Civil Domain Workshop:
Civil Robotics Multi Annual Roadmap

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Civil Domain

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The Civil domain covers applications managed by civil authorities, national and local government and robots operated by regional and national agencies or by contractors engaged in public works. These range from support for the civil infrastructure, e.g. roads and rivers, to support for law enforcement and the emergency services. These public services are most often managed by civil authorities, city councils, local governments and national government departments and agencies. The protection of the public and the efficient maintenance of services mean that the basis for the purchase of services must show either cost saving or an enhancement of service delivery in order to justify public expenditure. The legal and ethical operation framework will be that of the civil authorities. This market is broadly characterised by Business to Government (B2G) business models.

Sub-Domains

Civil Infrastructure	Search and Rescue	Environment	Law Enforcement	Emergency Services	Science Support
The decommissioning and inspection of hazardous infrastructure.	Search and rescue, both over wide areas such as at sea, or in closed spaces such as buildings	Providing up to date information about environments changes to provide early warnings .	Using robots for law enforcement typically for tracking and monitoring.	Support for emergency such as firefighting, pollution control, emergency aid.	Highly specialised research tools designed for a specific purpose.

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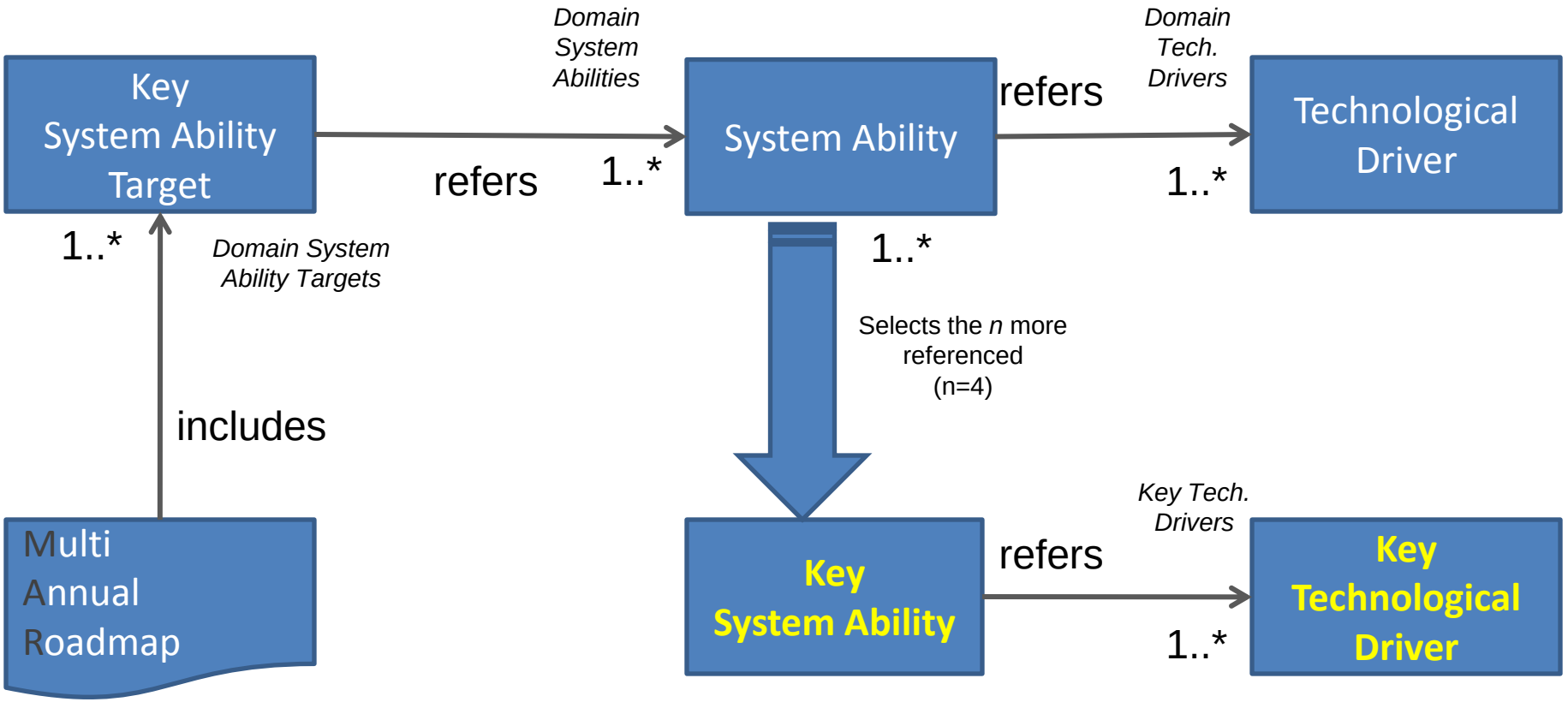
Civil Domain Key System Abilities & Technologies Identification



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TG Civil Robotics Status & Next Actions

- TG Stakeholders:
  - Status: There are 26 stakeholders including both Industries and Research Centres
- Activities
  - Current activities:
    - ① To maintain the MAR Civil Robotics paragraphs for completeness, and coherence
    - ② To maintain synergies among stakeholders, e.g. via “shared” System Requirements vs. System Ability in MAR Development
    - ③ To contribute to the orientation document
  - Next (beneficial)Actions:
    - ① To revise domain key technologies target
    - ② To establish and maintain relationships with other both TGs which relates with Civil Robotic Market: Domain TG, Robotic Market TGs, Technological TGs.
- Multi Annual Roadmap:
  - Status: A new version for Call 2 has been issued on 6th, February;
- Product Visions
  - Status: There are 6 Key Product Visions (see next slide for details)

TG Civil Robotics Product Visions

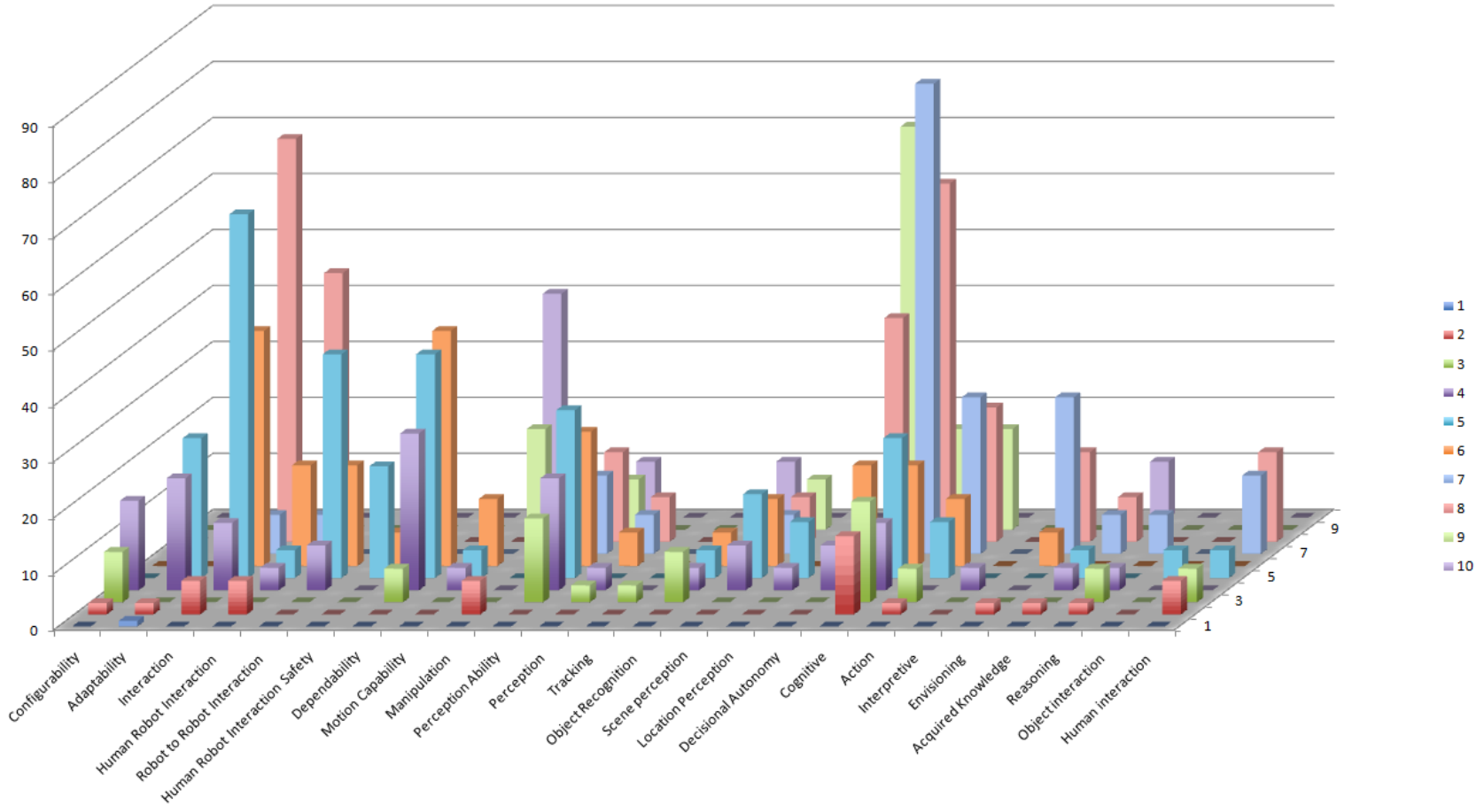
1. **Heterogeneous Robot Teams for Disaster Management Support:** which is a multirobot system which provides for support to Disaster Management Missions via squads of networked, cooperative robotic systems
2. **Debris Navigator:** which is a small size “extra-mobile” UGV with autonomous navigation capability in unstructured environments
3. **Family of “Autonomous” underwater vehicles:** which is a family of innovative underwater vehicles, operating as ROV (Remotely Operated Vehicle), AUV (Autonomous Underwater Vehicle) and/or HAUV (Hybrid AUV) characterized by augmented system operative autonomy.
4. **Tool for Smartness:** which is a toolset which allows for different kinds of standard (already in service) mobile platforms (both ground and surface) to become fully high-level teleoperated by means of an innovative Ground Station.
5. **Hand Shake – 2 Hands Manipulator:** which is a mobile unmanned platform that is equipped with a novel generation of dexterous manipulator based on : (i) 2 Collaborating Robotic Arms and (ii) 2 Fully Sensorized Hand Shape End-Effectors.
6. **Advanced Monitoring System of the Environment :** which is a surveillance system, based on the collaboration and integration of three segments (Aerial – Ground – Communications) in support of the phases of prevention and control of a wide range of events.

Multi Annual Roadmap: Key System Ability Target

- **System Ability Target: 81**
- **System Ability Components Covered: All but the new Social Interaction**
- ***Total References to* System Abilities: 190**
- **Key *System Abilities addressed***
  - Cognitive (Group): 47 References
  - Interaction (Group): 36 References
  - Dependability: 24 References
  - Decisional Autonomy: 20 References
- **Less Relevant System Abilities:**
  - Tracking: 1 Reference
  - Interpretive: 1 Reference
  - Location Perception: 3 References
  - Object interaction: 1 References
- **Most Addressed Ability Levels (out of 10):**
  - Level 5: 39 References
  - Level 4: 30 References
  - Level 6: 27 References
  - Level 8: 26 References

Multi Annual Roadmap: Addressed System Ability Distribution

System Ability Targets references to System Ability and System Ability Levels



Cognitive

- *Description*:
  - The ability to: (i) interpret the task and environment such that tasks can be effectively and efficiently executed even where there exists environmental and/or task uncertainty, (ii) interpret human commands delivered in natural language or gestures, (ii) interpret the function and interrelationships between different objects in the environment and understand how to use or manipulate them, (iii) plan and execute tasks in response to high level commands, (iv) work interactively with people as if like a person.
- *Technology Drivers:*
  - Systems *Development*
  - Perception
  - Human Robot Interaction
  - Cognition
- *Action Ability (16 References)*
  - The ability of the robot system to act purposefully within its environment and the degree to which it is able to carry out actions and plan those actions. These abilities build on perception and decisional autonomy abilities. Action ability also co-depends on the other cognitive abilities.
- *Human interaction (10 References)*
  - The ability which relates to the interaction between a human and one or more robots with cognitive components.
- *Envisioning (8 References)*
  - The ability of the robot system to assess the impact of actions in the future. This may reduce to prediction but in the higher levels involves an assessment of the impact of observed external events

Physical Interaction

- *Description*:
  - The ability of a system to interact physically, either with users, operators or other systems around it, including other robots. The ability to interact is critical to many areas of application. Interaction depends on both the medium of interaction and on the context and flow of the interaction. The ability to physically interact covers four specific areas of interaction:
    - ✓ Human-robot interaction
    - ✓ Robot-robot Interaction
    - ✓ Interaction safety.
- *Technological Drivers:*
  - Human Robot Interaction
  - Communications
  - Perception
  - Cognition
- *Robot to Robot Interaction:Level 5 - Team coordination (8 References)*
  - Two or more robots are able to collaborate to achieve a task outcome that could not be achieved by either robot alone, or by each robot operating independently.
- *Human to Robot Interaction: Level 8 - Mission Goal setting (6 References)*
  - The system is able to execute tasks to achieve a mission. The user is able to interact with the system to direct the overall objectives of the mission.
- *Human-Robot Interaction Safety: Level 5 - Dynamic User detection (4 References)*
  - The robot or its support systems detect users within its operating zone and dynamically defines a safe zone that envelopes the user where the robot controls its motion to be safe.

Dependability

- *Description*:
  - The ability of the system to perform its given tasks without systematic errors. Dependability specifies the level of trust that can be placed on the system to perform. This may be in terms of a MTBF or that we trust it to look after a person for a day.
- *Technology Drivers:*
  - Systems Development
  - Perception
  - Cognition
- *Level 5 - Task dependability (7 References)*
  - The robot system is able to recognise the impact of a failure on the overall task it is undertaking and re-task activities in order to minimise the impact of the failure on the task. This may also include self repair as an alternative task.
- *Level 6 - Mission dependability (8 References)*
  - The robot is able to recognise the impact of a failure on the overall objectives of a mission and communicate the nature of the failure to other systems and robots to minimise the impact on the mission objectives. In turn the robot is able to receive and interpret mission failures from other robots and systems and re-task its actions to compensate.
- *Level 7 - Predictive dependability (7 References)*
  - The robot system is able to predict that a planned future action may result in a loss of dependability, or that the effect of the partial failure of a component can be mitigated by altering future actions. Thus the robot is able to extend its dependability by taking action in advance of failure in order to reduce the effect on dependability.

Decisional Autonomy

- *Description*:
  - The ability of the robot to act autonomously. Nearly all systems have a degree of autonomy. It ranges from the simple motion of an assembly stopped by a sensor reading, to the ability to be self sufficient in a complex environment.
- *Technology Drivers:*
  - Perception
  - Cognition
- *Level 6 - Constrained task autonomy (3 References)*
  - The system adapts its behaviour to accommodate task constraints. These might be negative impacts in terms of failed sensors, or the need to optimise power utilisation or other physical resources the process depends on, (water, chemical agents, etc). Alternatively these might be constraints imposed by sensing ability, the environment or the user.
- *Level 8 Dynamic autonomy (5 References)*
  - The system is able to alter its decisions about actions within the time frame of dynamic events that occur in the environment so that the execution of the task remains optimal to some degree.
- *Level 9 - Mission oriented autonomy (8 References)*
  - The system is able to dynamically alter its tasking both within and between several high level tasks in response to dynamic real time events in the environment.

Key Technologies

- *Perception (Driver for: Cognitive, Physical Interaction, Dependability, Decisional Autonomy)*
  - Perception technology provides a robot with the means to measure and interpret its environment. In order to enable intelligent behaviour, perception technologies process raw sensor measurements to infer additional information and represent sensor data in a useful way.
- *Cognition (Driver for: Cognitive, Physical Interaction, Dependability, Decisional Autonomy)*
  - Cognition is the system wide process that provides an agent with the ability to understand, given only partial knowledge, how things might possibly be, not just now but at some point in the future, and to use this understanding to influence action.
- *Systems Development (Driver for: Cognitive, Dependability)*
  - The technologies underlying Systems Development focus on the methodological and software aspects used in system development and integration process. This combination of technologies aims to deliver the underlying engineering methods and software tools for robot developers and manufacturers to use during the design, development and integration phases.
- Human Robot Interaction *(Driver for: Cognitive, Physical Interaction)*
  - The development of intuitive and natural interfaces allowing the operation of complex robotic systems with less training and lower fatigue levels. Interaction will take many different forms from immersive virtual worlds to direct and precise physical interaction.
- *Communications (Mechatronics) (Driver for: Physical Interaction)*
  - In view of the increasing complexity of robotics systems, communication protocols and code generation tools are needed, which allow to easily design flexible topologies of sensors and actuators and to automatically generate and configure the code for their communication.

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Discussion

- *Networking with Technological Topic Groups: Pros & Cons:*
  - Cross Fertilization
  - Domain System Abilities Target as driver to Technologies
  - Increase the impact on end-user communities
  - ….
- *Networking with Platform Topic Groups: Pros & Cons:*
  - Cross Fertilization
  - Domain System Abilities Target as driver to Platform capabilities
  - Increase the impact on end-user communities
  - ….
- *Networking with other Domain Topic Groups: Pros & Cons:*
  - Cross Fertilization
  - Common Domain System Abilities Target as driver to similar Technologies
  - Increase the impact on common end-user communities
  - ….
- *Networking with Support Topic Groups: Pros & Cons:*
  - Cross Fertilization
  - Domain System Abilities Target as driver to Standards, Benchmarking, ELS,…
  - Increase the impact on end-user communities
  - ….

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