

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

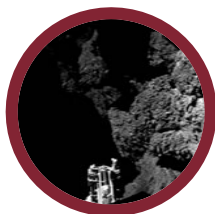


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Tätigkeitsbereiche



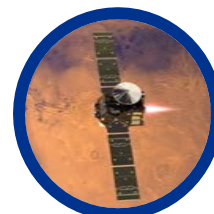
**Weltraum-
wissenschaft**



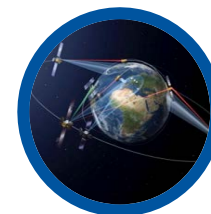
**Bemannte
Raumfahrt**



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



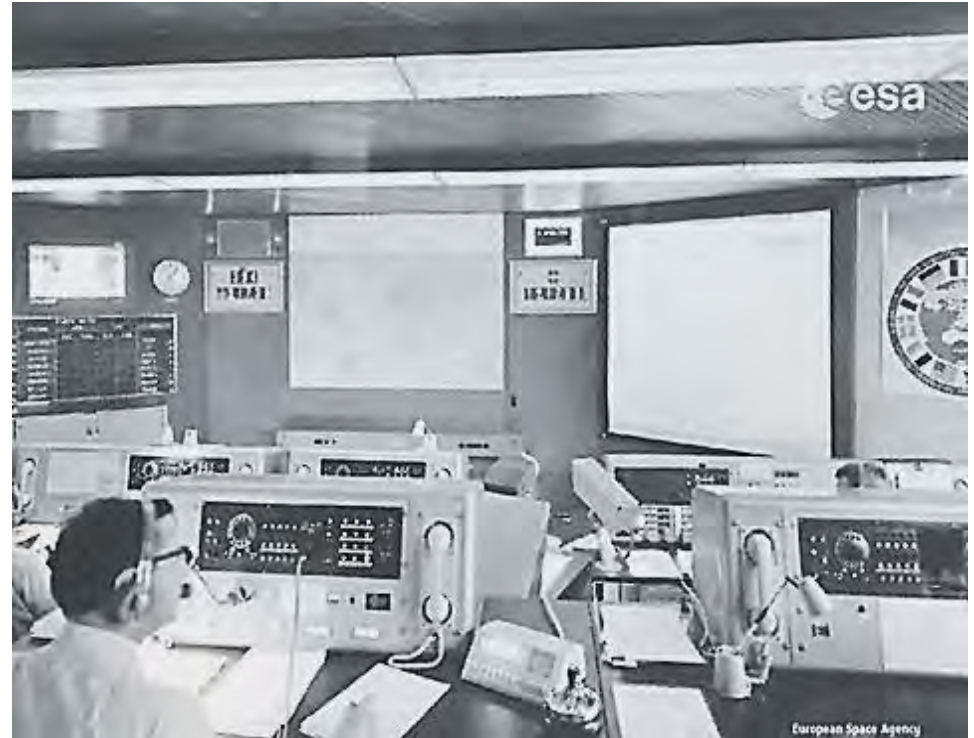
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ESOC: Fakten & Historie

- 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,...)

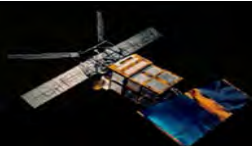


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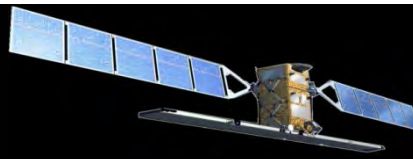
Missionen der Erdbeobachtung



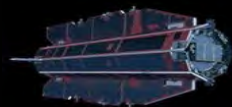
ERS-1/2



ENVISAT



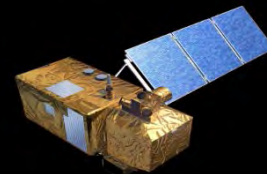
Sentinel 1
SAR imaging
2014 A / 2016 B



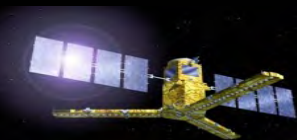
GOCE



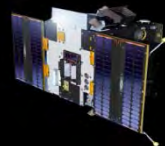
CRYOSAT



Sentinel 2
Multi-spectral imaging
2015 A / 2016 B



SMOS



PROBA 1



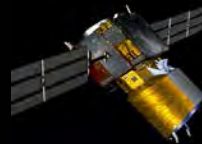
PROBA V



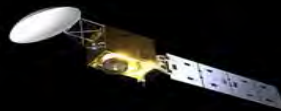
Sentinel 3
Ocean and global land
monitoring
2015 A / 2017 B



SWARM



AEOLUS



Earthcare



Sentinel 5p
Low-orbit atmospheric
2017

Vulkanausbruch des Ätna Juli 2001 – Aschewolke

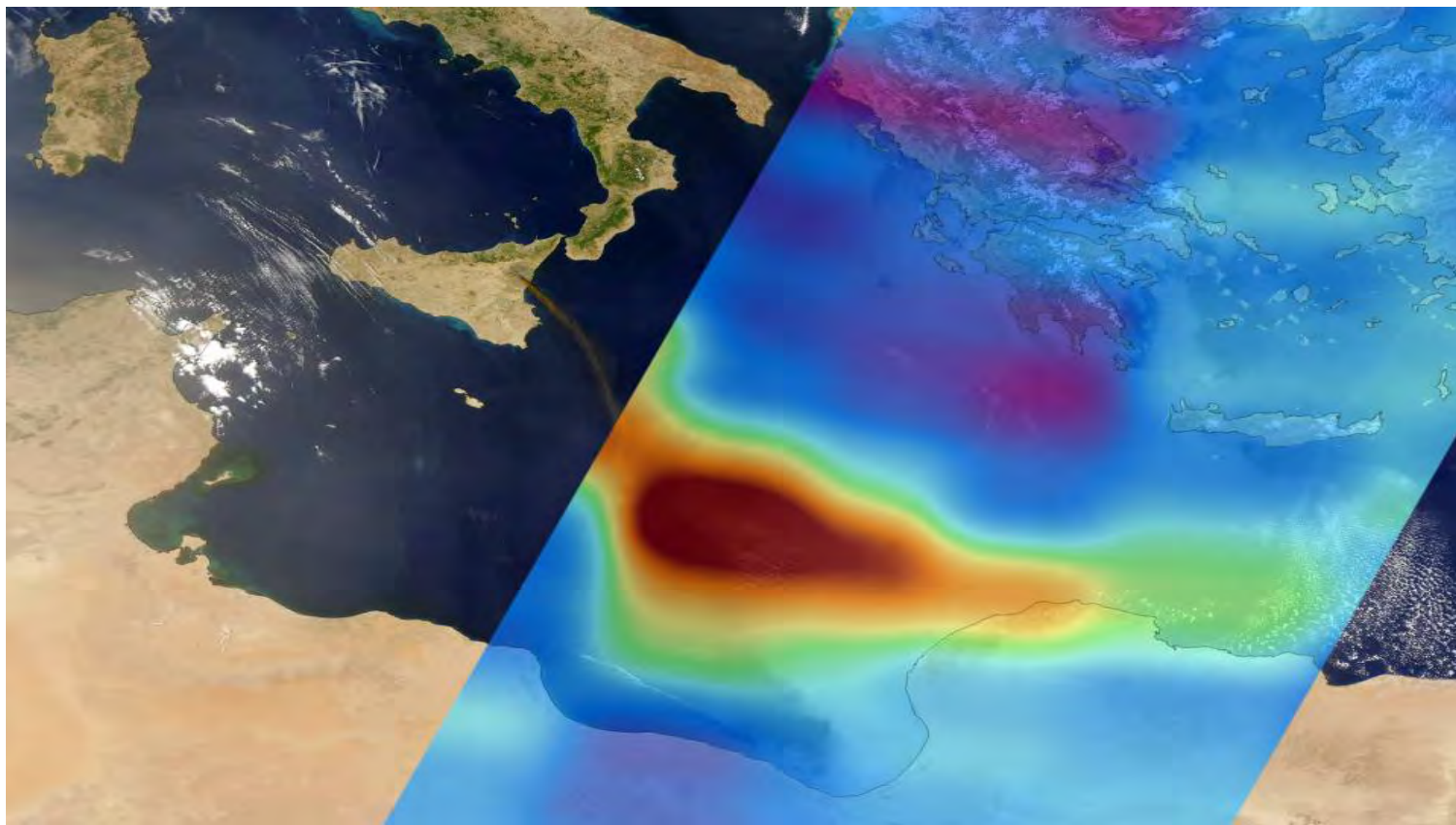


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Ausbruch des Ätna und Schwefeldioxidwolke

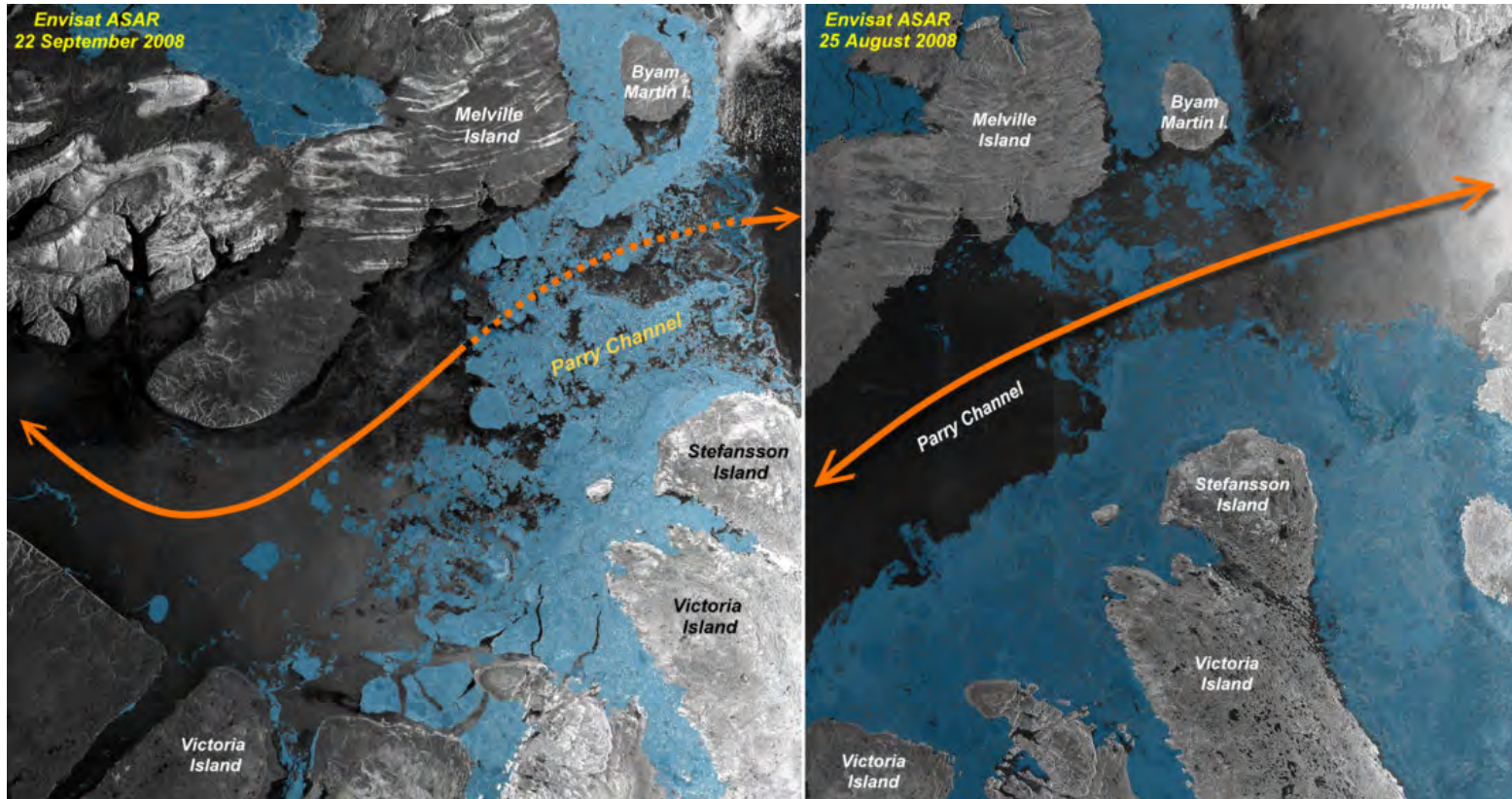


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Eisstand der Nordwestpassage



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Copernicus: Flüchtlingscamp

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



WGS84: 32.666667 33.666667
 AD: 32° 40' 00" N 33° 40' 00" E
 Projection: UTM
 Datum: WGS84

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

Map Scale: 1:10000
 Projection: UTM
 Datum: WGS84

Cartographic information:
 1:10000
 EPSG:31433
 UTM
 WGS84
 UTM
 WGS84

Legend

General information:

- Pathway

Build-Up Area:

- Humanitarian Camp

Topographical:

- Local Road

Buildings:

- Compound
- Water treatment plant
- Station
- Power generator
- Market
- School
- Medical
- Veterinarian
- Showering facility
- Water tower

Category	Value
Area (km²)	1.2
Perimeter (km)	4.5
Population	1000
Area (ha)	120
Perimeter (m)	4500
Area (m²)	120000
Perimeter (m)	4500
Area (m²)	120000
Perimeter (m)	4500

Map Information:

Map Date: 08/02/2013
 Map Scale: 1:10000
 Map Projection: UTM
 Map Datum: WGS84

Data Source:

Map Date: 08/02/2013
 Map Scale: 1:10000
 Map Projection: UTM
 Map Datum: WGS84

Disclaimer:

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Map Production:

Map Date: 08/02/2013
 Map Scale: 1:10000
 Map Projection: UTM
 Map Datum: WGS84

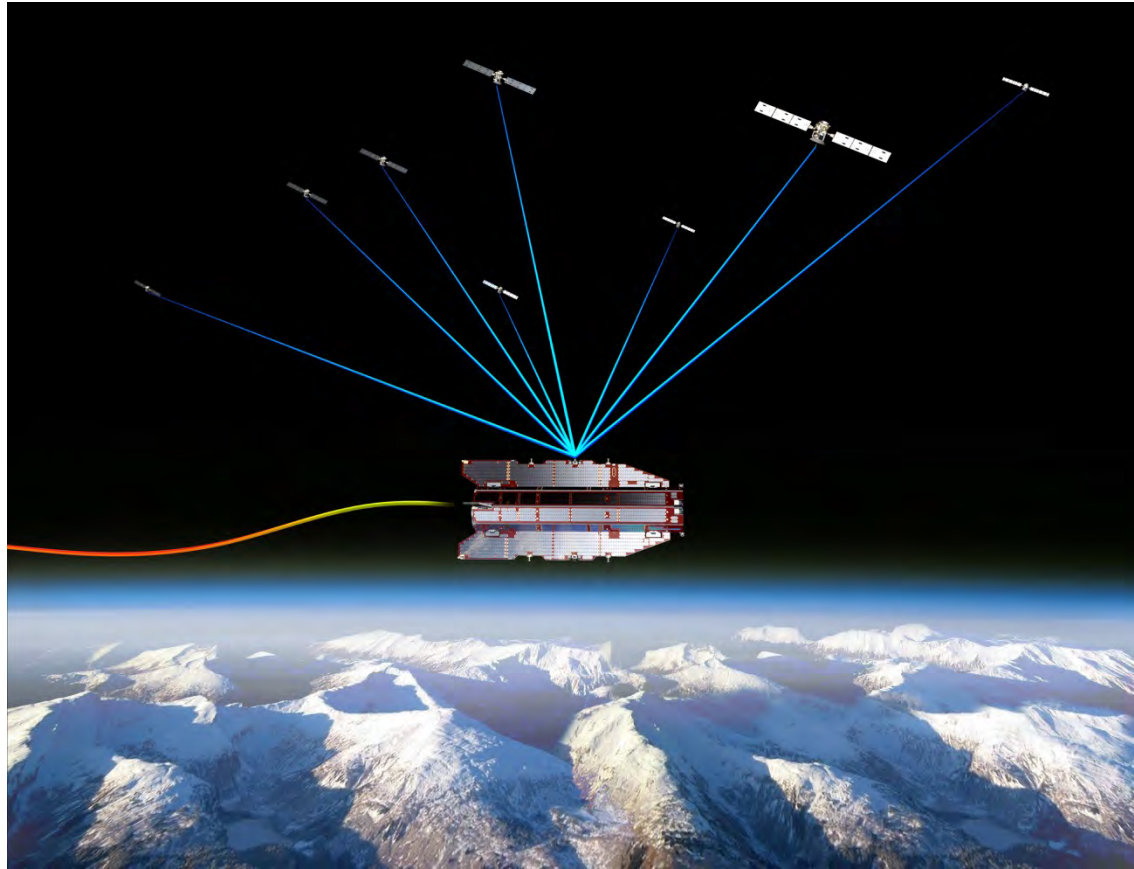
Legend:

- Swiss Red Cross
- ESA
- OGC/OGD

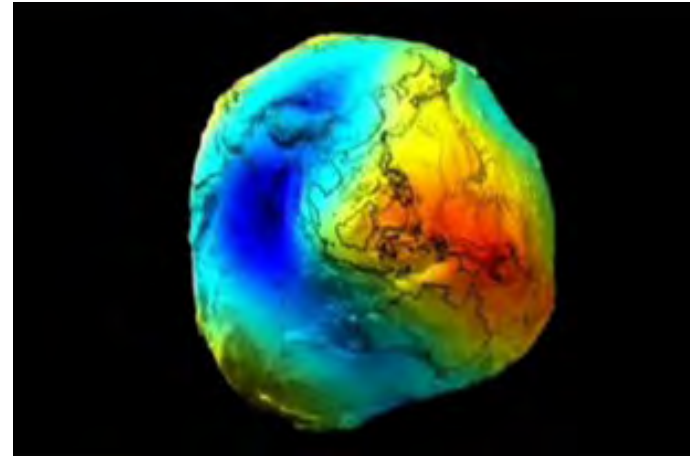
Logos:

OGC/OGD
 ESA
 Copernicus



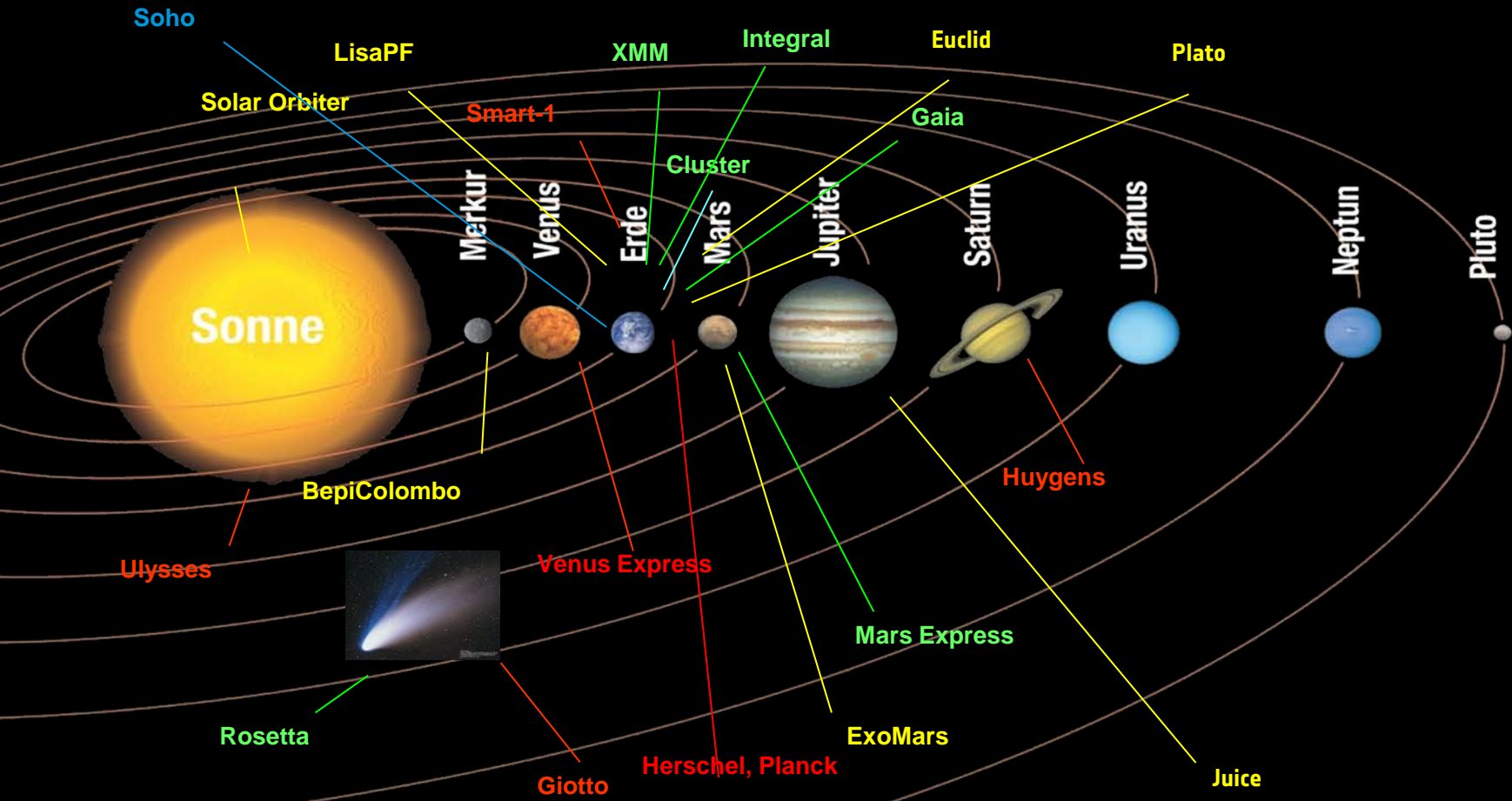


- Neue Technologien (GNSS)
- Neue Erkenntnisse
Gravitationspotential der Erde
- Verbesserung der Genauigkeiten
- Neue Anwendungen



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Wissenschaftsmissionen der ESA im Sonnensystem



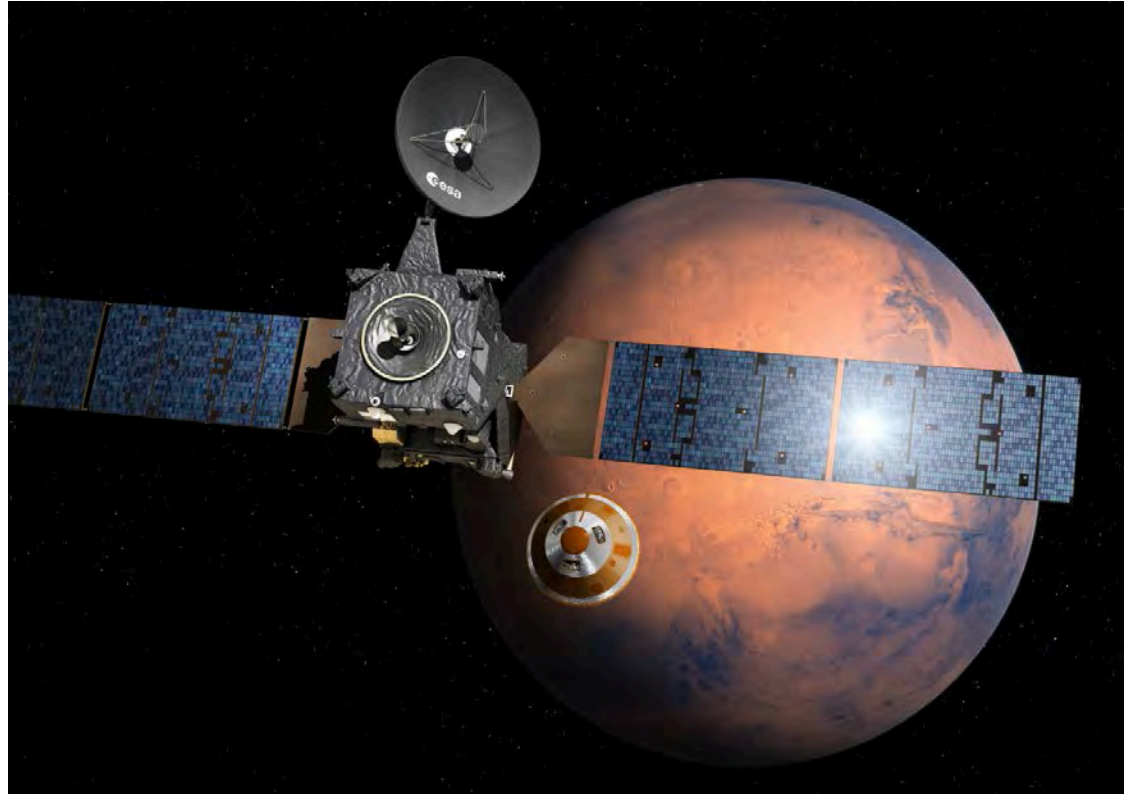
Huygens: Saturnmond Titan (Januar 2005)



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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)

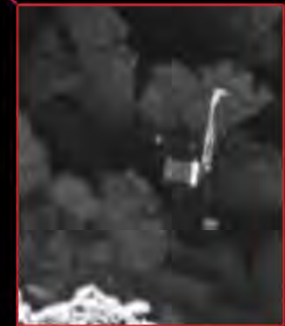
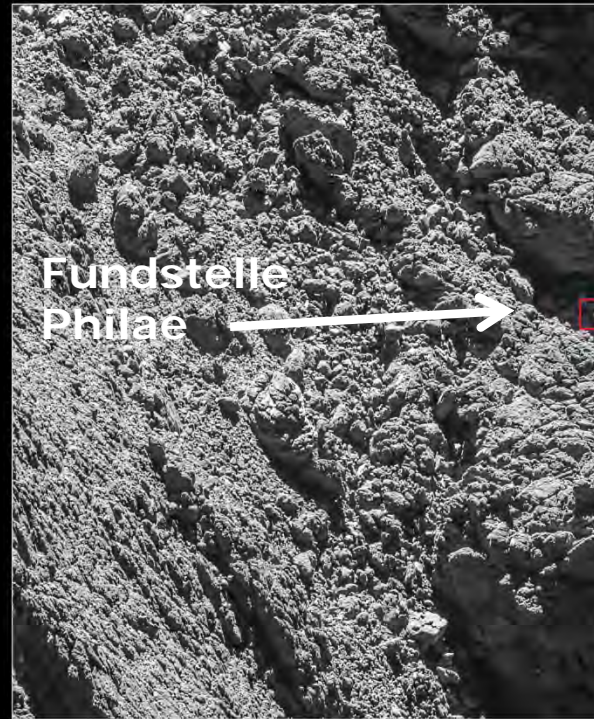
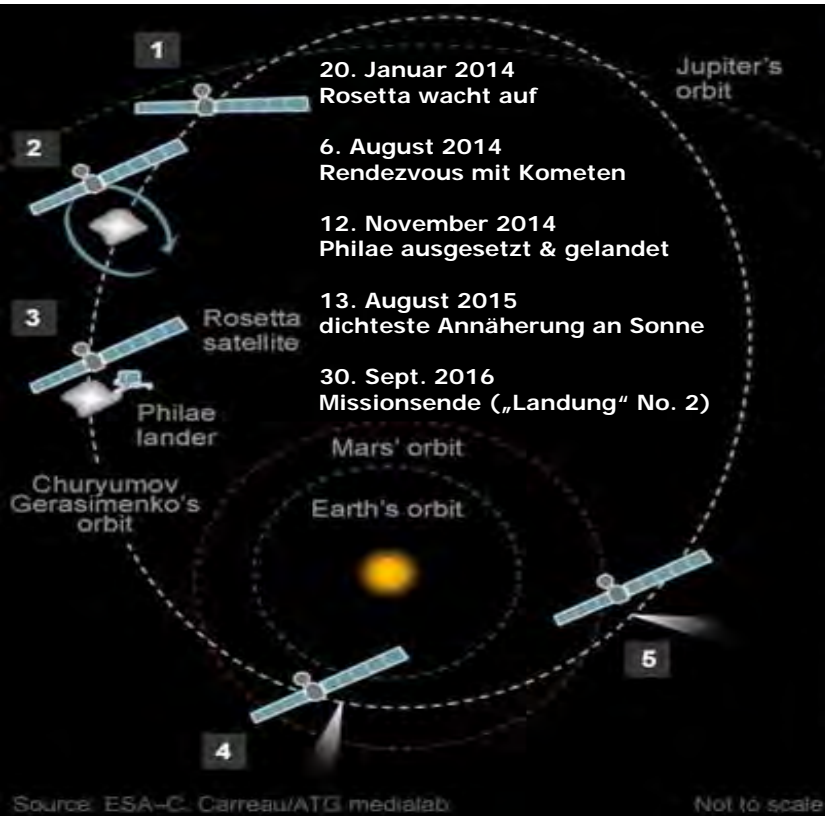


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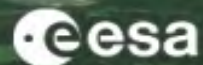


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Rosetta – Europas Kometenjäger



→ DARMSTADT



Darmstadt

Arheilgen

4100 m

Europäische Beiträge:

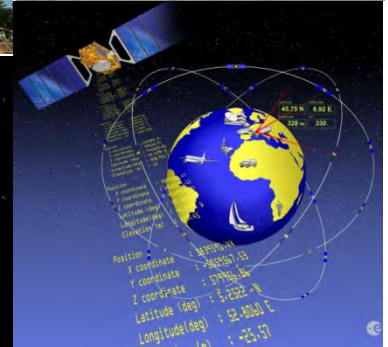
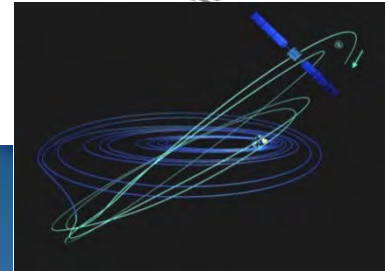
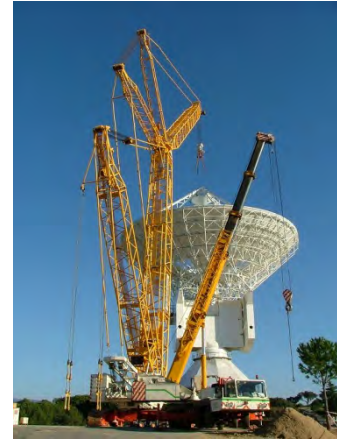
- Columbus Modul
- ATV
- MPLM
- Node 2
- Node 3
- Cupola
- Ext. Nutzlasten
- ERA
- DMS-R



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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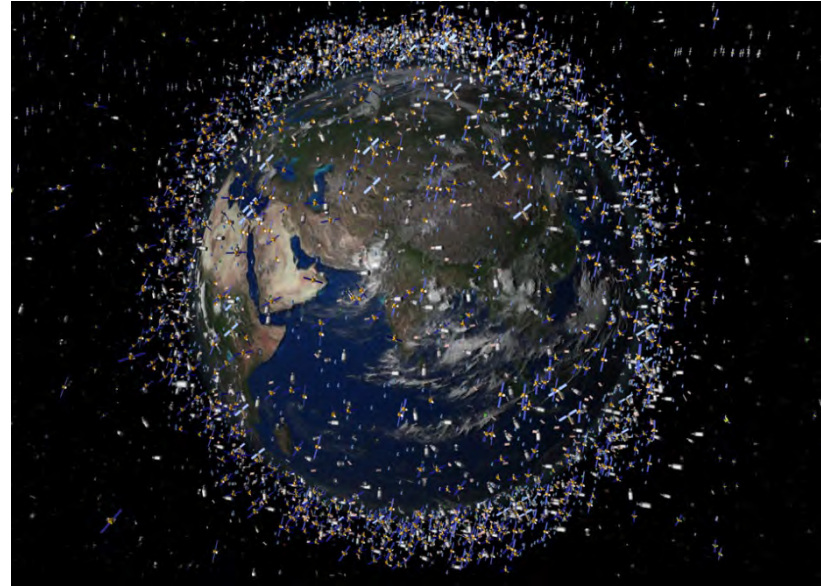
ESOC: Weltraumumgebung

- 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



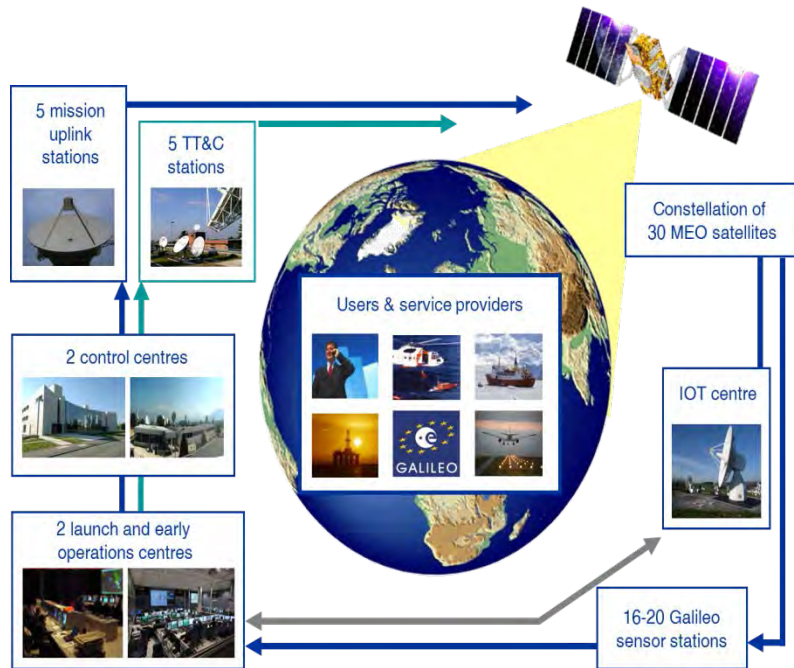
Navigation



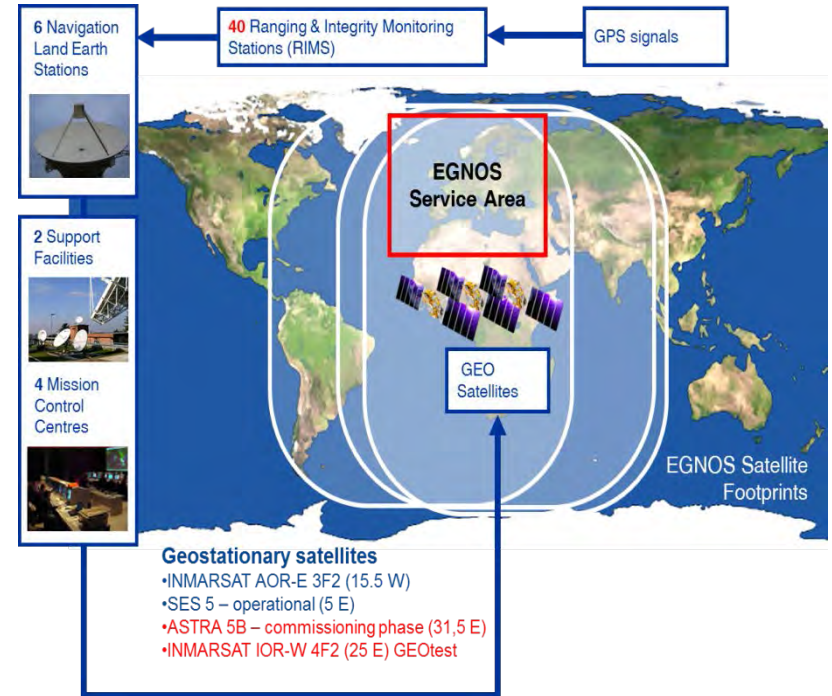
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Galileo



EGNOS



Navigation - GNSS

Globale Satelliten Navigationssysteme (GNSS)

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

Regionale Satelliten Navigationssysteme

- QZSS (Japan)
- IRNSS (Indien)

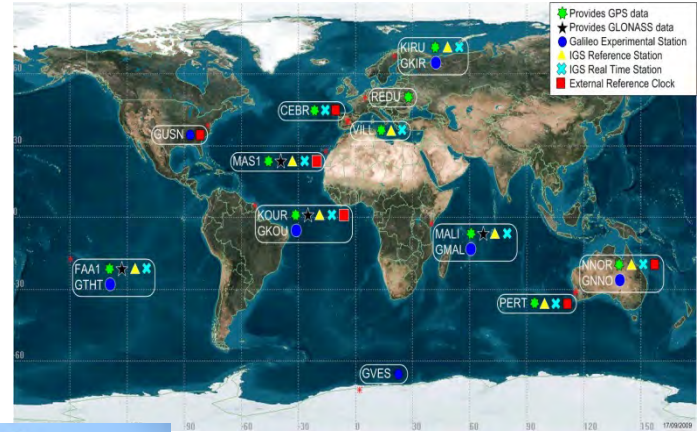
Space Based Augmentation Systems (SBAS)

- 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



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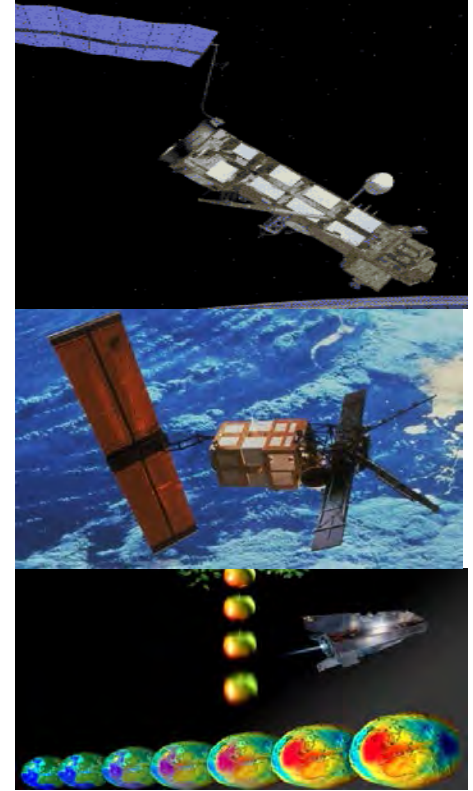
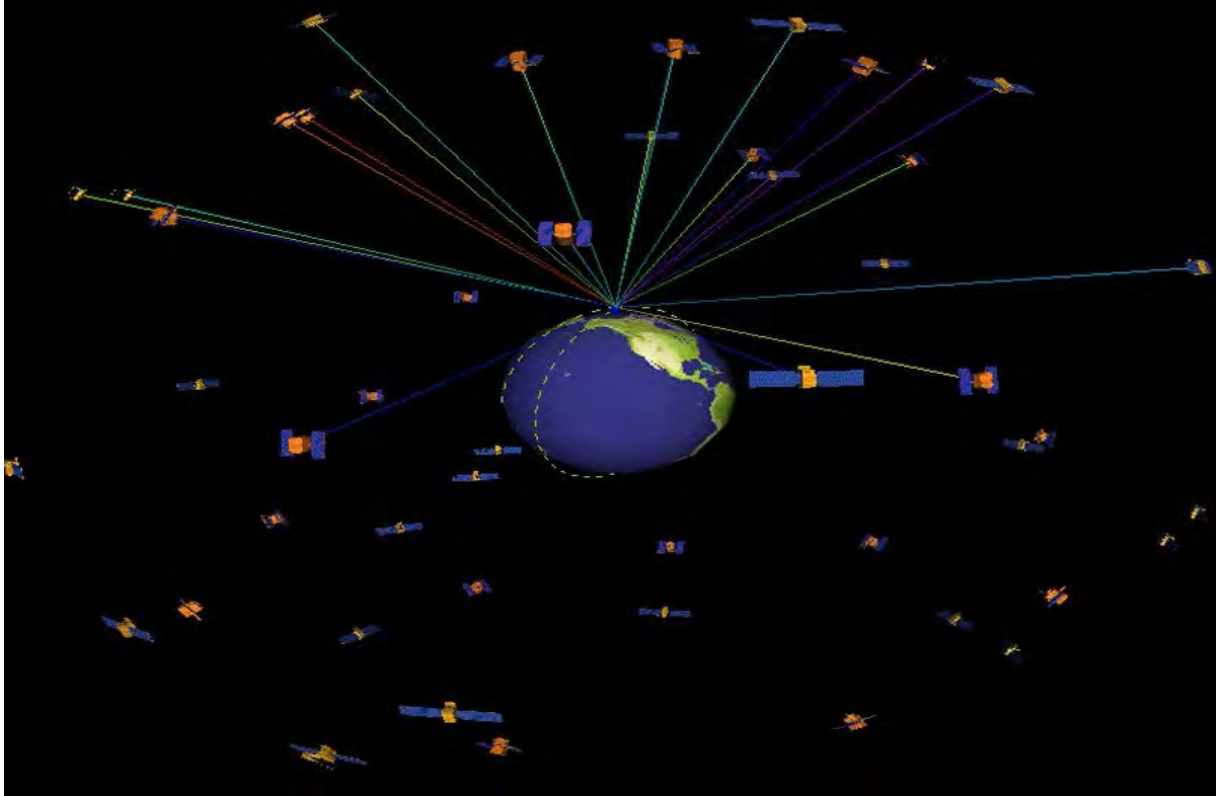
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Betrieb von Global Sensor Station Network - GNSS Receivers



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Navigation – Prazise Bahbestimmung im cm Bereich



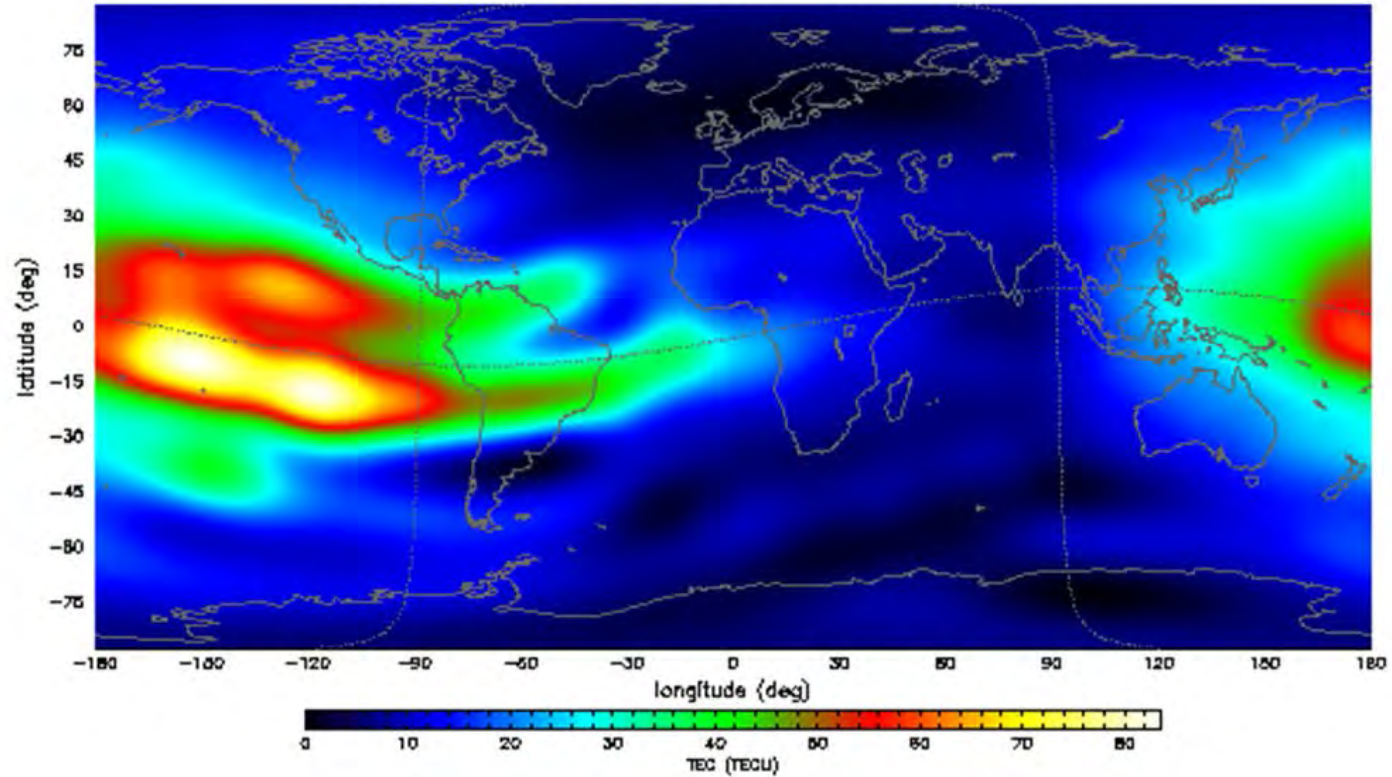
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Navigation – Monitoring der Ionosphäre

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



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Navigation - Erreichbare Positionsgenauigkeiten durch GNSS

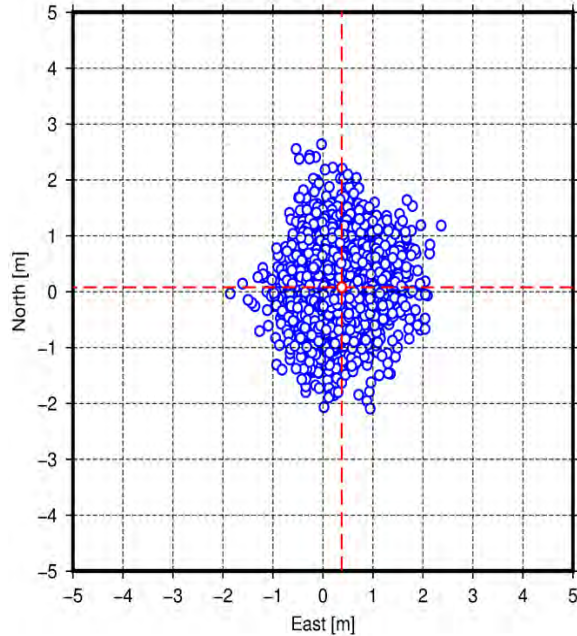


GAL E1-E5a

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

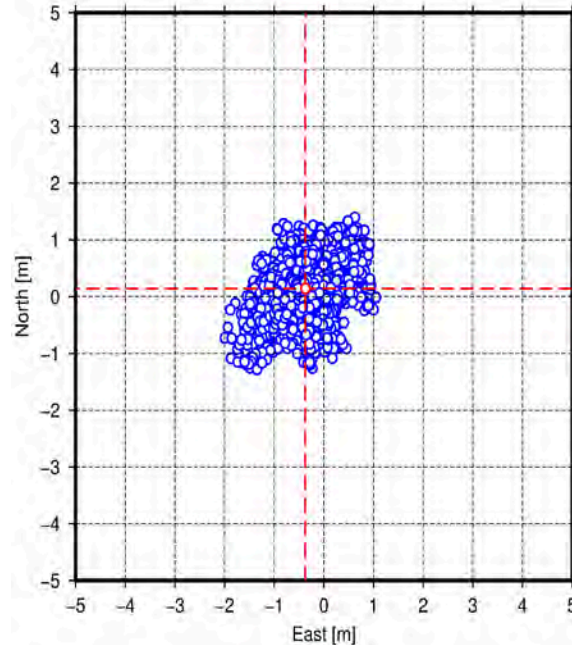


GPS L1-L2 / GAL E1-E5a

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

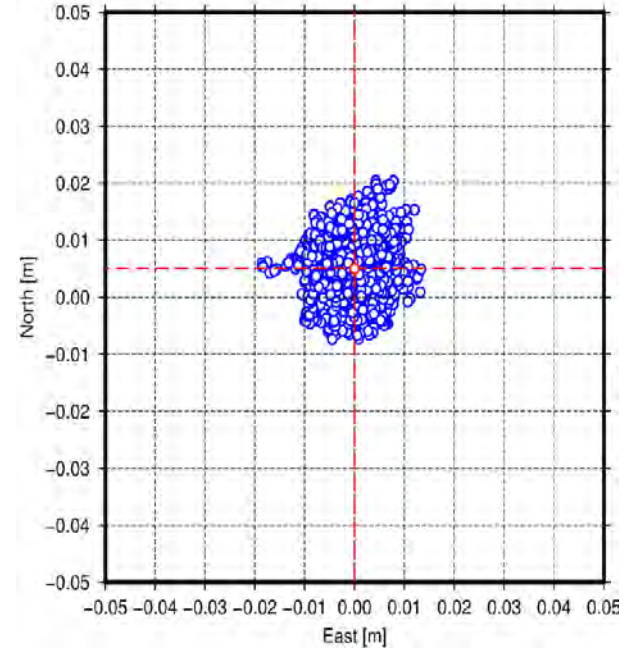


GPS L1-L2 / GLO G1-G2 / GAL E1-E5a / BEI B1-B2

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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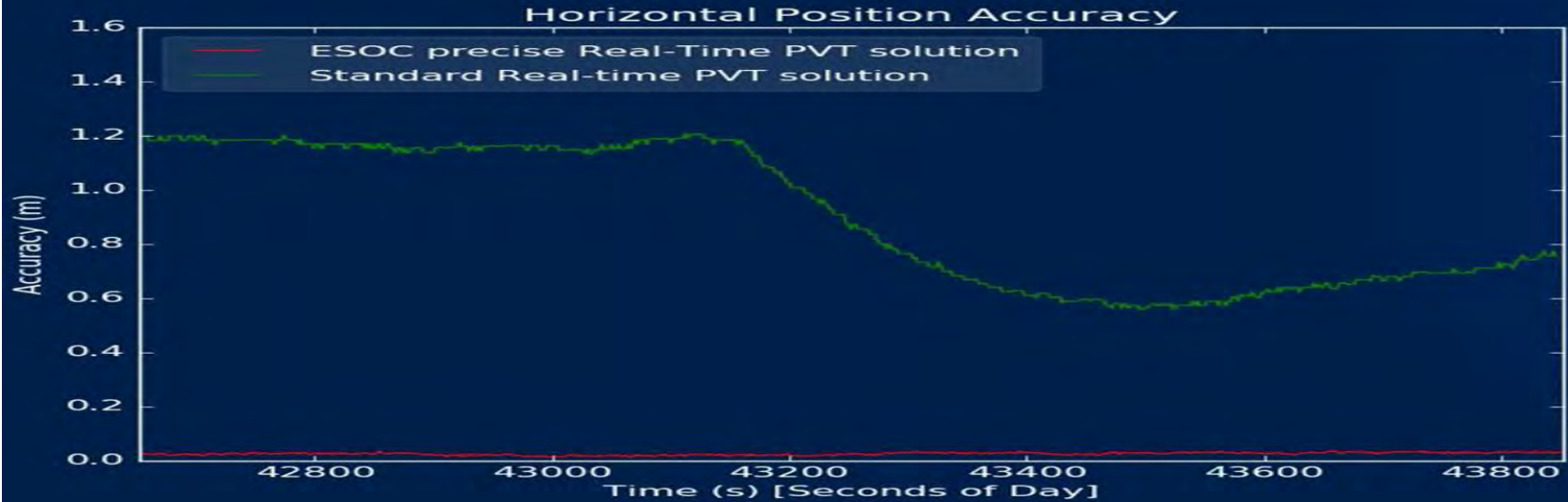


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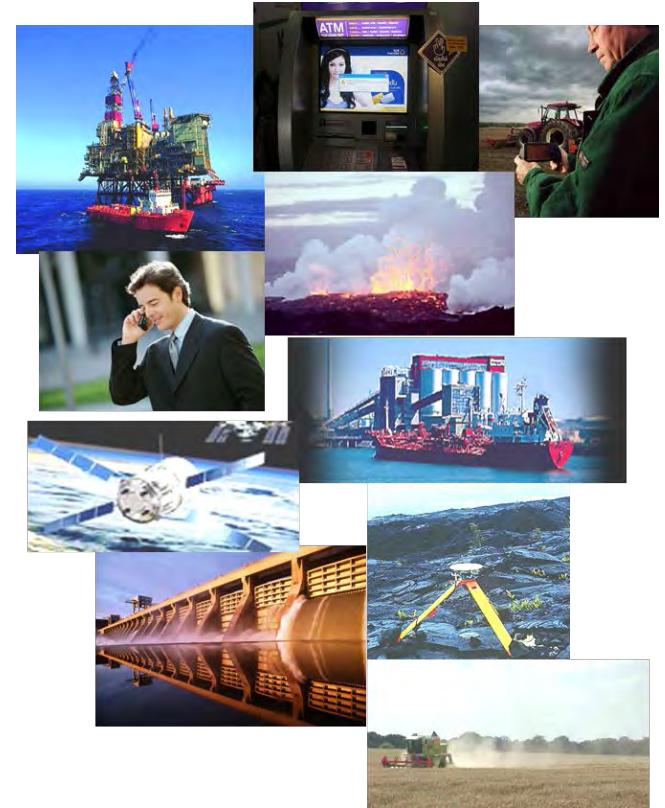
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Mo 25 Apr 2016



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- Space Applications
- Agriculture, precision farming
- Machine Guidance
- Fisheries
- Forestry
- Civil Engineering, Mining, Oil
- Static Applications, Public Works
- Surveying and Mapping
- Weather
- Timing and synchronization
 - Banking
 - Electricity network
 - Communication network



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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Mehr Informationen:
www.esa.de

