# COMMERCIAL APPLICATIONS OF SPACE-ENABLED ROBOTICS – SMART CITIES AND INFRASTRUCTURE USE-CASES

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## 1. INTRODUCTION

This document lists the use cases to be used as part of the ’Smart Cities and Infrastructure’ thematic area within the umbrella of the “Commercial Applications of Space-Enabled Robotics” thematic call for proposals.

The use cases presented result from the cooperation between the European Space Agency (ESA) and various stakeholders with interests in the domain of Smart Cities and Infrastructure. It aims at developing sustainable services leveraging space assets and robotics technology in consort to address key challenges and opportunities.

When writing the initial proposal (APQ/Outline proposal), the applicant will make clear what use case(s) their solution will address, if chosen from those provided here.

## 2. ANNEX A: SMART CITIES AND INFRASTRUCTURE USE CASES

### 2.1. Ferrovial

Ferrovial is a global infrastructure operator committed to developing innovative and sustainable solutions for a world on the move. With more than 70 years of experience, its family of companies holds leadership positions in transportation infrastructure, construction, waterworks, and energy. The company operates in 15 countries, with U.S. headquarters in Austin, Texas. Ferrovial employs more than 4,000 people across the U.S. and over 20,000 around the world. Ferrovial is dually listed on the Dutch and Spanish stock exchanges. For more information, visit www.Ferrovial.com.

A key consideration for all use-cases below is to move from current approaches to more advanced approaches through enhanced autonomy, higher data-refresh rates, while providing high-fidelity data and analytics outputs related to areas of interest across the globe (though North America, South America, Europe, and Australia are the primary geographies targeted).

#### *2.1.1. Real-Time Progress Monitoring (Construction)*

Monitoring civil construction sites (e.g. Highways construction and earth-moving activities) in “real time” and surroundings, covering aspects including:

1. Cross-Section Volume report.
2. Volume calculations for every section.
3. Any information that can be included in surveying reports (e.g. grade-checking reports, volume grid and heatmap reports).
4. BIM (Building Information Model) Comparison / Digital Twin (comparisons against the design or previous as-built versions).

Targeted benefits include:

- Time saving during on-site inspections.
- Monitoring safety, quality, quantities, and compliance.
- Replace on-site-derived topography with aerial mapping and analytics.
- Stakeholders quickly receive the accurate information they need to closely monitor projects without having to be on-site.
- Identify and resolve potential issues before they require costly rework.
- Get the data needed for accurate billing.
- Pre-construction through design evaluation and validation.
- Win more bids with accurate and fast estimations.
- Closely monitor earthwork progress and execution metrics.

With respect to the above there is the possibility to compare satellite imagery with semi-automated machinery for quality and quantity tracking as well as site planning (e.g. resource planning with various scenarios). Drone imagery may be considered for accurate deployment.

### *2.1.2. Health and Safety Inspections (Construction, Energy)*

Remote site visits/assessments and risk identification in civil construction sites, and general management site visits.

Targeted benefits include:

- Site inspection facilitated from desktop.
- Enhanced safety monitoring, risk assessments and planning.

- Automatic generation of alerts using novel AI solutions.

Solutions may include use of satellite services in consort with on-site sensing capabilities, and linked with machinery (geofencing of areas, emergency stops, etc.). Novel AI solutions may help detect issues and provide alerts or trigger actions.

### *2.1.3. Monitoring Environmental Impact in Construction Sites (Construction, Airports, Energy, Highways)*

Monitoring environmental impact of/on construction sites (e.g. weather monitoring, air quality, noise monitoring, vegetation health).

Targeted benefits include:
- Real-time data to support immediate actions to stop environmental hazards.
- Track hazards.
- Tool to monitor ESG (Environmental, Social and Governance) KPIs (Key Performance Indicators)
- Plan more efficient operations with total site view.

Solutions may include sensor fusion by combining varied data sources, machinery telemetry (fuel consumption, idle times, etc.), and others.

### *2.1.4. Asset Condition Monitoring (Construction, Airports, Energy)*

Application areas of interest include monitoring of:
- Road Maintenance
  - Pavement/road temperatures (around 0 degrees +/- 5 degrees) for winter maintenance and driver information.
  - Detect subtle displacements on the ground and/or remote bridge/structure monitoring.
- Solar PV arrays (energy leakage, vegetation, security (theft protection)

- Wind turbines (including market/geographic analysis).
- Power lines.
- Detection of faulty lightbulbs in street lighting and lampposts at scale.

Targeted benefits include:

- Near-real-time identification of critical infrastructure damage which can result in fatal accidents or costly penalty fees.
- Maximize solar array ROI (Return on Investment).
- Run “before” & “after” scenarios to allow for change monitoring and detection.
- Automatic inspections using AI with alerts for further investigation (e.g. identify faulty PV systems).
- Identify "under-served" areas to develop new sites (accounting for land use, population density and future growth, topography, average wind speeds and solar exposure etc.).

### *2.1.5. Asset Automatic Inventory (Highways)*

Use of high-fidelity data to pre-construct an asset database (e.g. to include lampposts, roadside units, cabinets, etc) for highway infrastructure.

Targeted benefit is to reduce the number of manual interventions by “pre-loading” identified assets in the database. This might be achieved through use of combined sensing techniques, machine learning algorithms and asset management software.

### *2.1.6. Autonomous Vehicle Support (Highways)*

In relation to autonomous vehicles, leveraging derived positioning and sensor data combined with digital infrastructure sensors in the road to enhance traffic flow, security, and general communications.

Targeted benefits are to support streamlined operations on highways and potentially tolling use-cases.

## 2.2. City of Amsterdam

Amsterdam, capital of the Netherlands, has more than 100 kilometres of canals. The city of Amsterdam would like to make further of use of them. This use-case invites innovative robotics applications for the enhanced use of the canals across the following areas:

### 2.2.1. Canal Infrastructure Monitoring

Amsterdam is a few meters below sea-level and built on reclaimed land. The city is 'floated' on thousands of poles. The canal walls and bridges were never designed to handle the loads they are being subjected to today by heavy vehicles and it is very difficult to assess the impact on the canal walls under water. Effective solutions for identifying, assessing, and monitoring such impacted infrastructure, for wear and for subsidence, would be valuable. Solutions may explore the use of water-based robotics achieve in combination with satellite technology or data to meet this end.

### 2.2.2. Garbage Collection and Delivery via Canals

The City of Amsterdam is not able to build underground garbage containers in the city centre. This means residents and businesses leave their garbage on the streets – the bags get opened and waste is dispersed by seagulls and rats. It would be of value to understand if the canals could be used for (autonomous) garbage collection and delivery of the garbage to waste sorting centres. Thus, offering an alternative to heavy vehicle transport in the city (and supporting in alleviating the issue mentioned in 2.2.1).

### 2.2.3. Goods Delivery via Canals

There are thousands of hotels, restaurants, cafes, etc. in the city centre, the City of Amsterdam would like to see transport over water for logistics distribution. It could be for food and perishable goods from the Food Distribution Centre, but also parcels/packages. The ability to efficiently transport items across the water would be positive but this would still require effective means of moving the goods from the water onto the land. which may require large-scale infrastructure changes such as use of cranes. Water transport can be very expensive and still requires large amounts of human intervention. Effective, affordable, autonomous solutions to goods delivery via the canals would be of interest, and this would also offer some alternative to heavy vehicle use on land.

### *2.2.4. Passenger Transportation via Canals*

Autonomous solutions for passenger transportation via canals is of interest. Similar to 2.2.1, this is in view of relieving the burden of land transport, but also to enhance the attractiveness of Amsterdam as a tourist destination with seamless and efficient canal-based transportation.

### *2.2.5. On-Demand Infrastructure on the Canals*

The on-demand, rapid assembly of infrastructure, such as temporary bridges and floating pontoons, are of interest, perhaps enabled by modular robotic platforms. This is in view of exploring the possibility of temporary footbridges or an ad-hoc event space such as for a Sunday floating farmer’s market, for example, utilising water area instead of the equivalent on land. Once concluded, the waterway could be reopened to water mobility (and other services).

### *2.2.6. Other Innovative Solutions utilising the Canals*

The overall objective is to build smart or intelligent canals which see them being used for what they were original designed for – transportation of goods and people – and to create broader added-value where possible and sustainable. Thus, innovative ideas leveraging robotic systems and space assets to deliver societal benefits are sought.

### *2.2.7. Support to Urban Planning for Better Land Use*

Solutions to support improved urban planning are sought in order to better design or conceptualise the use of the limited amount of available land space available. This is to facilitate a move towards more human-centric public spaces (as opposed to vehicle-centric) with an emphasis on multi-modal sustainable mobility that is seamless, affordable, and safe to use.

## 2.3. Visit Flanders

Visit Flanders is the tourism destination management organisation for Flanders, northern part of Belgium. The organisation is a governmental body that is responsible for the tourism development in Flanders and the marketing of Flanders abroad.

### 2.3.1. Measuring Tourist Flows

Measuring the number of tourists has become very important. It was in the past but now since over tourism has become an issue it is even more important, and it has become more complex. In the past Visit Flanders used the official statistics of overnight stays, but this is not sufficient anymore for several reasons:

a) Concerning over tourism, the day tourists play an important role. Official statistics don't give a view of this.
b) Overnight statistics don't show flows of tourists which is important information in managing a destination.
c) The official overnight statistics only show figures for official accommodations. In the past this was almost exhaustive but with the rise of Airbnb and other rental platforms the number of unofficial accommodations has risen. To tackle the problem of the rental platforms, Visit Flanders uses data from a specific source that scrapes Airbnb data on the website, but this causes another problem because on those rental platforms there are also a lot of official accommodations active and the share of both is not known.

Visit Flanders experimented in the past already with telecommunications data (as the only source and each time from one provider) and always focusing on specific events and geographically small in size. Visit Flanders was never completely satisfied with the results. Several issues appeared.

### 2.3.2. Measuring Sustainability

As with many destination management organisations, Visit Flanders focuses on sustainable tourism. To measure the sustainability, Visit Flanders developed a theoretical framework of indicators, but these are not easy or suboptimal to fill in. Specifically, emissions are very difficult. $CO_2$ emission for example, is calculated only for travellers using air and only for the part of air transport using a formula-based number of arrivals in Flanders and the theoretical emissions linked to that distance per country of origin to Flanders. The real emissions are more than just those linked to air travel but approaching air transport in general might also not be ideal.

Therefore, solutions that may support the approximation of $CO_2$ emissions resulting from tourism are welcomed.

### *2.3.3. Other Innovative Solutions*

Visit Flanders is also open to novel solutions that will make travel to the destination more appealing to tourists. This could be related to improved accessibility in relation to general tourists and those with disabilities, improved sustainability through e.g. preservation of natural assets such as national parks, prevention and mitigation of illicit and anti-social activities (such as parking in non-designated areas), or otherwise.