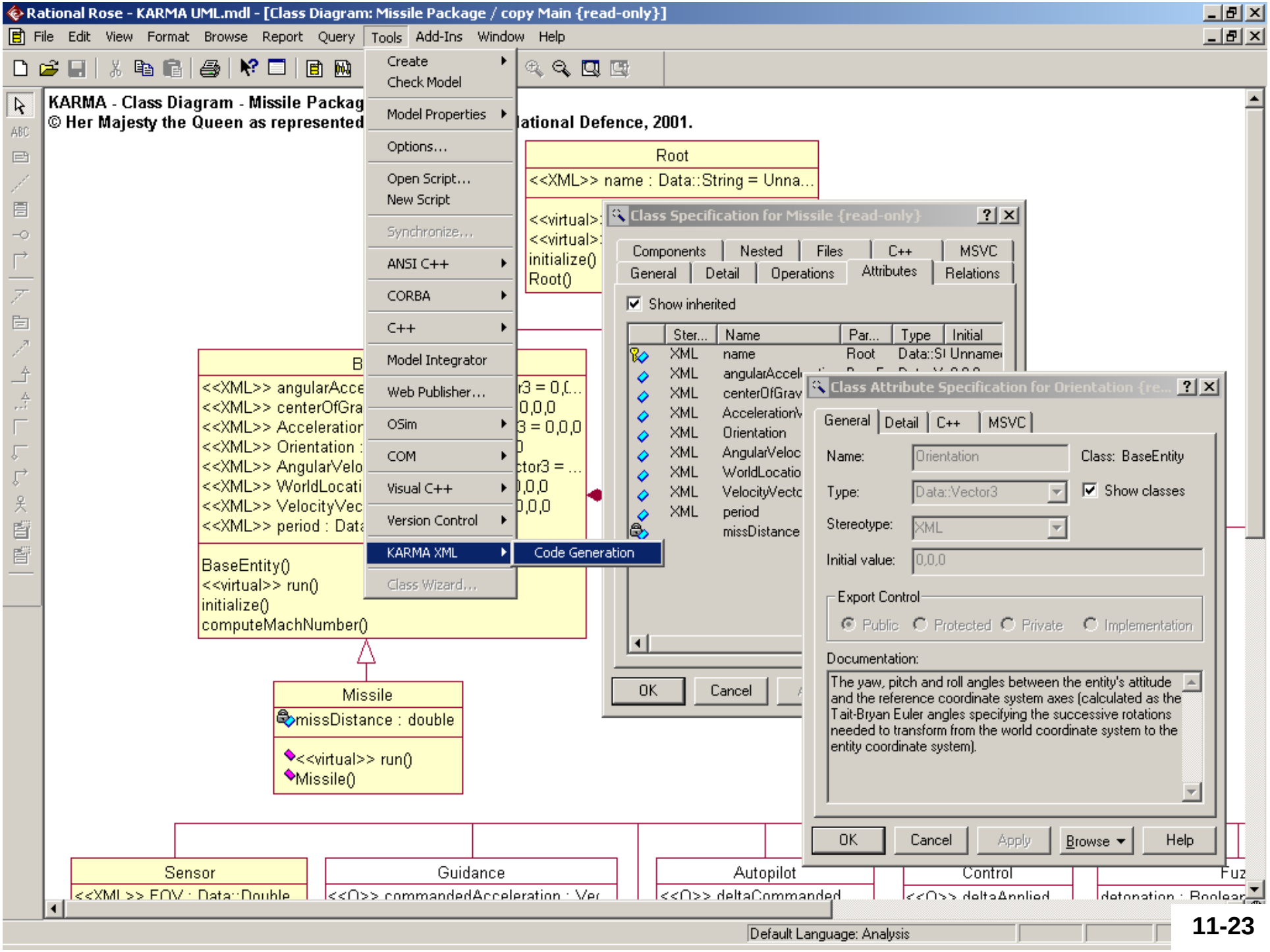
<<struct>> (
Guidance (
Guidance/a
Gyroscope
IMU
KARMA - Class Diagram - Missile Package
© Her Majesty the Queen as represented by the Minister of National Defence, 2001.
Root
<<XML>> name : Data::String = Unnamed
<<virtual>> getParameter()
<<virtual>> setParameter()
initialize()
Root()
BaseEntity
<<XML>> angularAcceleration : Data::Vector3 = 0,0,0
<<XML>> centerOfGravity : Data::Vector3 = 0,0,0
<<XML>> AccelerationVector : Data::Vector3 = 0,0,0
<<XML>> Orientation : Data::Vector3 = 0,0,0
<<XML>> AngularVelocityVector : Data::Vector3 = 0,0,0
<<XML>> WorldLocation : Data::Vector3 = 0,0,0
<<XML>> VelocityVector : Data::Vector3 = 0,0,0
<<XML>> period : Data::Double = 1
BaseEntity()
<<virtual>> run()
initialize()
computeMachNumber()
#partList
0..*
Part
<<virtual>> run()
Part()
observe
0..*
Missile
missDistance : double
<<virtual>> run()
Missile()
Sensor
<<XML>> FOV : Data::Double = 2
<<virtual>> run()
Sensor()
Seeker
<<virtual>> run()
Seeker()
Guidance
<<O>> commandedAcceleration : Vector3
<<I>> LOSRate
<<virtual>> run()
Guidance()
changeState()
Autopilot
<<O>> deltaCommanded
<<I>> commandedAcceleration
<<virtual>> run()
Control
<<O>> deltaApplied
<<I>> deltaCommanded
<<virtual>> run()
Fuze
detonation : Boolean
targetPosition : Vector3
<<XML>> fuzingConeLength
<<XML>> fuzingConeHalfAn
<<XML>> targetGeometryMa
FindTarget()
run()
ForceGenerator
<<virtual>> run()
Log
For Help, press F1
Default Language: Analysis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File Edit View Format Browse Report Query Tools Add-Ins Window Help
Create
Check Model
Model Properties
Options...
Open Script...
New Script
Synchronize...
ANSI C++
CORBA
C++
Model Integrator
Web Publisher...
OSim
COM
Visual C++
Version Control
KARMA XML
Code Generation
Class Wizard...
KARMA - Class Diagram - Missile Packag
© Her Majesty the Queen as represented
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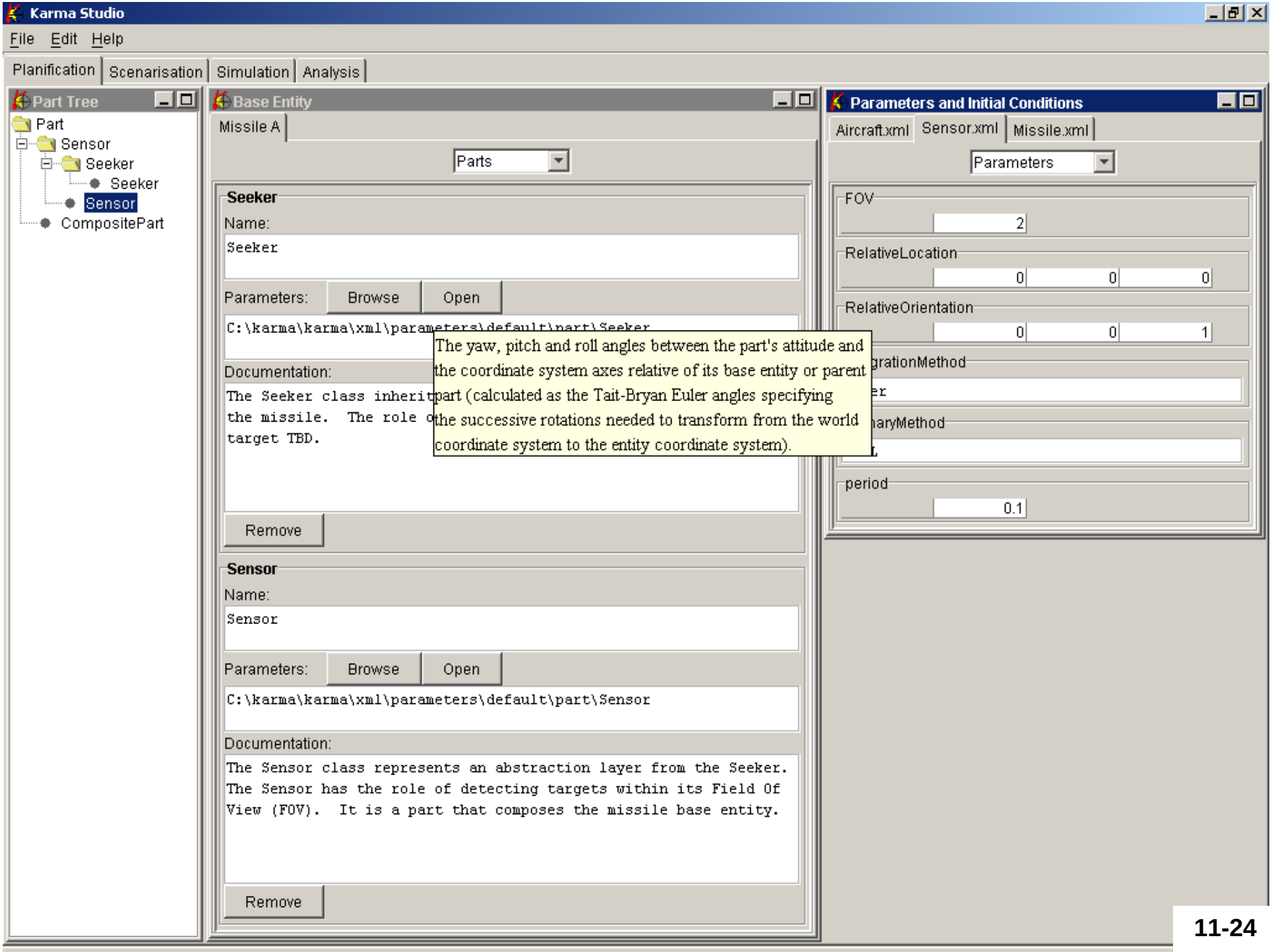
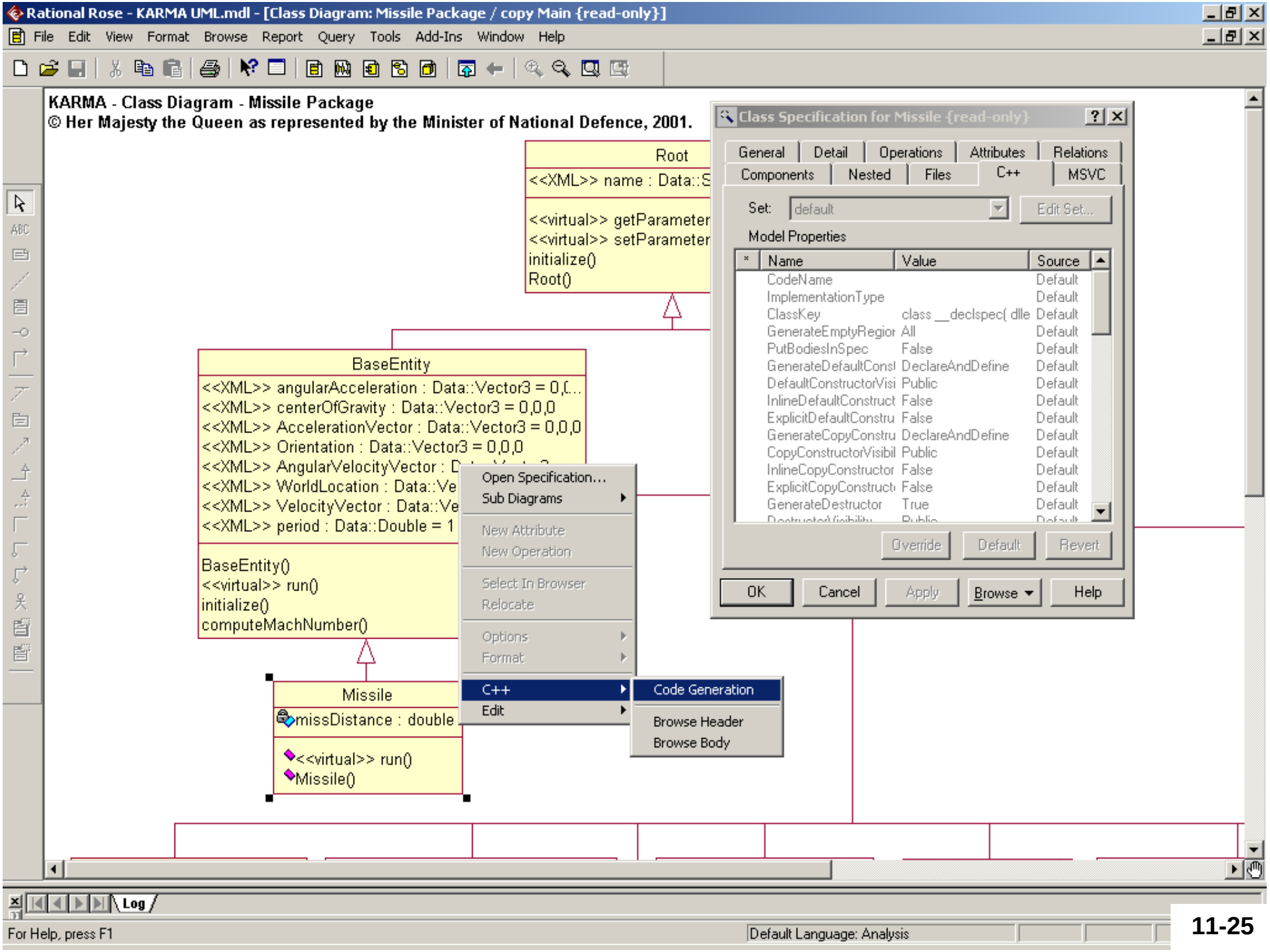
Root
<<XML>> name : Data::String = Unna...
<<virtual>>
<<virtual>>
initialize()
Root()
Class Specification for Missile {read-only}
Components Nested Files C++ MSVC
General Detail Operations Attributes Relations
Show inherited
Ster... Name Par... Type Initial
XML name Root Data::St Unname
XML angularAccel
XML centerOfGrav
XML Acceleration
XML Orientation
XML AngularVeloc
XML WorldLocatio
XML VelocityVecto
XML period
missDistance
OK Cancel
Class Attribute Specification for Orientation {re...
General Detail C++ MSVC
Name: Orientation
Class: BaseEntity
Type: Data::Vector3
Show classes
Stereotype: XML
Initial value: 0,0,0
Export Control
Public Protected Private Implementation
Documentation:
The yaw, pitch and roll angles between the entity's attitude and the reference coordinate system axes (calculated as the Tait-Bryan Euler angles specifying the successive rotations needed to transform from the world coordinate system to the entity coordinate system).
OK Cancel Apply Browse Help
<<XML>> angularAcce
<<XML>> centerOfGra
<<XML>> Acceleratior
<<XML>> Orientation :
<<XML>> AngularVelo
<<XML>> WorldLocati
<<XML>> VelocityVec
<<XML>> period : Data
BaseEntity()
<<virtual>> run()
initialize()
computeMachNumber()
Missile
missDistance : double
<<virtual>> run()
Missile()
Sensor
Guidance
Autopilot
Control
Default Language: Analysis


Karma Studio
File Edit Help
Planification Scenarisation Simulation Analysis
Part Tree
Part
Sensor
Seeker
Seeker
Sensor
CompositePart
Base Entity
Missile A
Parts
Seeker
Name:
Seeker
Parameters: Browse Open
C:\karma\karma\xml\parameters\default\part\Seeker
Documentation:
The Seeker class inherit
the missile. The role o
target TBD.
Remove
Sensor
Name:
Sensor
Parameters: Browse Open
C:\karma\karma\xml\parameters\default\part\Sensor
Documentation:
The Sensor class represents an abstraction layer from the Seeker.
The Sensor has the role of detecting targets within its Field Of
View (FOV). It is a part that composes the missile base entity.
Remove
The yaw, pitch and roll angles between the part's attitude and the coordinate system axes relative of its base entity or parent part (calculated as the Tait-Bryan Euler angles specifying the successive rotations needed to transform from the world coordinate system to the entity coordinate system).
Parameters and Initial Conditions
Aircraft.xml Sensor.xml Missile.xml
Parameters
FOV
2
RelativeLocation
0 0 0
RelativeOrientation
0 0 1
period
0.1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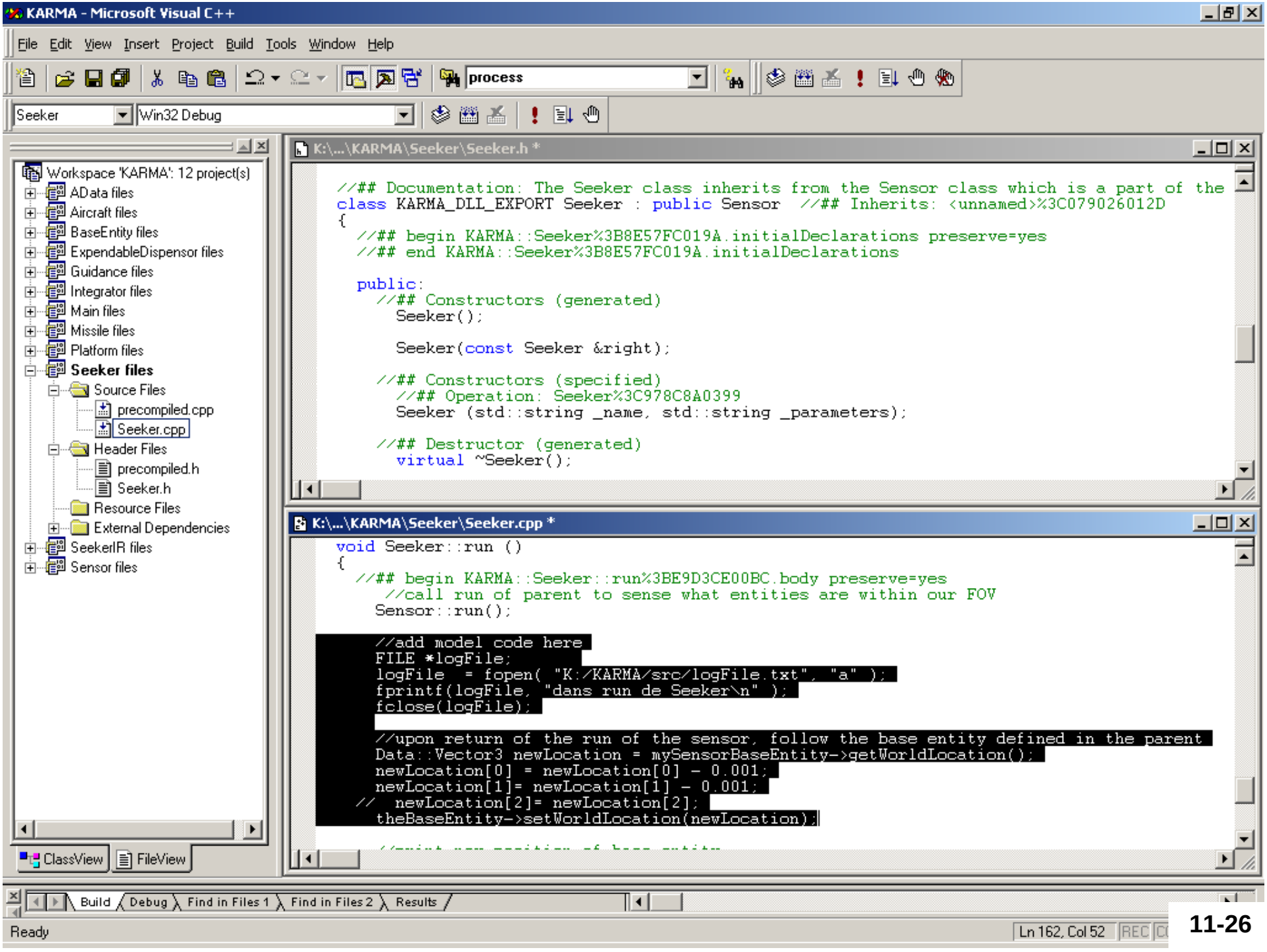
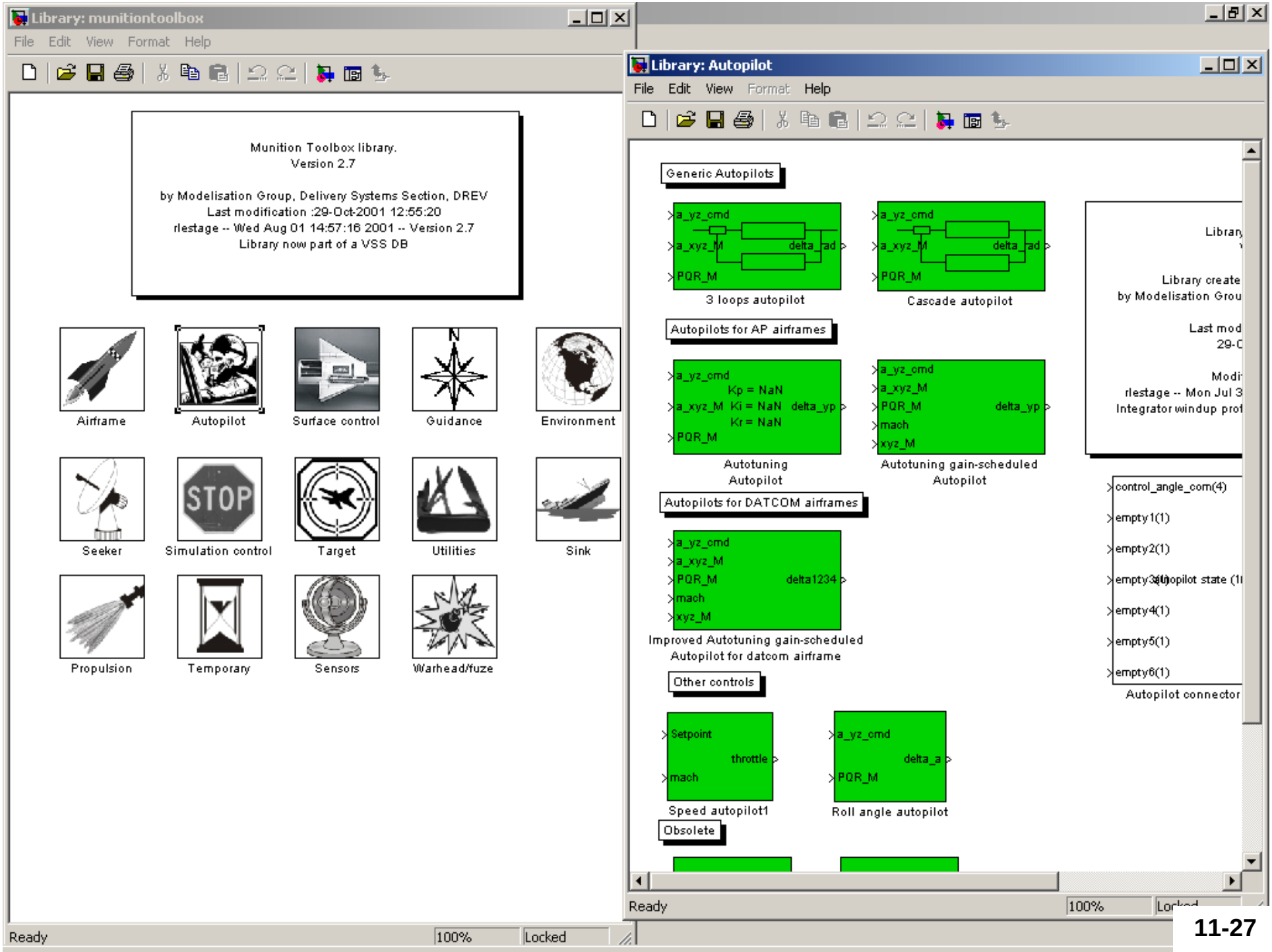
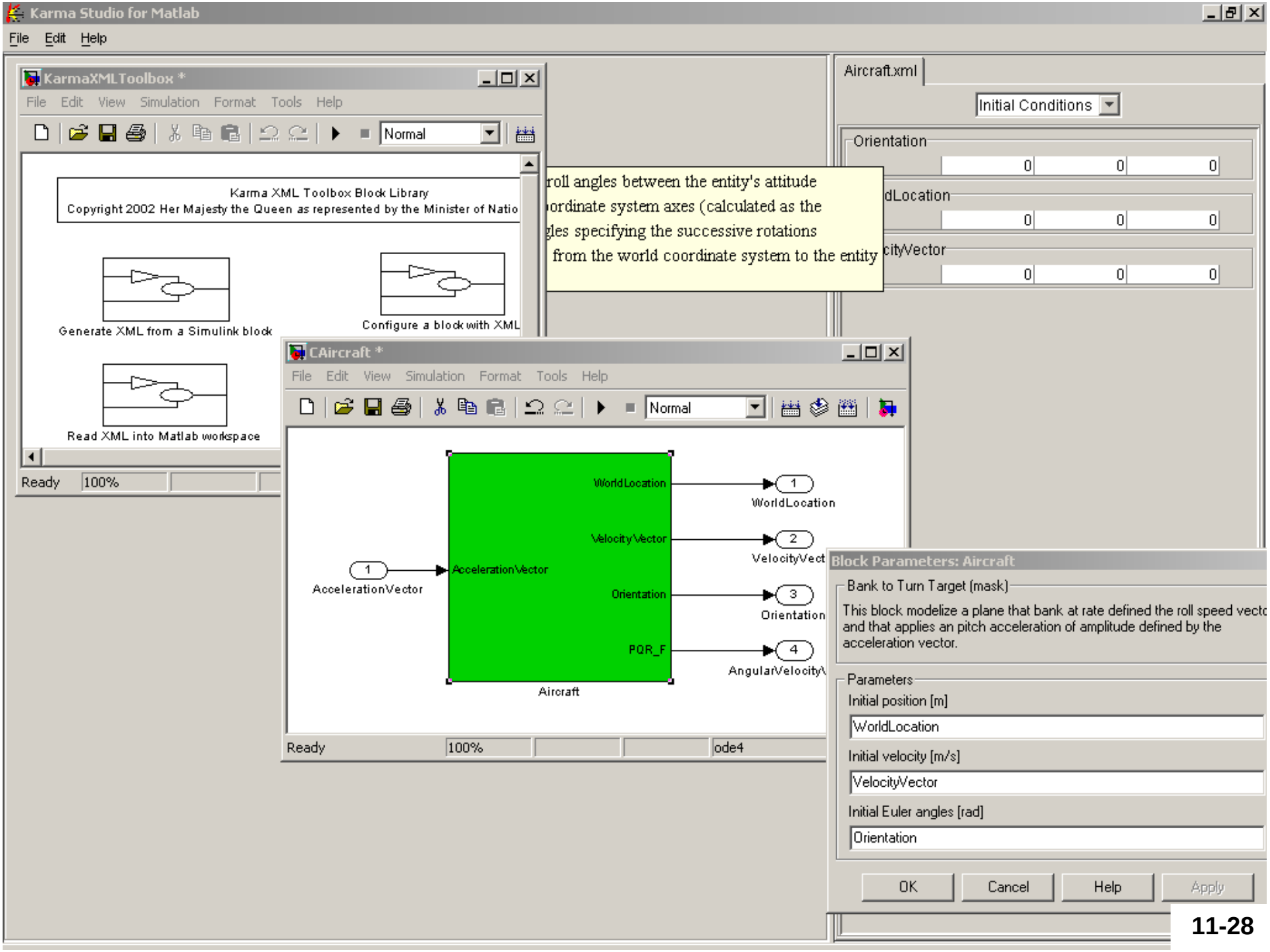
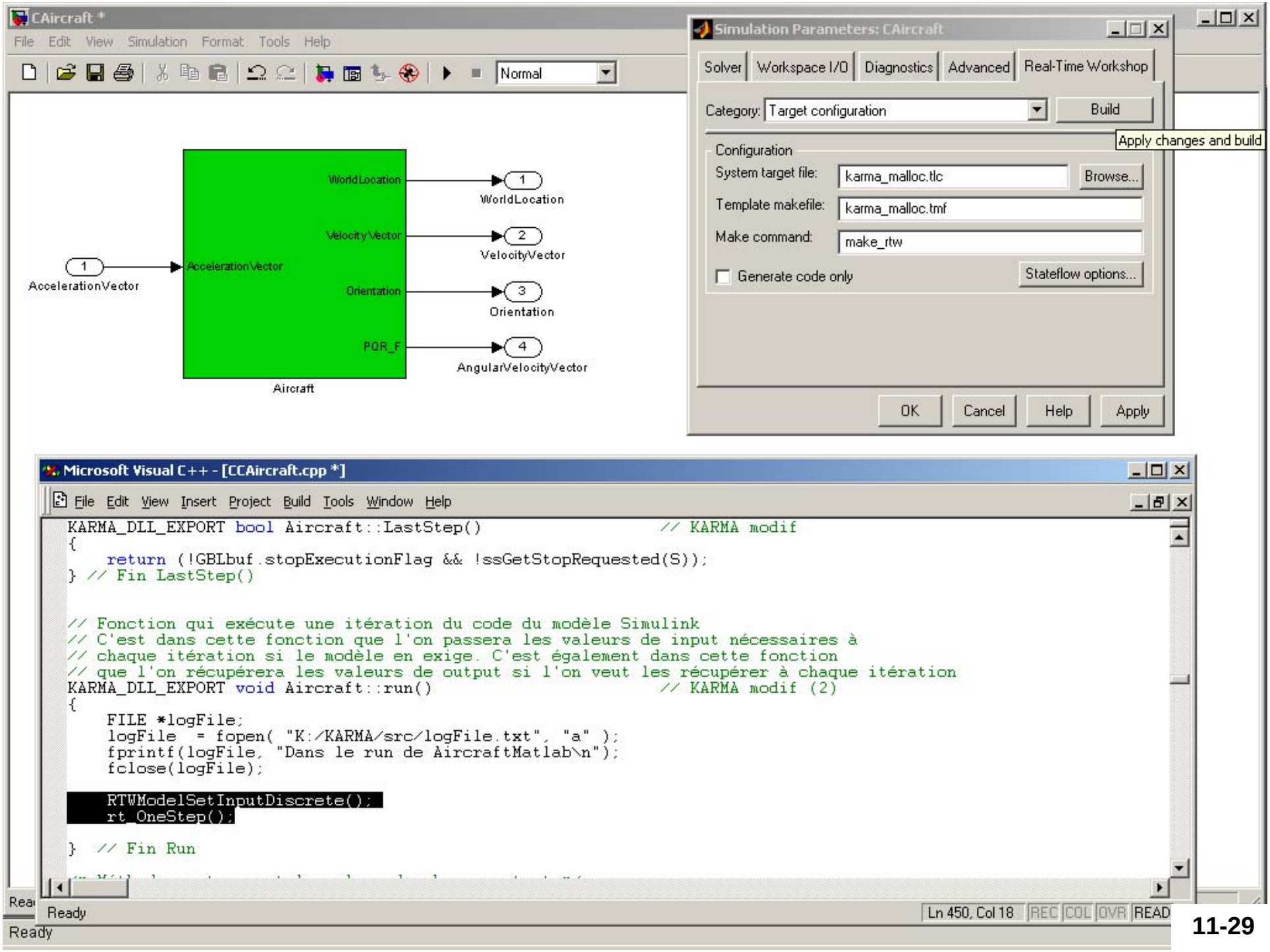
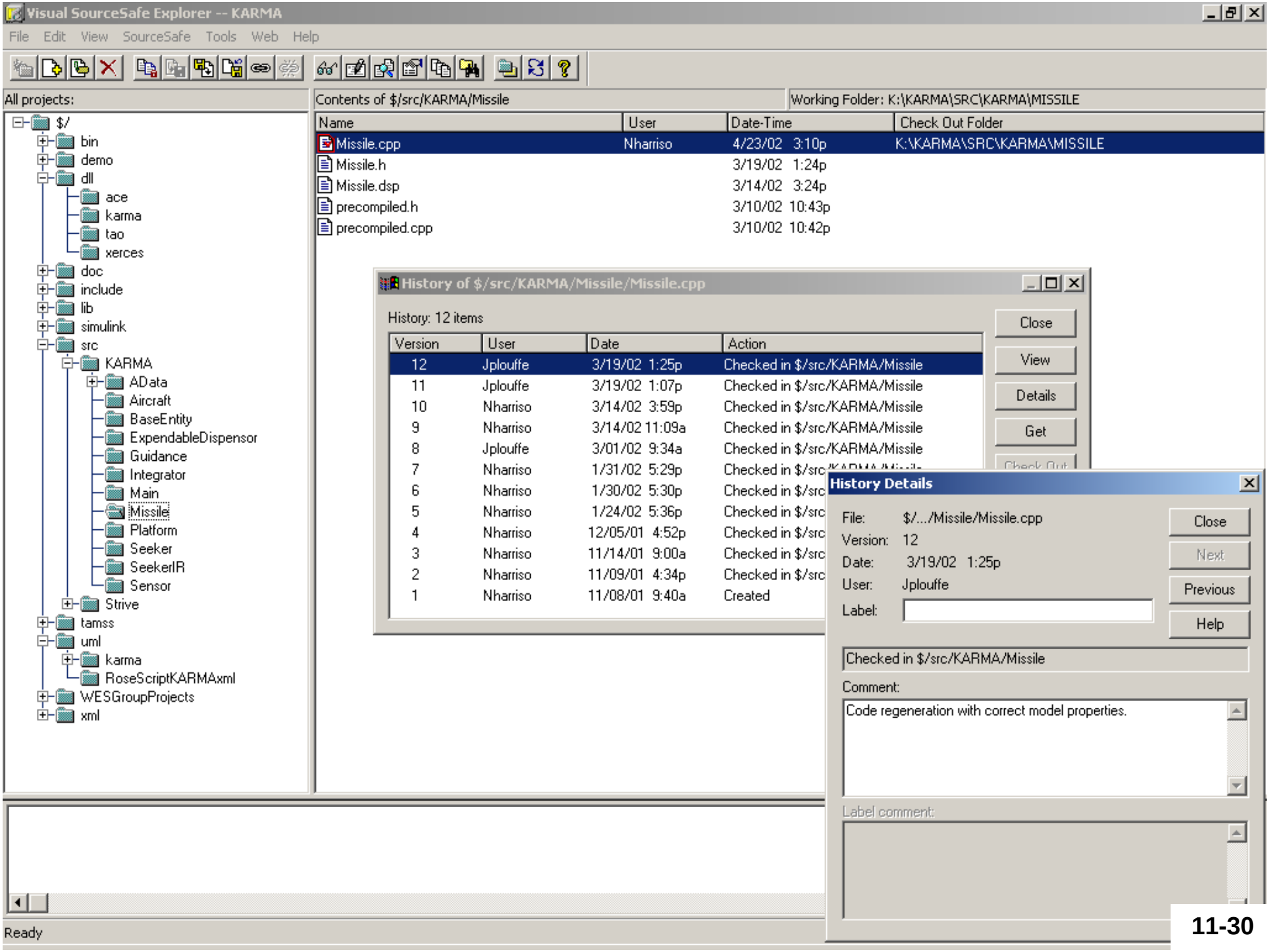
KARMA - Class Diagram - Missile Package
© Her Majesty the Queen as represented by the Minister of National Defence, 2001.
Root
<<XML>> name : Data::S
<<virtual>> getParameter
<<virtual>> setParameter
initialize()
Root()
BaseEntity
<<XML>> angularAcceleration : Data::Vector3 = 0,(...
<<XML>> centerOfGravity : Data::Vector3 = 0,0,0
<<XML>> AccelerationVector : Data::Vector3 = 0,0,0
<<XML>> Orientation : Data::Vector3 = 0,0,0
<<XML>> AngularVelocityVector :
<<XML>> WorldLocation : Data::Ve
<<XML>> VelocityVector : Data::Ve
<<XML>> period : Data::Double = 1
BaseEntity()
<<virtual>> run()
initialize()
computeMachNumber()
Missile
missDistance : double
<<virtual>> run()
Missile()
Open Specification...
Sub Diagrams
New Attribute
New Operation
Select In Browser
Relocate
Options
Format
C++
Edit
Code Generation
Browse Header
Browse Body
Class Specification for Missile {read-only}
General Detail Operations Attributes Relations
Components Nested Files C++ MSVC
Set: default
Edit Set...
Model Properties
Name Value Source
CodeName Default
ImplementationType Default
ClassKey class __declspec(dlle Default
GenerateEmptyRegior All Default
PutBodiesInSpec False Default
GenerateDefaultCons DeclareAndDefine Default
DefaultConstructorVisi Public Default
InlineDefaultConstruct False Default
ExplicitDefaultConstru False Default
GenerateCopyConstru DeclareAndDefine Default
CopyConstructorVisibil Public Default
InlineCopyConstructor False Default
ExplicitCopyConstruct False Default
GenerateDestructor True Default
Override Default Revert
OK Cancel Apply Browse Help
Log
For Help, press F1
Default Language: Analysis

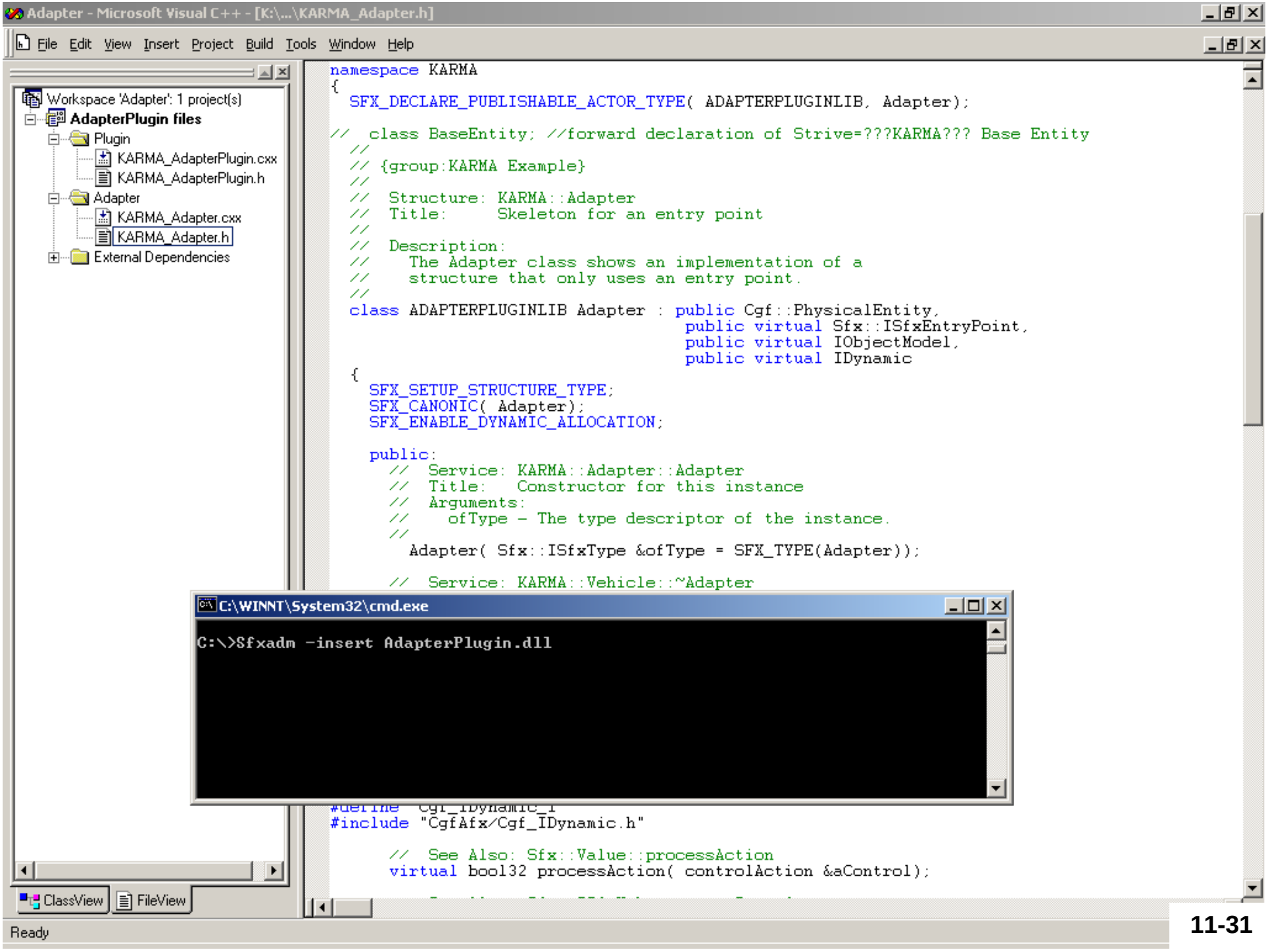

KARMA - Microsoft Visual C++
File Edit View Insert Project Build Tools Window Help
process
Seeker
Win32 Debug
Workspace 'KARMA': 12 project(s)
AData files
Aircraft files
BaseEntity files
ExpendableDispensor files
Guidance files
Integrator files
Main files
Missile files
Platform files
Seeker files
Source Files
precompiled.cpp
Seeker.cpp
Header Files
precompiled.h
Seeker.h
Resource Files
External Dependencies
SeekerIR files
Sensor files
ClassView
FileView
K:\...\KARMA\Seeker\Seeker.h *
//## Documentation: The Seeker class inherits from the Sensor class which is a part of the
class KARMA_DLL_EXPORT Seeker : public Sensor //## Inherits: <unnamed>%3C079026012D
{
//## begin KARMA::Seeker%3B8E57FC019A.initialDeclarations preserve=yes
//## end KARMA::Seeker%3B8E57FC019A.initialDeclarations
public:
//## Constructors (generated)
Seeker();
Seeker(const Seeker &right);
//## Constructors (specified)
//## Operation: Seeker%3C978C8A0399
Seeker (std::string _name, std::string _parameters);
//## Destructor (generated)
virtual ~Seeker();
K:\...\KARMA\Seeker\Seeker.cpp *
void Seeker::run ()
{
//## begin KARMA::Seeker::run%3BE9D3CE00BC.body preserve=yes
//call run of parent to sense what entities are within our FOV
Sensor::run();
//add model code here
FILE *logFile;
logFile = fopen("K:/KARMA/src/logFile.txt", "a");
fprintf(logFile, "dans run de Seeker\n");
fclose(logFile);
//upon return of the run of the sensor, follow the base entity defined in the parent
Data::Vector3 newLocation = mySensorBaseEntity->getWorldLocation();
newLocation[0] = newLocation[0] - 0.001;
newLocation[1]= newLocation[1] - 0.001;
// newLocation[2]= newLocation[2];
theBaseEntity->setWorldLocation(newLocation);
Build
Debug
Find in Files 1
Find in Files 2
Results
Ready
Ln 162, Col 52
REC

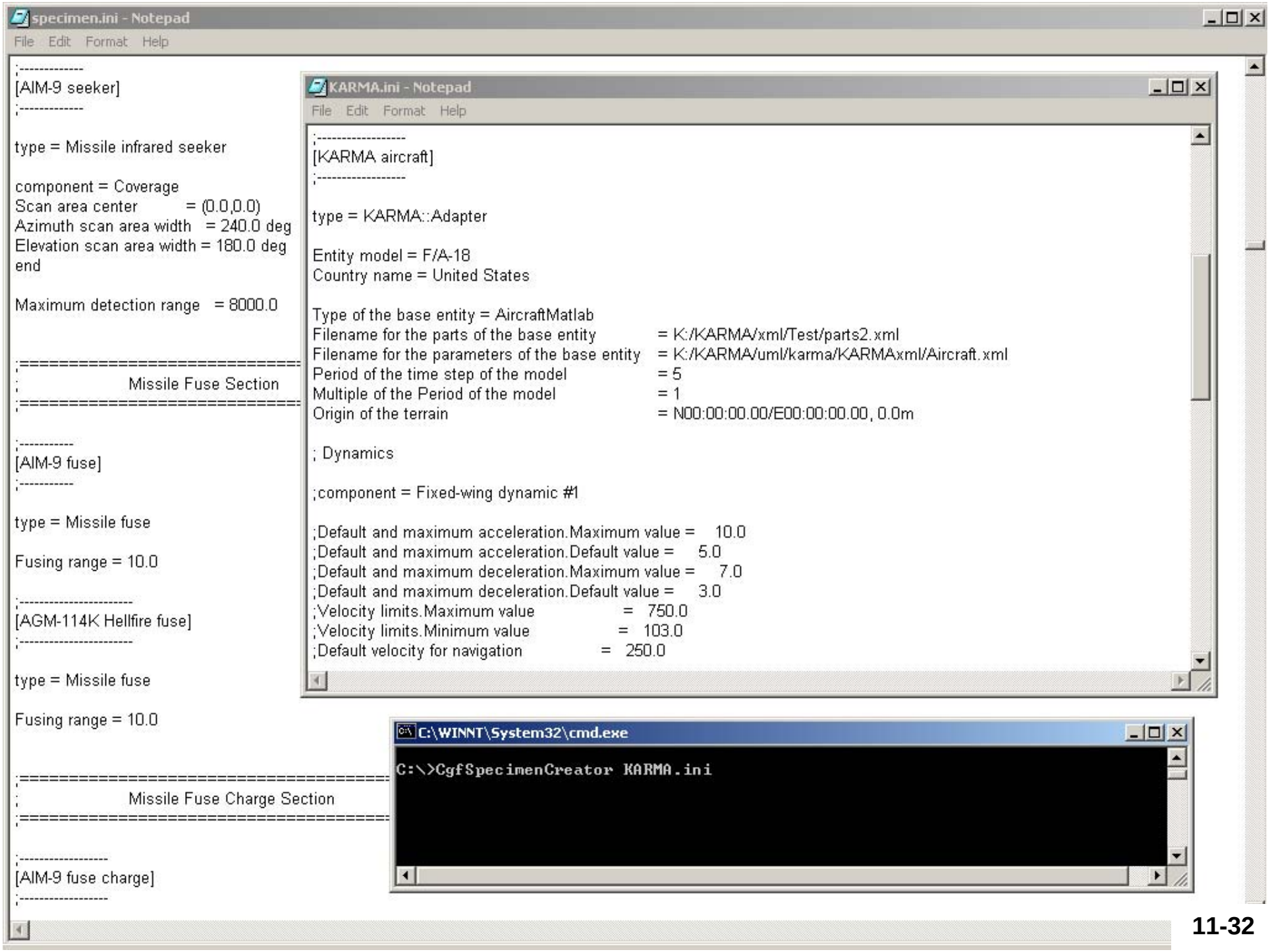

Library: munitiontoolbox
File Edit View Format Help
Munition Toolbox library.
Version 2.7
by Modelisation Group, Delivery Systems Section, DREV
Last modification :29-Oct-2001 12:55:20
rlestage -- Wed Aug 01 14:57:16 2001 -- Version 2.7
Library now part of a VSS DB
Airframe
Autopilot
Surface control
Guidance
Environment
Seeker
Simulation control
Target
Utilities
Sink
Propulsion
Temporary
Sensors
Warhead/fuze
Ready
100%
Locked
Library: Autopilot
File Edit View Format Help
Generic Autopilots
a_yz_cmd
a_xyz_M
PQR_M
delta_ad
3 loops autopilot
Cascade autopilot
Autopilots for AP airframes
Kp = NaN
Ki = NaN
Kr = NaN
delta_yp
Autotuning Autopilot
mach
xyz_M
Autotuning gain-scheduled Autopilot
Autopilots for DATCOM airframes
delta1234
Improved Autotuning gain-scheduled Autopilot for datcom airframe
Other controls
Setpoint
throttle
Speed autopilot1
delta_a
Roll angle autopilot
Obsolete
control_angle_com(4)
empty1(1)
empty2(1)
empty4(1)
empty5(1)
empty6(1)
Autopilot connector
Ready
100%

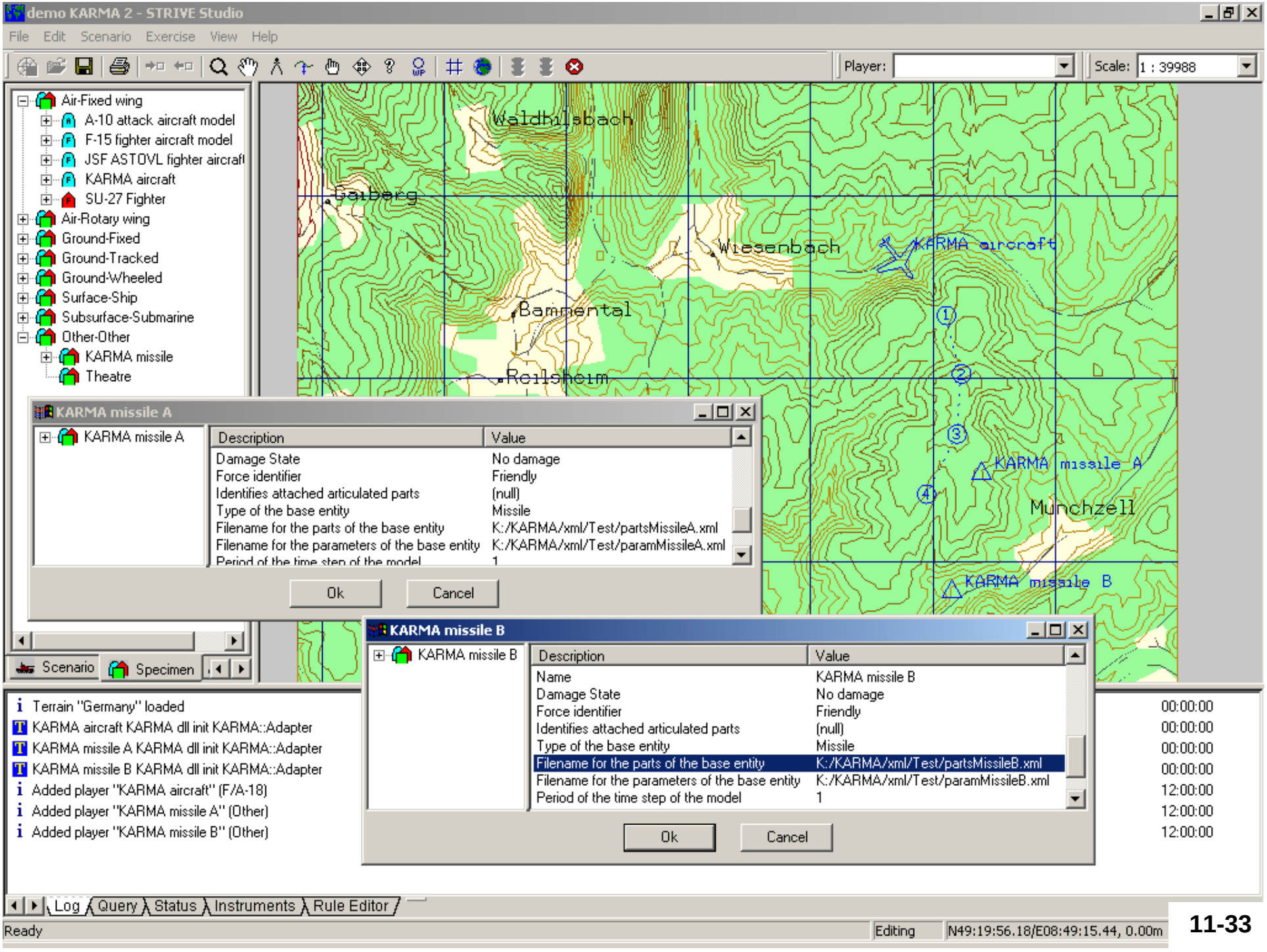

Karma Studio for Matlab
File Edit Help
KarmaXMLToolbox *
File Edit View Simulation Format Tools Help
Normal
Karma XML Toolbox Block Library
Copyright 2002 Her Majesty the Queen as represented by the Minister of Natio
Generate XML from a Simulink block
Configure a block with XML
Read XML into Matlab workspace
Ready 100%
roll angles between the entity's attitude
ordinate system axes (calculated as the
gles specifying the successive rotations
from the world coordinate system to the entity
Aircraft.xml
Initial Conditions
Orientation
0 0 0
dLocation
0 0 0
cityVector
0 0 0
CAircraft *
File Edit View Simulation Format Tools Help
Normal
WorldLocation
VelocityVector
Orientation
PQR_F
1
WorldLocation
2
VelocityVect
3
Orientation
4
AngularVelocity
1
AccelerationVector
AccelerationVector
Aircraft
Ready 100% ode4
Block Parameters: Aircraft
Bank to Turn Target (mask)
This block modelize a plane that bank at rate defined the roll speed vecto
and that applies an pitch acceleration of amplitude defined by the
acceleration vector.
Parameters
Initial position [m]
WorldLocation
Initial velocity [m/s]
VelocityVector
Initial Euler angles [rad]
Orientation
OK Cancel Help Apply


CAircraft *
File Edit View Simulation Format Tools Help
Normal
WorldLocation
VelocityVector
Acceleration\Vector
Orientation
PQR_F
1
WorldLocation
2
VelocityVector
1
AccelerationVector
3
Orientation
4
AngularVelocityVector
Aircraft
Simulation Parameters: CAircraft
Solver
Workspace I/O
Diagnostics
Advanced
Real-Time Workshop
Category: Target configuration
Build
Apply changes and build
Configuration
System target file: karma_malloc.tlc
Browse...
Template makefile: karma_malloc.tmf
Make command: make_rtw
Generate code only
Stateflow options...
OK
Cancel
Help
Apply
Microsoft Visual C++ - [CCAircraft.cpp *]
File Edit View Insert Project Build Tools Window Help
KARMA_DLL_EXPORT bool Aircraft::LastStep() // KARMA modif
{
return (!GBLbuf.stopExecutionFlag && !ssGetStopRequested(S));
} // Fin LastStep()
// Fonction qui exécute une itération du code du modèle Simulink
// C'est dans cette fonction que l'on passera les valeurs de input nécessaires à
// chaque itération si le modèle en exige. C'est également dans cette fonction
// que l'on récupérera les valeurs de output si l'on veut les récupérer à chaque itération
KARMA_DLL_EXPORT void Aircraft::run() // KARMA modif (2)
{
FILE *logFile;
logFile = fopen("K:/KARMA/src/logFile.txt", "a");
fprintf(logFile, "Dans le run de AircraftMatlab\n");
fclose(logFile);
RTWModelSetInputDiscrete();
rt_OneStep();
} // Fin Run
Ready
Ln 450, Col 18
REC COL OVR READ
Ready

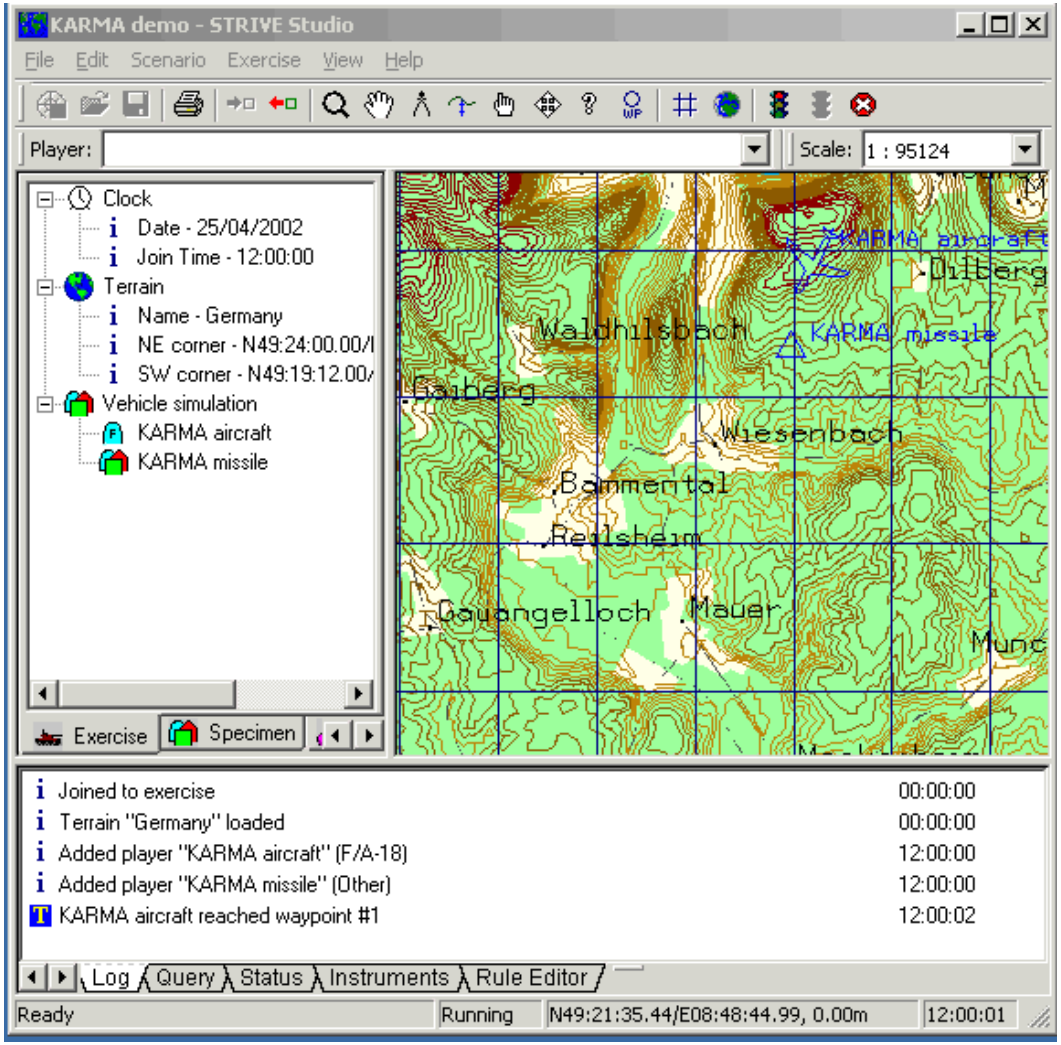

Visual SourceSafe Explorer -- KARMA
File Edit View SourceSafe Tools Web Help
All projects:
$/
bin
demo
dll
ace
karma
tao
xerces
doc
include
lib
simulink
src
KARMA
AData
Aircraft
BaseEntity
ExpendableDispensor
Guidance
Integrator
Main
Missile
Platform
Seeker
SeekerIR
Sensor
Strive
tamss
uml
karma
RoseScriptKARMAxml
WESGroupProjects
xml
Contents of $/src/KARMA/Missile
Working Folder: K:\KARMA\SRC\KARMA\MISSILE
Name User Date-Time Check Out Folder
Missile.cpp Nharriso 4/23/02 3:10p K:\KARMA\SRC\KARMA\MISSILE
Missile.h 3/19/02 1:24p
Missile.dsp 3/14/02 3:24p
precompiled.h 3/10/02 10:43p
precompiled.cpp 3/10/02 10:42p
History of $/src/KARMA/Missile/Missile.cpp
History: 12 items
Close
View
Details
Get
Check Out
Version User Date Action
12 Jplouffe 3/19/02 1:25p Checked in $/src/KARMA/Missile
11 Jplouffe 3/19/02 1:07p Checked in $/src/KARMA/Missile
10 Nharriso 3/14/02 3:59p Checked in $/src/KARMA/Missile
9 Nharriso 3/14/02 11:09a Checked in $/src/KARMA/Missile
8 Jplouffe 3/01/02 9:34a Checked in $/src/KARMA/Missile
7 Nharriso 1/31/02 5:29p Checked in $/src/KARMA/Missile
6 Nharriso 1/30/02 5:30p Checked in $/src
5 Nharriso 1/24/02 5:36p Checked in $/src
4 Nharriso 12/05/01 4:52p Checked in $/src
3 Nharriso 11/14/01 9:00a Checked in $/src
2 Nharriso 11/09/01 4:34p Checked in $/src
1 Nharriso 11/08/01 9:40a Created
History Details
File: $/.../Missile/Missile.cpp
Version: 12
Date: 3/19/02 1:25p
User: Jplouffe
Label:
Close
Next
Previous
Help
Checked in $/src/KARMA/Missile
Comment:
Code regeneration with correct model properties.
Label comment:
Ready


Adapter - Microsoft Visual C++ - [K:\...\KARMA_Adapter.h]
File Edit View Insert Project Build Tools Window Help
Workspace 'Adapter': 1 project(s)
AdapterPlugin files
Plugin
KARMA_AdapterPlugin.cxx
KARMA_AdapterPlugin.h
Adapter
KARMA_Adapter.cxx
KARMA_Adapter.h
External Dependencies
ClassView
FileView
namespace KARMA
{
SFX_DECLARE_PUBLISHABLE_ACTOR_TYPE(ADAPTERPLUGINLIB, Adapter);
// class BaseEntity; //forward declaration of Strive=???KARMA??? Base Entity
//
// {group:KARMA Example}
//
// Structure: KARMA::Adapter
// Title: Skeleton for an entry point
//
// Description:
// The Adapter class shows an implementation of a
// structure that only uses an entry point.
//
class ADAPTERPLUGINLIB Adapter : public Cgf::PhysicalEntity,
public virtual Sfx::ISfxEntryPoint,
public virtual IObjectModel,
public virtual IDynamic
{
SFX_SETUP_STRUCTURE_TYPE;
SFX_CANONIC(Adapter);
SFX_ENABLE_DYNAMIC_ALLOCATION;
public:
// Service: KARMA::Adapter::Adapter
// Title: Constructor for this instance
// Arguments:
// ofType - The type descriptor of the instance.
//
Adapter(Sfx::ISfxType &ofType = SFX_TYPE(Adapter));
// Service: KARMA::Vehicle::~Adapter
C:\WINNT\System32\cmd.exe
C:\>Sfxadm -insert AdapterPlugin.dll
#include "CgfAfx/Cgf_IDynamic.h"
// See Also: Sfx::Value::processAction
virtual bool32 processAction(controlAction &aControl);
Ready


specimen.ini - Notepad
File Edit Format Help
;------------
[AIM-9 seeker]
;------------
type = Missile infrared seeker
component = Coverage
Scan area center = (0.0,0.0)
Azimuth scan area width = 240.0 deg
Elevation scan area width = 180.0 deg
end
Maximum detection range = 8000.0
;============================
; Missile Fuse Section
;============================
;-----------
[AIM-9 fuse]
;-----------
type = Missile fuse
Fusing range = 10.0
;----------------------
[AGM-114K Hellfire fuse]
;----------------------
type = Missile fuse
Fusing range = 10.0
;====================================
; Missile Fuse Charge Section
;====================================
;-----------------
[AIM-9 fuse charge]
;-----------------
KARMA.ini - Notepad
File Edit Format Help
;-----------------
[KARMA aircraft]
;-----------------
type = KARMA::Adapter
Entity model = F/A-18
Country name = United States
Type of the base entity = AircraftMatlab
Filename for the parts of the base entity = K:/KARMA/xml/Test/parts2.xml
Filename for the parameters of the base entity = K:/KARMA/uml/karma/KARMAxml/Aircraft.xml
Period of the time step of the model = 5
Multiple of the Period of the model = 1
Origin of the terrain = N00:00:00.00/E00:00:00.00, 0.0m
; Dynamics
;component = Fixed-wing dynamic #1
;Default and maximum acceleration.Maximum value = 10.0
;Default and maximum acceleration.Default value = 5.0
;Default and maximum deceleration.Maximum value = 7.0
;Default and maximum deceleration.Default value = 3.0
;Velocity limits.Maximum value = 750.0
;Velocity limits.Minimum value = 103.0
;Default velocity for navigation = 250.0
C:\WINNT\System32\cmd.exe
C:\>CgfSpecimenCreator KARMA.ini


demo KARMA 2 - STRIVE Studio
File Edit Scenario Exercise View Help
Player:
Scale: 1 : 39988
Air-Fixed wing
A-10 attack aircraft model
F-15 fighter aircraft model
JSF ASTOVL fighter aircraft
KARMA aircraft
SU-27 Fighter
Air-Rotary wing
Ground-Fixed
Ground-Tracked
Ground-Wheeled
Surface-Ship
Subsurface-Submarine
Other-Other
KARMA missile
Theatre
Waldhilsbach
Gaiberg
Wiesenbach
Bammental
Reilsheim
KARMA aircraft
KARMA missile A
Munchzell
KARMA missile B
KARMA missile A
KARMA missile A
Description
Value
Damage State
No damage
Force identifier
Friendly
Identifies attached articulated parts
(null)
Type of the base entity
Missile
Filename for the parts of the base entity
K:/KARMA/xml/Test/partsMissileA.xml
Filename for the parameters of the base entity
K:/KARMA/xml/Test/paramMissileA.xml
Period of the time step of the model
1
Ok
Cancel
KARMA missile B
KARMA missile B
Description
Value
Name
KARMA missile B
Damage State
No damage
Force identifier
Friendly
Identifies attached articulated parts
(null)
Type of the base entity
Missile
Filename for the parts of the base entity
K:/KARMA/xml/Test/partsMissileB.xml
Filename for the parameters of the base entity
K:/KARMA/xml/Test/paramMissileB.xml
Period of the time step of the model
1
Ok
Cancel
Scenario
Specimen
Terrain "Germany" loaded
KARMA aircraft KARMA dll init KARMA::Adapter
KARMA missile A KARMA dll init KARMA::Adapter
KARMA missile B KARMA dll init KARMA::Adapter
Added player "KARMA aircraft" (F/A-18)
Added player "KARMA missile A" (Other)
Added player "KARMA missile B" (Other)
00:00:00
00:00:00
00:00:00
00:00:00
12:00:00
12:00:00
12:00:00
Log
Query
Status
Instruments
Rule Editor
Ready
Editing
N49:19:56.18/E08:49:15.44, 0.00m

Demo


KARMA demo - STRIVE Studio
File Edit Scenario Exercise View Help
Player:
Scale: 1 : 95124
Clock
Date - 25/04/2002
Join Time - 12:00:00
Terrain
Name - Germany
NE corner - N49:24:00.00/I
SW corner - N49:19:12.00/
Vehicle simulation
KARMA aircraft
KARMA missile
Exercise
Specimen
KARMA aircraft
KARMA missile
Waldhilsbach
Wiesenbach
Bammental
Reilsheim
Mauer
Joined to exercise 00:00:00
Terrain "Germany" loaded 00:00:00
Added player "KARMA aircraft" (F/A-18) 12:00:00
Added player "KARMA missile" (Other) 12:00:00
KARMA aircraft reached waypoint #1 12:00:02
Log Query Status Instruments Rule Editor
Ready
Running
N49:21:35.44/E08:48:44.99, 0.00m
12:00:01