Using MicroStrategy to Analyse the Publications Impact of ESA Missions

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1. Abstract

Throughout my four-week internship at the European Space Agency (ESA), I used MicroStrategy software to assess and compare the publications impact of ESA missions. I was fortunate to have the guidance of three supervisors: Salim Ansari (Scientist/IT specialist), Bernard Foing (Scientist), and Imy Matthews (MicroStrategy expert). With the help of these professionals, I learned how to gather data on the publications for each mission, organize this data into visualizations on the software, and use these visualizations for analysis and comparison. My method consisted of research on MicroStrategy and ESA missions, practice with the software (e.g. playing with dashboards, designing documents), and the creation of two final documents. The first document displays the publications for Gaia, Herschel, INTEGRAL, ISO, Mars Express, Planck, Rosetta, SOHO, Venus Express, and XMM-Newton. The second document presents the publications by Austria, Belgium, Germany, Spain, France, Italy, the Netherlands, and the United Kingdom for Herschel, INTEGRAL, and XMM-Newton. Using the information from both documents, I compared total impacts and analysed impacts over time by looking at launch dates, first publications, peak publications, and the path the publications were ending on. On the first document, SOHO and XMM-Newton have the largest total impact because they are the oldest operational missions. Most impacts are immediate and start within two years of launch and peak within 10 years of launch. The order of peak publications is similar to the order of total publications. Publications are peaking, stabilising, or declining. Gaia, Herschel, and Planck are young peaking missions. Mars Express, Rosetta, and Venus Express are middle-aged stabilising missions. SOHO and ISO are old declining missions. XMM and INTEGRAL are outliers. The second document shows the national impacts of Herschel, INTEGRAL, and XMM. Countries with the largest impacts were involved with the mission/science operations, science teams, industrial teams, PI instrument teams, and prime contractors. For each mission, the two largest impacts are always by big countries and the three smallest impacts are always by the same small countries. Germany and Spain stand out because they have consistently large impacts for all missions. There are several connections between the first and the second document. Most national impacts are also immediate and the same missions peak within 10 years of launch. The order of total publications and average peak publications is the same. The national impacts do not appear to be declining for INTEGRAL and stabilising for XMM-Newton, but there is some indication that Herschel's impact is peaking. MicroStrategy is useful for comparing and analysing the role of missions and countries in science and could be applied to other datasets at ESA.

2. Introduction

This report aims to summarize my four-week internship at the European Space Agency (ESA). During my experience, I learned the basics of MicroStrategy software and employed its analytical tools to assess the publications impact of ten ESA missions as well as the publications impact by country for three specific missions.

The first week was dedicated to research on MicroStrategy. Many organizations use MicroStrategy to analyse internal and external data and rely on this to make well-informed business decisions. At ESA, MicroStrategy is used for administrative purposes (e.g. cost fixing) but could provide benefits if applied to the scientific domain. I met with my supervisors Salim Ansari (IT specialist), Bernard Foing (Scientist), and Imy Matthews (MicroStrategy expert) to make a tentative plan combining MicroStrategy and data from scientific missions.

In the second week, I studied ESA missions and their launch dates, lifetimes, objectives, instruments, and teams. I was given two Excel spreadsheets to work with on MicroStrategy. One contained the number of annual publications for Gaia, Herschel, INTEGRAL, ISO, Mars Express, Planck, Rosetta, SOHO, Venus Express, and XMM-Newton from 2000 to 2015. The second spreadsheet focused on the number of annual publications by Austria, Belgium, France, Germany, Italy, the Netherlands, Spain, and the United Kingdom for Herschel, INTEGRAL, and XMM-Newton from 2001 to 2014.

To become familiar with MicroStrategy, I spent the third week experimenting with the program. With the assistance of Imy and a manual, I learned how to format data, import data, create dashboards, and create/edit visualizations on the dashboards (e.g. grids, line graphs, bar graphs, heat maps, bubble grids). After this, my goal was to create a document for each spreadsheet. I designed a layout for my final two documents and presented it to Imy and Salim for feedback.

After some challenges and adjustments in the fourth week, I completed the final two documents. The first document is titled "Publications for ESA Missions" and visualizations the impacts of Gaia, Herschel, INTEGRAL, ISO, Mars Express, Planck, Rosetta, SOHO, Venus Express, and XMM-Newton over the last fifteen years. This document enables the user to look at the data of any combination of missions over time as well as the data for all missions each individual year. The second document is titled "Publications by Country for ESA Missions" and visualizes the Austrian, Belgian, German, Spanish, French, Italian, Dutch and English impacts of Herschel, INTEGRAL, and XMM-Newton over the last fifteen years. On this document, the user can look at the data from any individual country over time as well as the data for all missions each individual year.

Using the first document, I can compare the total impacts of the missions and analyse the impacts over time by looking at the launch dates, first publications, peak publications, and the paths they were ending on. SOHO and XMM-Newton have the largest total impact and are the oldest operational missions. Excluding the impacts of SOHO and ISO (since data before 2000 is missing), all impacts are immediate and start within two years of launch and all impacts except XMM-Newton peak within 10 years of launch. The order of peak publications is similar to the order of total publications. Planck and Mars Express have dramatic impacts because their peaks are higher than other missions that have more publications. Publications are peaking, stabilising, or declining. Gaia, Herschel, and Planck are young peaking missions. Mars Express, Rosetta, and Venus Express are middle-aged stabilising missions. SOHO and ISO are old declining missions. XMM is an old stabilizing mission and INTEGRAL is a middle-aged declining mission.

On the second document, I can examine which countries are involved with what missions. France, the United Kingdom, and Spain have the largest impacts for Herschel. Italy, France, and Germany dominate the publications for INTEGRAL. Germany, Italy, and the United Kingdom have the most publications for XMM-Newton. These countries have the largest impacts because they are involved with the mission operations, science operations, data collection and processing, science teams, industrial teams, and PI instrument teams. The nationality of the prime contractor of each mission corresponds with the top impact. When looking at big countries and small countries separately, Germany and Spain stand out. They are the only countries with consistently large impacts for all missions. The two largest impacts are always by big countries and the three smallest impacts are always by the same small countries.

There are several connections between the first and the second document. Most national impacts are immediate and start within two years of launch. All national impacts for Herschel and INTEGRAL peak within 10 years of launch while most national impacts for XMM-Newton do not. XMM-Newton is typically at the top and INTEGRAL is consistently at the bottom for the number of publications and the average peak publications. The second document does not reflect that the impact of INTEGRAL is declining and that the impact of XMM-Newton is stabilizing. However, it does slightly indicate that Herschel is peaking. Creating these documents was useful for comparing and analysing the role of missions and countries in science. MicroStrategy is a valuable tool for studying the nature of scientific impacts.

3. Method

A. Week one: MicroStrategy research

I. *MicroStrategy, business intelligence, business analytics*

Salim Ansari told me to look into MicroStrategy, business intelligence, and analytics

- MicroStrategy is a company that provides business intelligence
- It develops software that helps organizations analyse internal and external data
- This allows them to make educated data-driven business decisions
- There are four main software products
    - MicroStrategy Analytics, a business intelligence software for navigating through and analysing big data
    - MicroStrategy Mobile, a software platform for building mobile business applications for the iPhone, iPad, Android, and BlackBerry
    - Usher, a mobile identity software application which provides an electronic replacement for employee IDs, keys, and proximity cards
    - Alert, a mobile commerce application platform for building branded mobile applications for marketing, commerce, and loyalty (MicroStrategy, 2014)
- Many renowned organizations are customers of MicroStrategy
    - Target uses it to examine and improve all aspects of operation
    - Hilton uses it to analyse the global company and the brand portfolio at the executive, functional, and properties level
    - Gucci uses it to improve the customer shopping experience
    - Four Seasons uses it to build a global business intelligence system
    - Facebook uses it to ensure productivity of the workforce and information (MicroStrategy, 2015)
- What is the difference between business intelligence and business analytics?
    - Business intelligence can “transform raw data to meaningful and useful information” for business analytics
      (Business Analytics, 2012)
    - Business analytics can use “statistical and quantitative data” to develop new insights on business performance
      (Business Analytics, 2013)

II. *Scientific data from the Astrophysics Data System (ADS)*

Bernard Foing showed me how to assess the impact of ESA missions on the scientific community by looking them up on a database

- There are many scientific databases that store publications for ESA missions
    - The Astrophysics Data System (ADS), Web of Science, Google Scholar
- The Astrophysics Data System provides the number of publications, the number of citations, and the h-index (ranking = citations) for each search
- This data is useful if I want to get an idea of the scientific impact of each mission
- However, it is important to pay attention to language and to determine a reliable standardised method for collecting this data
- Some ESA missions have names that are more common and ambiguous (e.g. "Rosetta" could refer to Rosetta Stone, "Planck" is the last name of renowned physicist Max Planck, "Integral" is also a mathematical object)
- Searching these missions may return publications that are not relevant to the ESA mission and give a higher number of publications
- In this case, Boolean logic can be used to narrow down the search (e.g. "Rosetta" AND "satellite", "Planck" AND "mission")

III. *Analytics Project*

Salim Ansari, Imy Matthews, and I had a meeting where we discussed the plan for the following weeks and the basics of MicroStrategy

- At ESA, MicroStrategy is used for predominantly administrative purposes such as reporting on procurement and managing phone bills
- This is carried out on a company-specific application called CAMERA (Corporate Account Management Electronic Reporting Application)
- Salim sees additional potential with MicroStrategy's business intelligence tools and believes I could use them to analyse scientific data from space missions (e.g. scientific impact, scientific impact by country)
  (Palmer, 2014)
- Imy gave me an Analytics Project instruction sheet which showed me how to
    - Access ESA's MicroStategy Analytics
    - Format data so that it is compatible with the software
    - Import data into the MicroStrategy environment
    - Determine schema objects
        - Attributes – business concept from the data source (e.g. month, year, missions, country)
        - Metrics – business numeric concepts that represent measurements, calculations, formulas (e.g. sales, costs, number of publications)
    - Create a dashboard where I can play with my data, discover trends, and obtain useful information using grids and charts

B. Week two: ESA missions research

Before I could begin my Analytics Project, I needed data to work with. Bernard gave me an Excel spreadsheet containing the number of annual publications for Gaia, Herschel, INTEGRAL, ISO, Mars Express, Planck, Rosetta, SOHO, Venus Express, and XMM-Newton from 2000 to 2015. I researched these missions in depth to assist me with my later analysis. Salim gave me another Excel spreadsheet focusing on the number of annual publications by Austria, Belgium, France, Germany, Italy, the Netherlands, Spain, and the United Kingdom for Herschel, INTEGRAL, and XMM-Newton from 2001 to 2014. For these three missions, I investigated relevant national teams, technologies, projects, institutes and companies

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I. Gaia (astrometry)

Launch - 2013
Mission end - 2018
Objective

- "Survey more than one billion stars in our Galaxy and beyond" and to use this data to answer "fundamental questions about the formation and evolution of our galaxy"

Instruments

- ASTRO (astrometer)
- BP/RP (blue/red photometer)
- RVS (radial velocity spectrometer)

Countries involved

- A fully European mission
- Mission operations in Germany
- Science operations in Spain
- Ground stations in Spain and Australia
- Scientists from ESA member states and partners for instrument development and science data analysis
  ("Gaia: fact sheet," 2013)

II. Herschel (far-infrared/sub-mm astronomy)

Launch - 2009
Mission end - 2013
Objective

- "Study the formation of galaxies in the early universe" and the creation of stars" and to examine the "chemical compositions of the atmospheres", various surfaces, and the universe itself

Instruments

- HIFI (heterodyne instrument for the far infrared)
- PACS (photo-detector array camera and spectrometer)
- SPIRE (spectral and photometric imaging receiver)

Countries involved

- Mission operations in Germany

- Science operations in Spain
- Ground stations in Spain and Australia
- Ground stations in French Guiana and Spain right after launch
- Control centres for instruments in Germany (HIFI), the Netherlands (PACS), and the United Kingdom (SPIRE)
- Scientists from ESA member states and partners for instrument development and science data analysis
  (“Herschel: fact sheet,” 2013)

III. INTEGRAL (gamma-ray astronomy)

Launch - 2002
Mission end - 2018
Objective

- “Provide insight into the most violent and exotic objects of the universe” (e.g. black holes, neutron stars, supernovae) and the “formation of new chemicals elements and mysterious gamma-ray bursts”

Instruments

- SPI (spectrometer)
- IBIS (imager)
- JEM-X (x-ray monitor)
- OMC (optical monitor)

Countries involved

- Mission operations in Germany
- Science operations in Spain
- Science data in Switzerland
- Ground station in Sweden
- Principal investigator institutes for instruments in France (SPI, IBIS), Germany (SPI), Italy (IBIS), Denmark (JEM-X), Spain (OMC)
- Scientists from ESA member states and partners for instrument development and science data analysis
  (“INTEGRAL: fact sheet,” 2015)

IV. ISO (infrared astronomy)

Launch – 1995
Mission end – 1998
Objective

- “Make chemical diagnoses of celestial objects” (e.g. planets, comets, and stars)

Instruments

- ISOCAM (camera)
- ISOPHOT (photometer)
- SWS (short wavelength spectrometer)
- LWS (long wavelength spectrometer)

Countries involved

- Science operations in Spain
- Ground station in the United States

- Scientists from ESA member states and partners for instrument development and science data analysis
  (“ISO: fact sheet,” 2013)

V. Mars Express (Mars orbiter and lander)

Launch – 2003
Mission end – 2018
Objective
- To answer the “fundamental questions about the geology, atmosphere, surface environment, history of water, and potential for life on Mars”

Instruments
- OMEGA (visible and infrared mineralogical mapping spectrometer)
- SPICAM (ultraviolet and infrared atmospheric spectrometer)
- MARSIS (sub-surface sounding radar altimeter)
- PFS (planetary Fourier spectrometer)
- ASPERA (analyser of space plasmas and energetic atoms)
- HRSC (high resolution stereo camera)
- MELACOM (mars express lander communications)
- MaRS (mars radio science experiment)
- VMC (visual monitoring camera)

Countries involved
- Mission operations in Germany
- Ground station in Australia
- Scientists from ESA member states and partners for instrument development and science data analysis
  (“Mars Express: fact sheet,” 2015)

VI. Planck (map of Cosmic Microwave Background)

Launch – 2009
Mission end – 2011
Objective
- “Map the Cosmic Microwave Background anisotropies”, “test inflationary models of the early Universe”, “measure amplitude of structures in the Cosmic Microwave Background”, and “perform measurements of Sunyaev-Zeldovich effect”

Instruments
- HFI (high frequency instrument with bolometric detectors)
- LFI (low frequency instrument with radio receivers)

Countries involved
- Mission operations in Germany
- Science operations in Spain
- Ground stations in Spain and Australia
- Principal investigators for instruments in France (HFI) and Italy (LFI)

- Scientists from ESA member states and partners for instrument development and science data analysis
  ("Planck: fact sheet," 2015)

VII. Rosetta (comet rendezvous)

Launch – 2004
Mission end – 2016
Objective
- "Rendezvous with and enter orbit around, comet 67P/Churyumov-Gerasimenko and to perform observations of the comet's nucleus and coma"

Instruments
- Rosetta Orbiter
  - Alice (an ultraviolent imagining spectrograph)
  - CONSERT (comet nucleus sounding experiment by radio wave transmission)
  - COSIMA (cometary secondary ion mass analyser)
  - GIADA (grain impact analyser and dust accumulator)
  - MIDAS (micro-imaging dust analysis system)
  - MIRO (microwave instrument for the rosetta orbiter)
  - OSIRIS (optical, spectroscopic, and infrared remote imaging system)
  - ROSINA (rosetta orbiter spectrometer for ion and neutral analysis)
  - RPC (rosetta plasma consortium)
  - RSI (radio science investigation)
  - VIRTIS (visible and infrared thermal imaging spectrometer)
- Rosetta Lander
  - APXS (alpha particle x-ray spectrometer)
  - CIVA (comet nucleus infrared and visible analyser)
  - ROLIS (rosetta lander imaging system)
  - CONSERT (comet nucleus sounding experiment by radiowave transmission)
  - COSAC (cometary sampling and composition)
  - PTOLEMY (an instrument measuring stable isotope ratios)
  - MUPUS (multi-purpose sensors for surface and sub-surface science)
  - ROMAP (rosetta lander imaging system)
  - SD2 (sampling, drilling and distribution system)
  - SESAME (surface electric sounding and acoustic monitoring experiments)

Countries involved
- Mission operations in Germany
- Ground stations in Australia and French Guiana
- Scientists from ESA member states and partners for instrument development and science data analysis
  ("Rosetta: fact sheet," 2015)

VIII. SOHO (Sun, from core to beyond)

Launch – 1995
Mission end – 2018
Objective

- “Study the internal structure of the Sun, its…outer atmosphere and the origin of the solar wind”

Instruments

- CDS (coronal diagnostic spectrometer)
- CELIAS (charge element and isotope analysis system)
- COSTEP (comprehensive supra-thermal and energetic particle analyser collaboration)
- EIT (extreme ultraviolet imaging telescope)
- ERNE (energetic and relativistic nuclei and electron experiment)
- GOLF (global oscillations at low frequencies)
- LASCO (large angle and spectrometric coronagraph)
- MDI/SOI (Michelson Doppler imager)
- SUMER (solar ultraviolet measurement of emitted radiation)
- SWAN (solar wind anisotropies)
- UVCS (ultraviolet coronagraph spectrometer)
- VIRGO (variability of solar irradiance and gravity oscillations)

Countries involved

- Commanded from the United States
- Data retrieved via Deep Space Network in the United States, Spain and Australia
- Scientists from ESA member states and partners for instrument development and science data analysis
  (“SOHO: fact sheet,” 2014)

IX. Venus Express (Venus orbiter)

Launch – 2005
Mission end – 2015
Objective

- “Study the atmosphere, the plasma environment, and the surface of Venus”

Instruments

- ASPERA-4 (analyser)
- MAG (magnetometer)
- PFS (spectrometer)
- SPICAV (spectroscopy)
- VeRa (radio)
- VIRTIS (spectrometer)
- VMC (camera)

Countries involved

- Mission operations in Germany
- Ground stations in Spain and Australia
- Science operations in Spain

- Scientists from ESA member states and partners for instrument development and science data analysis
  (“Venus Express: fact sheet,” 2014)

X. *XMM-Newton (x-ray astronomy)*

Launch – 1999
Mission end – 2018
Objective
- “Study celestial X-ray sources” and “help scientists solve a number of cosmic mysteries, ranging from the enigmatic black holes to the origins of the Universe itself”

Instruments
- EPIC (European photon imaging camera)
- RGS (reflection grating spectrometer)
- OM (optical monitor)

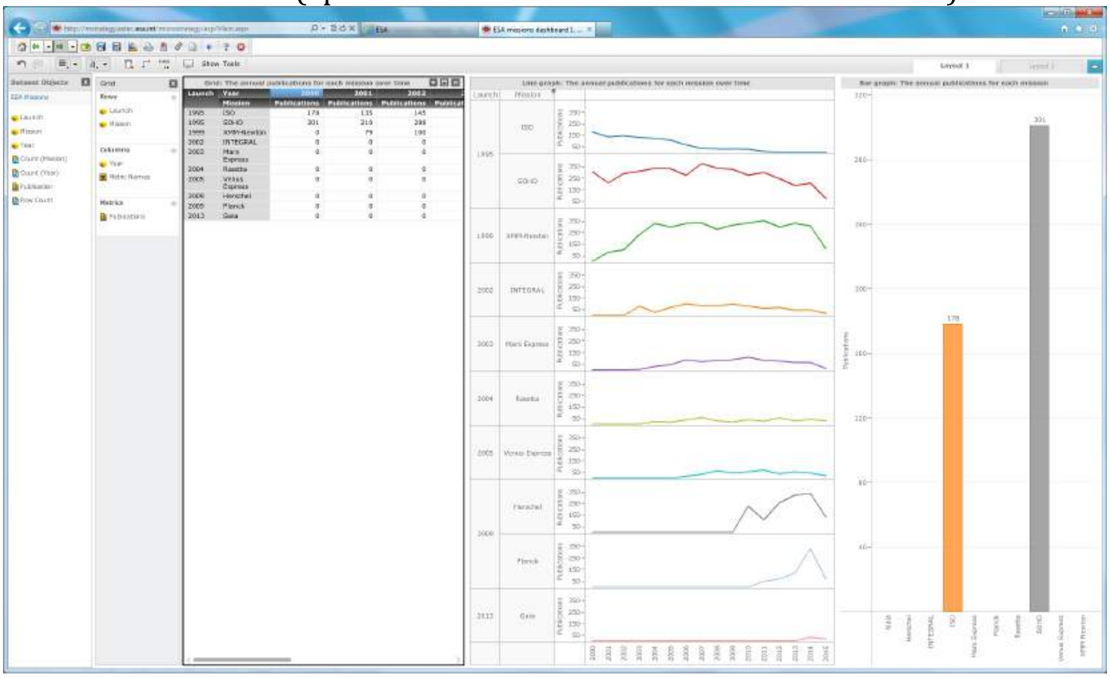
Countries involved
- Mission operations in Germany
- Science operations in Spain
- Ground stations in Australia and French Guiana
- XMM-Newton Survey Science centre that process and exploits the data collected from the mission (international ESA collaboration of institutes in Spain, UK, Italy, Germany and France, led by Leicester University, project director from France, Potsdam)
- Scientists from ESA member states and partners for instrument development and science data analysis
  (“XMM-Newton: fact sheet,” 2014)

C. Week three: MicroStrategy practice

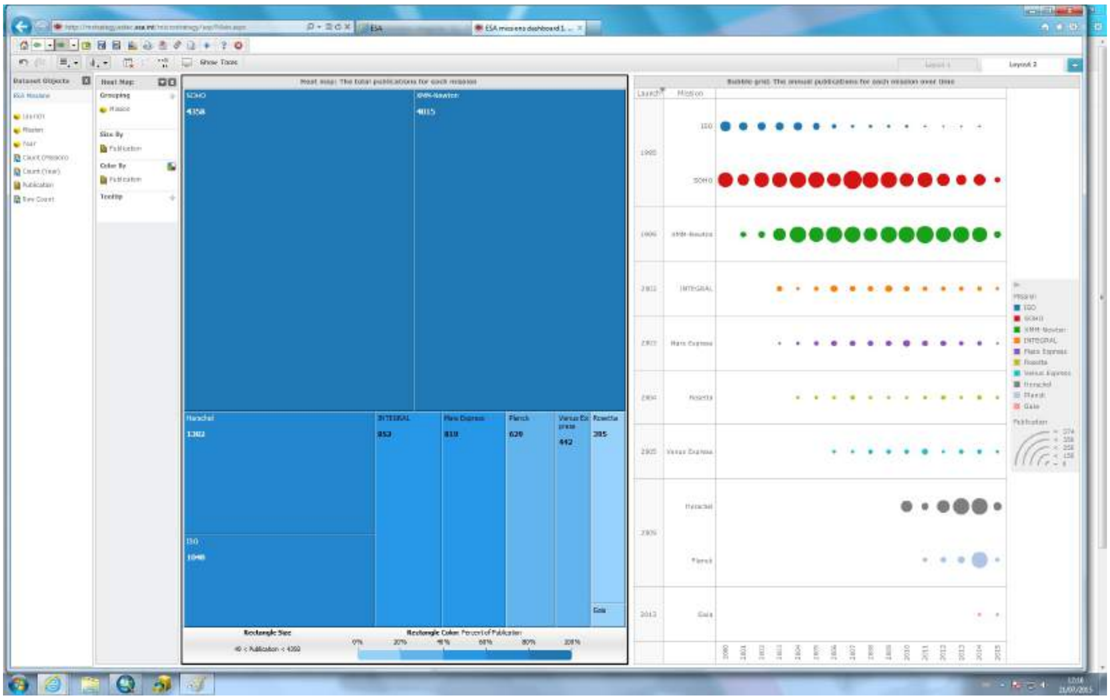
I. *Dashboards*

I played around on MicroStrategy and became familiar with the program by formatting and importing data, creating dashboards, and experimenting with visualizations.

Practice Dashboard I (Spreadsheet I on Publications for ESA Missions)

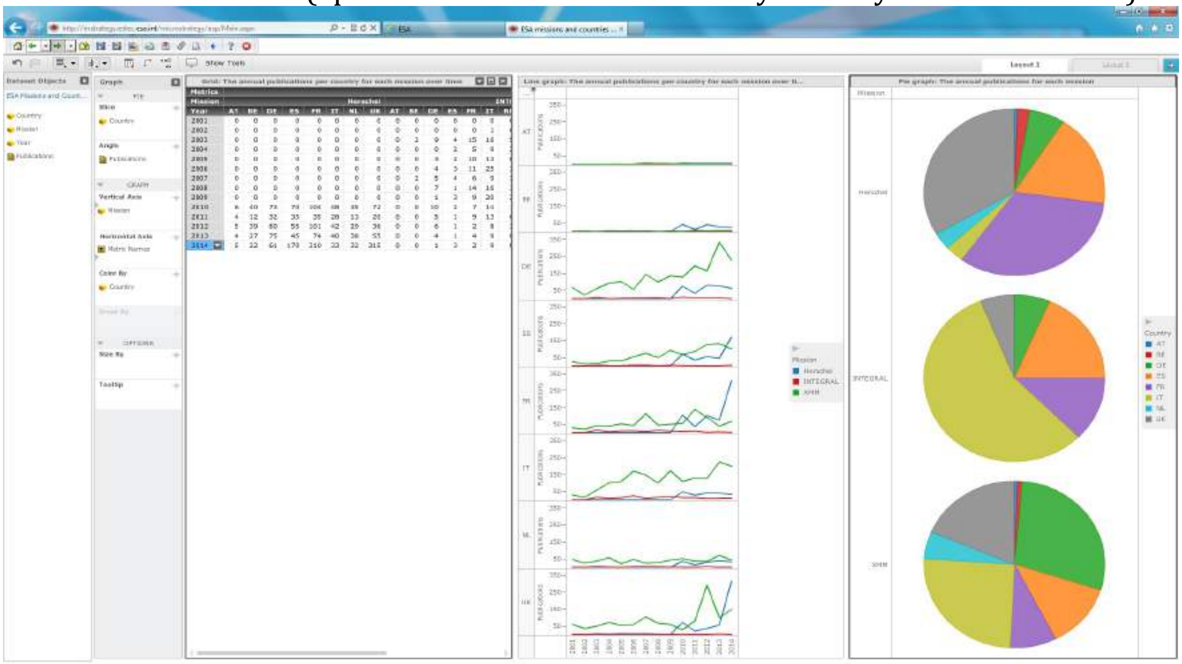


Contains a grid, a line graph (publications for each mission over time), and a selective bar graph (publications for each mission in a selected year)

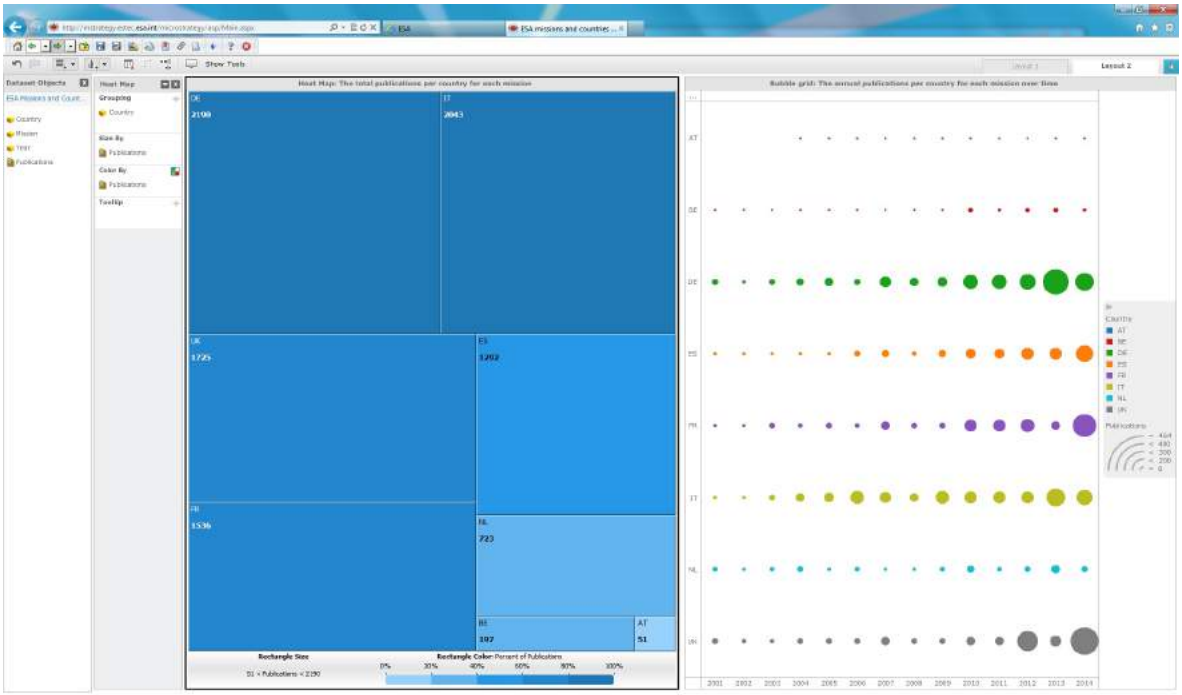


Contains a heat map (total publications for each mission) and a bubble grid (publications for each mission over time)

Practice Dashboard II (Spreadsheet II on Publications by Country for ESA Missions)



Contains a grid, a line graph (publications by country for each mission over time), and a selective pie graph (publications by country for each mission in a selected year)

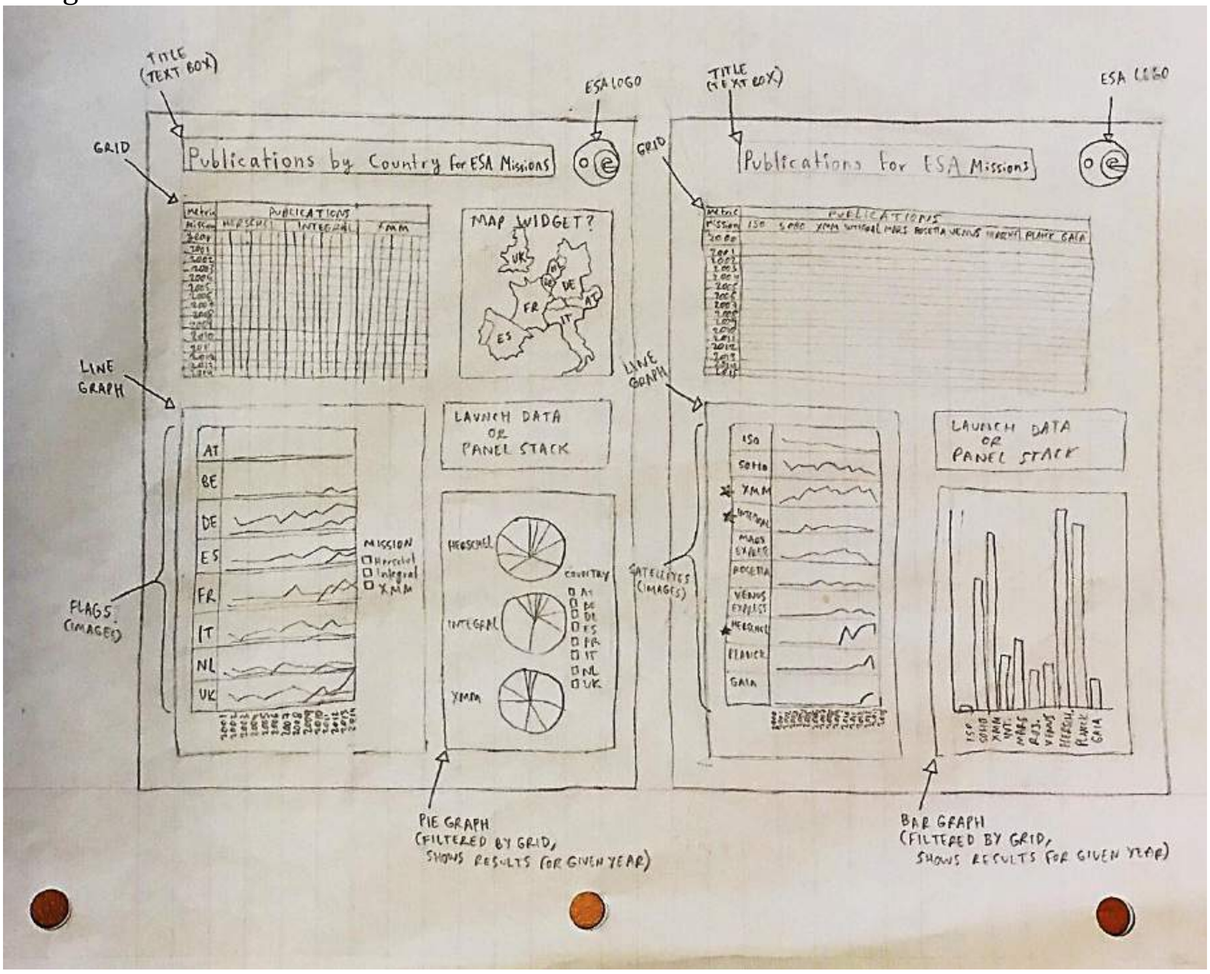


Contains a heat map (total publications by country) and a bubble grid (publications by country over time)

This exercise was helpful because it taught me which visualizations were best suited to represent my data. I then moved on to Document mode, the format I would be using for the final product, and designed a layout for my final two documents.

II. Design

Design for Documents I and II



After presenting my design to Imy and Salim, I learned that the Map Widget required special permission on the software and would not be executable. As a result, I decided to use a Button Bar with flags to represent the countries. This was one of many small adjustments I made to my original layout. At first I had difficulties following the design because it involved several chart-making features I had used in Dashboard mode that were less advanced or absent in Document mode. However, once I became accustomed to Document mode (via trial-and-error) I was able to create the documents I had in mind.

D. <u>Week four: Final documents</u>

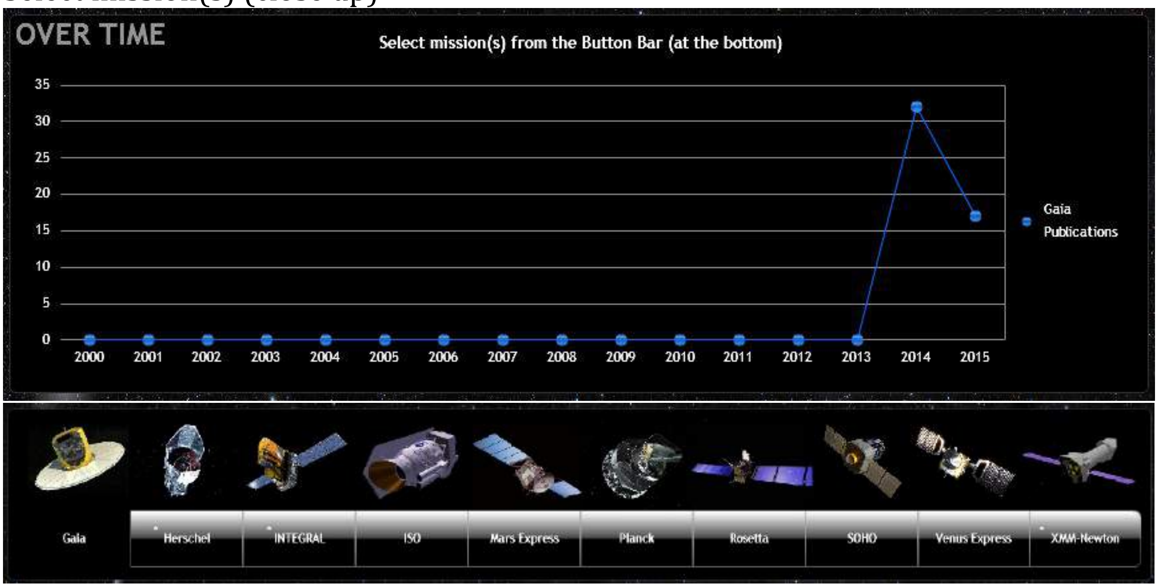
I. *Document I*

The first document is titled "Publications for ESA Missions" and visualises the publications for Gaia, Herschel, INTEGRAL, ISO, Mars Express, Planck, Rosetta, SOHO, Venus Express, and XMM-Newton over the last 15 years. This document enables the user to look at the data for any combination of missions over time as well as the data for all missions each individual year.

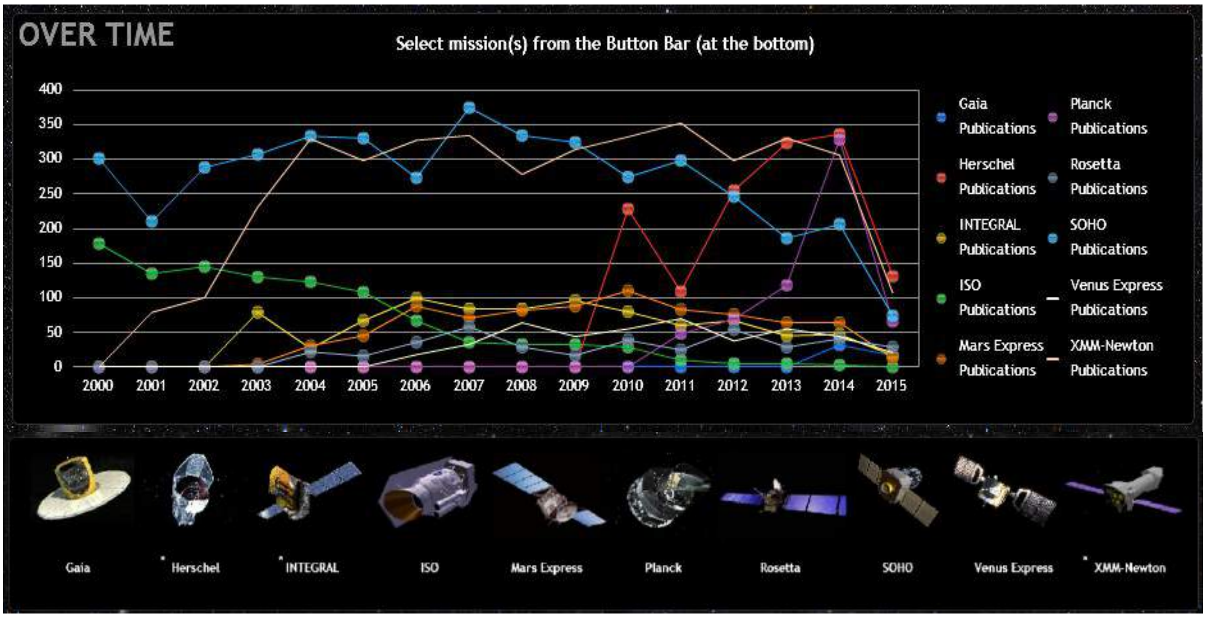
Document I: Publications for ESA Missions

Example: No mission and Total (all years) is selected

Select mission(s) (close up)



Example: Only the Gaia mission is selected

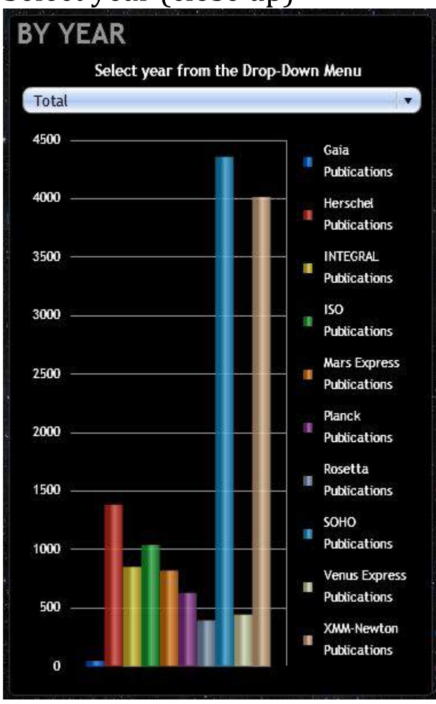


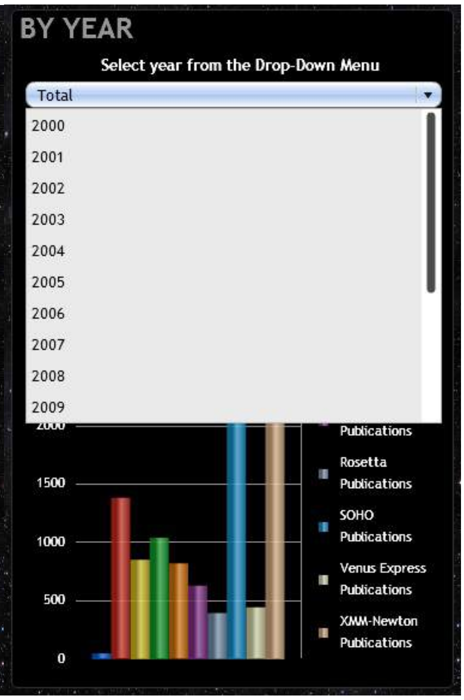
Example: All missions are selected

Grid (close up)

Launch	Mission	Metrics / Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
			Publication															
1995	ISO		178	135	145	130	123	108	67	36	33	33	29	10	5	5	3	0
1995	SOHO		301	210	288	307	333	330	273	374	334	324	274	298	246	186	206	74
1999	XMM-Newton		0	79	100	231	329	298	327	334	278	314	332	352	298	330	306	107
2002	INTEGRAL		0	0	0	79	27	67	99	84	84	96	80	60	67	45	47	17
2003	Mars Express		0	0	0	4	31	45	88	71	82	88	110	83	76	64	64	13
2004	Rosetta		0	0	0	0	22	16	36	58	29	17	39	25	54	29	41	29
2005	Venus Express		0	0	0	0	0	0	18	33	64	44	55	70	38	55	44	21
2009	Herschel		0	0	0	0	0	0	0	0	0	0	228	109	255	323	336	131
2009	Planck		0	0	0	0	0	0	0	0	0	0	0	48	69	118	328	66
2013	Gaia		0	0	0	0	0	0	0	0	0	0	0	0	0	0	32	17

Select year (close up)



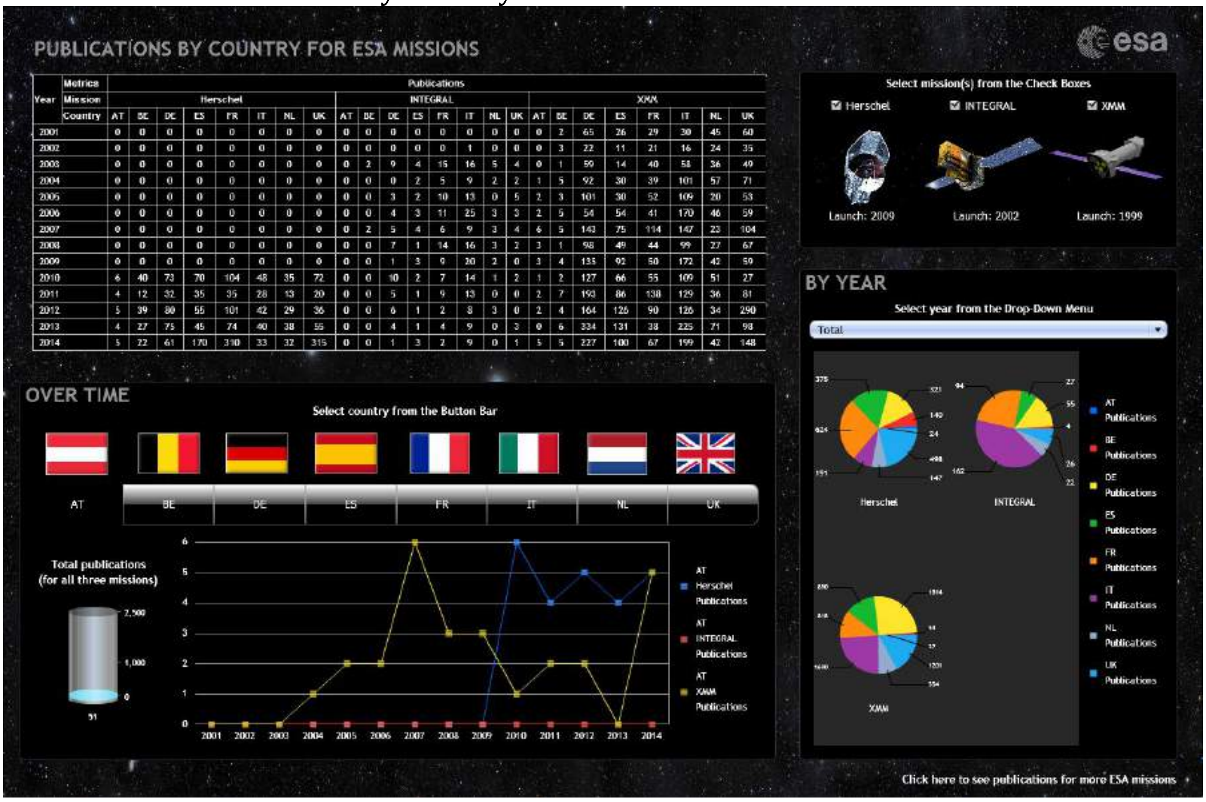


Example: Total (all years) is selected; any year can be selected from the menu

II. *Document II*

The second document is titled “Publications by Country for ESA Missions“ and visualises the publications by Austria, Belgium, France, Germany, Italy, the Netherlands, Spain, and the United Kingdom for Herschel, INTEGRAL, and XMM-Newton over the last 15 years. On this document, the user can look at the data for any individual country over time as well as the data for all countries each individual year. The user can also view any combination of missions over time and by year.

Document II: Publications by Country for ESA Missions

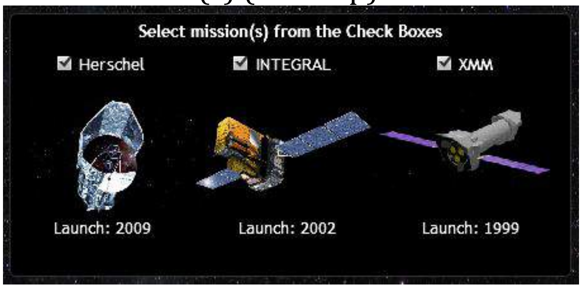


Example: Austria, Total (all years), and all three missions are selected

Grid (close up)

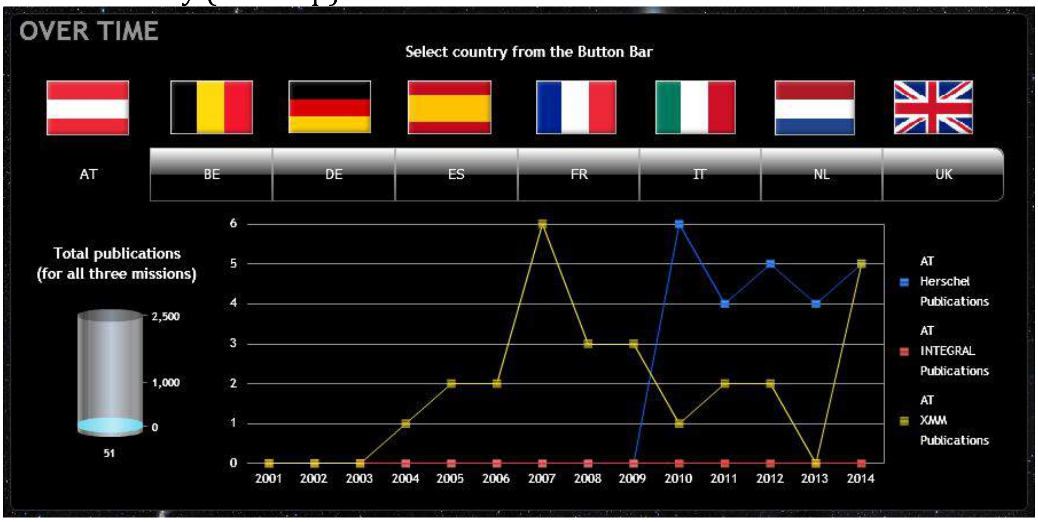
Year	Metrics	Publications																							
	Mission	Herschel								INTEGRAL								XMM							
	Country	AT	BE	DE	ES	FR	IT	NL	UK	AT	BE	DE	ES	FR	IT	NL	UK	AT	BE	DE	ES	FR	IT	NL	UK
2001		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	65	26	29	30	45	60
2002		0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3	22	11	21	16	24	35
2003		0	0	0	0	0	0	0	0	0	2	9	4	15	16	5	4	0	1	59	14	40	58	36	49
2004		0	0	0	0	0	0	0	0	0	0	0	2	5	9	2	2	1	5	92	30	39	101	57	71
2005		0	0	0	0	0	0	0	0	0	0	3	2	10	13	0	5	2	3	101	30	52	109	20	53
2006		0	0	0	0	0	0	0	0	0	0	4	3	11	25	3	3	2	5	54	54	41	170	46	59
2007		0	0	0	0	0	0	0	0	0	2	5	4	6	9	3	4	6	5	143	75	114	147	23	104
2008		0	0	0	0	0	0	0	0	0	0	7	1	14	16	3	2	3	1	98	49	44	99	27	67
2009		0	0	0	0	0	0	0	0	0	0	1	3	9	20	2	0	3	4	135	92	50	172	42	59
2010		6	40	73	70	104	48	35	72	0	0	10	2	7	14	1	2	1	2	127	66	55	109	51	27
2011		4	12	32	35	35	28	13	20	0	0	5	1	9	13	0	0	2	7	193	86	138	129	36	81
2012		5	39	80	55	101	42	29	36	0	0	6	1	2	8	3	0	2	4	164	126	90	126	34	290
2013		4	27	75	45	74	40	38	55	0	0	4	1	4	9	0	3	0	6	334	131	38	225	71	98
2014		5	22	61	170	310	33	32	315	0	0	1	3	2	9	0	1	5	5	227	100	67	199	42	148

Select mission(s) (close up)



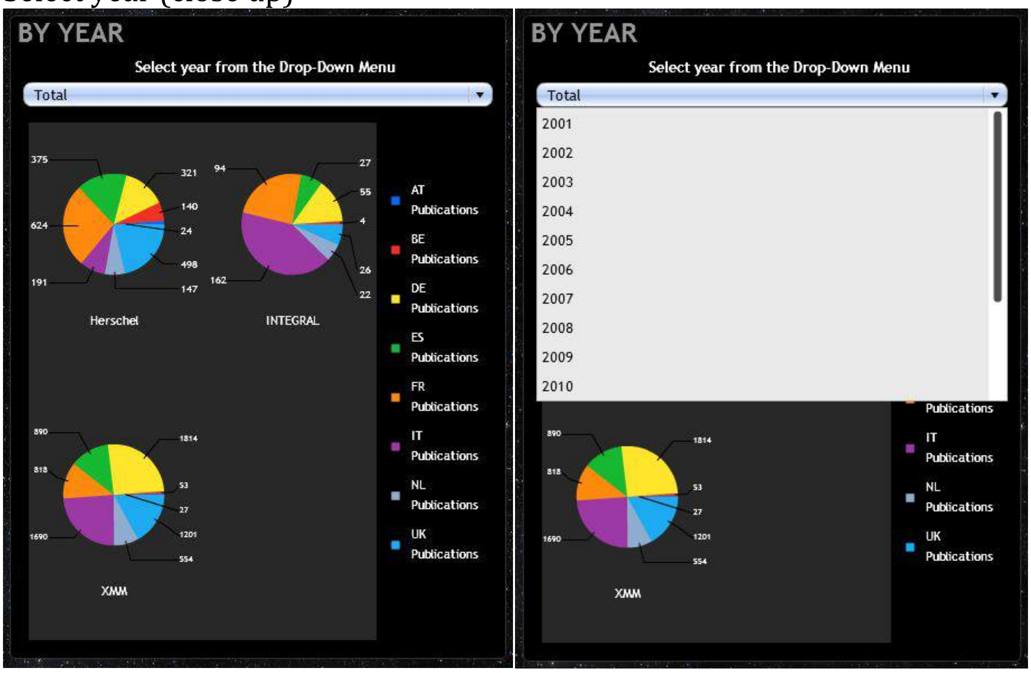
Example: All three missions are selected

Select country (close up)



Example: Austria and all three missions are selected; the cylinder on the left shows the total publications by country and only one country can be viewed at a time

Select year (close up)



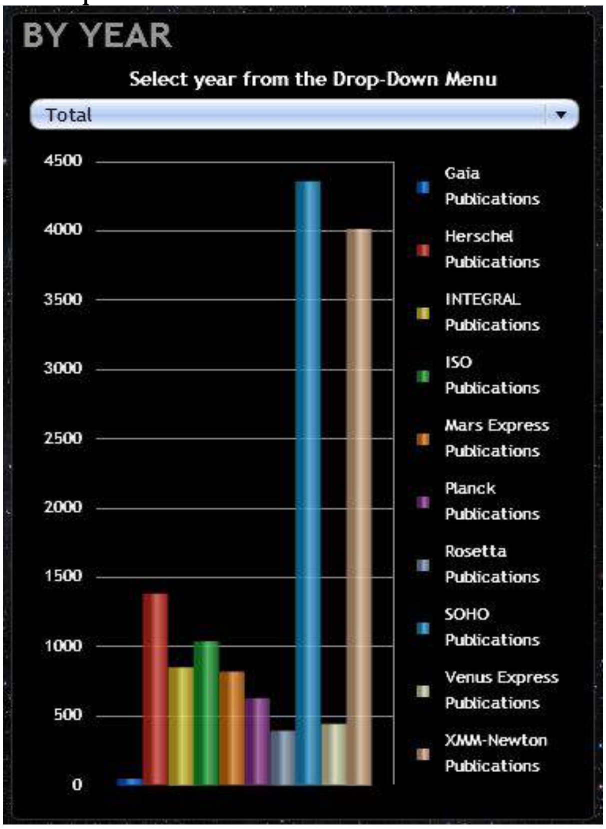
Example: Total (all years) is selected; any year can be selected from the menu

4. Results and analysis

A. <u>Publications for ESA missions</u>

I. Total publications

Total publications for all missions



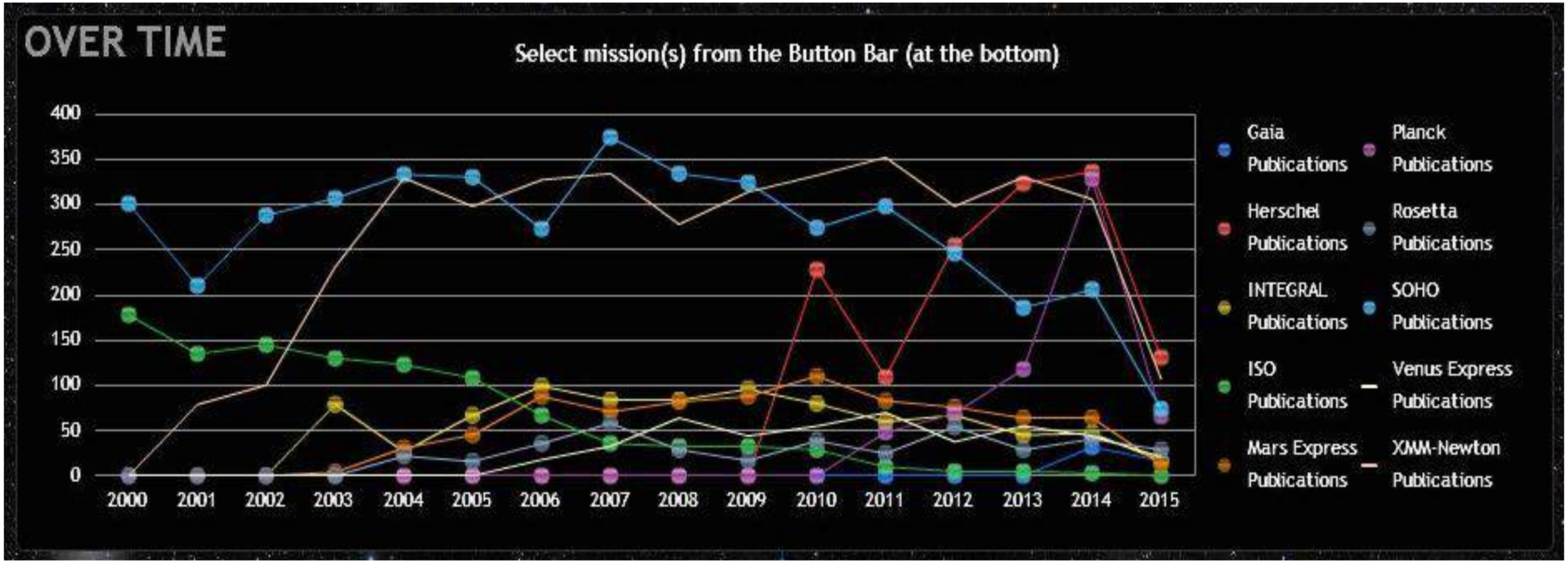
- SOHO > XMM-Newton > Herschel > ISO > INTEGRAL > Mars Express > Planck > Venus Express > Rosetta > Gaia
- SOHO has the most publications (4358)
- Gaia has the least publications (49)
- The mean of publications is 1398.1
- The median of publications is 835
- The range of publications is 4309

Total impact

- SOHO and XMM-Newton have around 4000 to 4500 publications
    - They have the largest total impact by far (almost 3x as many publications as Herschel and about 4x as many as the other missions) despite missing the publications from before 2000
    - This is likely because they are the two oldest operational missions in the set and have had the most time to collect and return data
        - All other missions (excluding ISO) were launched after 2001
- Herschel and ISO have around 1000 to 1500 publications
    - Herschel has a greater total impact than many older missions in the set (i.e. ISO, INTEGRAL, Mars Express, Rosetta, Venus Express)
    - This is likely because it collected a lot of data in a short period of time
    - ISO has less publications than SOHO, XMM-Newton, and Herschel
    - This could be because its mission ended much earlier in 1998 and because the data does not include publications from before 2000
- INTEGRAL, Mars Express, and Planck have around 500 to 1000 publications
- Venus Express, Rosetta, and Gaia have around 0 to 500 publications each
    - Gaia has a low total impact because it is the newest mission and it is still in the beginning stages

All missions (2000 – 2015)

- SOHO and XMM-Newton consistently at top
- ISO gradually declines to zero
- Herschel and Planck take off after 2009
- INTEGRAL, Mars Express, Rosetta, Venus Express, and Gaia clustered at bottom



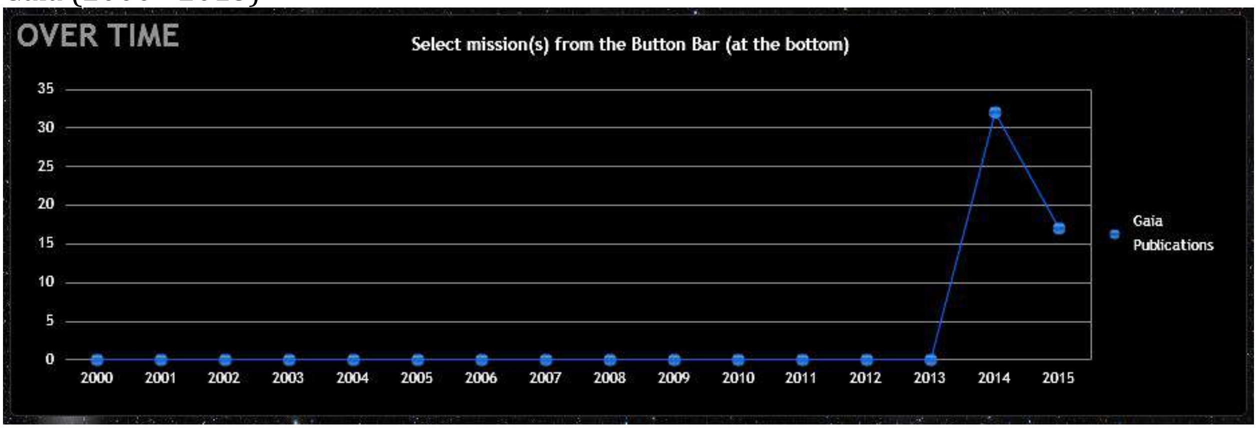
II. Annual publications

The data for 2015 is incomplete because it was collected half way throughout the year. Thus, I will only discuss trends up to 2014.

Standardizing trends

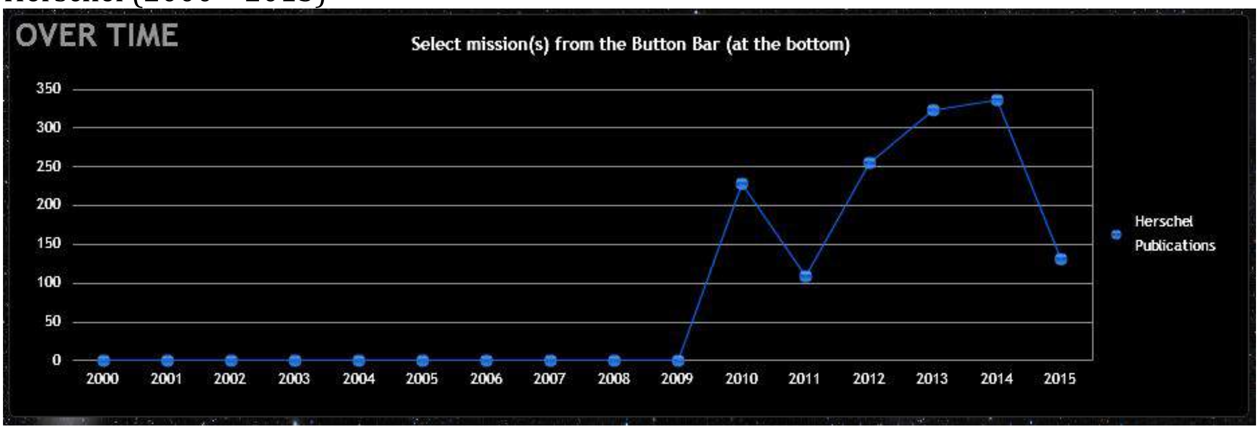
- Stable: change in publications < 50
- Slight increase/decrease: 50 > change in publications < 100
- Increase/decrease: change in publications > 100
- Dip/rise: change in publications (over the span of one year) > 50
  Only mentioned when it contradicts the direction of graph

Gaia (2000 - 2015)



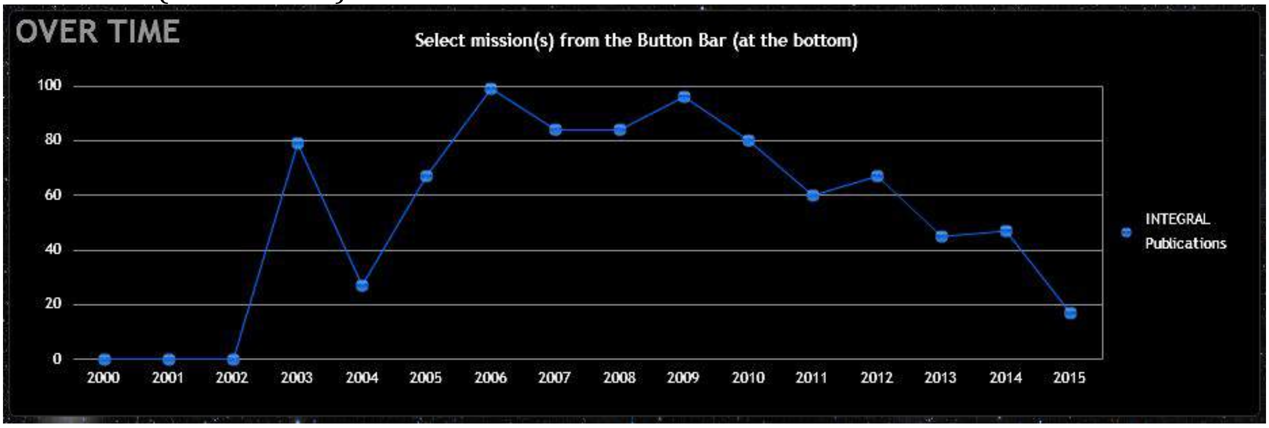
Publications start and peak in 2014 (peak = 32)

Herschel (2000 – 2015)



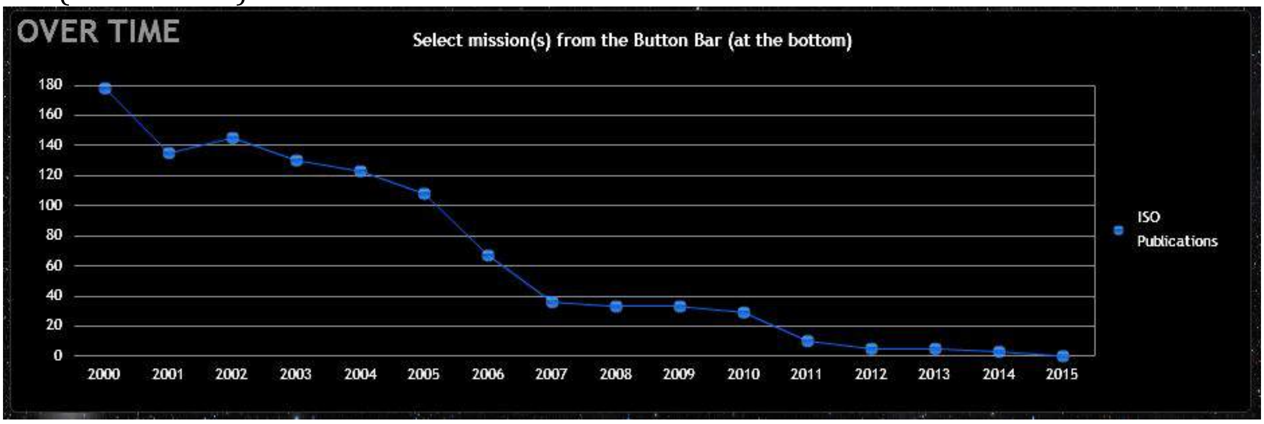
Publications start in 2010, dip in 2011, and increase until peak in 2014 (peak = 336)

INTEGRAL (2000 - 2015)



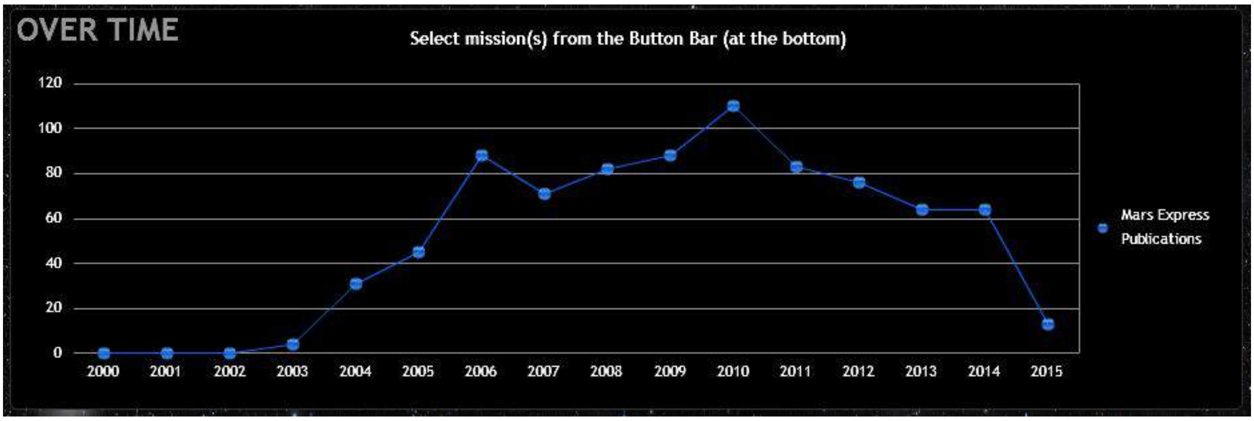
Publications start in 2003, dip in 2004, slightly increase until peak in 2006 (peak = 99), and slightly decrease until 2014

ISO (2000 - 2015)



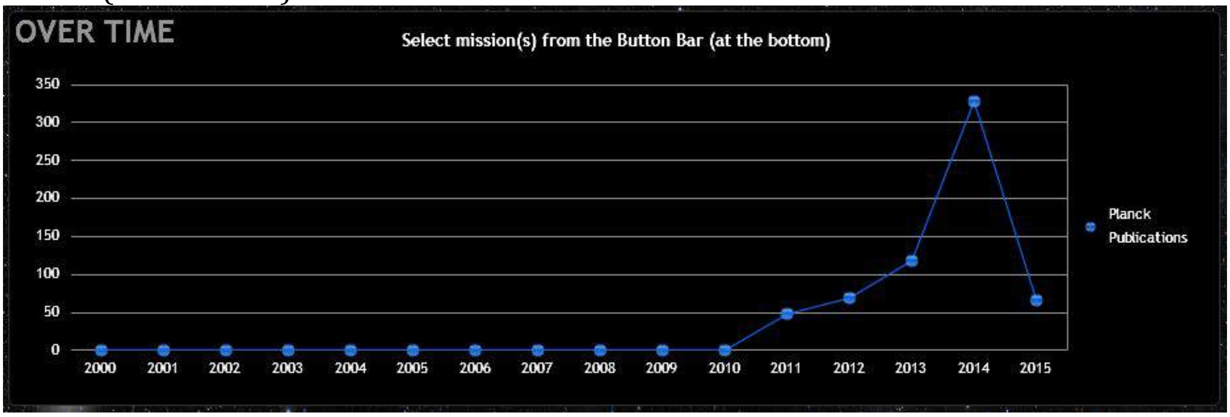
Publications start and peak in 2000 (peak = 178), and decrease until 2014

Mars Express (2000 - 2015)



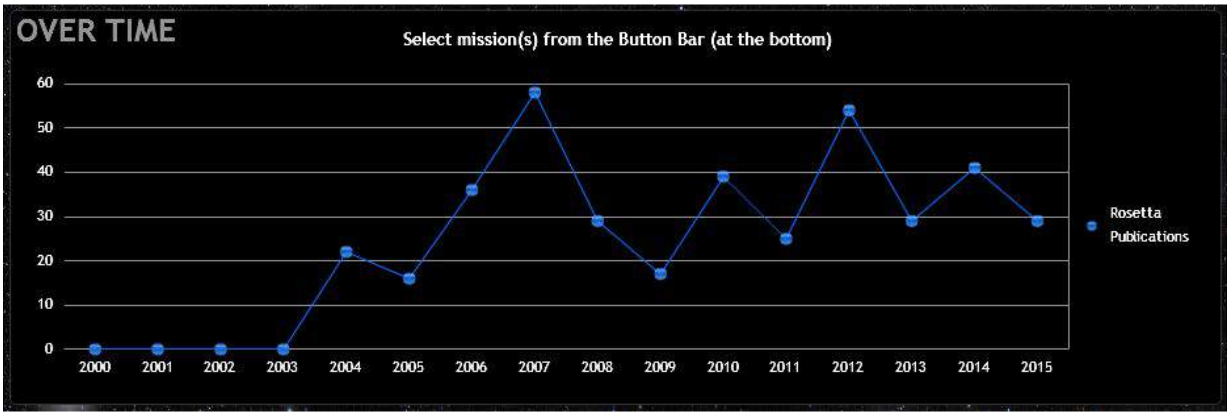
Publications start in 2003, increase until peak in 2010 (peak = 110), and remain stable until 2014

Planck (2000 - 2015)



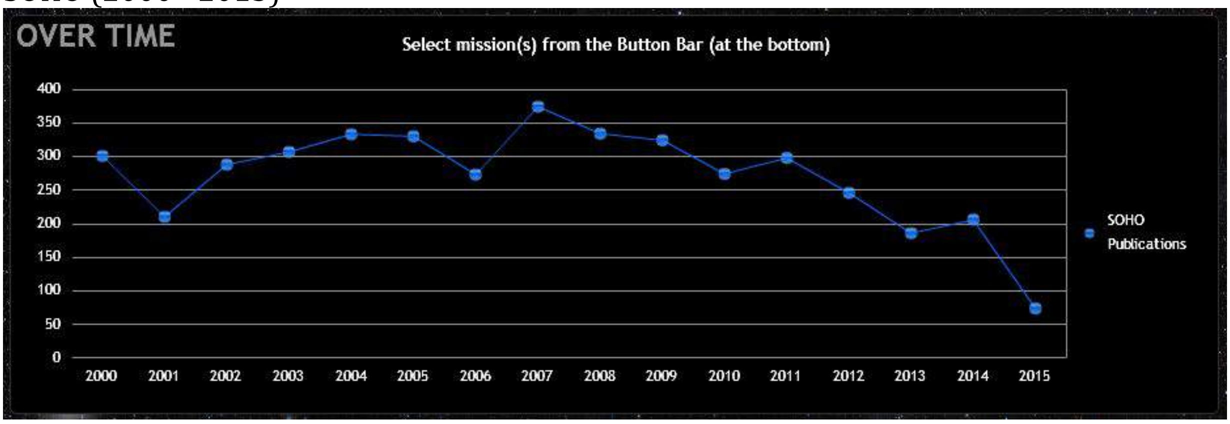
Publications start in 2011 and increase until peak in 2014 (peak = 328)

Rosetta (2000 - 2015)



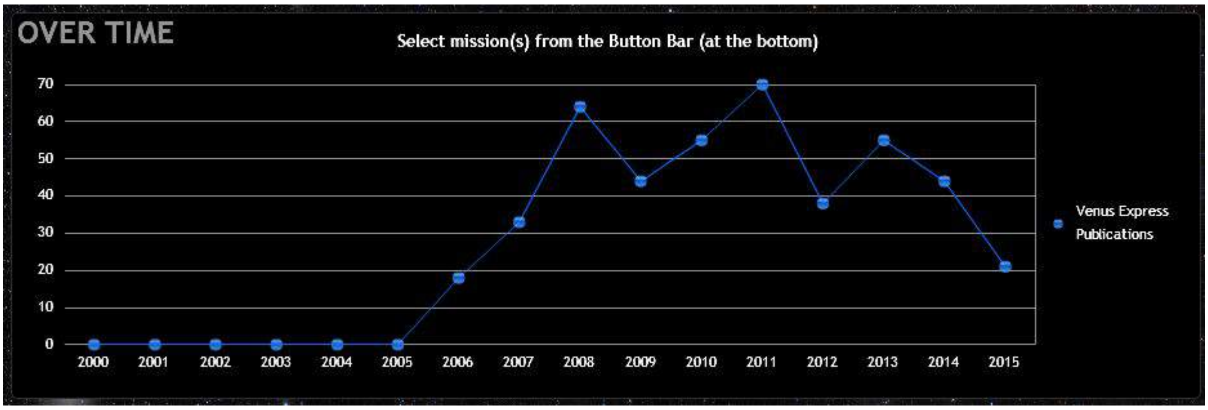
Publications start in 2004 and remain stable until 2014 with peak in 2007 (peak = 58)

SOHO (2000 - 2015)



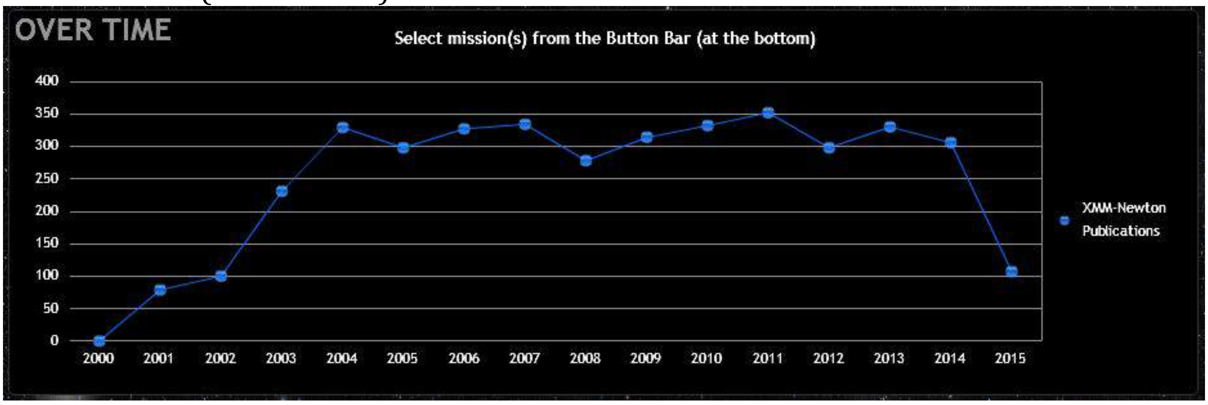
Publications start in 2000, dip in 2001, increase until 2005, dip in 2006, rise until peak in 2007 (peak = 374), and decrease until 2014

Venus Express (2000 - 2015)



Publications start in 2006 and remain stable until 2014 with peak in 2011 (peak = 70)

XMM-Newton (2000 - 2015)



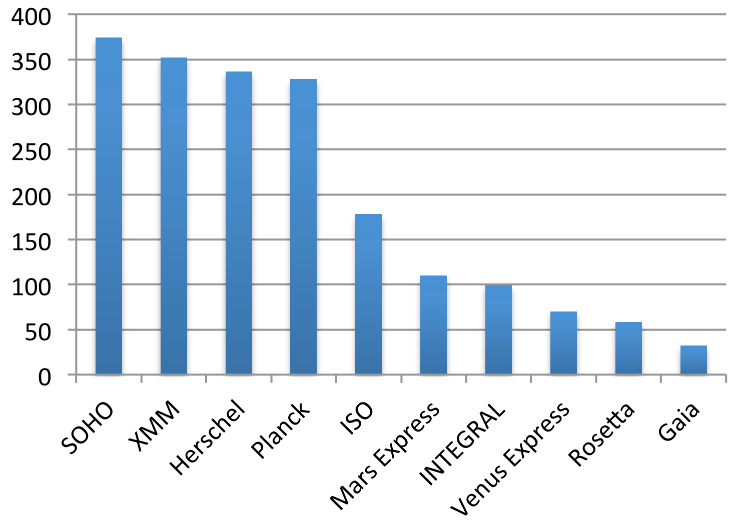
Publications start in 2001, increase until 2004, and remain stable until 2014 with dips in 2008/2012 and peak in 2011 (peak = 352)

III. *Comparisons*

- Start of impact
  - For most missions, the first publications appear one year after launch
  - For Mars Express and Rosetta, they appear the same year as the launch so they are the missions with the most immediate impact
  - For XMM-Newton and Planck, there is a slight delay in impact as their first publications appear only two years after launch
  - There is no data before 2000 so even though the graph shows that publications for SOHO and ISO first appear five years after launch, it is likely that their impacts started earlier

- Peak of impact
  - Almost every mission reaches a peak of impact within 10 years of launch
  - The mean, median, and mode time between the launch of a mission and the peak of impact is around five years (this calculation excludes SOHO and ISO since there is insufficient data before 2000)
  - XMM-Newton reaches a peak 12 years after launch and stands out by having the impact with the longest climb

Peak publications for all missions

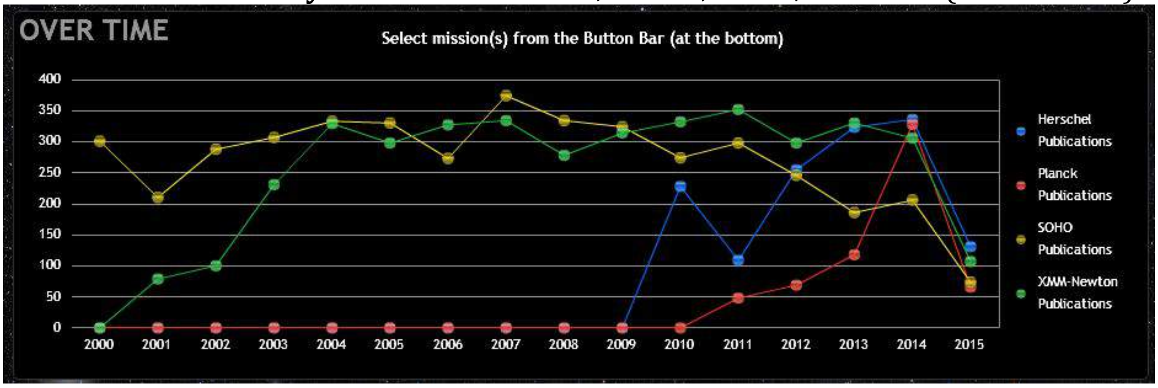


- SOHO > XMM > Herschel > Planck > ISO > Mars Express > INTEGRAL > Venus Express > Rosetta > Gaia
- SOHO has the highest peak (374)
- Gaia has the lowest peak (32)
- The mean peak is 193.7
- The median peak is 144
- The range of peaks is 342

    - SOHO, XMM, Herschel, and Planck have peaks in between 300 – 400
        - They have the highest peaks of impact (almost 2x as high as that of ISO and about 3x as high as those of the other missions)
    - Mars Express and ISO have peaks in between 100 – 200
    - INTEGRAL, Venus Express, Rosetta, Gaia have peaks in between 0 – 100
    - The order of peak publications is similar to the order of total publications
    - This makes sense considering that the total publications are a sum of the annual publications (and the peak publications are indicative of the annual publications if the graph is relatively even)
    - The main differences are the rankings of Planck and Mars Express
        - Planck has a higher peak than ISO, Mars Express and INTEGRAL even though it has less total publications
        - Mars Express has a higher peak than INTEGRAL even though it has less total publications
    - Thus, Planck and Mars Express have more rapid and uneven impacts

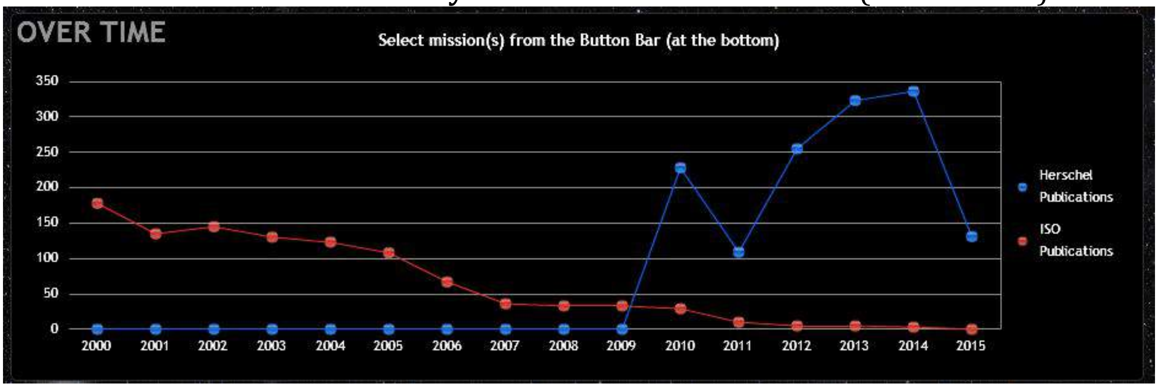
- End of impact
    - There are three directions in which publications are moving:
        1. Peaking (ending on a peak)
        2. Stabilising (ending on a stable path)
        3. Declining (ending on a decline)
    - All peaking missions are young (launched after 2005)
        - Gaia, Herschel, Planck
    - Almost all stabilizing missions are middle-aged (launched after 2000)
        - Mars Express, Rosetta, Venus Express
    - Almost all declining missions are old (launched before 2000)
        - SOHO, ISO
    - XMM-Newton and INTEGRAL are the outliers
        - XMM-Newton is a stabilizing mission that is old
        - INTEGRAL is a declining mission that is middle-aged

Traditional vs. trendy missions: Herschel, Planck, SOHO, and XMM (2000 - 2015)



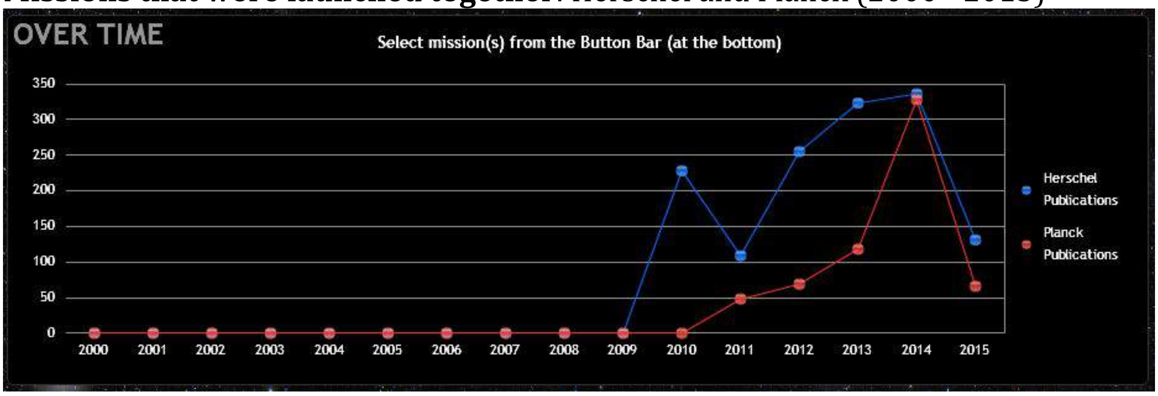
From 2000 onwards, SOHO's impact dominates until XMM-Newton's impact catches up in 2004. Over time, the impacts of the old missions decline and stabilise as the impacts of the two young missions start to peak. Eventually, Herschel's impact and Planck's impact take over in 2014 and end on a peak.

Old vs. new infrared astronomy missions: Herschel and ISO (2000 - 2015)



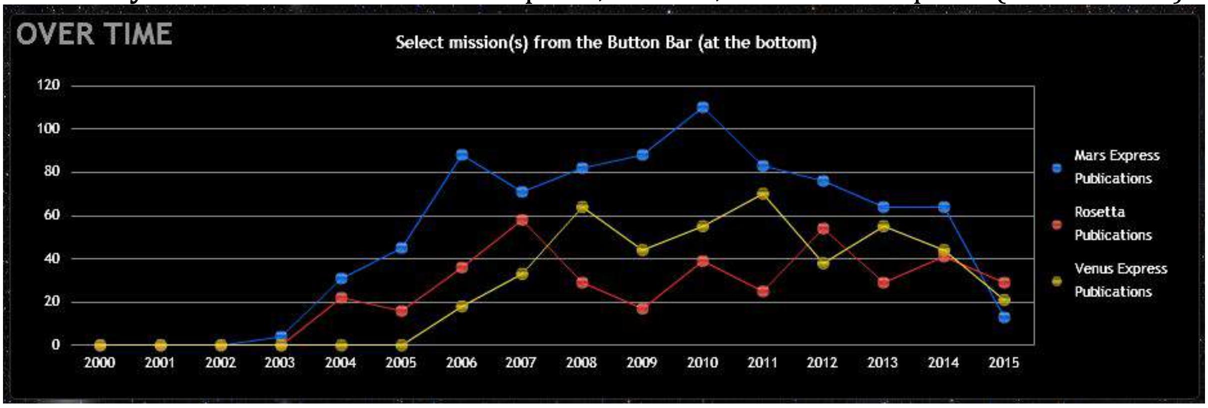
From 2000 onwards, ISO's impact dominates but embarks on a gradual decline. In 2009, Herschel's impact drastically overtakes that of ISO. As the impact of the young mission peaks, the impact of the old mission shrinks until it is almost zero.

Missions that were launched together: Herschel and Planck (2000 - 2015)



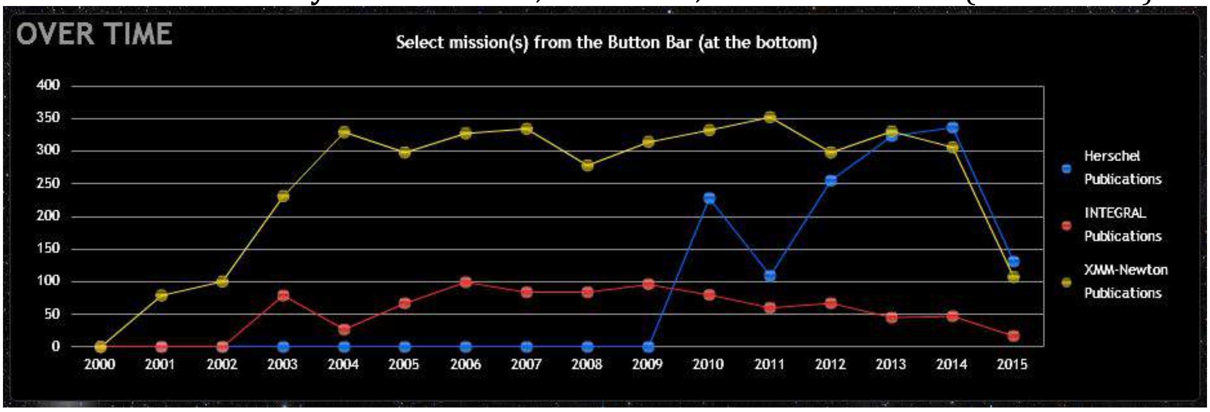
The impacts of the two young missions are not present until after they are launched together in 2009. Herschel's impact takes off first in 2010 and Planck's impact follows one year later. Both impacts end on a peak in 2014.

Planetary science missions: Mars Express, Rosetta, and Venus Express (2000 - 2015)



At the beginning of the twenty-first century, the impacts of the three middle-aged missions are not present. Mars Express's impact takes off in 2003, and subsequently dominates the other impacts. The impacts of Rosetta and Venus Express follow in 2004 and 2006 (respectively) and have similar magnitudes. After peaking, all three impacts finish on a stable path.

Missions with country data: Herschel, INTEGRAL, and XMM-Newton (2000 - 2015)

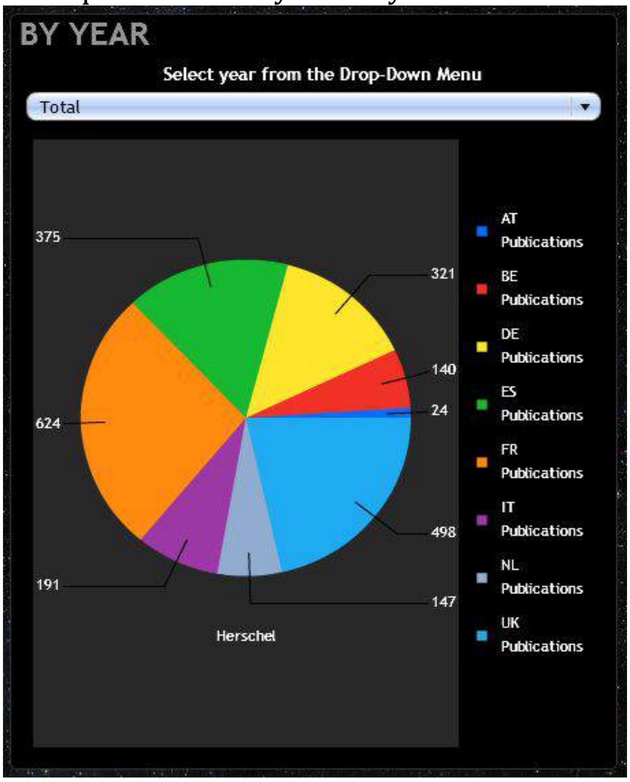


XMM-Newton's impact takes off in 2001 and INTEGRAL's impact follows in 2003. Over time, the impact of the old mission dominates the impact of the middle-aged mission. The impact of the old mission peaks later and starts to stabilise while the impact of the middle-aged mission peaks earlier and starts to decline. In 2010, Herschel's impact starts to peak, immediately taking over that of INTEGRAL. In 2014, the impact of the young mission takes over that of XMM-Newton and ends on a peak.

B. <u>Publications by country for ESA missions</u>

I. Total publications

Total publications by country for Herschel



- FR > UK > ES > DE > IT > NL > BE > AT
- France has the most publications (624)
- Austria has the least publications (24)
- The mean of the publications is 290
- The median of the publications is 256
- The range of the publications is 600

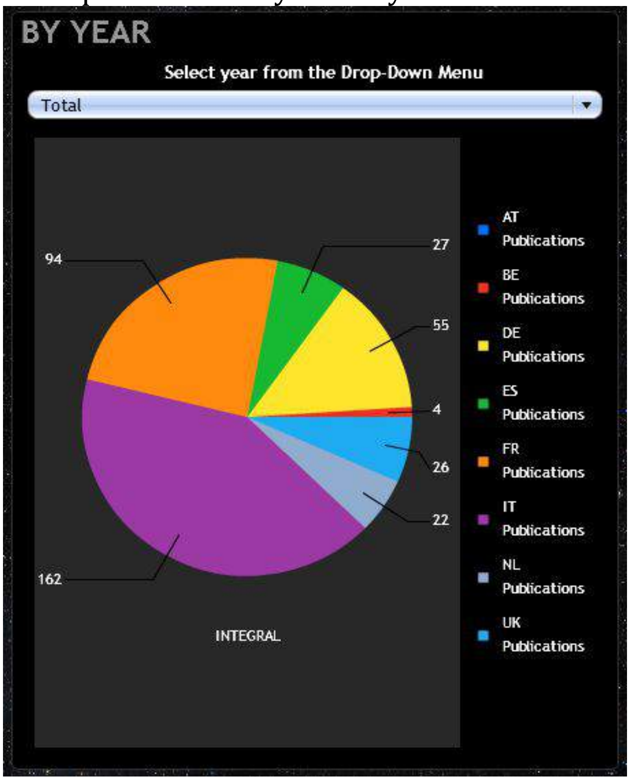
Total impact

- France (624)
  - Thales Alenia Space was the prime contractor for the mission
  - Two members in science team (mission scientist, SPIRE Co-Pi)
  - Eight companies in the industrial team
- United Kingdom (498)
  - SPIRE Instrument Control Centre
  - One member in the science team (SPIRE principal investigator)
  - Seven companies in the industrial team
- Spain (375)
  - Herschel Science Centre
  - One member in the mission team (mission manager / science operations manager) and two in the science team (mission scientist, head of HSC)
  - 12 companies in the industrial team
- Germany (321)
  - European Space Operations Centre
  - PACS Instrument Control Centre
  - One member in the science team (PACS principal investigator)
  - 19 companies in the industrial team
- Italy (191)
  - Six companies in the industrial team

- Netherlands (147)
    - HIFI Instrument Control Centre
    - Two members in the mission team (project scientist, project manager) and science team (mission scientist, HIFI principal investigator)
    - Five companies in the industrial team
- Belgium (140)
    - One member in the science team (PACS Co-PI)
    - Six companies in the industrial team
- Austria (24)
    - Two companies in the industrial team

("Herschel: industrial team," 2011).
("Herschel: mission team," 2013).
("Herschel: science team," 2015).

Total publications by country for INTEGRAL



- IT > FR > DE > ES > UK > NL > BE > AT
- Italy has the most publications (162)
- Austria has the least publications (0)
- The mean of the publications is about 48.8
- The median of the publications is 26.5
- The range of the publications is 162

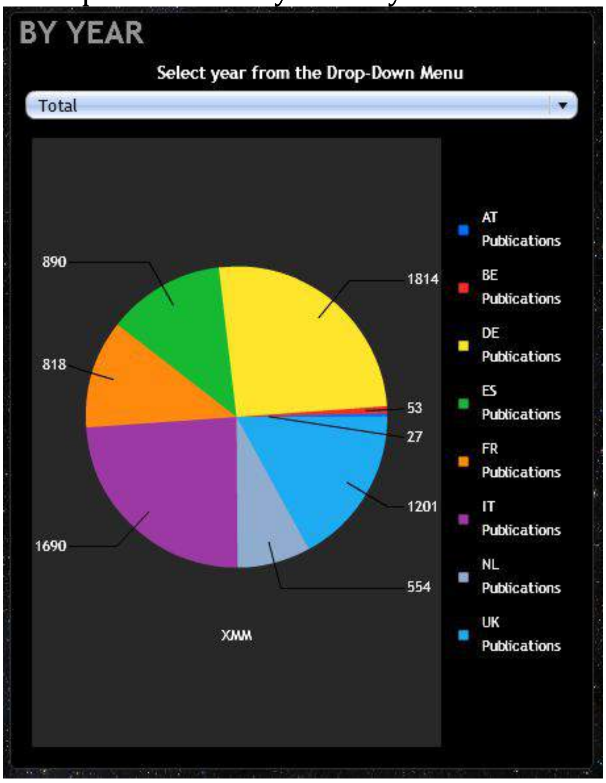
Total impact

- Italy (162)
    - Alenia Spazio was the prime contractor of the mission
    - Two principal investigator instrument teams for IBIS
    - Two members in the Integral Users Group (chair, co-PI IBIS)
    - IAS, one company, two institutes, and one university in the industrial team
- France (94)
    - One principal investigator instrument team for SPI and one for IBIS
    - Two members in the Integral Users Group (co-PI IBIS, co-PI SPI)
    - CNES, one laboratory, and one research institution in the industrial team

- Germany (55)
    - Mission operations
    - One principal investigator instrument team for SPI
    - Two members in the Integral Users Group (co-PI SPI, repr. PROTON launcher)
    - DLR and two research institutes in the industrial team
- Netherlands (22)
    - Three members in the Integral Users Group (external scientist, time allocation committee chair, mission scientist)
    - ESTEC in the industrial team
- Spain (27)
    - Science operations
    - One principal investigator instrument team for OMC
    - Four members in the Integral Users Group (PI OMC, project scientist, mission manager, dep. project scientist)
    - One laboratory and two universities in the industrial team
- United Kingdom (26)
    - Principal investigator institute for IBIS
    - One member in the Integral Users Group (external scientist)
    - One company and two universities in the industrial team
- Belgium (4)
    - Two universities in the industrial team
- Austria (0)

("INTEGRAL: industrial team," 2014).
("Membership of the INTEGRAL Users Group," 2014).

Total publications by country for XMM-Newton



- DE > IT > UK > ES > FR > NL > BE > AT
- Germany has the most publications (1814)
- Austria has the least publications (27)
- The mean of the publications is about 880.9
- The median of the publications is 854
- The range of the publications is 1787

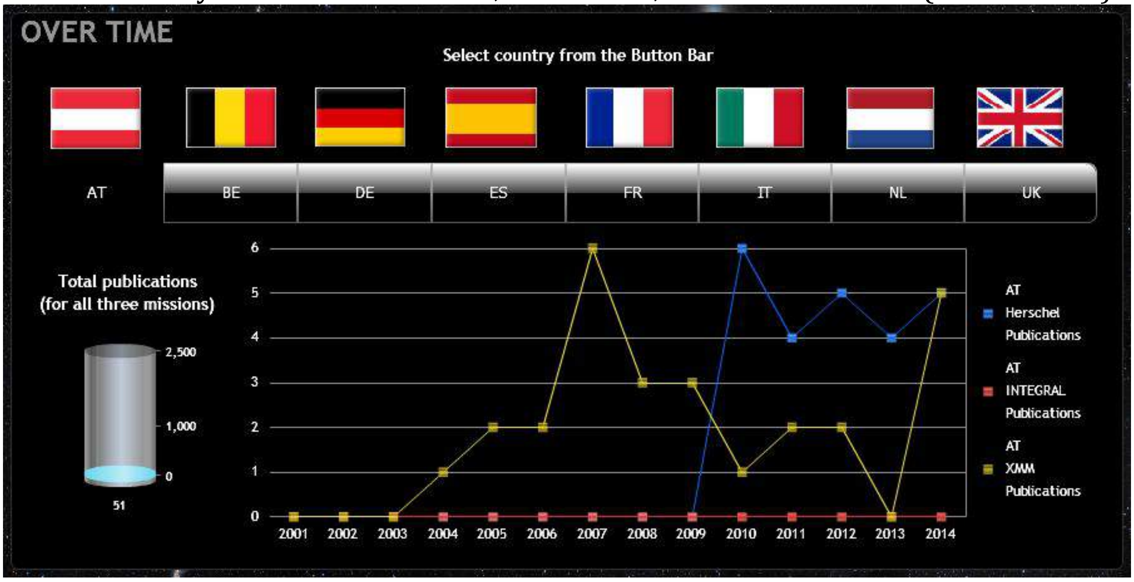
Total impact

- Germany (1814)
    - Dornier Satellitensysteme (part of Daimler Chrysler Aerospace) was the prime contractor of the mission
    - Mission operations
    - One member in mission team (project scientist)
    - Two instrument teams for EPIC
    - Seven companies in the industrial team
- Italy (1690)
    - Media Lario in Cannes developed the X-ray Mirror Modules
    - Three instrument teams for EPIC
    - Six companies in the industrial team
- United Kingdom (1201)
    - One university leads the XMM-Newton Survey Science Centre (the SSC has ten European institutes spread throughout France, the United Kingdom, Germany, Spain, and Italy)
    - Two principal investigator instrument teams for OM and EPIC, and another instrument team for EPIC
    - Five companies in the industrial team
- Spain (890)
    - Science operations
    - One member in mission team (project scientist)
    - Six companies in the industrial team
- France (818)
    - Three instrument teams for EPIC
    - Seven companies in the industrial team
- Netherlands (554)
    - One principal investigator instrument team for RGS
    - One member of the mission team (missions manager)
    - Seven companies in the industrial team
- Belgium (53)
    - One instrument team for OM
    - Three companies in the industrial team
- Austria (27)
    - Three companies in the industrial team

(Bagnasco et al., 1999).
("Space science: XMM-Newton factsheet," 2014).
("XMM-Newton Survey Science Centre," 2015).

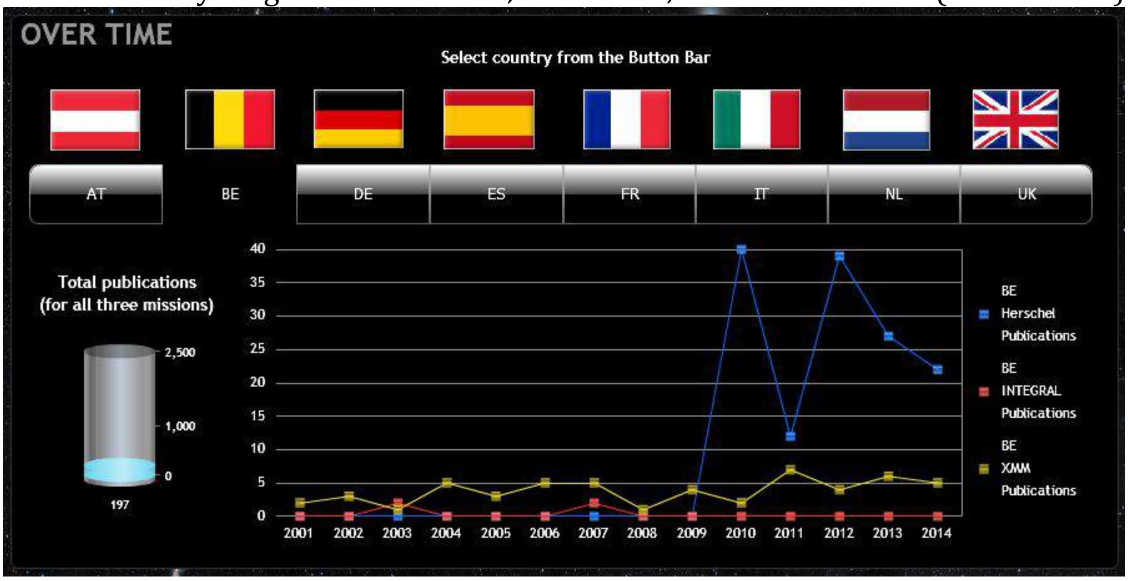
II. *Annual publications*

Publications by Austria for Herschel, INTEGRAL, and XMM-Newton (2001 - 2014)



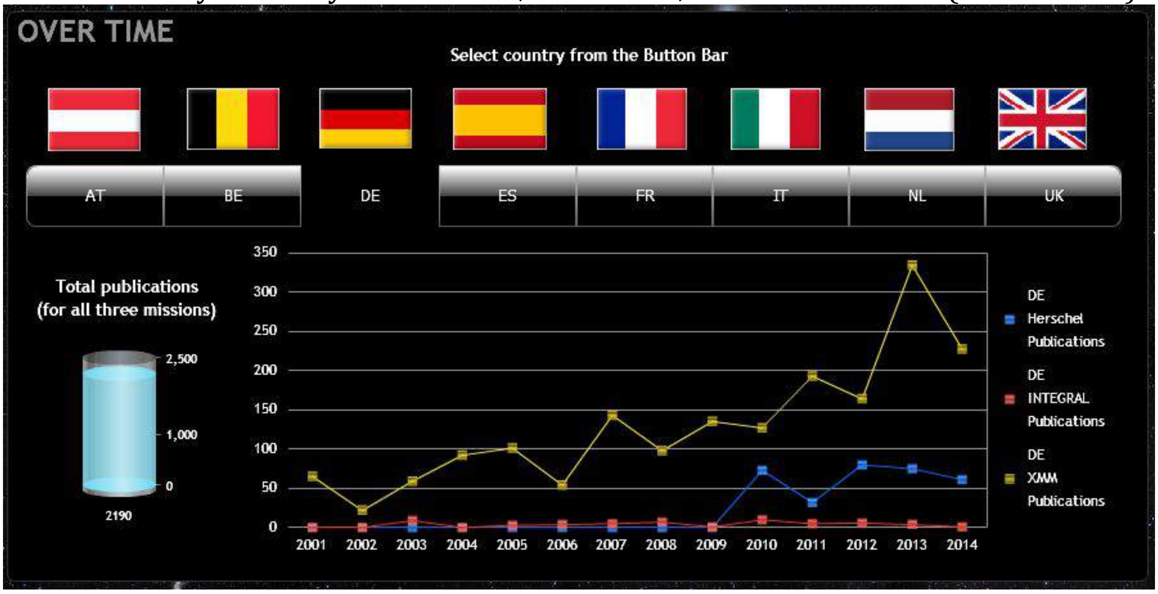
- The total number of publications is 51
- XMM (27): Publications start in 2004 and peak in 2007 (peak = 6)
- Herschel (24): Publications start and peak in 2010 (peak = 6)
- INTEGRAL (0): No publications

Publications by Belgium for Herschel, INTEGRAL, and XMM-Newton (2001 - 2014)



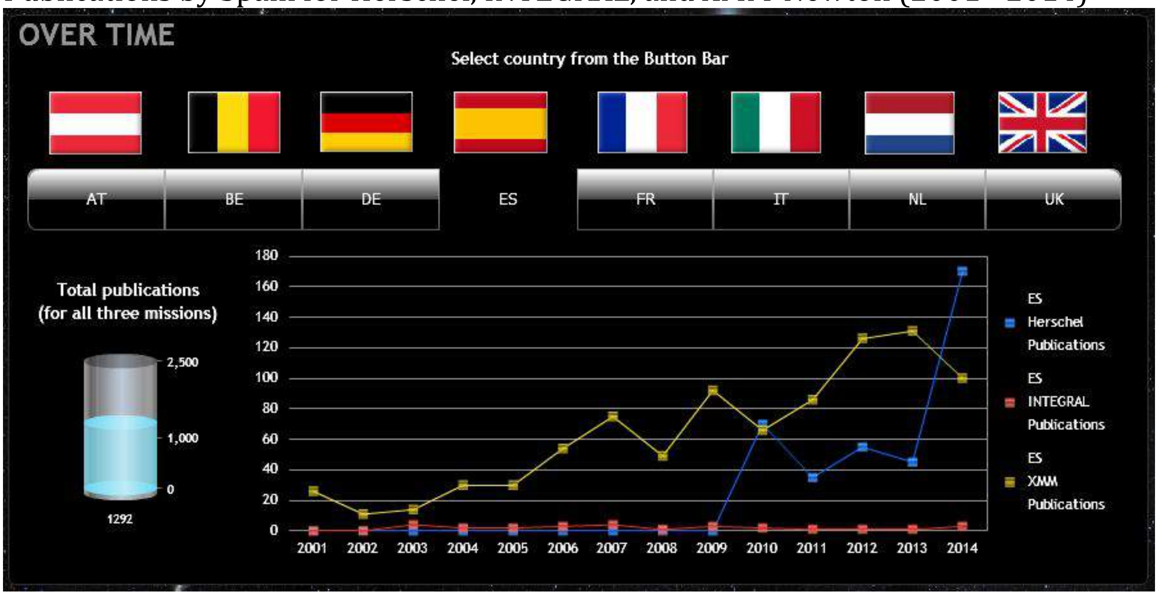
- The total number of publications is 197
- Herschel (140): Publications start and peak in 2010 (peak = 40)
- XMM (53): Publications start in 2001 and peak in 2011 (peak = 7)
- INTEGRAL (4): Publications start in 2003 and peak in 2003/2007 (peak = 2)

Publications by Germany for Herschel, INTEGRAL, and XMM-Newton (2001 - 2014)



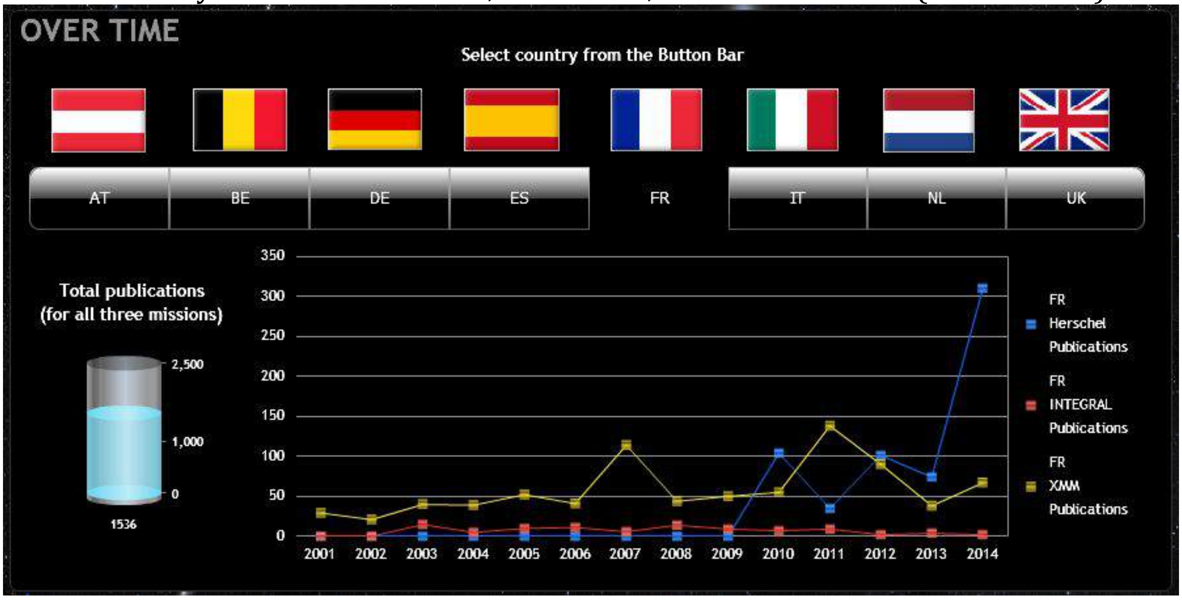
- The total number of publications is 2190
- XMM (1814): Publications start in 2001 and peak in 2013 (peak = 334)
- Herschel (321): Publications start in 2010 and peak in 2012 (peak = 80)
- INTEGRAL (55): Publications start in 2003 and peak in 2010 (peak = 10)

Publications by Spain for Herschel, INTEGRAL, and XMM-Newton (2001 - 2014)



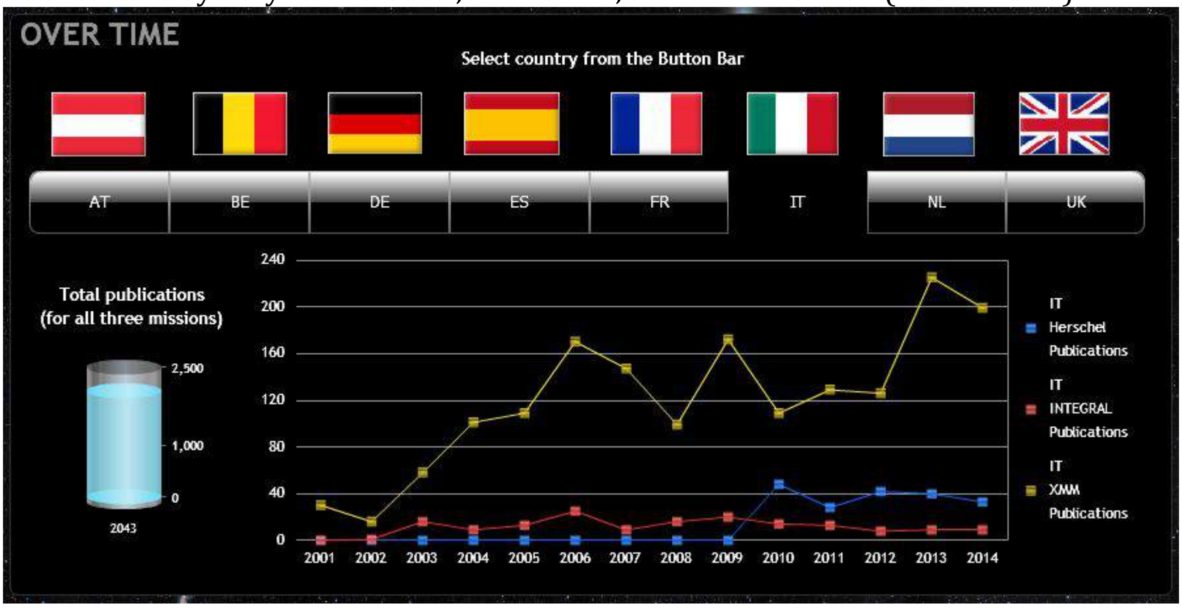
- The total number of publications is 1292
- XMM (890): Publications start in 2001 and peak in 2013 (peak = 131)
- Herschel (375): Publications start in 2010 and peak in 2014 (peak = 170)
- INTEGRAL (27): Publications start in 2003 and peak in 2003/2007 (peak = 4)

Publications by France for Herschel, INTEGRAL, and XMM-Newton (2001 - 2014)



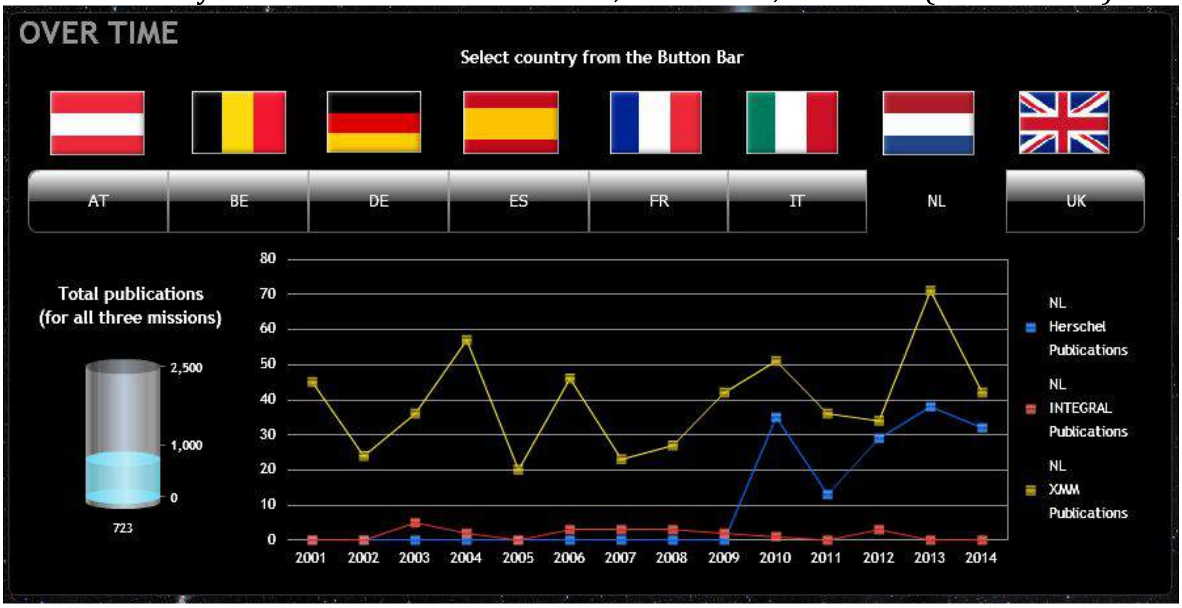
- The total number of publications is 1536
- XMM (818): Publications start in 2001 and peak in 2011 (peak = 138)
- Herschel (624): Publications start in 2010 and peak in 2014 (peak = 310)
- INTEGRAL (94): Publications start in 2003 and peak in 2003 (peak = 15)

Publications by Italy for Herschel, INTEGRAL, and XMM-Newton (2001 - 2014)



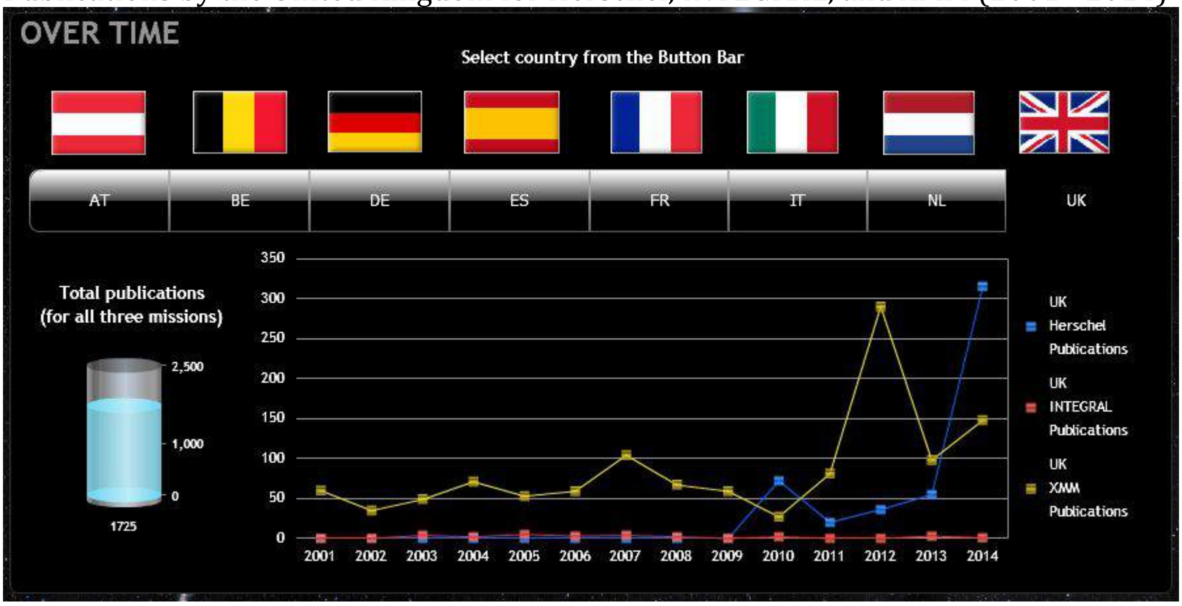
- The total number of publications is 2043
- XMM (1690): Publications start in 2001 and peak in 2013 (peak = 225)
- Herschel (191): Publications start and peak in 2010 (peak = 48)
- INTEGRAL (162): Publications start in 2003 and peak in 2006 (peak = 25)

Publications by the Netherlands for Herschel, INTEGRAL, and XMM (2001 - 2014)



- The total number of publications is 723
- XMM (554): Publications start in 2001 and peak in 2013 (peak = 71)
- Herschel (147): Publications start in 2010 and peak in 2013 (peak = 38)
- INTEGRAL (22): Publications start and peak in 2003 (peak = 5)

Publications by the United Kingdom for Herschel, INTEGRAL, and XMM (2001 - 2014)



- The total number of publications is 1725
- XMM (1201): Publications start in 2001 and peak in 2012 (peak = 290)
- Herschel (498): Publications start in 2010 and peak in 2014 (peak = 315)
- INTEGRAL (26): Publications start in 2003 and peak in 2005 (peak = 5)

III. Comparisons

- Recall the order of the national impacts for each mission
  - Herschel: FR > UK > ES > DE > IT > NL > BE > AT
  - INTEGRAL: IT > FR > DE > ES > UK > NL > BE > AT
  - XMM: DE > IT > UK > ES > FR > NL > BE > AT
- In terms of total publications, XMM-Newton > Herschel > INTEGRAL

- **Big countries**: Germany, Italy, the United Kingdom, France
  - Two big countries are always first but the order changes by mission
  - Germany is the only big country that is in the first half for all missions
  - It has more total publications than all the countries
  - France has a high impact for Herschel but a low impact for XMM-Newton while Italy has a high impact for XMM and a low impact for Herschel

- **Small countries**: Spain, the Netherlands, Belgium, Austria
  - The Netherlands, Belgium, and Austria are always last in the same order
  - Spain is the only small country that is in the first half for all missions
  - It has more total publications than the other small countries

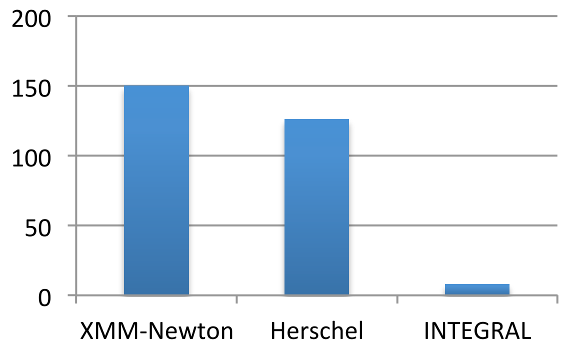
- Start of impact
  - All national impacts for Herschel start in 2010 (one year after launch)
  - All national impacts for INTEGRAL start in 2003 (one year after launch)
  - All national impacts for XMM start in 2001 (two years after launch) except that of Austria, which starts in 2004 (three years after launch)
  - If Austrian publications are excluded then the national impacts for each mission start the same year as the impacts in the first document (p. 25)

- Peak of impact
  - All national impacts for Herschel and INTEGRAL peak within 10 years of launch and most national impacts for XMM-Newton do not
  - For Herschel, the national impacts peak in between 2010 – 2014
    - France, United Kingdom, and Spain have the largest impacts and make up 65 per cent of publications
    - All three impacts peak the same year as the overall impact (p. 22)
  - For INTEGRAL, the national impacts peak in between 2003 – 2010
    - Italy, France and Germany have the largest impacts and make up 80 per cent of publications
    - Only the impact of Italy, which makes up forty per cent of publications, peaks the same year as the overall impact (p. 23)
  - For XMM-Newton, the national impacts peak in between 2007 – 2013
    - Germany, Italy, and United Kingdom have the largest impacts and make up 67 per cent of publications
    - None of these impacts peak the same year as the overall impact
    - However, the impact of France, which makes up 12 per cent of the publications, does (p. 25)

The correlation between the peak years of the national impacts and the peak years in the first document appears to be strongest for Herschel and weakest for XMM-Newton

- In all countries, INTEGRAL consistently has the least publications and the lowest peak
- Almost all countries have more publications for XMM-Newton than for Herschel
- Belgium is the only country that has more publications for Herschel
- In the United Kingdom, France, Spain, and Belgium, the impact for Herschel has a higher peak than that of XMM-Newton
- However, when the national peak publications are averaged out, they are higher for XMM-Newton than for Herschel

Averages of the national peak publications for Herschel, INTEGRAL, and XMM-Newton



- XMM > Herschel > INTEGRAL
- XMM has the highest peak (150)
- Herschel has the median peak (126)
- INTEGRAL has the lowest peak (8)
- The range of peaks is 142

The average peaks for the three missions are in the same order as the peaks in the first document (p. 25)

- End of impact
    - Earlier in the report I hypothesized that Herschel is a young peaking mission, INTEGRAL is a middle-aged declining mission, and XMM-Newton is an old stabilizing mission (p. 25)
    - For Herschel, only the impacts of France, the United Kingdom, and Spain end on a peak (but they are the most influential impacts for the mission)
    - For INTEGRAL, national publications are low so it is difficult to analyse the direction in which they are moving
    - For XMM-Newton, the majority of the national impacts do not stabilise after 2011 but increase
    - The correlation between the direction of the national impacts and the direction of the impacts in the first document appears to be stronger for Herschel than for INTEGRAL and XMM-Newton

5. Conclusion and summary

With the help of MicroStrategy I was able to obtain useful information from grids and charts and discover trends among the impacts. On the documents, I could compare the total impacts of the missions and analyse an impact over time. I broke down each impact by looking at the launch, the year the first publications appeared, the year the publications peaked, the magnitude of the peak, and the direction the publications were moving in after the peak.

The first document shows that SOHO and XMM-Newton have the largest total impacts by far (almost 3x as many publications as Herschel and about 4x as many as ISO, INTEGRAL, Mars Express, Planck, Venus Express, Rosetta, Gaia). This is likely due to the fact that they are the oldest operational missions. The document also shows that all impacts are immediate and start within two years of launch (excluding the impacts of ISO and SOHO, which start five years after launch but are missing data before 2000). On the charts, it is easy to spot that all impacts peak within 10 years of launch (excluding the impacts of XMM-Newton and SOHO, which both peak 12 years after launch but are missing data before 2000). Furthermore, one can see that the order of peak publications is similar to the order of total publications. The main difference is that Planck and Mars Express are ranked higher in peak publications and thus have more rapid and uneven impacts. Finally, there are three directions in which publications are moving: they are peaking, stabilising, or declining. Gaia, Herschel, and Planck are young peaking missions. Mars Express, Rosetta, and Venus Express are middle-aged stabilising missions. SOHO and ISO are old declining missions. XMM, an old stabilizing mission, and INTEGRAL, a middle-aged declining mission, are outliers.

The second document shows the national impacts of Herschel, INTEGRAL, and XMM. France, the United Kingdom, and Spain have the largest impacts for Herschel because they are involved with the science operations, science team, industrial team, and PI instrument team for SPIRE. Italy, France, and Germany dominate the publications for INTEGRAL because they have members in the mission operations, INTEGRAL Users Group, industrial team, and PI team for IBIS and SPI. For XMM-Newton, Germany, Italy, and the United Kingdom have the most publications because they contribute to the mission operations, industrial team, XMM-Newton Survey Science Centre, X-ray mirror modules, and PI instrument teams for EPIC and OM. The prime contractor of each mission has the same nationality as the largest impact (i.e. Thales Alenia Space (FR), Alenia Spazio (IT), Dornier Satellitensysteme (DE)). When isolating the bigger countries, namely Germany, Italy, the United Kingdom, and France, certain observations can be made. The top impact of every mission is always a big country but never the same one. Germany has the most publications and is the only big country that has consistently large impacts for all three missions. Comparing the small countries, namely Spain, the Netherlands, Belgium, and Austria, also provides insight. The Netherlands, Belgium, and Austria have the three smallest impacts for all three missions. Spain stands out because it has more publications than the other small countries and consistently large impacts for all missions.

There are several results that coincide with the first document. To begin, most national impacts are immediate and start within two years of launch. Secondly, all national impacts for Herschel and INTEGRAL peak within 10 years of launch while most national impacts for XMM-Newton do not. Not all national impacts peak the same year as the impacts in the first document. An influential portion of Herschel's national publications peak the same year but the majority of XMM-Newton's publications do not. Thirdly, when we compare the number of publications and the peak publications of each country, XMM-Newton is typically at the top and INTEGRAL is consistently at the bottom. All countries except Belgium have more publications for XMM-Newton than for Herschel. The United Kingdom, France, Spain, and Belgium have higher peaks for Herschel but when the national peaks are averaged out, XMM-Newton has the highest average peak. In terms of end of impact, the second document does not reflect that INTEGRAL is a declining mission and that XMM-Newton is a stabilizing mission. For Herschel, only the impacts of France, the United Kingdom, and Spain end on a peak but since they are the most influential impacts for the mission they are indicative of a peaking direction. For INTEGRAL, national publications are low so it is difficult to analyse the direction in which they are moving. The correlation between the direction of the national impacts and the direction of the impacts in the first document appears to be stronger for Herschel than for the other missions.

MicroStrategy is a valuable tool for comparison and analysis. It has allowed me to explore trends in mission impacts and decompose impacts over time. By comparing the impacts of missions with one another and looking at the national breakdown of three specific missions, I could learn about the role of missions and countries in science. MicroStrategy has been useful for studying the nature of scientific impacts, specifically for ESA missions, and could be applied to other scientific data at ESA.

Thank you for this opportunity.

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