SIMDAT

Data Grids for Process and Product Development using Numerical Simulation and Knowledge Discovery

Project no.: 511438

Grid-based Systems for solving complex problems – IST Call 2

Integrated project

SIMDAT

Deliverable

D.9.1.1 Consolidated Automotive Requirements Statement

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1 Introduction

1.1 Purpose

The growing competition in the automotive industry requires continuous reduction of development and innovation cycles. On the other hand the demands on quality, safety and comfort are increasing. During the past years, advances in the area of CAD, CAE and CAT technologies and processes have contributed significantly to the ability of the automotive industry to keep up with these requirements. However, despite some initial success, these three disciplines are currently not integrated well enough to be able to exploit the benefits which the industry expects from a seamless integration of the underlying data and processes.

Today, the data resulting from the CAD-, CAE-, and CAT-processes are stored in separate databases without common interfaces. As a result, the respective development processes are not linked well enough. In addition, the development teams in the automotive industries often work from distributed locations. This is due, in part, to the inclusion of external engineering partners. It is also due to the ongoing transition from many small manufacturers to a few large conglomerates. This transition requires the integration of previously separate teams into single virtual development teams. Theses teams need to work on common car platforms to reduce development costs, while maintaining the specific functional characteristics of the sub brand they are responsible for.

In summary, the aspect of distributed locations includes two integration aspects: firstly, the integration of multiple sites of one organisation, and secondly the integration of multiple organisations. As a result, the automotive industry faces the challenge of integrating different disciplines (CAD, CAE, CAT) as well as different locations and organisations (see Figure 1).

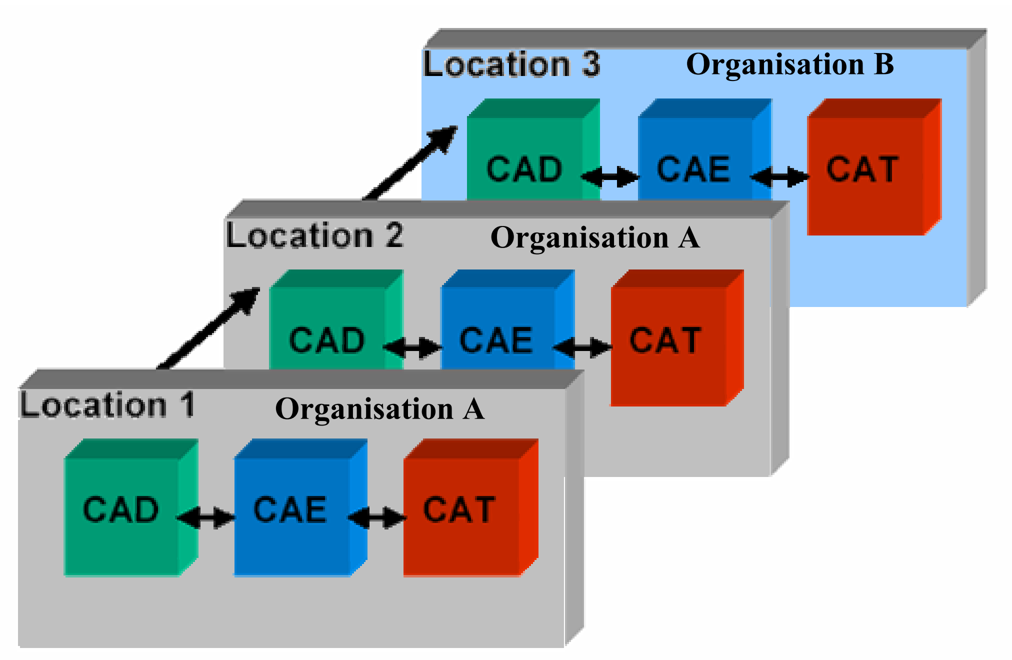

Figure 1: Integration of Disciplines and Locations/Organisations in SIMDAT

The integration of disciplines and locations using Grid technologies will enable the automotive industries to efficiently solve complex problems, which cannot be handled sufficiently today.

This document describes the requirements for simulation data Grids in the SIMDAT Automotive Activity. It is the result of the work performed during project months 1-6 in the SIMDAT work package WP9.1.

This document focuses mainly on the technologies required within the automotive activity.

1.2 Scope

The "Automotive Requirements Provision" provides the consolidated requirements of the automotive industry (in this case RENAULT, IDESTYLE and Audi) for Grid based simulation data environments.

The goal is to streamline the initial functional and performance requirements regarding a simulation data Grid to avoid lack of acceptance. For example, aspects of any kind of interoperability and compatibility between different OS systems (e.g. Linux, Windows, UNIX) need to be investigated and the resulting requirements need to be identified in order to make sure that the SIMDAT technology areas take these into account in their design decisions.

Further examples of problem areas in an automotive simulation data Grid are:

- Connectivity interoperability (network, file transfer, …)
- Data format interoperability (OS specific data formats)
- Data processing interoperability (performance, scales, precision, calculation)
- Authentication interoperability
- Federation supporting web services (process integration and optimization).

At this point, this document focuses on the automotive requirements which are most relevant for the first 12 months of the SIMDAT project. However, it is clear that not all issues will have been solved in the initial automotive demonstrators which are due by PM12. These issues will be addressed during PM 13-48, also taking into account refined and/or additional requirements which are being identified during the further course of the SIMDAT project.

1.3 Definitions, Acronyms and Abbreviations

1.3.1 Acronyms

- PAM-CRASH: crash simulation software developed by ESI.
- MSC.NASTRAN: FEA software developed by MSC.Software.
- CAE-Bench: Integrated environment for management of simulation data and processes at AUDI AG.
- MSC.SimManager: name of software product from MSC which is the basis of simulation data and process management systems similar to CAE-Bench.

1.3.2 Abbreviations

- PSE: Problem Solving Environment, for example CAE-Bench/MSC.SimManager.
- SDM: Simulation Data Management
- SAMD: SIMDAT AutoMotive Demonstrator
- NVH: Noise Vibration Harshness
- CAD: Computer Aided Design
- CAE: Computer Aided Engineering
- CAT: Computer Aided Testing
- FEA: Finite Element Analysis
- IAS: Integration of Analysis Services

1.4 References

[1] Stefan Mayer et al.: Consolidated Evaluation and Comparisons Documentation for Recommended Implementation Plan for Integration of Analysis Services. SIMDAT Deliverable D7.1.1.
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[3] Wolfgang Sperling et al.: Ontology Technology Requirement and Implementation Plan. SIMDAT Deliverable D6.1.1.
[4] Nabeel Azam et al.: Consolidated Requirements Report Workflows for Scientific Applications. SIMDAT Deliverable D5.1.1.
[5] Josef Reicheneder et al.: Definition of SAMD Reference Model and Use Case. SIMDAT Deliverable D11.1.1.

1.5 Overview

Changing global markets and rising competition have, in the last decades, caused radical changes in the way cars are built and developed. These changes will continue over the next years. In virtual product development, we are faced with an increase in the required number of numerical simulations, variants and government regulations. Simultaneously, we benefit from decreasing costs for computer power and storage. Advanced possibilities in the virtual functional design of product characteristics, stochastic investigations and multidisciplinary optimisation are only a few examples of developments and trends in the area of numerical simulations. One way to overcome these challenges is the usage of complex problem solving environments, in this case data and process management systems.

These systems support the simulation engineer in two ways:
- First, by using standardisation and automation of the workflow he can avoid routine jobs in documentation and evaluation. The engineer is then able to concentrate on the essential technical tasks.
- Second, data and process management systems enable the analyst to reconstruct find and compare results within collaborating groups. This is not restricted to the "traditional" simulation fields of structural analysis and computational fluid dynamics but also includes other disciplines such as the simulation of the energy requirements of on-board electrical systems.

In the next few years we will be faced with additional challenges in the field of simulation data and process management (SDM). On the one hand, a further integration of the different CA-disciplines like CAD, CAE and CAT is needed. On the other hand, distributed sites of one OEM as well as partners have to be integrated in a virtual organisation, with secure access to federated information.

SIMDAT focuses on these challenges. On the one hand we have the simulation data management with its special requirements (distribution, huge amounts of data, data security and backup operations). On the other hand we have the integration of the different disciplines CAD, CAE and CAT with different data formats, data descriptions and repositories.

During the first six months of the automotive area within SIMDAT the work has primarily concentrated on the requirements gathered from the automotive partners. A summary of the collected requirements and their assignment to the SIMDAT technology areas is provided in this document. First, Section 2 gives an overview of the specific scenarios and requirements of the two main users, Audi and RENAULT. Section 3 then contains a consolidated list of automotive requirements, grouped by the SIMDAT technologies.

2 Specific Requirements of Audi and RENAULT

2.1 Perspective

This section is intended to provide input for the requirements of the automotive activity from the point of view of the two major end-users, Audi and RENAULT. As this view is strongly application-oriented, only a subset of the requirements is addressed. The detailed, consolidated requirements are then listed in Section 3.

The functional and performance requirements are derived from the SIMDAT automotive environment and use cases (see [5] for details), observations of existing systems and practices in automotive product development, brainstorming sessions, scenario analyses, and predictions of future trends.

In summary, users would like to use Grid-enabled data management or problem solving environments (PSE) and analysis services in a similar way as they run simulations on local data with locally installed analysis codes today. They do not want to deal with the added complexities of a large Grid infrastructure.

2.2 Audi Requirements

The Audi requirements represent the needs of a typical OEM-OEM federation scenario. This is the use case scenario which Audi will concentrate on during the first 12 project months (see [5] for more details). In this scenario, Audi for now concentrates on the discipline crash. NVH, the second major discipline for functional car body design, will be involved at a later stage of the project.

In this scenario, the user interacts with simulation data and simulation codes via a complex problem solving environment (PSE), like CAE-Bench/MSC.SimManager at Audi. These complex PSEs manage the full analysis process including pre-processing, solving, post-processing and reporting. All data, actions, and workflows are managed by the PSE. For the execution of simulation codes such systems typically also make use of available queuing systems like LSF and SGE for scheduling jobs to available compute resources. Figure 2 shows a screenshot of a typical PSE (MSC.SimManager), in the so-called “Process View”. The user invokes a simulation code like PAM-CRASH in this example simply by selecting “Run Crash Simulation” in the left hand navigation tree or by selecting the corresponding blue box in the process map.

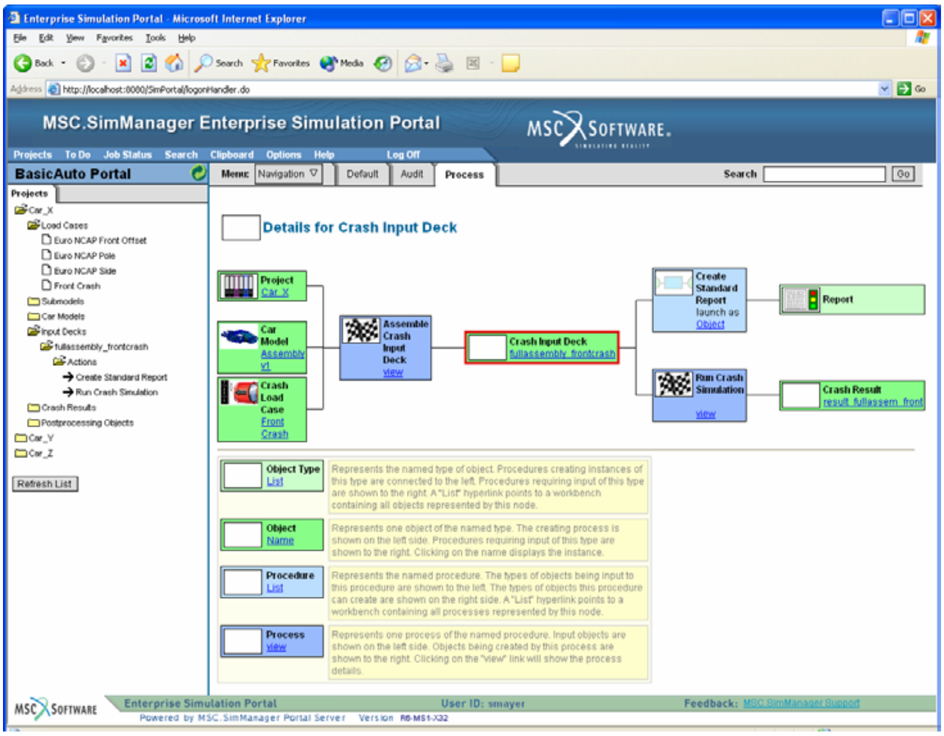

Figure 2: Screenshot of Automotive Problem Solving Environment for Crash Analysis

The major goal of Audi within SIMDAT is to achieve a federated environment in which independent instances of problem solving environments at different sites can be interconnected to provide an enterprise-wide consolidated view on all car design data, independent of the physical location of the data. An example would be two PSE instances at Audi and SEAT, which are interconnected to allow engineers in both companies to view each other's data, provided they have been granted the necessary permissions. Figure 3 and Figure 4 show screenshots of potential PSE installations at both sites. The Audi site is supposed to hold all data related to the two-door SAMD coupe (test data created by Audi for the SIMDAT project, see [5] for more details), whereas the SEAT site holds all corresponding data for the four-door sedan. Both sites can browse the full federated data set containing the data for both cars.

During the course of SIMDAT this scenario will be implemented.

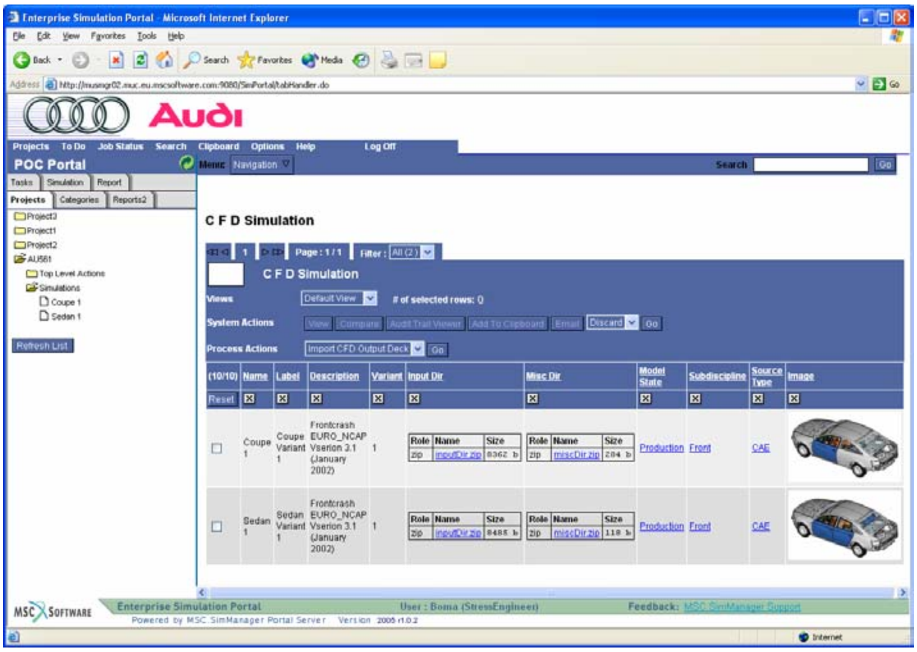

Figure 3: Screenshot of the Envisaged Audi System

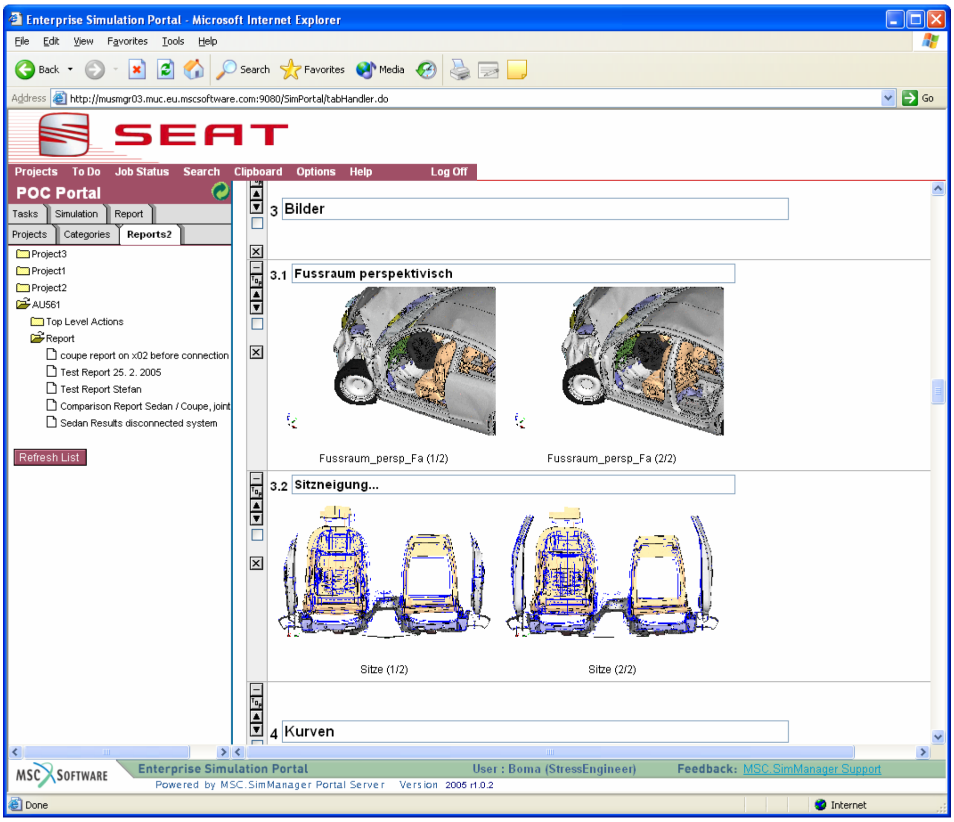

Figure 4: Screenshot of the Envisaged SEAT System

The following requirements have been specified by Audi for this scenario:

1. IT Infrastructure for distributed engineering data Grids
   It is expected that the software and methods developed within SIMDAT will match with the network and operating system environment used in the automotive industry today.
2. Data sharing, data exchange, distributed data and databases
   Special attention has to be paid to the exchange of potentially very large raw simulation result files. For example, users at a remote site may want to do an interactive evaluation of crash results on their local workstation, which requires today a download of the large crash simulation output files to the local workstation.
3. Security of data and data access
   The major focus of this requirement is on the authorization of users within a Virtual Organization according to disciplines, locations, and roles.
4. Standardized data representation
   One topic within SIMDAT will be problem-specific analysis services (meshing, mesh assembly, crash simulation, etc.) as opposed to application-specific services (e.g. MEDINA service). Such services require standard input and output data to be independent of the actual tools underneath.
5. Integration of applications
   The automotive industry uses a large variety of tools for crash analysis, structural mechanics simulation, pre-processing, post-processing, stochastic analysis, parametric concept design, etc. It is necessary to define standard means of integrating any analysis tool into a SIMDAT Grid context.
6. Integration of different frameworks
   Framework in this context is a synonym for Problem Solving Environment (PSE). Not all partners in a SIMDAT automotive Grid will run the same problem solving environment, or even the same version. Therefore it is required that PSEs of different versions and vendors cooperate seamlessly in a Grid.
7. CAD integration and pre-processing for distributed data Grids
   SIMDAT also has to deal with the challenge of integrating design (CAD) and simulation (CAE). Coupling of CAD and CAE has some special challenges, for example to transfer parameterized geometry to parameterized Finite Element Models.
8. CAT Integration for distributed data Grids
   Simulation is about supporting and partially replacing physical test. A major task is the correlation of simulation and physical test results. SIMDAT is expected to provide solutions for this problem too, for example by coupling PSEs managing simulation and test data.
9. Knowledge Discovery and Data Mining
   Ultimately, the management of simulation data has the goal to obtain new conclusions from existing data. In particular, in distributed environments it is currently difficult to draw such conclusions. SIMDAT is expected to deliver concrete tools to enable data mining on distributed simulation data Grids.

2.3 RENAULT Requirements

The RENAULT requirements represent the needs of a typical OEM and partner integration scenario. This is the use case scenario which RENAULT and IDESTYLE will concentrate on during the first 12 project months (see [5]). Figure 5 shows an overview of this scenario.

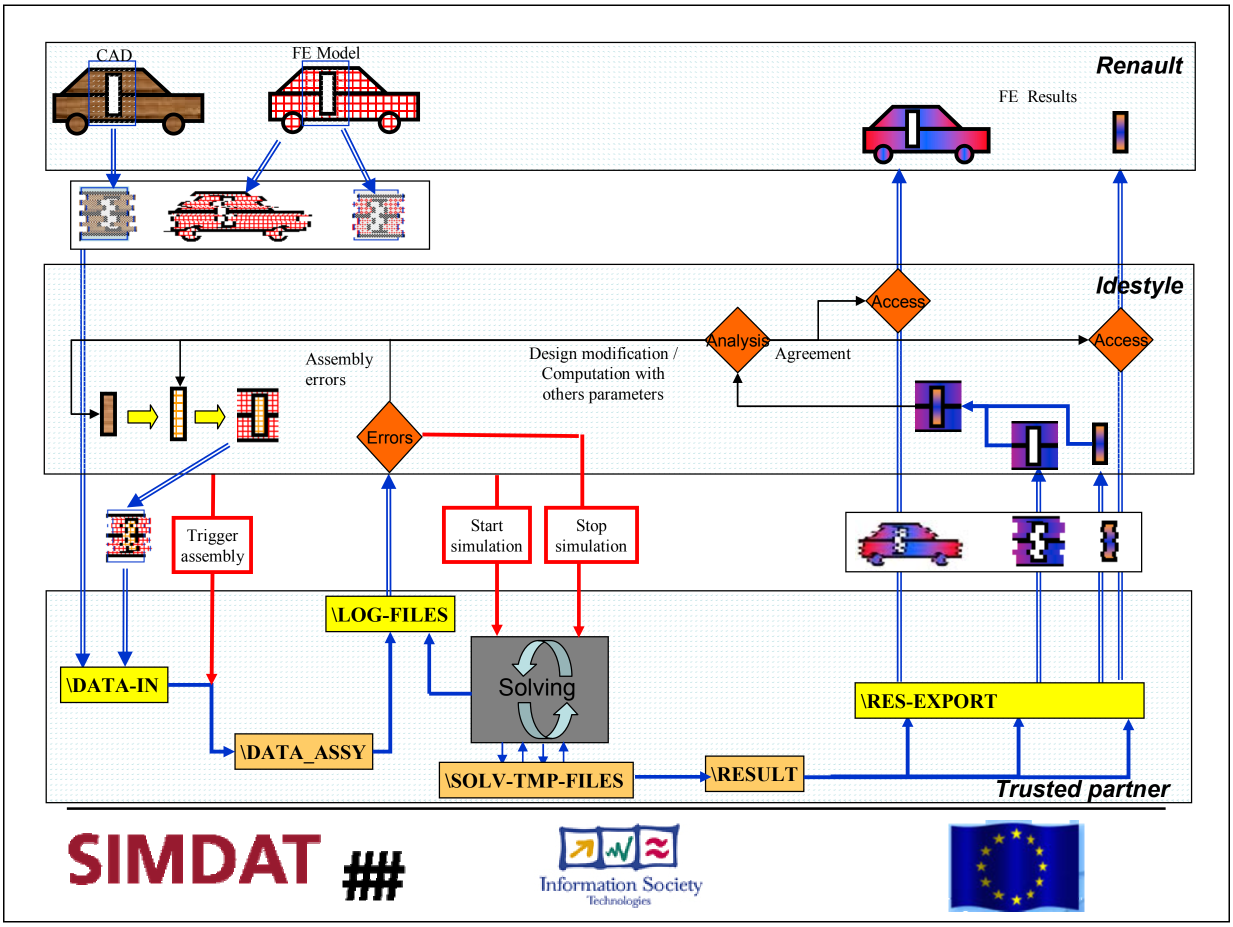

Figure 5: RENAULT/IDESTYLE Scenario

The design process is mainly based on Digital MockUp (DMU). Vehicle performance validation relies widely on digital simulation. The simulation process integrates a substantial number of steps such as mesh generation tools, analysis codes, data sharing or data exchange procedures. Because of this complexity, it is advantageous to perform such simulations through an efficient Problem Solving Environment (PSE).

As with other vehicle manufacturers, RENAULT involves numerous partners or subsidiary companies in the design process of vehicles, IDESTYLE in particular. The expected PSE would be required to enhance collaborative work between RENAULT and its partners by sharing simulation data and analysis services. In particular, the selected PSE will allow sharing or exchanging data in a more convenient and secure way, through the use of user-friendly interfaces encapsulated within web services as well as through the provision of rigorous data access control and data encryption.

A major concern about collaboration with partners deeply involved in the vehicle design is security of data. Partners need a lot of information to design the components they are in charge of and it is obvious that the dissemination of vehicle data among many partners means a total loss of confidentiality if data are not secure.

The problem concerns both the carmaker, who wants to keep confidentiality of vehicle design data, and partners who want to protect their knowledge such as material constitutive laws of their components.

A robust data encryption is necessary to allow a tight collaboration between RENAULT and its partners. Moreover, we need partial encryption allowing the partner to see the just necessary data for his work and to return the results while protecting his specific know-how.

Confidentiality aspects concern digital models of parts, particularly styling parts, architecture of the vehicle, material constitutive laws, modeling skills, etc.

Another advantage of a robust data encryption would be the ability to use the Internet as opposed to a private and secured network, such as ENX, which tend to be very costly and not always affordable for small companies. It would then be possible to get services from qualified small companies, in a larger partnership.

Intensive digital simulation requires hardware resources that are not always available to a company (e.g. during peaks of activity). Grid technologies will provide a way of giving access to external hardware resources in a convenient and secure way.

Summing up, the following major requirements have been identified by RENAULT for this scenario:

1. Data sharing, data exchange, distributed data and databases
   For RENAULT and IDESTYLE, this requirement implies in particular the need to integrate multiple organizations (OEMs, subsystem suppliers, engineering partners) into Virtual Organizations.
2. Security of analysis services, data and data access - Encryption of data for collaboration with suppliers
   This is crucial for the requirement to use "public networks" such as the Internet as networking infrastructure for Virtual Organizations. This applies not only to the complete encryption of data to be exchanged, but also to the partial hiding of simulation data. Sub-system suppliers should only have access to those parts of the car design which they need, such as the CAD environment of their sub-system, simulation results for their sub-system, and selected results for the complete car which are required to assess the functional performance of their sub-system.
   The following points will be the main subjects of the RENAULT demonstrator:
   a. Robust encryption of data providing a high level of security so that they can use the common web network instead of a private network such as ENX.
   b. Partial encryption of data allowing partners to see just the data necessary for their work and to return the results while protecting their own know how
3. Integration of analysis services
   Appropriate templates are required which allow a quick embedding of existing simulation codes into analysis services.
4. Abstraction of resources
   Grid technologies should provide a single and consistent view to the end-user and allow him to use resources without having to worry about infrastructure or details of

business processes. The end-users should be able to use services in a similar way as they run simulations on local data and hardware.

5. Grid technologies based on open standards
   This is necessary to avoid difficulties when implementing the tools in different environments.
6. IT Infrastructure
   SIMDAT technologies should be able to run in most IT infrastructures such as Windows, Unix and Linux, and to work across existing firewalls.
7. Both batch and interactive analysis services have to be available.
8. Focus on specific applications
   ESI COMPOSER and PAM-CRASH, but also MSC.SimManager as RENAULT is interested in this software that could be tested in their company in the future.
9. Speed
   As performance is crucial for end-users, speed is one of the highest prioritized requirements.
10. Accuracy
    It is necessary to pass the desired computer architecture and software version as parameters to an analysis service launching a calculation, as results are strongly depending on these parameters.

3 Consolidated Requirements

This section lists the consolidated requirements for the automotive activity. The consolidated requirements take up the individual requirements of the two major end-users Audi and RENAULT described in the previous section and break them down by the SIMDAT technology areas.

3.1 Grid Infrastructure/Distributed Data Access

3.1.1 Functional Requirements

Requirement	Description	Priority
Standards compliance	WS-I compliance	High
Grid middleware	Availability of Grid middleware to be integrated in federated PSEs	High
Authentication service	Ability to authenticate users including ability to handle federated identity in the virtual organisation	High
Authorisation Service	Policy-driven access control to data and compute resources	High
Data transfer / access service	Transfer/access of flat files	High
Distributed read and write access	Analysis services need to read and write data from/to distributed PSE instances	High
Operating system support	Support all major operating systems such as Windows, Linux and proprietary Unix	High
Network	Interoperate smoothly with existing WAN/LAN infrastructures, use standard Internet, not ENX	High
Hardware	Applicability of SIMDAT results to hardware available at Audi and MSC, RENAULT and IDESTYLE	High
Single interface to compute service	Ability to access compute services with different scheduling requirements through single interface Reservation of compute resources Encapsulation at runtime in compute service	Medium
Resource discovery	Ability to discover alternate services due to service failure or unavailability	Low
Test data	Test models and simulation results including post processing data to be provided by the automotive partners	High
Setup of infrastructure	Setup of the test infrastructure, in the Audi scenario setup of two CAE-Bench reference installations by MSC	High

3.1.2 Performance Requirements

Requirement	Description	Priority
Fast data transfer service	Timely transfer of data of the order of Gigabytes comparable to ftp	High
Scalability	The infrastructure needs to be scalable to enable exploitation by at least 100 simultaneous active users and several hundreds of registered, but currently inactive users	High
Fast http response	Engineers work interactively with PSEs, which are server-based web applications	High
Manageability	The infrastructure and policy specification management overhead should not grow exponentially with scale	High

3.2 *Administration of Virtual Organisation*

3.2.1 Functional Requirements

Requirement	Description	Priority
Identity management services	Ability to create and manage digital user identities	High
Authentication service	Ability to authenticate users and transactions Ability to communicate securely Ability to handle federated identity within virtual organisation	High
Authorisation Service	Policy driven access control to data and compute resources	High
Auditing	Execution and resource audit for QA purposes across the federated environment	High
Accounting	Accounting capabilities in order to charge for service provisioning	Medium/Low
Encryption	Enhanced security by use of certificates	Medium
Infrastructure	Ability to use standard Internet to avoid costly special networks such as ENX	High

3.2.2 Performance Requirements

Requirement	Description	Priority
Scalability	The infrastructure needs to be scalable to enable exploitation by at least 100 simultaneous active users	High
Manageability	The infrastructure and policy specification management overhead should not grow exponentially with scale of system	High

3.3 *Workflow*

3.3.1 Functional Requirements

Requirement	Description	Priority
Workflow access to web services and resources	Workflow composition tool needs to have the ability to dynamically access web services including links to Authentication and Authorisation services	High
Ability to handle long duration process	Services can have long duration (order of 1 week). Ability to check progress by polling/notification therefore required. Ability to close workflow tool and return to check state also required.	High
Exception handling	Ability to specify behaviour due to service failure, connectivity failure, decision points, user intervention	High
Remote batch execution of workflow	Ability to submit workflow to be remotely executed Workflow enactor as a service	Medium
Parallel workflow execution	Ability to execute the workflow in parallel (same workflow executed with a range of inputs simultaneously)	High
Workflow execution optimisation	Control of workflow execution with constraints of service availability	Medium/Low
Workflow	Ability to publish workflow via a web portal	Medium

publishing		
Workflow mining	Ability to search workflow database using meta-data	Low
Workflow language interoperability	Ability to exploit workflows in other standards based workflow enactors	Medium
Analysis services	Workflows must be able to interface with analysis services	Medium

3.3.2 Performance Requirements

Requirement	Description	Priority
Simple user interface	Workflow specification/construction/authoring tool needs to have a simple interface	High

3.4 Analysis Services

3.4.1 Functional Requirements

Requirement	Description	Priority
Batch analysis services	Wrap analysis codes running in batch mode as Grid-enabled analysis services	High
Interactive analysis services	Wrap analysis codes running in interactive mode as Grid enabled analysis services	Medium
Application specific analysis services	Analysis services for certain application codes, for example PAM-CRASH	High
Problem specific analysis services	Analysis services for solving certain problem classes, for example meshing	Medium
Analysis service control	Ability to control service (run, suspend, stop)	High
Access to intermediary output	Ability to monitor process output during execution (stdout, stderr files)	High
Polling and or notification	Ability for client to poll state or for client to register for a callback mechanism (SMS, email, callback service)	High
Auditing	Execution and resource audit for QA purposes	High
QoS measures	Ability to describe quality of service provided by analysis service (e.g. for crash service to be independent of platform specific round-off errors)	Medium/Low
Accounting	Accounting capability to allow charging for service provisioning	Medium/Low
Access to results	Policy-controlled access to results	Medium
Results lifetime	Ability to specify lifetime of results	Medium
Data representation	Standardized data formats for problem specific services	Medium
Reference implementation	Reference implementation for remote calls to services within PSEs available	Medium

3.4.2 Performance Requirements

Requirement	Description	Priority
Speed of second level services	Speed of data transfer, database queries etc. have to be high – overhead has to be low	Medium

3.5 *Ontologies*

3.5.1 Functional Requirements

Requirement	Description	Priority
Ontology construction	Ability to create appropriate and extendable ontologies for SIMDAT test cases describing the product as well as the concepts in the design process	High
Ontology interrogation	Ability to interrogate the ontology to extract information	High
Ontology driven data access	Ability of knowledge service to access ontologically described data	Medium/Low
Ontology service	Ontology needs to be available as web service	Medium
Ontology reasoning	Ontology reasoning modules have to be extended for understanding the consequences of the rule setting	Medium

3.5.2 Performance Requirements

Requirement	Description	Priority
Ease of use	Ability to create and manage ontologies within an easy-to-use environment	Medium

3.6 *Knowledge Services*

3.6.1 Functional Requirements

Requirement	Description	Priority
Identification of relationships and patterns	Ability to discover patterns given an ontologically described data set	Medium/Low
Distributed knowledge aggregation	Ability for a member of the VO to access aggregated knowledge about the whole problem using ontology described data to generate aggregated knowledge that is not otherwise visible to a single team, organisation or specialist	Medium/Low
Distributed data access	Query mechanism of PSEs works on local and remote data simultaneously	High
Second level tools	Second level tools such as a model disassembler has to be available	Medium

3.6.2 Performance Requirements

Requirement	Description	Priority
None		