TOUCH AND DESIGN

DESCRIPTION AND ANALYSIS OF SHOW CASES

by
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Abstract
This document reports the activities related to T'nD Show Cases performed in the last year of the project. The activity has concerned the evaluation of the system performed by users external to the project. The testers have been invited to freely try the system and to express their opinion about the concept proposed by the system and the novel haptic interfaces implemented for creating and exploring virtual shapes.

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0. Index

1. Executive Summary

This WP has been performed during the third year of the project. The activities planned in the WP as described in the Annex I are the following.

"This task will organize some experiments for evaluating the concepts and the system developed in the project with users external to the project. There will be two types of experiments: one oriented to emphasize the novel characteristics of the system having in mind new application fields and areas, and the second one oriented to specifying in a quantitative and detailed way the possible and/or requested improvements. In order to structure the users' comments and evaluation, the questionnaire defined in WP7 will be used, addressing several aspects of the developed system: functional characteristics, usability, training needed, skill required, robustness, etc.
The task will include:

- *identification of selected users, especially skilled to perform the task;*
- *selected users freely use the system and report impressions, comments, suggestions, etc."*

The activities have been coordinated by PoliMI, that also hosts the system prototype, and have seen the participation of the developer partners and the end users. The psychologist partner has helped in the definition of the testing methodology and questionnaires.
It was decided to organise some formal testing sessions involving external testers, as well as to take advantage of people visiting PoliMI's labs for organising some demonstrations and tests of the T'nD system. In total, 12 end users visited and tried the system. Their comments have always been very positive about the concepts proposed by the project. Besides, PoliMI and think3 have organised several presentations of the project results and of the T'nD system. Most of these presentations have been performed to Japanese companies where the project has been very much appreciated and a great interest has been demonstrated about the evolution of the prototype and the possible development into a commercial product.
In addition, some more formal evaluation tests have been organised. A group of end-users has been contacted, and some of them invited to test the system. In total we had 6 testers, all having experience in surface modelling. Also in this case, all testers reported a strong appreciation of the concepts proposed by the project. Some major issues have been reported concerning the graphical user interface and the stability of the system. Besides, the testers have provided some good suggestions for improving the future version of the system.
Following the results of use case sessions organised in WP7 (reported in D14), we have considered necessary to ask another user to test the system. The person we involved in the testing is the target user of the T'nD system: a professional expert in manually making models and in using CAD tools (specifically, thinkdesign tool). At the end of the testing session, which lasted one full day, he declared to be very pleased with the system. He considered the system offering very few and effective commands, and making particularly easy to start playing with the system as compared with CAD systems commands. The tester was delighted by the fact that with T'nD one does not really work but rather play with the tool, and this is another way of working that is very much appreciable and enjoyable.

2. Introduction

The aim of this activity concerning Show Cases has been to test and evaluate the T'nD system with users that are external to the project. The idea was to involve some potential users working in the industrial design area in order to disseminate the concept related to the new technology developed for supporting product design and also to gather opinions about the use of the T'nD system from people who did not participate to the specification of the system requirements, test cases, and metrics for results evaluation. Therefore, PoliMI has taken the opportunity to ask all people visiting its lab to test the T'nD system for having a feedback about it. Furthermore, some more formal testing sessions have been organized involving some designers proposed by T'nD end user partners and by think3. They have been invited to test the system, and have been asked to compile a questionnaire expressing their opinion about the system in general, the user interface, the usability of the system, its performance and the potential benefits they may find in the proposed approach.
This document describes the Show cases strategy developed for performing the tests and presents the results.

3. Show cases procedure

The procedure we have adopted for show cases consists in organizing some formal testing sessions involving external testers, and also to take advantage of people visiting PoliMI's labs in order to get some feedback about the T'nD system.

3.1. Visiting end-users and presentations

The T'nD system has been installed at PoliMI lab in Milano. The lab is often visited by representatives from industry and from academic centers coming from all around the world. PoliMI has taken the opportunity of inviting all visitors operating in the industrial design field to test the T'nD system. The tests have been organized in a very informal way during the visits. Visitors were asked to try the system and to comment its various aspects and functionalities. The comments have been written down into a notebook and reported in this deliverable.
Another strategy for getting comments about the system has been through presentations. PoliMI, and some other T'nD partners, have taken any opportunity of presenting the system using slides and videos. Even if the attendees of the presentations had not the opportunity of trying the system, they expressed anyway their opinions about the system, and most of the time the interest in trying it physically.

3.2. Planned evaluation sessions with end-users

A more formal way for organizing test cases has been defined with the contribution of some project partners. A list of potential testers has been compiled by Alessi, Pininfarina and PoliMI. This has been done mainly for practical reasons: it was easier to have Italian people visiting PoliMI's lab and testing the system. These people were selected on the basis of their ability of making physical and/or digital models of products. The testers were invited to spend a couple of hours for getting acquainted with the system, creating the model of a selected object and answering to a final questionnaire. As a result of this activity, six testers performed the use cases.

4. Visiting end-users and presentations

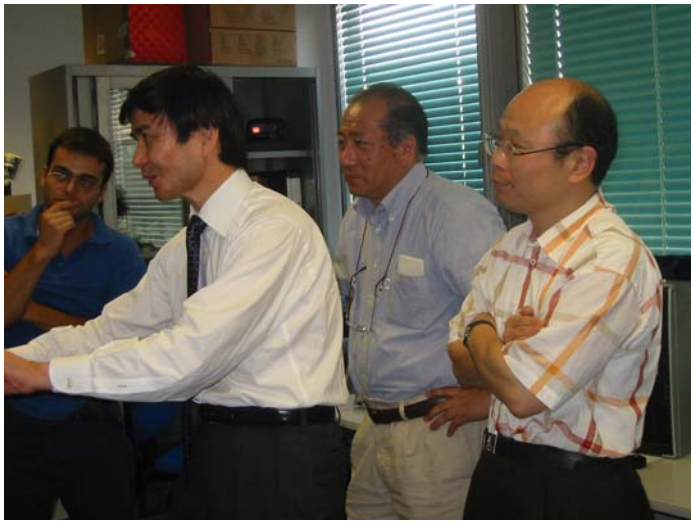
This section describes the presentations and demonstrations organized in order to present the T'nD project and results. Some presentations have been done to potential users through the use of slides and videos. Some other people have been invited to test the T'nD system during their visit to Politecnico di Milano. These people have performed an informal test of the system. They have been asked to give comments about the basic concepts of the system, its pros and cons, and its possible improvements. In the following, the presentations and the tests are described.

4.1. End-users visiting PoliMI

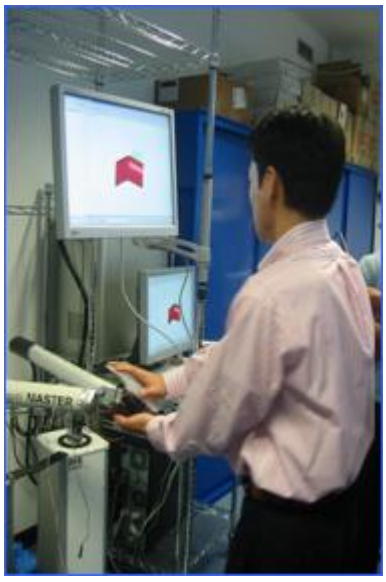
Several people working in the product design and industrial design field have visited PoliMI in the last year. Some of them have been invited to test the T'nD system. The people selected were mainly working in the development of products with particular aesthetical requirements in terms of surface quality and smoothness to be manufactured. The users visiting PoliMI labs are listed in the following table.

Date	***People***	***Company***	***Role***
June 06	Maura Mengoni	Teuco	Designer
June 06	Gioachino Acampora	Carrozzeria Castagna	Designer
27 July 06	Hiro Shimada	Nihon Unisys Solutions, Ltd.	Team leader of software development for car design
27 July 06	Yoshinori Ogata	Toyota (J)	Project General Manager, Corporate IT department
27 July 06	Atsushi Takagi	Toyota (J)	Group Manager, Corporate IT department
26 July 06	Emanuele Ricci	Freelance	Designer/Journalist (DOMUS)
July 06	Daniele Gulmini	AVIO Group (I)	Senior designer
30 Aug 06	Vittorio Romagnoli	Powertrain (I)	Senior engineer
8 Sept 06	Satoshi Kamio	HONDA (J)	Senior designer
9 October 06	Hiroshi Watanabe	think3 (Japan)	Technical consultant
9 October 06	Naoji Akimoto	think3 (Japan)	technical manager
16 October 06	Daniele Costa	Italdesign-Giugiaro	Designer

Some pictures taken during the test of the system are shown in the following.



Yoshinori OGATA, July 27 2006



Hiroshi WATANABE, October 9 2006

4.1.1. System evaluation and comments

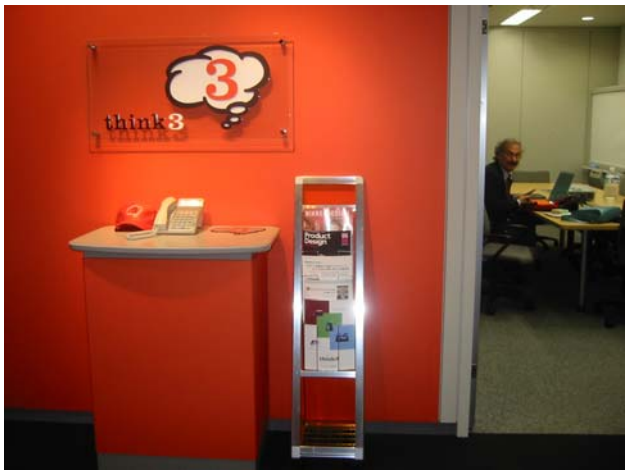
The comments of people that tried the T'nD system have always been very positive. The concept of using a virtual tool that is alike a real rake for removing material was very much appreciated, as well as the concept at the basis of the tool for exploring shapes.
Toyota people gave some useful comments about the haptic rake: they suggested to add the possibility of controlling the thickness of the material being removed, and to improve the performances of the system so that the tool could be moved faster as it happens in real life.
The identification of the position of the tool in space was reported as a problem from most of the users. Conversely, users liked the possibility of selecting the virtual tool profile so as to choose the most appropriate tool for the shape being created.
Especially Japanese people were interested to know the following development of the system, and the plan for transforming the prototype into a product available on the market.

4.2. Presentations

Several presentations of the project have been performed in Japan during a trip of the T'nD project coordinator in occasion of the presentation of the T'nD results at the FISITA Conference 2006. In this occasion the coordinator has visited think3 branch in Tokyo, which has several contacts with Japanese automotive companies. Many dissemination actions about T'nD project have been performed to several of these companies. The list of presentations performed during this last year is reported in the following table. The coordinator has shown project results through slides and videos. Several people will come to test the prototype when they will happen to be in Europe during 2007.

Date	***Location***	***People***	***Company***	***Role***
30 Nov. 06	Tokyo	Hiroshi WATANABE	think3 (Japan)	technical consultant
30 Nov. 06	Tokyo	Toru KAWAGUCHI	think3 (Japan)	President & Representative Director VP of Japan Operation, think3 Inc.
30 Nov. 06	Tokyo	Takayuki MATSUOKA	think3 (Japan)	Manager, Major Account Development
30 Nov. 06	Tokyo	Tetsuya WASABA	HONDA R&D	Assistant Chief Designer - Advanced Design Studio, HONDA R&D Co.
30 Nov. 06	Tokyo	Daiya KAKU	HONDA R&D	Senior Manager, Styling Design Development Division
30 Nov. 06	Yokohama	Jun MARUYAMA	Mazda Motor Coprporation	Modeler, Advance Design Group, Design Division
30 Nov. 06	Tokyo (think3 K.K.)	Hideki TAOKA	HONDA Engineering Co., Ltd	Senior Staff Engineer of Production Enginnering. Deputy General Manager

Building hosting think3 office in Roppongi, Tokyo.



T'nD coordinator at think3 office in Tokyo.

4.2.1. Comments

People from Honda appreciated and supported the idea of integrating the sense of touch to shape modeling tools. The main reason is related to the fact that designers are used to use touch for modeling new shapes, for checking and controlling their quality, to check shape proportions, etc. They also appreciated the idea of basing the T'nD system on top of a CAD tool that offers functionalities such as undo, reflection lines, high quality surfaces that are very useful for designers, and augmenting the modeling and exploring modalities by means of haptics.
For what concerns the functional and technical aspects of the T'nD system, they were interested in understanding which is the allowed dimension of the object to model, and the kind of malleable material that the system is able to simulate.
Finally, Honda people were questioning about the most appropriate user of the T'nD system, whether he had to be a modeler, a designer, or both.
In conclusion, they see an opportunity of using T'nD system in the future for reducing the number of physical prototypes they currently build for new products, and for improving the final quality of their products because more variants may be considered in the lapse of time usually available for the conceptual phase of new products. In fact, they report that it is a common trend very typical of Japanese companies to pay more attention to the reduction of lead-time sometimes to the detriment of the global quality of products.

The conceptual design of new Mazda cars starts with the creation of the clay model which is refined two or three times before being accepted. Each refinement loop takes about one week. When the car is then created digitally using some CAD tools, the modeler would still like to have the opportunity to check the quality of the shape. Unfortunately, it is only possible today by means of the use of some mathematical-based functionality of CAD tools which allow users to check surface patch continuity and surface reflection lines. They have expressed their great interest in visiting Politecnico di Milano and physically experience the T'nD system, when they will be in Europe.

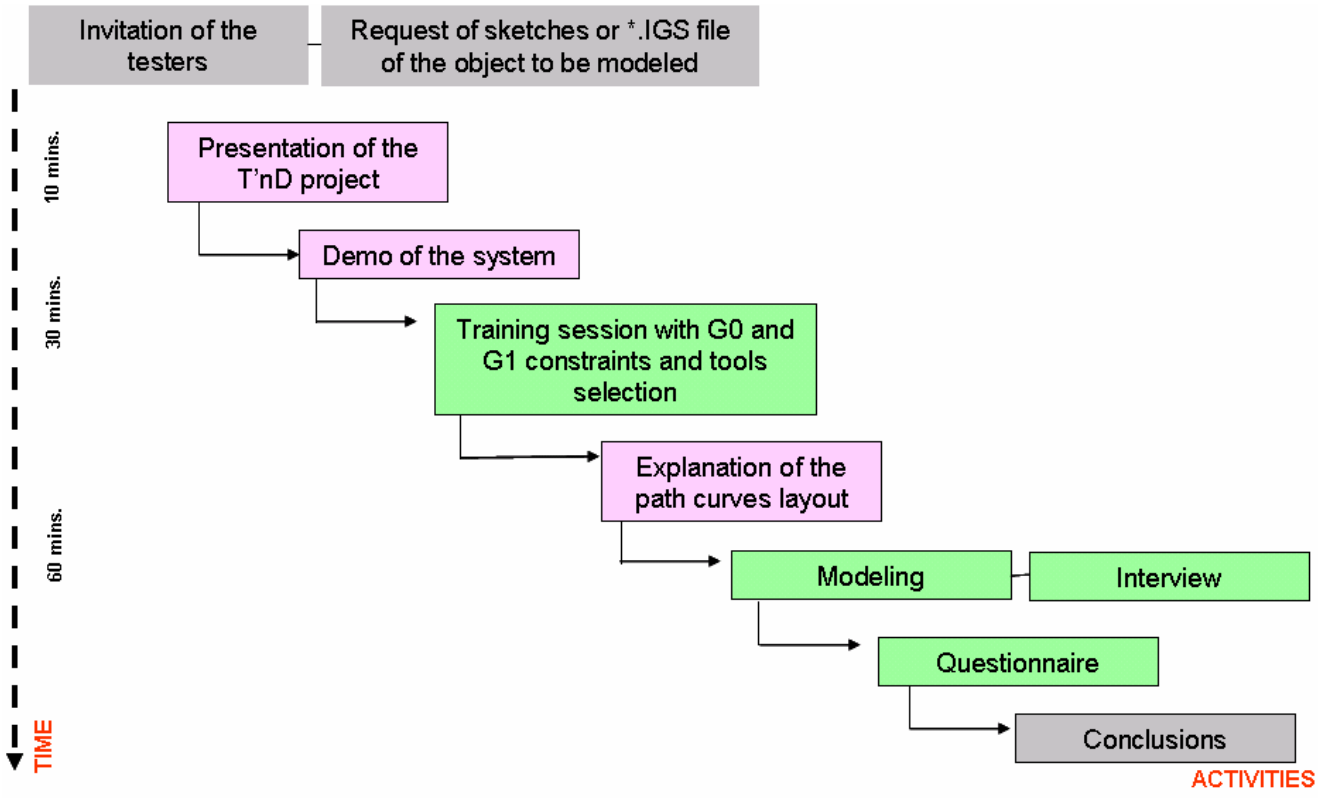
5. Planned evaluation sessions

The tasks of WP9 have concerned show cases and specifically it intended to illustrate to external testers of the consortium the functionalities and potentialities achieved at the end of the Touch and Design project.

A list of potential testers has been proposed by T'nD end users, mainly Alessi and Pininfarina. For practical reasons, most of the testers were Italian and geographically located around Milano and Torino areas. The show case procedure is shown in the following figure.

An invitation has been sent to the all potential testers by email, including a T'nD project short presentation (reported in Appendix 1). Invited testers were asked to provide in advance the CAD model or some 2D sketches of the object they intended to create using the T'nD system in order to permit us to upload the file and the basic construction geometry into the system interface. The provided model was related to the testers' design field (automotive or industrial design product) and of medium-low complexity in order to have the opportunity to fully exploit the potentialities of the system. Since the testers were external to the consortium, no particular constraints were set both in terms of time and goal achievement.

The testing procedure consisted of an initial demonstration of the system and its functionality, followed by 30 minutes of training performed using a demo CAD model and a variable time frame dedicated to accomplishing the modeling of the provided object. This was required to allow users to get acquainted with the system and the haptic interface. Mainly the scraping tool has been used for creating the object shape. The use of the exploring/sanding tool has been demonstrated at the end of the testing session, in order to evaluate the quality of the obtained surface.
In order to collect data about the testing sessions, we made use of video recording (during the all duration of the session, for recording the users' gestures and comments) and a final questionnaire (reported in Appendix 2).
In this report we intend to provide both quantitative data concerning video recording and questionnaire results, and some qualitative data related to user's impressions and suggestions for possible T'nD system improvements.



5.1. List of end-users contacted

A list of potential testers has been proposed by T'nD end users, mainly Alessi and Pininfarina. For practical reasons, most of the testers were Italian and geographically located in Milano and Torino areas. Furthermore, the testers' selection criteria have been based on their design experience (with digital and physical modelling capabilities) independently from their specific industrial field. The list of testers is reported in the following table.

Potential User	*Reference*
MR&D Institute	**Polimi**
Da Silva (VW)	**Polimi**
Whirlpool	**Polimi**
FT&A	**Polimi**
Paolo Bertoni (STS surfaces)	**Pininfarina**
Stefano Giovannoni	**Alessi**
Stevenson (FIAT)	**Pininfarina**
Ing. Armigliato (IVECO)	**Pininfarina**
A.Zagato / M. Pedraccini	**Pininfarina**
P. Momo (IBM)	**Alessi**
M. Capuani / A. Pellizzari (domus academy)	**Alessi**
G. Picardo (Honda Italia)	**Pininfarina**
P. Di Muro (ZF Trimax)	**Pininfarina**
Protoscar (Svizzera)	**Polimi**
Massimo Giacon, Elena Le Fons	**Alessi**
Guido Venturini	**Alessi**
Miriam Mirri	**Alessi**
Frederic Gooris	**Alessi**
Rodrigo Torres	**Alessi**
Nicole Sargenti	**Alessi**

5.2. Invitation sent to potential testers

An invitation has been sent to the all potential testers by email, including a T'nD project short presentation (reported in Appendix 1). The invitation consists of a flyer presenting the objective of the project and the achieved results. It shortly describes the T'nD system developed and its functionality. The flyer includes the description in English and Italian, since most of the potential testers invited were Italian.

5.3. Questionnaire

A questionnaire has been defined in order to be used to collect information and users' impressions (reported in Appendix 2). This questionnaire was given to the testers to complete after using the T'nD system, and mainly addresses the following issues:

1. Perceived usefulness
   Testers were asked to rate the usefulness of the system for shape creation, for shape modification and for shape evaluation; to rate the usefulness for designers and/or modelers; to estimate the process benefits and performances; to estimate the perceived improvements of quality of product model; to express the satisfaction with the overall

performances of the system, and to judge the possibility to integrate/replace tools and practice currently used with T'nD system.

2. Perceived usability
   Testers were asked to evaluate the easiness to learn using the system, the haptic feel of interaction, graphics/visual feel of interaction, the precision, the quality of shape, the results achieved compared to expected/desired, possibility to exploit users' skill.

3. Evaluation of physical tool
   Testers were asked to evaluate some aspects of the haptic tools like the ease of learning, the ease of use after learning, the intuitiveness, the precision, the comfort, the d.o.f. of motions, the workspace, etc.

4. Evaluation of visual aspects
   Testers were asked to evaluate visual aspects like correctness of visual definition of surfaces, appearance of visual rendering of surfaces, possibility to evaluate the shape from its rendering, the relation of visual rendering offered by T'nD compared to the one offered by other CAS/CAD tools.

5. Suggestions from users
   - What changes would the user recommend to improve the current system?
   - What new development would the user suggest to improve the current system?
   - What applications and possibilities does the user envision for the use of the system?

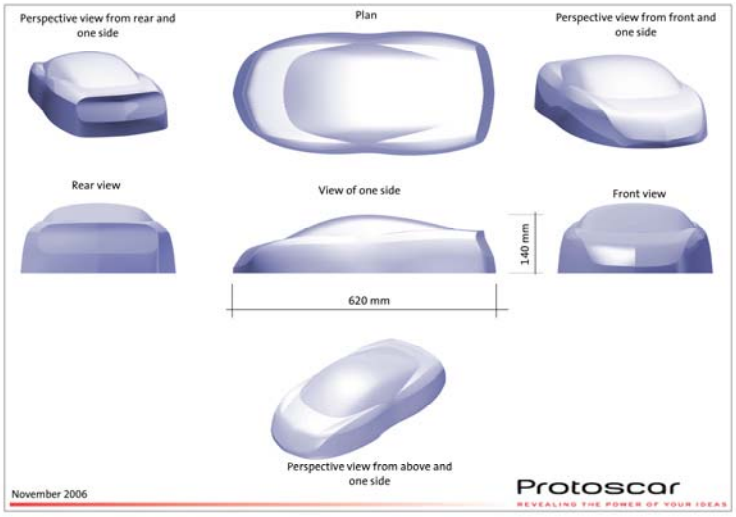
5.4. Evaluation sessions

This section presents the evaluation sessions performed by six testers. The description of each testing session includes a presentation of the tester profile, a description of the object to create and the related tasks, the steps executed for the creation of the digital object, some images of the object created, and a synthesis of the questionnaires results. The questionnaires filled in by the testers are reported in Annex 3.

5.4.1. User 1

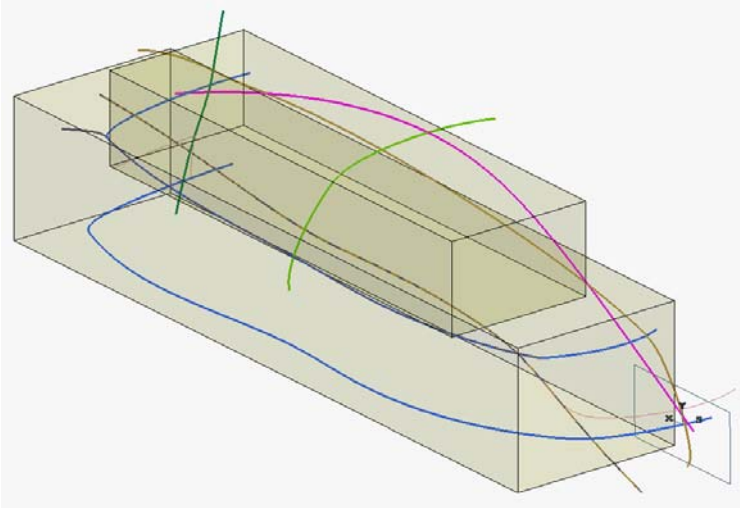
Tester profile

The first tester was coming from a Swiss based automotive consultancy, with a strong background in digital modeling and a consistent experience in physical modeling (both with clay and other materials). The tester intended to model a simplified silhouette of a scaled car normally used for color evaluation in his company (see following picture).



Description of object to create and tasks

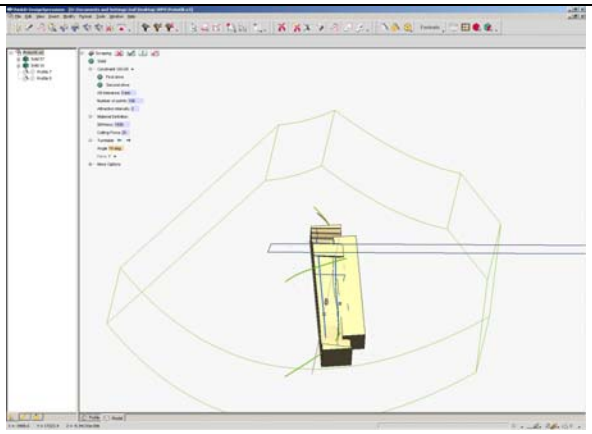
The intended object was the silhouette of a scaled and simplified car with some typical flat and curved surfaces and more complex surface features and the height of the doors. In order to define an achievable goal some features have been simplified and the model layout has been optimized by the use of constraints curve. Specifically the shape of the window part was impeding the scraping of the upper surface of the body of the car. We defined a strategy based on two steps modeling by means of the use of one block of clay for the main body parts and a second one for the glass surfaces.



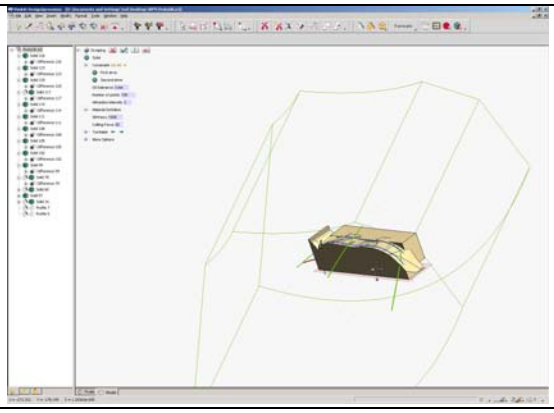
Steps for digital object creation

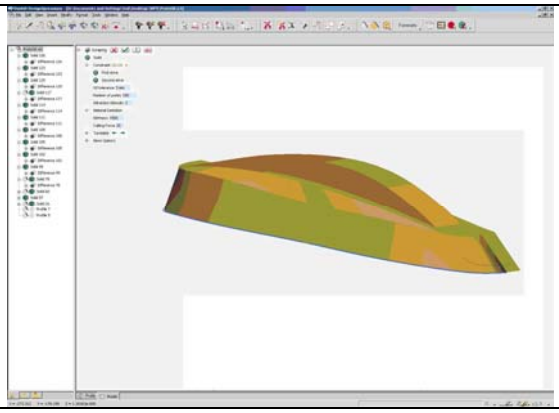
In order to speed up the process, we provided the tester with the complete set up of the scene including the basic blocks of clay and all the necessary path lines and curved tools required. The user was then free to define his own strategy, i.e. making a free scraping or choosing the path lines he thought to be more appropriate to obtain the final shape.

In this case, the tester started with the upper surface of the model to define the major silhouette of the car and get a comprehension of the final shape, and then moved to the side of the car to conclude with smaller detail refinements. Unfortunately, because of software instability the process had to be repeated several times because the tester was impeded to save the obtained shape. Positive remark is that by defining several times the same shape the tester achieved a higher level of accuracy in controlling the tool and by consequence he was able to define cleaner surfaces and also decrease the performing time.



Images of model created





Questionnaire results

The general impression the tester had of T'nD system was quite good, with a relatively strong appreciation of the system layout and the concept behind the system. Specifically, the tester appreciated the quality of force feedback provided by the haptic interface, which was coherent to physical clay relatively to his experience, and the additional features of the virtual modeling tool relative to shading and reflection lines display. Still some problems related to the positioning of the tool over the object resulted critical, since the tester had some difficulties in defining the correct contact point of the tool for starting to scrape material. In the end the tester was impressed by the intrinsic potentialities of the system, but in his opinion a refining phase for providing more reliability to the system is necessary.

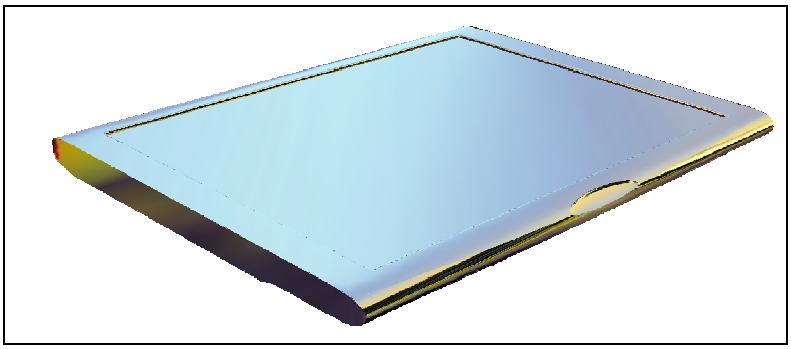
5.4.2. User 2

Tester profile

The second tester was coming from a small design studio based in Milan oriented to product design that benefits from the collaboration of famous internationally renowned designer. The designer has a background in all typical design areas such as concept development, physical modeling (but no previous experience with clay) and digital modeling with mid-range tools (Rhino and Solid Works). The tester intended to model the external surface of a self designed tablet PC.

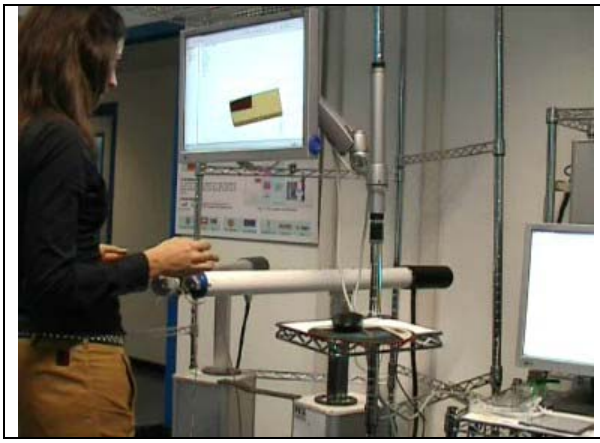
Description of object to create and tasks

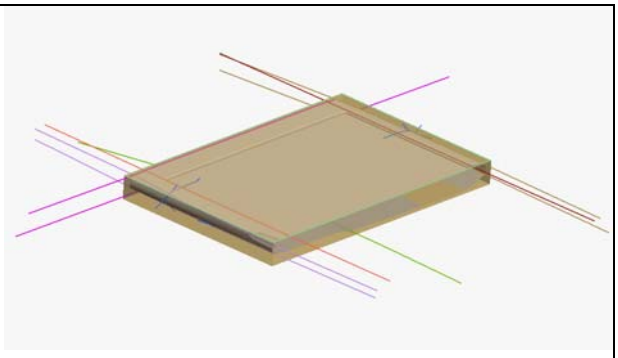
The object intended to model was a tablet PC, which was definitely of low complexity very similar, in terms of sequence of actions, to the one we were used to use for demos. The tester provided us an *.IGS file from which path curves and curved profile for tool definition were extrapolated and further elaborated by us for providing the user with the complete set up on the day of testing.



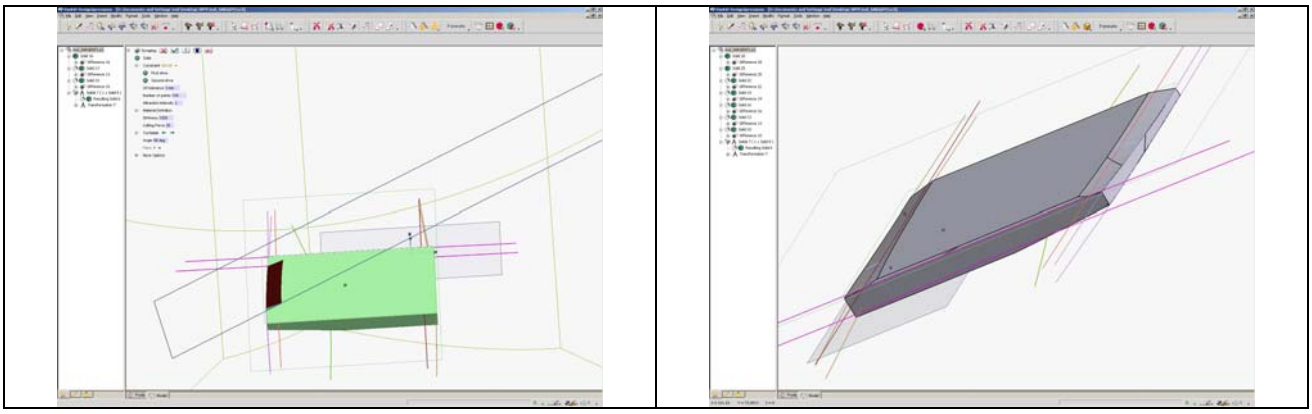
Steps for digital object creation

The user was let free to define his own modeling strategy given the basic block of clay and the necessary path curves and special tools. As in the previous case the user started by removing a large amount of digital clay at the beginning so as to define the basic structure of the shape with the regular rectangular tool and subsequently refining the features by working on smaller scale details with curved tool sets. Due to the low complexity of the model, no further scraping operations were required.





Images of model created

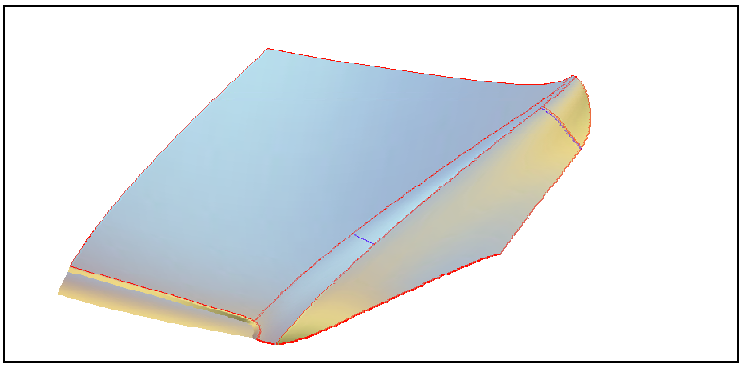


Questionnaire results
The user was extremely satisfied by the system and expressed high appreciation about the concept and for what concerns the T'nD system layout. Specifically, in her opinion the quality of the result and the time necessary for concept visualization and development has been highly appreciated. Besides, in her opinion, the system could be positively considered as integrating typical CAD/CAS tools and physical modeling. This consideration was mainly due to the still open problems of the T'nD system related to detail design that do not provide yet the required accuracy. The tester assessed the system as being closer to digital modeling rather than to physical methodology, possibly because of the options available such as object shading and the possibility to freely rotate the block in space.

5.4.3. User 3

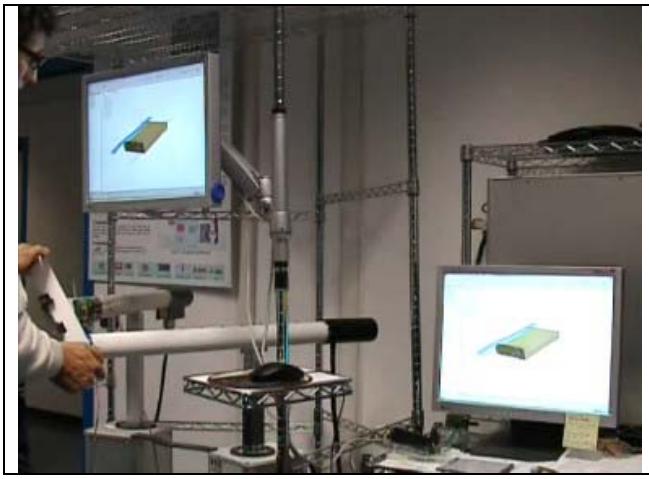
Tester profile
The third tester was coming from a globally renowned automotive design and engineering consultancy company where he plays the role of digital modeler. Specifically his previous role was physical modeler (using clay and typical modeling methodologies of automotive field) who, because of the digitalization of the process, has moved to the digital activity by using high end surface modeling tools.

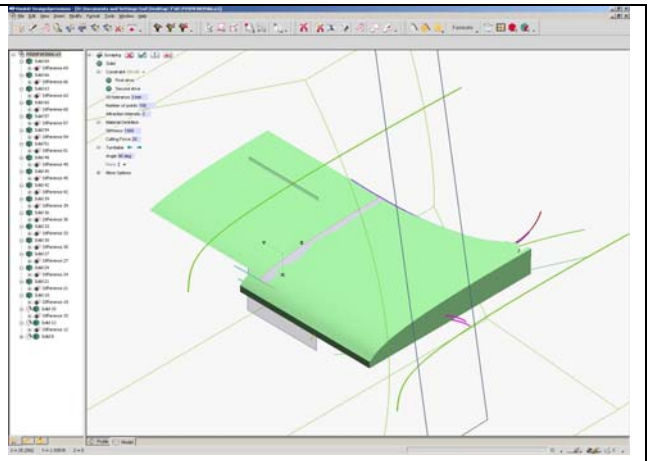
Description of object to create and tasks
In this testing session the tester intended to model the bonnet of a car showing medium/high complexity of the shape. To achieve the result the tester provided us an *.IGS file of the model and we pre-elaborated it to obtain path curves and required tools.



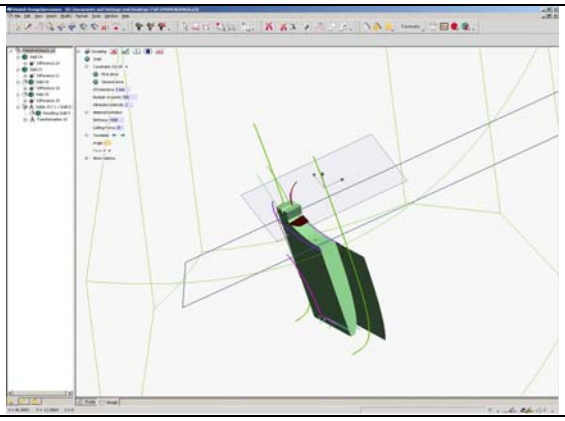
Steps for digital object creation

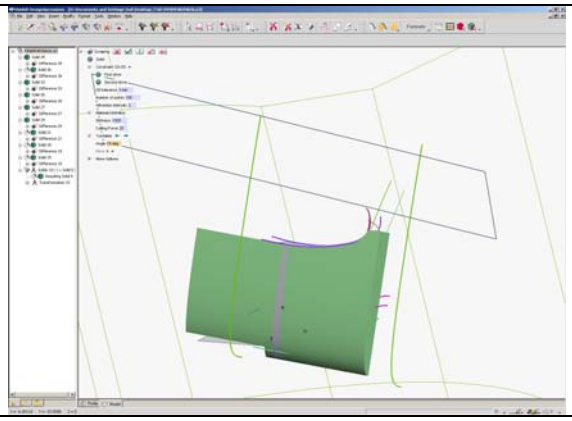
As stated in the previous cases the tester was provided with all necessary path curves and extracted tools to perform his modeling depending on his strategy with no external influences. Still some changes had to be made from us since the intended model was based on surfaces and the T'nD system can define complex shapes but still depending on solid modeling. In this case we defined a solution to support the achievement of the final goal by defining an offset of contour curves on the lower part of the shape obtaining the required solid shape of the bonnet. As in the previous cases the tester started scraping the external lines defining the basic shape and then adding details to the design. Still some parts of the shape were inflating inwards and it was extremely difficult to remove material with a convex profile without interfering with the adjacent surfaces.





Images of model created





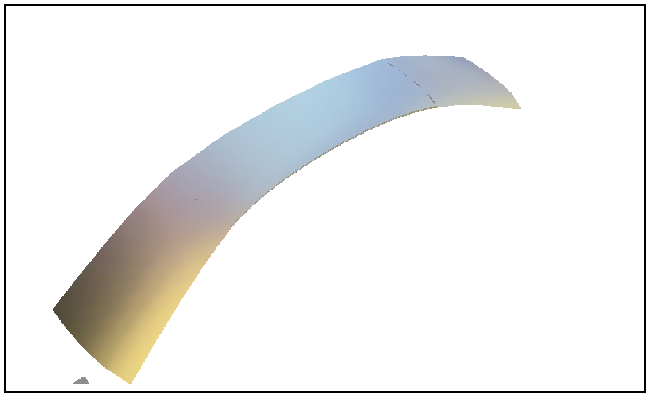
Questionnaire results

The tester assessed a medium level of satisfaction with the system and defined physical modeling to be much easier to use compared to T'nD, both in respect to visualization and navigation issues and final shape achievements. Still the tester defined T'nD as being an extremely intuitive system easy to learn and to interact with. Probably, major problems still are in GUI layout that requires, as the tester affirmed, too many steps for set up before actually starting the modeling phase. Concerning the quality of the final shape the user was completely unsatisfied because of the edgy style of the surfaces and the stability of the haptic system itself that was causing the tester to attempt many trials before actually getting what intended. A detailed analysis of the results has shown that the mathematical quality of the driving curve provided as input data was not good enough. Since the system generates the surface starting from this curve, a pure visual evaluation of the final result is not acceptable and also misleading.

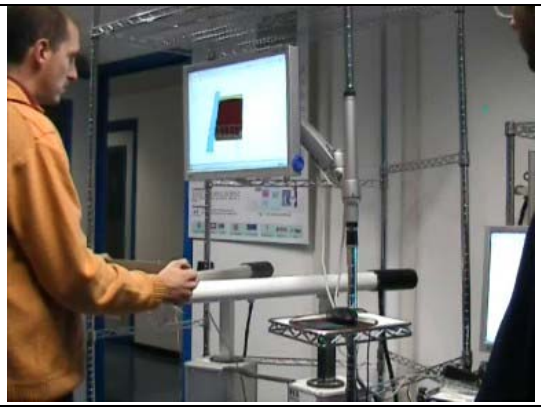
5.4.4. User 4

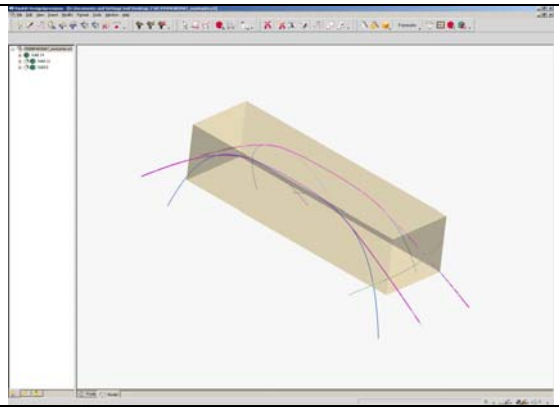
Tester profile
The fourth tester, as the third tester, was coming from a globally renowned automotive design and engineering consultancy company where is there employed as automotive designer. As all the other testers he has experience in physical modeling, hand sketching and high end CAS tools knowledge.

Description of object to create and tasks
Contrary to the previous testing session, the tester, in this case, wanted to test the system with an extremely simple, still accurate, part of a car body, the upper connecting imperial where the shape remains almost constant with some lateral twisting along the spine of the shape. As in previous cases an *.IGS file was provided, path curves and required tools were extrapolated before the testing session.

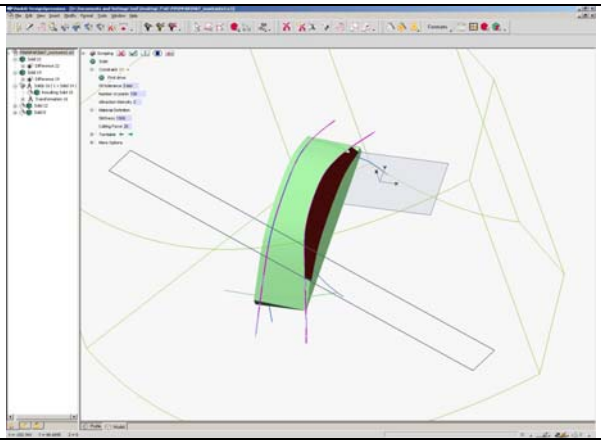


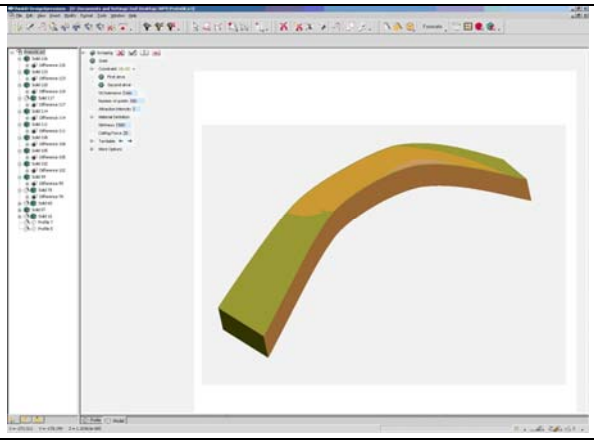
Steps for digital object creation
In this test case the tester was free to define his own modeling strategy. Still, since no "main" curve to obtain the basic shape were available and the shape was of relatively low complexity the tester intended to try to model without making use of path curves just by acting on the translation and rotation of the rake. In this case, even if the T'nD system permits users to set the stiffness values of the material, the tester had some problems to control the Y penetration of the tool in the material and, by consequence, had to make use of a single path line with G0 constraint. Besides, the tester made many attempts to get the intended shapes through different ways and investigating all the functionalities of the T'nD system.





Images of model created



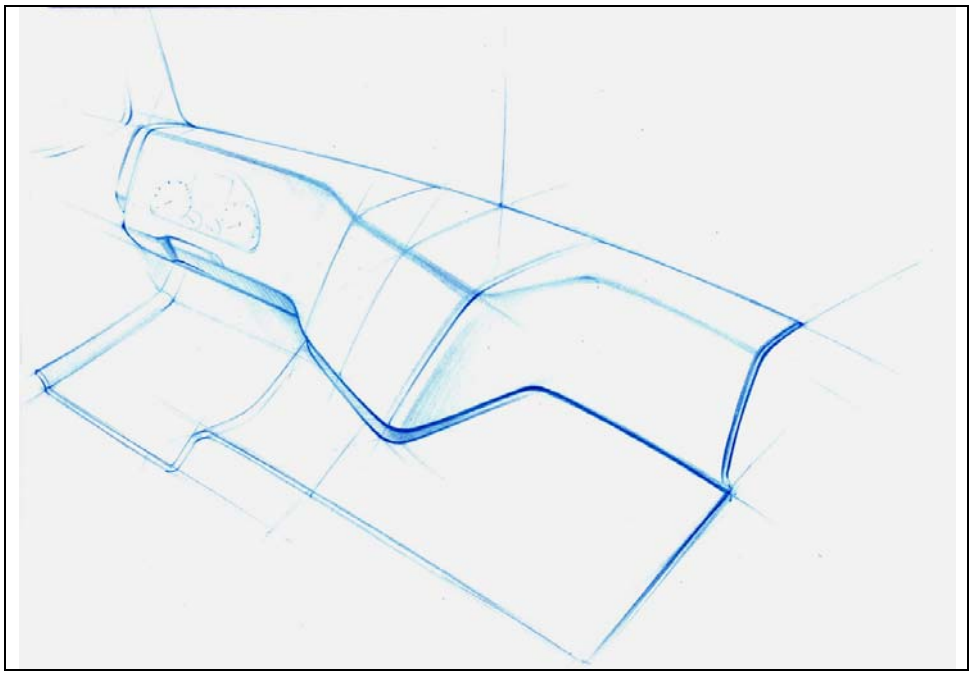


Questionnaire results
The tester scored an extremely high level of appreciation of the T'nD system both at conceptual and implementation level. Specifically the tester assessed the good qualities of the T'nD system for concept development mainly related to the intuitive and time performing capabilities of the system. Still some results relative to interface layout and navigation into the virtual environment were defined as being extremely negative and annoying, possibly because of the high number of steps required to set up the system before scraping, and because of difficulties in defining the correct spatial positioning of the tool. By consequence, even if the tester had effectively tested a number of different ways to obtain the final shape, the obtained result was not meeting his expectations in terms of detail quality of the surfaces.

5.4.5. User 5

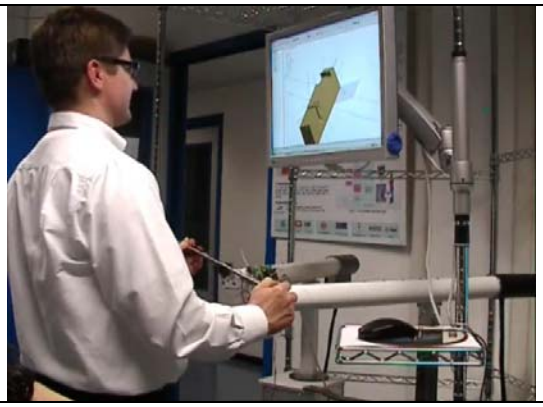
Tester profile
The fifth tester was coming from a renowned international truck company with a specific background in industrial design applied to transportation design; in fact he was the responsible for concept development of the interior design for trucks. He has a strong background in digital modeling, uses advanced surface modeling tools, and has some experience in physical modeling, but not directly with clay modeling.

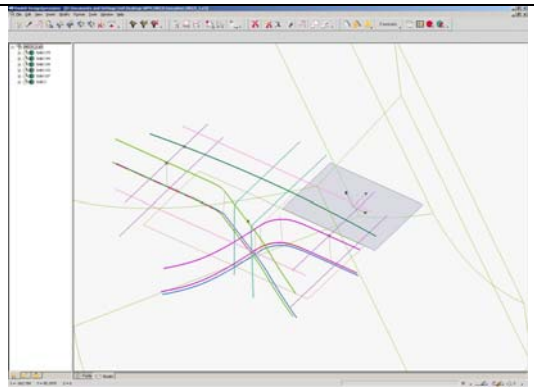
Description of object to create and tasks
The tester intended to model the main shape of the dashboard of a truck with some very basic features and surface curvature. To achieve this, he provided us with a very simple sketch of the object. On that basis, path curves and solid layout have been built and provided to him as a support for using the T'nD system.



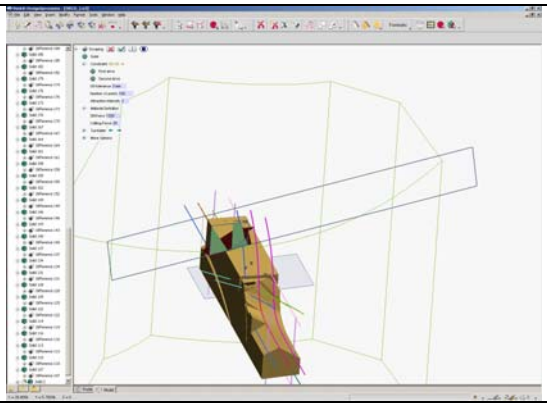
Steps for digital object creation

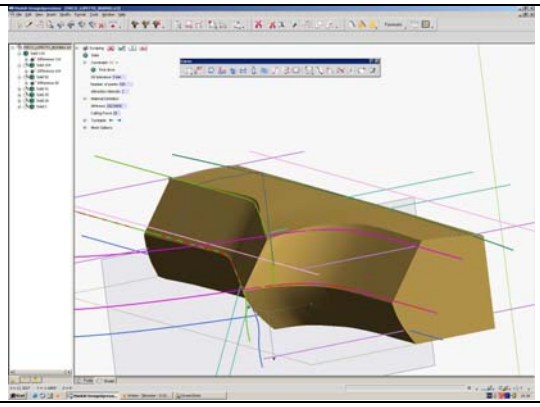
The creation of the object has started by defining the main block of material by using the external path curves. Subsequently, the tester has started removing material in the position in front of the passenger seat in order to achieve the discontinuity of the shape. This was done firstly in one direction (from the center to the right, referring to the above sketch), and then by removing the other slice of material that would virtually be in front of the driver. The last step consisted in optimizing the top surface by using a curved tool and adding some quick refinements.





Images of model created



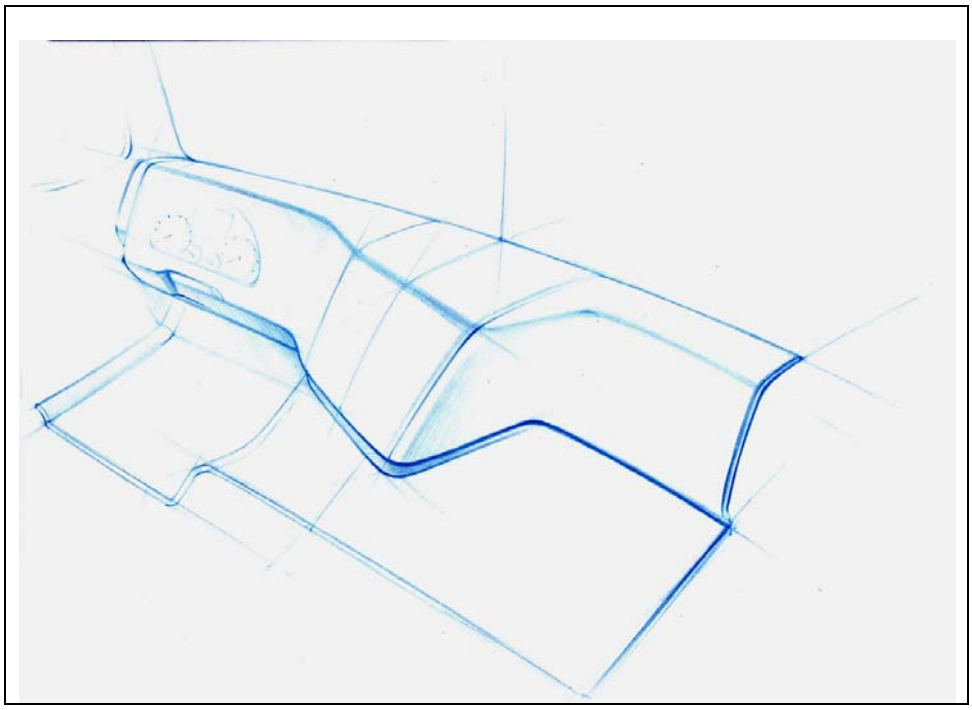


Questionnaire results
The tester has appreciated the system for what concerns the general layout but highlighted some complaints related to some aspects relative to the easiness of use and the achievable surface quality supported by the system. Specifically, the tester disliked some aspects relative to the GUI that judged as being not reliable for tracking his position over the virtual block of clay and the misalignment between the hands and the visual display that were not spatially coherent. Intrinsically, this kind of perception of the system defined results that were not so precise and reliable as one would expect.

5.4.6. User 6

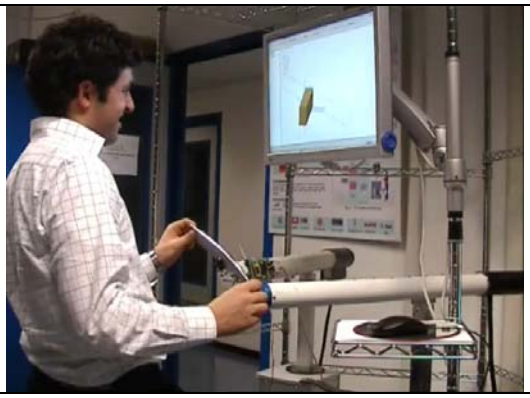
Tester profile
The sixth tester, as the previous one, was coming from an international truck company with expertise in digital shape modeling and a background as interior designer of truck's cabins. As the previous tester he has some low level background in physical modeling but with no direct experience in clay modeling. Being extremely skilled in digital modeling, he could well and fully understand the functioning and the behavior of the T'nD system.

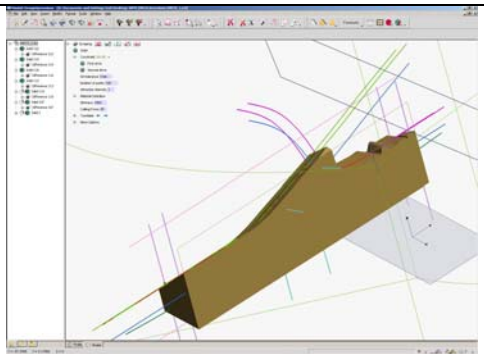
Description of object to create and tasks
In a separate session, the tester performed the same truck's dashboard as in the previous testing condition.



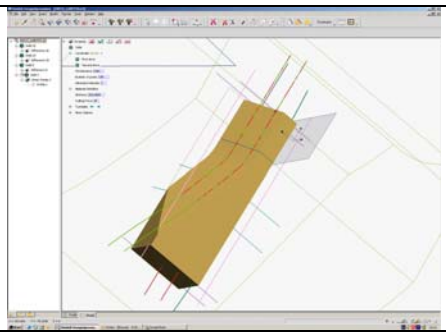
Steps for digital object creation

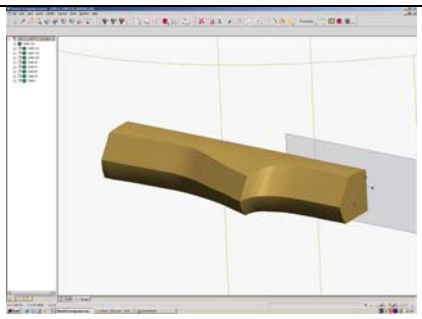
Differently to his colleague, the tester adopted a slightly different strategy by removing first the inner part of the dashboard as the driver's and passenger's front parts and then by defining the shape by operating on external profiles, and finally on the top surface of the dashboard.





Images of model created





Questionnaire results

The tester appreciated the system for being used for activities related to product concept generation. Particularly, he well evaluated the characteristic of the system for supporting both physical and digital modeling, and also the benefits deriving from the two aspects: e.g., having the possibility to receive a force feedback when removing material, and, at the same time, to get good shading and lighting properties, and the possibility to change the tool and obtaining curved profiles. Still, some drawbacks mainly deriving from the incorrect spatial perception of the tool position made the tester complaining about the quality of the achievable surfaces and the obtained result, that, in his opinion, was not comparable at the moment with the one offered by current CAD and CAS technologies.

5.5. Analysis of the testing results

The interviews and the questionnaires provided by the testers have been analyzed in order to highlight which aspects of the T'nD system have been considered as positive and which ones require additional study and development or improvements.

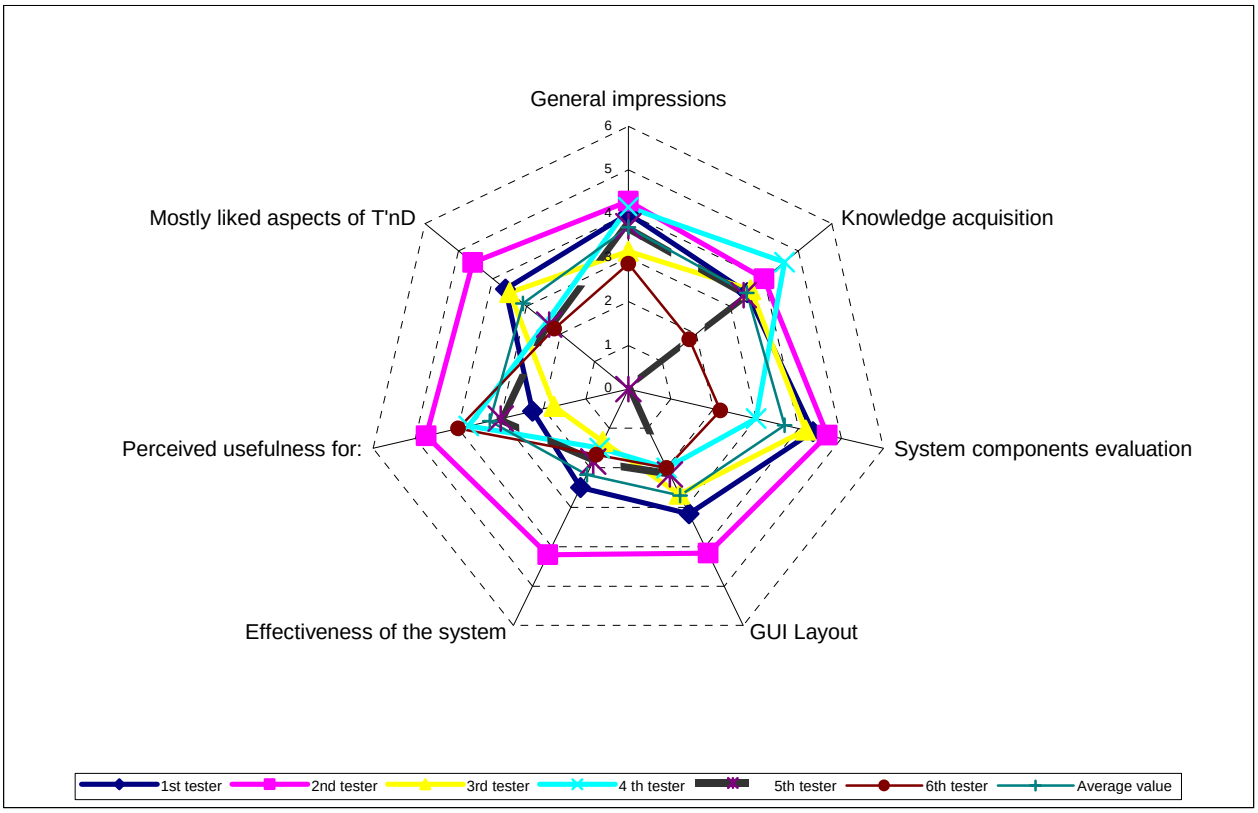
5.5.1. Questionnaire data tabulation

The answers given by the testers to questions included in the questionnaire have been tabulated in some excel tables, where the scores for each question have been reported.

	1st tester Protoscar (16/11)	Scale	2nd tester Sargenti	Scale	3rd Tester Pininfarina 1	Scale	4 th tester Pininfarina 2	Scale	5th tester IVECO	Scale	6th tester IVECO	Scale	Results by group
General impressions													
Did you like the concept?	5	6	6	6	4	6	6	6	5	6	5	6	5,17
Did you like the system?	4	6	4	6	4	6	6	6	4	6	3	6	4,17
If you could, would you use it again?	4	6	6	6	3	6	6	6	4	6	5	6	4,67
Was it easy to use?	5	6	4	6	2	6	1	6	3	6	2	6	2,83
The system layout was coherent?	5	6	4	6	4	6	3	6	3	6	2	6	3,50
How do you rate its effectiveness for concept development?	3	6	4	6	4	6	6	6	5	6	2	6	4,00
How do you rate its effectiveness for detail design?	2	6	2	6	1	6	1	6	2	6	1	6	1,50
Total score	28,00	42,00	30,00	42,00	22,00	42,00	29,00	42,00	26,00	42,00	20,00	42,00	27,25
Average score	4,00	6,00	4,29	6,00	3,14	6,00	4,14	6,00	3,71	6,00	2,86	6,00	3,89
	Yes=1, No=0												
Concept evaluation	60	Y/N											yes per question
Do you have experience in physical modeling?	1		1		1		1		1		1		6/6
The force feedback was coherent?	1		1		1		0		1		0		4/6
TnD is easier to use than physical modeling?	0		0		0		0		0		1		1/6
Precision of movement is better in Physical Modeling?	0		1		1		0		1		0		3/6
Perception of proportions is easier in physical modeling?	0		1		1		0		1		1		4/6
Light shading is better in TnD	1		1		1		N/A		1		1		5/6
Yes per group	3/6		5/6		5/6		1/5		5/6		4/6		14/23
Knowledge acquisition													
How do you judge the total time for modeling?	N/A	N/A	4	6	4	6	4	6	3	6	1	6	3,2
Was it easy to define the first shape?	N/A	N/A	4	6	2	6	6	6	3	6	2	6	3,4
Did you make many mistakes?	N/A	N/A	4	6	5	6	6	6	2	6	1	6	3,6
Did you reach the result you expected?	2	6	2	6	2	6	1	6	4	6	1	6	2
Do you expect the next system release to be easier?	5	6	6	6	6	6	6	6	5	6	4	6	5,5
Total score	7	12	20	30	18	30	23	30	17	30	9	30	17
Average score	3,5	6	4	6	3,6	6	4,6	6	3,4	6	1,8	6	3,48
System components evaluation													
How do you judge the display?	5	6	5	6	6	6	4	6	N/A	6	2	6	4,2
How do you judge the haptic rake?	3	6	5	6	3	6	4	6	N/A	6	3	6	3,6
How do you judge the force display?	5	6	5	6	5	6	1	6	N/A	6	2	6	3,6
How do you judge the working position?	5	6	4	6	5	6	4	6	N/A	6	3	6	4,2
How do you judge the interaction modality?	4	6	4	6	3	6	1	6	N/A	6	1	6	2,6
How do you judge the overall comfort?	4	6	5	6	4	6	4	6	N/A	6	2	6	3,8
Total score	26	36	28	36	26	36	18	36	0	36	13	36	24,25
Average score	4,33	6	4,67	6	4,17	6	3,00	6	0,00	6	2,17	6	3,67
GUI Layout													
How do you judge the user interface?	4	6	4	6	2	6	1	6	3	6	2	6	2,67
How do you judge the visual feedback?	1	6	4	6	3	6	4	6	2	6	2	6	2,67
How do you judge the command prompting feedback?	5	6	4	6	4	6	1	6	2	6	2	6	3,00
How do you judge the navigation into the Virtual environment?	4	6	5	6	2	6	4	6	2	6	2	6	3,17
How do you judge the display of the object while modeling?	1	6	4	6	3	6	1	6	2	6	2	6	2,17
How do you judge the display of the object while checking?	4	6	5	6	2	6	1	6	2	6	2	6	2,50
Total score	19	36	25	36	16	36	12	36	13	36	12	36	18
Average score	3,17	6	4,17	6	2,67	6	2,00	6	2,17	6	2,00	6	2,69
Effectiveness of the system													
Are you satisfied with your result?	2	6	4	6	2	6	1	6	2	6	2	6	2,17
How do you judge the precision in positioning the tool over the object?	3	6	5	6	1	6	1	6	2	6	2	6	2,33
How do you judge the control of the shape?	2	6	N/A	6	2	6	1	6	2	6	2	6	1,80
How do you judge the control of the motion?	3	6	5	6	1	6	1	6	3	6	2	6	2,50
How do you judge the output compared with a CAS/CAD system by time?	3	6	3	6	1	6	4	6	1	6	1	6	2,17
How do you judge the output compared with a CAS/CAD system by quality?	2	6	4	6	1	6	1	6	1	6	1	6	1,67
Total score	15	36	21	36	8	36	9	36	11	36	10	36	13,25
Average score	2,50	6	4,20	6	1,33	6	1,50	6	1,83	6	1,67	6	2,17
Perceived usefulness for:													
Usefulness of the system to develop new concept?	3	6	6	6	2	6	4	6	5	6	6	6	4,33
Produce solid model's from another person's design?	2	6	4	6	2	6	6	6	3	6	4	6	3,50
Comunicate ideas to others?	3	6	6	6	2	6	4	6	3	6	5	6	3,83
Detail concept?	1	6	3	6	1	6	1	6	1	6	1	6	1,33
Total score	9	24	19	24	7	24	15	24	12	24	16	24	12,5
Average score	2,25	6	4,75	6	1,75	6	3,75	6	3,00	6	4,00	6	3,25
T'nD could Integrate/Replace													
2D Drawing tools	N/A		integrate		N/A		N/A		N/A		N/A		n/a
3D CAS tools	N/A		integrate		N/A		N/A		integrate		integrate		half reported integ
3D CAD Surface	N/A		integrate		N/A		N/A		N/A		N/A		n/a
3D CAD Solid	N/A		integrate		N/A		N/A		N/A		integrate		n/a
Hand made prototypes	integrate		integrate		N/A		integrate		N/A		replace		integrate also repla
RP prototypes	integrate		integrate		N/A		integrate		integrate		integrate		integrate RP
result													
Mostly liked aspects of T'nD													
Ease of initial learning	5	6	5	6	5	6	4	6	2	6	2	6	3,83
Ease of use after learning	5	6	5	6	5	6	4	6	3	6	3	6	4,17
Interactivity	5	6	4	6	4	6	4	6	4	6	3	6	4,00
Intuitiveness	5	6	5	6	6	6	1	6	3	6	3	6	3,83
Reliability	1	6	4	6	4	6	4	6	1	6	2	6	2,67
Accuracy		6	3	6	2	6	1	6	1	6	1	6	1,33
Time Saving		6	4	6	0	6	1	6	1	6	1	6	2,00
Quality of shape	2	6	4	6	1	6	1	6	1	6	1	6	1,67
Reuse of results		6	5	6	2	6	1	6	2	6	2	6	2,00
Support for task performance		6	4	6	3	6	3	6	2	6	2	6	2,33
How did you like the force feedback?	3	6	6	6	4	6	4	6	5	6	4	6	4,33
Do you remember how many steps you had to perfrom before scraping?	N/A		N/A		7		6		0		N/A		N/A
Would you define the system closer to PM or DM?	3	6	6	6	1	6	1	6	3		N/A	6	2,8
Total score	29	72	55	72	42	72	29	72	28	66	24	72	38,75
Average score	3,63	6	4,58	6	3,50	6	2,42	6	2,33	5,5	2,18	6	3,11

5.5.2. Chart showing general results

A radar chart has been used to provide and overall presentation of the scores related to each aspect of the T'nD system considered in the questionnaire.

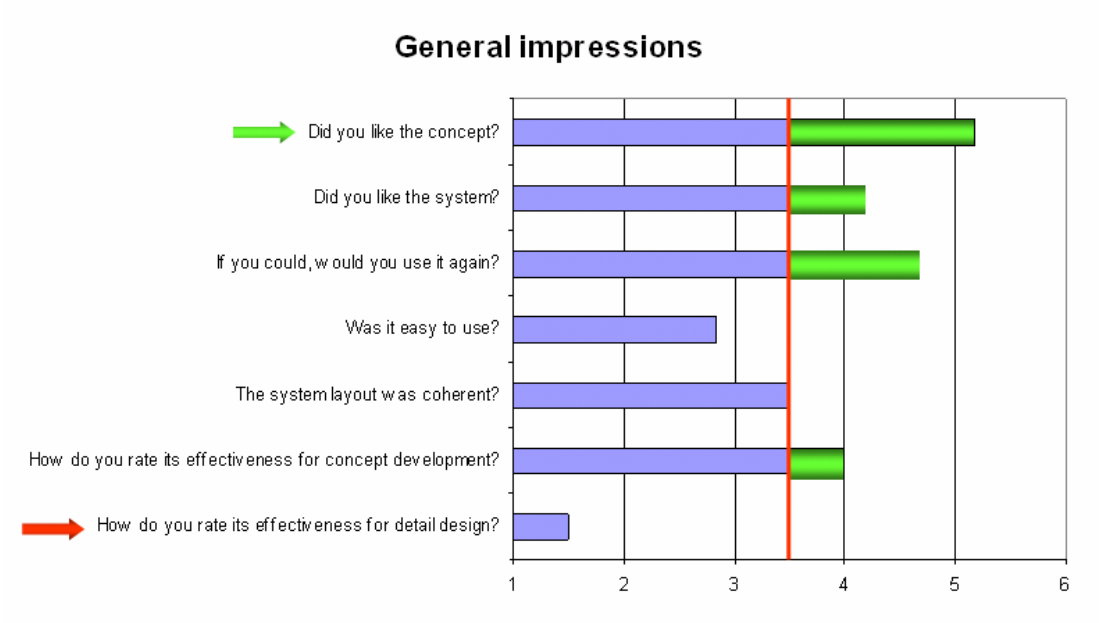


5.5.3. Questionnaire results

In the following results are reported relative to questionnaire's final outcomes, clustered according to the type of questions. In each table, we have indicated with arrows the most positive and the most negative aspect, and we have also highlighted in green those scores that are above the average value.

General impression

The general impression of the Touch and Design system was good. All the testers reported a high level of appreciation of the concept layout and what they could actually test. Specifically, the system achieved a high evaluation rate relatively to the aspects concerning concept generation, which is considered the primarily most important phase in any design activity where the designer has to express his idea. Still, as it has been previously highlighted, some issues in terms of easiness of system and use of the system for detailed design came out. The testers' comments were very valuable in defining where the efforts for increasing T'nD system performances have to be address.

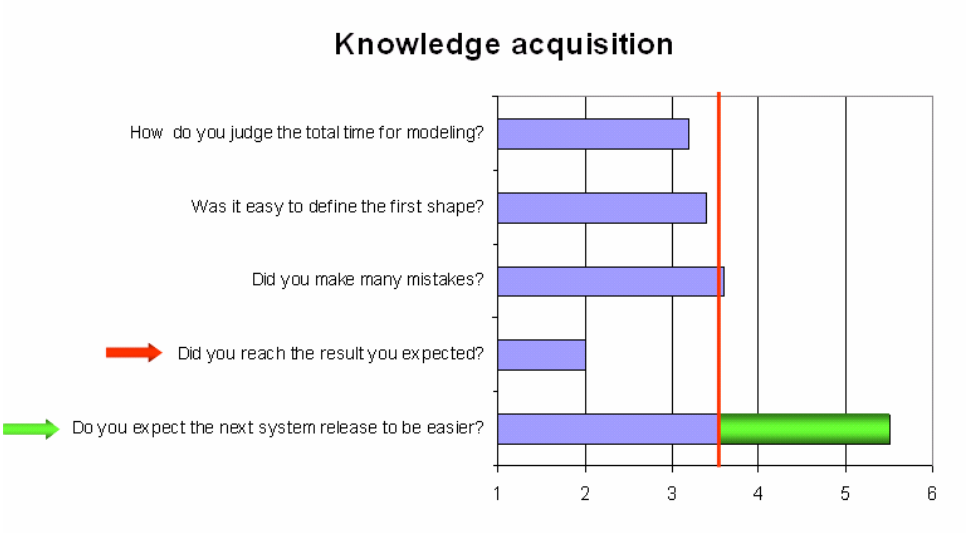


Concept evaluation

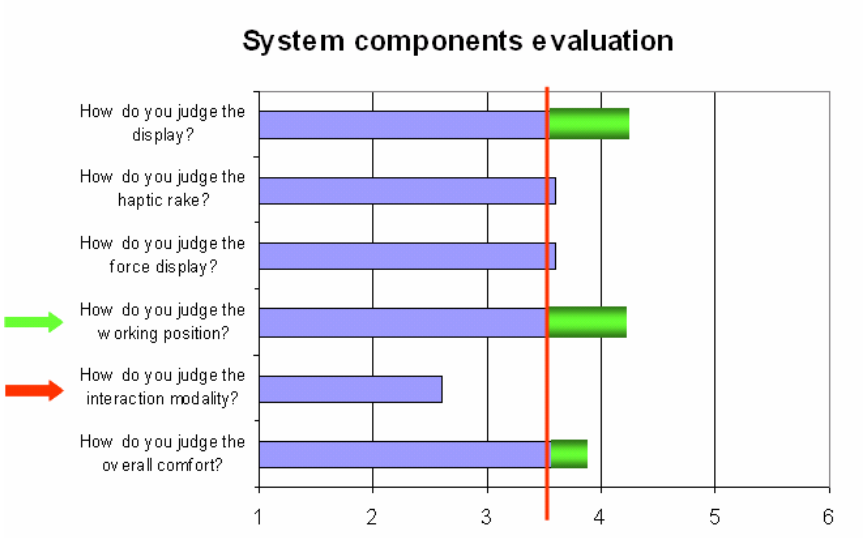
The concept evaluation part of the questionnaire intended to gather some data about specific physical modeling information compared to the use of the T'nD system, and some details about the testers' profile. Specifically, it has resulted that most of the testers had practical experience both in physical modeling and digital modeling and that certainly defined an important filter for what concerns their opinion about T'nD system layout and settings. In fact, *all testers agreed on the fact that the system, by operating a manual-based methodology with a digital model, is able to better display better light shading compared to what happens in physical reality*. Still, it has been reported that the T'nD system is not so easy to use compared to physical modeling, possibly because in terms of forces (with four agreements out of six testers) the system is coherent, but still something is missing for what concerns the navigation and the perception of object proportions.

Knowledge acquisition

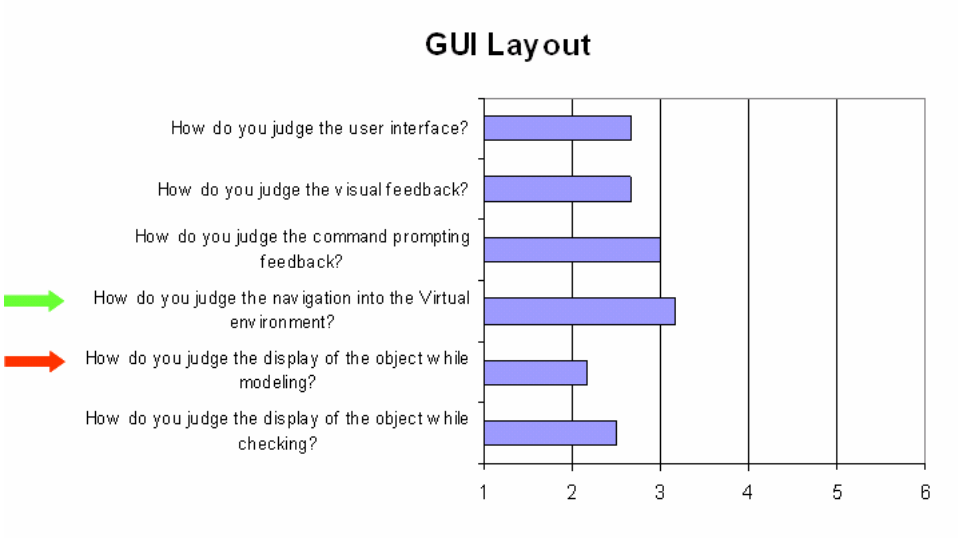
The knowledge acquisition part of the questionnaire intended to go more in detail into the understanding and evaluation of the system by the users' perspective. It has resulted that the testers were complaining about some functionalities of the system related to the aspects inherent to usability and achievement of the intended shape. Still, the results also show that for what concerns the modeling time, testers were not so unsatisfied and they have higher expectations for future system's improvements.



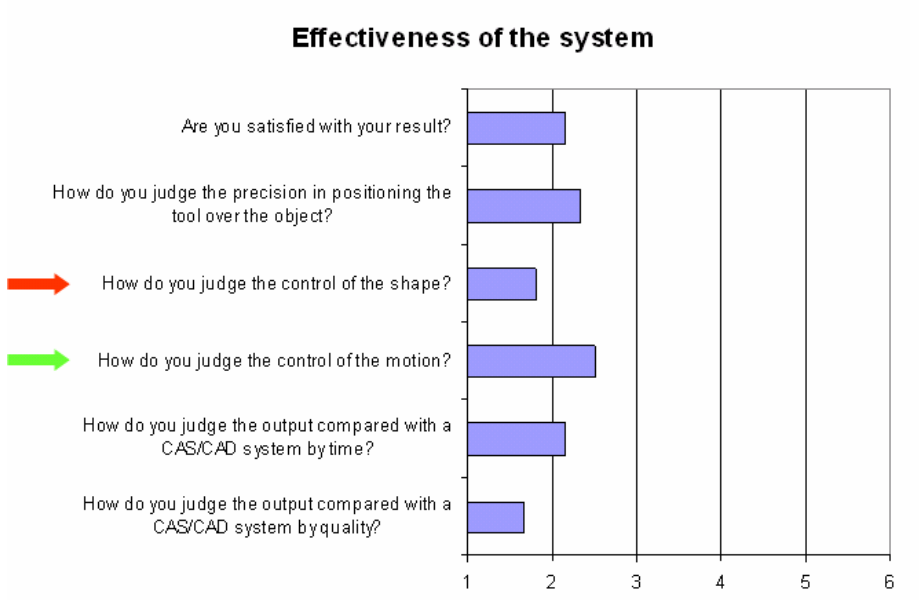
System components evaluation (Functionalities)
In this section we intended to investigate the single component's functionalities and evaluation by the invited testers. As it is possible to observe from the graph below, the tester judged interesting the working position, the display characteristics of the system and the rake layout, both in terms of handling and force release. What becomes evident is the fact that they disliked the interface, specifically for what concerns some interactions like zoom or pan that required the use of the mouse to be correctly performed. By the way, the provision of an appropriate interface for the use of these functionalities was out of the scope of the T'nD system. These results highlight that the general layout and system's architecture of the T'nD was coherent and performing.



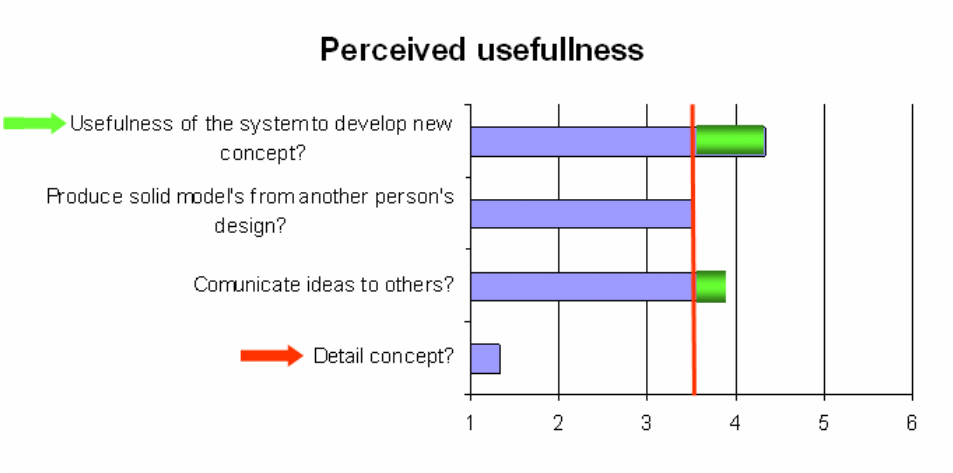
GUI layout (Functionalities)
In this section of the questionnaire we intended to gather some data relative to the graphical user interface layout and impressions of the testers. Testers assessed the good quality in terms of navigation into the virtual environment and, specifically, the aspects related to commands and parameters feedback. Still, some shortcomings relative to the object display in the scene are evident by the low level of appreciation by the testers, particularly for what concerns the object display while modeling or performing some checking operations. This result is also coherent with the judgment of the interface in general terms where the achieved value is slightly below the average.



Effectiveness of the system (Goal achievements)
In this section we wanted to gather some results relatively to the perceived effectiveness of the system in visualizing tester's concept. As it is possible to observe, testers were not quite satisfied with the system, specifically for what concerns the achievement of the result and the control of the shape. Nonetheless the system was not judged as being "not precise" because it requires some adaptation to its functionalities and some longer training furthermore they disliked the aspects inherent to the control of the motion. Still, it has resulted that in no cases the system could be affirmed to be better than a CAD/CAS application in terms of quality of model and overall time necessary to create a shape.

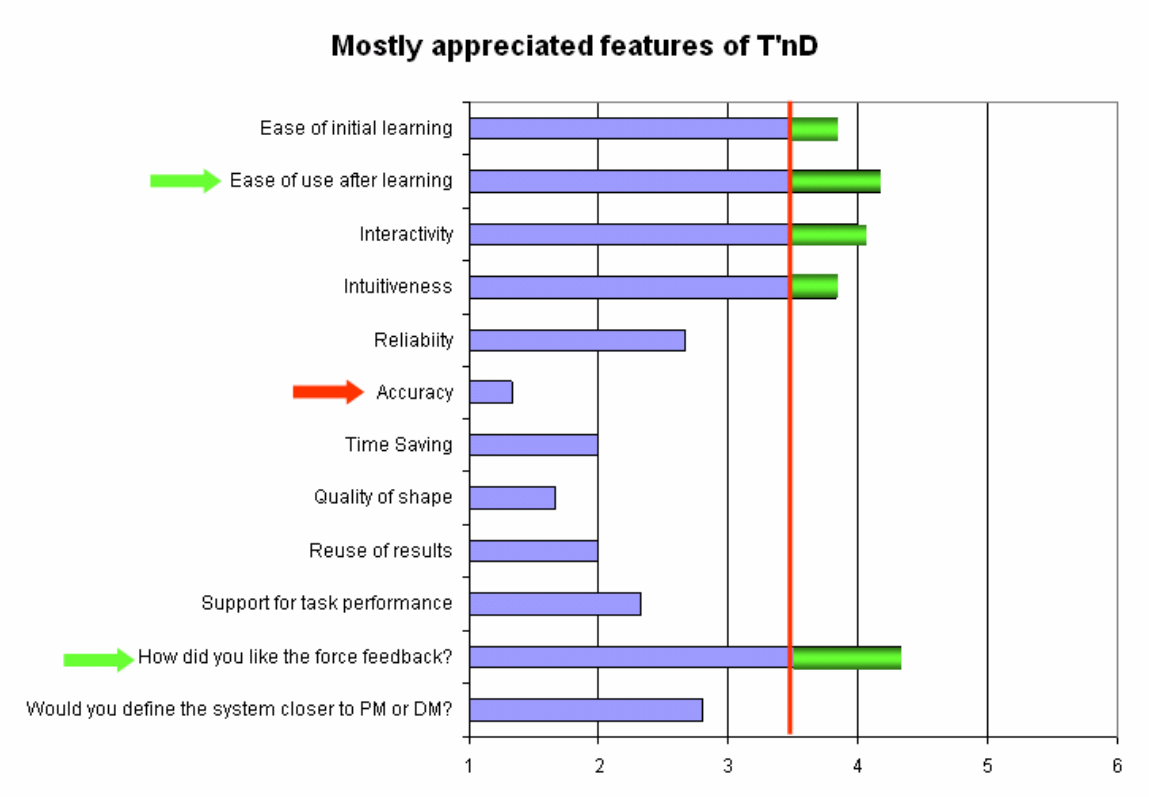


Usefulness of the system
The T'nD system has been defined, as we have seen in the first section, as a good device for concept generation because of its intrinsic ability in defining in a fast and intuitive way basic or even more complex shapes and therefore enabling the communication of the concept to other people. Clearly the testing results highlight that the system is perceived as being not specifically oriented to more detailed design or to define someone else's design.



Mostly appreciated features of T'nD

In the final section of the questionnaire we intended to ask to the testers in a direct way which was the aspects they mostly liked. The force feedback and the aspects related to the ease of use and intuitiveness, as we have seen in the previous sections, were the mostly appreciated feature of the T'nD system. This result clearly highlights the generation of a correct system layout and the study of physics-based interactions reliable in terms of realism, even for clay experts end users. In fact most of the testers perceived the system as being something hybrid, but in any case closer to physical modeling modality than to the digital one. Still, some aspects resulted not so effective to the eyes of final testers, specifically for those aspects concerning finer interaction and system's stability that leads to the definition of more refined and accurate shapes and consequently reduce the performing time and the possibility of reusing results at a higher level.



Sanding tool

For what concerns the evaluation of the sanding tool, the users reported that the force feedback provided by the device was good. The evaluation of the modification control was quite difficult to appreciate, mainly because the kind of modification was rather small, and because the modification was not applied during the operation, but instead at the end of the user's action. Anyway, it was appreciated that at the end of the modification action the overall quality of the modified surface is guaranteed and maintained.

5.5.4. Suggestions for system improvement

The following two main suggestions for system improvement have come out from the testing sessions:

- Adding a system based on pedal to manage object orientation functions (zoom, pan, …)
- Having a more flexible rake so that by pulling the corners the tool can automatically change the curvature of the virtual tool

These suggestions for system's improvement are intrinsically interesting, specifically because they highlight the fact that the testers have perceived in a good way the potentialities deriving from the implementation of typical VR technologies within a modelling system and they were expecting this virtual interface to be more complete and, consequently, more capable for substituting the current interaction modalities based on mouse and keyboard. Furthermore, these suggestions are also coming from a practical point of view because of the necessity, for what concerns pan and zoom operations, to stop moving the rake, holding it in one hand and then proceeding in orienting the object by the use of the other hand. Still, the implementation possibility is not that immediate, besides the easily accomplishable technical reasons, because of the fact that for defining a performing 3D interface, accurate studies and testing activities must be performed.

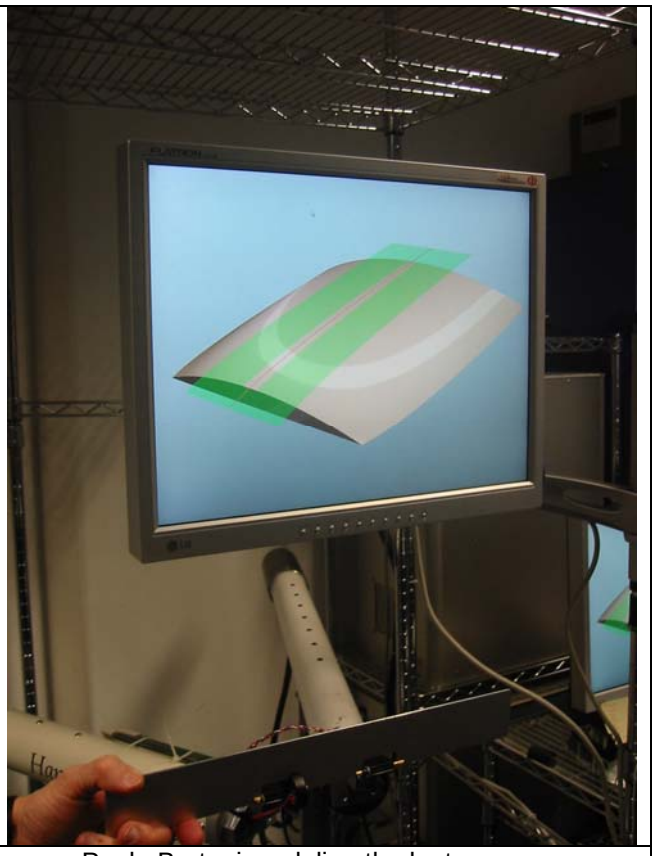
Testers have also provided a second interesting interaction suggestion, implementing a physical tool that can actively change the curvature of the virtual tool by curving the metal plate with both hands. This technique is deriving from clay modelling praxis and is certainly interesting to consider for future implementation.

Furthermore, an extremely important issue, as recorded in almost all testing sessions, refers to the visual output of the system that needs some improvements to better define the position of the virtual tool in the space. Not necessarily it has to be accomplished by acting on the parallax (the misalignment between hands and eyes), but on providing a stereoscopic view.

6. Additional show case

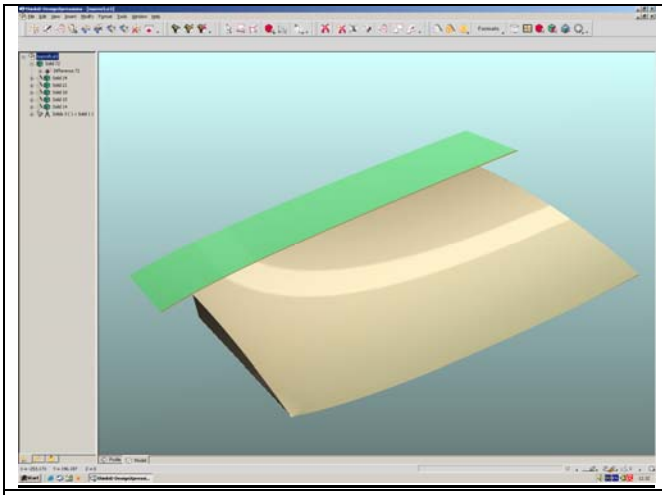
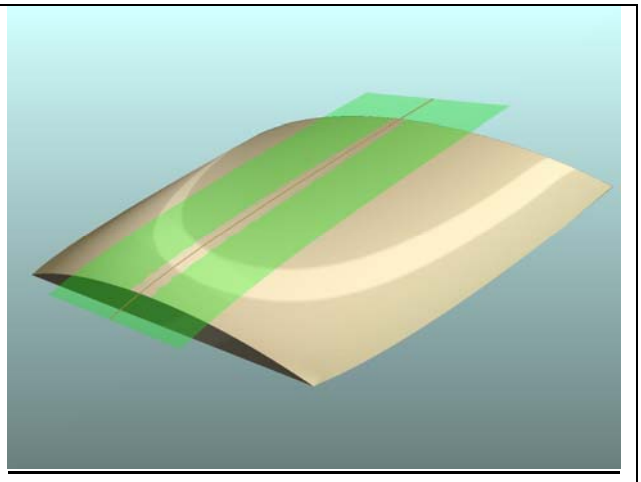
The results we obtained from the testing sessions performed in WP7 by students from Politecnico di Milano and Universitat de Girona were useful in order to have some feedback about the system functionalities and their impression about the system. The tests were very well designed and organized by PsyCLE. The analysis of the testing results showed that the system has high potentiality but it has still some interaction and usability problems that need to be addressed.
We were aware of the fact that the students had not enough experience in hand made modelling as well as in mastering the think3 modelling tool. Therefore, the partners decided to make an effort for solving some problems detected during the test and have an external user to test the system again. We agreed on the fact that the tester had to be the ideal user of the T'nD system: a modeller skilled in modelling hand made prototypes, and also a skilled user of thinkdesign. Thus, we identified in Paolo Bertoni the ideal T'nD system user. He is holding 15 years experience in car design; he is capable of making hand made physical prototypes and is an expert user of surface modelling and in particular of thinkdesign. He visited PoliMi on February 7th 2007, and worked on a full day with the T'nD system. We asked him to spend the morning for practicing with the system. In the afternoon we asked him to model two objects that were already been modelled during the use cases: the laptop cover and a dashboard of a truck.

Paolo Bertoni, February 7th 2007

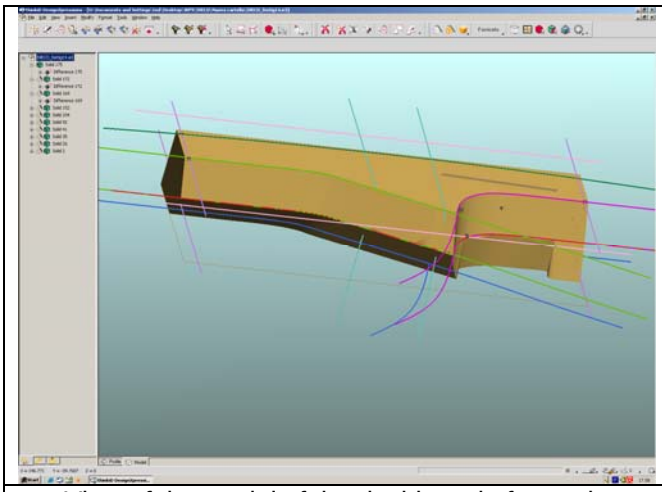
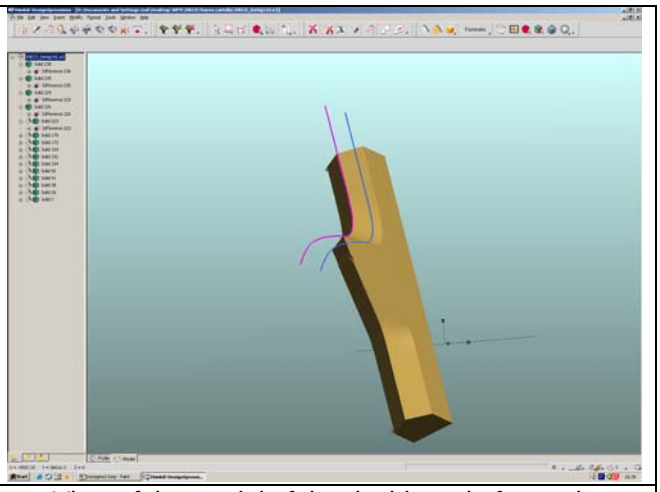


Paolo Bertoni modeling the laptop cover.

He was able to quickly make a very good surface. Using the G1 modelling modality and a curved rake that he designed he created the surface showed in the following pictures with just one scraping action. The curved rake was created having in mind the kind of highlight that was a target for him. The image on the left hand side shows the created model: the highlight demonstrates the high quality of the surface. The image on the right hand side shows the whole laptop cover created using the mirroring command; it is possible to notice the quality of the overall surface having continuity along the mirroring line.

	
Model of the laptop cover: half model.	Complete laptop cover created using the mirroring command.

He created also a dashboard of a truck that was created starting from the same curves used by users 5 and 6. As it is possible to appreciate in the following pictures, the quality of the created model is good, despite the fact that the initial basic curves are not of very good quality.

	
View of the model of the dashboard of a truck.	View of the model of the dashboard of a truck.

At the end of the testing sessions he was really very pleased with the system. He expressed his conviction that a novel user of the system, but expert modeller and designer as he is, requires one or maximum two days training for getting acquainted with the system and its working modality. He stated that the system offers very few and effective commands, and this makes particularly easy to start playing with the system as compared with CAD systems commands. He was delighted by the fact that with T'nD one does not really work but rather play with the tool, and this is another way of working that is very much appreciable and enjoyable.

At the end of the testing session we asked Paolo Bertoni to fill in the same questionnaire we have proposed to students in the testing sessions run in WP7 and to provide some suggestions for improving the system, and to highlight the aspects of the system that he likes and those he does not like and that we need to address in the future system releases.
Paolo Bertoni's suggestions are the following:

- You should consider setting a standard working position and rotate the object and the path curves like CATIA with metaphoric mouse sphere on top right.
- In order to improve the use of the sequence of functions → rotate → evaluate → stop rotation mode → go back working, it might be useful to add one button on the rake, or add

a trackball-based Bluetooth mouse to the model for moving and turning [this hypothesis requires to be validated].
- Connect the view rotation command to the turntable so that when rotating the model the tool is rotated as well.
- Add a button on the rake for applying the resulting scraping action performed.
- Regarding the sanding tool, you should consider adding a skin which is flexible and rigid enough not to feel the underlying mechanical connection of the "spider".
- See the shadow of the tool in the environment to get depth cues (this hypothesis requires to be validated).

Paolo Bertoni pointed out the following very positive aspects of the system that can make the excellence of the system:
- Moving around to get all views and to better understand the shape.
- Great force feedback and realism.

Besides, the system has some good consolidated features:
- Rotation → turntable is good for starting with the project outline and having right angles.
- To have both full view for maximal external shape and detail view for refinements.

Paolo Bertoni's identified non positive aspects of the system are the following:
- Object not linked to the tool because it is very difficult to control.
- Not correct to link the shape to the tool, the consequent mistake was view changing instead of rotation.
- Starting point (first area of contact between the rake and the block) is difficult to manage because of excessive dumping.
- Difficulties in controlling the relative positioning of the object with the tool and the scene.

7. Discussion about the results

In general the six testers reported a strong appreciation of the concept proposed by the T'nD system and the intrinsic possibilities of such technology. In this sense it has resulted that the system has been well conceived since all characteristics related to ease of use and intuitiveness of the system layout were judged extremely positive, as well as all characteristics related to system components.

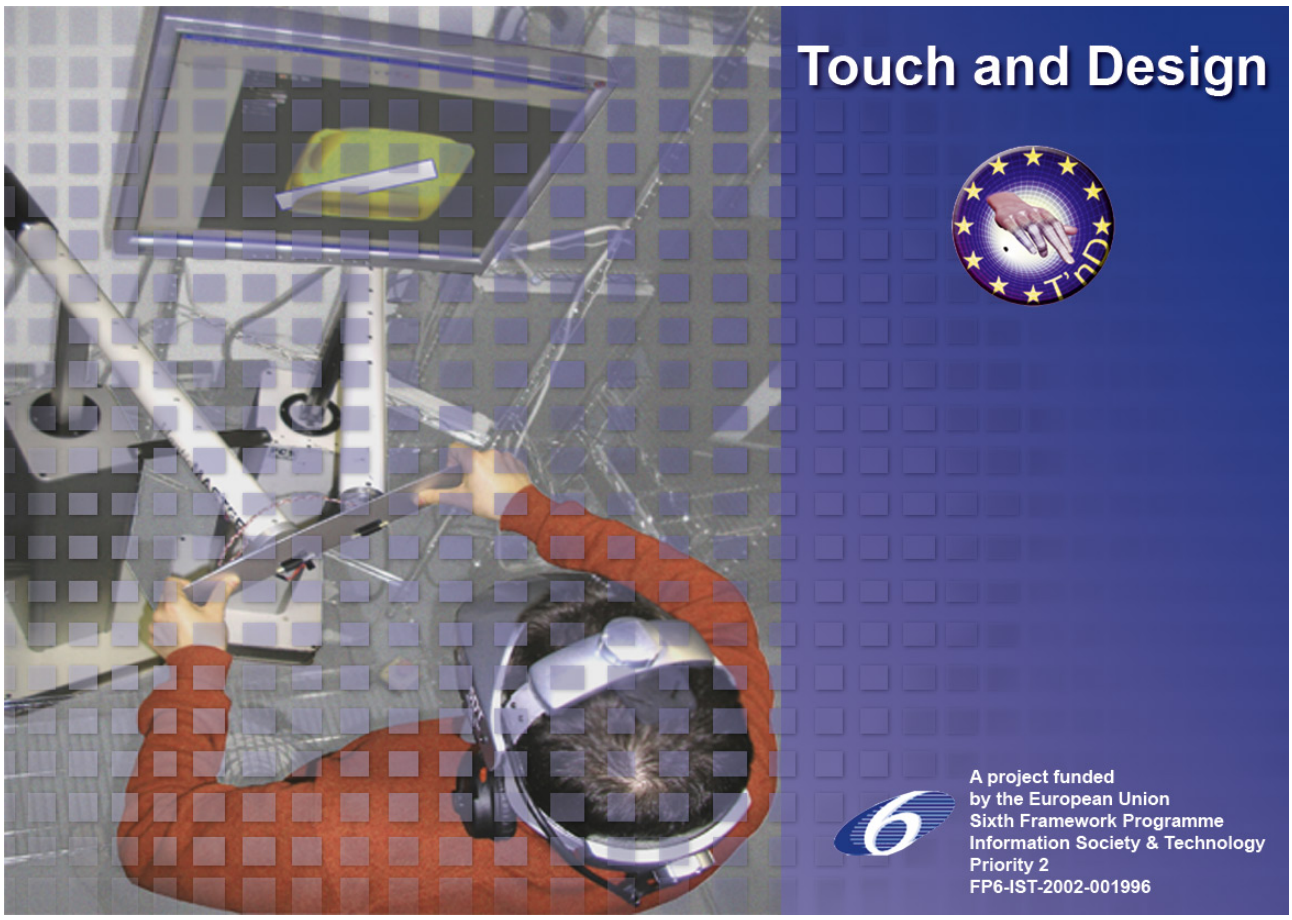
Some strong issues relative to the user interface and the stability of the haptic system was persistent. These problems heavily compromised the perception of the system relatively to its quality and potentialities. In fact none of the testers have actually been able to achieve the expected result and the obtained shape was not as accurate and qualitatively as good as they might have expected. If we observe the gathered data from the questionnaire and the video recording we can also notice that concerning the GUI one of the lowest score was relative to the display of the object and tool positioning. In fact the testers, thanks to light shading and perspective parameters, had a good three dimensional viewing, but still not sufficient to perceive the complexity of spatial depth and therefore to define a mental connection between the position of their arms in the physical space and the virtual one. During the testing sessions it occurred several times that the tester, while trying to retrieve the position of the virtual rake, was accidentally touching the surface removing a small undesired slice of material of the surface he was working on. Furthermore, the system during the testing session was not very stable and the tester wished the system, even if still in the prototypal phase, to be more reliable. It should be underlined the importance that the mathematic of the driving curves requires to be of good quality in order to get at the end a good quality class-A surface. Indeed, a pure visual evaluation of the results is not enough for evaluating the quality of the obtained surface.

Contrary to our expectations the tester defined the system interesting for developing new concept (that can be interpreted as silent dialogue in the designer's mind) but not to communicate ideas to others and to disseminate one's idea. The force feedback, assessed as being excellent during the initial testing of the system, gathered a medium value that means that it can still be improved. During the interviews it has resulted that the forces displayed and the holding of the rake were good, but the damping of the tool when touching the object was quite annoying and was leading to imprecise movements due to the necessity to contrast the deriving movement of the rake against the block of clay.

In none of the cases the T'nD system was interpreted as a substitution of classical CAS/CAD tools, but it was mainly considered as integration to these tools. Specifically, the comparison considering time was slightly higher in terms of results than by output quality.

Concluding the general impressions about the system provided by the limited but meaningful number of testers was quite good and some improvements in terms of user interface and interaction have been suggested as necessary in order to obtain a completely coherent and well performing system.

Appendix 1



Introduzione

Il progetto Touch and Design è un progetto di Ricerca finanziato dall'Unione Europea che vede coinvolti partner provenienti dal mondo accademico e industriale.

Nel corrente contesto di sviluppo di prodotti industriali il processo di digitalizzazione sta assumendo un ruolo strategico e fondamentale per garantire tempi di sviluppo sempre più ridotti. Tuttavia questa tendenza porta con sè diversi aspetti negativi: i designer non sono soddisfatti dell'attuale livello di interazione con il computer e dall'altro lato i modellisti hanno un ruolo sempre più marginale nel processo con la diretta conseguenza di perdita di preziosa esperienza nonchè conoscenza pratica e manuale

Il sistema T'nD

Il progetto T'nD, giunto al terzo ed ultimo anno di attività intende affrontare queste tematiche proponendo un nuovo sistema di modellazione virtuale basato sulla metodologia di modellazione fisica della plastilina.

L'utente ha a disposizione una spatola simile a quelle utilizzate per la modellazione della plastilina a sua volta connessa con due sistemi haptic in grado di restituire un feedback di forze consistente con quanto avviene nel mondo reale.
L'utente può rimuovere materiale da un blocco iniziale di plastiilina virtuale definendo una geometria precisa basata su NURBS, e quindi compatibile con le successive fasi di sviluppo prodotto.

Introduction

The Touch and Design project is financially supported by the European Union and is jointly developed by academic and industrial partners.

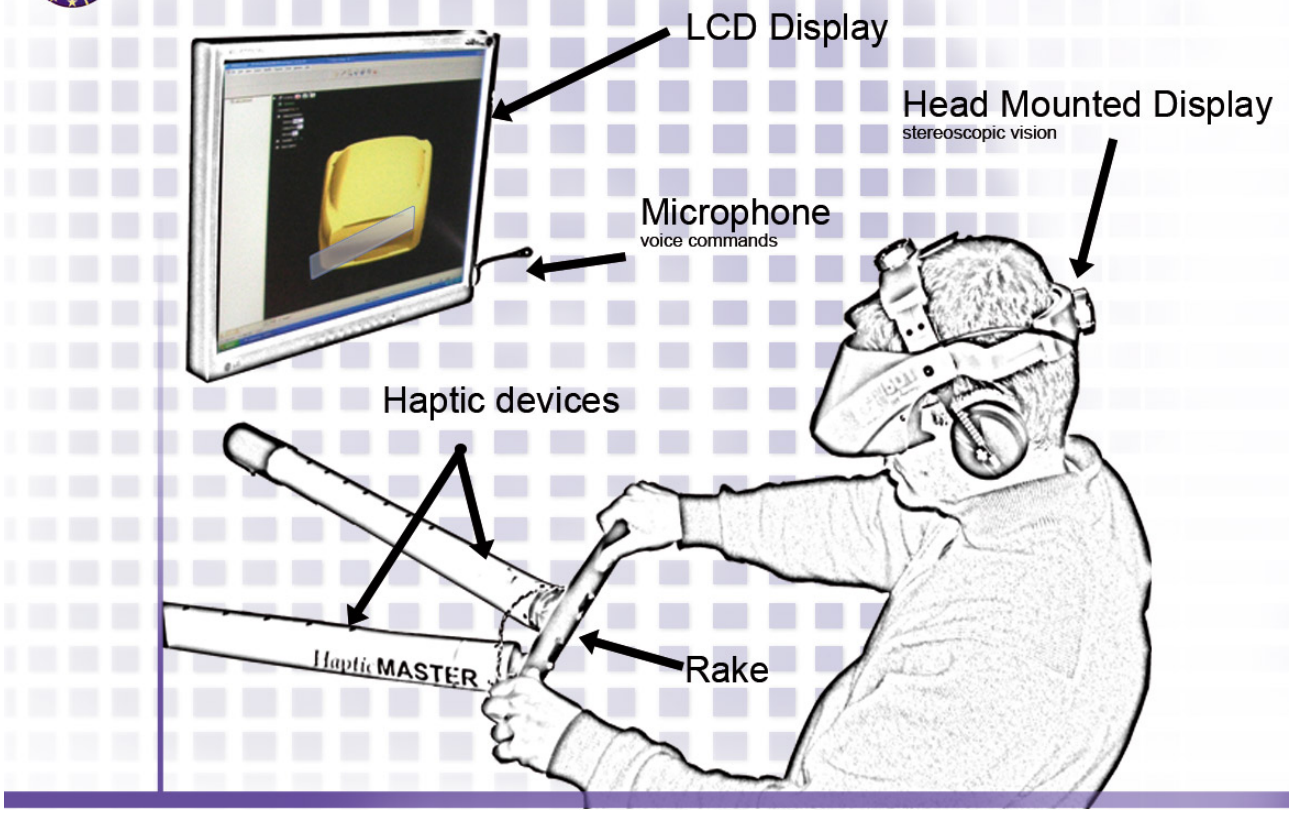
In the current product development context, the digitalization of the process is becoming an increasingly strategic issue, necessary to allow the compression of development time. Though, in this situation, some aspects result controversial: on one side designers are dissatisfied by current interaction level with the computer, on the other we are assisting at a dismiss of the modelers within the process with the inherent lost in terms of human competencies, extremely precious for the whole system.

The T'nD system

The T'nD project is now at its third and final year of development and its aim intends to deal with the previously illustrated concerns by proposing a novel virtual modeling system based on physical clay modeling methodology.

The user can use a rake, similar to the one used for modeling physical clay, connected with towo haptic devices able to provide a force fedback comparable with the one of the real world.
In the virtual environment, once defined the first contact with the virtual clay, the user can start to model it in an intuitive way defining a NURBS based geometry, compatible with the subsequent development phases.

Architettura del sistema / system architecture



T'nD testing

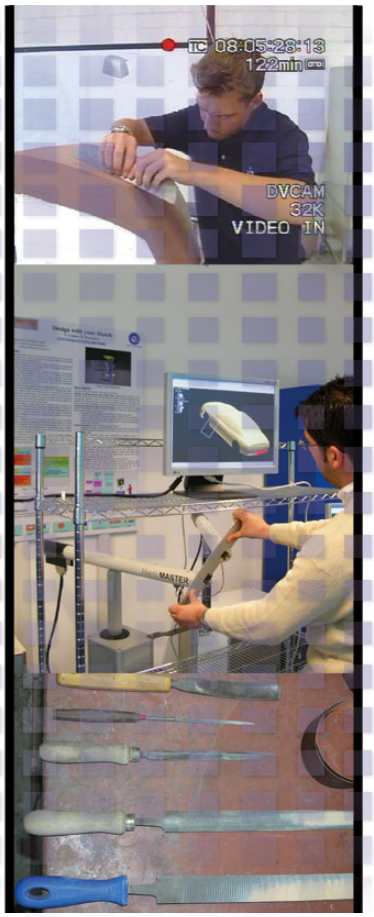
Il progetto T'nD è entrato nella fase finale di validazione ed è possibile presentarlo a persone esterne al progetto al fine di ottenere impressioni riguardanti le sua funzionalità. Questo sistema rappresenta uno dei sistemi ancora in fase di studio a livello europeo in grado di proporre un nuovo metodo di interazione con il CAD.

Un gruppo selezionato di utenti è invitato venire a provare liberamente il sistema e modellare le forme più attinenti al proprio campo di progettazione.

Il testing avrà la durata di circa 2 ore in cui dovrete compilare un primo questionario per identificare il vostro profilo, quindi un test di circa un'ora (a vostra scelta) in cui verrete monitorati con riprese video, e un questionario conclusivo al fine di ottenere delle valutazioni qualitative al riguardo e possibilmente anche alcuni suggerimenti per migliorare il sistema.

Tutti i vostri dati e le riprese video non saranno diffusi a terzi al di fuori dei partner di progetto e verranno utilizzati solo per redigere dcumenti di ricerca in maniera del tutto anonima.

Il sistema T'nD si trova presso il Politecnico di Milano, Dipartimento di Meccanica presso il campus Milano - Bovisa.



T'nD testing

The T'nD project is now in the final validation phase and is open to be presented to people external to the consortium in order to gather objective data and comments about its functionalities. This system represents a prototype of possible future interaction modalities and modeling methodologies in the CAD environment.

A selected group of testers is invited to freely test the system and try to model the shapes typical their specific design field.

The test will last aproximately 2 hours and you will have to complete a first questionnaire to identify your profile, then to follow you will be able to model a shape that you most like directly with the T'nD system for one hour (you will be video monitored) and finally a closing questionnaire to provide some qualitative feedbacks and possibly even some tips to improve the sytem.

All your data and video recording will not be diffused to any person external to the T'nD consortium and they will be used just for research purposes without any explicit refer to your testing session.

In order to grant your privacy, each partecipant will be invited privately and you will not meet any other external tester.

The T'nD system is located at Politecnico di Milano, Department of Mechanical Engineering, campus Milano Bovisa.

Vi ringraziamo per la Vostra cortese attenzione, augurandoci di vedervi presto a Milano per testare il sistema T'nD, rimaniamo a Vostra completa disposizione per eventuali chiarimenti.

We thank you for your kind attention, remaining at your full disposal for any clarification, we hope to see you soon in Milan.

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dott. Umberto Giraudo
umberto.giraudo@polimi.it

Appendix 2

User identification: _____

Please answer to these questions after performing the T'nD system evaluation testing.

1. First impressions

1.1 General impressions

	☹	😐	☺
Did you like the concept?	☐	☐	☐
Did you like it?	☐	☐	☐
If you could, would you use it again?	☐	☐	☐
Was it easy to use?	☐	☐	☐
The system layout was coherent?	☐	☐	☐
How do you rate its effectiveness for concept development?	☐	☐	☐
How do you rate its effectiveness for detail design?	☐	☐	☐

2. Knowledge acquisition

2.1 Learning curve

	☹	😐	☺
How do you judge the total time for modelling?	☐	☐	☐
Was it easy to define the first shape?	☐	☐	☐
Did you make many mistakes?	☐	☐	☐
Did you reach what you expected?	☐	☐	☐
Do you think that the next time will be easier to make the same model?	☐	☐	☐

3. Functionalities

3.1 System components evaluation

	☹	😐	☺
How do you judge the display?	☐	☐	☐
How do you judge the rake?	☐	☐	☐
How do you judge the force display?	☐	☐	☐
How do you judge the working position?	☐	☐	☐
How do you judge the interaction modality?	☐	☐	☐
How do you judge the overall comfort?	☐	☐	☐

3.2 GUI Layout

	☹	😐	☺
How do you judge user interface?	☐	☐	☐
How do you judge the visual feedback?	☐	☐	☐
How do you judge the command prompting			

feedback? ☐☐☐☐☐☐

How do you judge the navigation into the Virtual environment? ☐☐☐☐☐☐

How do you judge the display of the object while modelling? ☐☐☐☐☐☐

How do you judge the display of the object while checking? ☐☐☐☐☐☐

4. Goal achievement

4.1 Efficacy

	☹	😐	☺
Are you satisfied with your result?	☐	☐	☐
How do you judge the precision in positioning the tool over the object?	☐	☐	☐
How do you judge the control of the shape?	☐	☐	☐
How do you judge the control of the motion?	☐	☐	☐
How do you judge the output compared with a CAD/CAS system by time?	☐	☐	☐
How do you judge the output compared with a CAD/CAS system by quality?	☐	☐	☐

4.2 Evaluate the effectiveness of the T'nD for:

	☹	😐	☺
Develop new concepts	☐	☐	☐
Produce physical models from others' ideas	☐	☐	☐
Communicate ideas to others	☐	☐	☐
Detail concepts	☐	☐	☐

4.3 Do you hypothesize that the T'nD system could integrate/replace:

	integrate	replace	NA
2D Drawing tools	☐	☐	☐
3D CAS tools	☐	☐	☐
3D CAD surface	☐	☐	☐
3D CAD solid	☐	☐	☐
Multimodel (physics based)	☐	☐	☐
Hand-made prototypes	☐	☐	☐
RP prototypes	☐	☐	☐
Other	_____		

4.4 Evaluate the following aspects of the T'nD you mostly liked:

	☹ ☹ ☺	N.A.
Ease of initial learning	☐☐☐☐☐☐	☐
Ease of use after learning	☐☐☐☐☐☐	☐
Interactivity	☐☐☐☐☐☐	☐
Intuitiveness	☐☐☐☐☐☐	☐
Reliability	☐☐☐☐☐☐	☐
Precision	☐☐☐☐☐☐	☐
Time saving	☐☐☐☐☐☐	☐
Quality of shape	☐☐☐☐☐☐	☐
Reuse of results	☐☐☐☐☐☐	☐
Support for task performance	☐☐☐☐☐☐	☐
How did you like force feedback?	☐☐☐☐☐☐	☐
Do you remember how many tasks you had to perform before actually starting scraping?	____	☐
Would you define the system closer to physical modelling or digital modelling?	☐☐☐☐☐☐	
	physical digital	

5. Open questions

5.1 Was there any special feature that you liked or defined interesting?

5.2 Was there any feature you didn't like?

5.3 Did you have any particular problem at the beginning for learning and understanding how to use it?

5.4 How do you find it compared to the current CAD/CAS system you use?

5.5 Do you have any suggestion for improving the system?

Appendix 3

Questionnaire – User 1 (date: 16.11.2006)

1. First impressions

1.1 General impressions

	☹	😐	☺
Did you like the concept?	☐	☐	☒
Did you like the system?	☐	☒	☐
If you could, would you use it again?	☐	☒	☐
Was it easy to use?	☒	☐	☒
The system layout was coherent?	☐	☐	☒
How do you rate its effectiveness for concept development?	☐	☒	☐
How do you rate its effectiveness for detail design?	☒	☐	☐

2. Knowledge acquisition

2.1 Learning curve

	☹	😐	☺
How do you judge the total time for modelling?	☐	☐	☐
Was it easy to define the first shape?	☐	☐	☐
Did you make many mistakes?	☐	☐	☐
Did you reach what you expected?	☒	☐	☐
Do you think that the next time will be easier to make the same model?	☐	☐	☒

3. Functionalities

3.1 System components evaluation

	☹	😐	☺
How do you judge the display?	☐	☐	☒
How do you judge the rake?	☐	☒	☐
How do you judge the force display?	☐	☐	☒
How do you judge the working position?	☐	☐	☒
How do you judge the interaction modality?	☐	☒	☐
How do you judge the overall comfort?	☐	☒	☐

3.2 GUI Layout

	☹	😐	☺
How do you judge user interface?	☐	☒	☐
How do you judge the visual feedback?	☒	☐	☐
How do you judge the command prompting			

feedback?	☐☐☐☐☒☐
How do you judge the navigation into the Virtual environment?	☐☐☐☒☐☐
How do you judge the display of the object while modelling?	☒☐☐☐☐☐
How do you judge the display of the object while checking?	☐☐☐☒☐☐

4. Goal achievement

4.1 Efficacy

	☹ ☐	😐 ☐	☺ ☐
Are you satisfied with your result?	☐	☒	☐☐☐
How do you judge the precision in positioning the tool over the object?	☐	☐	☒☐☐☐
How do you judge the control of the shape?	☐	☒	☐☐☐☐
How do you judge the control of the motion?	☐	☐	☒☐☐☐
How do you judge the output compared with a CAD/CAS system by time?	☐	☐	☒☐☐☐
How do you judge the output compared with a CAD/CAS system by quality?	☐	☒	☐☐☐☐

4.2 Evaluate the effectiveness of the T'nD for:

	☹ ☐	😐 ☐	☺ ☐
Develop new concepts	☐	☐	☒☐☐
Produce physical models from others' ideas	☐	☒	☐☐☐☐
Communicate ideas to others	☐	☐	☒☐☐☐
Detail concepts	☒	☐	☐☐☐☐

4.3 Do you hypothesize that the T'nD system could integrate/replace:

	integrate	replace	NA
2D Drawing tools	☐	☐	☒
3D CAS tools	☐	☐	☒
3D CAD surface	☐	☐	☒
3D CAD solid	☐	☐	☒
Multimodel (physics based)	☐	☐	☒
Hand-made prototypes	☒	☐	☐
RP prototypes	☒	☐	☐
Other	_____		

4.4 Evaluate the following aspects of the T'nD you mostly liked:

	☹	😐	☺	N.A.
Ease of initial learning	☐	☐	☒	☐
Ease of use after learning	☐	☐	☒	☐
Interactivity	☐	☐	☒	☐
Intuitiveness	☐	☐	☒	☐
Reliability	☒	☐	☐	☐
Precision	☐	☐	☐	☒
Time saving	☐	☐	☐	☒
Quality of shape	☐	☒	☐	☐
Reuse of results	☐	☐	☐	☒
Support for task performance	☐	☐	☐	☒

How did you like force feedback?	☐	☒	☐	☐

Do you remember how many tasks you had to perform before actually starting scraping? _____ ☒

Would you define the system closer to physical modelling or digital modelling?	☐	☒	☐	☐
	physical		digital	

5. Open questions

5.1 Was there any special feature that you liked or defined interesting?

I personally find interesting the general concept. The connection between physical and virtual is well thought.

5.3 Was there any feature you didn't like?

The stability of the system was not good

5.3 Did you have any particular problem at the beginning for learning and understanding how to use it?

N/A

5.6 How do you find it compared to the current CAD/CAS system you use?

It is still to be developed in terms of precision of the shapes

5.7 Do you have any suggestion for improving the system?

N/A

Questionnaire – User 2 (date: 23.11.2006)

1. First impressions

1.1 General impressions

	☹	😐	☺
Did you like the concept?	☐	☐	☒
Did you like the system?	☐	☒	☐
If you could, would you use it again?	☐	☐	☒
Was it easy to use?	☐	☒	☐
The system layout was coherent?	☐	☒	☐
How do you rate its effectiveness for concept development?	☐	☒	☐
How do you rate its effectiveness For detail design?	☒	☐	☐

2. Knowledge acquisition

2.1 Learning curve

	☹	😐	☺
How do you judge the total time for modelling?	☐	☒	☐
Was it easy to define the first shape?	☐	☒	☐
Did you make many mistakes?	☐	☒	☐
Did you reach what you expected?	☒	☐	☐
Do you think that the next time will be easier to make the same model?	☐	☐	☒

3. Functionalities

3.1 System components evaluation

	☹	😐	☺
How do you judge the display?	☐	☒	☐
How do you judge the rake?	☐	☒	☐
How do you judge the force display?	☐	☒	☐
How do you judge the working position?	☐	☒	☐
How do you judge the interaction modality?	☐	☒	☐
How do you judge the overall comfort?	☐	☒	☐

3.2 GUI Layout

	☹	😐	☺
How do you judge user interface?	☐	☒	☐
How do you judge the visual feedback?	☐	☒	☐
How do you judge the command prompting feedback?	☐	☒	☐

How do you judge the navigation into the Virtual environment? ☐☐☐☐☒☐

How do you judge the display of the object while modelling? ☐☐☐☒☐☐

How do you judge the display of the object while checking? ☐☐☐☒☐☐

4. Goal achievement

4.1 Efficacy

	☹	😐	☺
Are you satisfied with your result?	☐	☐	☐☒☐☐
How do you judge the precision in positioning the tool over the object?	☐	☐	☐☐☐☒☐
How do you judge the control of the shape?	☐	☐	☐☐☐☐☐☐
How do you judge the control of the motion?	☐	☐	☐☐☐☐☒☐
How do you judge the output compared with a CAD/CAS system by time?	☐	☐	☒☐☐☐
How do you judge the output compared with a CAD/CAS system by quality?	☐	☐	☐☐☐☒☐☐

4.2 Evaluate the effectiveness of the T'nD for:

	☹	😐	☺
Develop new concepts	☐	☐	☐☐☐☐☒
Produce physical models from others' ideas	☐	☐	☐☐☐☒☐☐
Communicate ideas to others	☐	☐	☐☐☐☐☒
Detail concepts	☐	☐	☒☐☐☐

4.3 Do you hypothesize that the T'nD system could integrate/replace:

	integrate	replace	NA
2D Drawing tools	☒	☐	☐
3D CAS tools	☒	☐	☐
3D CAD surface	☒	☐	☐
3D CAD solid	☒	☐	☐
Multimodel (physics based)	☒	☐	☐
Hand-made prototypes	☒	☐	☐
RP prototypes	☒	☐	☐
Other	_____		

4.4 Evaluate the following aspects of the T'nD you mostly liked:

	☹	😐	☺	N.A.
Ease of initial learning	☐	☐	☒	☐
Ease of use after learning	☐	☐	☒	☐
Interactivity	☐	☒	☐	☐
Intuitiveness	☐	☐	☒	☐
Reliability	☐	☒	☐	☐
Precision	☒	☐	☐	☐
Time saving	☐	☒	☐	☐
Quality of shape	☐	☒	☐	☐
Reuse of results	☐	☐	☒	☐
Support for task performance	☐	☒	☐	☐

How did you like force feedback?	☐	☐	☐	☐	☐	☒	☐

Do you remember how many tasks you had to perform before actually starting scraping? _____ ☒

Would you define the system closer to physical modelling or digital modelling?

☐	☐	☐	☐	☐	☒
physical					digital

5. Open questions

5.1 Was there any special feature that you liked or defined interesting?

- *Adapting of stiffness*
- *Defining the tools*
- *Defining spline GO*

Was there anything annoying in the use of the system?
It didn't work most of the time.
Tool and projection of tool were in completely different places

5.2 Was there any feature you didn't like?

The visual feedback while modelling is slow and not always accurate.

5.3 Did you have any particular problem at the beginning for learning and understanding how to use it?

It was difficult to understand the placement of the tool in the space.

5.4 How do you find it compared to the current CAD/CAS system you use?

It saves time in the concept process compared with the CAD system that I am using. It helps you to visualize really fast the shapes you want to design.

5.5 Do you have any suggestion for improving the system?

- *Work on the visual feedback while modelling*

- *Work on the precision of the motion over the object*
- *Work on the positioning of the tool in virtual environment*

Questionnaire – User 3 (date: 6.12.2006)

1. First impressions

1.1 General impressions

	☹	😐	☺
Did you like the concept?	☐	☐	☒
Did you like the system?	☐	☐	☒
If you could, would you use it again?	☐	☒	☐
Was it easy to use?	☒	☐	☐
The system layout was coherent?	☐	☐	☒
How do you rate its effectiveness for concept development?	☐	☐	☒
How do you rate its effectiveness For detail design?	☒	☐	☐

2. Knowledge acquisition

2.1 Learning curve

	☹	😐	☺
How do you judge the total time for modelling?	☐	☐	☒
Was it easy to define the first shape?	☒	☐	☐
Did you make many mistakes?	☐	☐	☒
Did you reach what you expected?	☒	☐	☐
Do you think that the next time will be easier to make the same model?	☐	☐	☒

3. Functionalities

3.1 System components evaluation

	☹	😐	☺
How do you judge the display?	☐	☐	☒
How do you judge the rake?	☐	☒	☐
How do you judge the force display?	☐	☐	☒
How do you judge the working position?	☐	☐	☒
How do you judge the interaction modality?	☐	☒	☐
How do you judge the overall comfort?	☐	☐	☒

3.2 GUI Layout

	☹	😐	☺
How do you judge user interface?	☒	☐	☐
How do you judge the visual feedback?	☐	☒	☐
How do you judge the command prompting feedback?	☐	☐	☒
How do you judge the navigation into			

the Virtual environment?	☐☒☐☐☐☐
How do you judge the display of the object while modelling?	☐☐☒☐☐☐
How do you judge the display of the object while checking?	☐☒☐☐☐☐

4 Goal achievement

4.1 Efficacy

	☹ ☐	😐 ☐	☺ ☐
Are you satisfied with your result?	☐	☒	☐☐☐☐
How do you judge the precision in positioning the tool over the object?	☒	☐	☐☐☐☐
How do you judge the control of the shape?	☐	☒	☐☐☐☐
How do you judge the control of the motion?	☒	☐	☐☐☐☐
How do you judge the output compared with a CAD/CAS system by time?	☒	☐	☐☐☐☐
How do you judge the output compared with a CAD/CAS system by quality?	☒	☐	☐☐☐☐

4.2 Evaluate the effectiveness of the T'nD for:

	☹ ☐	😐 ☐	☺ ☐
Develop new concepts	☐	☒	☐☐☐☐
Produce physical models from others' ideas	☐	☒	☐☐☐☐
Communicate ideas to others	☐	☒	☐☐☐☐
Detail concepts	☒	☐	☐☐☐☐

4.3 Do you hypothesize that the T'nD system could integrate/replace:

	integrate	replace	NA
2D Drawing tools	☐	☐	☒
3D CAS tools	☐	☐	☒
3D CAD surface	☐	☐	☒
3D CAD solid	☐	☐	☒
Multimodel (physics based)	☐	☐	☒
Hand-made prototypes	☐	☐	☒
RP prototypes	☐	☐	☒
Other	_____		

4.4 Evaluate the following aspects of the T'nD you mostly liked:

	☹	😐	☺	N.A.
Ease of initial learning	☐	☐	☒	☐
Ease of use after learning	☐	☐	☒	☐
Interactivity	☐	☒	☐	☐
Intuitiveness	☐	☐	☒	☐
Reliability	☐	☒	☐	☐
Precision	☒	☐	☐	☐
Time saving	☐	☐	☒	☐
Quality of shape	☒	☐	☐	☐
Reuse of results	☒	☐	☐	☐
Support for task performance	☐	☒	☐	☐
How did you like force feedback?	☐	☒	☐	☐

Do you remember how many tasks you had to perform before actually starting scraping? ___7 ☐

Would you define the system closer to physical modelling or digital modelling?

☒ ☐ ☐ ☐ ☐ ☐

physical digital

5. Open questions

5.1 Was there any special feature that you liked or defined interesting?

-

5.2 Was there any feature you didn't like?

The fact that it was impossible to perceive the depth, and it was difficult to find the references for positioning the tool.

5.3 Did you have any particular problem at the beginning for learning and understanding how to use it?

No.

5.4 How do you find it compared to the current CAD/CAS system you use?

It is possible to compare T'nD only with CAD tools which use digital operators:

5.5 Do you have any suggestion for improving the system?

It would be interesting the introduction of the solid adding function. Only material removing functionality is rather limiting.

Questionnaire – User 4 (date: 6.12.2006)

1. First impressions

1.2 General impressions

	☹	😐	☺
Did you like the concept?	☐	☐	☒
Did you like the system?	☐	☐	☒
If you could, would you use it again?	☐	☐	☒
Was it easy to use?	☒	☐	☐
The system layout was coherent?	☐	☒	☐
How do you rate its effectiveness for concept development?	☐	☐	☒
How do you rate its effectiveness For detail design?	☒	☐	☐

2. Knowledge acquisition

2.1 Learning curve

	☹	😐	☺
How do you judge the total time for modelling?	☐	☒	☐
Was it easy to define the first shape?	☐	☐	☒
Did you make many mistakes?	☐	☐	☒
Did you reach what you expected?	☒	☐	☐
Do you think that the next time will Be easier to make the same model?	☐	☐	☒

3. Functionalities

3.1 System components evaluation

	☹	😐	☺
How do you judge the display?	☐	☒	☐
How do you judge the rake?	☐	☒	☐
How do you judge the force display?	☒	☐	☐
How do you judge the working position?	☐	☒	☐
How do you judge the interaction modality?	☒	☐	☐
How do you judge the overall comfort?	☐	☒	☐

3.2 GUI Layout

	☹	😐	☺
How do you judge user interface?	☒	☐	☐
How do you judge the visual feedback?	☐	☒	☐
How do you judge the command prompting feedback?	☒	☐	☐

How do you judge the navigation into the Virtual environment? ☐☐☐☒☐☐

How do you judge the display of the object while modelling? ☒☐☐☐☐☐

How do you judge the display of the object while checking? ☒☐☐☐☐☐

4 Goal achievement

4.1 Efficacy

	☹	😐	☺
Are you satisfied with your result?	☒	☐	☐☐☐☐
How do you judge the precision in positioning the tool over the object?	☒	☐	☐☐☐☐
How do you judge the control of the shape?	☒	☐	☐☐☐☐
How do you judge the control of the motion?	☒	☐	☐☐☐☐
How do you judge the output compared with a CAD/CAS system by time?	☐	☐	☐☒☐☐
How do you judge the output compared with a CAD/CAS system by quality?	☒	☐	☐☐☐☐

4.2 Evaluate the effectiveness of the T'nD for:

	☹	😐	☺
Develop new concepts	☐	☐	☐☒☐☐
Produce physical models from others' ideas	☐	☐	☐☐☐☐☒
Communicate ideas to others	☐	☐	☐☐☒☐☐
Detail concepts	☒	☐	☐☐☐☐☐

4.3 Do you hypothesize that the T'nD system could integrate/replace:

	integrate	replace	NA
2D Drawing tools	☐	☐	☒
3D CAS tools	☐	☐	☒
3D CAD surface	☐	☐	☒
3D CAD solid	☐	☐	☒
Multimodel (physics based)	☐	☐	☒
Hand-made prototypes	☒	☐	☐
RP prototypes	☒	☐	☐
Other	_____		

4.4 Evaluate the following aspects of the T'nD you mostly liked:

	☹	😐	☺	N.A.
Ease of initial learning	☐	☐	☒	☐
Ease of use after learning	☐	☐	☒	☐
Interactivity	☐	☐	☒	☐
Intuitiveness	☒	☐	☐	☐
Reliability	☐	☐	☒	☐
Precision	☒	☐	☐	☐
Time saving	☒	☐	☐	☐
Quality of shape	☒	☐	☐	☐
Reuse of results	☒	☐	☐	☐
Support for task performance	☐	☒	☐	☐
How did you like force feedback?	☐	☐	☒	☐
Do you remember how many tasks you had to perform before actually starting scraping?		6		☐

Would you define the system closer to physical modelling or digital modelling?

☒ ☐ ☐ ☐ ☐ ☐

physical digital

5. Open questions

5.1 Was there any special feature that you liked or defined interesting?

I really liked the use of the tool in order to create shapes.

5.2 Was there any feature you didn't like?

There was a chaotic way of manage the shape regarding with the sights and the movements. It was impossible to skim the shape without "cutting" it.

5.3 Did you have any particular problem at the beginning for learning and understanding how to use it?

I only used the scraping tool, but after two times you use it, it become very intuitive. It lacks some window of dialogues to create a selection of overlapping elements.

5.4 How do you find it compared to the current CAD/CAS system you use?

I don't think it would be possible to use it now.

5.5 Do you have any suggestion for improving the system?

Questionnaire – User 5 (date: 12.01.2007)

1. First impressions

1.1 General impressions

	☹	😐	☺
Did you like the concept?	☐	☐	☒
Did you like the system?	☐	☒	☐
If you could, would you use it again?	☐	☐	☒
Was it easy to use?	☐	☒	☐
The system layout was coherent?	☐	☒	☐
How do you rate its effectiveness for concept development?	☐	☒	☐
How do you rate its effectiveness For detail design?	☒	☐	☐

2. Knowledge acquisition

2.1 Learning curve

	☹	😐	☺
How do you judge the total time for modelling?	☐	☐	☐
Was it easy to define the first shape?	☐	☐	☐
Did you make many mistakes?	☐	☐	☐
Did you reach what you expected?	☐	☐	☐
Do you think that the next time will Be easier to make the same model?	☐	☐	☐

3. Functionalities

3.1 System components evaluation

	☹	😐	☺
How do you judge the display?	☐	☐	☐
How do you judge the rake?	☐	☐	☐
How do you judge the force display?	☐	☐	☐
How do you judge the working position?	☐	☐	☐
How do you judge the interaction modality?	☐	☐	☐
How do you judge the overall comfort?	☐	☐	☐

3.2 GUI Layout

	☹	😐	☺
How do you judge user interface?	☐	☒	☐
How do you judge the visual feedback?	☐	☒	☐
How do you judge the command prompting feedback?	☐	☒	☐

How do you judge the navigation into the Virtual environment? ☐☒☐☐☐☐

How do you judge the display of the object while modelling? ☐☒☐☐☐☐

How do you judge the display of the object while checking? ☐☒☐☐☐☐

4. Goal achievement

4.1 Efficacy

	☹	😐	☺
Are you satisfied with your result?	☐☒☐☐☐☐		
How do you judge the precision in positioning the tool over the object?	☐☒☐☐☐☐		
How do you judge the control of the shape?	☐☒☐☐☐☐		
How do you judge the control of the motion?	☐☒☐☐☐☐		
How do you judge the output compared with a CAD/CAS system by time?	☒☐☐☐☐☐		
How do you judge the output compared with a CAD/CAS system by quality?	☒☐☐☐☐☐		

4.2 Evaluate the effectiveness of the T'nD for:

	☹	😐	☺
Develop new concepts	☐☐☐☐☒☐		
Produce physical models from others' ideas	☐☒☐☐☐☐		
Communicate ideas to others	☐☐☒☐☐☐		
Detail concepts	☒☐☐☐☐☐		

4.3 Do you hypothesize that the T'nD system could integrate/replace:

	integrate	replace	NA
2D Drawing tools	☐	☐	☒
3D CAS tools	☒	☐	☐
3D CAD surface	☐	☐	☒
3D CAD solid	☒	☐	☐
Multimodel (physics based)	☐	☐	☐
Hand-made prototypes	☐	☒	☐
RP prototypes	☒	☐	☐
Other	_____		

4.4 Evaluate the following aspects of the T'nD you mostly liked:

	☹	😐	☺	N.A.
Ease of initial learning		☒		☐
Ease of use after learning			☒	☐
Interactivity			☒	☐
Intuitiveness		☒		☐
Reliability	☒			☐
Precision	☒			☐
Time saving	☒			☐
Quality of shape		☒		☐
Reuse of results		☒		☐
Support for task performance		☒		☐
How did you like force feedback?			☒	☐
Do you remember how many tasks you had to perform before actually starting scraping?		8		☐
Would you define the system closer to physical modelling or digital modelling?		☒		
	physical		digital	

5. Open questions

5.1 Was there any special feature that you liked or defined interesting?

The possibility of changing tools and of using curves in the space to lead the hands works.

5.2 Was there any feature you didn't like?

-

5.3 Did you have any particular problem at the beginning for learning and understanding how to use it?

Yes, I had some troubles to understand what I was doing and where I was operating in the space.

5.4 How do you find it compared to the current CAD/CAS system you use?

It is completely different and you cannot compare them.

5.5 Do you have any suggestion for improving the system?

Improve the feedback and the control, and the system stability as well.

Questionnaire – User 6 (date: 12.01.2007)

1. First impressions

1.1 General impressions

	☹	😐	☺
Did you like the concept?	☐	☐	☒
Did you like the system?	☐	☒	☐
If you could, would you use it again?	☐	☒	☐
Was it easy to use?	☐	☒	☐
The system layout was coherent?	☐	☒	☐
How do you rate its effectiveness for concept development?	☐	☐	☒
How do you rate its effectiveness For detail design?	☒	☐	☐

2. Knowledge acquisition

2.1 Learning curve

	☹	😐	☺
How do you judge the total time for modelling?	☒	☐	☐
Was it easy to define the first shape?	☐	☒	☐
Did you make many mistakes?	☒	☐	☐
Did you reach what you expected?	☒	☐	☐
Do you think that the next time will Be easier to make the same model?	☐	☐	☒

3. Functionalities

3.1 System components evaluation

	☹	😐	☺
How do you judge the display?	☐	☒	☐
How do you judge the rake?	☐	☐	☒
How do you judge the force display?	☐	☒	☐
How do you judge the working position?	☐	☐	☒
How do you judge the interaction modality?	☒	☐	☐
How do you judge the overall comfort?	☐	☒	☐

3.2 GUI Layout

	☹	😐	☺
How do you judge user interface?	☐	☐	☒
How do you judge the visual feedback?	☐	☒	☐
How do you judge the command prompting feedback?	☐	☒	☐
How do you judge the navigation into			

the Virtual environment?	☐☒☐☐☐☐
How do you judge the display of the object while modelling?	☐☒☐☐☐☐
How do you judge the display of the object while checking?	☐☒☐☐☐☐

4 Goal achievement

4.1 Efficacy

	☹ ☐	😐 ☐	☺ ☐
Are you satisfied with your result?	☐	☒	☐☐☐
How do you judge the precision in positioning the tool over the object?	☐	☒	☐☐☐
How do you judge the control of the shape?	☐	☒	☐☐☐
How do you judge the control of the motion?	☐	☐	☒☐☐☐
How do you judge the output compared with a CAD/CAS system by time?	☒	☐	☐☐☐☐
How do you judge the output compared with a CAD/CAS system by quality?	☒	☐	☐☐☐☐

4.2 Evaluate the effectiveness of the T'nD for:

	☹ ☐	😐 ☐	☺ ☐
Develop new concepts	☐	☐	☒☐☐
Produce physical models from others' ideas	☐	☒	☐☐☐
Communicate ideas to others	☐	☒	☐☐☐
Detail concepts	☒	☐	☐☐☐☐

4.3 Do you hypothesize that the T'nD system could integrate/replace:

	integrate	replace	NA
2D Drawing tools	☐	☐	☒
3D CAS tools	☒	☐	☐
3D CAD surface	☐	☐	☒
3D CAD solid	☐	☐	☒
Multimodel (physics based)	☐	☐	☒
Hand-made prototypes	☒	☐	☐
RP prototypes	☒	☐	☐
Other	_____		

4.4 Evaluate the following aspects of the T'nD you mostly liked:

	☹	😐	☺	N.A.
Ease of initial learning		☒		☐
Ease of use after learning			☒	☐
Interactivity			☒	☐
Intuitiveness			☒	☐
Reliability	☒			☐
Precision	☒			☐
Time saving	☒			☐
Quality of shape	☒			☐
Reuse of results		☒		☐
Support for task performance		☒		☐
How did you like force feedback?			☒	☐
Do you remember how many tasks you had to perform before actually starting scraping?		____		☒
Would you define the system closer to physical modelling or digital modelling?	physical		digital	

5. Open questions

5.1 Was there any special feature that you liked or defined interesting?

I think that the concept itself is very interesting, but the real state of the art is quite low.

5.2 Was there any feature you didn't like?

One has to work with the hands, but must look into the monitor (no direct visual feedback is provided)

5.3 Did you have any particular problem at the beginning for learning and understanding how to use it?

The lack of feedback makes the modelling operation very imprecise. You cannot understand where you are (position in the modelling space).

5.4 How do you find it compared to the current CAD/CAS system you use?

I think that at the moment CAS is better integrated into the design development process.

5.5 Do you have any suggestion for improving the system?

You can use the T'nD and a virtual reality system together.