TOUCH AND DESIGN

DISSEMINATION AND EXPLOITATION IN T'nD

by
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Abstract

This document describes the dissemination strategy that is applied for the communication and dissemination of T'nD project results, and also the exploitation strategy defined by the partners for exploiting the project results.

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0. Index

1. Introduction

This document presents the dissemination and exploitation strategy defined by the T'nD partners. The aim is to identify some actions to perform that allow the partners to communicate and disseminate project achievements and also to plan an appropriate and successful exploitation of results and of products developed.

The three main activities to perform are the following:

- *Dissemination*: dissemination of results outside the project;

- *Communication*: communication of results within the project;

- *Exploitation*: exploitation of results through commercial products.

Chapter 2 briefly presents the project, its objectives, the expected results and the current achievements.

Chapters 3 and 4 describe the strategy for communicating and disseminating the project within and outside the project.

Chapters 5 to 8 present the content available in T'nD to disseminate and the channels to use for disseminating the project content. Chapter 9 presents the target audience.

Chapters 10 and 11 present the related projects and networks and the partners' responsibilities.

Chapters 12 to 15 describe the exploitation strategy, the results to exploit and the market analysis.

2. Description of the T'nD project

EC PROGRAMME	IST
PROJECT TITLE:	Touch and Design
ACRONYM:	T'nD
PROGRAMME TYPE:	6th FP (Sixth Framework Programme)
CONTRACT NUMBER:	FP6-IST-001996
PROJECT WEB SITE:	www.kaemart.it/touch-and-design
START DATE:	01.01.2004
END DATE:	31.12.2006
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Executive summary
Research objectives Today, modelers are used to produce physical prototypes (PMU) of products by modeling and manipulating material like clay, foam material, wood, etc. Modelers have knowledge on shapes control in their hands, and the skill they have developed is a high value to be preserved. Unfortunately, PMUs require time to be developed, are expensive and not easy to test. Conversely, designers use CAD tools to develop virtual models that are less expensive, less costly and easier to test than PMUs. Actually, designers are dissatisfied using mouse & keyboard to design 3D shapes, and would like to be physically more active in the product creation phases. Therefore, CAD tools require to be enriched with more user friendly and effective ways of interaction, not only based on mouse & keyboard, but using interaction tools allowing for the exploitation of modelers' skills. **T'nD** aims at developing a novel system for shape generation and modification based on *novel haptic interaction* and *intelligent shape manipulation operators* in order to exploit existing manual skill of modelers and designers. Designers will be able to work with their full hands, as modelers do in their daily work, using a novel haptic device, for modeling product shapes. Haptic technology will be integrated together with modeling operators for providing a working environment offering high degree of usability and acceptance, comfort of usage, flexibility for any kind of user, including inexperienced users.

Expected results
The project will provide the following technical results:
  • Improvement of theoretical foundations in the field of shape modelling and haptics in respect to state-of-the-art.
  • Scenarios showing the evolution and specifications for future haptic interaction methods and devices.

- • Improvement of *cognitive ergonomics theories*, including integration of vision and haptics in human-machine interaction.
- • Stand-alone components: - *new haptic manipulator*, performing real-time rendering of complex shapes, and providing full-hand interaction; - *new shape modelling techniques* supporting easy and intuitive creation and deformation of shapes.
- • Prototype of an *innovative system integrating shape modelling and haptic manipulator*.
- • *New architecture* integrating and synchronizing different control loops (modeling, visualization and haptic) for multimodal interfaces.
- • *Best practice* for end-users.

Projects' current achievements

The current outcome of the project are the following (updated at Nov. 2005):

- FCS-CS hardware haptic platform with 5+1 DOF
- Prototype of haptic tool for scraping
- Prototype of haptic tool for testing surface quality
- Algorithm for computing sweeping operations according to a selected geometrical profile with several constraints
- Algorithm for computing forces based on chip removal
- Prototype integrating haptic scraping tool and material removal and force computation algorithms.

Broad dissemination and use intentions for the expected outputs

Several dissemination and exploitation possibilities can be considered, according to partners' profile. IPR are addressed in the C.A. Some exploitation possibilities are the following:
- Bring some of the haptic device prototypes into production. Exploitation performed by a single member of the Consortium (FCS-CS) or by a group of members (FCS-CS and think3).
- Integrate the sweeping algorithm into a CAD tools. Exploitation is performed by think3.
- Exploit the integrated prototype (hardware and software components). This can be done by a single member of the consortium, by a group of members, or by an established spin-off company.
- Identify potential customers of the project results (software components, hardware components, integrated system).
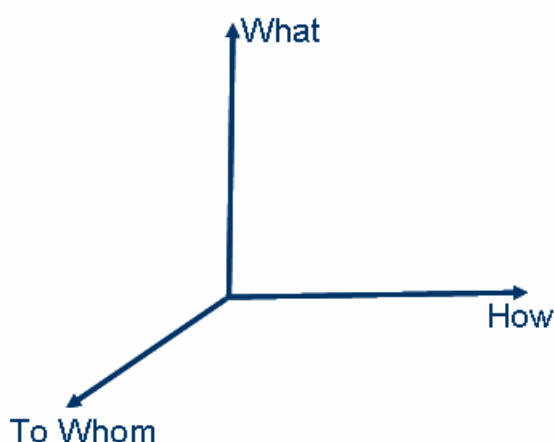
3. Communication to internal public

The partners are interested in communicating the project results within their companies and departments.

The strategy for disseminating the results within the project considers the following issues (see figure below):

- Content to disseminate (What).
- Dissemination media (How).
- Target audience (To Whom).

Each partner is responsible for implementing the most appropriate dissemination actions within its company or department.

4. Dissemination to external public

All T'nD partners are deeply involved in disseminating the project outcomes and achievements aiming at:

- Presenting and communicating T'nD practice and technology, and its benefits, to general public, to potential users and customers;
- Presenting T'nD research innovative technical achievements to the scientific community.

Similarly to internal communication, the strategy for disseminating the results outside the project considers the following issues:

- Content to disseminate (What).
- Dissemination media (How).
- Target audience (To Whom).

All dissemination activities towards external public are carried out paying due attention to confidentiality and IPR issues, as agreed by the project partners.

5. Content

The first issues addressed for T'nD dissemination is to analyze **what** can be disseminated, at which level and when within the project timeline. The content to disseminate depends on the project timeline and maturity of the results. The T'nD project has identified the following main contents to disseminate, available in the three years:

Year 1 (2004)	Year 2 (2005)	Year 3 (2006)
• Project objectives • Approach • Conceptual Aspects • Scenarios • Users' reqs analysis	• System overview, specs, architecture • Prototypes • First evaluation results	• Technological implementation (system prototypes) • Show cases • System testing/evaluation results

The following figure shows a more detailed plan of the available results during the project lifetime.
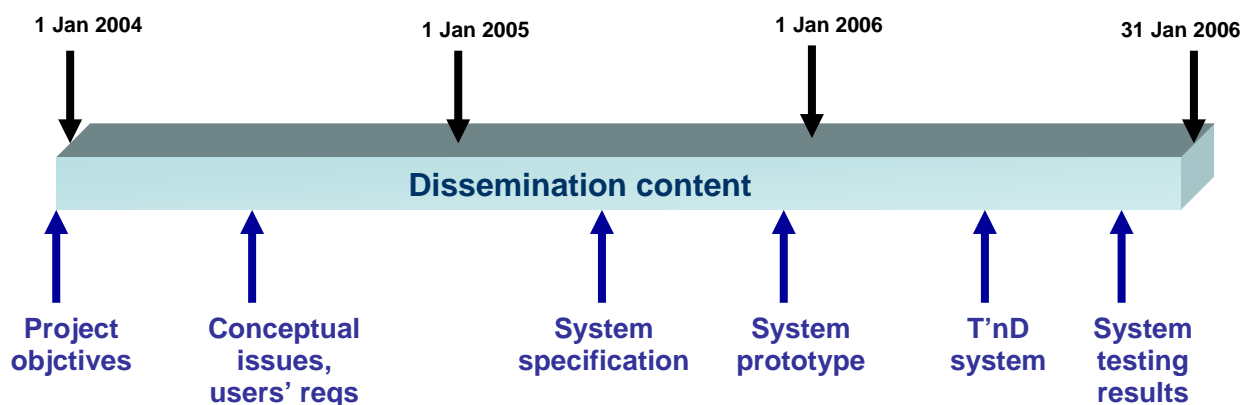
In the *first year*, the T'nD project develops basic ideas, concepts, and users' requirements that are at the basis of the system development. These results are described in the following documents:
- Deliverable D0 - Project Presentation (Public)
- Deliverable D1 – Hardware and software technology update (Public)
- Deliverable D4 – Users' skill acquisition and analysis (Confidential)
- Deliverable D5 – Theoretical foundations (Confidential)
- Deliverable D6 – Definition of scenario and test cases (Public)
- CD-ROM including Scenarios (Public)

The figure below shows the availability of the deliverables during the first year of the project. Most of these results can be communicated to a broad audience. The project steering committee has to decide what included in the Confidential reports can anyway be disseminated outside the project.

In the *second year*, the project develops the specification of the system, some hardware and software prototypes, and first evaluation and testing of the prototypes. The results are the following:

- Deliverable D8 – Hardware, software and application specification (Confidential)
- D11 – First version of Prototype (Public)
- CD-ROM showing prototype

The figure below shows the availability of the deliverables during the second year of the project. The first prototype will be installed at Politecnico di Milano, and will be demonstrated to people visiting, and will also be shown in a video available through the project web site or distributed in a CD-ROM. Papers on the description of non confidential technical aspects and testing and evaluation results may be published at conferences and in journals in the area of CAD, haptics, Computer graphics, virtual reality.

In the *third year*, the project develops the final version of the T'nD system, some show cases for demonstrating the project results, and performs evaluation and testing of the system. The expected results are the following:

- D11 – Final version of Prototype (Public)
- CD-ROM showing prototype (Public)
- D14 – Test case evaluation report (Public)
- D16 – Show cases (Public)

The figure below shows the availability of the deliverables during the third year of the project. The final prototype will be installed at Politecnico di Milano, and will be demonstrated to people visiting, and will also be shown in a video available through the project web site or distributed in a CD-ROM. Show cases can also be shown and tested by users. Papers on the description of non confidential technical aspects and testing and evaluation results may be published at conferences and in journals in the area of CAD, haptics, Computer graphics, virtual reality, and cognitive ergonomics.

5.1.   Type of content

The following types of content which will be made available for dissemination have been identified:

- Project deliverables
- Scientific papers and articles (for conferences/journals)
- Flyers
- Poster
- CD/DVD including project results
- Video showing use of prototype/ system
- Demonstration of system
- Press reviews

6. Communication and dissemination Channels

This section presents the communication channels which include *how* the content may reach the appropriate target community.

The following communication channels have been identified:

- Conferences
- Journals
- Presentations
- Press conferences
- Public web site
- Collaborative space
- Newsletters
- Links to project web site from other sites
- Press office of partners
- Mailing list
- E-advertising
- Special Interest User Groups
- Associations (industrial, category, professionals, national, etc.)
- TV programmes/shows

7. Content available in T'nD

7.1.   Scientific papers and articles

Scientific and technical papers are planned to be written and prepared as soon as results are achieved and available. Appropriate dissemination channels (conferences and journals) are identified for publishing the papers. The tables reported in *Annex 3* include the list of papers published and presented at conferences, and the list of papers published in journals.

7.2.   Flyer

A flyer has been developed at the beginning of the project and has been updated about every six months. The updated version of the flyer is reported in *Annex 4*.

7.3.   CD-ROM

Some CD-ROM including the project presentation, some public reports and some videos showing the scenarios and the system prototype has been prepared to be distributed at events and to people potentially interested in the project.

7.4.   Press Review

Press releases are distributed by the press offices of partners (especially PoliMI and think3).
Several press reviews about the project have appeared so far. The following table reports the list of press reviews published since the beginning of the project. The press reviews are reported in *Table 5.*

PRESS REVIEW - YEAR 2004

Date	Press Review	Location	Responsible
June-04	Plast Design	France	think3
June-04	Pixel, n. 93	France	think3
July 2004	Industrie Technologies n. 76	France	think3
July-August	Progettare	Italy	Alessi
September 2004	CAD Magazine, n 119	France	think3
September 2004	Les Echos n. 19234	France	think3
October 2004	Harvest, n. 84	France	think3
November 2004	L'Usine Nouvelle, n. 2940	France	think3
December 2004	CADplus, n°6/2004	Germany	think3

PRESS REVIEW - YEAR 2005

Date	Press Review	Location	Responsible
June 3 2005	Corriere Motori	Italy	PoliMI
Nov. 2005	ID FORUM TOKYO 2005	Japan	Alessi, think3

7.5.   Quality check of dissemination content

A form for collecting information on dissemination activities has been defined. Each partner is requested to fill in the form with details about dissemination activities they are involved in. The form is reported in *Annex 1*. This practice has been promoted by the coordinator in order to monitor and guarantee the quality of published results of the project T'nD.

8. Channels used in T'nD

Several channels for communicating and disseminating the project content have been thought about. In the following sections the most relevant ones are illustrated in details.

8.1.   Identification of relevant topics for dissemination

T'nD main topics of interest for the dissemination and communication activities of the project are the following:
- Haptics
- Human Computer Interaction - HCI
- Multimodal interaction

- Geometric and shape modeling
- CAD/CAID/CAIDS
- Physics-based modeling
- Cognitive ergonomics

8.2.   Relevant conferences for T'nD dissemination

Since year 1 the project has identified a list of upcoming conferences that may be of interest for the project dissemination aims.

A list of the most important conferences that would be important to attend, and where it would be relevant to present results (covering the above topics) is the following:

- IEEE VirtualReality
- Virtual Concepts
- Eurohaptics Conference and
- IEEE Symposium on Haptic interfaces
- SMI – Shape and Modeling International
- CAID & CD
- CAD
- HCI International
- CHI
- ICMI
- SIGGRAPH
- Eurographics
- CGI
- Graphite
- HAAMAHA
- IEA

A table including events relevant for the project has been prepared. The table includes the following items:
- information about the conference; name, location, URL
- relevance of the conference (decided by partners)
- type of submission planned
- content
- deadline
- authors
- status

CONFERENCE			Relevance	Type of submission	Content	Deadline	Authors	Status
Name	Location	URL	(0-10)					

The tables compiled for years 2005 and 2006 are reported in *Annex 2, Table 1*.

8.3.   Relevant journals for T'nD dissemination

The project has also identified a list of journals that may be of interest for the project dissemination. A list of journals relevant in the topics mentioned in §8.1 is the following:

- International Journal of Shape Modeling
- Computer Graphics World
- Computer Aided Design
- ACM transaction on Human Computer Interaction
- Communication of the ACM
- Computer Graphics Forum

- IEEE Transactions on robotics and automation
- Journal of Robotic Systems
- Presence-Teleoperators and Virtual environments
- Human Factors
- Applied Ergonomics
- Virtual Reality

A table including journals relevant for the project has been prepared. The table includes the following items:

- information about the journal: name, editor, URL
- relevance of the journal
- content
- deadline
- authors
- planned submission date
- status

JOURNAL			Relevance	Content	Deadline	Authors	Date	Status
Name	Editor	URL	(0-10)					

The table compiled for relevant journals is reported in *Annex 2, Table 2*.

In order to disseminate the results to a very wide audience, a contribution to the public web site (www.haptics-e.org) with on line papers is also planned.

8.4.   Press Conferences and Presentations

Partners intend to participate to any event (conference, workshop, press conference, etc.) where it will be possible to present T'nD project and its results. A certain number of press conferences and of presentations have been attended and organized by T'nD partners up to now.

Date	Event	Audience		Attendees	Presenter
3-Nov	IST 2003 Conference, Milano (I)	Research, industry	All	100	PoliMI
4-Feb	Workshop on "Creativity and Cognition", Cognisud & Univ. Provence, Aix-en-Provence (F)	Research, industry	France	40	PsyCLE
Jan, Feb & Mar 04	Courses on "Creativity and Cognition " – Fac. of Psychology – PsyCLE – Univ. Provence (Aix-Marseille I)	Students in Master degree	France	20	PsyCLE
4-Feb	Courses on "Design problem-solving " – Fac. of Psychology – PsyCLE – Univ. Provence (Aix-Marseille I)	Students in degrees	France	20	PsyCLE
4-Jun	Mazda (J)	Industry	Japan	20	think3
4-Jul	Hokkaido University, Sapporo (J)	Research	Japan	80	PoliMI
4-Jul	International workshop on Digital Design, Keio University, Tokyo,	Research	Japan		PoliMI
Jun, Dec 04	Honda HGW	Industry	Japan		think3

4-Dec	Honda HGA	Industry	Japan		think3
4-Dec	SONY	Industry	Japan		think3
Sept 05	Urbino	Research	Italy		PoliMI
Nov. 05	ID-FORUM, 2005 Tokyo	Industry	Japan		Alessi

8.5. Public web-site

The public web site of the T'nD project has been established since the beginning of the project. The URL of the web site is the following: **www.kaemart.it/touch-and-design.** The content of the web site is constantly updated by the coordinator. The layout of the web site has been changed at the end of the second year project. It is shown in the following picture.

8.6. Collaborative space

A collaborative space has been set up for supporting collaboration of partners and also for internal disseminating the project results. The collaborative space is based on BSCW public technology. A snapshot of the collaborative space is shown in the following.

T'nD collaborative space can be found at the folloiwing address: **www.kaemart.it/bscw/bscw.cgi**

It can be also reached through a link from the T'nD public web site.

8.7. Links to T'nD web site

The T'nD web site is referred by some web pages:

- Politecnico di Milano: www.kaemart.it/~uc, www.kaemart.it/~mb

- think3: www.think3.com (in advanced R&D)

- Alessi: www.alessi.com

- Cordis: www.cordis.eu

8.8. Mailing list

The coordinator has collected a list of e-mail addresses of people potentially interested in the T'nD projects. They are both academic as well as from industry. The references have been collected in occasion of conferences, workshops, exhibitions, etc. At the moment, the list includes about 50 entries.

8.9. Associations

Some associations have been identified, that might be interested in receiving some material about the T'nD project to distribute to its members. The following Italian associations have been identified:

- ADM – Associazione Disegno di Macchine (adm.ing.unibo.it)
- ADI – Associazione per il Disegno Industriale (www.adi-design.org)

8.10.   E-advertising

The project will use the internet and all related communication means to disseminate the outcomes of the project. Some good means seem to be newsgroups and special interest user groups. Some newsgroups will be identified as potential candidates to disseminate news about the project.
After the first and final versions releases the project will post press releases to newsgroups.

9. Target audience

The target audience consists of groups **to whom** the communication and dissemination is oriented to. The audience may be inside the project and outside the project.

9.1.   Inside the project

We can identify some categories of people potentially interested to the project results within the partners company. The categories are the following:

- people involved in the project
- designers
- modelers
- managers
- researchers

People involved in the project
The project plans to inform people involved in the project through project meetings and sub-meetings, through the collaborative space and through e-mail.

Designers and Modelers
The project plans to inform and demonstrate to designers and modelers new practices and innovative tools for modeling products. The best way to inform and gain interest from these users is to organize sessions and demonstrate the prototype, and ask them to try it. This activity is mainly performed within the project workpackage WP7 – Evaluation.

Managers
The project plans to inform companies' managers about progresses and achievements of the projects, and benefits of results for the company. This is mainly done through the use of presentations, videos, documents.

Researchers
The project plans to inform researchers who are colleagues of people involved in the project, and who works on similar topics, about the results and achievements of the project.

9.2.   Outside the project

- Academic community: researchers at Universities and research centers, students
- Industrial community (potential customers, potential users).
- General public

9.2.1. Academic Community

Project results are disseminated to the academic and research world mainly through scientific reports and presentations. The strategy for presenting the research results includes the following:

- identify topics of interest and related topics
- identify upcoming relevant events (conferences, workshops, etc.) and relevant journals and special issues
  - submit papers
  - attend and present at conferences
- identify academic/research communities (target groups, group of interest)
- identify related projects and network

Dissemination to students, who are the potential users of tomorrow, is important as well. For this reason, the academic partners plan to include presentations of the project within their courses and lessons.

Besides, it is planned to spend some time to show the project results to students of the Faculty of Industrial Design at Politecnico di Milano and Universitat de Girona, and also to involve them in the evaluation tests, in order to create a critical mass in using the new product design practice proposed by T'nD to those people who will be potentially the future designers in industry. PsyCLE plans to present the results to classes of courses in psychology and cognitive ergonomics.

9.2.2. Industrial Community

For what concerns the industrial context, the target groups include companies working in the product design and industrial design fields. Each partner has several individual relations with users and customers.
The industrial communities to target have been identified according to the type of results.

Community likely to be interested in the T'nD integrated system:
- Industrial design bureau.
- Industrial design companies operating in various sectors related to T'nD (car, aerospace, domestic appliances, etc.).
- Companies operating in sectors not directly related to T'nD.

Community likely to be interested in the T'nD geometric modeling system:
- Geometric modeling software developers (CAM, animation, etc.)

Community likely to be interested in the T'nD haptic system:
- Developers of haptic systems in various sectors (modeling, medical field, games, etc.).

Contacts with external people, potentially interested in the project results, will be established within the project workpackage WP9 – Show Cases.

9.2.3. General public

The aim of the project dissemination also includes raising public interest in new technologies, showing and demonstrating how new technology works, the technology evolution, and the design practice evolution. The partners plan to write some popular articles describing the T'nD system, how it works and its potential applications to distribute to non technical magazine and journals.

9.3.   Content and communication channels selection

Appropriate content and communication channels are selected according to the target audience and the type of information to disseminate. The following table includes the type of content related to specific type of audience. This table helps the partners to select the most appropriate dissemination actions, according to the type of audience that is intended to reach.

Type of audience (TO WHOM)	Project deliverables (confidential)	Project deliverables (public)	Scientific papers and articles	Project presentation	Flyer	Poster	CD-ROM	Video	Demonstration of system	Press review
Internal audience										
People involved in the project	X	X	X	X	X	X	X	X	X	X
P.O. & Reviewers	X	X	X	X	X	X	X	X	X	X
Management		X		X				X	X	X
External industrial audience										
Managers		X		X				X	X	X
Designers									X	
Modelers									X	
Researchers		X	X						X	
Academic community										
Researchers		X	X	X	X	X	X	X	X	
Students			X					X	X	
Industrial community										
industrial design bureau				X	X		X	X	X	X
industrial design companies				X	X		X	X	X	X
Geomteric modelin sw developers			X	X			X	X	X	X
haptic system developers			X	X			X	X	X	X
Generic public										
generic audience								X	X	X

The following table includes the relation of the type of content with the most appropriate distribution channels.

Type of audience (TO WHOM)	Project deliverables (confidential)	Project deliverables (public)	Scientific papers and articles	Project presentation	Flyer	Poster	CD-ROM	Video	Demonstration of system	Press review	Communication channels (HOW)
Internal audience											
People involved in the project	X	X	X	X	X	X	X	X	X	X	
P.O. & Reviewers	X	X	X	X	X	X	X	X	X	X	
Management		X		X				X	X	X	
External industrial audience											
Managers		X		X				X	X	X	
Designers									X		
Modelers									X		
Researchers			X	X					X		
Academic community											
Researchers			X	X	X	X	X	X	X		
Students			X					X	X		
Industrial community											
industrial design bureau				X	X		X	X	X	X	
industrial design companies				X	X		X	X	X	X	
Geomteric modelin sw developers			X	X			X	X	X	X	
haptic system developers			X	X			X	X	X	X	
Generic public											
generic audience								X	X	X	
			X	X	X	X					Conferences
			X								Journals
			X	X	X			X	X		Public presentations
				X	X		X	X	X	(X)	Press Conferences
		X									Newsletters
		X	X	X				X		X	Links to project web site
				X			X	X		X	Press office of partners
		(X)		X							Mailing list
		(X)		X						X	E-advertising
		X	X	X							Special Interest User Groups
					X		X				Associations
								X	X		TV programmes/shows
			X	X				X			Public Web site
	X	X	X	X	X	X	X	X		X	Collaboration space

10. Related projects and networks

The dissemination strategy also plans to make contacts with other projects that are finished or ongoing in order to create link for possible use, re-use of results, and for planning new activities to perform in collaboration. This is done on the basis of individual contacts, or through the participation to events that might be useful for understanding dissemination at industrial partners.

Project Name	Type	Ref	URL	Contact
ENACTIVE	FP6 NoE		http://www.enactivenetwork.org/	bergamasco@sssup.it
AIM@SHAPE	FP6 NoE	IST - 506766	http://www.aim-at-shape.net/	biana.falcidieno@ge.imati.cnr.it
TOUCH-HAPSYS	FET Presence	IST-2001-38040	http://www.touch-hapsys.org/	m.buss@ieee.org
INTUITION	FP6 IST	IST 507248-2	http://www.intuation-eunetwork.net	aamditis@mail.ntua.gr
HAPTEX	IST-FET	IST-6549	http://www.haptex.miralab.unige.ch	thalmann@miralab.unige.ch

11. Partners' responsibilities

All partners are invited to provide and develop material for the dissemination of T'nD results. In particular, academic and research partners should write scientific papers and articles as soon interesting results are achieved. The developer and end-user partners may contribute in this activity. The coordinator monitors this activity. Partners are asked to fill in and send the coordinator a form (reported in *Annex 1*) providing details about the publication, and also a copy of the paper before submitting it. The Coordinator checks the publication content, and makes sure that it doesn't include confidential information of the project.

The coordinator has the responsibility of maintaining and updating the public web site and the project collaborative space, of providing flyer, poster and presentations, and videos of the project results.

Industrial partners are invited to take care of the release of press reviews and press releases, through their press offices and press media.

12. Exploitation strategy

This section includes the first draft of the exploitation strategy of the T'nD project. First, we describe the results of the project and the plans that the partners have to use those results.

For what concerns the system, the project will yield several exploitable haptic products. The first of these is the six degree of freedom haptic device, consisting of two Haptic Masters coupled by the novel end-effector developed in the course of the project. This setup will be offered to clients both separately, and as a part of the integrated system for the T'nD virtual clay modeling application.

The separate offer will be a *6-DOF stand-alone unit* for generic haptic applications. Such generic applications include general haptic manipulation, and in particular virtual assembly in a simulated factory environment. There has been considerable interest in the past from companies working in this field, notably the automotive and aviation industries, for a high-strength, high-stiffness, large reach, six degree of freedom haptic device. The exploitation strategy will consist of approaching these companies with the new product, and at the same time marketing it through the normal channel of haptic device distributors all over the world.

The second haptic product exploitable from the T'nD project will be the *active curving surface patch* (sanding tool). This is a completely novel development, for which a market will still need to be created. This product will need to be brought to the attention of the market through example applications and demos at conferences on haptics, before it can be offered simply as a product, since there cannot be a demand for a product which is completely novel and hence unknown to the haptics community at large.

The project result will mainly be used for industrial development. To produce an integrated environment to better satisfy end users needs in the industrial design sector for a free-form shape modeling based on haptic technology. The activities related to exploitation will be concentrated in the final stages of the project. Up to now think3 monitors continuously the market evolution with his customers but also taking into account competitors improvements. The analysis renews the high interest for this kind of product confirming the promising business opportunities.

The strategy for exploiting the T'nD integrated system has not been yet detailed by the partners. The partners are interested to find an agreement for marketing the T'nD workstation and some potential customers have also been contacted. A more formalized agreement is at the moment under discussion among the partners.

13. Overview of main project results

No	Description of the result	Category (A, B, C)*	Partner(s) owning the result(s) (referring to specific patents, copyrights, etc.) & involved in their further use
1	6-DOF haptic system equipped with virtual clay scraping tool	A	FCS-CS, PoliMI
2	Sanding tool	A	FCS-CS, PoliMI
3	Sweeping algorithm	A	think3
4	Force computation algorithm	A	PoliMI
5	Integrated system	A	FCS-CS, think3, PoliMI

(*)
- A: results usable outside the Consortium
- B: results usable within the Consortium
- C: non usable result

13.1. Haptic tools

The haptic tools developed include the *six degree of freedom platform* consisting of two Haptic Masters coupled by the novel six degree of freedom user interface, the software to use this new six degree of freedom platform to render virtual objects and in particular curved surfaces, and in addition to this the curved haptic patch which can either sit on the full six degree of freedom end-effector, or be used as a separate shape display.

The market has been asking for large scale, large force six degree of freedom haptic devices for a long time, and the T'nD project result is considered to be the first device which can satisfy this need. This result is definitely usable both within the Consortium and outside of it as a separately marketable product.

The haptic curving surface patch is another spin-off from the work done in the T'nD project which can be used both within the consortium for further research into the haptic sensation, and outside the consortium for similar research and, in future, for increased realism in the display of virtual haptic objects.

13.2. Sweeping algorithm

The sweeping algorithm has been presented in deliverable *D5 - Theoretical Foundations*. It is a twofold one. A global sweep component undertakes a general motion along a G0-only continuous trajectory coupled with a set of different relative motions applied to a relative frame. This component is used once under-constrained motions -as described by the users- have been identified. The way to describe the motions can be either via haptic examples or by CAD menus (that is more complex for the user). Several cases of constraints can be applied, thus several motions must be implemented on top of the global sweep component.

13.3. Force computation algorithm

The force computation algorithm and software is based on a physics-based model of the interaction between a plastic or visco-elastic material and a scraping tool. It is based on chip removal theories and methods and evaluates the forces necessary to scrape a chip of material on the basis of the shape of the profile of the rake, the area of interaction, the angle of the tool, the friction between chip and tool.

The physics-based modeling approach could be used with other CAD systems and haptic devices, but since T'nD is the first prototype in this area the application market has to be created from scratch on the basis of these first experiences.

13.4.   Integrated prototype

In addition to the direct uses of each developed parts (software, hardware) the partners plan to use the integrated prototype as an introduction tool to some potential users (other than those of the consortium) in order to check the market response. According to the result of the investigation they might industrialize the prototype to make it an actual marketable product. They also plan to use the experience and know-how gained to provide consulting on T'nD software and other results.

14. Detailed description of the results

This section includes a detailed description of the project results.

No.	Name
1	**6-DOF haptic system virtual clay scraping tool**

CONTACT PERSON FOR THIS RESULT:

Name	Piet Lammertse
Organization	FCS-CS
e-mail	piet.lammertse@fcs-cs.com

DESCRIPTION

Description of the product:
The haptic tools developed include a six degree of freedom platform consisting of two Haptic Masters coupled by a novel six degree of freedom user interface, plus the software to use this new six degree of freedom platform to render virtual objects and in particular curved surfaces.
Target market:
The initial target market is to use the platform in the integrated version of the T'nD system for virtual clay modeling in the automotive industry. Other markets include general haptic displays, in particular in assembly training and evaluation in the automotive and aviation industries.
Current state of development:
The six degree of freedom has been tested for five active degrees and one passive. The principle is easily extended to six active degrees of freedom. The current end-effector represents a squeegee plate type of interface for virtual clay modeling. Some development of this end-effector shape is needed for other applications. An active area of development outside the T'nD project, is a rationalization of the manufacturability of the Haptic Master devices which form the basis of the product. It is estimated that with proper redesign of the basic platform, the full six degree of freedom system can be built for the current price of one three degree of freedom device.
Time to application market:
The market has been asking for large scale, large force six degree of freedom haptic devices for a long time, and the T'nD project result is considered to be the first device which can satisfy this need. The time of application to market is zero. The first quote has already been applied for by a US customer. The version with rationalized production is expected to take another year of development outside the T'nD project.
Collaboration sought:
FCS has sought and found collaboration with the US Moog group for financing further haptic developments. The Moog group has acquired the shares of the company and promising developments are currently being sought out.

DOCUMENTATION AND INFORMATION ON THE RESULT

Doc. type	Details (title, general description)	Status: **PU= Public** **CO= Confidential**
Report	Deliverable D8 – System conception	CO
Report	Deliverable D11 – System development and integration	CO

INTELLECTUAL PROPERTY rights

Type of IPR	KNOWLEDGE:			Pre-existing Know-how	
	Current		Foreseen	Tick	Details
	Tick	Details			
Patent applied for					
Patent granted					
Patent search carried out					
Registered design					
Trademark applications					
Copyrights					
Secret know-how					
Other: specify					

Quantified data about the result

Items (about the results)	Actual current quantity	Estimated (or future) quantity
Time to application/market (months after the end of the project)		
Number of (public or private) entities potentially involved in the implementation of the results:		
- of which SMEs:		
Targeted use audience: of reachable people		
S&T publications (referenced publications only)		
Publications addressing general public (DVD, WEB sites)		
Publications addressing decision takers/public authorities/etc.		
Visibility for the general public	YES	

No.	Name
2	**Haptic tool: sanding tool**

CONTACT PERSON FOR THIS RESULT:

Name	Piet Lammertse
Organization	FCS-CS
e-mail	piet.lammertse@fcs-cs.com

DESCRIPTION

Description of the product:
The haptic curving surface patch is a completely novel result of the work done in the T'nD project. It can be used both within the consortium for further research into the haptic sensation, and outside the consortium for similar research and, in future, for increased realism in the display of virtual haptic objects.
Target market:
Target markets are where shape exploration by human users is required. Applications include virtual design evaluation both within the framework of the T'nD project and outside of it.
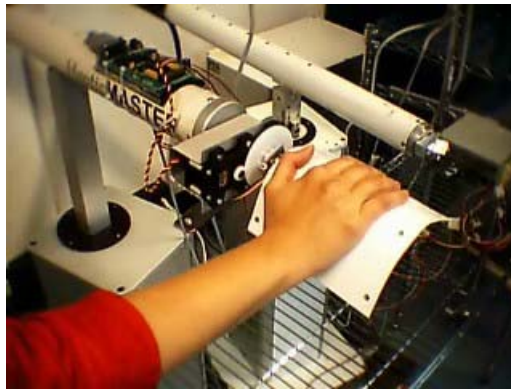Current state of development:
At the moment, the device is in an initial state of development. The device currently displays a single degree of curvature. More study and development is needed in the areas of double curvature and saddle planes (three degrees of freedom), and possibly surfaces of higher than G2 order. Also, software development is needed to couple the curvature to the virtual model and to the motions of the six degree of freedom haptic platform.
Time to application market:
Depending on speed of development, time to market is on the order of two or three years at least.
Collaboration sought:
FCS has sought and found collaboration with the US Moog group for financing further haptic developments. The Moog group has acquired the shares of the company and promising developments are currently being sought out.

DOCUMENTATION AND INFORMATION ON THE RESULT

Doc. type	Details (title, general description)	Status: **PU= Public** **CO= Confidential**
Report	Deliverable D8 – System conception	CO
Report	Deliverable D11 – System development and integration	CO

INTELLECTUAL PROPERTY RIGHTS

Type of IPR	KNOWLEDGE:			Pre-existing Know-how	
	Current		**Foreseen**	**Tick**	**Details**
	Tick	**Details**			
Patent applied for			✓		
Patent granted					
Patent search carried out	✓				

Registered design					
Trademark applications					
Copyrights					
Secret know-how					
Other: specify					

Quantified data about the result

Items (about the results)	Actual current quantity	Estimated (or future) quantity
Time to application/market (months after the end of the project)		24/36
Number of (public or private) entities potentially involved in the implementation of the results:		
- of which SMEs:		
Targeted use audience: of reachable people		
S&T publications (referenced publications only)		
Publications addressing general public (DVD, WEB sites)		
Publications addressing decision takers/public authorities/etc.		
Visibility for the general public	YES	

No.	Name
3	**Sweeping algorithm**

CONTACT PERSON FOR THIS RESULT:

Name	Alain Massabo
Organization	think3
e-mail	alain.massabo@think3.com

DESCRIPTION

Description of the product:

The sweeping algorithm has been presented in deliverable D5 "Theoretical Foundations". It is a twofold one.

1. A global sweep component undertakes a general motion along a G0-only continuous trajectory coupled with a set of different relative motions applied to a relative frame.
2. This component is used once under-constrained motions -as described by the users- have been identified. The way to describe the motions can be either via haptic examples or by CAD menus (that is more complex for the user).
3. Several cases of constraints can be applied, thus several motions must be implemented on top of the global sweep component

Target market:

Industrial design as well mechanical design and manufacturing (tool design).

Current state of development:

The global sweep component has been implemented and is already proposed in the current think3 products.

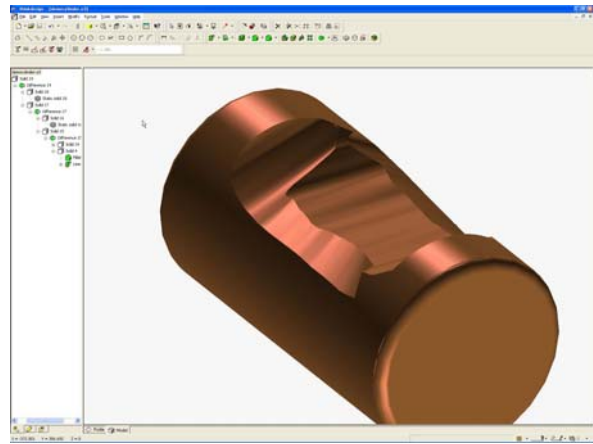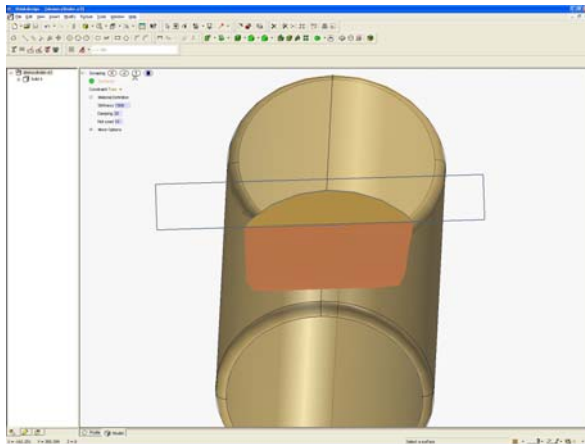The under-constrained motion implementations are on progress accordingly to the project plan.

Time to application market:

As mentioned above, the global sweep component is already inserted in the think3 product released.

The first cases of under-constrained motions defined/described my CAD menus will be inserted in think3 product during 2006.

Collaboration sought:

None at the moment.

DOCUMENTATION AND INFORMATION ON THE RESULT

Doc. Type	Details (title, general description)	Status: PU= Public CO= Confidential
Report	Deliverable D5 – Theoretical foundation	CO
Report	Deliverable D8 – System conception	CO
Report	Deliverable D11 – System development and integration	CO

INTELLECTUAL PROPERTY RIGHTS

Type of IPR	KNOWLEDGE:		Foreseen	Pre-existing Know-how	
	Current			Tick	Details
	Tick	Details			
Patent applied for					
Patent granted					
Patent search carried out					
Registered design					
Trademark applications					
Copyrights					
Secret know-how		✓	✓		✓
Other: specify					

Quantified data about the result

Items (about the results)	Actual current quantity	Estimated (or future) quantity
Time to application/market (months after the end of the project)	Already on the market	Along the project implementation
Number of (public or private) entities potentially involved in the implementation of the results:	All think3 users and potential customers	All think3 users and potential customers
- of which SMEs:		
Targeted use audience: of reachable people		
S&T publications (referenced publications only)	None	None
Publications addressing general public (DVD, WEB sites)	None	None
Publications addressing decision takers/public authorities/etc.	Standard think3 product demos	Standard think3 product demos
Visibility for the general public	YES	

No.	Name
4	**Force computation algorithm**

CONTACT PERSON FOR THIS RESULT:

Name	Umberto Cugini
Organization	PoliMI
e-mail	umberto.cugini@polimi.it

DESCRIPTION

Description of the product:
The force computation algorithm and software is based on a physics-based model of the interaction between a plastic or visco-elastic material and a scraping tool. It is based on chip removal theories and methods and evaluates the forces necessary to remove a chip of material on the basis of the physical characteristics of the material, the shape of the profile of the rake, the area of interaction, the angle of the tool, the friction between chip and tool.
Current state of development:
The mathematical model and the software implementing it are currently integrated with thinkdesign software and the software for controlling the HapticMaster device. Actually, they have been designed and implemented so as to be independent modules.
Time to application market:
The physics-based modeling approach developed could be used with other CAD systems and haptic devices, but since T'nD is the first prototype in this area the application market has to be created from scratch on the basis of these initial experiences.
Collaboration sought:
At the moment, no collaborations on that have been sought.

DOCUMENTATION AND INFORMATION ON THE RESULT

Doc. type	Details (title, general description)	Status: **PU= Public** **CO= Confidential**
Report	Deliverable D8 – System conception	CO
Report	Deliverable D11 – System development and integration	CO

INTELLECTUAL PROPERTY RIGHTS

Type of IPR	KNOWLEDGE:		Foreseen	Pre-existing Know-how	
	Current			**Tick**	**Details**
	Tick	**Details**			
Patent applied for					
Patent granted					
Patent search carried out					
Registered design					
Trademark applications					
Copyrights					
Secret know-how					
Other: specify					

Quantified data about the result

Items (about the results)	Actual current quantity	Estimated (or future) quantity
Time to application/market (months after the end of the project)		
Number of (public or private) entities potentially		

involved in the implementation of the results:		
- of which SMEs:		
Targeted use audience: of reachable people		
S&T publications (referenced publications only)		
Publications addressing general public (DVD, WEB sites)		
Publications addressing decision takers/public authorities/etc.		
Visibility for the general public		

No.	Name
5	**Integrated system (T'nD workstation)**

Name	
Organization	PoliMI, think3, FCS
e-mail	

DESCRIPTION

Description of the product:
The potential future product could be a sort of turnkey system oriented to industrial designers and modelers. It consists of a modeling environment developed on think3 CAS/CAD applications integrated with haptic interfaces provided by PoliMI and FCS.
Target market:
The target market consists of industrial design companies and studios.
Current state of development:
The first prototype has been developed and is being tested by end users. A more advanced version is going to be released in the next few months.
Time to application market:
The time to application market goes from 2 to 4 years.
Collaboration sought:
None at the moment.

DOCUMENTATION AND INFORMATION ON THE RESULT

Doc. type	Details (title, general description)	Status: PU= Public CO= Confidential
Report	Deliverable D5 – Theoretical foundation	CO
Report	Deliverable D8 – System conception	CO
Report	Deliverable D11 – System development and integration	CO

INTELLECTUAL PROPERTY RIGHTS

Type of IPR	KNOWLEDGE:			Pre-existing Know-how	
	Current		Foreseen	Tick	Details
	Tick	Details			

Patent applied for			✓		
Patent granted					
Patent search carried out	✓				
Registered design					
Trademark applications					
Copyrights					
Secret know-how		✓	✓		✓
Other: specify					

Quantified data about the result

Items (about the results)	Actual current quantity	Estimated (or future) quantity
Time to application/market (months after the end of the project)		
Number of (public or private) entities potentially involved in the implementation of the results:		
- of which SMEs:		
Targeted use audience: of reachable people		
S&T publications (referenced publications only)		
Publications addressing general public (DVD, WEB sites)		
Publications addressing decision takers/public authorities/etc.		
Visibility for the general public		

15. Preliminary analysis of target markets

15.1.   Haptic devices/technology market

- *Research & Development Labs developing and using such technology*

Numerous research and development laboratories around the world are using haptic technology for a variety of research. This includes both basic research on the psychophysics of haptics, and studies of actual or future applications. The interest on this topic is increasing so more labs and research teams will address this research area.

- *Consumer sector where the technology could be transferred and implemented*

Consumer markets where the new haptic technology could be implemented include the gaming industry, and remote presence such as being able to touch virtual objects, including, it has been suggested, the echo image of a foetus in the womb. Cost of the devices would have to decrease significantly before this type of application could ever reach wide spread use.

- *New potential markets*

New potential markets for high-strength, high stiffness six degree of freedom haptics are in the high end of the virtual reality market. The initial application fields that have been identified in research and in market studies include health care and factory automation. Health care includes robotic assistance for minimally invasive surgery, and neurological rehabilitation.

	Current	+ 5 years	+ 10 years
Size of the potential market	10	200	1000

	Current	+ 2 years	+ 4 years
Potential share/penetration	5 %	10 %	20 %
Potential additional turnover generated	0.5 M€	1.0 M€	4.0 M€
Potential joint venture/collaborations (*)		(*)	(*)

(*) Potential joint venture/collaborations:

Collaboration is being sought in the relevant fields of application. These will include partners in the automotive industry and in health care.

15.2.   CAS/CAS application market

- *Research & Development Labs developing and using such technology*

Very few labs are developing or are currently using such technologies. Based on the experience of early haptic device prototypes this area could become a potential niche market.

- *Consumer sector where the technology could be transferred and implemented*

The market sector dedicated to Computer Aided Industrial Design and Styling (CAIDS) is estimated at 2-3% of the total of the mechanical CAD market. think3 expects to take 8-10% of this market. According to Daratech Total Mechanical CAD/CAM and DMPM. Software and Services Sales 2005 Forecast - 3/28/2005 the estimated total sales market is $5.97 Billion, up 10% from 2004.

- *New potential markets*

	Current	+ 5 years	+ 10 years
Size of the potential market			

	Current	+ 2 years	+ 4 years
Potential share/penetration			
Potential additional turnover generated			
Potential joint venture/collaborations (*)			

(*) Potential joint venture/collaborations:
  - none

Annex 1

TOUCH AND DESIGN

Dissemination action – Description

Date:

The originator requests support and approval for a dissemination action for T'nD Project.
The following categories of dissemination actions apply:
- Paper presentation
- Local Event
- Open Workshop or Invited Special Session
- Spreading Workshop and Scientific Conference

Originator (Name, WP, Organisation):
Action
Objective of the Action
Description of the Action: (Category, location, date, plus 3 lines of text max)
Impact of the Action (Regional, National, International level, Size and nature of the target audience, Expected impact)
Other remarks
Approval (OK/NOK), Initials and Date
Complementary remarks:

Annex 2

TABLE 1

List of Conferences: Year 2005 (planning)

TABLE			Relevance	Type of submission	Content	Deadline	Authors	Status
Name	Location	URL	(0-10)					A
WorldHAPTICS	Pisa, 18-20.03.05	www.worldhaptics.com	10	poster		15.01.2005	Cugini	N
ASME/DETC	Long Beach, 24-28.09.05	www.asmeconferences.org/idetc2005	5	Full paper		14.02.2005	??	A
HAAMAHA 2005	San Diego, 18-21.07.05	www.haamaha.org	6	Paper		01.03.2005	Bordegoni	A
HCI International 2005	Las Vegas, 22-27.07.05	www.hci-international.org		Paper		01.03.05	Cugini	A
Virtual Concepts 2005	Biarritz, 08-10.11.05	www.virtualconcept.estia.fr		Paper		25.03.05	Cugini	A
SIGGRAPH	Los Angeles, 31-04.08.05	www.siggraph.org		Sketch		13.04.05	Cugini	R
XVII Ingegraf	Sevilla, 1-3.06.05	www.us.es/ingegraf		Paper		22.04.05	Bordegoni	A
EG 2005	Dublin, 29.08-02.09.05	www.eg.org/eg2005		Short Paper		22.04.05	Cugini	R
CAID&CD 2005	Delft, 29.05.05	www.io.delft.nl/caidcd2005		Paper		20.03.05	Cugini	A
AEIPRO							Tresserras	A
ICMI	Trento, 03.10.05	icmi05.itc.it		Short paper+poster		15.07.05	Bordegoni	A
GRAPHITE	Dunedin (NZ), 29.11.05	www.cs.otago.ac.nz/graphite		Paper		04.07.05	Cugini	A
INTERACT	Roma, 12.09.05	giove.cnuce.cnr.it/interact2005		Short		31.03.05	Cugini	R

CAD	Bangkok,20-24.06.05	www.cadconferences.com/CAD05.html		Full		30.11.04	Cugini	N

List of Conferences: Year 2006 (planning)

TABLE			Relevance	Type of submission	Content	Deadline	Authors	Status
Name	Location	URL	(0-10)					
TMCE 2006	Ljubljana, 18-22.04.06	www.tmce-symposium.org		paper		30.08.05	Bordegoni	A
HAPTIC Symposium	Arlington, 25-26.03.06	www.hapticssymposium.org	10			05.09.05	Lammertse	N
CHI 2006	Montreal, 24-27.04.06	www.chi2006.org		paper		23.09.05		N
CAD 06	Phuket,19-23.06.06	www.cadconferences.com		paper		15.12.05		N
SIGGRAPH	Boston, 30.07-03.08.2006	www.siggraph.org	8	sketch		24.01.06		N
EG 2006	Vienna, 4-8.10.06	www.eg.org/eg2006	8	Short paper		27.04.06		
EUROHAPTICS	Paris, 3-6.07.06	lsc.univ-evry.fr/~eurohaptics/index.html				15.02.06		
HCI International 2007	Beijing, 22-27.07.06	www.hcii2007.org		paper		30.10.06		
ASME/DETC	Philadelphia	www.asmeconferences.org/idetc06				06.02.06		
Graphics Interface	Quebec	www.cs.usak.ca/~gutwin/gl				19.12.05		N
Pacific Graphics	Taipei	graphics.im.ntu.edu.tw/pg2006				24.04.06		
AEIPRO	Valencia, 28-30.06.2006	www.aeipro.com	5	abstract		01.03.06		
INGEGRAF	Barcelona, 31.05-01.06.2006	Ingegraf.upc.edu	5	paper		15.01.06		N
Visual	Aix-en-Provence,							

Reasoning in Design	December 2006						
Conference on Creativity	Paris, July 2006						
Creativity and Cognition	Washington, March-April 2007						

TABLE 2

List of Journals

JOURNAL			Relevance	Content	Authors	Date	Status
Name	Editor	URL	(0-10)				
Progettare			5				
International Journal of Human Computer Studies							
Interacting with Computers							
Applied Cognitive Psychology							

Legenda Status:
> S: submitted
> N: not submitted
> A: accepted
> R: rejected
> W: writing

Annex 3

Summary of papers presented at Conferences

Conference name	Location and Date	Title of the paper	Author(s)	Type
WorldHaptics 2005	Pisa, 18-20.032005	Design with your Hands	Cugini U., Bordegoni M.	poster
CAID&CD2005 - International Conf. On Computer-Aided Industrial Design & Conceptual Design	Delft, 29.05-01.06.2005	Haptic System for shape generation	Bordegoni M., Cugini U.	paper
INGEGRAF	Sevilla, 1-3.06.05	Design virtual products using hands	Bordegoni M., Espinach X, Tresserras J.	paper
HAAMAHA - Human Aspects of Advanced Manufacturing Agility and Hybrid Automation	San Diego,18-21.07.2005	An empirical study on a user interface for a haptic-based clay modeling tool from best practice users' observation	Cugini U., Giraudo U.	paper
HCII2005 - HCI Internation 2005	Las Vegas, 22-27.07.05	Novel Interaction methods for product design	Bordegoni M., Cugini U.	paper
HCI 2005 workshop "Understanding & co-designing for Aesthetic Experience"	Edinburgh, 5.09.05	Conceptual design of a virtual clay modeling interface based on designers' hand movements analysis	M. Bordegoni, U. Cugini, U. Giraudo	paper
ICMI 2005 - International Conference on Multimodal Interface	Trento, 3-7.10.05	Using observations of real designers and modelers at work to inform the development of a novel haptic modeling interface	Giraudo U., Bordegoni M.	paper + poster
Virtual Concept, Biarritz	Biarritz,8-20.11.2005	Design product with your hands	Bordegoni M., Cugini U.	paper
GRAPHITE 2005	Dunedin (NZ), 29.11-02.12.2005	Create Free-form Digital Shapes with Hands	M. Bordegoni, U. Cugini, U. Giraudo	paper

Summary of papers published in Journals

Journal	Editor	Title of the paper	Author(s)	Date of Publication
Progettare n°289, (ISSN 1125-1549)		Nuove metodologie a supporto dell'industrial design	M. Bordegoni, U. Cugini	May 2005
Virtual Reality Journal, Special Issue on Haptic Interfaces and Applications	Springer Computer Graphics	Haptic modeling in the conceptual phases of product design	M. Bordegoni, U. Cugini	Jan 06
International Journal of Systems & Applications in Computer Graphics, SPECIAL ISSUE on Computer Graphics in Italy		Haptic technologies for the conceptual and validation phases of product design	M. Bordegoni, G. Colombo, L. Formentini	Jan 06

Details of publications (updated @ November 2005)

- **PUBLICATIONS 2004**

- Reference: **Poster presented at EGVE 2004 (Grenoble, 8-9 June, 2004)**
  Title: Touch and Design
  Authors: U. Cugini
  Abstract: the poster has been presented at the Eurographics Symposium on Virtual Environments.
  <file> Poster-EGVE.pdf

- **PUBLICATIONS 2005**

- Reference: **Poster presented at WorldHaptics 2005 (Pisa, 18-20 March 2005)**
  Title: Design with your hands
  Authors: M. Bordegoni, U. Cugini
  Abstract: the poster has been presented at the WorldHaptics 2005
  <file>WH05-poster.pdf

- Reference: **Paper published in Progettare, n°289, maggio 2005 (ISSN 1125-1549)**
  Title: Nuove metodologie a supporto dell'industrial design
  Authors: M. Bordegoni, U. Cugini
  Abstract: Paper published in the Italian technical journal Progettare.
  <file>progettare-maggio2005.pdf

- Reference: **Paper @ CAID&CD2005 (Delft, 29.05-01.06.2005)**
  Title: Haptic system for shape generation
  Authors: M. Bordegoni, U. Cugini
  Abstract: The paper presents the first results of the EU funded research project T'nD – Touch and Design that aims at developing a system based on shape manipulators and haptic tools for the creation, modification and evaluation of product shapes. The system offers modeling functionalities that resemble the actions modelers perform when molding malleable material for creating physical prototypes of products.
  <file>CAID2005-bordegoni-cugini.pdf

  Reference: **Paper @ INGEGRAF 2005 (Sevilla, 01-03.06.2005)**
  Title: Design virtual products using hands
  Authors: M. Bordegoni, F. Espinach, J. Tresserras
  Abstract: The industrial design process mainly deals with the initial conception of the product. It is traditionally characterized by the production of several physical prototypes made by skilled modelers molding plastic materials with their hands. Their purpose is showing the product and also evaluating its shape. The production of physical prototypes and their integration within the downstream digital activities of the product development process include practices like Reverse Engineering that are costly and time consuming. Some other practices have been adopted in the last decade, where designers themselves use CAS (Computer Aided Styling) tools for defining virtual prototypes of products. Anyway, also in this case some physical prototypes are built for product evaluation and final shape assessment. An alternative practice based on the use of *virtual and haptic prototypes* is proposed by the EU research project T'nD - Touch and Design (www.kaemart.it/touch-and-design) financially supported by FP6 IST Programme of the European Union. The project purpose is developing a system that aims at offering the possibility to build digital models of products using interaction modalities that are typical of the production of hand-made prototypes. It will also be possible to evaluate the digital models of products by touching them with hands. The system is expected to be easy, intuitive and pleasant to use for both designers and modelers so as to convince them to adopt it as daily working tool. The project has started analyzing the current design process of the partners operating in the industrial design sector, and observing how designers and modelers

operate. The paper describes the design process and the observations performed at Eiger, one of the project partners, that is a Spanish company designing and developing household articles. Besides, the paper describes T'nD system concepts, scenarios and the first developed prototype, and discusses how the innovative T'nD system is expected to improve the design process of Eiger. <file>INGEGRAF2005-bordegoni-et-al.pdf

Reference: **Paper @ 9th Internacional Congreso on Project Engineering AEIPRO (Malaga, 21-23 June 2005)**
Title: Design virtual products using hands
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Abstract: The industrial design process mainly deals with the initial conception of the product. It is traditionally characterized by the production of several physical prototypes made by skilled modelers molding plastic materials with their hands. Their purpose is showing the product and also evaluating its shape. The production of physical prototypes and their integration within the downstream digital activities of the product development process include practices like Reverse Engineering that are costly and time consuming. Some other practices have been adopted in the last decade, where designers themselves use CAS (Computer Aided Styling) tools for defining virtual prototypes of products. Anyway, also in this case some physical prototypes are built for product evaluation and final shape assessment. An alternative practice based on the use of *virtual and haptic prototypes* is proposed by the EU research project T'nD - Touch and Design (www.kaemart.it/touch-and-design) financially supported by FP6 IST Programme of the European Union. The project purpose is developing a system that aims at offering the possibility to build digital models of products using interaction modalities that are typical of the production of hand-made prototypes. It will also be possible to evaluate the digital models of products by touching them with hands. The system is expected to be easy, intuitive and pleasant to use for both designers and modelers so as to convince them to adopt it as daily working tool. The project has started analyzing the current design process of the partners operating in the industrial design sector, and observing how designers and modelers operate. The paper describes the design process and the observations performed at Eiger, one of the project partners, that is a Spanish company designing and developing household articles. Besides, the paper describes T'nD system concepts, scenarios and the first developed prototype, and discusses how the innovative T'nD system is expected to improve the design process of Eiger. <file> INGEGRAF2005-bordegoni-et-al.pdf

Reference: **Paper @ HCI International 2005 Conference (Las Vegas, 22-27 July, 2005)**
Title: Design virtual products using hands
Authors: M. Bordegoni, U. Cugini
Abstract: This paper describes the first results of a research project aiming at developing a system based on shape manipulators and haptic tools for the creation, modification and evaluation of shapes of industrial design products. The paper describes how the users' requirements have been studied and analyzed, and subsequently used for the definition of the interaction modalities and tools of the system. The system architecture is described, and a first prototype built for evaluating the system concepts is presented. Finally, some scenarios showing the short-term and long-term evolution of the system are presented. <file> HCII2005-bordegoni-cugini.pdf

Reference: **Paper @ HAAMAHA 2005 (San Diego, Ca, 18-21 July 2005)**
Title: Create product shapes with hand motions
Authors: M. Bordegoni, U. Cugini
Abstract: Typically, in the conceptual phase of product design both Virtual Models (VM) and Physical Mock-Ups (PMU) are produced for improving the validation activity of the project, but in both cases, some disadvantages arise. The European project Touch and Design (T'nD) (www.kaemart.it/touch-and-design) proposes an optimal tradeoff between the two practices with the implementation of an innovative modeling technique and a novel haptic interaction method. In this paper we present the gestures analysis of designers at work which has lead to the design and development of a freeform shape modeling system based on intuitive haptic tools. <file> HAAMAHA2005-giraudo-bordegoni.pdf

Reference: **Paper @ HCI 2005 Workshop "Understanding & co-designing for Aesthetic Experience" (Edinburgh, 5 September 2005)**

Title: Conceptual design of a virtual clay modeling interface based on designers' hand movements analysis
Authors: M. Bordegoni, U. Cugini, U. Giraudo
Abstract: The paper presents the results of the conceptual design of an intuitive interface for virtual clay modeling. The work has been carried out within the context of the research project *Touch and Design* (www.kaemart.it/touch-and-design) funded under the FP6 IST Programme of the European Commission. The conceptual design of the new system has been developed by initially observing modelers and designers when modeling clay for creating new products in the workshop. From the analysis of the observed actions, ways of working and craft tools used we have designed a system that is based on haptic tools and geometrical sweep operators that mimic the effects of craft tools like rakes and sandpapers on real clay. A first prototype of the system has been developed and tested by designers. The conceptual design of the system interface, the system prototype and the results of testing sessions are reported in the paper.
<file> HCI2005-WS-bordegoni-et-al.pdf

Reference: **Paper @ ICMI (Trento, 3-7.10.2005)**
Title: Using observations of real designers and modelers at work to inform the development of a novel haptic modeling interface
Authors: U. Giraudo, M. Bordegoni
Abstract: Gestures, besides speech, represent the mostly used means of expression by humans. For what regards the product design field, designers have multiple ways for communicating their ideas and concepts. One of them concerns the model making activity, where designers make explicit their concepts by using some appropriate tools and specific hand movements on plastic material with the intent of obtaining a shape. Some studies have demonstrated that visual, tactile and kinesthetic feedbacks are equally important in the shape creation and evaluation process. The European project "Touch and Design" (T'nD) (www.kaemart.it/touch-and-design) proposes the implementation of an innovative virtual clay modeling system based on novel haptic interaction modality oriented to industrial designers. In order to develop an intuitive and easy-to-use system, a study of designers' hand modeling activities has been carried out by the project industrial partners supported by cognitive psychologists. The users' manual operators and tools have been translated into corresponding haptic tools and multimodal interaction modalities in the virtual free-form shape modeling system. The paper presents the project research activities and the results achieved so far.
<file>ICMI2005-giraudo-bordegoni.pdf
<file>ICMI2005-poster.pdf

Reference: **Paper @ Virtual Concepts 2005 (Biarritz, 8-10 November 2005)**
Title: Design products with your hands
Authors: M. Bordegoni, U. Cugini
Abstract: The paper presents the initial results of a research project aiming at developing a shape modelling system that takes advantage from both virtual and physical prototypes oriented to conceptual design of industrial design products. The system allows designers to easily create, modify and evaluate shapes of products by interacting with a virtual model through a haptic tool operated with their hands, as well as they do in reality using physical craft tools. Differently from handmade prototyping techniques used in reality, the system allows users to obtain at the end of the modelling phase a digital model of the product that can be directly used in the downstream phases of the product development process.
<file> VirtualConcepts2005-bordegoni-cugini.pdf

Reference: **Paper @ GRAPHITE 2005 (Dunedin, NZ, 29.11-02.12-2005)**
Title: Create free-form digital shapes with hands
Authors: M. Bordegoni, U. Cugini
Abstract: Current tools aimed at supporting the conceptual phase of product design are not intuitive to use, and do not exploit designers' skill and creativity. This paper presents the results of a research work aiming at integrating user-friendly and effective ways of interaction based on ad-hoc haptic interfaces into free-form shape modeling systems.
<file> GRAPHITE2005-bordegoni-cugini.pdf

Reference: **Paper @ Virtual Reality Journal, Special Issue on Haptic Interfaces and Applications, Springer Computer Graphics, 2005.**
Title: Haptic modeling in the conceptual phases of product design
Authors: M. Bordegoni, U. Cugini
Abstract: The paper presents the results of a research project aiming at developing an innovative system for modeling industrial products based on haptic technology. The system consists of a CAD (Computer Aided Design) system enhanced with intuitive designer-oriented interaction tools and modalities. The system integrates innovative 6 degrees of freedom haptic tools for modeling digital shapes, with sweep operators applied to class-A surfaces and force computation models based on chip formation models. The system aims at exploiting designers' existing skills in modeling products, improving the products design process by reducing the necessity to build several physical models for evaluating and testing the product designs. The system requirements have been defined observing designers during their daily work and translating the way they model shapes using hands and craft tools into specifications for the modeling system and the haptic tool. The system prototype has been tested by designers who have found it intuitive and effective to use.
<file> VRJ -bordegoni-cugini.pdf

Reference: **Paper @ International Journal of Systems & Applications in Computer Graphics, SPECIAL ISSUE on Computer Graphics in Italy, Editor-in-Chief: José L. Encarnação, 2005**
Title: Haptic technologies for the conceptual and validation phases of product design
Authors: M. Bordegoni, G. Colombo, L. Formentini
Abstract: The paper presents two applications of haptic technologies to demonstrate how they can increase human computer interaction during different steps of design process. The first application aims at developing a system to generate digital shapes by manipulating haptic tools that resemble the physical ones that the modelers use in everyday work. The second is focused on the use of haptic interfaces to evaluate ergonomics of virtual products control boards. We designed and developed the mentioned haptic devices; the first uses two FCS HapticMaster equipped with a innovative strong and stiff 6 DOF device carrying simulated clay modeling tools. The second is an "ad hoc" mechatronic device able to simulate some controls with rotary motions (knobs). The described haptic devices are integrated in more complex virtual reality applications; the paper describes their architecture and the methodologies proposed to simulate material shaping and ergonomic validation. The main aspects of haptic modeling and rendering are also discussed.
<file> CG-colombo-bordegoni-formentini.pdf

Annex 4
T'nD flyer

Introduction

Today modelers are used to produce physical prototypes (PMU) of products by modeling and manipulating material like clay, foam materials, wood, etc. Modelers have knowledge on shape controls in their hands and the skill they have developed is a high value to be preserved.

Unfortunately, PMUs require time to be developed, are expensive and not easy to test. Conversely designers use CAD tools to develop virtual models that are less expensive, less costly and easier to test than PMUs. Actually, designers are dissatisfied using mouse & keyboard to design 3D shapes and would like to be physically more active in the product design process. Therefore CAD tools require to be enriched with more user friendly and effective ways of interaction, not only based on mouse & keyboard, but using interaction tools allowing for the exploitation of modeler's skills.

T'nD aims at developing a novel system for shape generation and modification based on novel haptic interaction and intelligent shape manipulation operators in order to exploit existing manual skill of modelers and designers.

Designers will be able to work with they full hands, as modelers do in their daily work, using a novel haptic device for modeling product shapes.

Haptic technology will be integrated together with modeling operators for providing a working environment offering high degree of usability and acceptance, comfort of usage, flexibility for any kind of user, including inexperienced users.

Physical Prototyping
is a practice extensively used for product design evaluation performed by designers, stylists and customers

Virtual Prototyping
is a practice used by designers for representing product concepts

Virtual hand made prototyping
is a new practice proposed by the innovative T'nD system based on shape manipulators and haptic tools allowing the creation, modification and evaluation of shapes.

T'nD system conception

Expected results

The project will provide the following technical results:

- Improvement of theoretical foundations in the field of shape modelling and haptics in respect to state-of-the-art.
- Scenarios showing the evolution and specifications for future haptic interaction methods and devices.
- Improvements of cognitive ergonomics theories, including integration of vision and haptics in human-machine interaction.
- Stand alone components:
  - new haptic manipulator, performing real time rendering of complex shapes and providing full-hand interaction;
  - new shape modeling techniques supporting easy and intuitive creation and deformation of shapes.
- Prototype of an innovative system integrating shape modeling and haptic manipulator.
- Best practice for end-users.

T'nD system will show high level performances to be daily used by designers. Thus, it will be easy and intuitive to use and will provide shape manipulation functionalities, that make designers save time and effort in complex shape design (for example, the system will provide "scraper" operators for smoothing the shape, intuitive operators for assisting the definition of constraints, and more).

One of the most innovative aspects provided by the system is that designers are not expected to know mathematics behind geometric modeling for designing complex shapes, but they can simply, directly and intuitively manipulate virtual shapes using the T'nD system.

Annex 5
Press Reviews

Plast Design, June 2004

Pixel n. 93, June 2004

Industrie Technologies n. 76, July 2004

Progettare, July-August 2004

CAD Magazine n. 119, September 2004

Harvest n. 84, September 2004

Les Echos n. 19234, September 2004

L'Usine Nouvelle n. 2940, November 2004

CADplus n°6/2004, December 2004

Corriere Motori, June 3 2005

ID Forum, Tokyo 2005