# GLOBEMAN21
# Global Manufacturing in the 21st Century

## Final Report

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# Executive Summary

Globeman21 has been an international collaboration to develop the business practices and techniques required to operate globally distributed enterprises in the environment and under the conditions anticipated for the future. The project was conducted as part of the international Intelligent Manufacturing System (IMS) program.

Globeman21 results include both the understanding of what are the effective new business practices and how these can be implemented. Models, frameworks and implementation methodologies have been established and demonstrated in 14 industrial pilots. The project sought to use available technologies in a way fitting the distributed business environment. However, where necessary, new technological advances were made and implemented.

The results cover a wide range of manufacturing industries from one-of-a-kind to repetitive manufacturing. The focus is on both management of the enterprises in the distributed environment and how products are supported over their lifetime by those global enterprises. Specific applications are considered within distributed management of operations, distributed design and – very importantly – within distributed support of operations, maintenance and renewal.

The impact of these results are already being seen in the partner companies. Some have already implemented their pilots into operative systems and all others are now doing it. However the biggest impact has been on the way the partners define their business processes and practices.
All project partners say that they have either got closer to their customers or have more effective processes to work with their business partners or have created new businesses for themselves.

By concentrating on the core skills of the partners and operating, itself, as a global enterprise, Globeman21 has been able to establish a sound concept for global manufacturing and also to develop and demonstrate many of the tools and methods that can be applied now and into the next century. A culture of networking and knowledge sharing has developed in the Globeman21 consortium and is an example for future businesses in the rapidly changing world environment.

The models and methodology for operation of a global manufacturing are very broad and cover many topics, such as: information access and control, product modelling, data communication and sharing of data infrastructure, product design strategies in distributed networks, methodology for designing and managing business processes, product life-cycle monitoring, customer support, networking with suppliers and customers, applying agent systems for monitoring enterprise operations and supply chain management.

The Final Report briefly outlines the specific achievements. More detail is available on the Globeman21 WWW (http://ims.toyo-eng.co.jp/). This web will be available for public study until the end of September 1999. Included in the web is an interesting and useful interactive overview of all of the Demonstrators. This may be viewed by selecting the heading "Globeman Demonstration" in the HOME page

Globeman21 partners can access the password-protected sections of the Globeman web (http://ims.toyo-eng.co.jp/) until the end of September 1999. In addition, each Partner can obtain a copy of the CD which includes this material. If there is any difficulty in accessing this information, contact the Co-ordinator for your region - see Appendix C in the Final Report. In the Intranet (Members Only) section of the web, the Section "Top View" has a sub-section "Final Reports". This provides full reviews of the activities and achievements in all WPs and Demonstrations. There are also other links – indexed by Globeman21 research structures - to WPs and Demonstrations providing earlier reports on specific groups.

# INTRODUCTION

Globeman21 project was an international R&D project under the Intelligent Manufacturing Systems (IMS) program. It studied the changes in manufacturing, especially the effects on global operations and distributed networks on company business practices and IT tools.  There was a special focus on management of extended enterprises and on product management throughout the whole life cycle.

## Project objectives

When proposed, the Globeman21 project was seen as having three major objectives:

1. Creation of the business processes; the methods, models and technologies, for the emerging global manufacturing environment. Global life-cycle management and enterprise integration were seen as key elements.
2. Illustration of the overall concepts in global manufacturing by developing a "common demonstrator" and illustration of specific technologies and practices by individual "industrial demonstrators".
3. Clear presentation of the findings of Globeman21, so that the participants and other companies can radically improve their business processes and environments.

In driving towards these general objectives many specific outcomes were expected, including:
- Increased understanding of the key business processes in manufacturing.
- New management tools to operate in a world of global virtual enterprises.
- New technologies and new applications in fields such as: modelling, simulation, control, artificial intelligence, team leadership and human organisation issues.
- Architecture for more efficient, high quality production in all domains of manufacture.

## Project Achievements

The project created both conceptual and practical results to support implementation and management of globally distributed consortiums in varying manufacturing industries.  Partners were pleased with the results and saw direct short-term benefits to business from new business practices and tools as well as longer term benefits from new understanding about global business collaboration and global R&D collaboration.

## Project Structure

The project consortium, with 35-50 partners, was a reasonably large group.  The majority of partners were industrial companies, supported by research institutes. Appropriate management and R&D structures and corresponding operating guidelines were formed to conduct and test the research.

# A.       PROJECT ACHIEVEMENTS

Many independent results were obtained. It is instructive to first consider the impact of the achievements on the partners and the manufacturing industry at large. This can be done by looking at three different areas of impact:

1. conceptual and theoretical models that will affect long-term thinking and practices,
2. direct business impact derived from the business demonstrators tested during the project and
3. the technological advances gained by the project.

Following this, the achievements are described in more detail. Appropriate links from the impact section to the detail section are provided.

In addition to this written report, there is extensive material available on the Globeman21 public web - http://ims.toyo-eng.co.jp/. In particular the reader is encouraged to look at the "Globeman Demonstration" (click on this heading in the home page) The web material will be available from March till October 1999. Because the international Globeman21 project is now finished, it is not possible to maintain this web page indefinitely.

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# 1. IMPACT OF THE ACHIEVEMENTS

## 1.1 Globeman21 Concept

A Globeman21 Concept was created. This defines the environment in which global manufacturing companies are working today. The concept also defines the characteristics of this environment and provides models and methodology to implement appropriate structures, companies and consortiums, to deal with distributed global manufacturing challenges.

The concept will help companies to understand the issues now critical in the global environment. Also it will support the implementation of global consortiums to manage the manufacturing tasks distributed around the world.

While not a complete guidebook to all issues in global manufacturing, the concept will support further formalisation of the global manufacturing theory and corresponding management theories. It highlights the need for implementation handbooks and new theories for distributed management systems.

The overall conceptual work of the Concept Team is outlined in Section A. 2.3.1. In addition some important areas were covered in work packages:

- Work Packages PG1WP2 (Section 2.1.1) and TG2WP1 (Section 2.1.6) describe the information control and access issues in a global environment
- Work Package PG1WP4 (Section 2.1.2) describes the Engineering and Production Integration Architecture (EPIA) - alias how Engineering and Production stages need to collaborate, in a distributed way, to produce better manufacturability of the design and production
- Work Package PG1WP5 (Section 2.1.3) describes the Generic Operations Support and Renewal (G-OSR) architecture for supporting remotely both the operations and renewal phases of a plant or product
- Work Package PG2WP2 (Section 2.1.4) describes Extended Enterprise Management - alias the issues concerning the management of companies in a distributed environment
- Work Packages TG1WP2 (Section 2.1.5) as well Product Modelling Teams describe (Section 2.3.3) describe how product modelling issues have to be managed in a distributed environment
- Work Package TG2WP3 (Section 2.1.7) and the IT Infrastructure Team (Section 2.3.3) deal with current and future IT technologies that can be used for implementation of global manufacturing.
- Work Package TG4WP1 (Section 2.1.11) supports the overall concept work by creating and advancing the theory of Generalised Enterprise Reference Architecture Methodology (GERAM)

In summary, the conceptual issues cover the business oriented models and practices of management of virtual/extended enterprises and the management of product life cycles. The Globeman21 concept does not cover organisational nor human learning/adaptation issues. These are left for consideration after the business practice concepts are in place, even though it is understood that none of these research areas can be finalised on their own, but all need strong interactive impact from each other.

## 1.2 Business Impact

The direct business impact of the project comes from the new understanding of distributed business practices provided by the conceptual thinking and from the industrial demonstrators (14 of them – see Section 2.2) that tested specific distributed business practices for the Globeman21 industrial Partners.

The impact is seen in operating systems already in use by some partners, following pilot demonstrations. Other systems are now being implemented, based on demonstrators.

However an even bigger impact has been claimed by some partners, who have explained the significant changes in their businesses, based on the new understanding and examples they have seen in their own work and that of others in Globeman21. Some examples are:

- Partner companies are changing the way they contact and support their customer.
- There is significant move from a 'travelling serviceman' concept to a 'remote help desk' concept for manufacturing companies. (it is to be noted, that in manufacturing the 'help desk' means a lot more customer support than that provided in the computer hardware and/or software applications business)
- Partner companies are changing the ways they collaborate with their business partners in distributed consortiums.
- Agility, based on distributed business practices have provided strong competitive advantages by reducing time to market/time to delivery.
- Partners have recognised new businesses opportunities, especially in added knowledge based services supporting their traditional product lines. This has also given them scope to get into new IT oriented businesses

## 1.3 Impact on Technologies

In Globeman21 the work on technologies was largely analysis of currently available commercial tools, both for enterprise modelling and for operation systems. That work was done to an extent in all industrial demonstrators (see Section A.2.2) but also extensively in specific Work Packages and Teams defined to analyse the different aspects of the environment (see Work Package PG1WP2, TG2WP1, TG2WP3 - Sections A2.1.1 & 2.1.8, 2.1.9 - and IT infrastructure Team – Section 2.3.4). In general it can be said, that the internet based/styled systems both within companies, as well as between them, will be the ones to use. However a lot of consideration is needed to define appropriate internet/extranet/intranet levels and securities for them. Also, the rapid change of business needs as well as IT tools available, is demanding very agile modelling and IT infrastructures. And certainly there is a need to be able to use modelling tools directly to create the frameworks for the operating environment. A complication is the fact that available tools are not mature enough for most companies.

In addition to analysing the currently available tools and trends seen in them, Globeman21 also created and tested new tools for distributed environment, including:
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- GERAM modelling was tested and advanced (see Concept team and T41)
- NCR's METIS Enterprise modelling tool was tested and its development was strongly supported by the work in several demonstrators in Globeman21
- Intelligent agents environment was advanced strongly by the work done in the project (see T3 , Section A.2.1.11)

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# 2. ACHIEVEMENTS IN DETAIL

## 2.1  Work Package Results

### 2.1.1 PG1WP2: Global Product Information Access and Control

The WP identified industrial needs, challenging process and existing technologies for Global Product Information access and control.  Tools and methods for design of Extended Enterprise (EE) and Virtual Enterprise (VE) were tested and applied in the demonstrators, VRIDGE and VIEWBID.

### 2.1.2 PG1WP4: Product Model Management

Systems for concurrent engineering in production and construction environments were studied from the stand point of optimisation in a global environment.

The framework " Engineering and Production Integration Architecture (EPIA)" was defined as a common deliverable that generalised specific deliverables extracted from associated demonstrators, viz. CONNET, DESMART, ProCOMA and PLANARIA.

EPIA covers the basic architecture and systems for the improvement of the manufacturability, productability and constructability at three viewpoints of the extended enterprise level:

1.  The extended enterprise level, where the main focus is on one-of-a-kind product projects and the one-of-a-kind product supply chain,
2.  The enterprise level, which focuses on product design and product configuration, and
3.  The factory level with a focus on repetitive product production system.

Based on the EPIA, business models and network models have been proposed on each of these levels.

### 2.1.3 PG1WP5: Operation Support and Renewal

Operations support and renewal (OSR) was focused on the management process by which product suppliers of large industrial equipment, such as plants and production facilities, provide support for user/owners to achieve optimal use of the equipment

Models and the framework have been developed from practical know how collected from industrial partners. Research activities have led to the development of:
*   an analysis of the operation support and renewal management issues
*   creation of a model of operation support and renewal management
*   creation of prototypes of operation support and renewal management
*   iterations to refine the model and to test the prototypes

Demonstrators have been implemented in the context of the industry partners' requirements.  The experiences gained in the demonstrators Ahlremote, Farley and Neo-Kaizen provide tools for customer operations, support and renewal in a wide range of situations.

### 2.1.4 PG2WP2: Management of Manufacturing

This WP has developed business systems for Extended Enterprise Management (EEM).  EEM has two key aspects: management of networks and management of virtual enterprises.  A network could be a group of manufacturing companies who co-operate in a network to deliver products or services to customers all over the world. Each partner contributes to the network with its own core competencies. Whenever a customer requests a product or a service from the network a Virtual Enterprise (VE) is created to deal with the specific need of the customer.

In the workpackage the following results have been achieved:

- Concepts for Extended Enterprise Management have been developed.
- A methodology for how to design an EE concept has been outlined.
- Characteristics of an extended enterprise are identified, forming a generic model for EEM.
- Each industrial company has described their EEM concepts with the EEM model.

Each industrial company has developed demonstrators illustrating different aspects of the Generic EEM model. The demonstrators will be exploited internally in the companies. The demonstrators are: Ahlglobe: PREM, GlobOS, ICOM-BPR and ConNet:

## 2.1.5 TG1WP2: Global product Model

A study of the modelling of design background information (DBI) (Demonstrator: PROMINENCE) and simulation based on this (Demonstrator: WISE) was carried out. The major deliverable is a prototype for the DBI management system. The system was developed, based on commercially available systems of work flow management and a data base system. The prototype was used for evaluating the usefulness of DBI in practical design. The deliverable also provides the WP with a common environment for future extensions. The system's framework and its information contents has been used in other GM21 work packages having a related research issues.

## 2.1.6 TG2WP1: Data Communication and Sharing Infrastructure

The WP has developed innovative processes by investigating new and advanced technologies of "Data Communication and Sharing Infrastructure". Applications and testing were carried out in the VRIDGE and VIEWBID Demonstrators.

Specific developments and implementation included:
- Information Infrastructure of Extended Enterprise (EE) and Virtual Enterprise(VE).
- Data Sharing Technologies of EE/VE
- Data Management of Workbench
- VRIDGE/VIEWBID Workbench Front-end

## 2.1.7 TG2WP3: Tool Integration

An integration of the results of TG2/WP1, which supports VRIDGE, VIEWBID, Farley and other Globeman Demonstrators. These results have been integrated with other technologies from outside of Globeman21 and provided to IT Infrastructure Team.

An evaluation Report of ARRI/SIA Architecture has been written.

## 2.1.8 TG3WP1: Generic Agent Shell

This WP has built on the University of Toronto's ODO scheduling technology and technology developed as part of WP3 (see below) to develop a generic customizable constraint-based scheduling and coordination agent capable of operating in a reconfigurable multi-layer multi-agent environment. The achievements include:

1. Development of a Conversational Agent Co-ordination Language. This allows programmers to build multiagent applications by defining the distributed execution environments of agents, agents interaction by means of conversation plans and conversation rules, the communication language used by agents.

2. A WWW Interface to the Agent Environment. This interface supports the user in monitoring and influencing the work of agents through the WWW.

3. A Behaviour Description and Execution System. This supports the definition of agent goals, of the organisational structure inside which the agent operates, of the norms and regulations governing the organisation, of the reasoning tools enabling agents to reason about norms, situations and goals in order to decide on their

actions, co-ordinate and negotiate with other agents. Also provides the scheduling tools (from W1) needed for agents to plan their behaviour and the action execution tool needed by agents to carry out planned actions.

4. An Integrated Agent Shell: The final product, integrating the above components.

## 2.1.9 TG3WP2: Co-ordination Protocols

This WP studied protocols for effective lateral and vertical co-ordination among agents in realistic supply chain settings. In particular it examined the integration of advanced schedulers within agents and their co-ordinated use across the supply chain.   The outcomes were:

1. Protocols for Teamwork Co-ordination in a Virtual Supply Chain. Using the Agent Shell developed in W3, this consists of an operational  horizontal and vertical co-ordination protocol for managing teamwork in an experimental (yet realistic) supply chain environment.

2. Co-ordination Protocols for Dealing With Perturbation in Supply Chains. This is a full, realistic supply chain simulation which uses co-ordination protocols that deal with unexpected perturbations and disruptions. The simulation investigates how advanced co-ordination protocols can limit the negative effects of perturbations in a supply chain.

## 2.1.10 TG3WP3: Constrained-Based Scheduling Shell

This WP has developed:

1. A Constraint Directed Scheduling Shell. The constraint directed scheduling shell integrates and allows opportunistic switching between generative and repair scheduling methods based on measurement of properties of the constraint graph, or textures, used to perform activity, resource and time ordering.

2. Comparative Evaluation of Texture Based Scheduling. An evaluation of our scheduling method against other recent approaches aimed at producing a more accurate assessment of the strengths and limitations of our scheduling method.

## 2.1.11 TG4WP1: Methodology & Tools for Business Process Analysis and Design

Starting from methodologies described in the literature, TG4WP1 provided increasingly refined versions of an easy to use enterprise integration architecture and methodology.  The WP gave guidance and consultancy to several GM21 Demonstrators.

Outcomes included the further development of the Generalised Enterprise Reference Architecture and Methodology (GERAM).  GERAM allows management to select and combine elements of best practice to create a complete enterprise engineering capability for small or comprehensive change.  This was verified in the VRIDGE Demonstrator. The experimental results also contributed to the maturing of the GERAM architecture, and ISO standardisation.

With the help of TG4WP1 the VRIDGE Demonstrator developed various enterprise models, e.g. for the VRIDGE Inc. Virtual Project Enterprise. The need for an Enterprise Engineering Workbench with integrated meta-modelling capability (such as METIS, ProcessWise, PTech), and the ability to interface to other modelling and simulation tools was recognised.  Based on this, the VRIDGE Workbench was specified.

Many results have been published in journals, books and at conferences, two theses, and a further book publication is planned.

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# 2.2 Industrial Demonstrators

Three main areas were covered by the demonstrators, and the descriptions are grouped under these headings:

- **Distributed Management**
- **Distributed Support (for Operations, Maintenance and Renewal)**
- **Distributed Design**

Some of the demonstrators covered more than one of the areas

## 2.2.1 Distributed Management

### AhlGlobe – Tool for the Distributed Project Team

The aim of the demonstrator was to create a collaborative project management tool for managing a one-of-a-kind pulp mill project in a global environment. Information is the key factor both in the project management and control and in the co-operation with the project partners.

Work within AhlGlobe included the creation of:

- a rough model for collaborative business processes to be used with the project and with its business partners
- an information technology specification for the new environment (more an architecture and application specification than tool specification)
- a software prototype demonstration of collaborative modules for project management of the whole distributed project team. This prototype was implemented in internet/web environment

Operating systems are being implemented in the Ahlstrom unit – based directly on the demonstrator results

**Partners:** Ahlstrom, VTT, HUT

### ConNet - Construction Network (Integration of product models in an heterogeneous distributed IT environment)

CONNET has demonstrated concurrent engineering and the use of an integrated product model in an extended enterprise in the construction industry. Knowledge based engineering is used to transform heterogeneous data from dynamically changing partners into a product model for cost estimating, production planning and procurement support.

The demonstrator acquired and applied IT tools for integration of design & production planning, including:

- a product model integration tool,
- tools for a concurrent engineering environment and
- background information libraries.

Models and specifications were adapted, including: business process models, product data models, an enterprise network model and IT system architecture.

**Partners:** YIT Corporation, VTT Building Technology
(ConNet belongs also to Distributed Design)

### GlobOS - Networking in a distributed environment.

The GlobOS demonstrator focused on representation of core competencies in a distributed shipbuilding environment. The idea is that a group of shipyards forms a network (GlobOS Net).   In GlobOS Net core competencies are described with generic assembly modules These  assembly modules can be manufactured at assembly module factories with methods offered by GlobOS Net partners. These modules/models are developed as part of a GlobOS Net tactical engineering process. Each partner in GlobOS Net is pre-qualified to manufacture one or more of the generic assembly modules.

The GlobOS virtual enterprise (VE) has two business processes, one engaged in operational engineering, the other in manufacturing a ship. The set-up of the VE takes costs and capacity into consideration.  The GlobOS demonstration demonstrates how engineers in a design centre can utilise the GlobOS intranet applications to evaluate the manufacturing methods and facilities available in the GlobOS Net.

GlobOS has developed a concept for networking among shipyards. Different partners in the network should be pre-qualified to deliver different type of generic steel structure assemblies for the final ship. The GlobOS demo illustrates how facilities, methods and assemblies can be modelled and shared within such a network. The models are supported with a tool that allow configuration of assembly modules (what to assembly), while advising about the assembly method (how to assembly).

**Partners :**   Odense Steel Shipyard Ltd., Technical University of Denmark

## ICOM-BPR - INTRACOM'S BUSINESS PROCESS REENGINEERING

The ICOM-BPR demonstrator, was a WEB based demonstration of a generic and integrated methodological approach, for Business Process Reengineering (BPR) and Continuous Improvement (CI). The development of the ICOM-BPR demonstrator was based on state-of-the-art Internet/Intranet technologies and the business process knowledge models are generated using the METIS-NCR enterprise modelling tool, as well as IDEF0 and IFEF3 editors. It consisted of three interactive modules:

- The GM21EU ICOM-BPR Home Page,
- The ICOM-BPR as part of Common Demonstrator,
- The ICOM-BPR Web Demo

The ICOM-BPR case study "Global Order Fulfilment process reengineering" is presenting best practise with illustrated examples, including business process models, performance analysis results, as well as evaluation and prioritisation methods of redesign and improvement options.

**Partner:** Intracom

# PLANARIA - Intelligent Manufacturing System deduced from Planaria

Focusing on the engineering and manufacturing stages of a production facility, the project has aimed at realising the  next generation manufacturing systems - minimising constraints in building production lines at the engineering stage and able to flexibly respond to changes in the environment at the manufacturing stage.

To establish the PLANARIA system, specific core technologies were developed:
- Autonomous assembly Robot Cell driven by CAD data (ARC),
- Flexible Transfer System (FTS) and
- Flexibility Evaluation Trial (FET).

ARC is an intelligent mechanical system for performing assembly procedures autonomously.  Firstly functions had to be developed, such as the ability to recognise a changing environment, the capability of automatically generating an assembly process program, and the learning ability for error recovery. These functions were then merged to develop a prototype CAD data driven assembly robot cell.

FTS is a flexible transfer system that can be reconfigured to adapt to changes in the manufacturing environment. The PLANARIA group first developed transfer modules that can move the work in any direction, and a control

method that can do path planning in real time. Then they built a prototype system.

FET is a trial for providing an objective evaluation of manufacturing system flexibility. The ability to change will be an important metric for future manufacturing systems, which means we will need to be able to evaluate flexibility. PLANARIA employed simulation to evaluate the flexibility of a manufacturing system applying next-generation elements.

**Partners:** Daikin Industries Ltd, Ricoh Company Ltd, Toyo Engineering Corporation, Institute of Industrial Science, University of Tokyo, Nagoya University,

# PREM - Optimised Regional Manufacturing (Decision support for resource optimisation in global cable manufacturing)

The PREM project was concerned with optimised policies for equipping the business units participating in a virtual enterprise. It was based on a matrix model with a central organisation creating, growing and shrinking the business units, while these semi-autonomous units co-operate to fulfill individual production orders.

The demonstrator resulted in:

- a model of stages, phases, processes, and mini-operations to provide an effective description of manufacturing capability
- an algorithms that has been developed to identify optimum routings
- a database schema that describes manufacturing operations for LP/IP optimisation
- LP/IP models to provide optimised equipment selection
- a scenario investigation, which shows that the extended enterprise approach can provide an extremely cost effective use of new equipment

PREM will help to create a global approach to manufacturing, based on optimising the utilisation of global resources for product designs to suit the global market.

The benefits from the project include:
- improved utilisation of manufacturing resources
- improved selection of new equipment
- reduced disturbances to demand patterns
- well planned investment strategies.
- reduced need for wasteful down sizing reorganisations

**Partners**: BICC

# VIEWBID Virtual Enterprise Workbench for World-wide Integration & Development

The key outcome of the VIEWBID demonstrator is the VIEWBID workbench, which has been developed collaboratively with the VRIDGE demonstrator. The VIEWBID workbench shares the same system architecture and basic functional modules.

The VIEWBID workbench provides a company with an integrated set of tools and methods for co-ordinating its global business process. This increases understanding of the key business processes in global manufacturing and provides:
New management tools to operate in a world of global virtual enterprise.
New technologies and new applications in fields such as: modelling, simulation, and control.
Architecture for more efficient production in all domains of manufacture, but particularly in small batch or one-off production.

**Partners:** CSIRO, Griffith University, HDH

# VRIDGE - Virtual and Real Information Technologies driven Global Engineering/Enterprise

Manufacturing systems integrated with Information Technologies in the 21st Century will change both the business and the life styles of engineers.

VRIDGE Inc. is a virtual enterprise, which carries out the design, procurement, construction, and manufacturing of a chemical plant. This virtual enterprise (VRIDGE Inc.) has facilitated the understanding of global manufacturing business processes and the investigation of the requirements for global product information access and control, as well as the IT infrastructures for virtual enterprises. Specific results include:

Establishing the VRIDGE Workbench

The desktop environment for global engineering using Virtual and Real Information Technologies

Increased understanding of the key business processes in global manufacturing.

New management tools to operate in a world of global virtual enterprise.

New technologies and new applications in fields such as: modelling, simulation, and control.

Architecture for more efficient production in all domains of manufacture, but particularly in small batch or one-off production.

**Partners:** TEC, Omron, Takenaka, MES, ETL, CSIRO, Griffith University, NCR/METIS

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# 2.2.2 Distributed Support

# AhlRemote - Remote Operations Support (Business model for remote support of pulp mill equipment)

The objective of AhlRemote was to test the newest technologies for remote operations support in a process plant environment. Based on these experiences an additional aim was to examine the impact of remote operations support technologies on the customer service process at Ahlstrom.

A real test environment was established in connection to a delivery project from Ahlstrom Machinery, Savonlinna, Finland, to a customer in Tasmania, Australia.

The following operator support solutions were implemented and tested:
- multimedia based operator training manuals,
- remote training using video conferencing,
- computer based process plant training simulator,
- remote process monitoring, and
- remote process diagnostics.

In collaboration with other PG1WP5 demonstrators, generic information architecture for operator support and renewal (OSR) was developed and the demonstrator was mapped against it.

The experiences from the test environment have shown to be very potential in improving the customer service functions at Ahlstrom. Actual exploitation of the results in a service business has been started.

**Partners**: A. Ahlstrom Corporation, VTT Automation, CSIRO

# Farley - Operations Support

This demonstration has been concerned with the development of customised, intelligent, remote diagnostics and service systems for global service support of machine installations. It has covered the topics: Remote Diagnostics; Remote Process Optimisation; Remote Knowledge Acquisition and Remote On-line User Manuals.

During the investigation, the FIRST methodology, which stands for the Frame for Integration of Remote Support Technologies, was developed. The FIRST methodology makes use of the IDEF3 process modelling language to describe the remote diagnostics and service support process in a model. In addition to process information, the

process model also captures the knowledge of experts in the form of knowledge based system and multimedia information to support the functions. A model conversion software called "Protoweb" was developed to transform the model into a web network which delivers the captured information to customers via the Internet. The advantage of this method over other maintenance support system is the highly generic nature of the methodology. This has enabled it to be applied to other areas including training, process optimisation, web based registration and animated illustrations.

**Partners:** Farley , CSIRO

# Neo-Kaizen - Operations Support and Renewal

Demonstrator (Neo-KAIZEN) was a part of operations support and renewal work package (PG1 WP5 ) of IMS Globeman21 research project. It consists of three parts:

1. Remote support for operator assignment in the assembly line,
2. Remote operations and renewal support for discrete process plant
3. Remote operations and renewal support for continuous process plant.

The demonstrator has developed the concept for Kaizen Activity under the IT environment and has proposed an integration architecture. In order to demonstrate the proposed concept, three demonstrations have been developed;
    Discrete assembly line for manual assembly
    Discrete assembly line for automation assembly
    Continues Plant
To realise the demonstrations, the following tools have been developed:
    Web based data logger system for data gathering from a shop floor
    Simulation system for evaluating the shop floor activities.
    Multimedia data instruction system

The demonstration has provided experience for integration between real and virtual models and for remote maintenance using Internet.

**Partners:** Japan Society for the Promotion of Machine Industry (JSPMI), OMRON Corporation
Mitsui Engineering and Shipbuilding Corporation (MES), Toyo Engineering Corporation (TEC)

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## 2.2.3 Distributed Design

# DESMART -

The DESMART project has been concerned with design for the global market. The demonstration was primarily associated with the design of electrical cables. It focused on a globally optimised approach to product design, based on customer product requirements and manufacturing plant capability world-wide. Tools have been developed which will support the creation of cable designs from a global set of design rules, but which conform to national standards and local manufacturing constraints.

The benefits from the project include:
- decreased material and manufacturing costs,
- elimination of duplicated technical and engineering effort,
- improved distribution of factory workloads,
- establishment of information links between design, manufacture and quality assurance.
- optimal response times for both local and global changes,
- quick deployment of excess production capacity for various market regions,
- conformation of products to many regional standards.

**Partners**: BICC

**ProComa** - Product Configuration Management (Industrial application of a product configuration management system)

The demand for operational as well as strategical support of product configuration leads to the need for seamless integration of product life cycle management (design, integration of engineering and production) and manufacturing management (supply chain management, distribution, etc.). ProCOMA supports customer-oriented product configuration in the fields of optical measurement systems and the integration of technical and organisational aspects into a problem-specific product realisation concept. It will be used for the decision making in the selection of internal or external suppliers and for the selection of manufacturing facilities for components specific to the customer needs.

ProCOMA has produced the Product Configuration Management Concept including:
- New and advanced processes and methodologies for product configuration management
- Models and methods for communication between enterprise entities and for computer supported problem/requirement specification
- Methodologies for creating customer and market specific products

The implementation and application of the ProCOMA software tool in LOT-Oriel led to 2 major benefits:
- Smooth operation in the LOT-Oriel extended enterprise, supporting and optimising information, material and workflow.
- Fast and efficient information gathering and therefore provision of up-to-date and reliable information on global supplier and customer markets as a basis for management decisions.

**Partners:** LOT-Oriel: , FhG-IPA: , NCR: ,


**PROMINENCE**  - Design Background information systems

PROMINENCE has focused on the background knowledge or information that provides the context for the determination of product attributes in the design stage. Design specifications, design procedures, design history, and production technology requirements could all be considered as examples of this. The demonstrator has been concerned with how to utilise this information/knowledge to construct and apply integrated knowledge bases. In this project, the term "Design Background Information" or DBI is used to express "background knowledge/information" in an abstract sense.

DBI includes information for each individual element of the product life cycle, and it gives instructions for factors and the factors themselves required by the product beginning from the initial design phase.


The major deliverable from the work is a prototype for DBI management system. The system was developed on the basis of commercially available systems, such as a work flow management system and a data base system. The prototype was used for evaluating the usefulness of DBI in practical design cases. It has been shown to be very useful and will be developed further by some of the partners.

**Partners**: Toyota Motor Corporation , IBM Japan Ltd , Mazda Motor Corporation , Ricoh Company Ltd , Mitsui Engineering & Shipbuilding Co., Ltd. , Toyoda Machine Works, Ltd. , University of Tokyo , Waseda University , Chuo University , Tokyo Denki University , Osaka Industrial University

**CONNET**: see Distributed Management demonstrators

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# 2.3 Globeman21 Team Achievements

## 2.3.1 Common Concept Team

The Globeman21 Concept defines the new dynamic, collaboration-based and distributed global business processes and the conceptual models behind them.   This team aims to ensure that the Globeman21 Concept can be implemented by manufacturing companies to reach a new level of effectiveness, speed and flexibility to deliver their customers their products and services and to support the users to utilise such products and services optimally over the product life times.

The Concept Team has achieved the following:
- GERAM has been developed and used as a basic reference architecture for the development of the generic models for EEM and PCLM.
- Concepts for Extended enterprise management have been developed, and models to describe the realisation of the concept through the formation of virtual enterprises has been created and described.
- A consistent terminology for the main themes (EEM and PLCM) has been developed based on definitions from GERAM. This Globeman21 Glossary can be found on the homepage (http://ims.toyo-eng.co.jp/).
- A set of descriptive parameters for extended enterprise networks and virtual enterprises has been developed and partly tested through the Globeman21 questionnaire. The descriptive parameters could also be considered as a taxonomy for EEM.
- A first version of a typology for extended enterprises has been developed, which is based on the taxonomy.
- Work has also been done, by different partners, to create a methodology for the creation and management of virtual enterprises. A first version using the Metis modelling tool is available on the Concept demonstration.

## 2.3.2 Globeman21 Demonstration Team

The Globeman21 Demonstration has been designed to assist the Globeman21 partners to benefit from the project by:

- Promoting  the use of developed methods and solutions
- Promoting the dissemination
- Demonstrating the results
    - Global manufacturing concept
    - Possibilities of using IT in networking
    - Achievements in the industrial demonstrators
    - Relationships and interactions between the demonstrators

The main outcome is the web demonstration (http://ims.toyo-eng.co.jp/ and also:http://extranet.vtt.fi/gm21/demo/). This demonstration consists of:

- An introduction to the project
- Three different tours to the results achieved in the industrial demonstrators:
    - Presentation of the business logic for the demonstrator
    - Identification of the relevant life cycle activity of the demonstrator
    - Dynamics of networking and the identification of demonstrators related to relevant phases in the network dynamics
- General presentation of methodological and conceptual work in the project
- Links to the demonstration of the achievements in all 14 industrial demonstrators

Links to presentations of concrete achievements in the conceptual, generic and methodological work

## 2.3.3 IT Infrastructure Team

The IT Infrastructure team was set up to:

- Support the creation of a Gobeman21 "memory" of what we have and know
- Support the Globeman21 partners in exchanging knowledge and understanding
- Support the needs of WPs and Demos
- Support the needs of Globeman21 as a project
- Specify minimum IT configuration for Globeman21 partners

In fulfilling its objectives of establishing the Globeman21 communication environment, the team conducted the following studies and tasks:

- Experimented with firewall crossing for the enforcement of control policies of Globeman21 and participating organisations.
- Evaluated and compared Lotus Notes Domino and WWW.
- Experimented with global video conferencing and introduced a Talk Room.
- Developed workbench architecture.
- Developed WWW enhancement services.
- More complete Web mirroring scheme were defined
- Prototyping of access control and data management were studied.
- Experimented and reported on Push Technology
- Time basis Web page presentation were studied - a mechanism to allow members to have a quick grasp of what is happening in GM21 was established.
- A list of IT used in Exhibitions and Demonstrators was prepared.

## 2.3.4 Communication Team

The Communication Team co-ordinated communications among Globeman21 partners using the results of R&D works of TG2. The service supported the R&D work of all Globeman21 members in both managerial and technical aspects.  It also provided one of platforms for WPs and Demonstrators to disseminate their deliverables.
In summary the Communication Team provided and operated the official Globeman21 WWW Service, including:

- WWW publishing and documents sharing plan
- Routine contents upload and maintenance service
- WWW reform for effective dissemination
- WWW enhancement service (mirroring, access control etc.)
- WWW masters supervision
- Maintaining and managing the Globeman21 Mailing-list Service

## 2.3.5 Product Model Team

A survey of product models has been completed and modelling tools have been used in GM21 demonstrators
These models have been analysed with evaluation tools.

Conclusions have been drawn as follows:

- There are many concepts of Product Models .
- It is necessary to use an appropriate Product Model (or modelling tools) for each application.
- -We can use (or see) information through multi-media such as WWW.
- - From the beginning of the model design it is necessary to consider data exchange between applications (STEP)
- Simulation with large scale models through the whole product life cycle process will be important, in the future.

## 2.3.6 Dissemination Team

This team has encouraged an monitored the development of the Globeman21 web pages, the preparation of CDs capturing the content of these pages, and the open publication and dissemination of Globeman21 results in books, papers and conference proceedings.  The Dissemination Team prepared this Globeman21 "Final Report".

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# 3. DISSEMINATION OF ACHIEVEMENTS

Globeman21 dissemination has been done in 2 main ways. First by providing the project and results information at the public Globeman21 web pages (http://ims.toyo-eng.co.jp/) and secondly by disseminating the project results in conferences, journals, books and thesis papers. And by arranging Open Days, where both the conceptual results have been presented as well as there has been Exhibition of the industrial demonstrator results.

## 3.1  Globeman21 Demonstration

To illustrate all results in a compact manner to manufacturing at large, a Globeman21 Demonstration was created. It is a web demonstration under the Globeman21 public web site (http://ims.toyo-eng.co.jp/). It contains brief illustration of all the main issues within Globeman21 and links the conceptual and practical results together by showing what industrial issues affected what conceptual work and vice versa.

## 3.2 Dissemination of results

The other dissemination has taken place by giving papers in conferences and seminars, writing articles to journals and via several thesis papers. (see Appendix A for a list of publications).

Also Globeman21 has exhibited its results in several occasions during its Plenaries. In Sydney 1996 and in Toronto 1997 presentations were given to industry guests. In October 1998 in London, as well as presenting papers, an exhibition of industrial demonstrators was given to invited guests.  In the closing of Globeman21 in Tokyo in March 1999, a full 2-day Open Forum was given. The Open Forum included both internal and external speakers and an exhibition of all 14 completed demonstrators.

# B.  GLOBEMAN21 AS A PROJECT

**(Please use Globeman21 web for further information about the project - http://ims.toyo-eng.co.jp/)**

# 1. BRIEF HISTORY OF GLOBEMAN21

## 1.1 The IMS Feasibility Study

In 1989 Professor Yoshikawa, then of Tokyo University, recognised that great benefits could arise by sharing the international expertise and the costs of research and development.  Based on his proposal an international program, Intelligent Manufacturing Systems (IMS), was initiated. The participating countries - Australia, Canada, the European Free Trade Association (EFTA) countries, the European Union (EU) and the USA - conducted first a feasibility study from 1992 until 1994. Five test case projects and one study project operated during the feasibility study.  Globeman21 was one of these test cases.

## 1.2 The Globeman21 Test Case

31 organisations from Australia, Canada, EU, EFTA, Japan and USA agreed by the second half of 1992 to form the Globeman21 consortium. Its goal was to determine the viability of international R&D co-operation for improvement of global manufacturing practices. The consortium was also to assess the mechanisms necessary to implement a full-scale IMS program.

The vehicle to determine this was a study to establish the requirements, which facilitate efficient global manufacturing businesses.  This included topics like concurrent engineering and supply chains, across time zones and enterprises – in other words, in a distributed environment.

The test case identified three essential features for manufacturing in the future.
- the "virtual enterprises", or close collaborations between companies and organisations (usually not bound together by long-term formal arrangements) all over the world, to produce a specific product or outcome.
- the need to integrate the whole life cycle of a product from initial conception through to final disposal
-  the adaptation and adoption of information technology (IT) in ways that integrate global enterprises, to achieve really close working relationships between widely scattered groups and people

These findings from the Feasibility Study became the basis for the Globeman21 full-scale research.

## 1.3 Transition Period

After the feasibility study, no official structure was in place for R&D projects under the IMS program. However several Globeman21 partners remained active in Australia, Europe and Japan and tested further collaboration between distributed partners, by using a simulated delivery project for testing.

At the same work went on to create the Globeman21 vision and further research objectives. Those definitions and requirements were then used to create the proposal for Full Scale project.

## 1.4 Formation of the Full-Scale Globeman21 Project

By mid 1995 a proposal was submitted to the International Steering Committee of the IMS program and a Consortium Co-operation Agreement (CCA) was prepared and signed by the 52 partners then in the project.

The project proposal concentrated on the 2 main issues found at the feasibility study: 'Global Product Life Cycle Management' and on' Global Manufacturing Management', which had been identified during the feasibility study.

However it was seen that these business issues needed to be supported with technology R&D, to provide the IT support both for modelling the new distributed & life-cycle environments as well to implement business processes in those environments. In the end 2 business process groups and 4 supporting technology groups were defined to structure the R&D work within the project.

# 1.5 Development of the project R&D structure during the Full Scale project

Originally the project then was made of 6 groups, 2 business process groups and 4 supporting technology groups. Those were then divided up to 32 Work Packages.

However, due to funding problems in the first year and half of the project, much of the planned work could be undertaken. Many of the defined work packages remained inactive and some were quickly merged together to create the cross-regional collaboration between regional research work.

Very early in the project it was also realised that findings must be verified in practice. That led to the creation within work packages of industrial demonstrators to implement partner specific solutions.

So, despite of funding problems, all industry specific work as well as the work about the specific conceptual issues was quite quickly activated. The remaining collaborative work needed to establish the common Globeman21 Concept and its overall illustration -was then organised with cross-regional and cross-functional teams. So the Concept Team and the Globeman21 Demonstration Team were formed. As that approach was found to be very beneficial, it was also adopted for other cross-regional work, including a study of available/necessary product modelling, IT infrastructures, project management in communications and in disseminating the project results.

# 1.6 Timing of IMS and of Globeman21

The time scale for the development of the international IMS project, from its initial inception by Professor Yoshikawa in Japan in 1989 is shown in Figure 1.
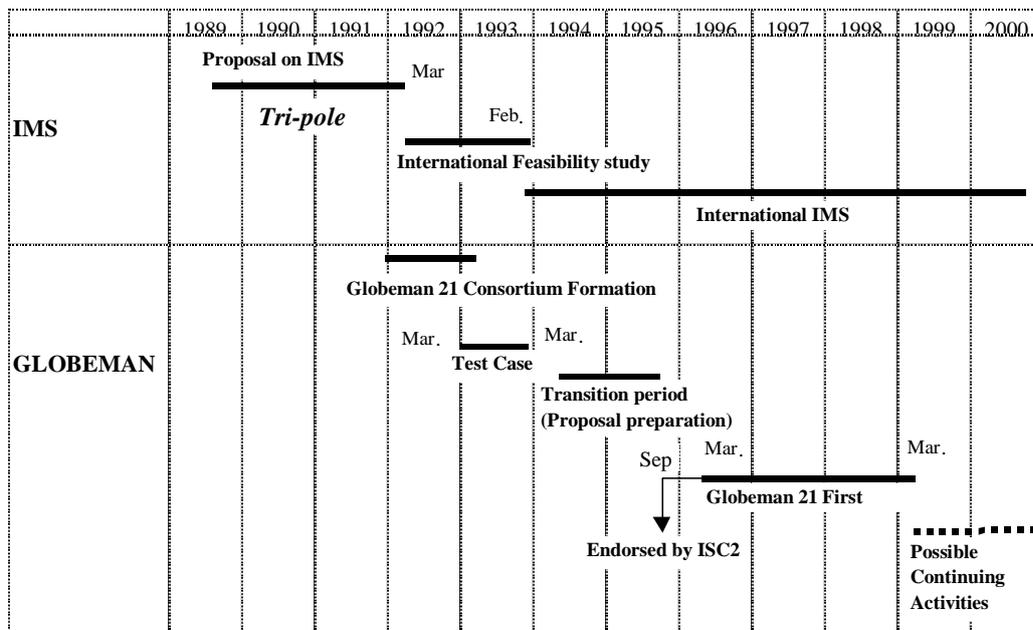


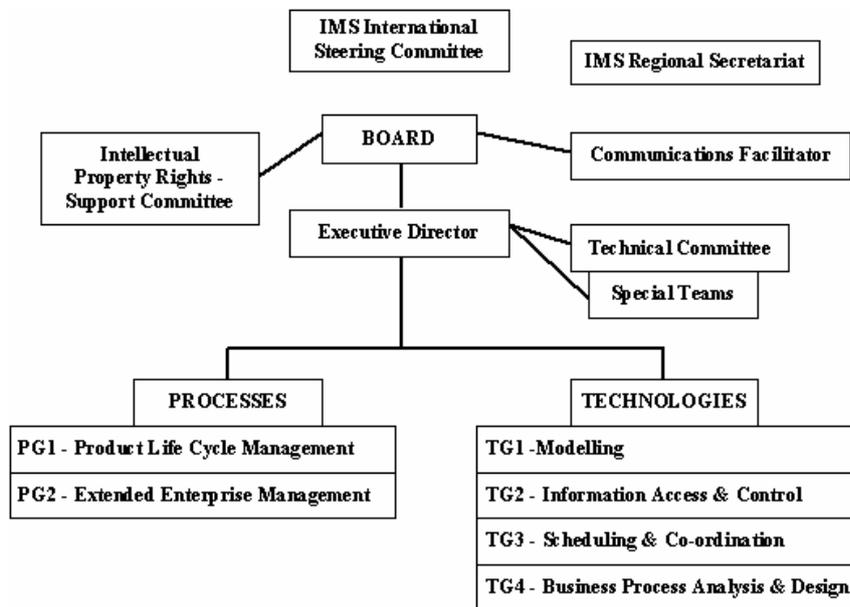FIGURE 1  History of the Globeman21 Project within the IMS Initiative
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# 2. GLOBEMAN21 STRUCTURALLY

## 2.1 CONSORTIUM MANAGEMENT STRUCTURE

The Globeman21 consortium adopted the management structure shown in figure 2. The Board consists of a representative from each of the active regions (Australia, Canada, EU, Japan and USA). A Chairman, Deputy Chair, Communications Facilitator and Executive Director were elected by the Board to serve an 18 month term of office. The Board normally meets at 6 monthly intervals. The Executive Director was Chair of the Technical Committee and plays the key role in managing the day to day affairs of the whole project. This means that the Executive Director had to have excellent communication with all parties in the consortium.  The role of Communicator Facilitator was important to ensure an effective communication network was established.

Management was then supported with monthly and other reporting procedures, to provide the Executive Director and the Technical Committee as well as the Board with relevant and current information about the project status.



*Figure 2 - Management Structure of Globeman21*
*(note: demonstrators are organised under individual work packages)*

## 2.2 R&D STRUCTURE

The R&D work was done under the management structure, but effort was taken to create a cross-regional, cross-structural environment, to accomplish the different results sought. Figure 3 shows how work packages, teams and demonstrators were working together, to create the results. The 'cross-xx' structural thinking actually led to very fruitful co-operation with sometimes-unexpected 'bonus' results.
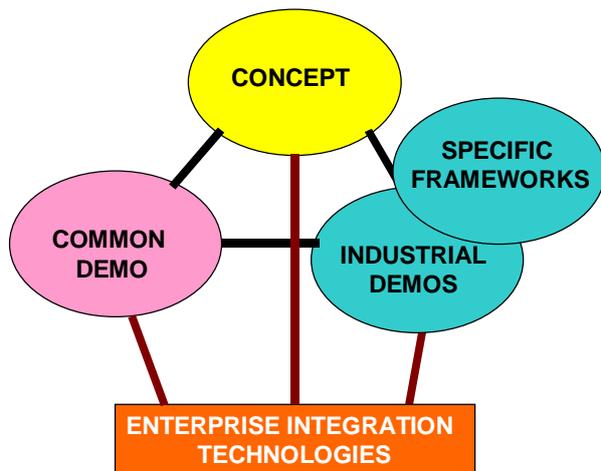
*Figure 3 : R&D 'cross'-structure*

## 2.3 COMMUNICATIONS STRUCTURE

The communications network was based primarily on e-mail and web pages.

Email directories were provided for several levels and groupings within the project to provide an easy and efficient knowledge transfer within project groupings. A centrally managed communication net provided all partner contact information and up-to-date information about project participants.

Web services were also started from the very beginning. The first implementations were quite simple to provide access to some common documents. As the working papers, results, internal reports and dissemination papers grew more numerous, the web was steadily updated. There were both internal and a public web sites and the internal web was divided between technology and management areas.
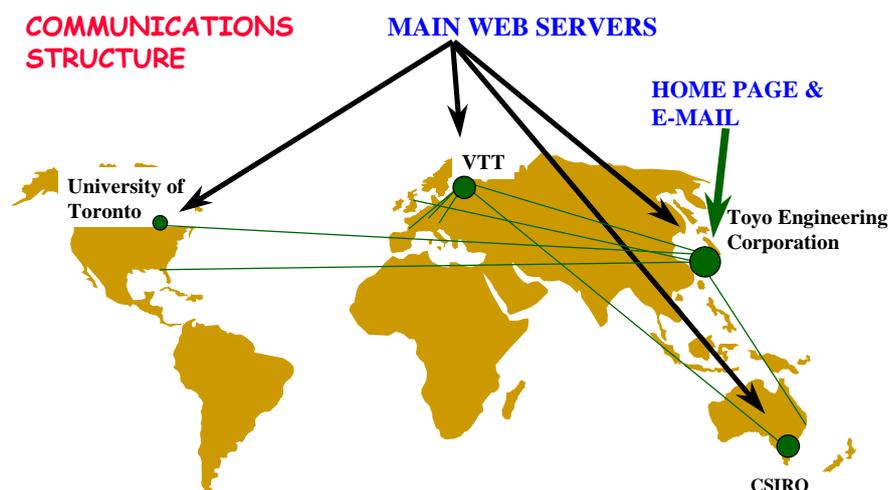


*Figure 4 Email and web structure*
Public web address: http://ims.toyo-eng.co.jp

## 2.4 MANAGEMENT ISSUES

Research management in Globeman21 proved to be similar to any co-operative research activity, but on a large, international scale, with: time, cultural and language barriers to be overcome. English was used for all communications. Different time zones in fact permitted 24 hour operations in some cases. Relatively frequent face

to face meetings of the Work Package groups were held in different regions. This was important to build rapport between people. Electronic communication was the element that enabled the whole project to operate.

The project balanced management and R&D activities across regions and partners. Even though there were many changes, rotational ones planned ahead and others either planned as necessary or unexpected when people moved from or into the project, the balance was quickly recovered. Trust grew and created a positive platform for collaboration and information exchange.

The other important issue was to manage by results. All work was defined based on short-term and long-term results. Those were then scheduled and followed-up. Regular reporting allowed all parties to be informed about meetings and other main events.

Establishing 'demonstrator' projects helped to overcome the classical difficulty of achieving real co-operation between industry and research partners. Demonstrators provided direct benefits for the industries involved and also served as test-beds for technologies under development by the researchers. This practice worked exceedingly well and provided major support for achievement in all of the active Work Packages.

Globeman21 held plenary meetings, open to people from all the participating partners, every six months. These provided an essential opportunity to share experiences and results, and to decide on future project activities. They were also important in building trust and understanding between people. Several partners have reported that the sharing of ideas and the breaking down of cultural differences has resulted in improved performance in the partner organisations.

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# 3. AGREEMENTS & GUIDELINES

Globeman21 management was supported with 2 main procedural agreements - with Consortium Co-operation Agreement (CCA) and with Operational Procedures. . More information is available on the Globeman21 WWW (http://ims.toyo-eng.co.jp/ipr)

## 3.1 Intellectual Property Rights (IPR) and the Consortium Co-operation Agreement (CCA)

The Consortium Co-operation Agreement (CCA) dated July 17, 1995,  was the main agreement, based on IMS Terms of Reference. It included intellectual property rights and others rights and responsibilities of Partners.  The CCA was a written agreement by all project Partners and was amended on November 1, 1997 by unanimous agreement in writing, again by all project Partners (CCA Amendement No. 1).

**Background of the CCA Document**

An Intellectual Property Rights Support Committee was set up before the project commenced.  This committee of 3 people from different regions produced the CCA, which was agreed by all partners, and the support committee guided the Board in monitoring and maintaining appropriate conditions for IPR

The CCA has two main purposes.  It sets a formal framework for the collaboration within the Project, and it ensures that there are no obstacles to the utilisation of the results.

The CCA is similar to the conventional European model, but incorporates a number of changes and additions resulting from:
- the mandatory conditions imposed by the TOR, in particular the intellectual property right (IPR) conditions: these mandatory conditions are underlined in the CCA.
- the needs of Partners to observe their domestic laws.
- the complexity of the Project's administrative structure, which results from the very large number and wide geographical spread of the Partners.

An outline of the content of the CCA and CCA Amendment No.1 is provided as an Appendix B

## 3.2 Operational procedures

An Operational Protocols document provided practical procedures to work in the project, from monthly reporting to overall communications standards and file formats. The Operational Protocols were enacted by the Board, based on recommendations from the Executive Director and the Technical Committee.

## 3.3 Globeman21 Partners

53 partners signed the Globeman21 Co-operative Collaboration Agreement (CCA) in July 1995.  During the course of the project several partners withdrew and some new partners joined.  The final list of partners is shown in Appendix C

# APPENDIX A.  Publications

## Journals & Proceedings

- Vesterager, Larsen, Cobbi, "Virtual Enterprise Architecture and Methodology – Initial Results from Globeman21 ICE'99",  Den Hague, the Netherlands, 15-17.3.1999 (English)
- Laszlo Nemes and Bob Brown "Globeman21 -Intentional Co-operation in Manufacturing Management" Australian Academy of Technological Sciences & Engineering, Focus, No.104, November/December 1998 (English)
- Hannu Syntera "Challenges in Global Manufacturing (as seen in Globeman21)", IiM '98, IMS Workshop, Gothenburg, Sweden, 9.10.1998 (English)
- Martin Ollus,  Kalle Kuhakoski, Anne Niemenmaa, Matti Uusitalo, Jukka Koponen, Matti Monkkonen, Erkki Pulkkinen,  Pekka Tervola, Kari Koskinen  "Systems for Support of Process Operations - Integration in Manufacturing",  IiM 98" in Sweden    (6-8 Oct. 1998) (English)
- Odd Myklebust, "Overview of IMS-Globeman21 and Introduction to GERAM", Industrial meeting, Aug 1998, Trondheim, Norwegian project Productivity P2005 (English)
- Martin Ollus, Eila Järvenpää, and Jukka Ranta "Networking in knowledge intensive businesses" Academy Of Business & Administrative Sciences, International Conference on Emerging Economies, Budapest, Hungary, July 13-15, 1998 (English)
- Matti Uusitalo, "Operations Support System for DD Washer", Control Systems'98, Tutorial Workshop, Haikko, Porvoo, Finland, 31.8.1998 (English)
- Vesterager, Kaas-Pedersen, Larsen, "Creating a Generic Extended Enterprise Management Model using GERAM - presentation of the IMS/Globeman21 project",  First International Symposium on Concurrent Enterprise (ISoCE '98), Sinaia, Romania, 4.-6. 6.1998 (English)
- Martin Ollus and Hannu Syntera, "Intelligent Manufacturing in Global Networks", Virtual Factory Conference, Dipoli, Espoo, Finland, 4-5.6.1998 (English)
- Mingwei Zhou, John Mo, Laszlo  Nemes, M. Shinonome, H. Hashimoto,  A. Fuse, Peter Bernus, Greg Uppington  "Design of a Virtual Manufacturing Enterprise and its Implementation in a Workbench"  DIISM 98 (May 1998) at ARRI, USA (English)
- M. Shinonome, H. Hashimoto, A. Fuse,  John P.T. Mo "Development of an information technology infrastructure for extended enterprise"  DIISM 98 (May 1998) at ARRI, USA (English)
- D G Karadimas  and P M Chrissohoos "Presentation of GM21 EU project and ICOM-BPR pilot objectives. Examination of links and potential relationships among GM21 EU and GLOBE" GLOBE Esprit project 21973 meeting, Athens, Greece, 29.-30.4.1998 (English)
- Hannu Syntera "Extended Enterprises. The New Way of Global Manufacturing", Copernicus Symposium, Wroclaw, Poland, 23.-24.4.1998 (English)
- Frank Lillehagen, "Knowledge Modelling in Globeman21", R&D Conference, Norway, 24.3.1998 (English)
- K. Christiansen "Virtual Enterprises in Shipbuilding", The Learning Organisation, Copenhagen, Denmark, 24.-25.3.1998 (English)
- Helena Walters and Hannu Syntera, "Global Manufacturing" ,First International Workshop on Intelligent Manufacturing Systems, Lausanne, Switzerland, 15.-17.3.1998 (English)
- Fuchigami, A., Peter Kerites, Hashimoto H., Kojima, S. "Self-scheduling of CAD data oriented assembly robot task" The 15th Annual Conference of RSJ 1997.9, RSJ (Japanese)
- Fuchigami, A., Peter Kerites, Hashimoto H., Kojima, S. "Research for CAD data Oriented Automatic Assembly Robot Module" JSME Annual Conference on Robotics and Mechatronics (ROBOMEC'97) volume.B P.949  `950, 1997.6, JSME  (Japanese)
- Fuchigami, A., Hashimoto H., Kojima, S. "3D-CAD Based Programming of Automatic Assembly Robot Cell System" The 14th Annual Conference of RSJ (The Robotics Society of Japan) 1996.11 Vol.3 pp.837-838 (Japanese)
- Fuchigami, A., Hashimoto H., Kojima, S. "Object Pose Estimation from Range Image Detected by Laser Range Finder" The 5th Symposium on Robot Sensors: by SICE (The Society of Instrument and Control Engineers) 1996.4, pp.115-118 (Japanese)
- Fuchigami, A., Hashimoto H., Kojima, S. "Picking of Freedom Object by Hand Eye System with High Speed Laser Range Finder" 1996 National Convention Record I.E.E. Japan: by IEEJ 1996.3, Vol.2 pp.51-52 (Japanese)

- Mori, K. et.al "Manufacturing System Aggregating Real Model and Virtual Model" Proc. of Advances in Production Management Systems 1996, pp.309-314 (English)

## Books

- Yoichi Kamio "Information Infrastructure Systems for Manufacturing," [pp.409-417 Globeman21:Enterprise Integration for Global Manufacturing towards the 21st Century] Chapman & Hall, 2-6 Boundary Row,London SE1 8HN,UK 0-412-78800-4 (*English)*
- H. Ohkura "Challenge of Japan- How to Introduce your Innovation to the Japanese Market? ", pp 11-63 OIIC/ Helsinki University of Technology, 1998 - *(English)*
- Ollus, Ranta and Ylä-Anttila(ed.) "Business Networks – Competition with Info, Speed and Agility (Finnish) Yritysverkostot-kilpailua tiedolla nopeudella ja joustavuudella Taloustieto Oy, Helsinki 1998
- Ollus, Ranta and Ylä-Anttila-(ed.) "Revolution of Networks. How to Manage the Network Company" (Finnish) Verkostojen vallankumous. Miten johtaa verkostoyritystä?
- Taloustieto Oy, Helsinki 1998
- T Williams, H Li, P Bernus, G Uppington, L Nemes "The Life-cycle of an Enterprise." Chapman and Hall, 1998 (*English)- -*
- P Bernus, L Nemes, T J Williams "Architecture for Enterprise Integration" Chapman & Hall, 1996 04-12 731 401 (*English)-*
- P Bernus, L Nemes, B Morris "The meaning of an enterprise model" Chapman & Hall, 1996, pp.183-200 (*English)- -*
- P Bernus, L Nemes "Modelling and Methodologies for Enterprise Integration" Chapman & Hall, 1996 04-12-756-307 (*English)*
- P Bernus, L Nemes "Application of enterprise modelling languages for concurrent engineering" (special issue of Concurrent Engineering Research & Applications) September, 1996 (*English)- -*

## Referred and Invited Papers

- G Uppington, P Bernus "Assessing the Necessity of Enterprise Change: Pre-feasibility and Feasibility Studies in Enterprise Integration". International Journal of CIM To appear 1998 (*English)*
- Martin Ollus, Eila Järvenpää, and Jukka Ranta, "Networking in knowledge intensive businesses" in "Corporate networks: emerging strategies of doing business." E. Järvenpää (Ed.), HUT Industrial Management and Work and Organizational Psychology, Working Paper No 16.  ISBN (paper) 951-22-4166-8, (electronic) 951-22-4167-6. 1998 (*English*
- Bernus P, G Uppington "Co-ordination of management activities - mapping organisation structure to the decision structure." In Coordination Technology for Collaborative Application - Organisations, Processes, and Agents. LNCS 1364 1998 in print (*English)*
- P Bernus, L Nemes "Requirement of the Generic Enterprise Reference Architecture and Methodology". Annual Reviews in Control Vol 21, pp. 125-136, 1997. (*English)*
- P Bernus, L Nemes "The Contribution of the Generalised Enterprise Reference Architecture to Consensus in the Area of Enterprise Integration." Proc ICEIMT97. K Kosanke, J Nell (Eds), Springer Verlag Enterprise Engineering and Integration - Building international consensus, pp. 175-189 (*English)*
- P Bernus "Business Evolution and Enterprise Integration." Proc ICEIMT97. K. Kosanke, J. Nell (Eds), Springer Verlag Enterprise Engineering and Integration - Building international consensus, pp. 140-151 (*English)*
- G Uppington, P Bernus "Identifying the need for change: Pre-feasibility studies and Feasibility Studies in Enterprise Integration." Proc ICARV'96, Dec 1996 ISBN 981-00-8551-6 Vol. 3/3, pp. 1565-1 (1996) (*English)*
- P Bernus, P Bertok, L Nemes "Modelling Dynamic Management Features in Virtual Enterprises." Computer Applications in Production Engineering 97 Chapman and Hall, 1997, pp. 643-655 (*English)*
- P Bernus, L Nemes "A framework to define a generic enterprise reference architecture and methodology (GERAM) "ICARV Conference on Automation Robotics & Computer Vision Vol.1 of 3, pages 88-99 November 1994 (*English)*
- P Bernus, L Nemes, TJ Williams and et al. "Architectures for integrating manufacturing activities and enterprises." Control Engineering Practice 2(6):939-960 December 1994 (*English)*
- P Bernus, L Nemes "Enterprise integration-engineering tools for designing the business processes of enterprises." Australia-Taiwan Joint Workshop on Materials Processing technology pages 151-158 June 1995 (*English)*

- A Tharumarajah, J Wells, L Nemes - "Comparison of the bionic, fractal and holonic manufacturing systems concepts."- Int. Journal on Computer Integrated Manufacturing - 3):217-226 1996 (*English*)
- P Bernus, L Nemes "Requirements of the generic enterprise reference architecture and methodology" Preprint of the 13th World Congress of IFAC volume B, pages 109-120 June-July 1996 (*English*)
- P Bernus, L Nemes "A framework to define a generic enterprise reference architecture and methodology Computer Integrated Manufacturing Systems" 9(3): 179-191 1996 (*English*)

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- Torma, "A Model for the Dynamic Planning of Industrial Projects" *Doctoral Thesis*, Helsinki University of Technology; Computer Science and Engineering ACTA POLYTECHNICA SKANDINAVICA; Mathematics, Computing and Management in Engineering Series No.85 Espoo, Finland, 1997, ISBN 952-5148-21-1
- Laitinen "Model Based Construction Process Management", *Doctoral Thesis,* Royal Institute of Technology; Construction Management and Economics Stockholm, Sweden, 1998  ISBN 91-7170-301-2,
- Siponen "Collaborative Information Sharing in Industrial Projects", *Master's Thesis,* Helsinki University of Technology; Information Processing Science Espoo, Finland 1998
- Tella "A Model of consortium formation," *Master's Thesis*, Helsinki University of Technology, Espoo, Finland, February 1999
- Lindström "Computer aided planning of industrial project consortia", *Master's Thesis*, Helsinki University of Technology, Espoo, Finland, February 1999

## Lectures and Seminars

- L. Nemes "Designing a Virtual Enterprise" at PROLAMAT'98 Internatinal Conference, Italy, September 1998
- Bernus, P.,  The Generalised Enterprise Reference Architecture and Methodology GERAM August, 1998, Sloan School of Management, MIT, August 1998
- Bernus, P., The Generalised Enterprise Reference Architecture and Methodology GERAM , National Institute of Standards, Gaithersburg , MD, USA, August, 1998
- Bernus, P., The Generalised Enterprise Reference Architecture and Methodology GERAM , June 1998, Univ of Saarlandes, Germany, seminar, June 1998
- Bernus, P., The Generalised Enterprise Reference Architecture and Methodology GERAM, management training seminar, ETI Co., Slovenia, June 1998
- Bernus, P., Mapping Organisation Structure to the Decision Structure , management training seminar, ETI Co., Slovenia, June 1998
- Bernus, P., "Decision Structure, Organisation and Global / Virtual Enterprise" Univ. Jaume, Spain, industry tutorial, June 1998
- H. Ohkura  "Challenge of Japan- How to Introduce your Innovation to the Japanese Market?", Helsinki/ Finland, May 1998
- H. Ohkura  "IMS and Intellectual Property Right in Global Joint R&D Consortium & its Actual Implementation" Seoul/ Korea, September 1997
- L Nemes "The investment and benefits for Australian companies in the international Intelligent Manufacturing Systems program" February 1997
- P Bertok, S M Lai, L Nemes "Co-operative design and the internet, current issues, future prospects" June 1996
- H. Ohkura and  M. Lampola "IPR in Global Joint R&D Consortium by 50 Partners" at CALS EXPO95, Long Beach/ USA, October 1995
- L Nemes "Innovation and commercialisation with international groups; collaboration through Intelligent Manufacturing Systems" September 1995
- L Nemes "Australian participation in the feasibility study" March 1995
- L Nemes "Technological scope of intelligent manufacturing systems" October 1994
- L Nemes "Intelligent manufacturing" October 1994
- H. Ohkura "Intellectual Property Rights in IMS Program", at IMS IPR Symposium, Tokyo/ Japan, June 1994

# APPENDIX B Summary of the CCA & CCA Amendment No.1

# CCA

Article 1 (Definitions)      definitions are to a mandatory format, imposed by the TOR.
Article 2 (Purpose & Scope)      commits the Partners to undertake the Project work.
Article 3 (Administration) brings in detailed administrative arrangements.  These are set out in an attachment (Exhibit D) to the CCA, in order to facilitate any future changes which prove to be necessary.  In our experience, the complexities are necessary in order to avoid the twin potential problems of:

Partners who may not perform their allotted tasks

leaders who may mis-use authority

Article 4 (Participation)    allows other parties to join the Project or to be treated as Affiliates (see below).
Article 5 (Responsibilities)      details the Partners' commitments in connection with the undertaking of the Project work.  In the case of a Partner being asked to leave, the others are to ensure that its tasks are re-allocated.
Article 6 (IPRs)      is partly in the mandatory format imposed by the TOR, and is concerned with the ownership of IPRs, including joint ownership:  it also sets up a mechanism to maximise the common benefit from patents on Foreground.
Article 7 (Publication & Dissemination)      imposes restrictions on the extent to which a Partner may publish his own Results.
Article 8 (Licensing Rights))      is also largely mandatory.  The difference between Background and Background Rights is that Background Rights are patented and Background is not.  Every Partner and its Affiliates are entitled to:

licenses to exploit the other Partners' Foreground (Results), royalty-free unless the owner is a non-profit organisation

licenses to exploit the other Partners' and their Affiliates' patented Background Rights which are needed for exploitation of all the Results, on normal commercial terms.

Furthermore, if any non-patented Background is licensed to the other Partners and their Affiliates, this has to be on fair, non-discriminatory terms.

Article 9 (Confidentiality) imposes restrictions on the extent to extent to which a Partner must keep the other Partners' Results and other information confidential.  Note that it is back-dated, in order to confirm the confidentiality of information exchanged since 28 February 1994.
Article 11 (Term)    governs the duration of the CCA.  Partners may not unilaterally leave the Project during the first two years.
Article 10, 12 and 13 (Government requirements, Settlement of Disputes and Miscellaneous) are routine.

# CCA Amendment No.1

1.   Guidelines for the Admission of Additional Partners
2.   Positive/ Negative Listing of Affiliates having IPR rights and obligations
3.   Guidelines for the Permission of non-Partner's Participation in Working Sessions
4.   Measures to Inactive Partner in performance in relation to Model Work Package Plan
5.   Detailed Organisation Conditions for Consortium Management

# APPENDIX C - List of Partners at Termination of Globeman 21 - 31 March 1999

**Region of Australia:**
Farley Cutting Systems Limited (Regional Co-ordinator)
The Broken Hill Proprietary Company Limited
Hawker de Havilland Limited
The Commonwealth Scientific and Industrial Research Organisation
Griffith University

**Region of Canada:**
University of Toronto (Regional Co-ordinator)

**Region of European Union( EU) & Norway:**
A. Ahlistrom Corporation (Joint Regional Co-ordinator)
BICC Public Limited Company (Joint Regional Co-ordinator)
Intracom S.A.
Fraunhofer Institute for Production Technology and Automation
Fraunhofer Institute for Production Systems and Design Technology-IWF YIT-Corporation
VTT Automation & Building Technology
Helsinki University of Technology Odense Steel Shipyard Ltd.
Technical University of Denmark/ Institute of Production Management and Industrial Engineering
L.O.T.-Oriel GmbH
NCR Norge AS ( former name - AT&T METIS)
Sintef Production Engineering

**Region of Japan:**
Toyo Engineering Corporation (Inter-Regional and Regional Co-ordinator)
Omron Corporation
Daikin Industries, Limited
Toyoda Machine Works, Limited
Toyota Motor Corporation
Mazda Motor Corporation
IBM Japan, Limited
Mitsui Engineering & Shipbuilding Company, Limited
Ricoh Company, Limited
Takenaka Corporation
University of Tokyo
Electrotechnical Laboratory
Japan Society for the Promotion of Machine Industry
Nagoya University
Institute of Industrial Science

**Region of The United States of America:**
Newport News Shipbuilding (Regional Co-ordinator)
University of Virginia