

Project logo



FP6 logo



Project no. TST5-CT2006-031548

SECURCRANE

**Design of an innovative system for the drive and control
of port cranes for safe remote operation**

Instrument: STREP

Thematic Priority: 1.6.2 – Sustainable Surface Transport

Publishable Final Activity Report

**Period covered: Full Project Duration
(from 01/05/2006 to 30/09/2009)**

Date of preparation: 30/12/2009

Start date of project: 01/05/2006

Duration: 41 months

Project coordinator name: Andrea DERITO

Project coordinator organisation name: SCIROIDEA S.p.A.

Revision: [Rev2]



Publishable Final Activity Report

Covering the full project duration (M0-M41)

From 01/05/2006 to 30/09/2009

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* PU = Public; PP = Restricted to other Programme participants (including EC); RE = Restricted to a group specified by the Consortium (including EC); CO = Confidential, only for members of the Consortium (including EC).

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REVISION

Revision 2

Final release.

Revision 1

First update.

Revision 0 (first issue)

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1. EXECUTIVE SUMMARY

This Publishable Final Activity Report is submitted after the Fourth (and last) Project Year and it comprises the following sections:

- **Project execution**, containing a summary description of project objectives, contractors involved, work performed and end results. This section briefly describes the methodologies and approaches employed and relates the achievements of the project to the state-of-the-art. It explains the impact of the project on its industry or research sector. It includes some photos illustrating the prototype achieved at the end of the project, the project logo and a reference to the project website.
- **Dissemination and use**, presenting the publishable results of the project.

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2. ABBREVIATIONS & ACRONYMS

ACRONYM	MEANING
ASM	Anti-Sway Module
CEO	Chief Executive Officer
CMM	Cargo Monitoring Module
EC	European Commission
HW	HardWare
IPR	Intellectual Property Right(s)
RCM	Remote Control Module
RMG	Rail-Mounted Gantry (crane)
RTG	Rubber-Tyred Gantry (crane)
SIOC	SECURCRANE INTEREST OPERATORS CLUB
SW	Software
WP	Work Package

Table 1: List of abbreviations and acronyms

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3. PROJECT EXECUTION

3.1 INTRODUCTION

SECURCRANE Project focused on port cranes to increase safety and working conditions, as well as overall performance, of human operators, reducing the gap between theoretical and real productivity (lifts/hour) of cranes. The core problem of crane productivity is the current drivers' working conditions inducing loss of efficiency of the human operator due to his stressing working conditions inside the cabin on top of the crane. SECURCRANE realised a **remote crane control**, possible now thanks to **innovative 3D vision and anti-sway** devices, safeguarding for the operator all information physically "sensed" by the body and seen by the eyes in his actual position on top of the crane: thus, a 3D TV image may supply the driver standing in a remote site with the same information and functions of crane cabin seat. Retrieval of additional information on handled containers done by the **Cargo Monitoring Module** completes SECURCRANE functions. SECURCRANE allows Terminal Operators to capitalise on their crane drivers' skill with limited investments.

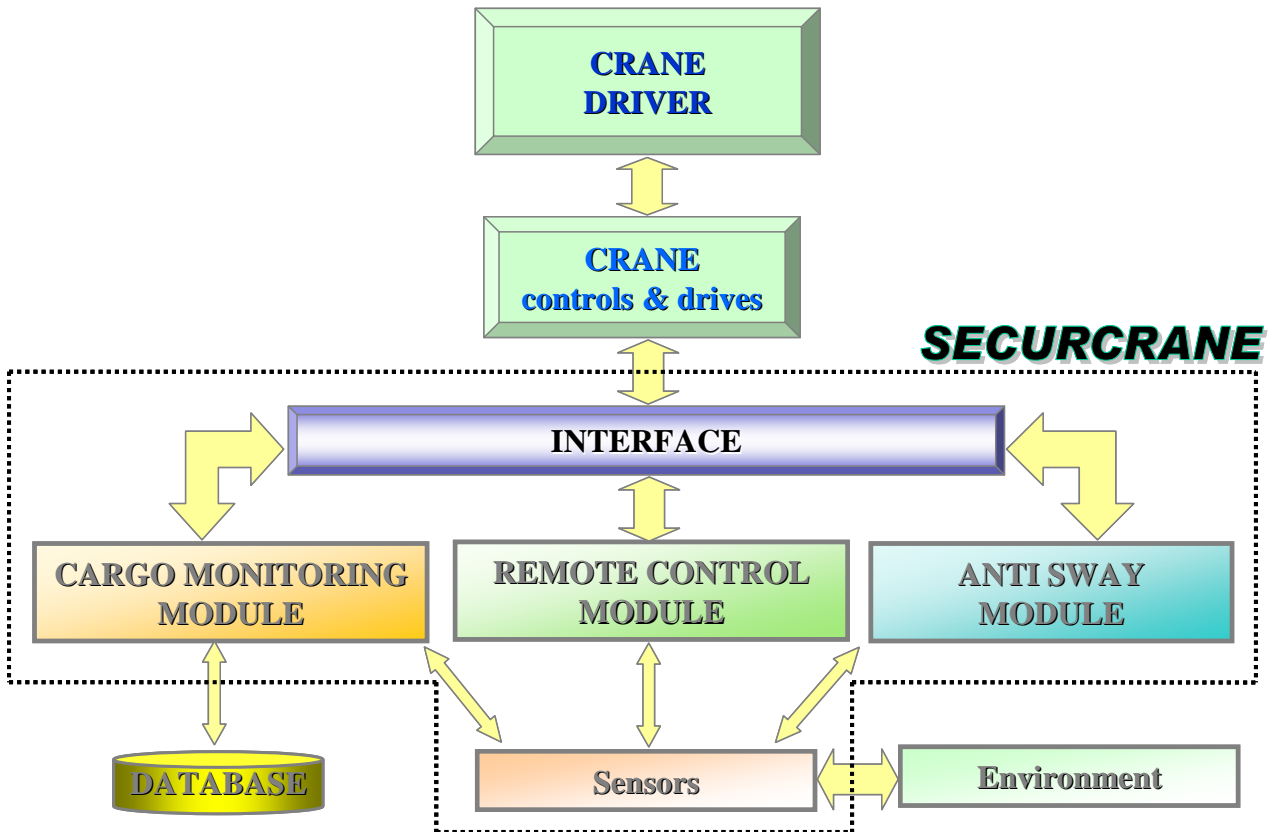


Figure 1: General relationships among the involved entities, where the Crane Driver is the Leader of the process of container handling (top of the pyramidal representation)

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3.2 SECURCRANE BACKGROUND & ADDRESSED PROBLEMS

In port cranes manufacturing field, due to highly detailed bids from buyers and severe price competition, manufacturers usually neglect risks for research & innovation. Current anti-sway devices are mainly based on several physical/electrical principles (combining sensors/actuators to re-balance sway and damp oscillations). Their performance rates and cost/benefit ratios are not satisfactory, and many crane operators declare to work switching off the anti-sway. The absence of efficient and effective perception systems and fast-response effective anti-sway devices refrained large introduction of remote crane control up to date. **SECURCRANE addressed 2 specific problems**, distinct but deeply interconnected, which affect crane operator's behaviour (thus, productivity & pay out of container cranes):

1. **the stressing working conditions of cranes operators** due to both physical stress (shocks, vibrations, accelerations due to cabin position suspended to trolley and cabin constrained movement along crane boom), and psychological stress (sway of spreader/container and time needed to engage corner casting holes with spreader twistlocks or into the "cones", which considerably frustrate drivers while average handling time per movement increases);
2. **the potential damages caused to intermodal units** (and/or goods inside them), relevant causes of resource-burning legal actions and, often, financial disbursements (insurance costs or direct refunding to Clients).

The project dealt with the social issue of innovation, involving crane drivers since project start and focussing on the re-qualification of drivers' future job position after remote crane cabin adoption.

3.3 SECURCRANE OBJECTIVES

SECURCRANE 2 objectives were reached by realising, installing and testing a **working prototype on a port crane in Le Havre** consisting of:

- the **Remote Control (RCM) Module Prototype**;
- The **Anti-Sway Module (ASM) Prototype**;
- The **Cargo Monitoring Module (CMM) Prototype**.

Each module, after passing laboratory tests, was installed and tested separately from the other modules. Then, **the three modules have been interfaced** and the overall **SECURCRANE System went under new tests for evaluation purposes**.

Besides the concrete technical objectives mentioned above, SECURCRANE **built wide cooperation with crane drivers' community** since the early stage of project activities. When the prototypes were installed, **crane drivers have been invited to trials where they could touch with their hands the innovation in practice, not in theory**. **RCM originated from past expertise developed in defence field applications** now transferred into this civil application subject to different constraints, environment, needs. Imagery system was innovative too, based on a patented system promising to overcome negative aspects of past 3D imagery systems. ASM originated from successful past experience in other science domains (mostly cognitive sciences & artificial

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intelligence devices design). ASM hardware simplicity, its fast response to external inputs, the past positive applications of the same know-how, and **the reduced hardware costs promise efficiency coupled with interesting cost/benefit ratio. CMM raises commercial attractiveness of SECURCRANE system reducing insurance costs & providing added-value services to Terminal Operators.** CMM acquires many container images performing functions like container identification (to avoid misoperations), extraction of geometric features (early detection of damages avoiding refunding Clients for damages made outside terminal premises), and other functions. CMM adopts technologies able to limit optic/geometric distortion and environmental/light adverse condition, while keeping hardware costs low.

3.4 SECURCRANE PARTNERS

Name	Organisation's (business) activity	Role in SECURCRANE project	Partners links
SCIROIDEA	Engineering, industrial automation, railway systems	Project coordination; design and development of the Cargo Monitoring Module (CMM).	www.sciroidea.com
ECA	Robotics and automation	ECA brought his knowledge in building remotely operated systems for various environments (nuclear, defence, transport, security) to build the remote control system for the crane to be driven from the ground. A dedicated 3D imagery system was built for this project using ECA experience in electronics and mechanics, and through a subcontractor for the optical parts.	www.eca.fr
TL & ASSOCIES	ICT & Logistics and human factor aspects	Technological interfacing (integration tasks) between new technologies and available cranes. Specifications, prototyping support and validation of the Remote Control Module. Drawing up operating procedures. Definition of training programmes for remote command.	www.tl-a.com
ENEA	Research mainly in the fields of Energy and Environment (Italian National Body) – Technology/Know-How Transfer to Industries (various fields of application)	Anti sway system design and development in synergy with Bertolotti S.p.A..	www.enea.it
INTECSA-INARSA	Engineering	Socio economy & implementation aspects as well as legal & regulation impacts.	www.intecsa-inarsa.es
Grand Maritime Havre	Port authority; Ship to shore handling; Crane drivers employment	Expression of needs and validation of new concepts. Availability of Ship to shore crane for testing and validation.	www.havre-port.fr
BERTOLOTTI S.p.A.	Industrial Planting and Heavy Machinery Automation Company	Anti sway Module Development with ENEA; installation and integration of newly developed systems.	www.bertolottispa.it

Table 2: List of SECURCRANE Partners, business activity, role in the project and internet website

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<p>SECURCRANE Logo</p>	<p>www.securcrane.info</p>	

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3.5 WORKING METHODS

Excluding Management, the project was organised in 5 workpackages:

- WP 1 (Users' needs vision, Funct. Req. & Arch.). Users needs vision (through interviews, questionnaires & advisory of key field experts/End User), was "translated" into proper functional requirements to draw up the SECURCRANE system architecture.
- WP 2 (Design, development & tests). Design and development of modules run separately because their applications were logically "installed" in different allocations on crane controls.
- WP 3 (Integration, Testing and Validation). Modules were integrated & tested to verify functionalities & performances of each module as well as of global system. Final results have been validated by the End User and other potential users.
- WP 4 – "Evaluation & Assessment". Identification of impacts (notably socio-economic) of introduction of SECURCRANE's technologies and associated organisational concepts, and "road map" for implementation.
- WP 5 – "Dissemination and Workshops". Major instruments have been SECURCRANE INTEREST OPERATORS CLUB (SIOC), distribution of brochures, update of project web page, and validation workshops.

3.6 INTERIM & FINAL RESULTS - OVERVIEW ON FUTURE APPLICATIONS

The major result is that **the first prototype of SECURCRANE system was installed on a port crane in Le Havre and proved being able to allow the remote control of the crane** by means of CCTV 3D images, **to practically eliminate the effects of the sway** when the driver puts the control joystick to idle, **and to monitor the handled cargo extracting and storing useful information.** The project reached its successful end at the end of September 2009. This research challenge was won, and it is expected that in the next years, first positive applications could involve the port cranes field where safer working conditions and more efficient drivers performance may be reached. Further application fields, in a medium term future, may benefit from the achievements of this research, such as the civil construction industry, just to mention the widest. The partnership included the End-User "Grand Port Maritime du Havre", both Research Bodies, such as ENEA, and Commercial Firms such as ECA, BERTOLOTTI and SCIROIDIA, reasonably granting the application of the research outputs into exploitable and marketable products.

Hereafter, some images of the three modules composing the first prototype of SECURCRANE system are presented.

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3.7 SECURCRANE PROTOTYPE IMAGES



Figure 2: SECURCRANE Remote Control cabin (with integrated Anti-Sway Module)



Figure 3: some of the boxes of the Cargo Monitoring Module prototype framing the container while moved

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4. DISSEMINATION AND USE

4.1 RESULT #1: REMOTE CONTROL MODULE (RCM)

4.1.1 BRIEF DESCRIPTION OF RCM

The **Remote Control Module** comprises two main components, one inside the cab on the crane trolley, the other on the ground in a room dedicated for the purpose. These two entities are interconnected by a link allowing on the one hand, recovery of video images (for video in relief – i.e., 3D – and 2D vision), and on the other hand, transmission and reception of all information necessary for driving the crane.

The component inside the cab manages all peripheral modules like pan&tilt device 3D vision and the control signals. These control signals come through CAN bus wire or parallel I/O wires.

In the ground control station, operator has access to two touch-panels and can observe the environment through 2 screens and one screen dedicated to 3D vision.

Crane driver can sit on arm chair control in safe position and can operate with no stress. His head is right, no bending. He can see all the workspace and around through screens and he can hear environment sound easily.

The main innovation of this system is the video configuration. 3D-module vision is dedicated to workspace and all other 2D cameras (PTZ modules) for all environment.

4.1.2 POSSIBLE MARKET APPLICATIONS/FURTHER RESEARCH

The RCM can be promoted as a single product to be integrated in existing cranes or as a part of the complete SecurCrane system. ECA envisions to approach either the crane supplier for the “new acquisition market” and several major European ports for the “used crane market”. The Remote Control Module coupled to an advanced 3D vision system can find a wide range of applications in transport, logistics, security and defence.

4.1.3 STAGE OF DEVELOPMENT

RCM was developed as demonstrator, and has achieved all expectations. It was used and evaluated by crane drivers who guided and advised SecurCrane team in order to dispose of an efficient equipment.

However, even if the RCM has proven the operational interest and achieved significant results, some work remains to be performed to get to a product.

4.1.4 COLLABORATION SOUGHT OR OFFERED

ECA is willing to pursue the development and the promotion of the system with SecurCrane partners and other companies wishing to enter in the project.

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4.1.5 COLLABORATOR DETAILS

To improve the current system, ECA needs to study the crane driver reaction and way of using the system. An ergonomic study has to be performed to ease the manipulation of the SecurCrane. The 3D vision system company has to be part of future tasks to perform.

4.1.6 INTELLECTUAL PROPERTY RIGHTS GRANTED OR PUBLISHED

Not applicable

4.1.7 CONTACT DETAILS

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4.2 RESULT #2: ANTI-SWAY MODULE (ASM)

4.2.1 BRIEF DESCRIPTION OF ASM

SECURCRANE Anti-Sway Module is an aiding tool at the disposal of the crane operator in order to compensate, mainly on demand, the container swaying movement. This aiding device, **UNLIKE THE SYSTEMS CURRENTLY AVAILABLE ON THE MARKET, DOES NOT INTERFERE WITH CRANE OPERATOR'S MANOEUVRES. IT COMPENSATES THE SWAY ONLY AFTER THE CRANE DRIVER RELEASES THE JOYSTICKS** (or when his commands are under the pre-set creeping speed).

This system:

- DOES NOT replace the crane operator's work. On the contrary, it is a support tool at his disposal;
- Can be applied also without the other project modules, even if it is developed – in the scope of this project – as a part of the whole system, and it should always work jointly with the Remote Control.

The crane operator is usually in his control cabin set on the top of the crane and operates the joysticks according to the trolley acceleration he perceives both **physically (i.e., body-sensed information) and visually** since he is onboard. He manoeuvres the trolley so as to constantly compensate the “offset” between the hanging container and the acceleration of the trolley. In many experiments made in the past, the remote control systems based on CCTVs and applied to the crane operation, failed mainly because of the *missing acceleration physical perception* of the crane drivers' body. This, together with the delay caused by the only visual perception of swaying movements, generated inadequate reactions in order to regain the proper control of the crane.

The anti-sway system proposed by Bertolotti S.p.A. and ENEA compensates the cargo swaying using the same perceptions that the crane operator has onboard the crane. In other words, the ASM system “feels” the cargo swaying and reacts compensating the difference between what it “feels” and what it “would like to feel” (ideal situation with no sway). Through this operation, ASM does not replace but supports the crane operator, being a valid aiding tool for him in his new remote position.

ASM is able to compensate swaying in any position of the container complete loading process (point A – translation – lowering – point B), but this is not the major objective of SECURCRANE project. The actual objective is to damp sways quickly during the crucial loading cycle stages, i.e. in proximity to the points A and B, thus almost eliminating any swaying and allowing the operator to use his joystick without constraints during the whole loading process.

ASM will therefore achieve the most demanding and stressful part of the operator job, i.e. the cargo swaying compensation, while the operator is free to focus on the most delicate stages of container hooking and positioning into a precise ship slot. As a result, the crane operator, in his new remote cabin, will be able to perform his tasks quickly and with a lower stress.

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ASM consists of infrared camera sensor, positioned under the trolley on the crane and able to take the relative position of the load thanks to the installed infrared light source along the vertical spreader-trolley. The captured images are elaborated by a controller. On crane driver's demand for the intervention of ASM, the controller changes the speed and direction of the trolley in accordance with the load position and motion so as to attenuate the sway in max. 3 or 4 strokes.

Apart for the push-button available on the joystick of the crane driver's cabin in order to enable/disable ASM intervention, ASM module is "transparent" to the crane operator.

4.2.2 POSSIBLE MARKET APPLICATIONS/FURTHER RESEARCH

The Anti Sway Module may give origin to a bouquet of different products in the next future. In particular, ASM could be exploited in the same configuration as for SECURCRANE (installation on board of a quay crane), but also on yard cranes, as well as in civil construction cranes. As far as its possible commercialisation is concerned, BRT is actually monitoring all possible solutions, i.e. the port cranes European market and the possible licensing to cover the rest of the world market. The indoor industrial crane market, as steel industries or nuclear industries, is another possible extension for ASM module development.

The main difference between SECURCRANE ASM and the products already available in the reference world market stands in shorter time to attenuate load sway attainable by the ASM thanks to the innovative technology involved.

The ASM market positioning will have to mediate between the additional functionalities offered by the ASM in respect to the existing products and the actual reference price of such products. This will be a key element for a successful market penetration of ASM innovative products in the next years.

4.2.3 STAGE OF DEVELOPMENT

The ASM is actually available at the stage of demonstrator. The industrial products will be subject to future development to improve safety functionality, as necessary concerning normative and law, and to improve availability to well run in different environment as fog, wind and particular sun light conditions.

4.2.4 COLLABORATION SOUGHT OR OFFERED

No collaboration is foreseen whit third parties to develop ASM module, but BRT will propose the anti sway as kit to install in heavy crane as pilot prototype to collaborate with crane clients and so improve the crane features as investment for the future.

4.2.5 COLLABORATOR DETAILS

A potential collaborator may be a steel industries client interested to improve their new and existing cranes or a Terminal Operator. The collaboration would consist in:

- The availability to install the ASM devices on board of crane;

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- Collaboration to survey the ASM system behaviour during normal operations.

BTR is fully available to recognise the direct cost of instrument, installation and commissioning as discount to the final price on the possible purchase.

4.2.6 INTELLECTUAL PROPERTY RIGHTS GRANTED OR PUBLISHED

Patent request filed.

4.2.7 CONTACT DETAILS

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4.3 RESULT #3: CARGO MONITORING MODULE (CMM)

4.3.1 BRIEF DESCRIPTION OF CMM

The Cargo Monitoring Module, in brief:

- **takes pictures of each container handled by the crane and stores them for future use;**
- **verifies the container integrity;**
- **searches for possible damages which already exist on the external container surface.** If any, CMM may send the staff signals/alarms (customisable);
- **is able to signal promptly** (through customisable signals/alarms) **any handling which was not foreseen in the loading/discharging list.**

CMM consists of sensors, mainly cameras, positioned in key-points on the crane structure and able to take proper pictures of each handled container from different points of view and angle-shots. The captured images are transferred via wireless link to a computer in the terminal office. The computer stores them for a middle-long term (according to the intended use). The aim is to get evidence that damage was already present at the arrival of the container at the terminal. This system prevents reimbursements to clients for damages occurred outside the terminal, for instance not assessed damages and/or damages caused jointly by the ship owner and the terminal operator. This automated monitoring system of the container conditions at the arrival also allows the negotiation of special discounted policies with the insurance companies.

The Cargo Monitoring Module – as to its design - intends to be completely or semi-completely “transparent” to the crane operator without creating additional tasks. The crane operators’ job is already very difficult and full of operations to be performed within a strict schedule which cause high level of stress during loading and unloading operations.

4.3.2 POSSIBLE MARKET APPLICATIONS/FURTHER RESEARCH

The Cargo Monitoring Module, as to its nature, may become a family of products in the next future. In particular the CMM could be exploited in the same configuration as for SECURCRANE (installation on board of a quay crane), but also in partially different configurations such as, for instance, on RTGs, RMGs, and gate check. As far as its possible commercialisation is concerned, SCIROIDEA SpA is actually interested in both possible solutions, i.e. the direct marketing (especially for the Italian and European markets) and the possible licensing to cover the rest of the world market. No consortium is actually foreseen, but the Company is open to further discussions with potentially interested partners.

There are some similar products already available in the reference world market, none of which is today capable of providing images with quality and details similar to those which CMM may provide thanks to the innovative technology adopted.

Indeed, the main difference between SECURCRANE CMM and the referred products stands in the higher image resolution attainable by the CMM thanks to the innovative technology involved (the linear scan approach).

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The CMM market positioning will have to mediate between the additional functionalities offered by the CMM in respect to the existing products and the actual reference price of such products. This will be a key element for a successful market penetration of CMM innovative products in the next years.

4.3.3 STAGE OF DEVELOPMENT

The CMM is already developed at the stage of demonstrator. The first industrial products coming out from the know-how generated in SECURCRANE are subject to further development and industrialisation by SCIROIDEA SpA.

4.3.4 COLLABORATION SOUGHT OR OFFERED

SCID actually considers that some internal development of the CMM prototype could lead, in reasonable time, to proposing the products on the market. No collaboration is foreseen with third parties, but it is possible that potential clients wishing to accelerate their purchase of CMM products propose to install a pilot prototype in their premises to finalise the development of the final product, having as direct advantage the possibility to customise the product and to test it prior to the final purchase.

4.3.5 COLLABORATOR DETAILS

The potential collaborator is a Terminal Operator interested in CMM functionalities, either on the quay cranes or at the gates of the terminal, or both, and wishing to contribute to the industrialisation of CMM with a twofold aim. First, the chance of customising the product for free; and, second, to evaluate the CMM products prior to investing in the purchase of such innovative product. The collaboration would consist mainly in:

- the availability of an installation on board of a crane (even a very old crane is suitable) or at a gate;
- some limited labour for the physical installation on the crane, or at the gate, (under the supervision of SCIROIDEA personnel);
- some limited labour for the analysis of the results (assisted by the automatic analysis tools made available by the CMM itself and by SCIROIDEA)

SCIROIDEA is fully available to recognise the direct costs sustained by the collaborator as a direct discount on the possible purchase of CMM products after the end of the collaboration. Joint marketing (partnership and/or alternative form) of the products could also be taken into consideration, if this is the case.

4.3.6 INTELLECTUAL PROPERTY RIGHTS GRANTED OR PUBLISHED

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