Challenges and Opportunities for Transfer of Technologies between Space and remote Subsea Operations

Stavanger, 28 January 2010

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Outline of the presentation

- The ESA Technology Transfer Program
- The main A&R space technologies and possible application cases to O&G:
  - Robotic manipulation
  - Vision system
  - Robot control station
  - Telepresence
- Other technologies
- Conclusions

Space -> O&G A&R Technology Transfer

websites:

- http://www.esa.int/SPECIALS/TTP2/
- http://www.technology-forum.com/

Specific study for the Oil&Gas (O&G) market field:

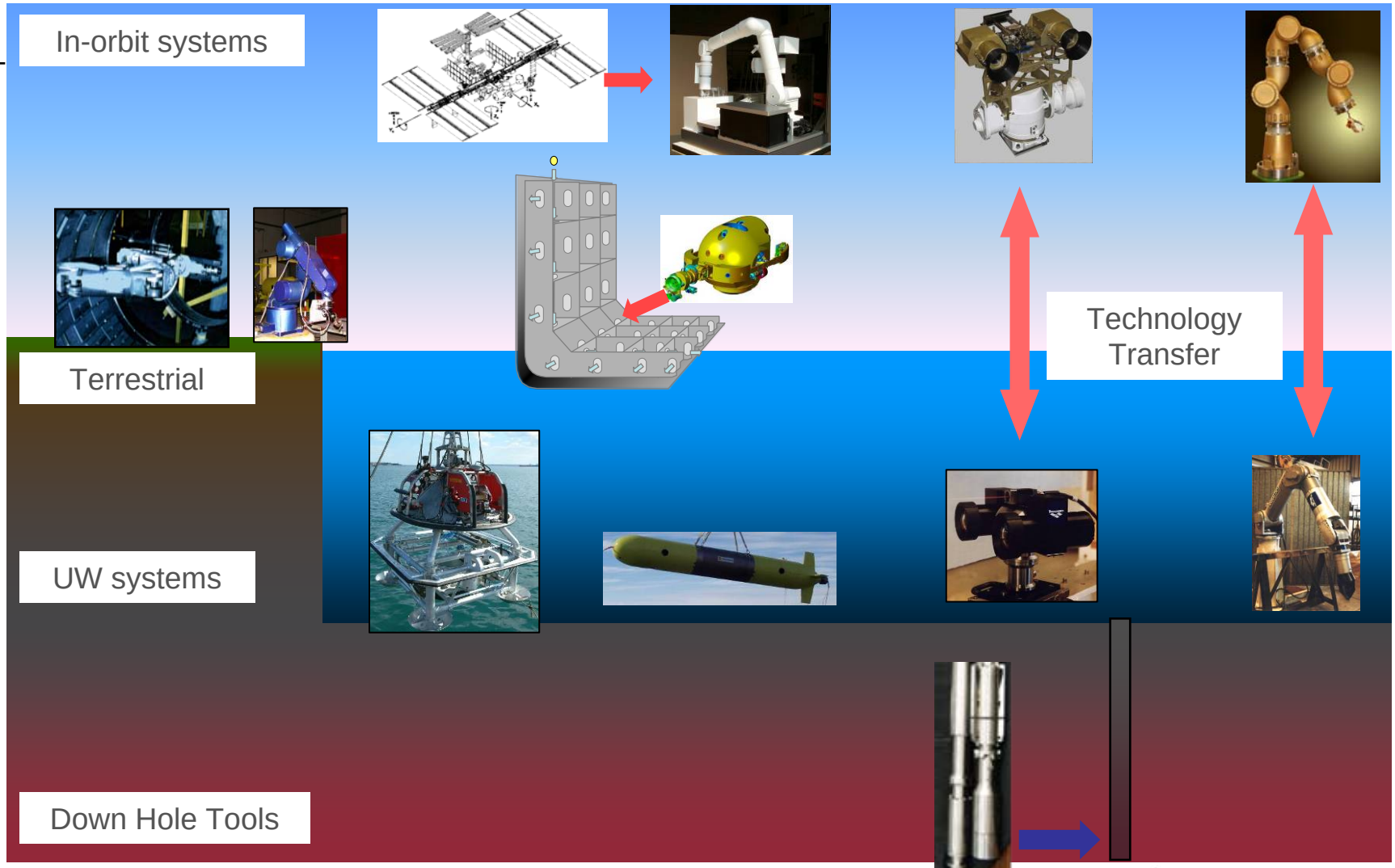
- Identification of technologies candidate for transfer from space to O&G
- Survey of current trends in O&G development programs and of their A&R technology needs
- Mapping of candidate space technologies to the identified needs.

Rationale of the study:

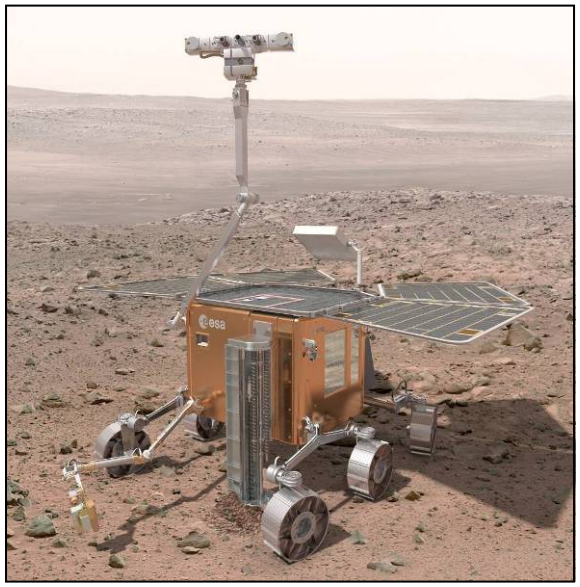
- Well known analogies between Space and O&G: remote and hostile environments
- The current trend in O&G is even more synergic with space (deeper water operations, autonomous systems for long-range exploration)
- The space A&R technology is developed and available.

Tecnomare selected for study execution for its active working in both fields (see next slide)

Tecnomare Spectrum of Activities



Space A&R: Main Development Programs



EXOMARS

EUROBOT

Development of related enabling A&R technologies for exploration and IMR, along the two parallel lines:

- Automation
- Telepresence

Robotic Manipulation in the O&G

- State-of-Art: master-slave operation
- Well known advantages:
  - user friendly
  - general purpose use in unstructured environments
  - proven effectiveness
- Drawbacks:
  - it requires good visual feedback
  - trial & error approach
  - no control of the contact force with the environment
  - it might be less effective in complex operations
- Possible development lines:
  - Automation (sensor-based and model based)
  - Telepresence

Schilling Robotics Titan 4

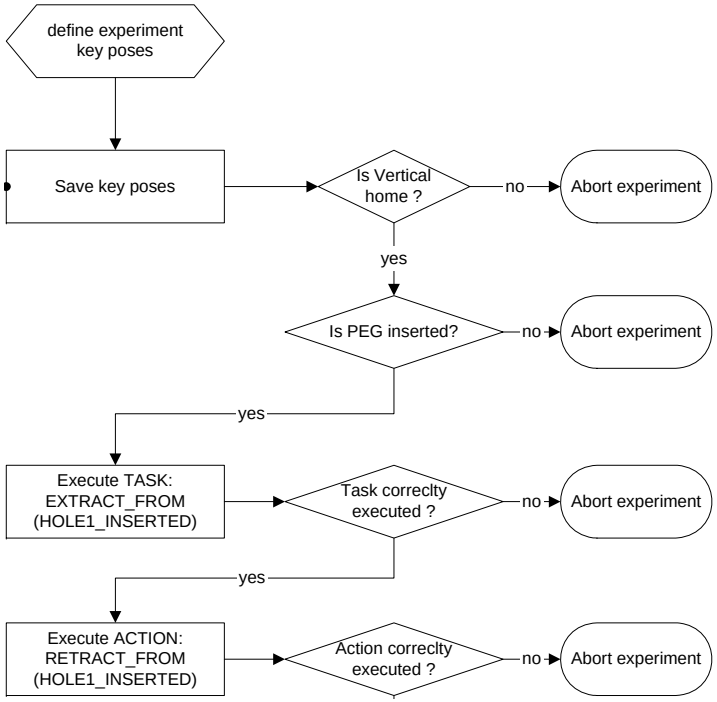
- Advanced controllers for space operations with limited feedback and demanding safety requirements are available, for automatic execution of complex tasks with human supervision and robotic teleoperation.

- Main features:
  - Powerful programming language
  - Automatic motion and force control
  - Teleoperation input

- Two implementations available:
  - The ESA A&R laboratory controller (CONTEXT): developed on the basis of well proven industrial controller, high reliability
  - The ASI Robot Controller for the Europa mission: developed ad hoc for space use, less proven, more flexible

Versatile robotic language for:

- arm motion programming,
- controller status management
- flexible data processing.



Other possible application of the same language:

- programming the mission of AUVs.

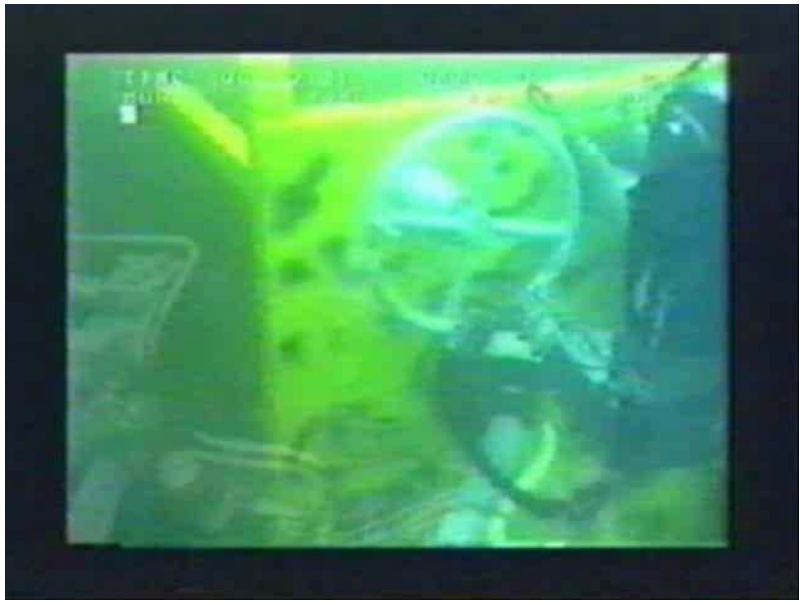
```
PROGRAM factMain(in:ARRAY[] OF
CHAR):INTEGER

VAR
        n:INTEGER;

PROT
        factorial(n:INTEGER):INTEGER;

BEGIN
        DECODE_INTEGER(in, n);
        n = 10;
        RETURN (factorial(n));
END factMain
```

Bluefin Robotics

Robotic Manipulation: Motion-Force Control

- Capability to control the manipulator arm motion both in free space *and* with the constraint of the environment
- The same control scheme can be implemented on underwater hydraulic manipulators, as demonstrated by the example below

Space arm operating a passive rotational mechanism (crank-like)



Schilling Titan 3 (with TM controller) operating a valve

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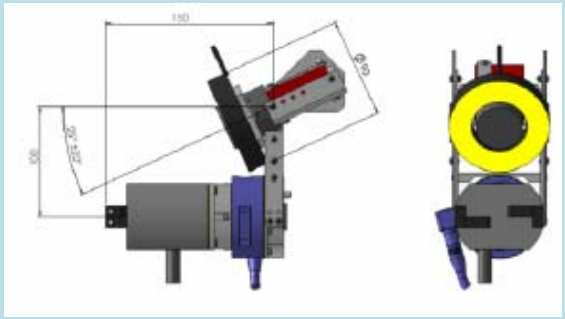
Vision System for Measuring the Workplace

Two developments for space are available:



VIMANCO (ESA)

(Vision-based MANipulator Control):

- State-of-art Object Recognition and Visual Servoing capability
- Maturity level: laboratory prototype

SVMS (ASI)

(Stereo Vision Measurement System):

- Measurement an tracking capability
- Maturity level: Flight Model

Heritage: TV Trackmeter, originally developed for underwater use and rated for 1000 m water depth

Possible advanced solution for O&G: TV Trackmeter stereo rig with VIMANCO SW

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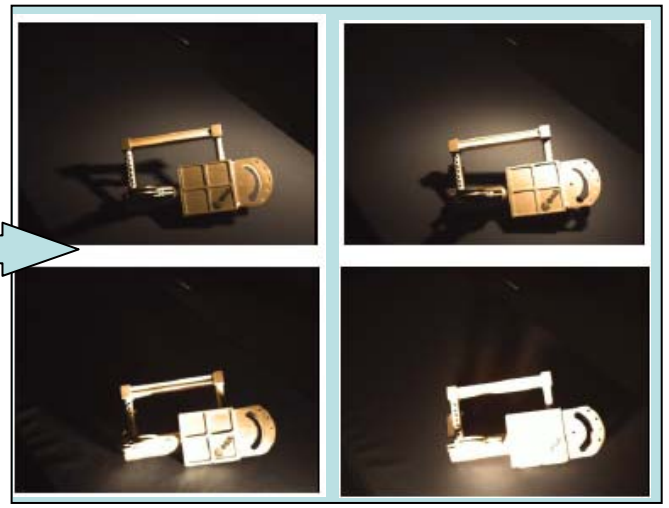
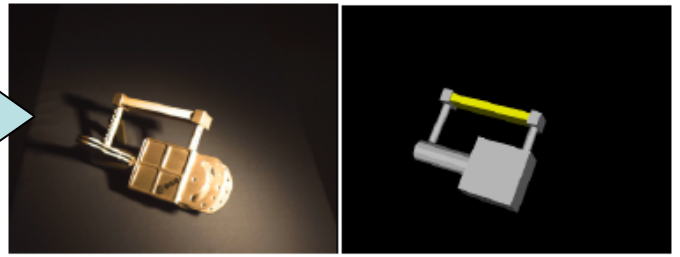
Object recognition:

- training phase to build an object database (with different images of the same object)

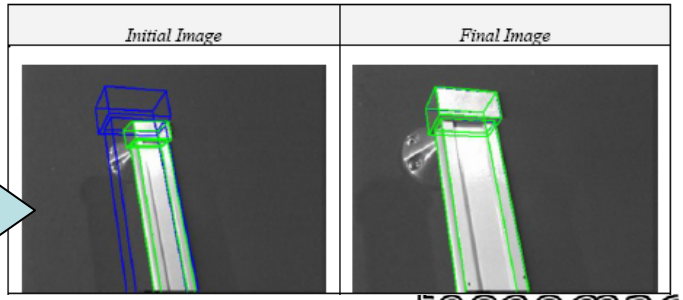


- very effective recognition capability, even with occlusions and variable light conditions



Visual servoing:

- matching of the recognized object model



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Distributed Robotics & Automation Environment for Advanced Missions Specification and Supervision: DREAMS (or similar systems)

DREAMS ground control station integrates:

- (off-line) high-level robot programming and verification
- (on-line) commanding robots at a remote site, i.e. to request the on-board execution of operations while supervising their evolution.

- It is designed to be re-instantiated for different missions and applications.

ESA Human Arm Exoskeleton

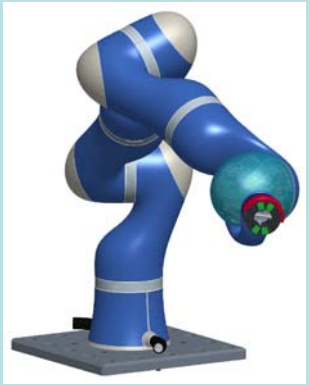
Outstanding features:

- teleoperation of any antropomorphic slave arm, with:
  - reflection of the interaction force on the environment
  - configuration feedback (i.e. control on the volume swept by the arm elbow to deal with the obstacles in the workplace)
- lightweight and wearable by the operator (other devices of the same type are pillar-based)
- auto-aligning procedure between human axes and robot axes of motion

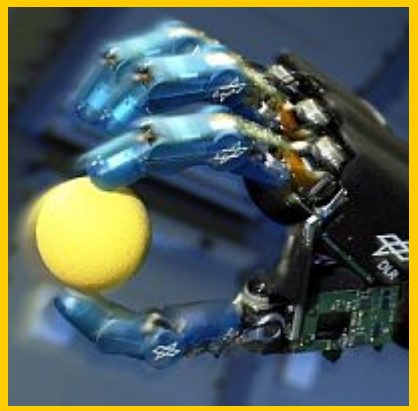
Other Space Technologies

Lightweight and dexterous arms

DEXARM

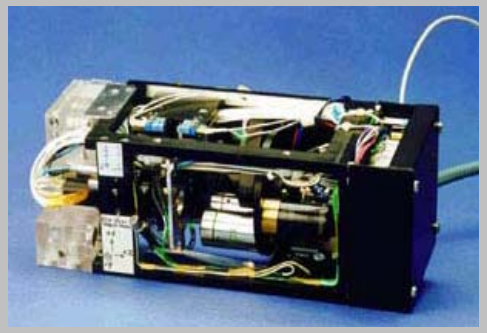


DLR



DLR Hand II
Dexterous grasping
and manipulation tool

Haptic Rendering
applied to Virtual
Reality



Miniaturized
Microscope System

EGOS-SCOS 2000: generic
mission control system
software of ESA

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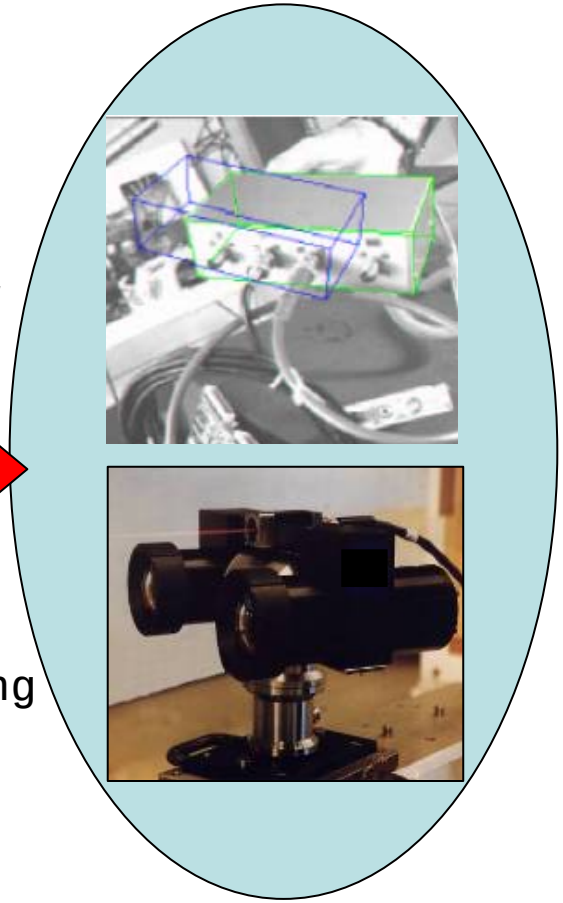
Conclusions

- Several advanced and powerful A&R technologies have been developed for space and are available
- New development trends in the O&G market can potentially benefit from such technologies
- Concrete example: a pilot project to readily implement a **state-of-art UW vision system** by integrating available building blocks:
  - vision SW developed for space
  - existing UW stereo rig
- If there is any interest in any of the presented technologies, this can be notified:
  - either to Tecnomare in the framework of the on-going study
  - or by contacting directly ESA
  - or by contacting IRIS (technology transfer agent in Norway)



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