Application of the Open Source Approach to Space Environment Analysis Tools

Seventeenth European Thermal & ECLS Software Workshop
21 – 22 October 2003

Outline

• Background

• The “Open Frontier” platform
  × Components
  × Licensing Issues
  × Data model
  × Architectural Design

• The ESABASE/Debris plugin
  × Open Frontier + ESABASE/Debris = PC ESABASE
  × PC ESABASE Online Presentation

• Summary + Outlook
Background

• **ESA Study**
  - “Porting of the existing ESABASE/Debris Application to PC platform“
  - Study Manager: G. Drolshagen (TOS-EES)
  - Duration: 01/2003 - 06/2004
  - Usage of Off The Shelf (OTS) tools and Open Source software strongly recommended
  - Open Interfaces (STEP) is a “must”

• **Approach:**
  - Provide a generic platform offering everything a high level SE analysis tool needs (Open Frontier)
  - Plug in ESABASE/Debris (pre-processors, post-processors and solver)

• **Open Frontier + ESABASE/Debris = PC-ESABASE**
• Open Frontier plugin philosophy is open to other pre- and post processors, solvers and also to different disciplines
Background

• Problem
  × Ageing Space Environment Analysis Tools
    • Cumbersome user interfaces
    • Restricted data models
    • Platform dependence
    • Undefined or non-existent interfaces to external tools
    × Extensive Pre- and post-processing
  × Serious constraints of their acceptance and availability (ESABASE;..)

• Task  (→ related to ESABASE/Debris)
  × Provide a PC based solution (Windows; Linux)
  × Replace the existing framework
  × Retain existing kernels (solver) as far as possible (ESABASE/Debris)
  × Provide interfaces to external tools (CAD → STEP)

Approach

• Usage of “Off The Shelf” (OTS) Software
  × prevents re-invention of the wheel and may save development effort
  
  but …
  × OTS solutions are normally far from providing ‘plug + play’ capabilities
  × Not every problem is solved by an OTS solution

• Open Source Software
  × avoids ‘proprietary’ dead-ends
  
  but ..
  × does not always provide a business case
Open Frontier

Components
Licensing Issues
Data model
Architectural Design

Identification of OTS Solutions

• What is needed?

  ✒ Framework Components
  • Graphical User Interface  Eclipse
  • Geometrical Model Viewer + Builder  Open Cascade
  • Result Viewer (2D; 3D graphs; ‘Special Plots’)  VisAD
  • Report generator  JFreeReport

  ✒ Platform
  • Flexible, transparent + scalable data model  OCAF
  • CAD data exchange (STEP compliance)  Open Cascade
Graphical User Interface

Eclipse

- What is Eclipse?
  - IBM states that "Eclipse is an IDE for anything, and for nothing in particular."
  - Wide distribution as Java IDE, but also in the IBM commercial tool world (WebSphere)

- Eclipse is a high level GUI platform
  - Widely accepted Look & Feel
    - Native GUI components → native user experience
    - Existing framework → less components to develop
    - Primitive GUI elements → Buttons, Checkboxes, Textfields, Trees
    - complex display/edit views → Viewers, Editors
    - Always state-of-the-art in contrast to self-developed solutions

- Eclipse is Open Source
- Eclipse encourages platform building
  - Plugin model with well defined interfaces
  - Built-in plugin development environment
Geometrical Model Viewer + Builder
Open Cascade

- What is Open Cascade?
  - Open Cascade is a geometric modelling toolkit
    - Create primitives such as prism, cylinder, cone and torus
    - Perform Boolean operations (addition, subtraction and intersection)
    - Compute properties such as surface, volume, centre of gravity, curvature
    - Compute geometry using projection, interpolation, approximation
  - Open Cascade is a 3D Viewer
    - ready-to-use user interaction and visualization services
    - 3D rotation, Zoom, Shading, graphical selection of geometrical objects
  - Open Cascade is Open Source
    - Based on the Swing Java 2™-based library, the Java Application Desktop (JAD ➔ commercial) makes the application portable on all platforms running the Java 2™ Virtual Machine

Application of the Open Source Approach to Space Environment Analysis Tools
Seventeenth European Thermal & ECLSS Software Workshop, 21 – 22 October 2003, ESA/ESTEC, Noordwijk, The Netherlands
Open Cascade Interfaces

• Open Cascade allows data exchange through standard interfaces
  • STEP
    • AP 203, 214
    • [209], “rough implementation” in latest release
    • SPE – PC ESABASE compatibility to be established by eta_max under ESA contract (prime: Simulog)
  • CAD
    • IGES, BREP, CSFDB
    • CATIA → free for users if bought by developer (license required)

Result Viewer
VisAD

Application of the Open Source Approach to Space Environment Analysis Tools
Seventeenth European Thermal & ECLS Software Workshop, 21 – 22 October 2003, ESA/ESTEC, Noordwijk, The Netherlands

page 13

Despite the slight distortion, the document content remains clear and unaltered.
VisAD

- What is VisAD?
  - VisAD is dedicated to the visualisation of scientific results
  - VisAD provides a wide range of customisation capabilities plus the possibility to extend the analysis and visualisation features.
  - VisAD is open source

- VisAD Benefits
  - highly customizable
  - huge feature range
  - supports 2D and 3D chart types
  - supports data manipulations

- VisAD is very well suited to visualise scientific data
- Geometry related results are mapped to geometry elements and displayed by means of OCC

JFreeReport

- JFreeReport supports
  - formatted on-screen display,
  - printer output and
  - PDF output.
  - XML based templates to define report formats.
Licensing Issues

- **Open Cascade**
  - being licensed under the Open Cascade Public License. It allows the distribution of „Derivative Programs“ with different licenses.

- **Eclipse**
  - Common Public License „[…] this license is intended to facilitate the commercial use of the Program […]“

- **VisAD** ➔ LGPL
- **JFreeReport** ➔ LGPL
- **Open Frontier** ➔ to be agreed with ESA
- **PC ESABASE** ➔ to be agreed with ESA

---

Datamodel
The Open Cascade Application Framework (OCAF)

- The establishment of a “good” data model is seen as a key issue

- **OCAF supports a key-driven data structure**
  - Allows to use any type topological and non-topological data
  - Allows free form data model structure as well as a hierarchical structure

- **OCAF allows label attributes**
  - Ready-to-use attributes as well as user-defined attributes

- **OCAF Features**
  - Existing data browser ➔ transparent and ‘readable’ data model
  - Open/Save functionality ➔ allows creation and exchange of data model images
  - Undo/redo mechanism ➔ allows data model changes at run time
  - Accessible from high level programming languages and from script languages

- Open Frontier data model as implemented by means of OCAF is flexible, easily maintainable, scalable.
**Data structure**

- **Document**
  - A complete data tree
  - Capable of loading/saving into/from files

- **Node/Label**
  - A container for data parameters

- **Leaf/Parameter**
  - A named variable containing a single value or an array of values

- **Property**
  - Each leaf/parameter has assigned a list of properties that describe the parameter and its behaviour in the GUI

**Open Frontier**

**Data model top level structure**

- **Analysis Project**
  - **Geometry model**
    - Spacecraft geometry
    - Pointing capabilities
    - Kinematic char.

- **Mission**
  - Orbit
  - Perturbations
  - Mission specifications

- **Output**
  - Orbital points
  - Object orientations
  - Results
  - Tabular results

- **Analysis: Debris**
  - Particle size limits
  - Debris model parameters
  - Meteoroid model parameters
  - Damager/failure equations

**PC ESABASE specific model**

**Open Frontier generic model**
Open Frontier
+ ESABASE/Debris
= PC ESABASE

The platform concept

Open Frontier
- Graphical User Interface
- Input Acquisition
- Visualisation
- Plug-In Module API
- Data Model
  - Geometry
generational data
pointing
kinematic
material information
  - Mission
orbit
time
perturbations
  - Output
pre-processing
geometrical results
tabular results
- General Services
  - Meshing
  - Position
  - Attitude
  - Raytracing

Debris Analysis Tool
- Debris Editor
- Debris Analysis
- Analysis: Debris
  - Debris model
  - Meteoroid model
  - Damage/Failure eq.
  - ...
Application of the Open Source Approach to Space Environment Analysis Tools
Seventeenth European Thermal & ECLSS Software Workshop, 21 – 22 October 2003, ESA/ESTEC, Noordwijk, The Netherlands

GUI Framework
(Eclipse)

Java

VisAD
(Java)

JFreeReport
(Java)

C/C++ Bridge

CFB

Pre - Proc.

Solver: ESABASE
(Fortran Binaries)

Post - Proc.

STEP

Open Cascade
(C++)

OCAF

C++ stubs

J N I

Java API

XML

Rep.

Zip

eta_max Architecture

eta_max space
Richard-Wagner-Str.1, 38106 Braunschweig

eta_max space
Richard-Wagner-Str.1, 38106 Braunschweig

PROJECT EXPLORER
List of available data files, organised in project directories

OUTLINE
Structured, generic visualisation of selected data file

PROPERTY EXPLORER
Generic editing of data model content

EDITOR AREA
Displays the appropriate editor for the opened file

CONSOLE
Display of analyser output

GUI concept

eta_max space
Richard-Wagner-Str.1, 38106 Braunschweig

eta_max space
Richard-Wagner-Str.1, 38106 Braunschweig

Application of the Open Source Approach to Space Environment Analysis Tools
Seventeenth European Thermal & ECLSS Software Workshop, 21 – 22 October 2003, ESA/ESTEC, Noordwijk, The Netherlands

page 23

page 24
Online Presentation

Implementation Approach: Purist Workflow

Choose File

Choose Section

Edit Property
Implementation Approach: User Friendly

Cascade by Choice
Calculation by Others
Date Editor with Dialog

Implementation Approach: OCAF Integration

- Open Cascade is integrated by an JNI contract
  - Eclipse file matches OCAF document
  - Tree nodes match OCAF labels
  - OCC view panel is integrated into Eclipse geometry editor
Implementation Approach: VisAd Integration

- VisAd is included via AWT/SWT integration bridge
  - VisAd panel is placed into an SWT editor panel
  - Commands are piped from OCAF to VisAd thru an automatic synchronization model

Summary and Outlook
Summary and Outlook

- Based on Open Source OTS tools the Open Frontier Platform has been created
- Open Frontier provides
  - An ergonomic framework for user input acquisition and visualisation
  - A highly flexible and scalable data model
  - An interface to external CAD tools
  - A generic plugin model for solvers from various disciplines
- The Plugin approach allows also proprietary plugins
- Open Frontier + ESABASE/Debris = PC ESABASE
  - Beta version providing most functions in principle implemented and running
  - The PC ESABASE tool providing all existing capabilities of ESABASE/Debris plus the Open Frontier advantages will be available in the second half of 2004
- Open Frontier demonstrates the applicability of Open Source software to high-profile analysis tools