

Mobilität im All und auf der Erde

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Head of Navigation Support Office
Europäisches Raumfahrt Kontroll Zentrum – ESA/ESOC

12. September 2016

$$\sin u + \sin v = 2 \sin \left(\frac{u+v}{2} \right) \cos \left(\frac{u-v}{2} \right)$$

$$\sin u - \sin v = 2 \cos \left(\frac{u+v}{2} \right) \sin \left(\frac{u-v}{2} \right)$$

$$\cos u + \cos v = 2 \cos \left(\frac{u+v}{2} \right) \cos \left(\frac{u-v}{2} \right)$$

$$\cos u - \cos v = -2 \sin \left(\frac{u+v}{2} \right) \sin \left(\frac{u-v}{2} \right)$$

$$A = \pi$$

Die ESA: Fakten und Zahlen



- Über 50 Jahre Erfahrung
- Nur friedliche Zwecke
- 22 Mitgliedsstaaten
- 8 Standorte in Europa
- 2.200 Mitarbeiter
- Budget 5,2 Mrd. € (2016)
- Entwicklung, Test und Flugbetrieb von bisher mehr als 80 Satelliten

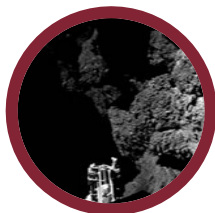


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Tätigkeitsbereiche



**Weltraum-
wissenschaft**



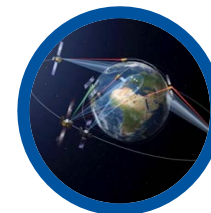
**Bemannte
Raumfahrt**



Raumflugbetrieb



Exploration



Telekommunikation



Erdbeobachtung



**Träger-
systeme**



Navigation



Technologie

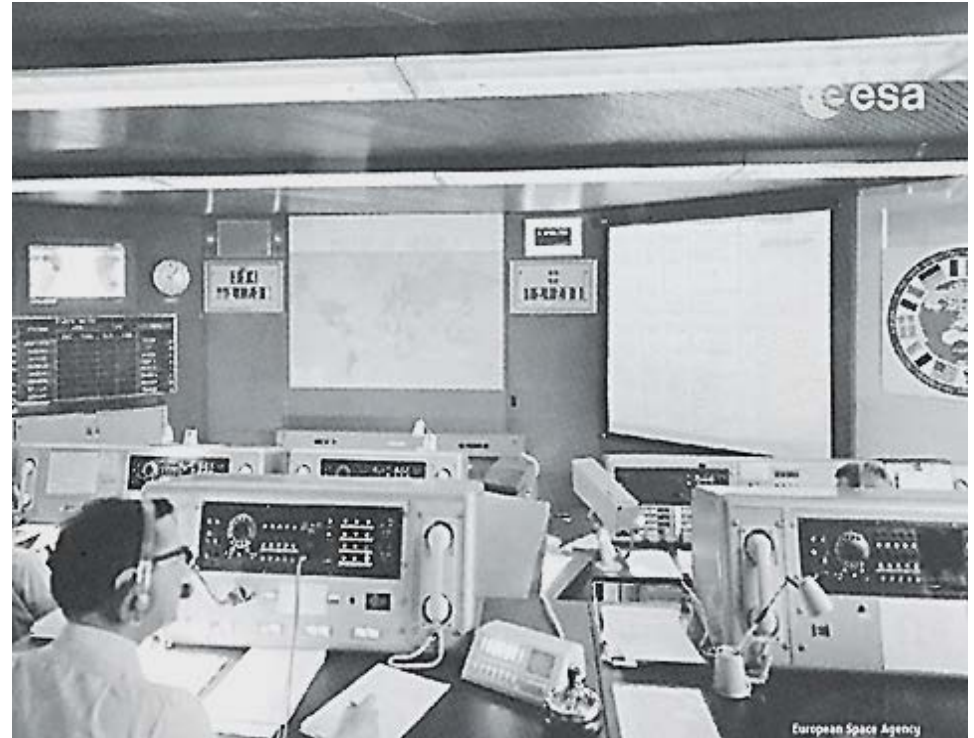
Europäische Raumfahrt

- Ca 35 000 Arbeitsplätze
- Sehr erfolgreich im kommerziellen Markt (> 50% Telekommunikation, Startdienste)
- Europäische Wissenschaftler an Weltspitze
- Forschungs- und Innovationszentren mit Weltruf



ESOC: Fakten & Historie

- Gründung am 8. Sept. 1967
- 3 Hauptaufgaben
 - Missionsbetrieb
 - Entwicklung und Bau des Bodensegments
 - Programm Weltraumlagerfassung
- 900 Mitarbeiter in Darmstadt, davon 270 ESA Mitarbeiter
- Zahlreiche Außenstellen, z.B. Bodenstationen



ESOC: Das Raumfahrt-Betriebszentrum

- 76 Satelliten gestartet
- 13 Missionen (19 Satelliten) im Orbit
- 10 Missionen in Vorbereitung
- Alle Missionsarten (erdnah, Konstellationen, interplanetar)
- 9 Satelliten aus Notlagen gerettet
- Einzigartige Sondermissionen, z.B. Rosetta
- Weltweite Kooperationen (USA, Russland, China, Japan,...)



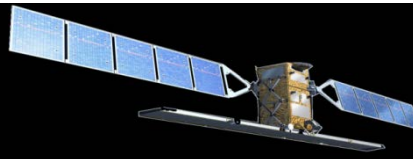
Missionen der Erdbeobachtung



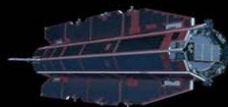
ERS-1/2



ENVISAT



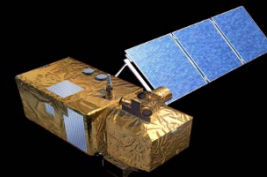
Sentinel 1
SAR imaging
2014 A / 2016 B



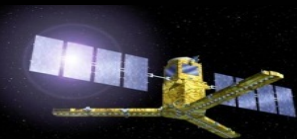
GOCE



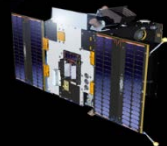
CRYOSAT



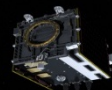
Sentinel 2
Multi-spectral imaging
2015 A / 2016 B



SMOS



PROBA 1



PROBA V



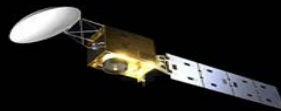
Sentinel 3
Ocean and global land
monitoring
2015 A / 2017 B



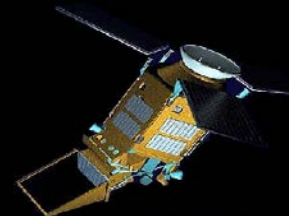
SWARM



AEOLUS



Earthcare



Sentinel 5p
Low-orbit atmospheric
2017

Vulkanausbruch des Ätna Juli 2001 – Aschewolke

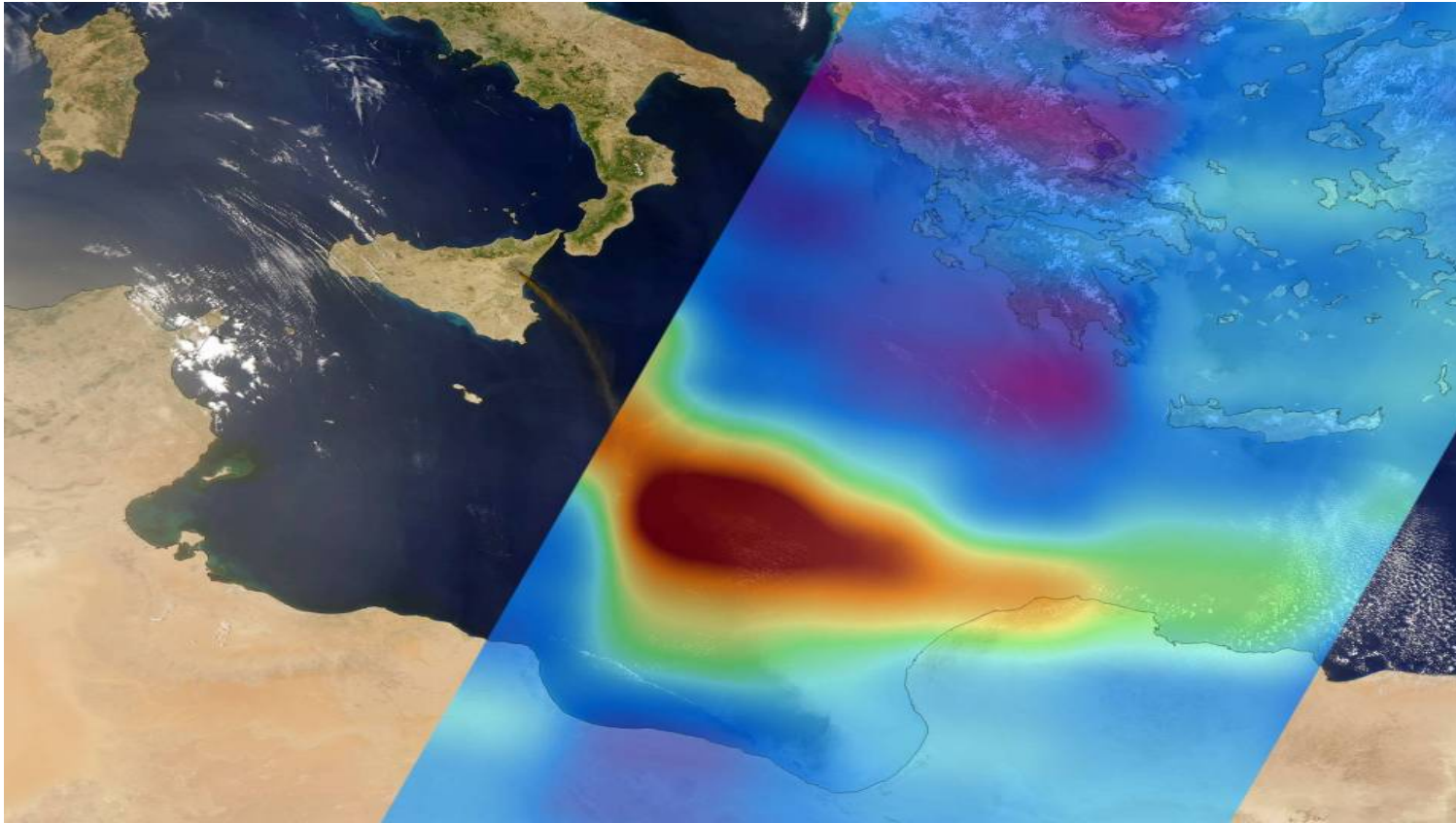


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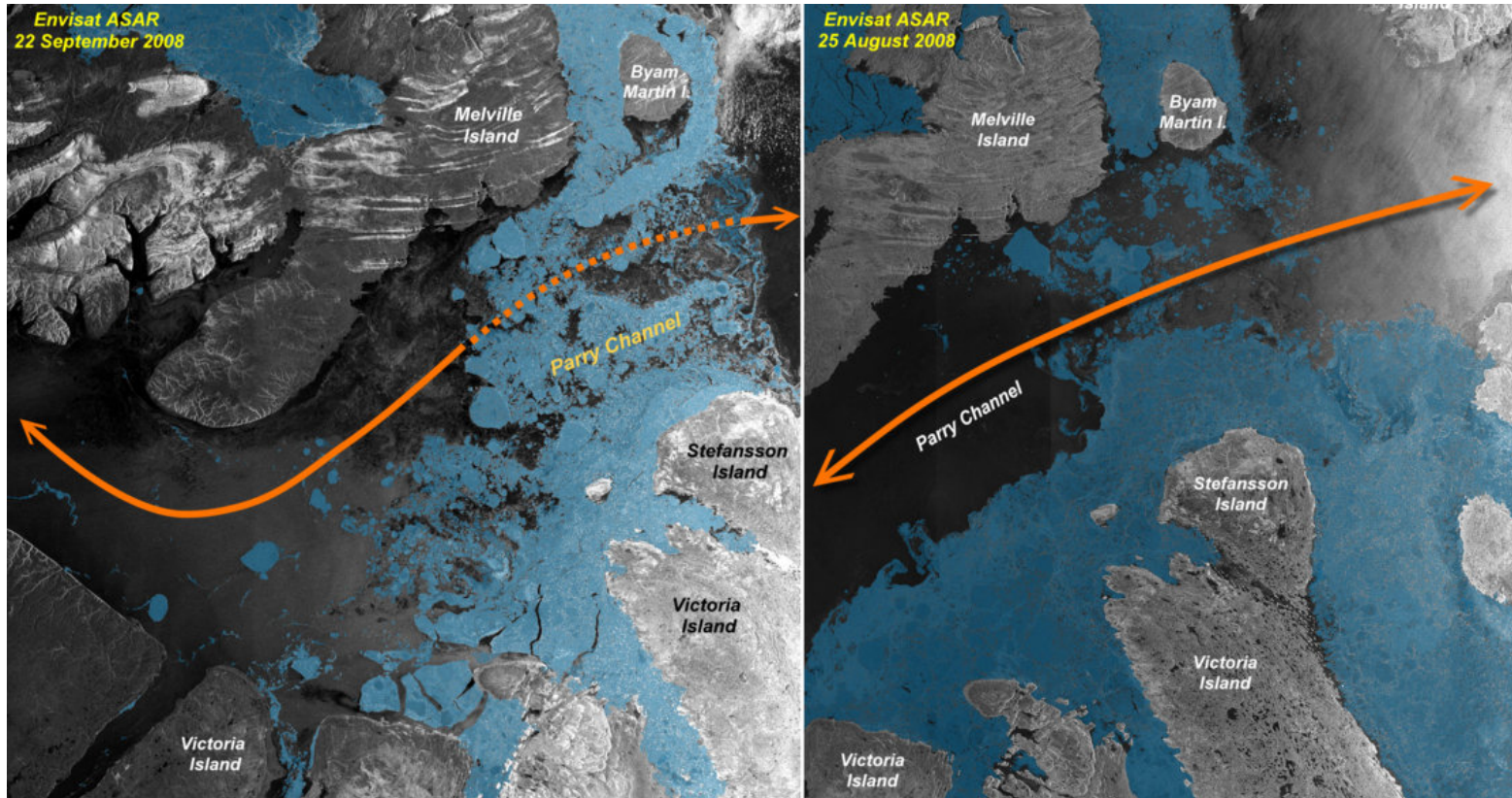
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Ausbruch des Ätna und Schwefeldioxidwolke



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Eisstand der Nordwestpassage



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Copernicus: Flüchtlingscamp

Optische Sat-Bilder von Camp in Jordanien, im Jahr 2014



MOSE number: 504
 Acquisition ID: 02888-028
 Product ID: 02888-028

Zarqa - JORDAN
Humanitarian Aid - 08/02/2013
 Reference Map - OGC/OGD

Production date: 12/03/2013

Cartographic information
 1:1000
 Publication: 09/01/13, last modification: 09/01/13
 Map coordinate system: WGS 1984 UTM Zone 37N
 Projection: UTM M geographic coordinates

Legend

General information
 - Perimeter
Build-Up Area
 - Multiple Camp
Topographical
 - Local Road

Buildings
 - Camp (toilet)
 - Water treatment plant
 - Kitchen
 - Power generator
 - Market
 - School
 - Mosque
 - Washroom
 - Showering facility
 - Water tank

Number for within Zarqa camp and date 12/03/2013	
Central toilet	1
Water treatment plant	1
Kitchen	1
Power generator	1
Market	1
School	1
Mosque	1
Washroom	1
Showering facility	1
Water tank	1

Map information
 This map is a 2D visualization of the Sentinel-2 satellite imagery. It is not a true color image. The colors are false colors used to highlight specific features. The map is based on the Sentinel-2 satellite imagery acquired on 08/02/2013. The map is a 2D visualization of the Sentinel-2 satellite imagery. It is not a true color image. The colors are false colors used to highlight specific features. The map is based on the Sentinel-2 satellite imagery acquired on 08/02/2013.

Data sources
 The data used in this map is derived from the Sentinel-2 satellite imagery. The data is provided by the European Space Agency (ESA).

Disclaimer of responsibility
 ESA is not responsible for any errors or omissions in this map.

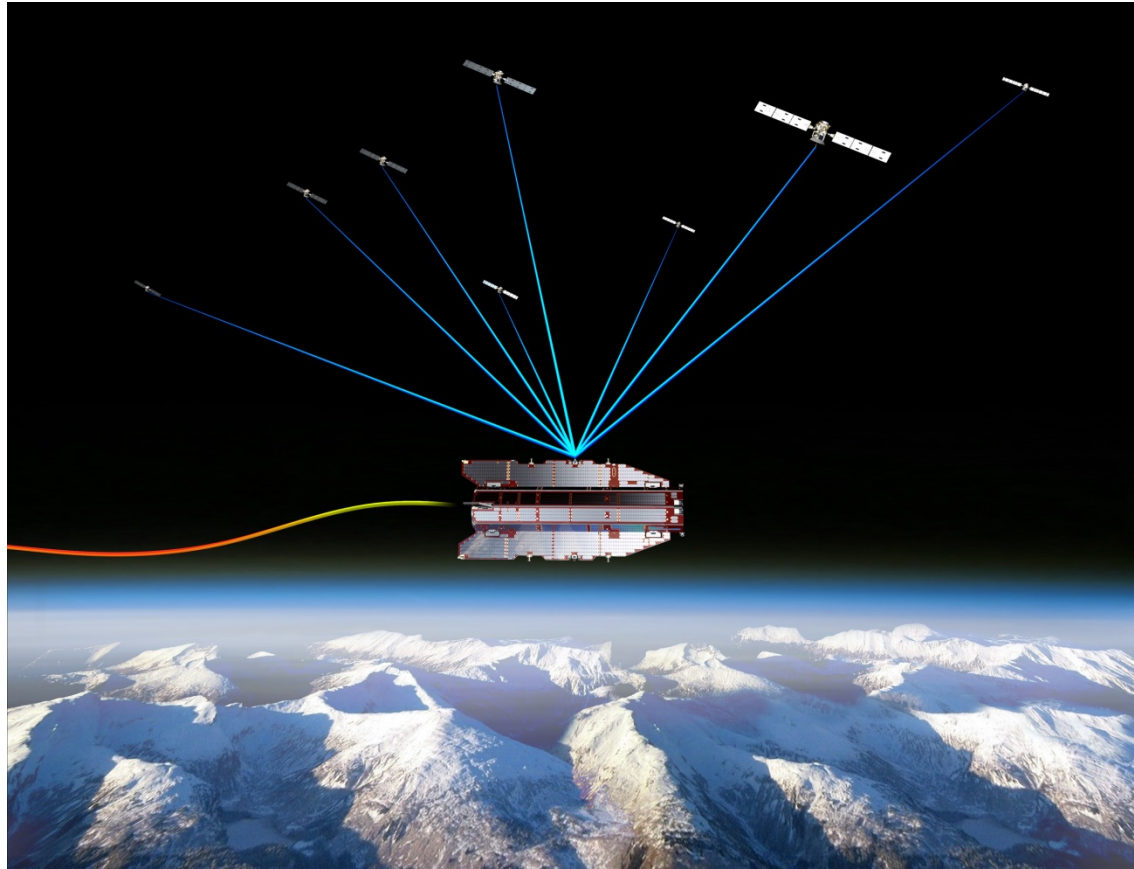
Footnote
 The content of this map is based on the Sentinel-2 satellite imagery.

Map Production
 This map was produced by the Copernicus programme.

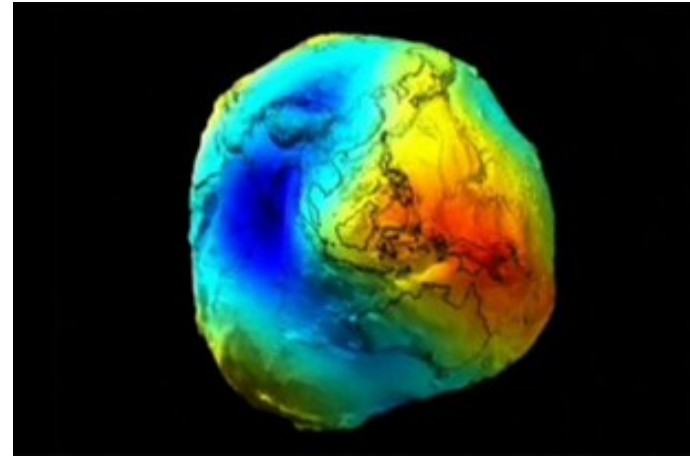
+ Information
 + Perimeter
 + Multiple Camp
 + Local Road
 + Camp (toilet)
 + Water treatment plant
 + Kitchen
 + Power generator
 + Market
 + School
 + Mosque
 + Washroom
 + Showering facility
 + Water tank

Gmes



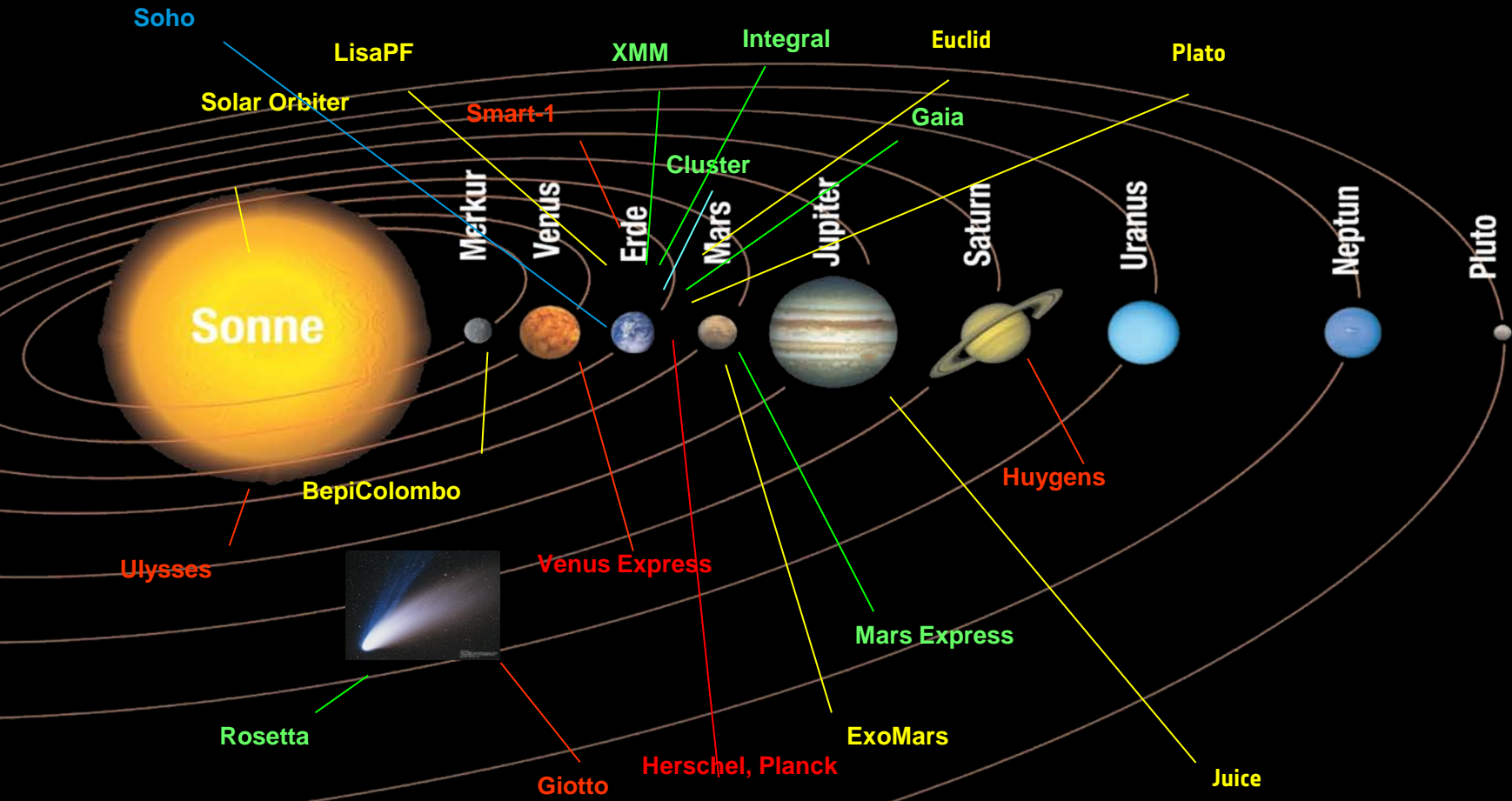


- Neue Technologien (GNSS)
- Neue Erkenntnisse
Gravitationspotential der Erde
- Verbesserung der Genauigkeiten
- Neue Anwendungen



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Wissenschaftsmissionen der ESA im Sonnensystem



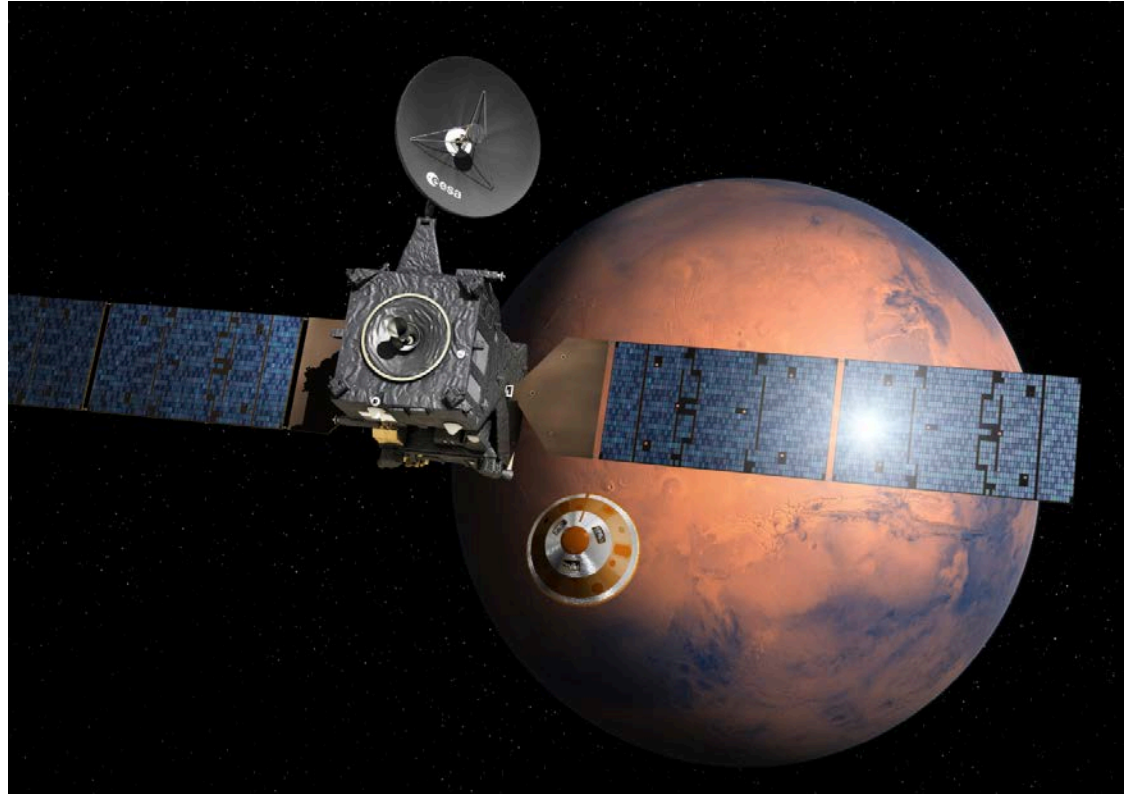
Huygens: Saturnmond Titan (Januar 2005)



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ExoMars

- EXOMARS Trace Gas Orbiter
 - 19. Oktober 2016, Ankunft am roten Planeten
 - Einschwenken von Mutterschiff
 - Weiche Landung von Schiaparelli-Testmodul
- EXOMARS Lander Rover
 - Start geplant 2020



Rosetta: Europas Kometenjäger (2015)

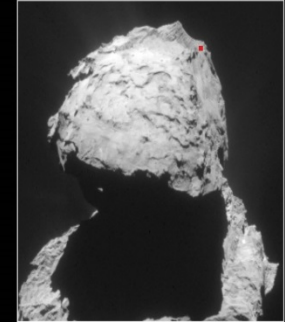
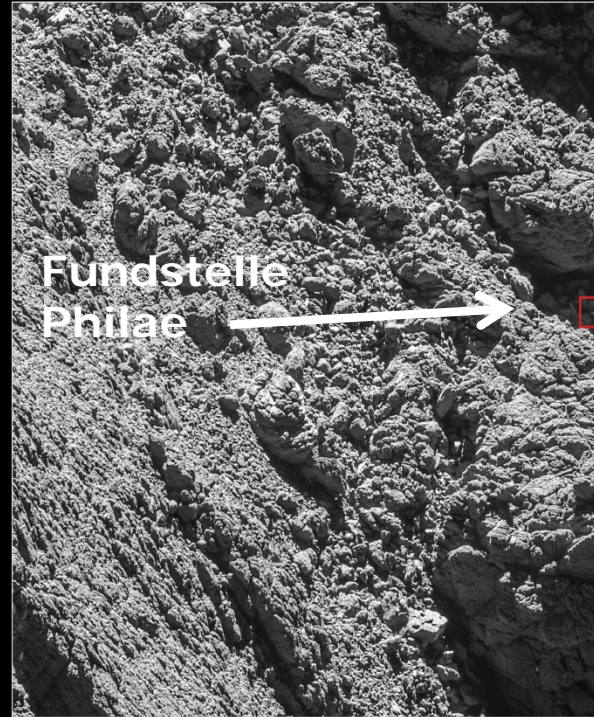
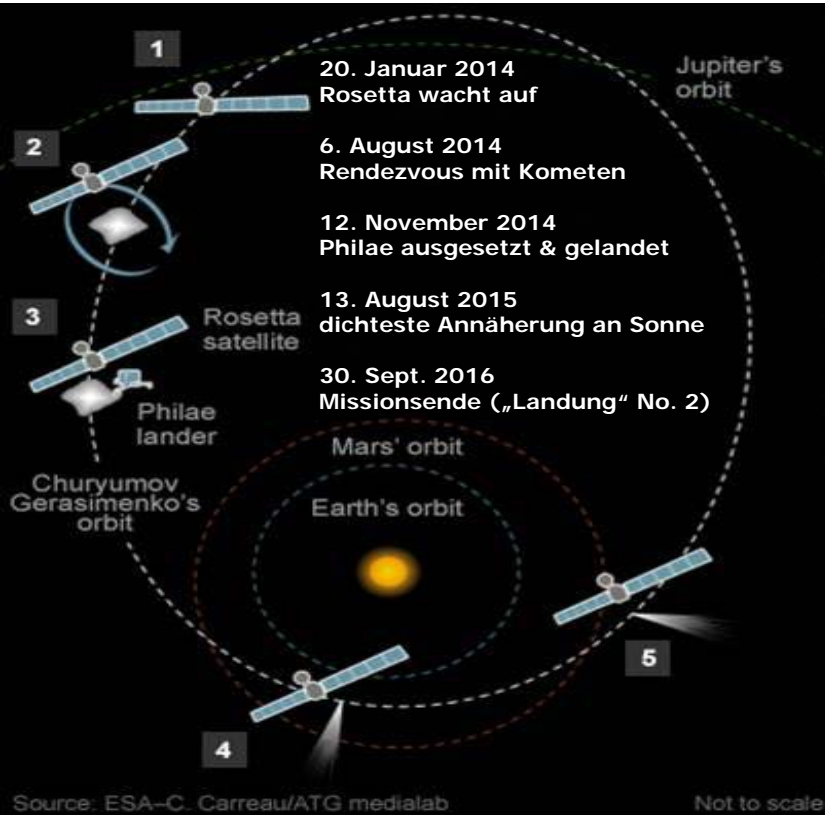


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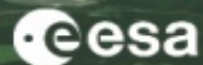


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Rosetta – Europas Kometenjäger



→ DARMSTADT



Darmstadt

Arheilgen

4100 m

Europäische Beiträge:

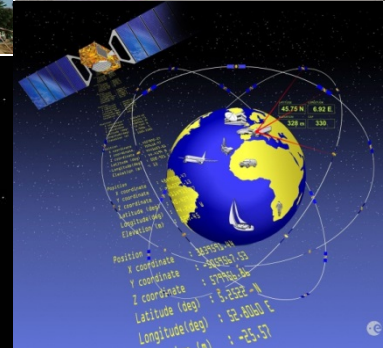
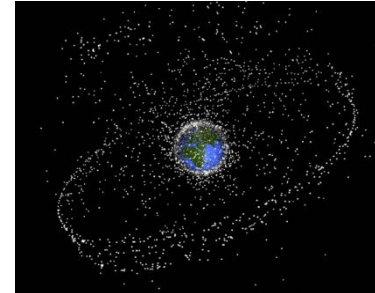
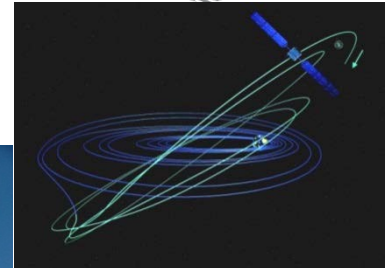
- Columbus Modul
- ATV
- MPLM
- Node 2
- Node 3
- Cupola
- Ext. Nutzlasten
- ERA
- DMS-R



ESOC: Ingenieurwissen



- Entwicklung und Bau von Bodensystemen
 - Kontrollzentren, Software, Antennen, Bodenstationen
- Einzigartiges Spezialwissen
 - Flugdynamik
 - Weltraumschrott
 - Präzisionsnavigation
- Internationale Standardisierung



ESOC: Weltweites Netz von Bodenstationen



New Norcia,
Australien



Cebreros,
Spanien



Malargüe,
Argentinien



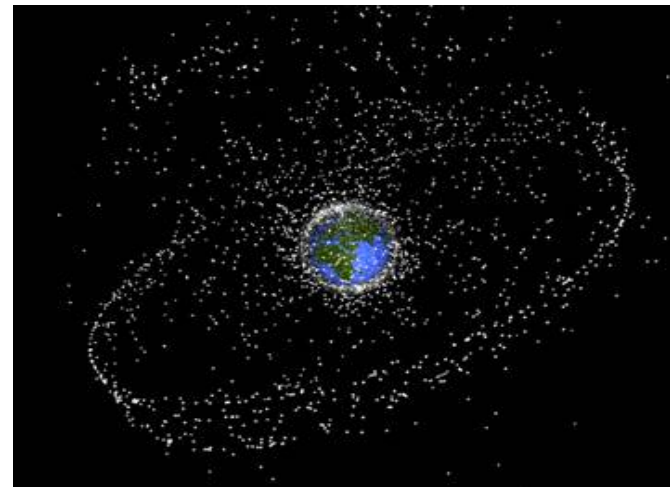
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ESOC: Weltraumumgebung

- Vorhersagedienst 24/7
- Ausweichmanöver (10 in 2015)
- Wiedereintrittsvorhersagen
- Risikobewertung nach Explosionen oder Kollisionen



Nachhaltige Nutzung des erdnahen Weltraums



- Sprunghafte Zunahme von Satelliten
 - Cubesats, Nanosats
 - Megakonstellationen
- Neu: Unabhängiges europäisches Programm
- Space Traffic Management
 - Weltraumlage-Erfassung (SSA)
 - E-Deorbit
 - Asteriod Impact Mission (AIM)



Programm zur Weltraumlage-Erfassung (SSA)



Erfassung von Objekten und Phänomenen die eine Gefahr für Raumfahrt und Erde darstellen

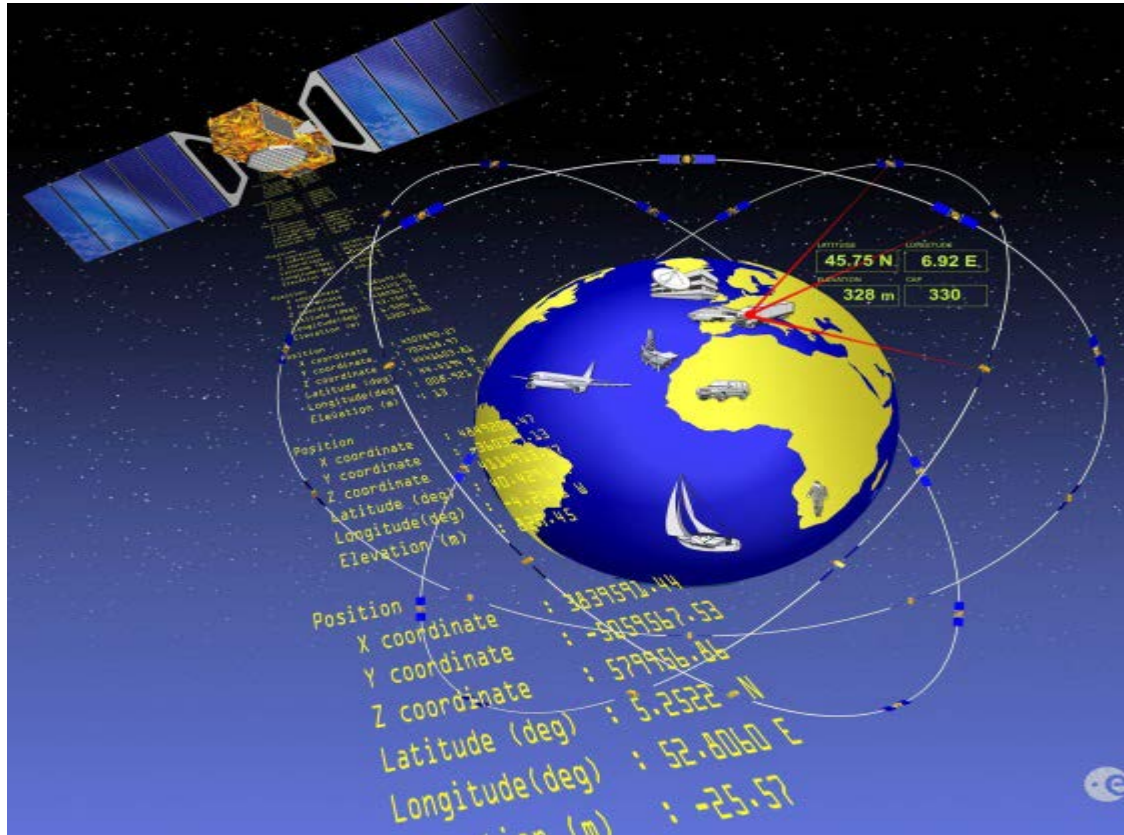
- Weltraumwetter (SWE)
- Erdnahe Objekte (NEO) z.B. Asteroiden, Kometen
- Weltraumüberwachung (SST) z.B. inaktive Satelliten

ESOC - Technologische Entwicklung

- **11 Gründungen** (derzeit rd. 2.000 Jobs) aus dem ESOC
- **Erst- und Referenzkunde** für mind. 20 weitere Firmen
- **EUMETSAT** (Wettersatelliten, 400 M€ Budget, 700 Jobs) in Darmstadt ist ein ESA/ESOC Spin-off
- **ESA Gründerzentrum Darmstadt**, geleitet von CESAH, bisher 70 Start-ups, 260 neue Jobs



Navigation

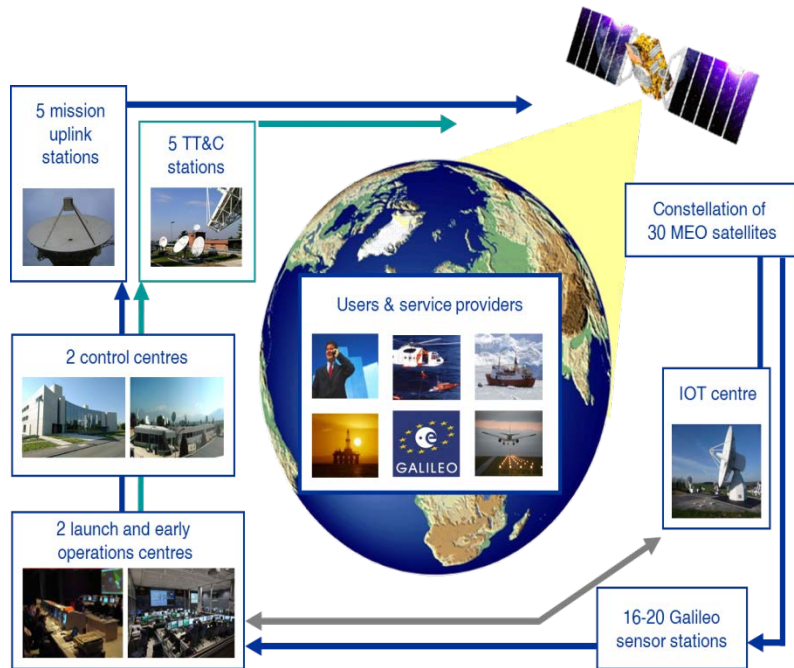


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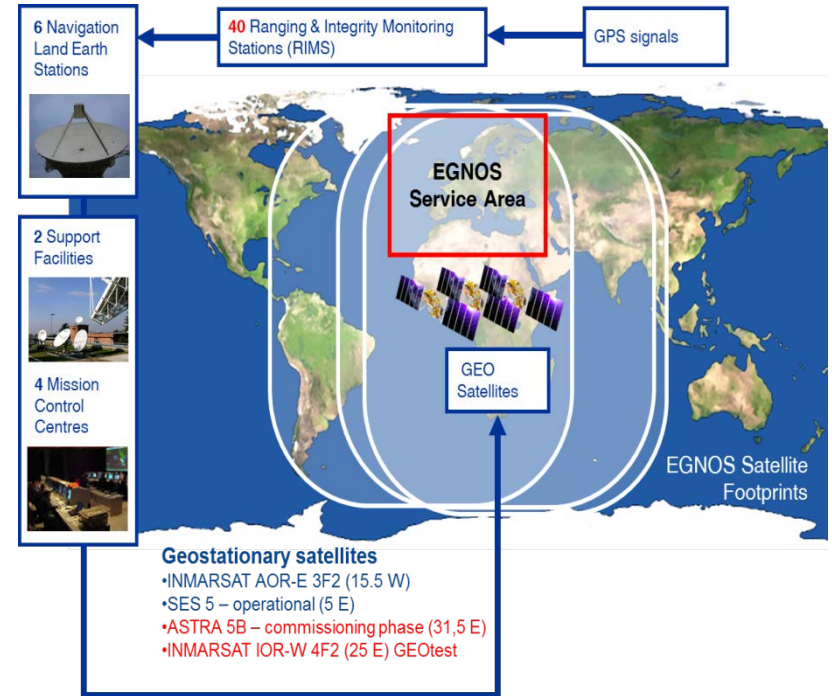


Navigation - Europa

Galileo



EGNOS



Navigation - GNSS

Globale Satelliten Navigationssysteme (GNSS)

- GPS (USA)
- GLONASS (Russland)
- Galileo (Europa)
- BeiDou (China)

Regionale Satelliten Navigationssysteme

- QZSS (Japan)
- IRNSS (Indien)

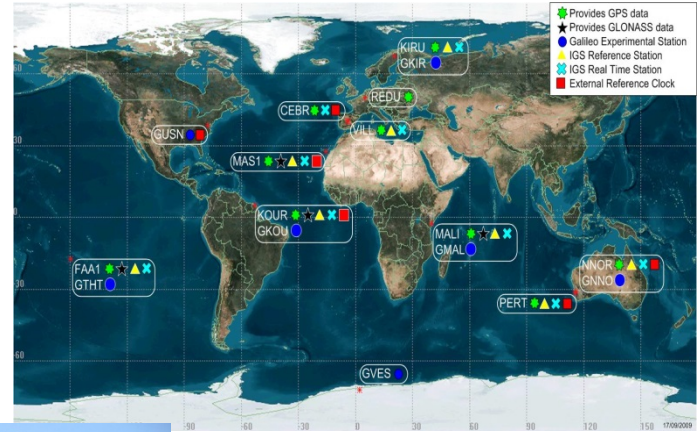
Space Based Augmentation Systems (SBAS)

- WAAS (USA)
- EGNOS (Europa)
- MSAS (Japan)
- SDCM (Russland)
- GAGAN (Indien)

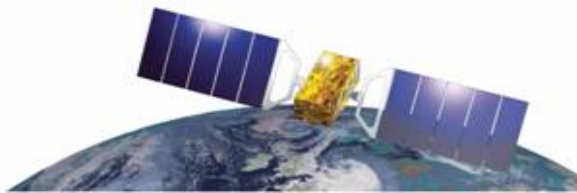
Nahe Zukunft:

- Anzahl der Satelliten in 2020 > 120
- Vielzahl von Frequenzen
- Vielzahl von Signalen

Navigation – Navigation Office am ESOC



esa
NAVIGATION
FACILITY

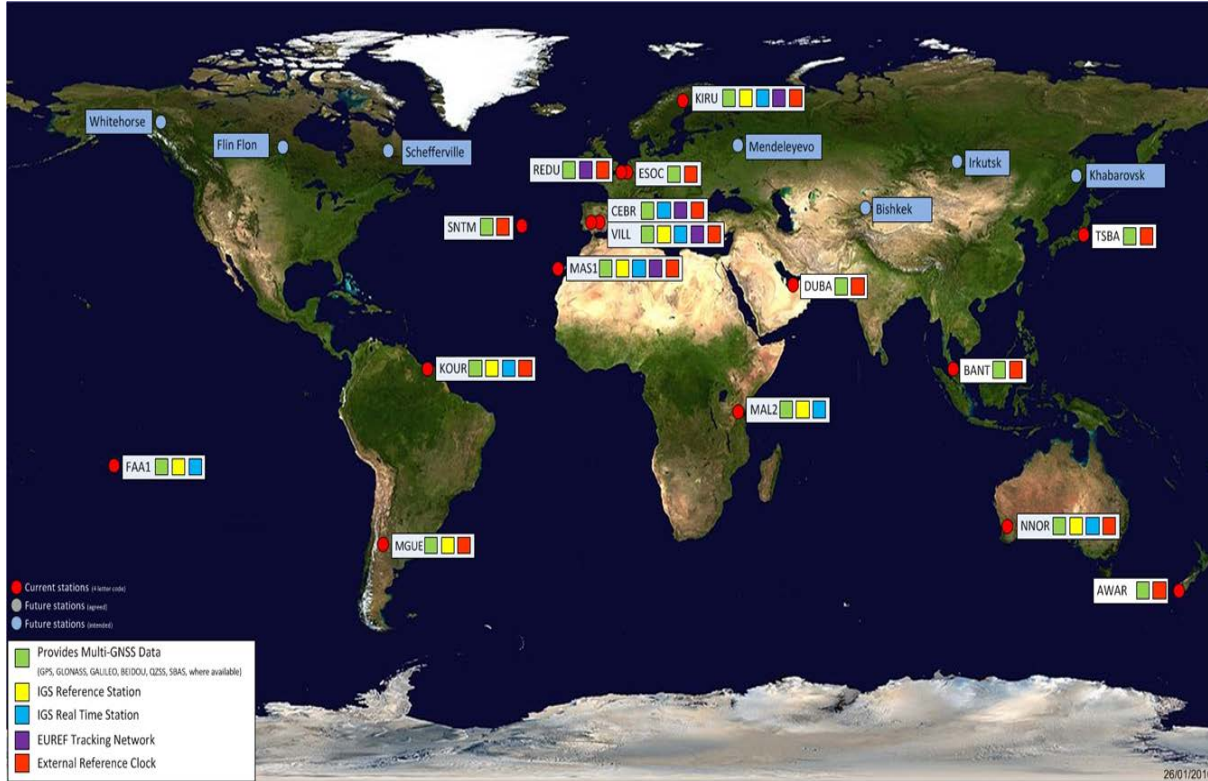


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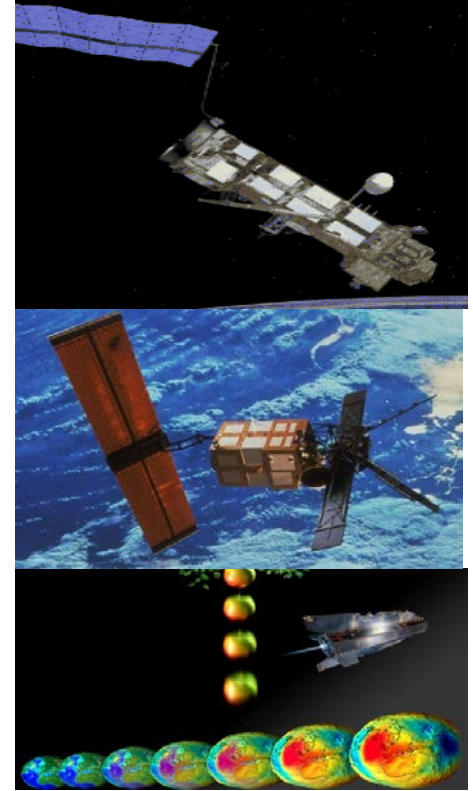
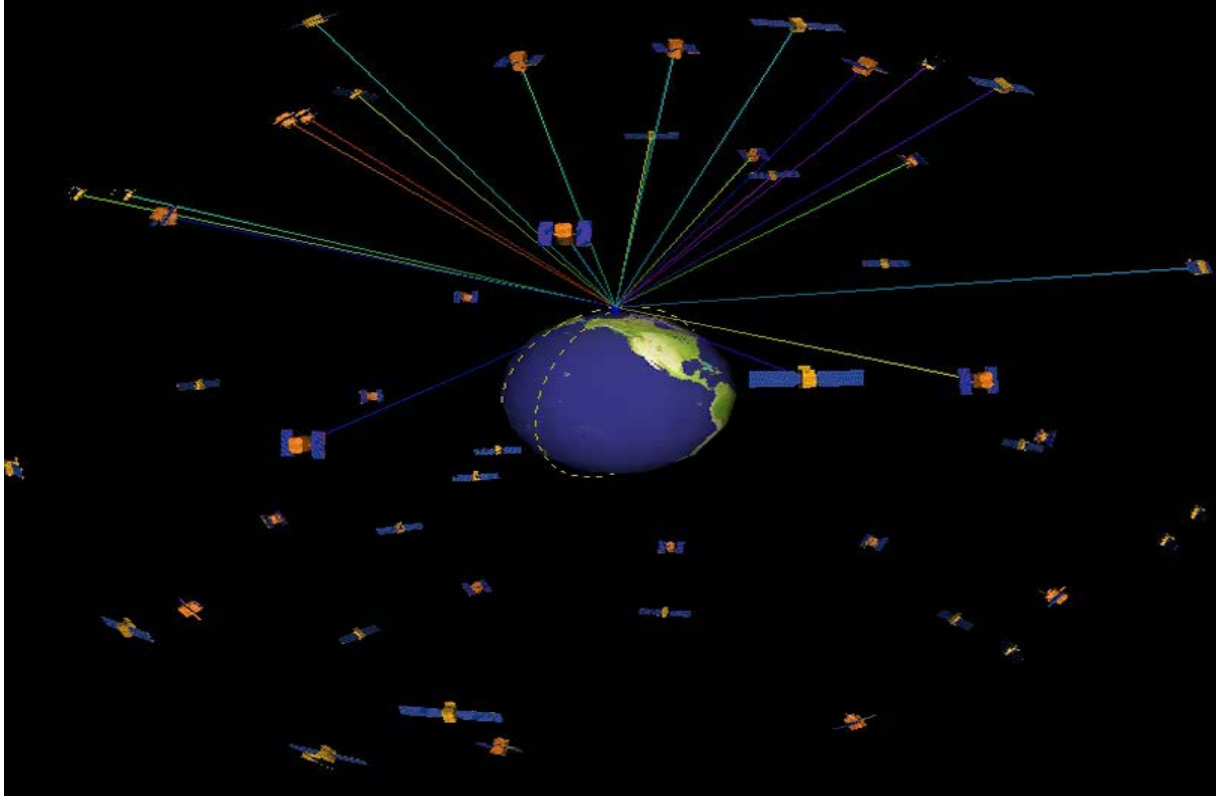
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Betrieb von Global Sensor Station Network - GNSS Receivers



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Navigation – Prazise Bahbestimmung im cm Bereich



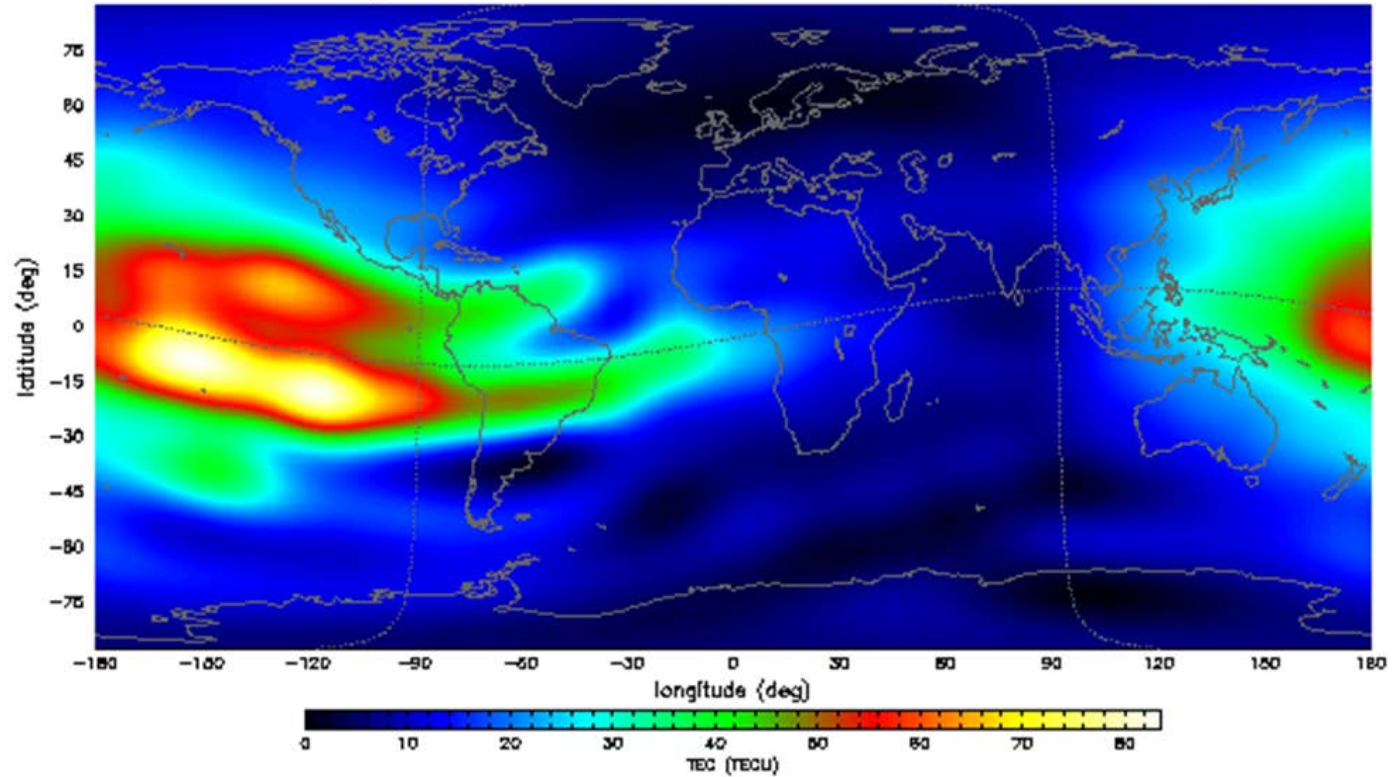
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Navigation – Monitoring der Ionosphäre

TEC MAP (height= 450.0 km) at 2011/03/24,00:00:00
ESA/ESCG SH: spherical harmonic model from 177 stas; n = 15, m = 15

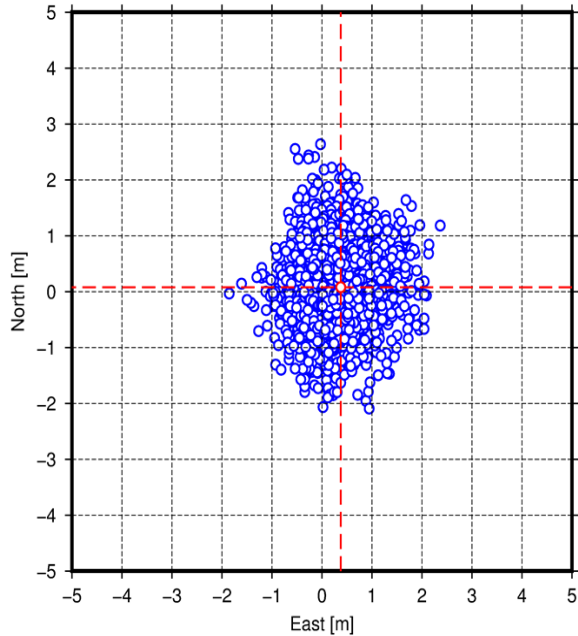


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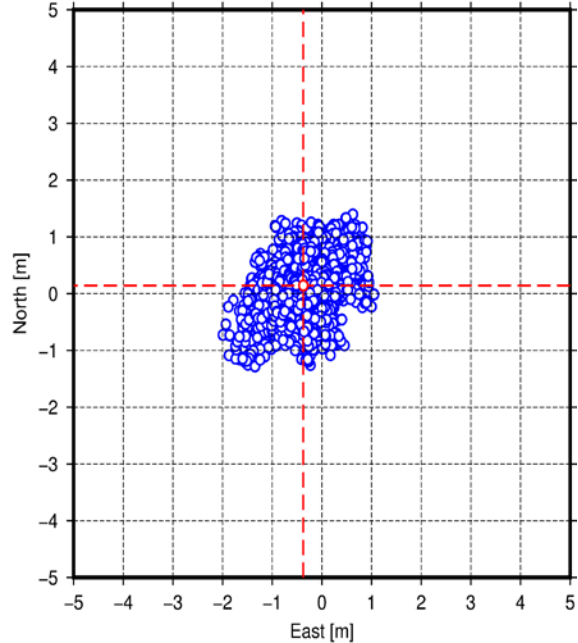
Navigation - Erreichbare Positionsgenauigkeiten durch GNSS



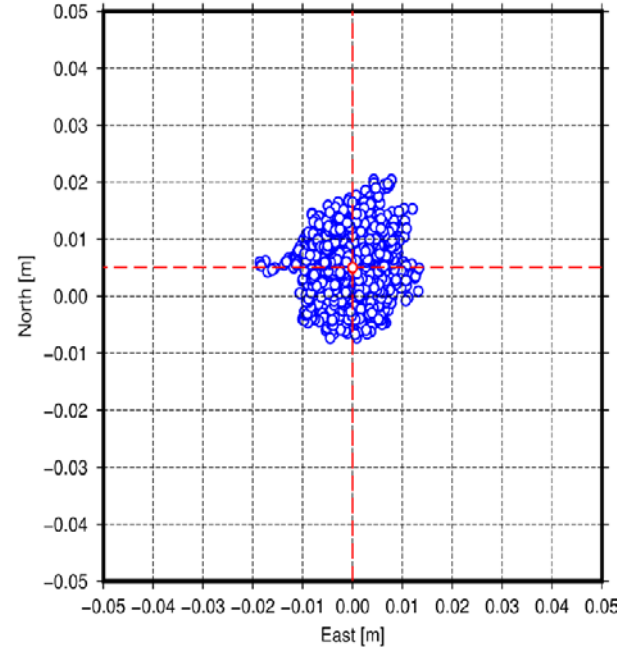
GAL E1-E5a
Broadcast Orbits / Code / 4-4 SV
MAS1 / 08-04-2016 / 15:00-15:45 UTC
RMS(2D): 0.953 m / STD(2D): 0.872 m



GPS L1-L2 / GAL E1-E5a
Broadcast Orbits / Code / 11-13 SV
NNOR / 31-03-2016 / 04:30-06:00 UTC
RMS(2D): 0.717 m / STD(2D): 0.596 m



GPS L1-L2 / GLO G1-G2 / GAL E1-E5a / BEI B1-B2
Precise Orbits / Code+Phase / 17-20 SV
MAS1 / 08-04-2016 / 15:00-15:45 UTC
RMS(2D): 0.008 m / STD(2D): 0.006 m



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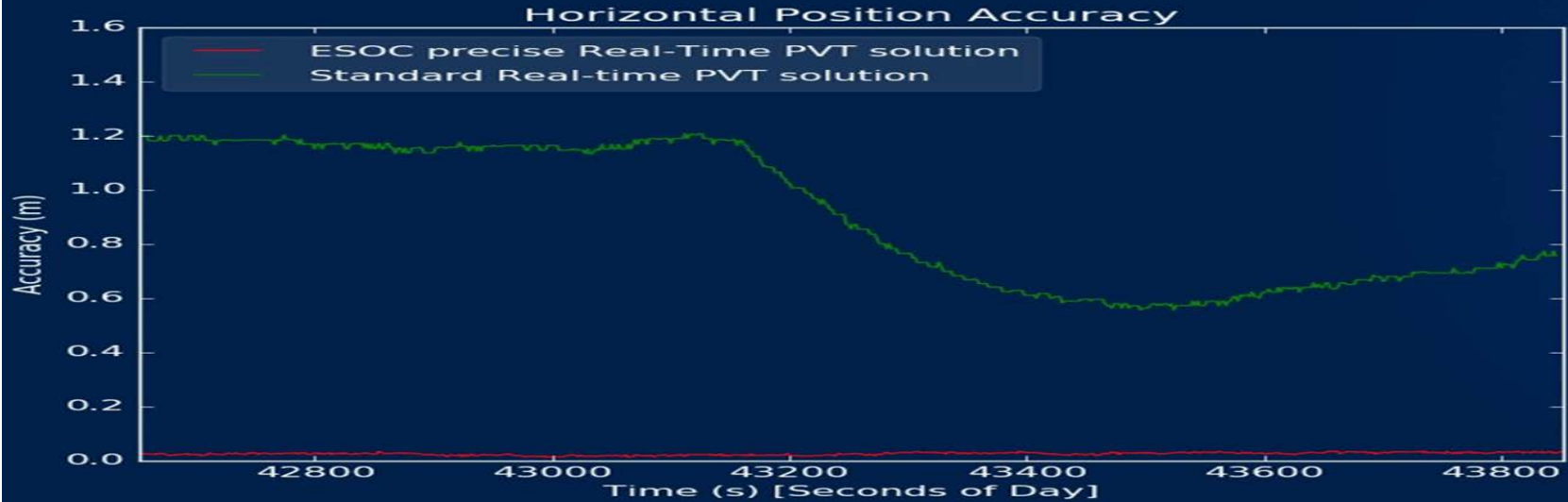


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Mo 25 Apr 2016



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GNSS wird von der EC als kritische Infrastruktur betrachtet

- Positionierung – kritische Güter, Flottenmanagement, ...
- Navigation – Polizei, Emergency Services, Militär, ...
- Timing – System und Netzwerk Synchronisation,
Elektrizität, Banken, Telekom Betreiber, ...





European Space Operations Centre

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esoc

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Mehr Informationen:
www.esa.de

