

A small satellite with solar panels is shown in the upper left corner, floating in space against a black background with stars.

# Satellite Applications for Waste Management



Issue/Revision: 1.0

Reference: ESA-TIAA-HO-2016-0735

Status: Draft

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## 10.00 – 11.15 Session 1

Welcome from ESA & KTN

Introductory talks (ESA)

- Integrated Applications Promotion programme
- Overview of Space Assets
- Previous activity covering space capabilities
- European Legislation
- Purpose of workshop and IAP opportunities

UK waste management activities;

- Steve Lee, Chartered Institution of Wastes Management (CIWM)
- Lesley Rapley, Exeter City Council
- Stephanie Gray, Isle of Man Government

Objectives for the day (ID)

- Briefing Information
- Discussion format
- Findings

## 11.30 – 13.00 Session 2 (facilitated small groups)

Facilitated discussion

- Commercial / Industrial / Domestic waste
- Biomass / Anaerobic digestion
- Landfill and illegal dumping

Potential Ways Forward

- Identify priority requirements
- Identify applicable satellite technologies
- Funding routes
  - Open competition
  - Invite proposals

## 13.00 – 13.45 Lunch and Networking hosted by KTN

## 13.45 – 14.30 Session 3

Reports from each facilitated group

Conclusions

## 14.30 Close and Networking

1. Welcome and Introduction
2. Presentation on ESA, ECSAT and IAP
3. Overview of Space Assets
4. Activity Examples using Space Assets
5. Purpose of the Workshop

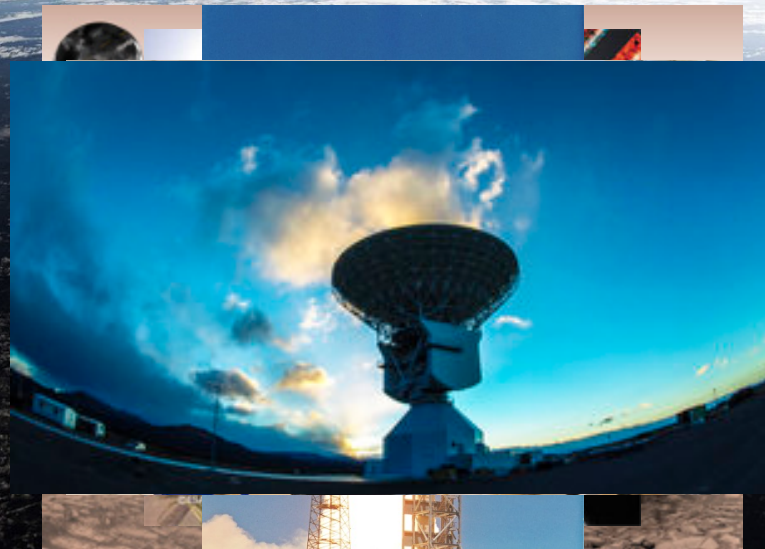


→ SERVING EUROPEAN  
COOPERATION AND INNOVATION



ESA is one of the few space agencies in the world to combine responsibility in nearly all areas of space activity.

- Space science
- Human spaceflight
- Exploration
- Earth observation
- Launchers
- Navigation
- Telecommunications
- Technology
- Operations







**OUR 22 MEMBER STATES COMBINING THEIR  
EFFORTS IN SPACE, FOR THE AVERAGE COST OF A  
CINEMA TICKET PER CITIZEN PER YEAR**

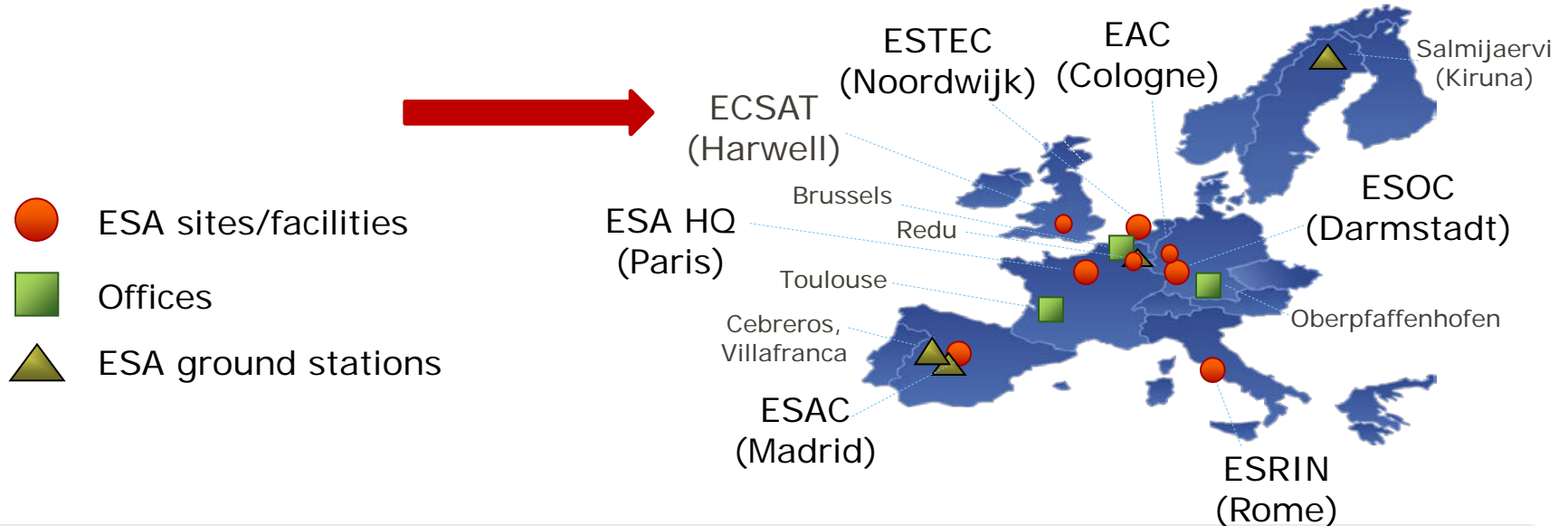
**ESA has 22 Member States: 18 states of the EU (AT, BE, CZ, DE, DK, ES, FI, FR, IT, GR, IE, LU, NL, PT, PL, RO, SE, UK) plus Norway and Switzerland. Estonia and Hungary are joining ESA in 2015.**

Seven other EU states have Cooperation Agreements with ESA: Bulgaria, Cyprus, Latvia, Lithuania, Malta, Slovakia and Slovenia. Discussions are ongoing with Croatia.

Canada takes part in some programmes under a long-standing Cooperation Agreement.



# ESA'S LOCATIONS





# Inauguration of ECSAT 9<sup>th</sup> July 2015



## Diversity in activities

- Telecommunications
- Integrated Applications
- Earth Observation
- Exploration
- Technology
- Business Incubation



## Specific identity

- Development of commercial space based products and services
- Development of downstream applications

## Gateway to rest of ESA, Europe and UK

- Bringing ESA to the UK
- Bringing the UK to ESA

## ESA's Telecommunications and Integrated Applications programme has a **dual objectives**:

- *To enhance the **competitiveness of Industry** by means of Research Development and Innovation of Satcom **products, services and applications***
- *To **support** the economy growth, **contribute** to the resolution of problems that affect the European Institutions and the **European society at large***

## Advanced Research on **TE**lecommunication Satellite **S**ystems (**ARTES**)

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*IAP is ESA's user driven strategy to leverage on space investments and develop sustainable services and new Missions*



**Earth  
Observation**

**Tele-  
communication**

**Navigation**

➔ **Developing new services for new user communities**

**Manned  
Spaceflight**

**User  
Demand**

**Feasibility  
Study**

**Demo**

**Operational  
Service**

# Providing a Steady Stream of Opportunities

## Thematic Areas



### ARTES IAP

#### Integrated Applications Promotion

*(using multiple space assets e.g. Satcom, Satnav, Earth Observation)*

### ARTES

#### Competitiveness & Growth

*(Capacity Building, Distance Learning, B2B/B2C, Telemedicine, etc.)*



The aim is to establish operational and economically sustainable services!

ESA funding is mostly up to 50%: industry and users contribute the other 50%, which helps ensure the services are sustainable.

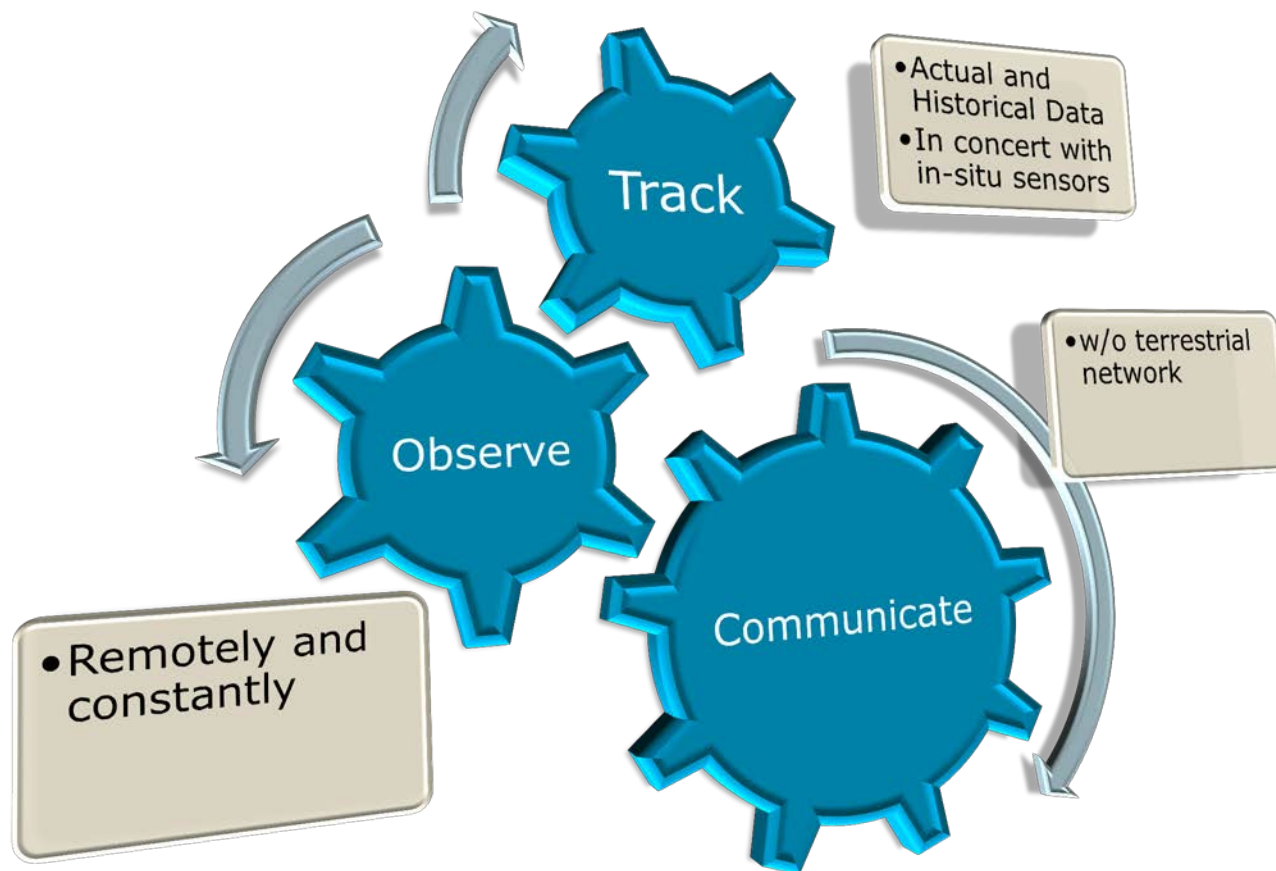
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European Space Agency



# Space technologies can enable you to....



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**Close and Networking**



# IAP Waste Management workshop Use of Space Assets

ECSAT, 19<sup>th</sup> January 2016

Tony Sephton – Special Projects Office

Integrated and Telecom Applications Department

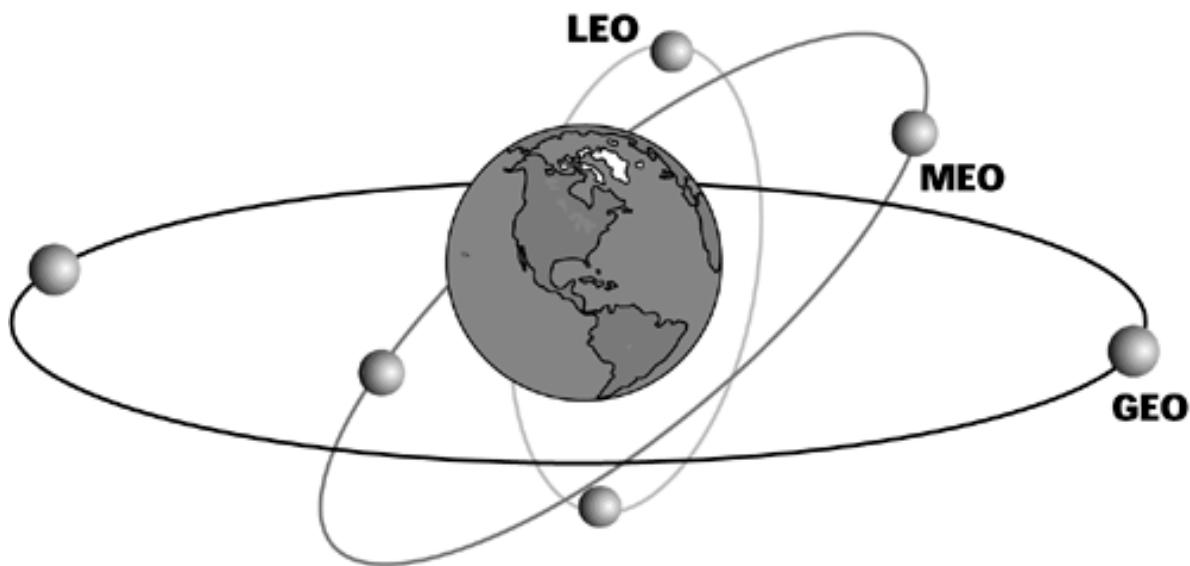
[tony.sephton@esa.int](mailto:tony.sephton@esa.int)

Ref. ????

Iss. 1.0

- Satellite Orbits
- Satellite technologies:
  - a. Remote Sensing.
  - b. SatCom.
  - c. SatNav.
  - d. Human Spaceflight.

# Typical Satellite Orbits



<http://flylib.com/>

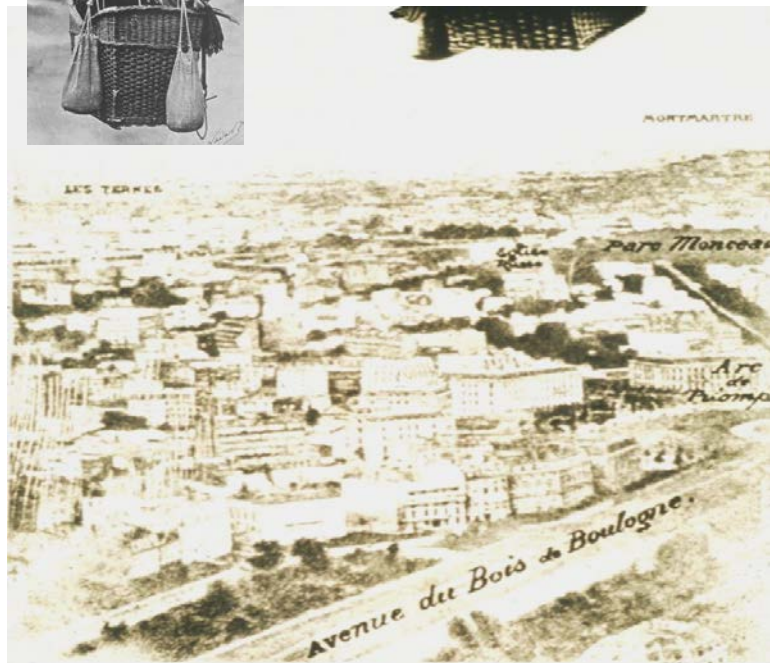


# Why Remote Sensing?



- Many monitoring issues are regional or global.
- Remote Sensing is:
  - a. Global.
  - b. Repetitive.
  - c. Consistent.
- Remote Sensing can provide:
  - a. Spatial information.
  - b. Temporal information.
  - c. Spectral information (frequency/wavelength).
  - d. Angular information (different view angles).
- For many operational applications, Remote Sensing is not exclusive but is **combined** with *in-situ* measurements.

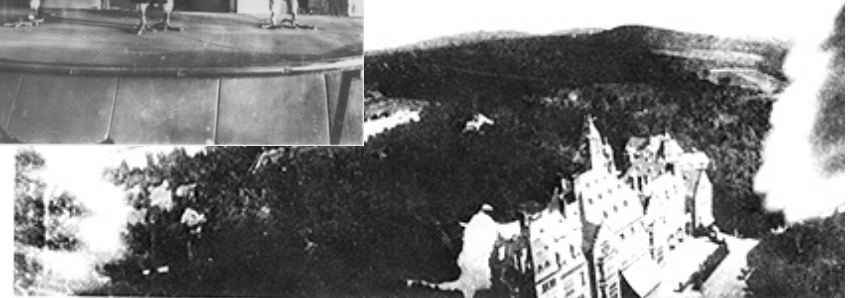
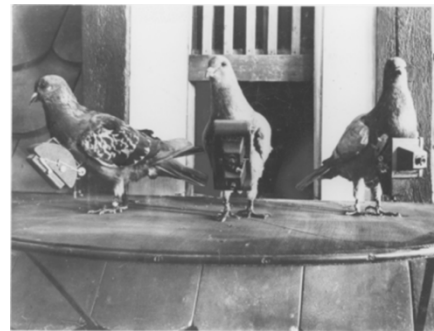
# Remote Sensing can be aerial as well as satellite, and not necessarily by plane !



Paris by balloon,  
1859

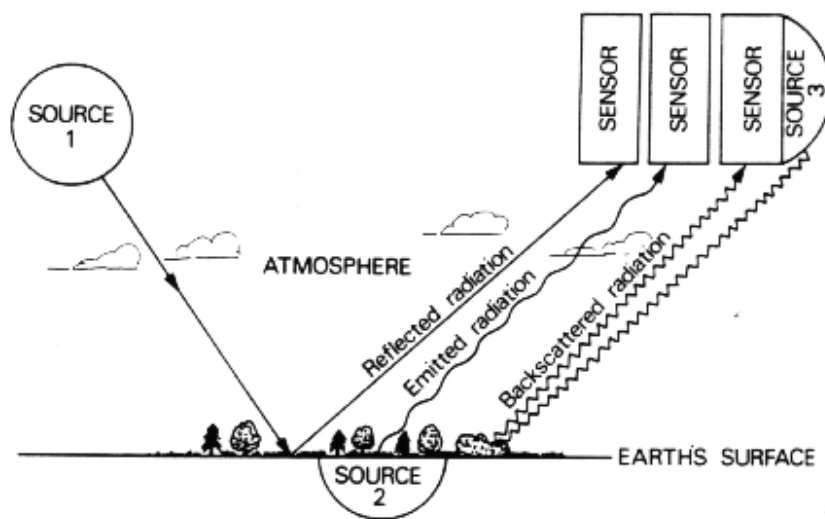
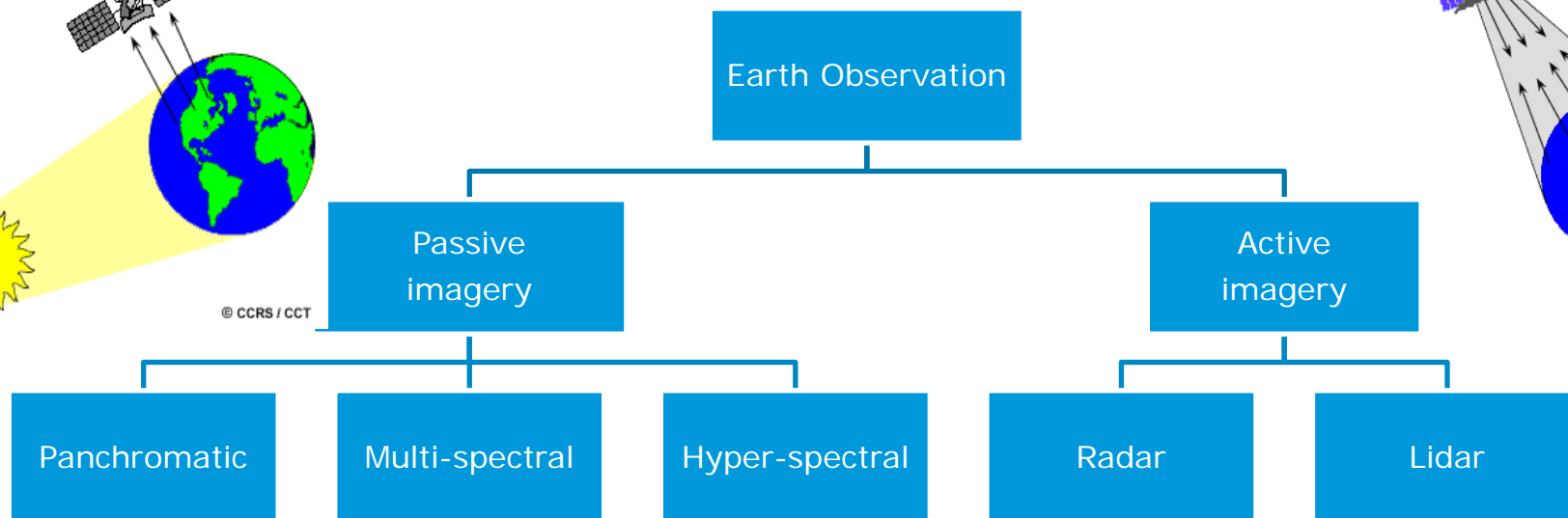
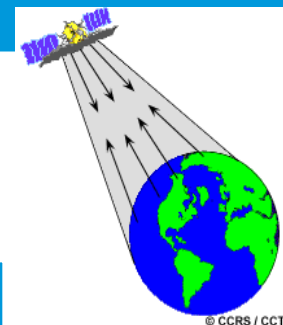
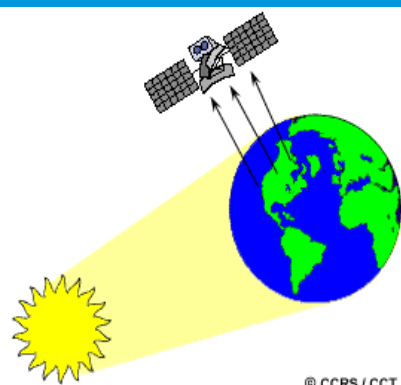


San Francisco by kite, 1906



Bavaria by pigeon, 1906

# Types of EO imagery



# EU Copernicus programme



European *independence* & contribution to *global observing system*

Global, timely and easily accessible information

- Data Continuity
- Complementary to Contributing Missions
- Long-term observations
- Open access to data
- Fully operational system
- Comprehensive EO system

Complementary to EU Galileo GNSS programme



Integration of Space and non-Space Assets provides excellent opportunities for enabling new services or innovative improvements in existing services





# Copernicus Space Component



**S1A/B:** Radar Mission: **Land and Ocean services**; 6 days with 2 sats;  
Land cover, soil moisture and water content, frost/thaw state



2014 onwards



**S2A/B:** High Resolution Optical Mission: **Land services**; 5 days with 2 sats; Land cover, biomass, fire frequency, cultivation, harvest, leaf chlorophyll and water content, leaf area index, forest parameters



2015 onwards



**S3A/B:** Medium Resolution Imaging (21 channels) and Altimetry Mission: **Ocean services**; 2 days with 2 sats; Ocean greenness, sea surface temp, sea salinity, scatterometry for winds, water quality and pollution



2016 onwards



**S4A/B:** Geostationary Atmospheric Chemistry Mission ; Atmospheric composition monitoring from geostationary orbit



2019 onwards



**S5P:** Low Earth Orbit Atmospheric Chemistry Mission; S5 Precursor to bridge the gap between Envisat (Sciamachy data in particular) and Sentinel-5



2016



**S5A/B/C:** Low Earth Orbit Atmospheric Chemistry Mission; Atmospheric composition monitoring from polar orbit



2020 onwards



**S6 (Jason-CS A/B):** Altimetry Mission



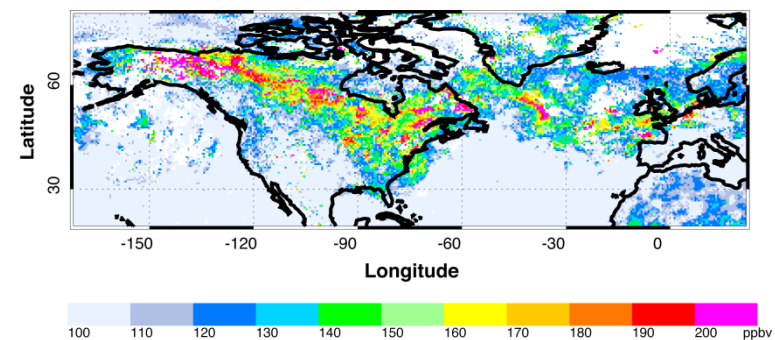
2019 onwards



# Operational Remote Sensing applications examples



- Meteorology.
- Land and vegetation (agriculture, forestry, desertification).
- Subsidence monitoring.
- Environmental impact assessment.
- Fire detection.
- Thermal energy efficiency of buildings.
- Border and Maritime surveillance.
- Ship routing.
- Ocean currents.
- Oil spill monitoring.
- Fisheries and aquaculture.
- Ice mapping (type, thickness, icebergs).
- Snow cover mapping.
- Flood mapping.
- Air pollution monitoring.



**Intense wildfires in Alaska  
in July 2004 -> pollution  
plumes**

European Space Agency

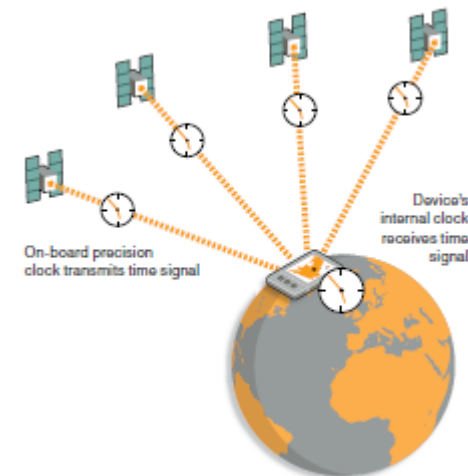
- Voice, text, imagery, video, M2M, ...
- Connecting **remote** places without terrestrial communications.
- Transmission of **secure** information.
- **BLOS** communication with RPAS.
- Applications requiring **large bandwidth** (lot of data / information).
- **Multicast / broadcast** applications.

Jan Dettmann | ESA-TTAA-RO-2016-0735 | ECSAT | 12/01/2016 | Slide 25

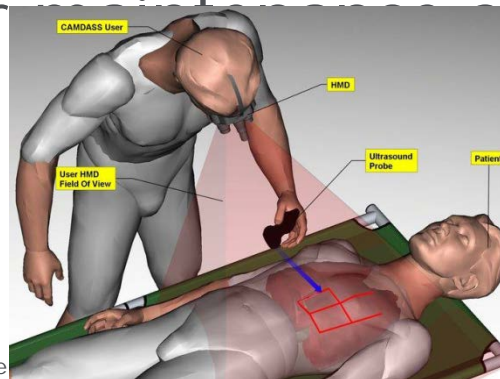
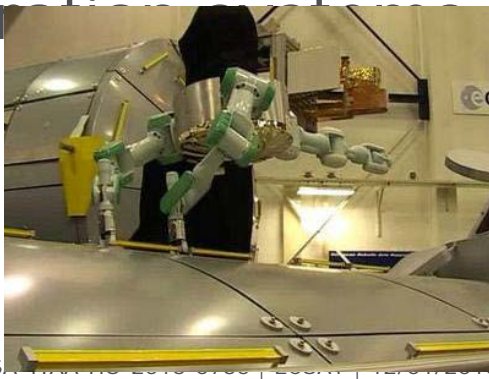
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C-band	4 – 8 GHz	<p>Transmissions immune to atmospheric conditions such as snow and rain.</p> <p>C-band transmissions have low power, so Ground Stations must be large to compensate, typically 4.5 - 18m diameter.</p> <p>Primarily used for voice and data communications as well as backhauling. International TV broadcast uses this frequency allocation heavily.</p>
X-band	8 - 12 GHz	Mainly used for military communications.
Ku-band	12 – 18 GHz	<p>The Ku-spectrum has higher power than C-band, allowing smaller Ground Stations to be used (&lt; 4 m diameter).</p> <p>Higher frequency of Ku-band makes it more susceptible to adverse weather conditions than C-band.</p> <p>Applications include consumer direct-to-home access, distance learning applications, retail and business connectivity.</p>
Ka-band	27 – 40 GHz	<p>Ka-band has a higher power frequency than Ku-band.</p> <p>Ka-band transmissions are even more sensitive to poor weather conditions than Ku-band, so not useful for tropical regions of the Earth.</p> <p>Applications include high-bandwidth interactive services such as high-speed Internet, videoconf and multimedia applications.</p>

- **Positioning** from **GNSS**:
  - Correction data such as RTK allows centimetric precision.
- **Tracking** of individual persons and goods.
- Precise **timestamping** of events.
- **GNSS reflectrometry**:
  - Sea state measurements.
  - Wide-swath altimetry.
- **SAT-AIS** for maritime applications.



- Platforms for **test payloads**:
  - Shuttle Radar Topography Mission (SRTM).
- Development of **eHealth** applications for astronauts.
- **Operational** payloads on the ISS:
  - Urthecast.
  - Icarus.
- **Robotics** and **Augmented Reality**, e.g. Tele-operation, telemedicine for medical support.



- **Mega-constellations** of numerous small cheap satellites.
  - > Near real-time global coverage.
- New commercial players, e.g. Google, Facebook, ...
- Higher bandwidth SatCom.
- **Optical** communications technology, e.g. European Data Relay Satellite (EDRS).
- **Reconfigurable** payload technologies -> greater in-orbit flexibility.
- **Multi-Constellation SatNav** (GPS, Galileo, GLONASS, Beidou, ...)
  - > Better availability of signal.



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# Examples: IAP Project



## **SSMART:**

monitoring and managing multimodal (road, rail, waterways) transports of dangerous goods for improving safety, coordination, information exchange, and communication for both routine transport operations as well as for emergency situations.



**Navigation:** Using GPS and augmentation systems the transports of dangerous goods will be tracked. One potential solution is re-routing of vehicles following safety considerations, e.g. to avoid traffic jams, road works or difficult weather conditions. In case of an accident, the exact position of the transport is vital to know.

**Satellite communications:** In case of poor or no coverage of cellular networks, a satellite network, presenting a highly reliable communication channel, will be used as a back up. Satellite communications will take place also in case of cellular network saturation which often occurs during a crisis / emergency situations.

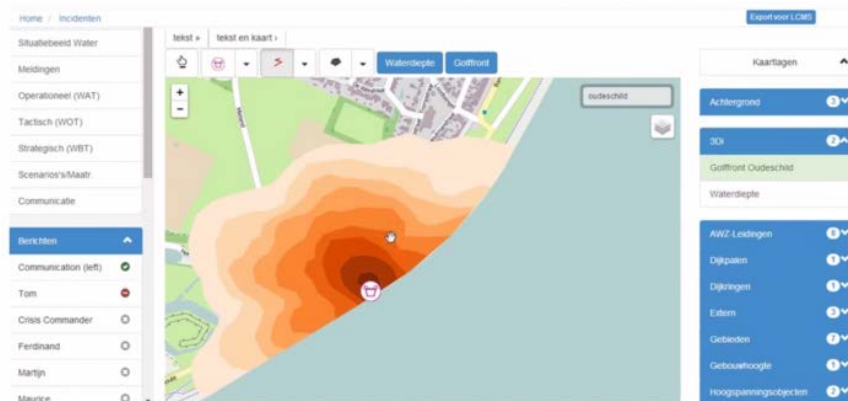
**Earth Observation:** Data from remote sensing satellites will be used for mapping applications and for disaster management

# Examples: IAP Project Eagle Space



Integration of space based capabilities in crisis management to support the joint combat of natural flooding and wildfire disasters.

Distribution of the situation on a map is of the utmost importance in the context of an effective emergency response.



**Earth Observation data** and derived maps provide an essential overview for the different phases of an incident (preparation, response, aftercare).

**Satellite communication** offers the essential possibility to share information in the field in situations where ground based facilities like a classic cellular network are disrupted.

**Satellite Navigation** based alerting services can alert civil people in the disaster area.

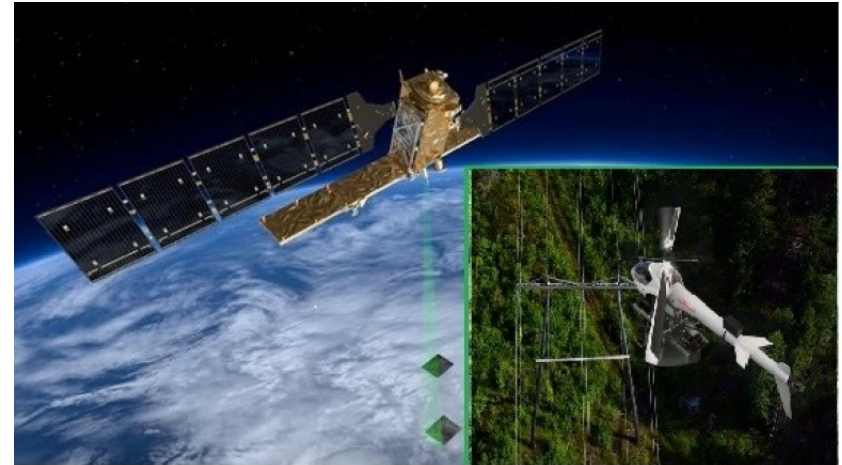
# Examples: IAP Project



Efficiently inspect geographically distributed infrastructure such as long networks and pipelines extending over tens of thousands of square miles of geographical area.

The needs defined by end users are:

- rapid recognition of damages after storm
- clearance need detection and prioritization of areas
- supervision of vegetation clearance
- cost efficiency of new methods



The proposed integrated solution includes two relevant space assets:

The **Satellite Earth Observation** is the only inspection method that does not require someone or something to visit the inspection site. It is able to deliver wide coverage, low cost data over the power line network and related vegetation frequently. This enables optimizing the timing and frequency for inspections and potentially replacing partially traditional inspection methods. SatEO data is significantly reducing costs for the maintenance inspections.

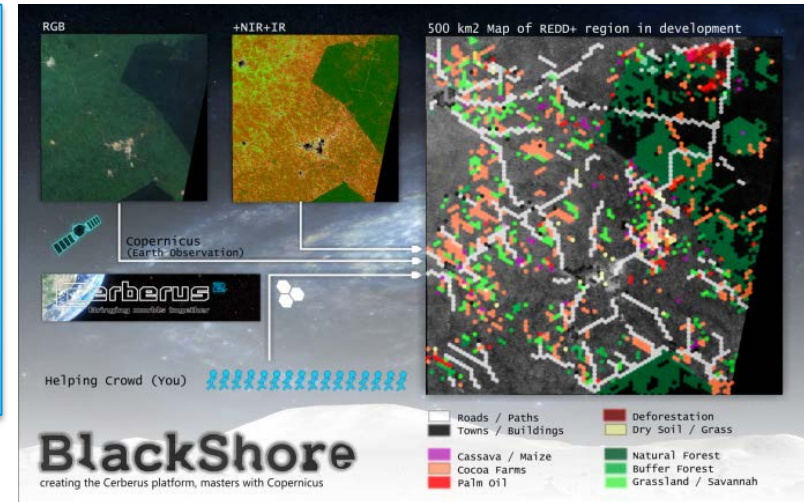
The dominating remote sensing method will be **UAV**, based on the **satellite navigation system GNSS**, due to its cost-efficiency, availability and support for both LiDAR and visual imaging.



# Examples: IAP Project



Development of a technology to transform satellite imagery into maps **through the use of crowdsourcing methods** to detect and avoid deforestation. The technology has the capability to generate maps faster and more thorough than experts.



**Earth Observation:** In Cerberus the crowd has interaction with the satellite products, which consists of existing EO images + project areas. In these areas the crowd maps the features matching in the existing requirements and other needs of the customer. Features that are of interest are: the localization of agriculture, rain forests, infrastructure and residential areas.

**Satellite navigation** is used in situ for both verification and execution of steps locally. Using navigation CERBERUS can verify on the ground what has been mapped from space. This is important for the validation of the system.

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# Waste Management legislation

Martin De Mercado Gonzalo

17/01/2016

Issue/Revision: 1.0

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## 1. EU waste generation facts:

- a. Around 3 billion tonnes of waste per year in total (2010).
- b. Hazardous waste is estimated in 100 mTonnes per year.
- c. 38 % of the household waste is recycled (2008), with potential up to 70 %.

## 2. Business opportunity:

- a. Waste management currently represents 1.1 % of EU's GDP.
- b. Potential to create up to 500,000 new jobs.

## 3. Regulation approach:

- a. Reduce environmental and health impact.
- b. Turn Europe into a "recycling society" :





1. Waste management statistics (Regulation 2150 / 2002):
  - a. EU countries shall transmit statistical results on waste management to Eurostat every two years.
  - b. Firms with less than 10 employees are excluded from any surveys.
2. EU Waste Framework Directive (2008/98/EC), revised in 2015:
  - a. Establishment of a waste hierarchy.
  - b. Polluter must pay the costs of waste management.
  - c. 2020 targets for recycling waste: 50 % household, 70 % demolition.
  - d. Does not cover certain types of waste such as waste water, radioactive, decommissioned explosives, faecal and animal carcasses



3. Landfill of waste (Directive 1999/31/EC), revised in 2011
  - a. Landfill sites divided in three categories, according to the waste: hazardous, non-hazardous and inert: only treated waste can be landfilled.
  - b. Levels of Biodegradable Municipal Waste sent to landfill must be no greater than 35% of the 1995 tonnage by 2016.
  - c. Landfill facilities may not accept used tyres or waste which is liquid, flammable, explosive or corrosive, or from hospitals and medical and veterinary practices.
  
4. Safe waste shipments (Regulation 1013/13/2006), within EU and with non-EU countries:
  - a. Shall be done in an environmentally sound manner.
  - b. Exports of waste to non-EU countries for disposal are prohibited. Imports of waste from non-EU countries for disposal or recovery are prohibited.
  - c. EU countries shall implement inspection mechanisms, focusing on problematic waste stream (hazardous, e-waste).

# SATELLITES FOR WASTE MANAGEMENT USER WORKSHOP

Ian Downey UK IAP Ambassador Platform, ECSAT  
19 January 2016

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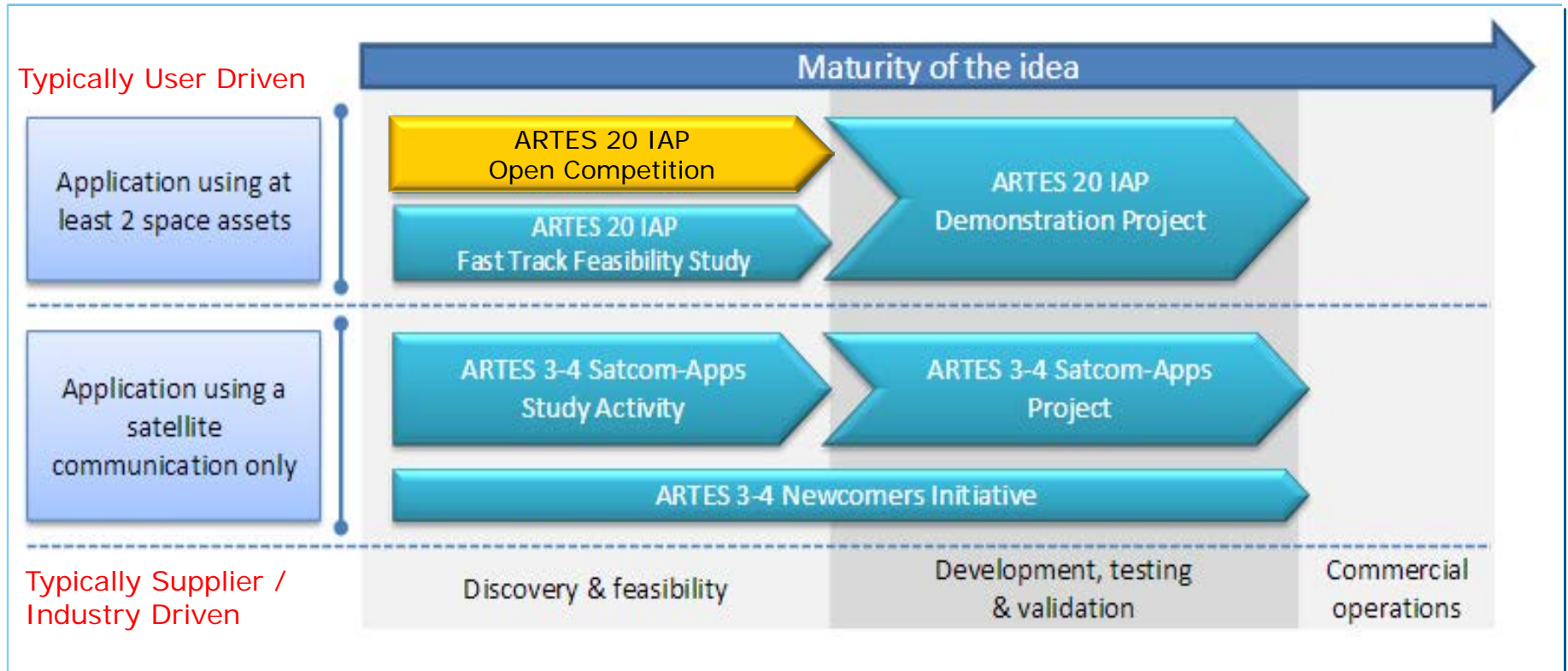
- Satellite technologies are not believed to be currently widely used in the Waste Management and Biomass Energy industry sector
- Satellite technologies have potential to support new or improve existing services for this sector
- Sector complexity: linkages with/between different parts, multiple players
- IAP Objectives:
  - Promotion of space applications to a wider range of users, especially those who are not aware of the benefits that space technologies can bring to them
  - Development of new operational services for these users, involving a broader participation by actors on both the demand and supply sides
  - Utilisation of at least two existing and different space-assets (EO, Satcom, SatNav, SAT-AIS, etc.)such as
  - Cross-fertilisation across disciplines
- Workshop aims to explore the technical and commercial challenges that must be overcome to transfer satellite technologies into the Waste Management and Biomass Energy sectors.
  - Better identify End User needs
  - Define the problem space
  - Inform suppliers, service providers and potential users of the satellite system capabilities

## Funding routes

- Continuously Open Call
  - Invite proposals
  - Identify priority requirements
  - Identify applicable satellite technologies
  - Develop outline proposal, iteration to full proposal
  - Implementation by direct negotiation
- Open competition
  - Define requirements
  - Define applicable satellite technologies
  - Develop Statement of Work
  - Issue competitive ITT

# ARTES Applications Funding Modes

<https://artes-apps.esa.int/opportunities>



# Objectives for the Day



- Background Information
  - Satellite Capabilities
  - Waste Sector Context
  - ESA Funding programme opportunities
- Facilitated discussion
  - Commercial / Industrial / Domestic waste
  - Biomass / Anaerobic digestion
  - Landfill and illegal dumping
  - Others? (e.g. Hazardous waste, e-Waste, etc.)
    - Cross cutting topics e.g. Logistics / Transport and Legislative drivers
- Discussion and findings of the workshop will help to:
  - Identify sector challenges and user requirements
    - Encourage potential proposals for direct negotiation
    - Assist scoping a potential open competition
  - Inform ESA in developing future programmes and help shape funding opportunities that reflect the needs of this community



# Europe's Waste Streams

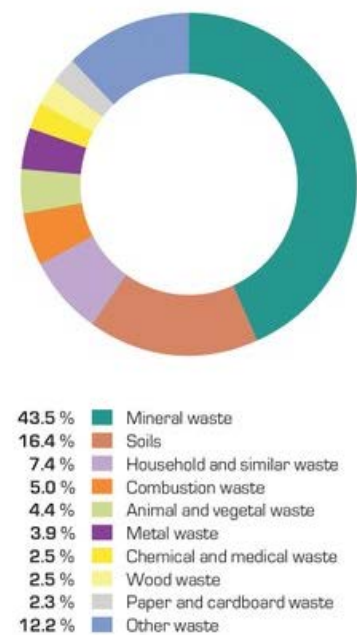
EEA Signals 2014:

In 2010, about 2500 million tonnes of waste was generated in the EU-28 and Norway

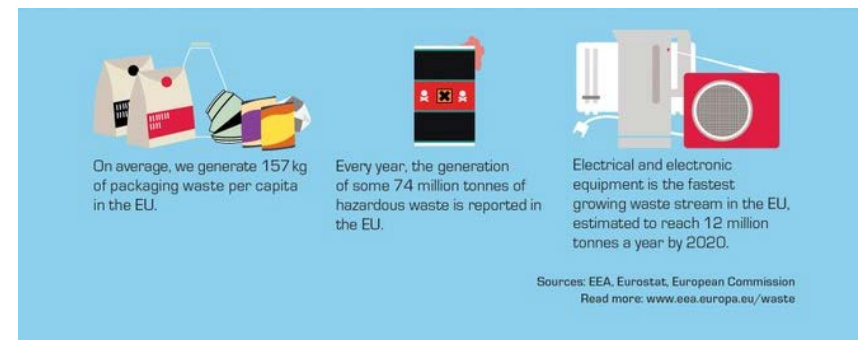
Waste streams by source



Waste streams by type of waste

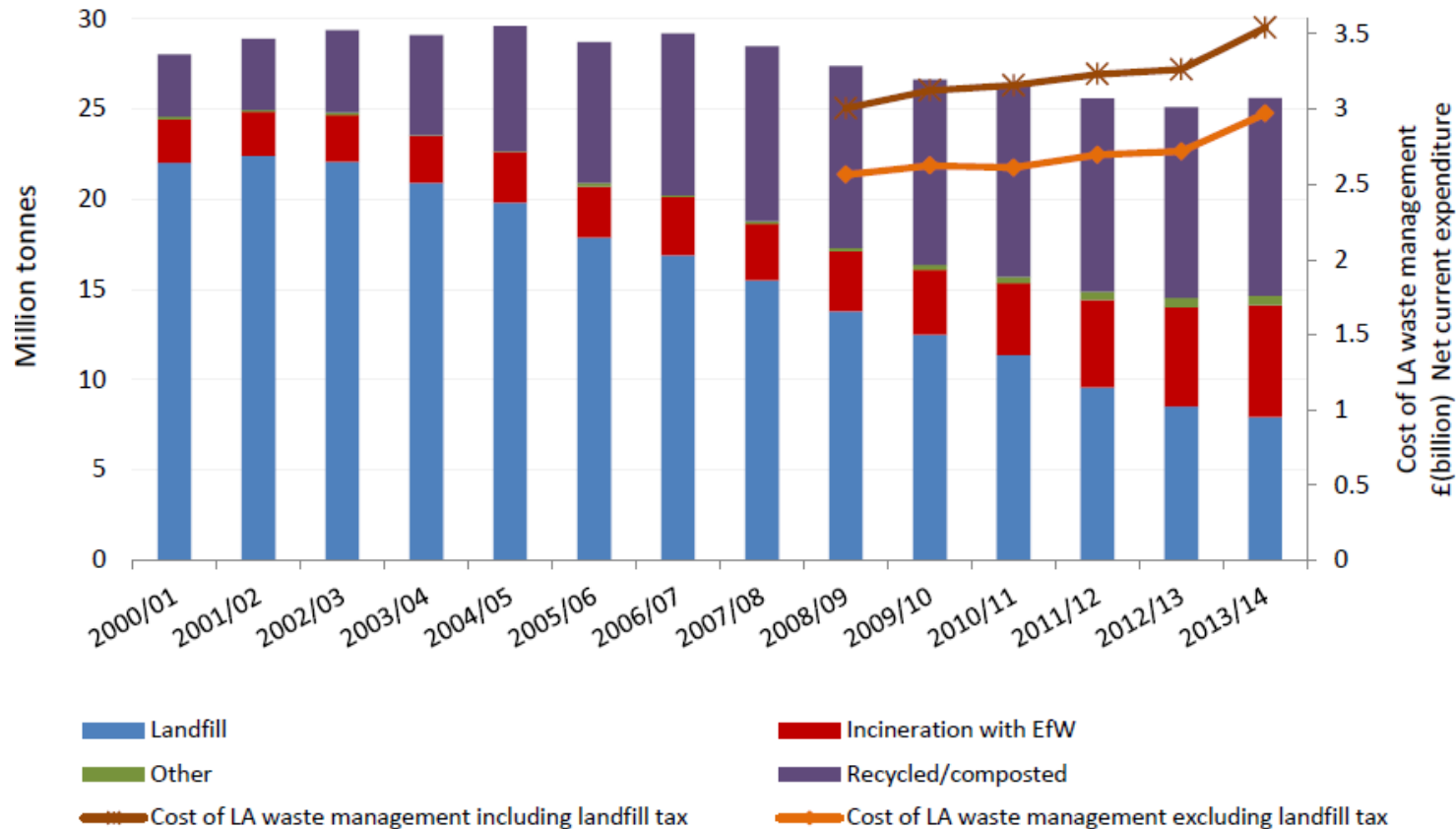


Source: Eurostat 2010 data on EU-28 and Norway



<http://www.eea.europa.eu/signals/signals-2014/articles/waste-a-problem-or-a-resource>

# Destination of Local Authority collected waste England, 2000/1 – 2013/14



Source: Defra Digest of Waste and Resource Statistics – 2015 Edition

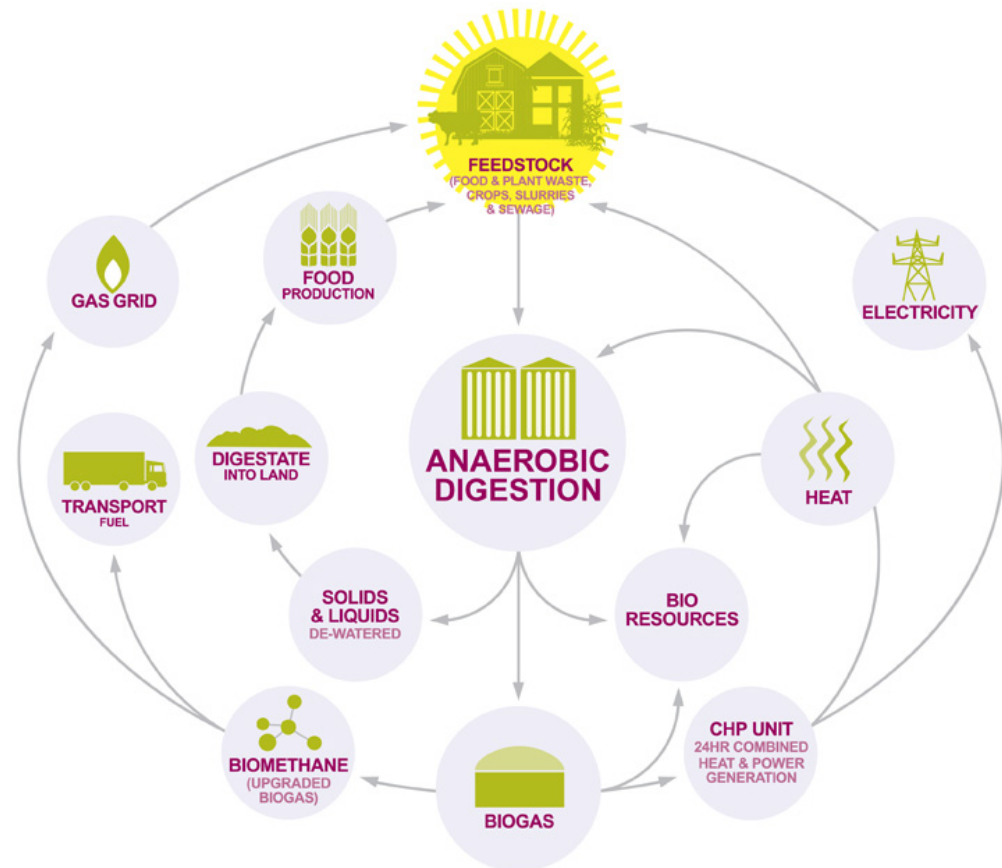
<https://www.gov.uk/government/statistics/digest-of-waste-and-resource-statistics-2015-edition>

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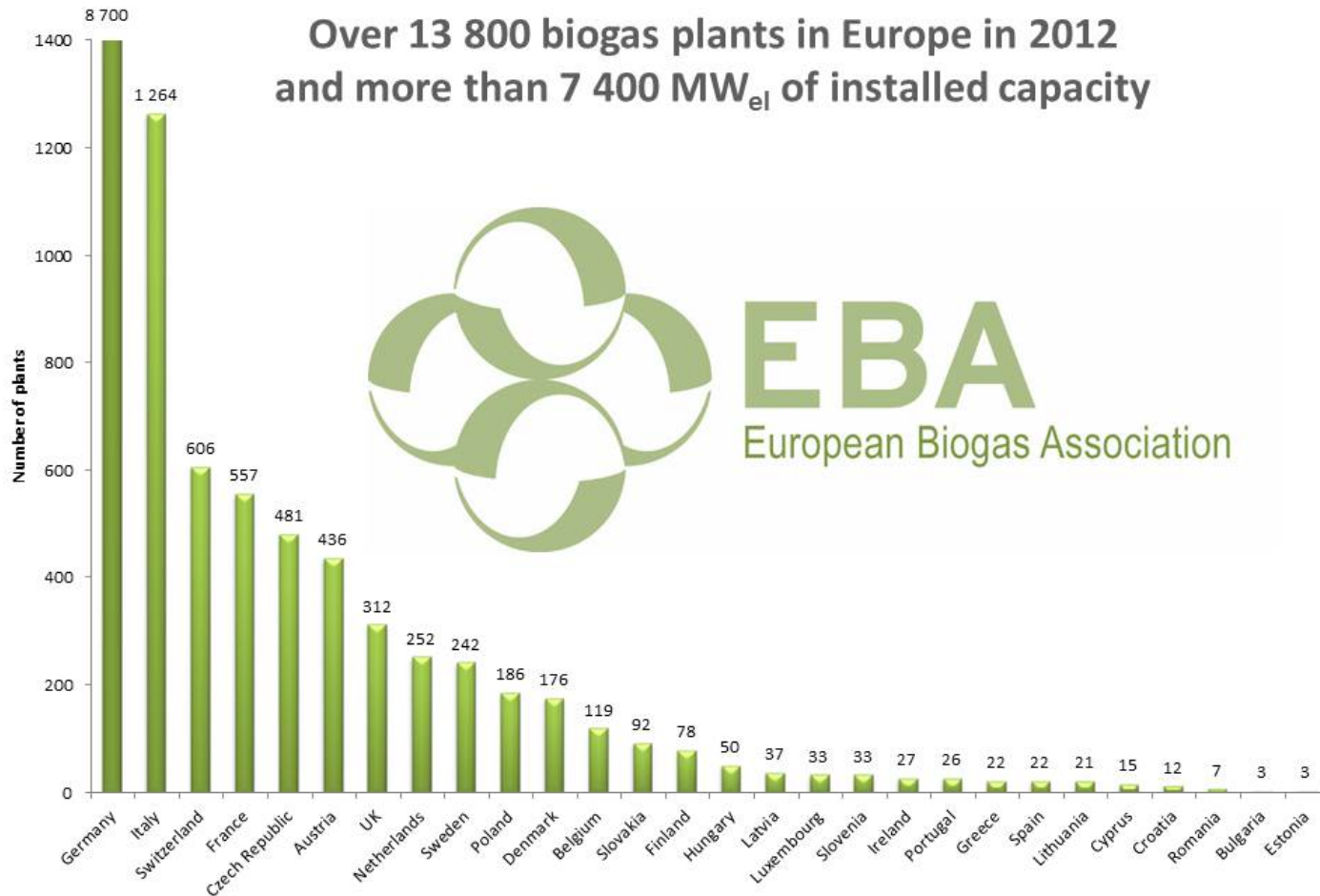
# Biomass Energy Burning Feedstock & Anaerobic Digestion

## Anaerobic Digestion (AD) processes and waste management issues

- Logistics of feedstock, domestic and imported sources, cross border movement of waste materials
- Reverse logistics/re-purposing waste outputs
- AD Outputs
- Methane, carbon dioxide gases (biogas), water and some organic material (digestate)
- Biogas burned to produce both heat and electricity (CHP)
- Methane can be used as vehicle fuel or injected into the gas grid.
- Digestate is nutrient-rich used for
  - Fertiliser
  - Feedstock for ethanol production
  - Low-grade building materials, e.g. fibreboard.\



<http://adbioresources.org/>

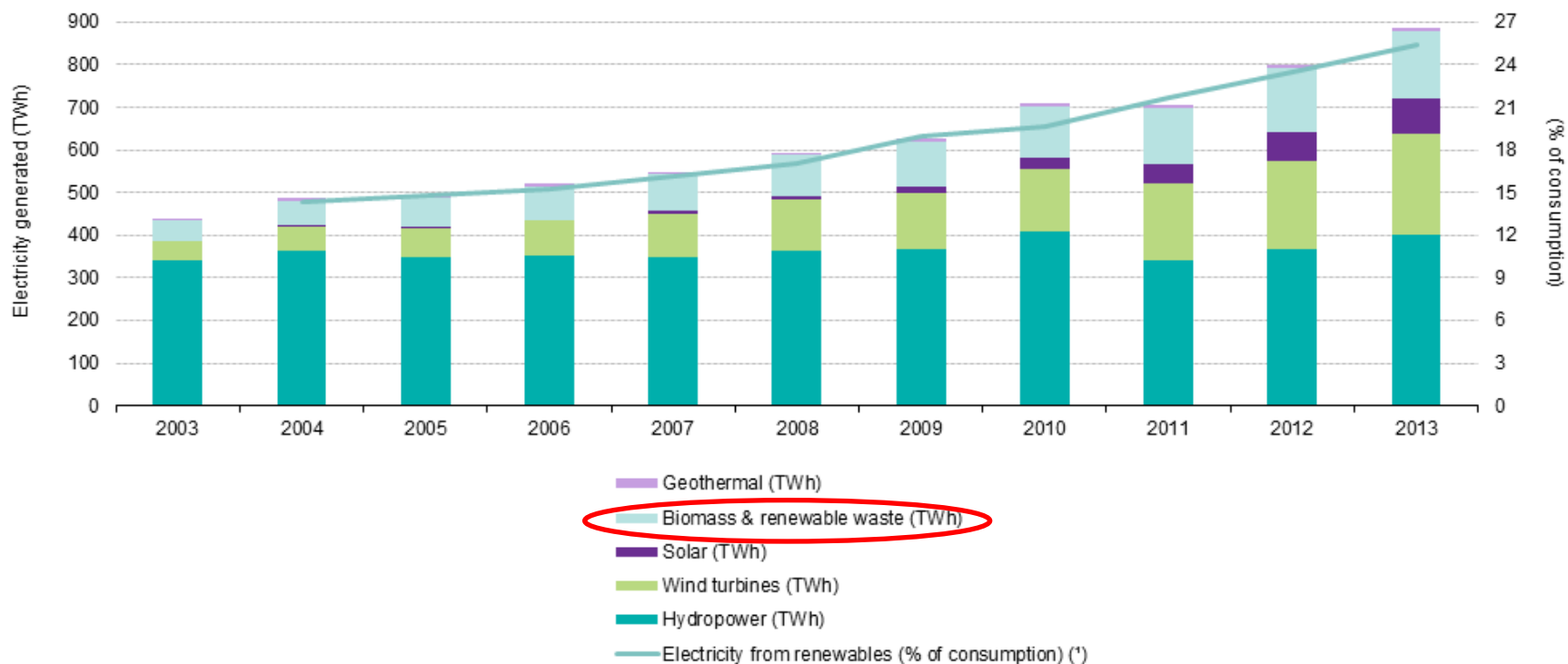


EBA 2012

<http://european-biogas.eu/2013/12/20/eba-presents-latest-biogas-production-statistics-europe-growth-continuous/>

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# Electricity From Renewables in EU



(\*) 2003: not available.

Source: Eurostat (online data codes: nrg\_105a and tsdcc330)

Electricity generated from renewable energy sources, EU-28, 2003–13

[http://ec.europa.eu/eurostat/statistics-explained/index.php/Renewable\\_energy\\_statistics](http://ec.europa.eu/eurostat/statistics-explained/index.php/Renewable_energy_statistics)

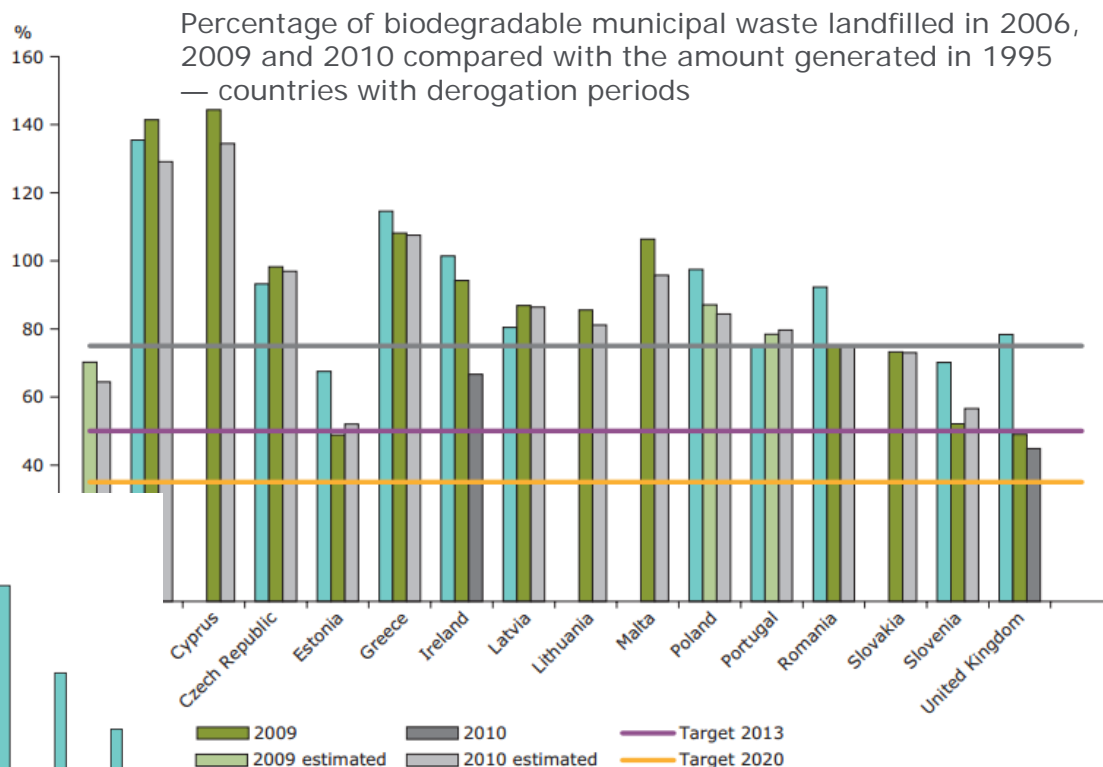
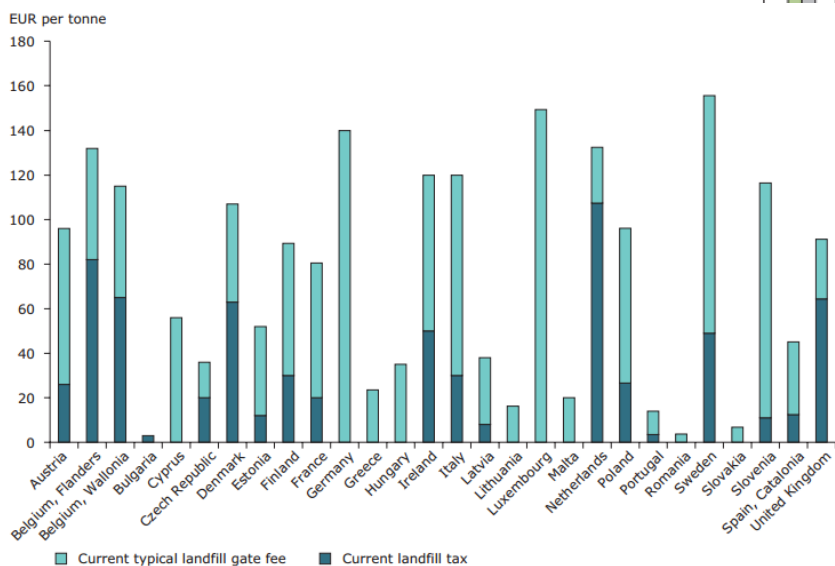
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# Landfill and Illegal Dumping

## Main priorities:

- Landfill pressures and impacts (planning, monitoring, etc.)
- 2016 Cessation
- Costs/Tax burden



Typical charge (gate fee and landfill tax) for legal landfilling of non-hazardous municipal waste in EU Member States and regions (2014)

<http://www.eea.europa.eu/publications/managing-municipal-solid-waste>  
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- What are the priority issues in delivering waste management services?
  - What do you do now
  - Links and dependencies
- What does the future hold?
  - What do you need to do
  - What keeps you awake at night
- How and where are these challenged / constrained?
  - Cost and Efficiency
  - Competition and Growth
  - Illegal activity
  - Health, Safety, Security
- Requirements for new or enhanced services?
  - Gaps
  - Common elements
  - Improvement / Innovation
- What is required to introduce new / enhanced services?
  - Business Incentives and/or regulatory drivers