Mobilität im All und auf der Erde

Prof. Dr.-Ing. Werner Enderle
Head of Navigation Support Office
Europäisches Raumfahrt Kontroll Zentrum – ESA / ESOC

12. September 2016

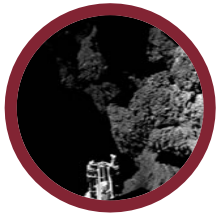
ESA UNCLASSIFIED - For Official Use

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

ESA UNCLASSIFIED - For Official Use

Tätigkeitsbereiche



Weltraum-
wissenschaft

Bemannte
Raumfahrt

Raumflugbetrieb

Exploration

Telekommunikation

Erdbeobachtung

Träger-
systeme

Navigation

Technologie

ESA UNCLASSIFIED - For Official Use

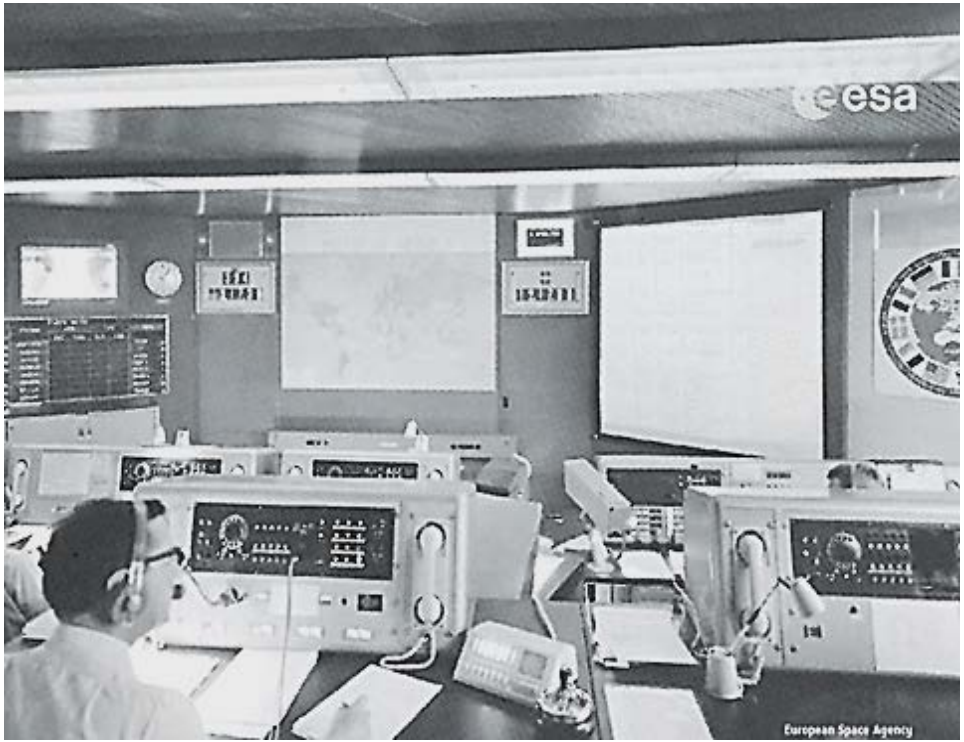
Europäische Raumfahrt

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

ESA UNCLASSIFIED - For Official Use

ESOC: Fakten & Historie

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



ESA UNCLASSIFIED - For Official Use

ESOC: Das Raumfahrt-Betriebszentrum

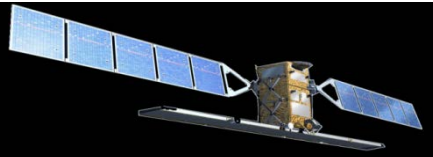
- 76 Satelliten gestartet
- 13 Missionen (19 Satelliten) im Orbit
- 10 Missionen in Vorbereitung
- Alle Missionsarten (erdnah, Konstellationen, interplanetar)
- 9 Satelliten aus Notlagen gerettet
- Einzigartige Sondermissionen, z.B. Rosetta
- Weltweite Kooperationen (USA, Russland, China, Japan,...)

ESA UNCLASSIFIED - For Official Use

Missionen der Erdbeobachtung

ERS-1/2

ENVISAT



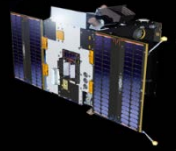
Sentinel 1
SAR imaging
2014 A / 2016 B

GOCE

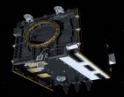
CRYOSAT

Sentinel 2
Multi-spectral imaging
2015 A / 2016 B

SMOS



PROBA 1

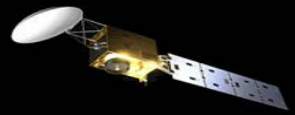


PROBA V

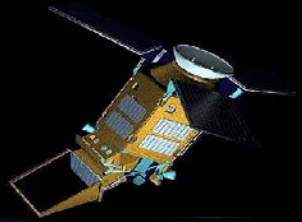
Sentinel 3
Ocean and global land monitoring
2015 A / 2017 B

SWARM

AEOLUS



Earthcare

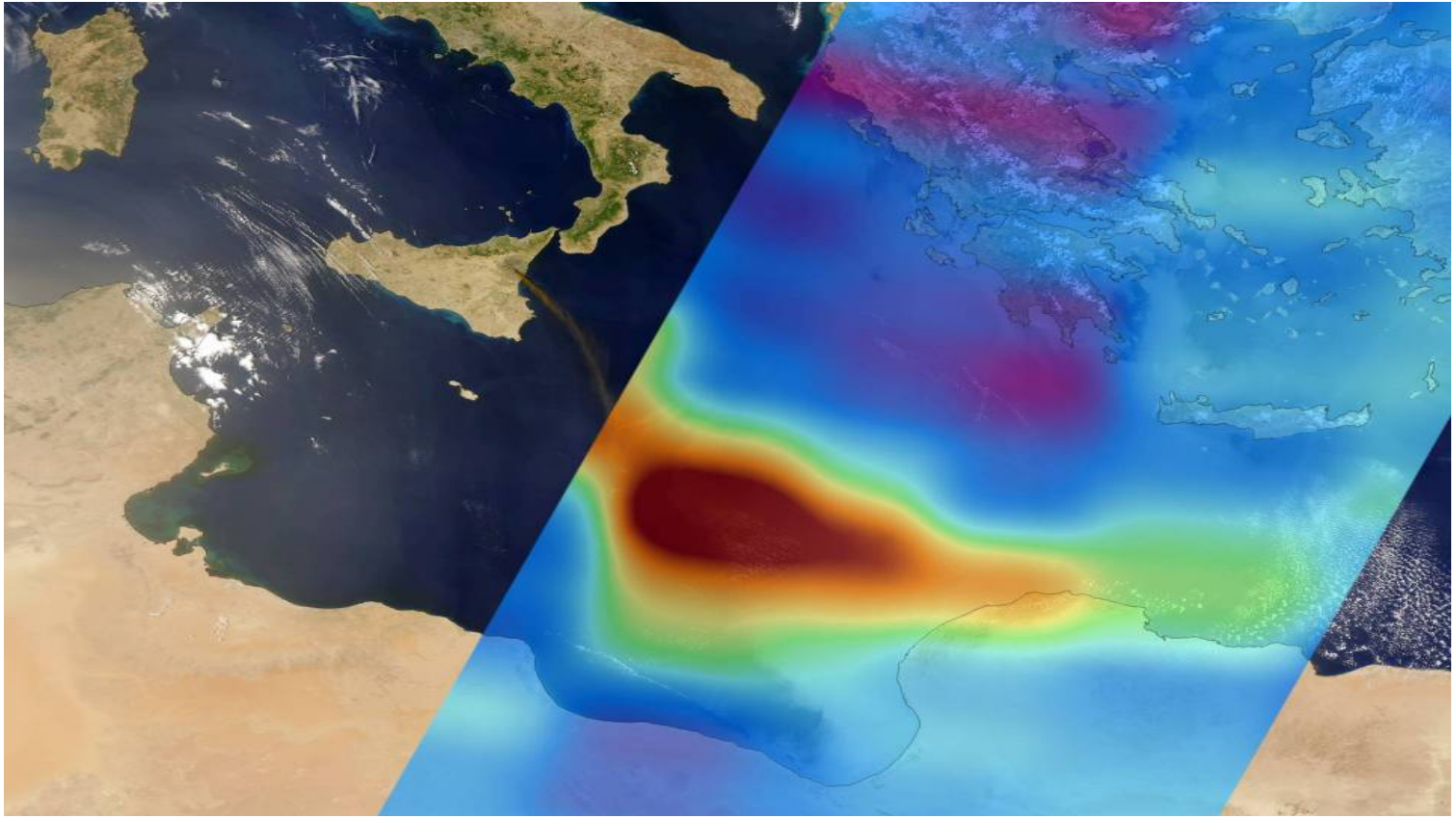


Sentinel 5p
Low-orbit atmospheric
2017

Vulkanausbruch des Ätna Juli 2001 – Aschewolke

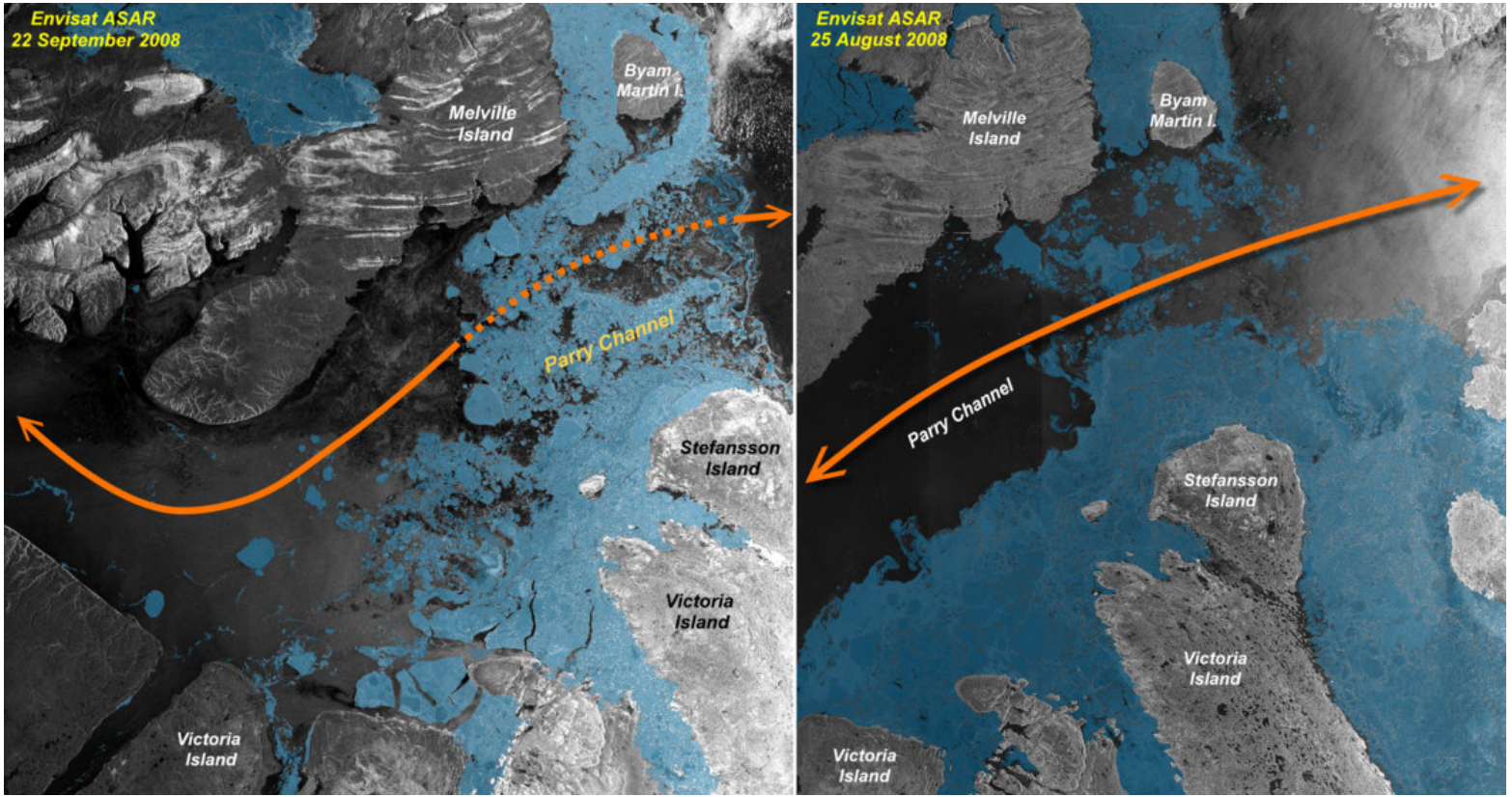
ESA UNCLASSIFIED - For Official Use

Ausbruch des Ätna und Schwefeldioxidwolke



ESA UNCLASSIFIED - For Official Use

Eisstand der Nordwestpassage



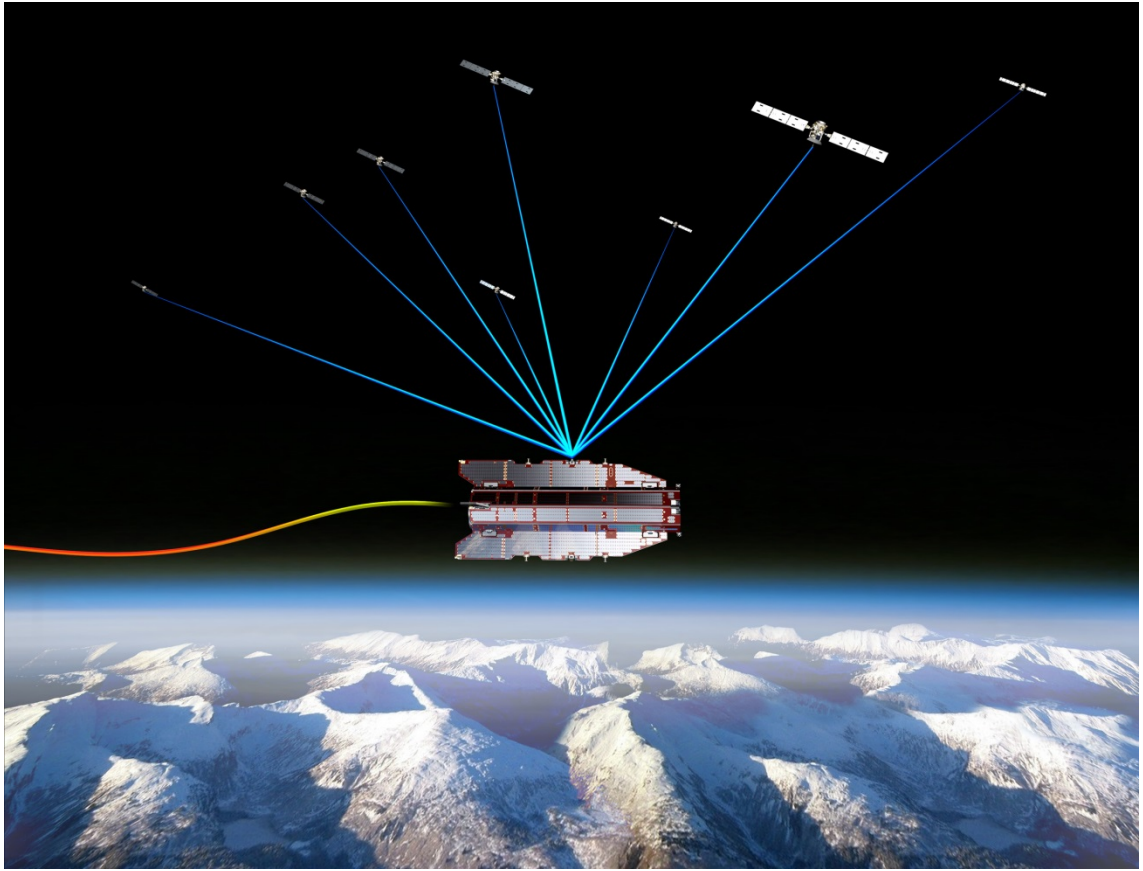
ESA UNCLASSIFIED - For Official Use

Copernicus: Flüchtlingscamp

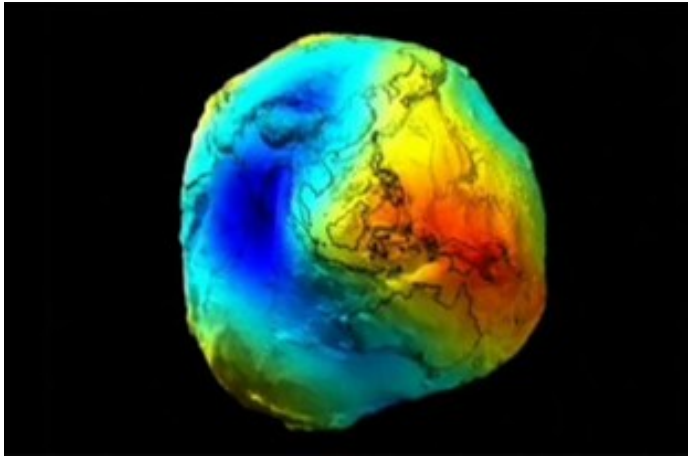
Optische Sat-Bilder von Camp in Jordanien, im Jahr 2014

European Space Agency

Erdbeobachtung – Praezise Bahnbestimmung der Satelliten

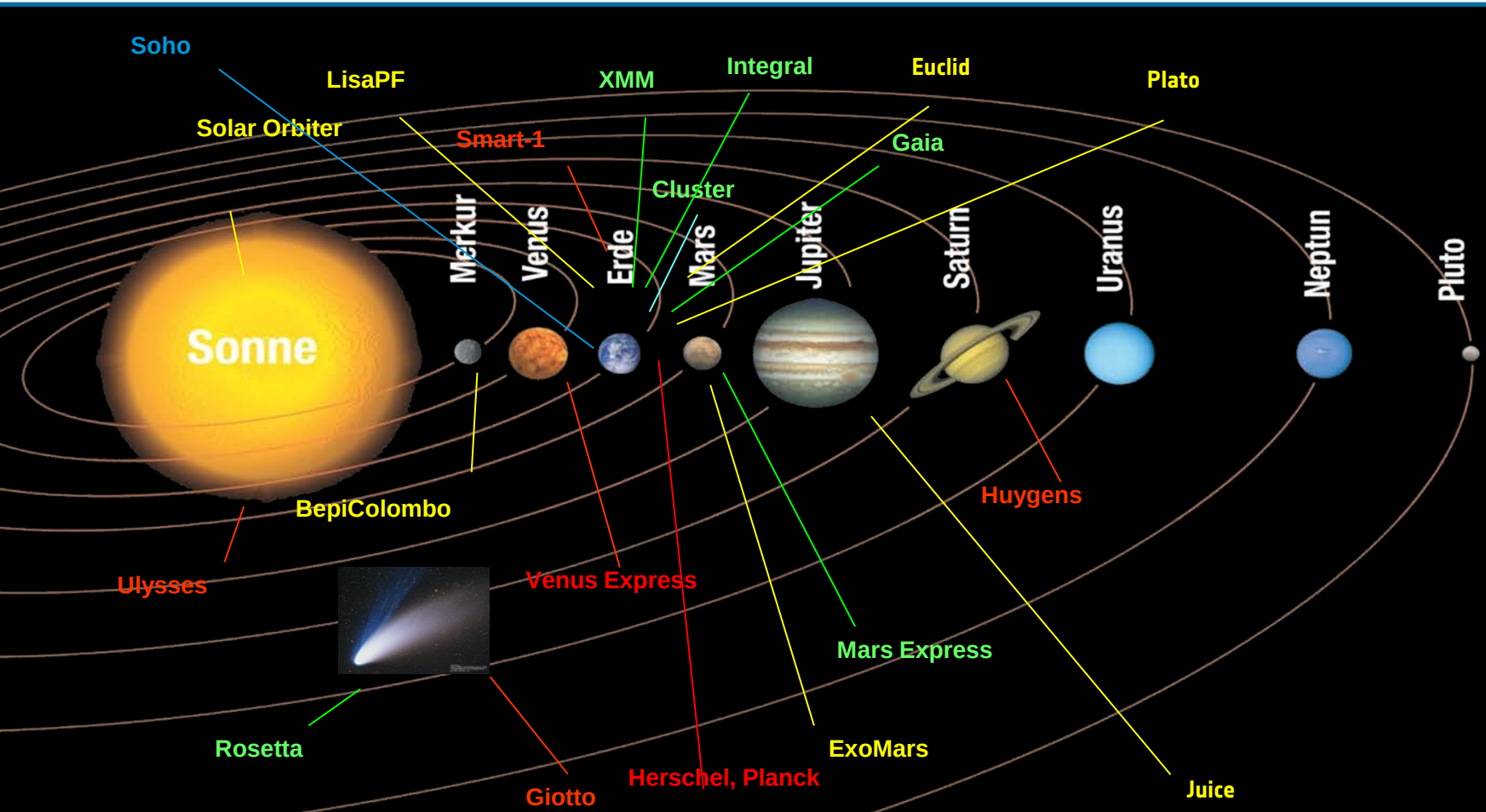


- Neue Technologien (GNSS)
- Neue Erkenntnisse Gravitationspotential der Erde
- Verbesserung der Genauigkeiten
- Neue Anwendungen



ESA UNCLASSIFIED - For Official Use

Wissenschaftsmissionen der ESA im Sonnensystem

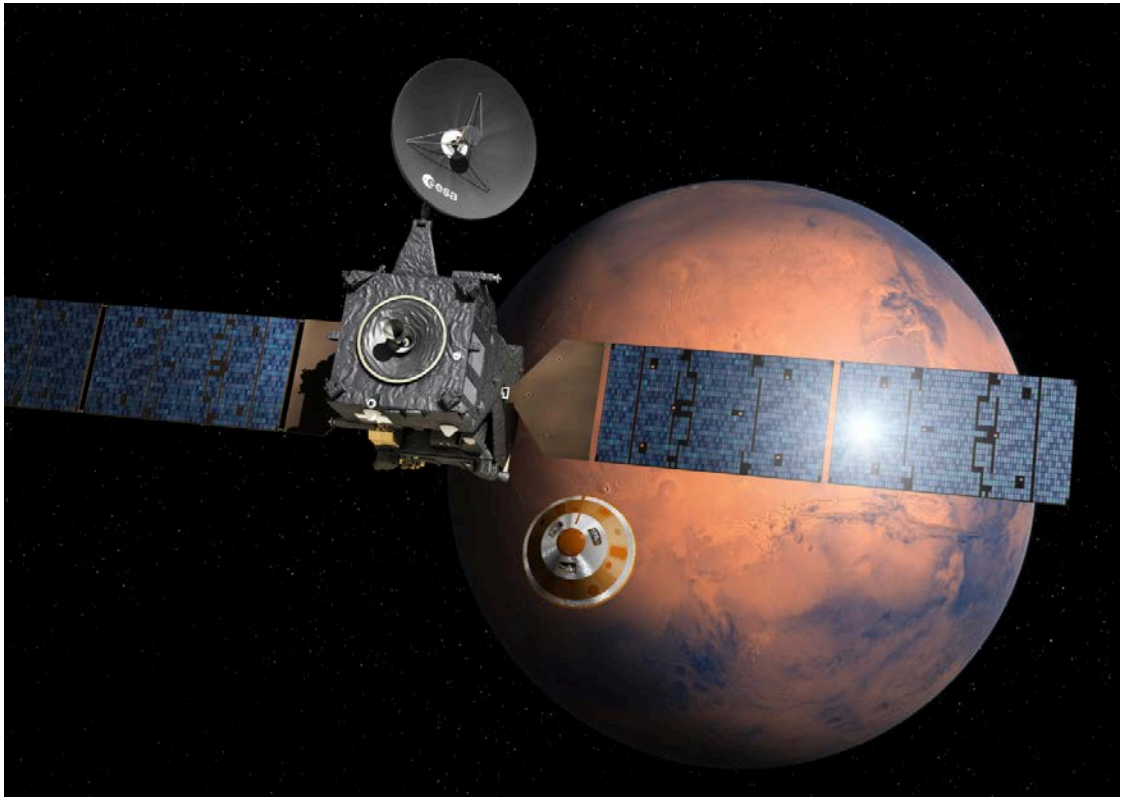


Huygens: Saturnmond Titan (Januar 2005)

ESA UNCLASSIFIED - For Official Use

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

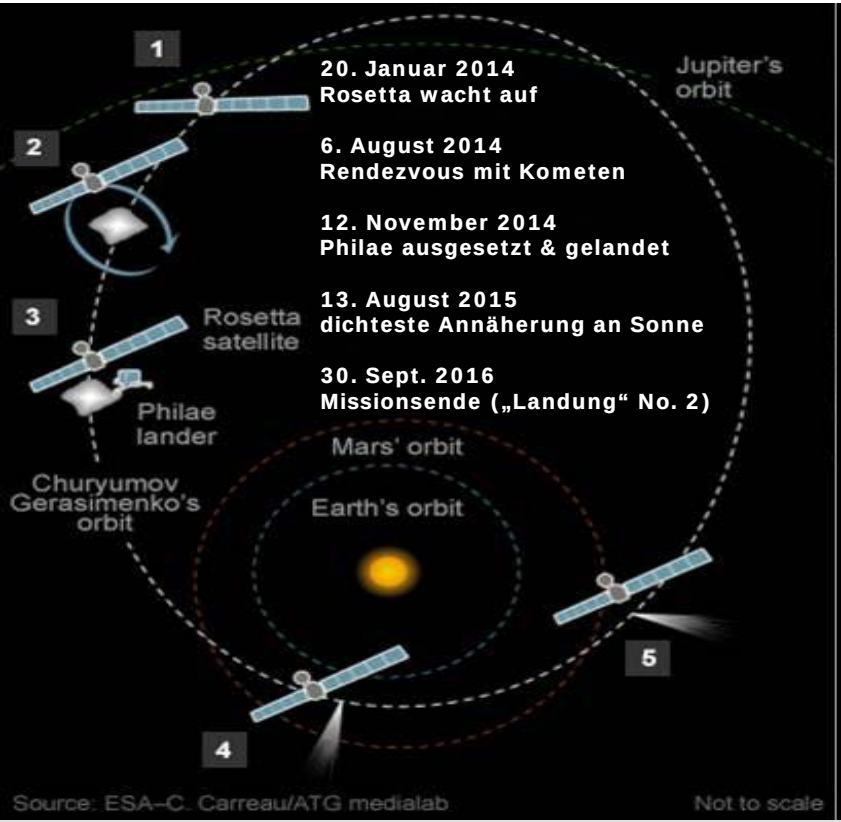


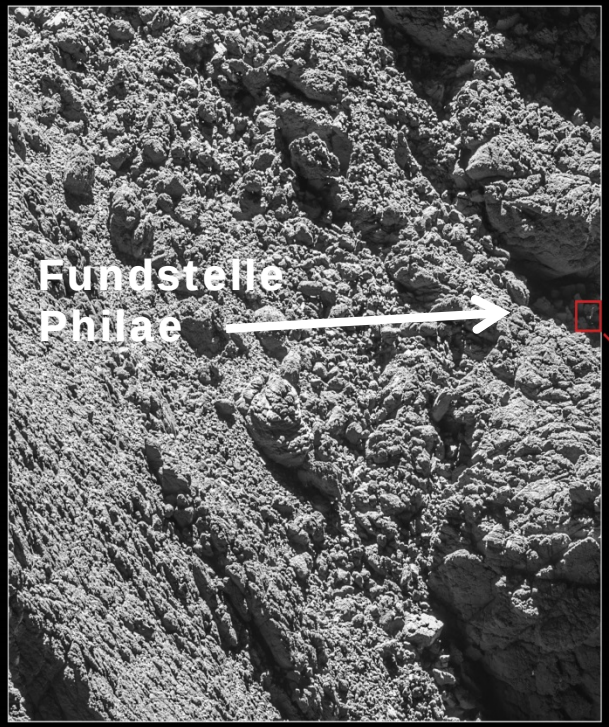
ESA UNCLASSIFIED - For Official Use

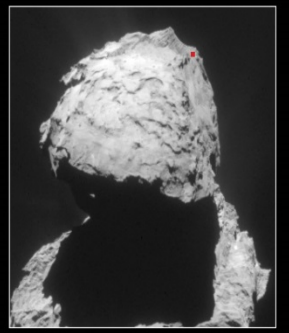
Rosetta: Europas Kometenjäger (2015)

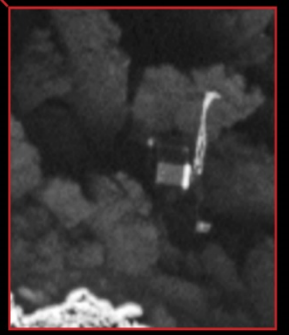
ESA UNCLASSIFIED - For Official

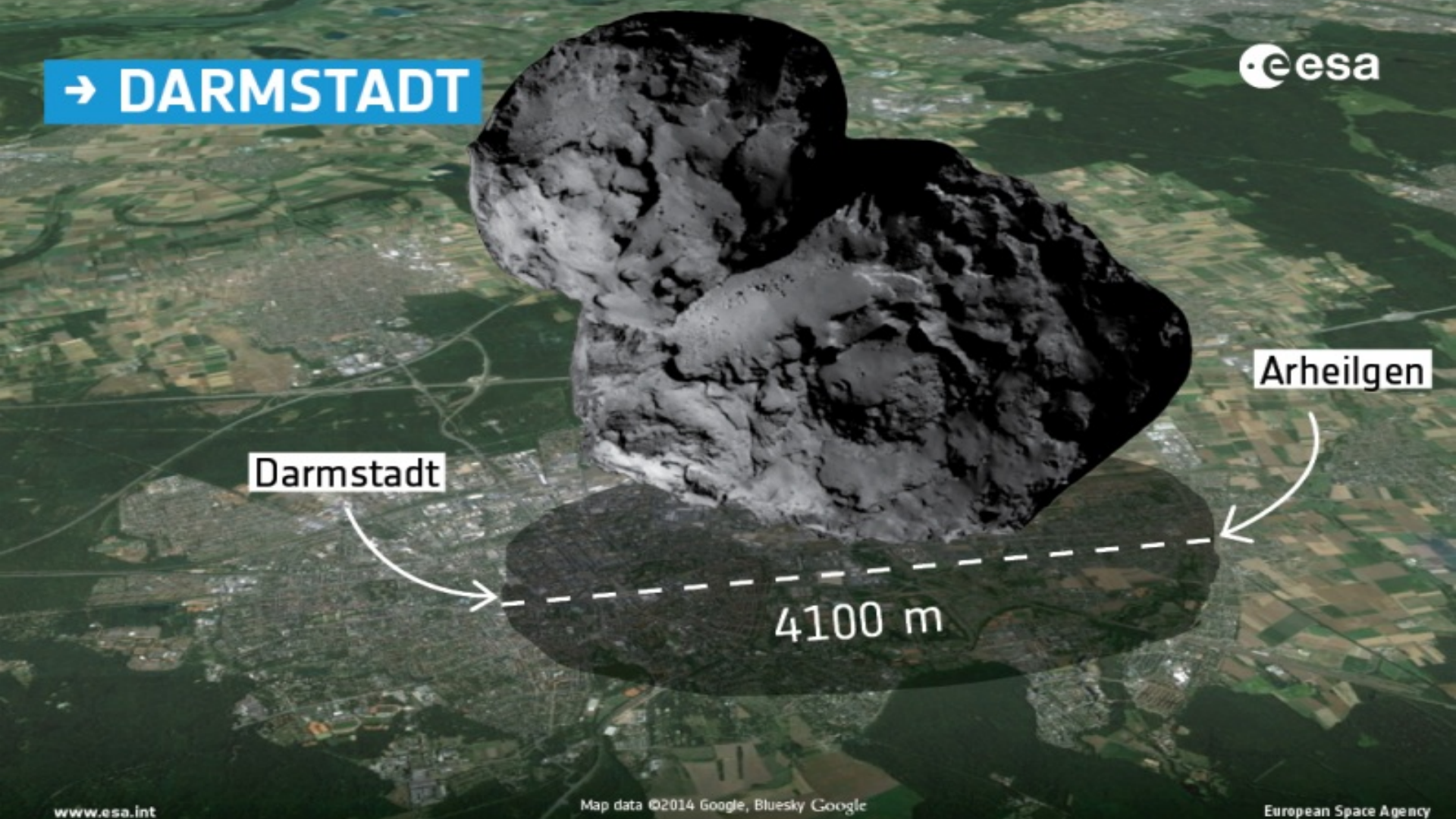
Rosetta – Europas Kometenjäger







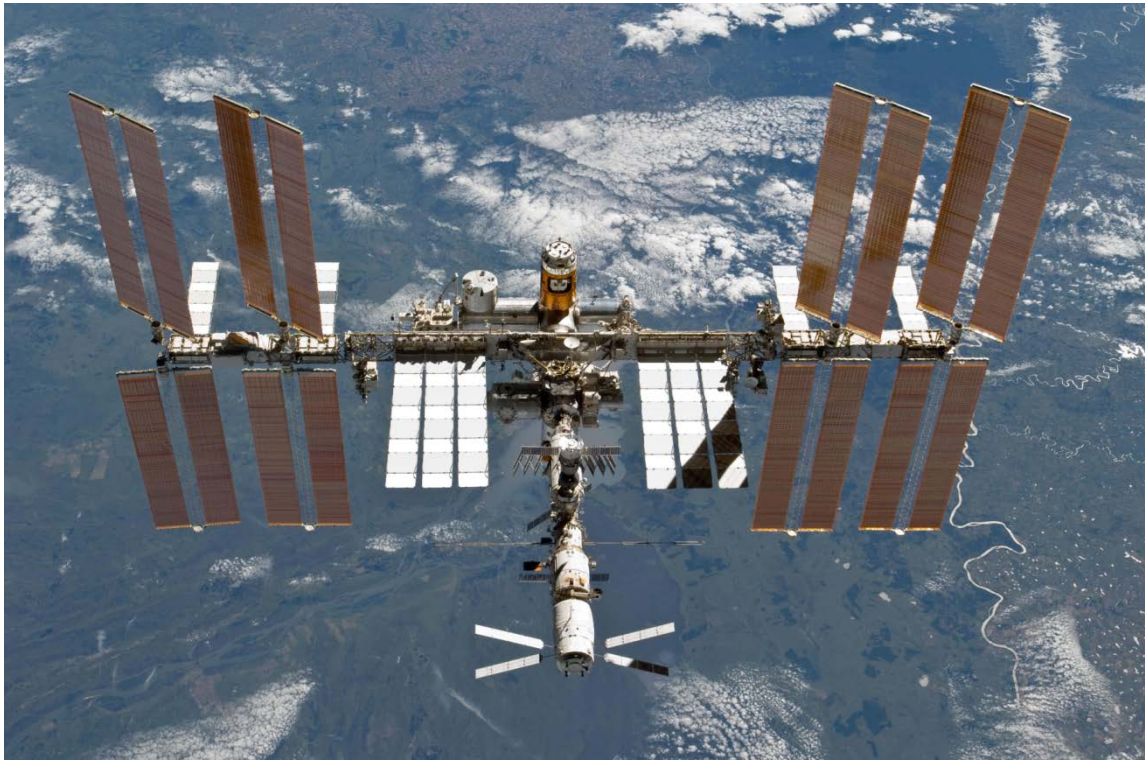



→ DARMSTADT
esa
Arheilgen
Darmstadt
4100 m
www.esa.int
Map data ©2014 Google, Bluesky Google
European Space Agency

Bemannte Raumfahrt - Columbus

Europäische Beiträge:

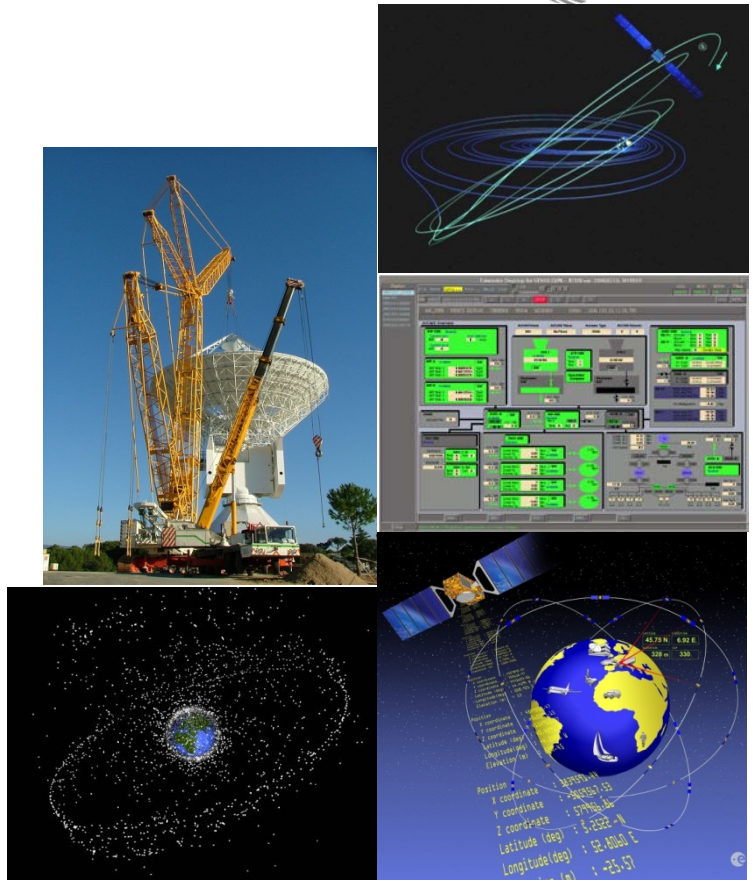
- Columbus Modul
- ATV
- MPLM
- Node 2
- Node 3
- Cupola
- Ext. Nutzlasten
- ERA
- DMS-R



ESA UNCLASSIFIED - For Official Use

ESOC: Ingenieurwissen

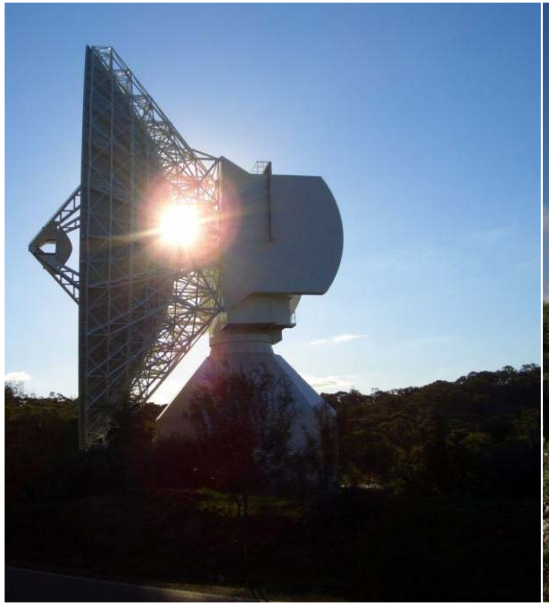
- Entwicklung und Bau von Bodensystemen
  - Kontrollzentren, Software, Antennen, Bodenstationen
- Einzigartiges Spezialwissen
  - Flugdynamik
  - Weltraumschrott
  - Präzisionsnavigation
- Internationale Standardisierung



ESA UNCLASSIFIED - For Official Use

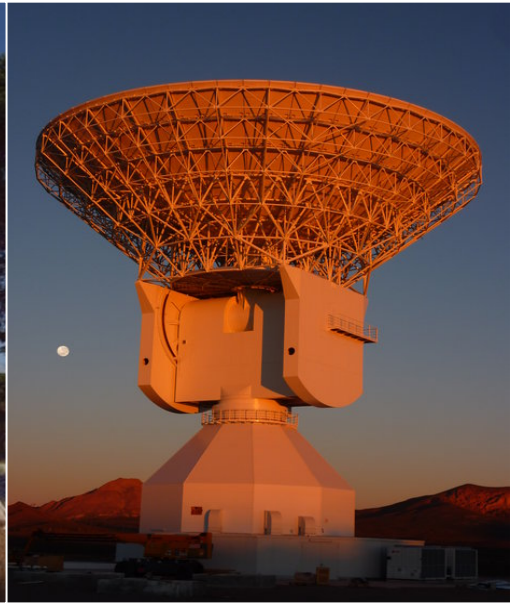
ESOC: Weltweites Netz von Bodenstationen

New Norcia, Australien



Cebreros, Spanien

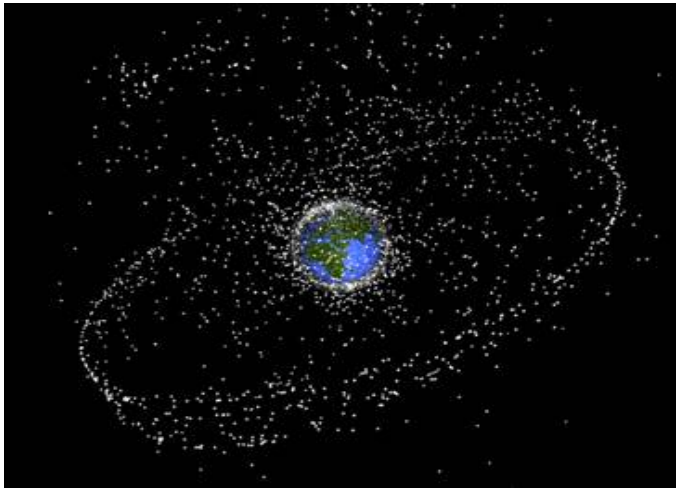
Malargüe, Argentinien



ESA UNCLASSIFIED - For Official Use

ESOC: Weltraumumgebung

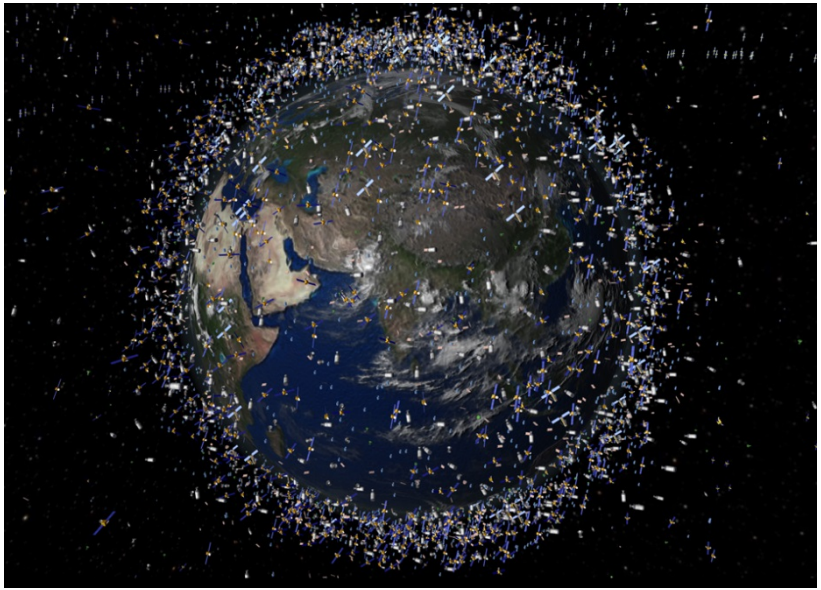
- Vorhersagedienst 24/7
- Ausweichmanöver (10 in 2015)
- Wiedereintrittsvorhersagen
- Risikobewertung nach Explosionen oder Kollisionen



ESA UNCLASSIFIED - For Official Use

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)



ESA UNCLASSIFIED - For Official Use

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

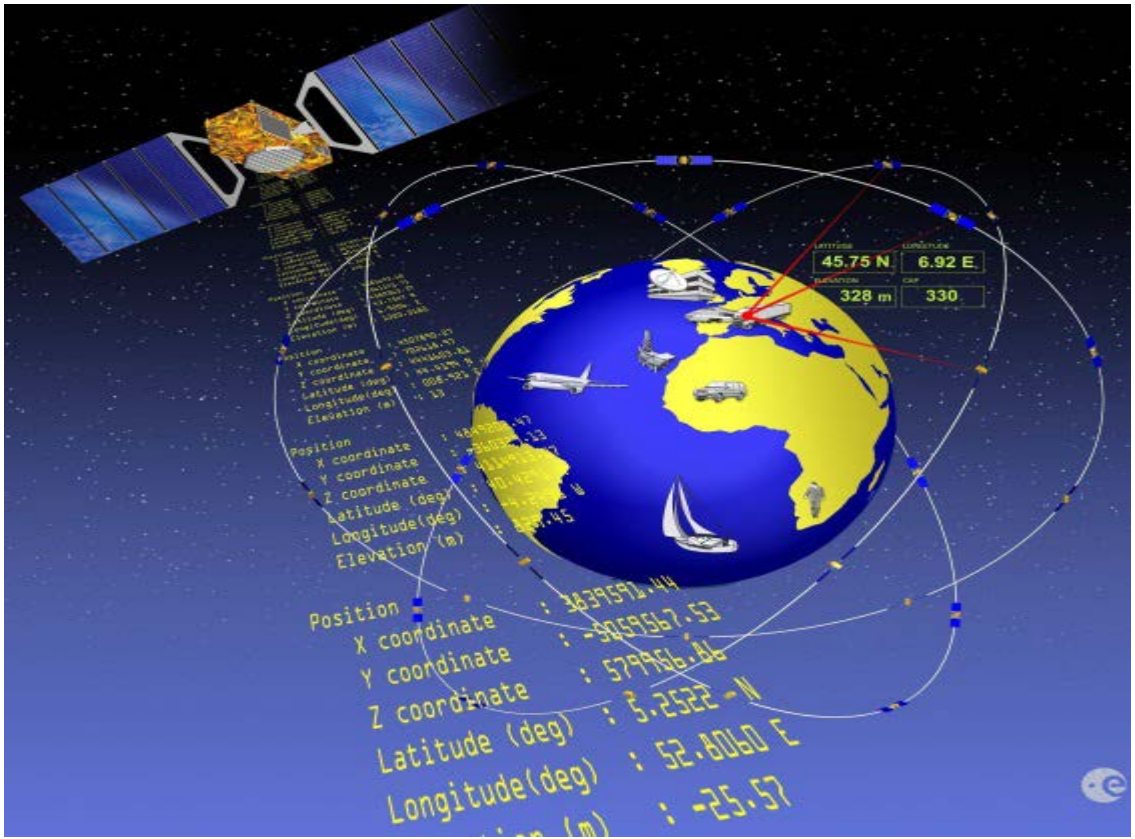
ESA UNCLASSIFIED - For Official Use

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

ESA UNCLASSIFIED - For Official Use

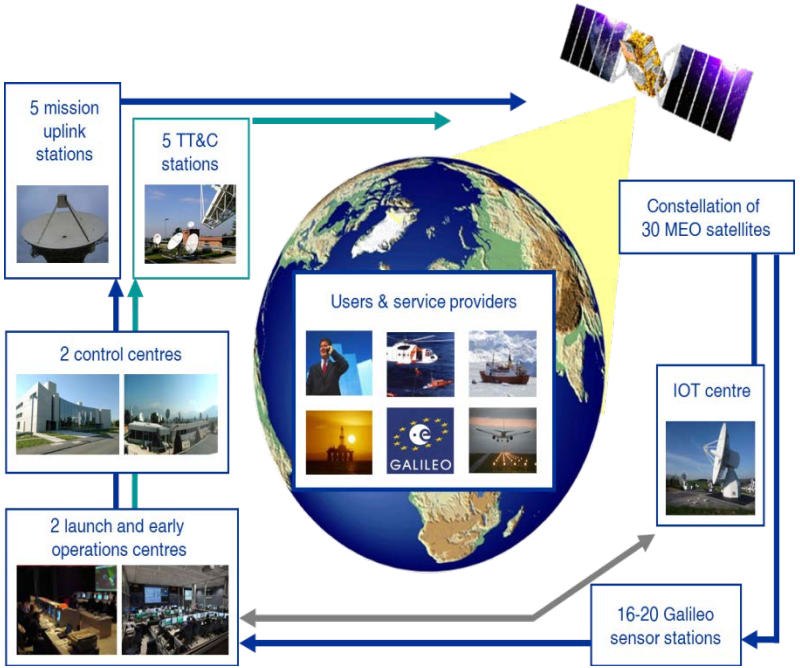
Navigation



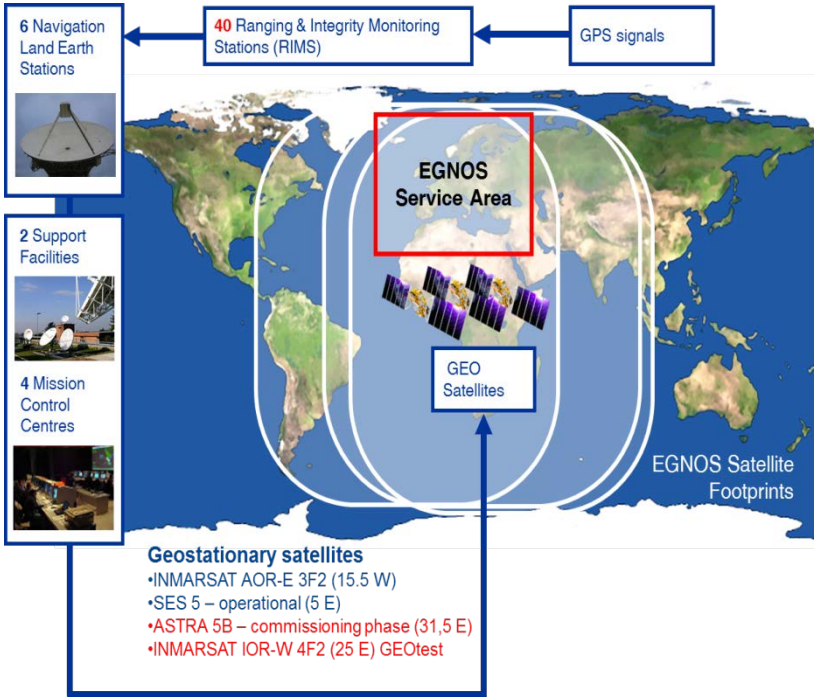
ESA UNCLASSIFIED - For Official Use

Navigation - Europa

Galileo



EGNOS



ESA UNCLASSIFIED - For Official Use

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)

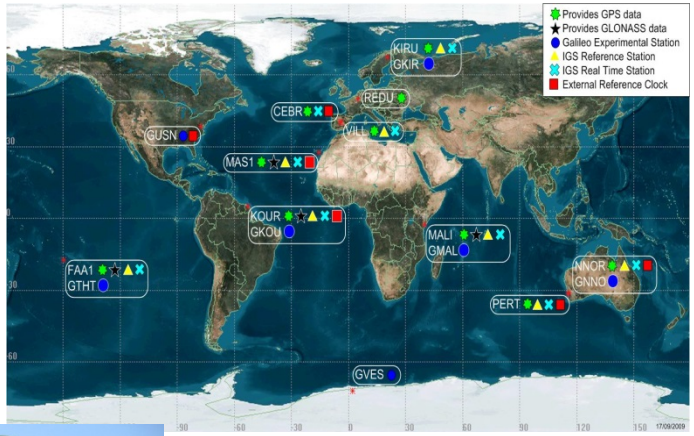
- WAAS (USA)
- EGNOS (Europa)
- MSAS (Japan)
- SDCM (Russland)
- GAGAN (Indien)

Nahe Zukunft:

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

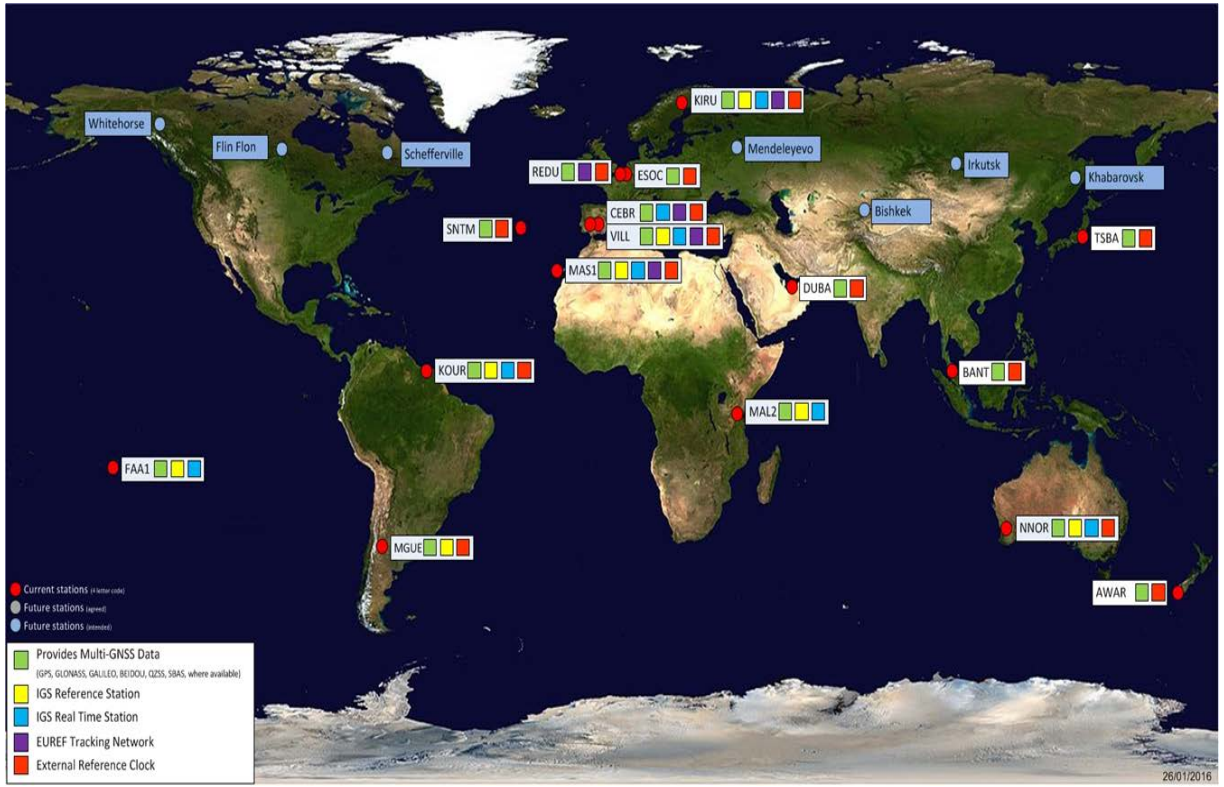
ESA UNCLASSIFIED - For Official Use

Navigation – Navigation Office am ESOC



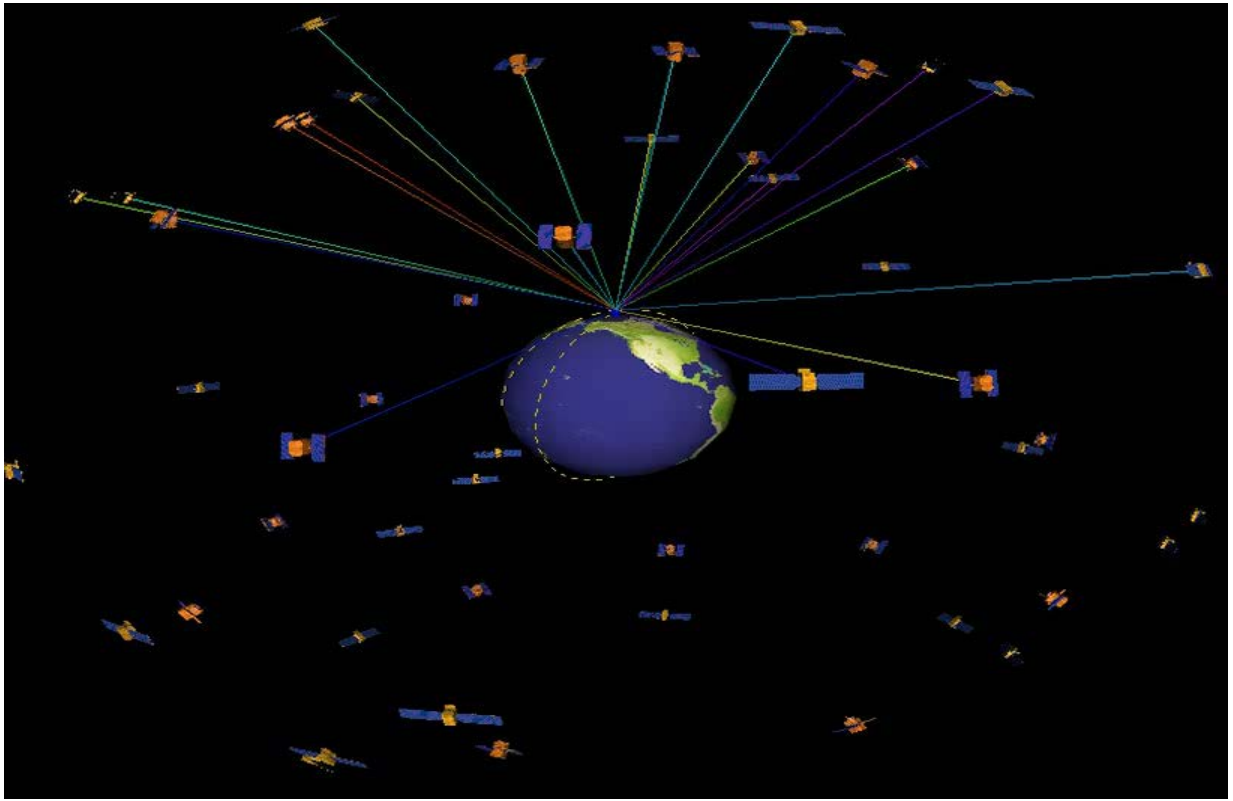
ESA UNCLASSIFIED - For Official Use

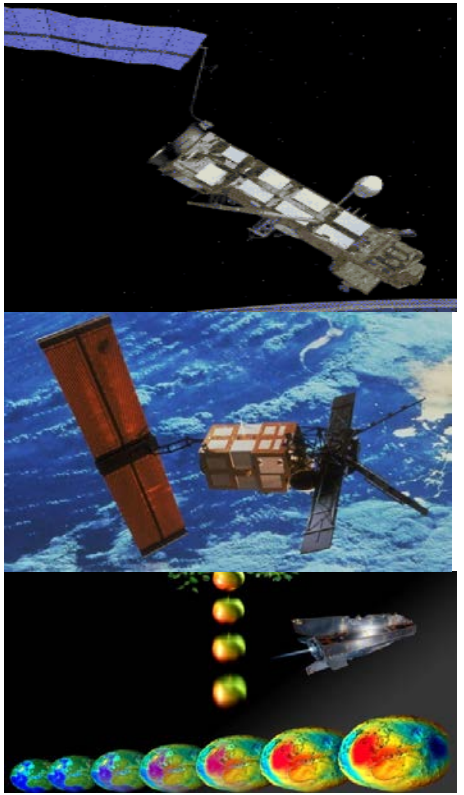
Betrieb von Global Sensor Station Network - GNSS Receivers



ESA UNCLASSIFIED - For Official Use

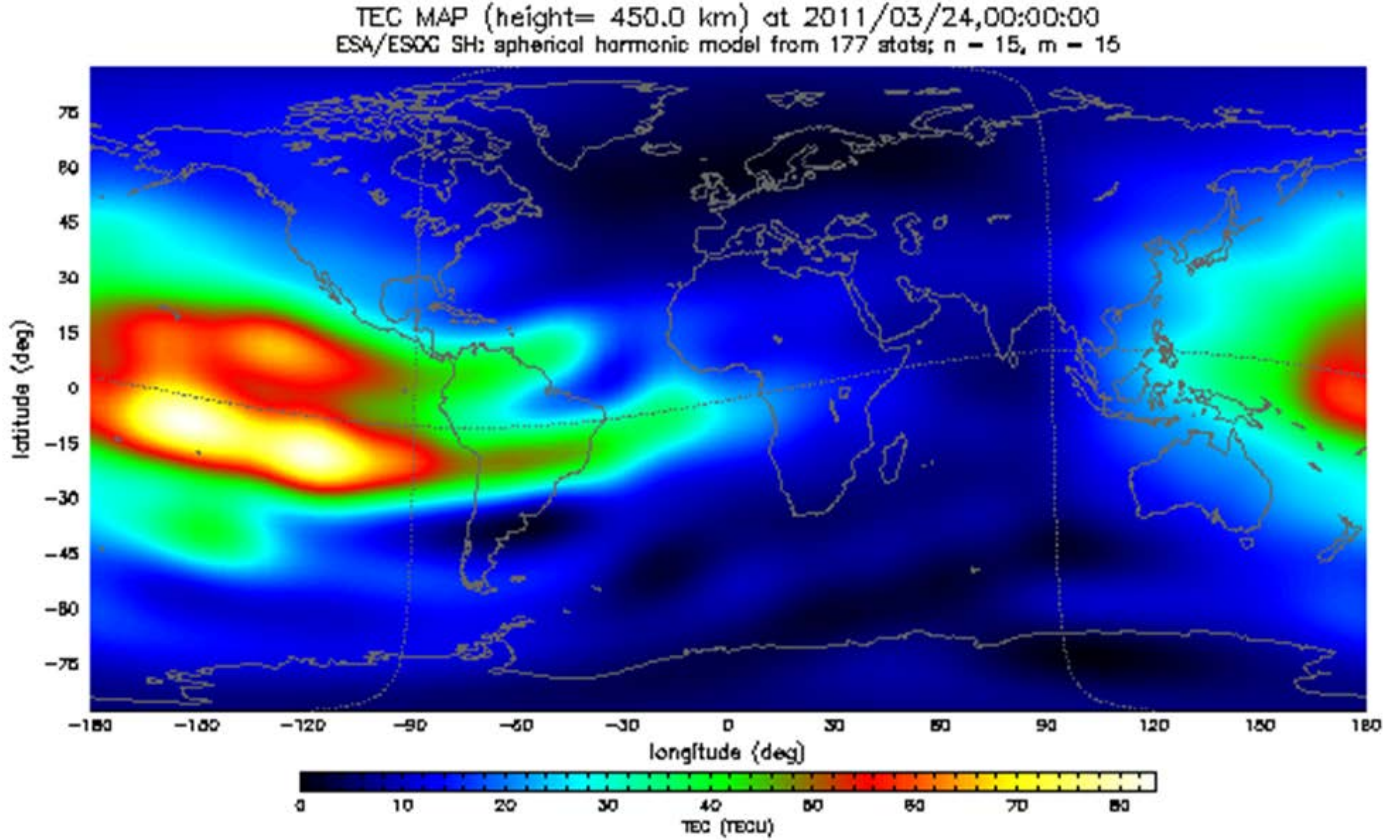
Navigation – Praezise Banhbestimmung im cm Bereich





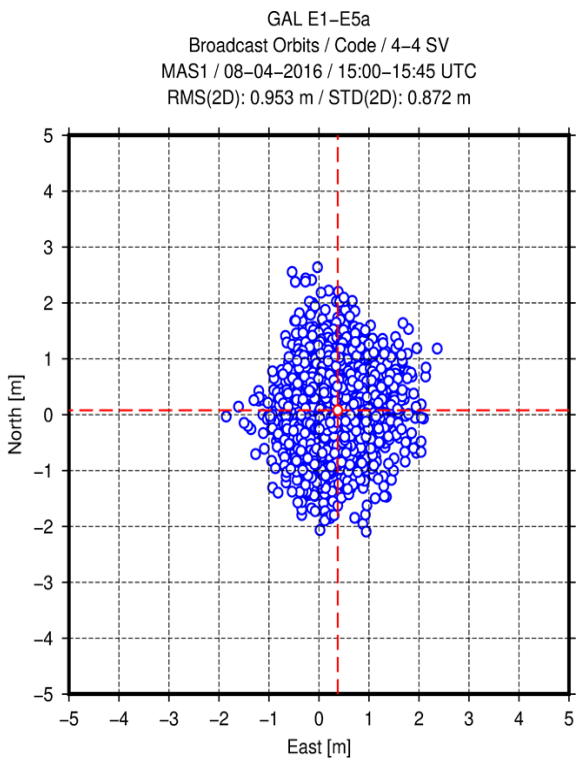
ESA UNCLASSIFIED - For Official Use

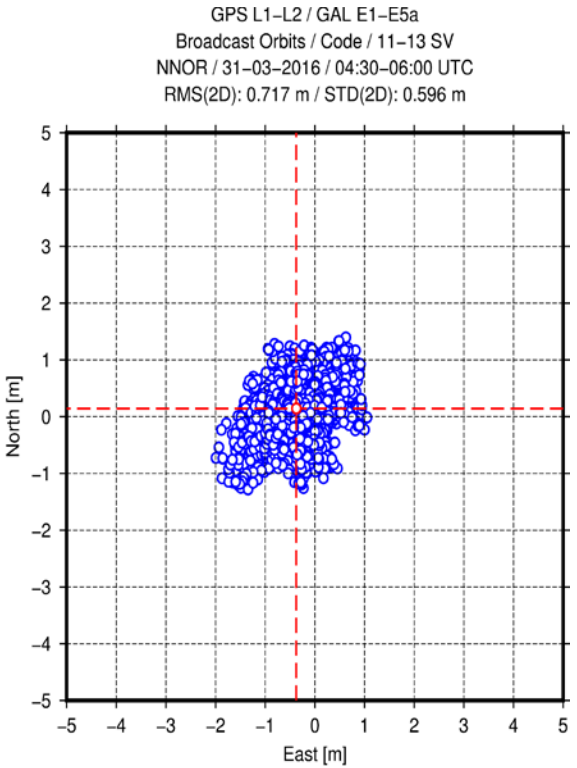
Navigation – Monitoring der Ionosphere

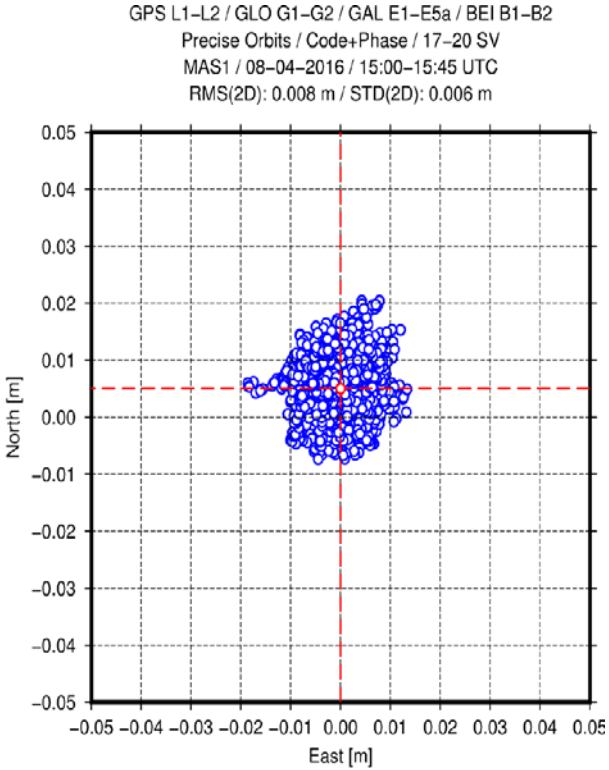


ESA UNCLASSIFIED - For Official Use

Navigation - Erreichbare Positionsgenauigkeiten durch GNSS

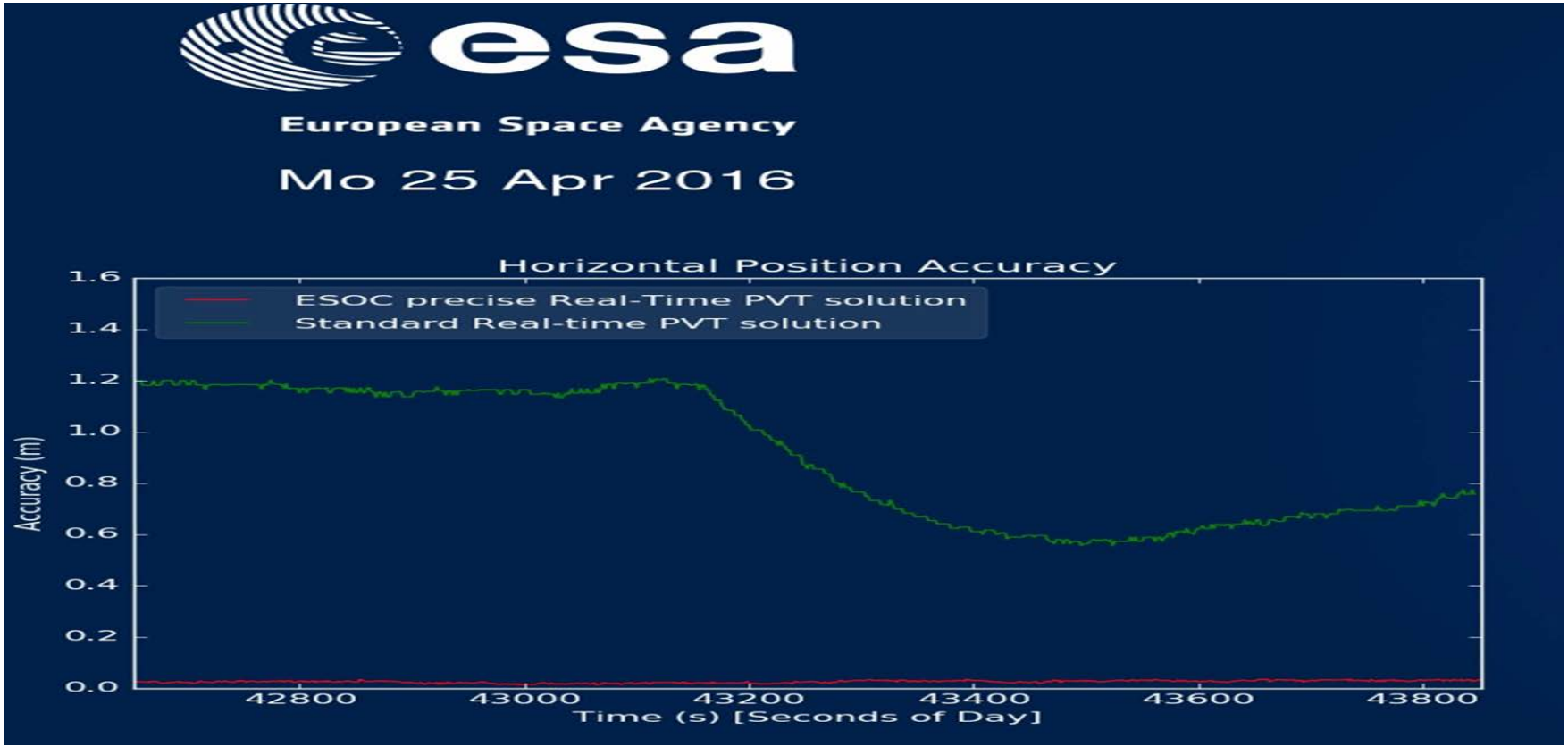






ESA UNCLASSIFIED - For Official Use

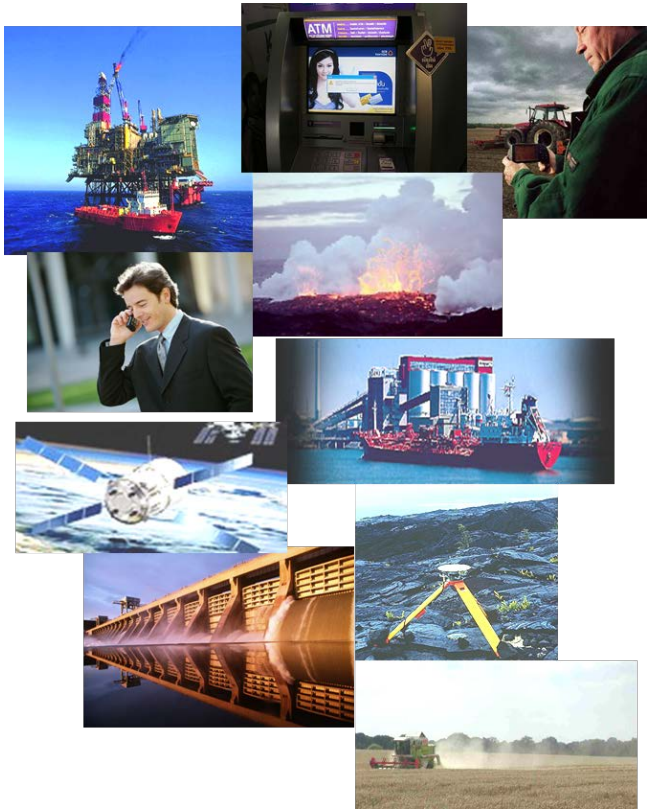
Navigation



ESA UNCLASSIFIED - For Official Use

Navigation

- 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

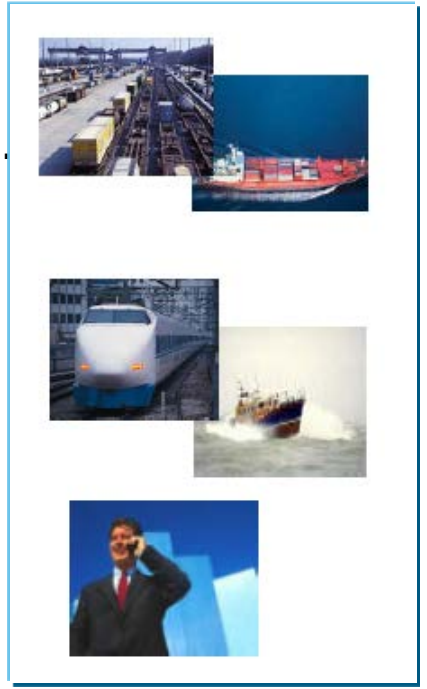


ESA UNCLASSIFIED - For Official Use

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,…



ESA UNCLASSIFIED - For Official Use

Mehr Informationen:
www.esa.de