How Does A Space Project Work ?

The Final Chapter: Operations

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Herschel Mission Manager
Elixir Training School
20-May-2011

Operating *WHAT* ? Satellites in different "disciplines"…

- Earth Observations
  - Weather
  - Environmental monitoring
  - Map making
- Telecommunications
  - Phone & videoconferences
  - Satellite TV
- Global Positioning Services
  - Navigation & Applications
- Manned Spaceflight
  - Science
  - Recreation
- Solar System Missions
  - Remote sensing
  - In situ measurements
- Astrophysics Missions
  - Almost all wavelength ranges

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Landfall of hurricane
Katrina 2005

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Ground truth #1
after landfall

European Space Agency

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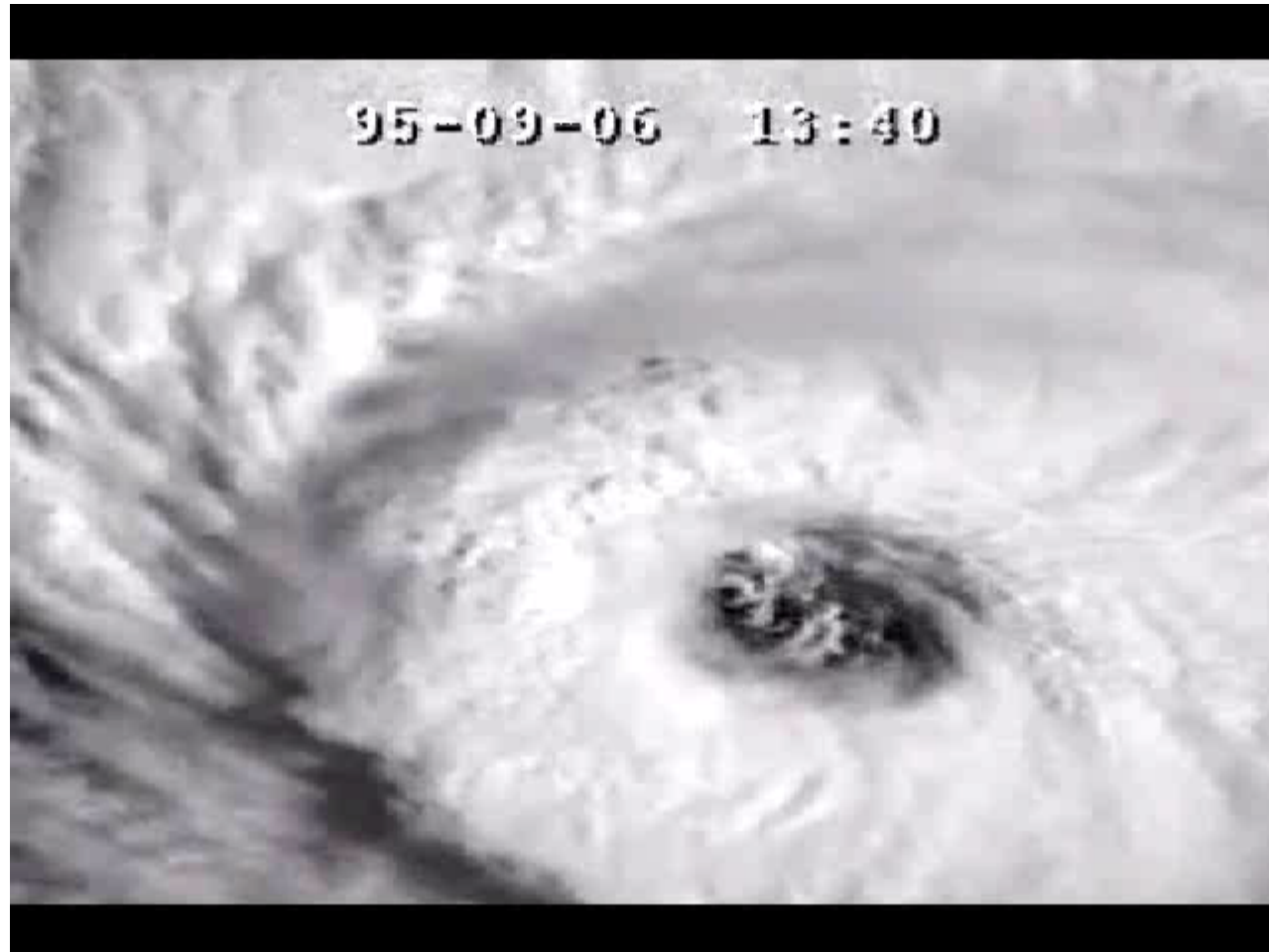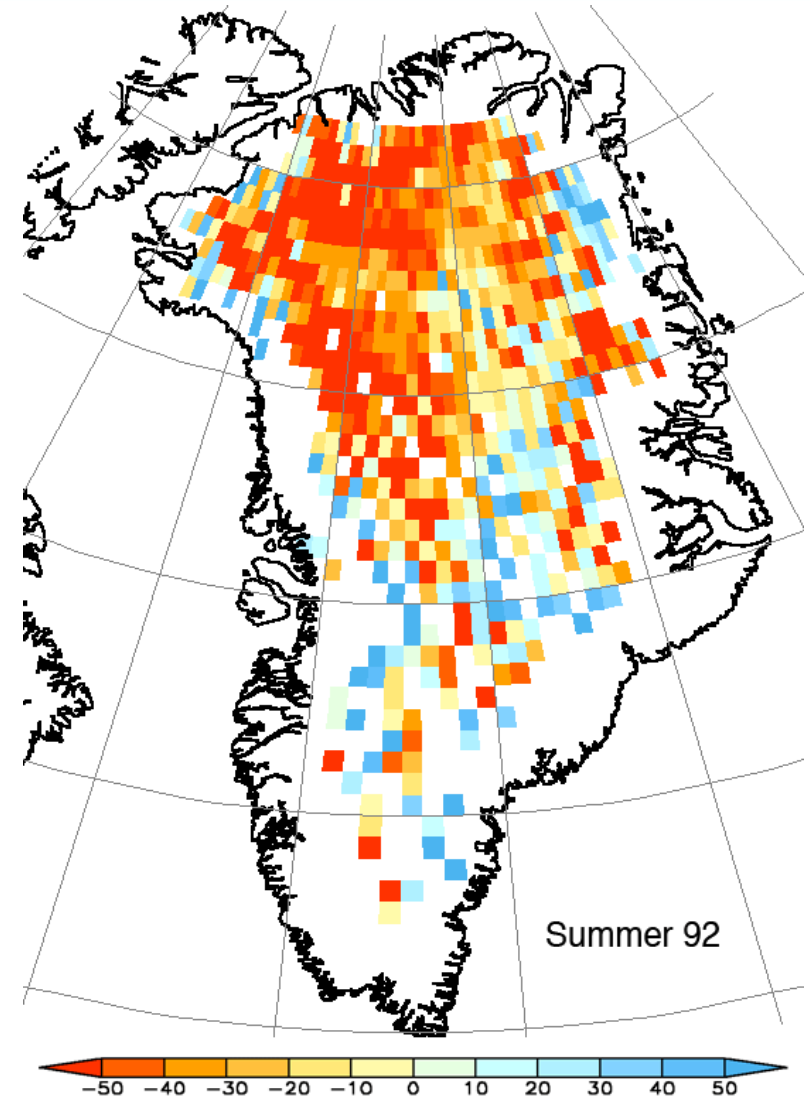

Ground truth #2
after landfall

esa

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Eye of hurricane
Luis 1995

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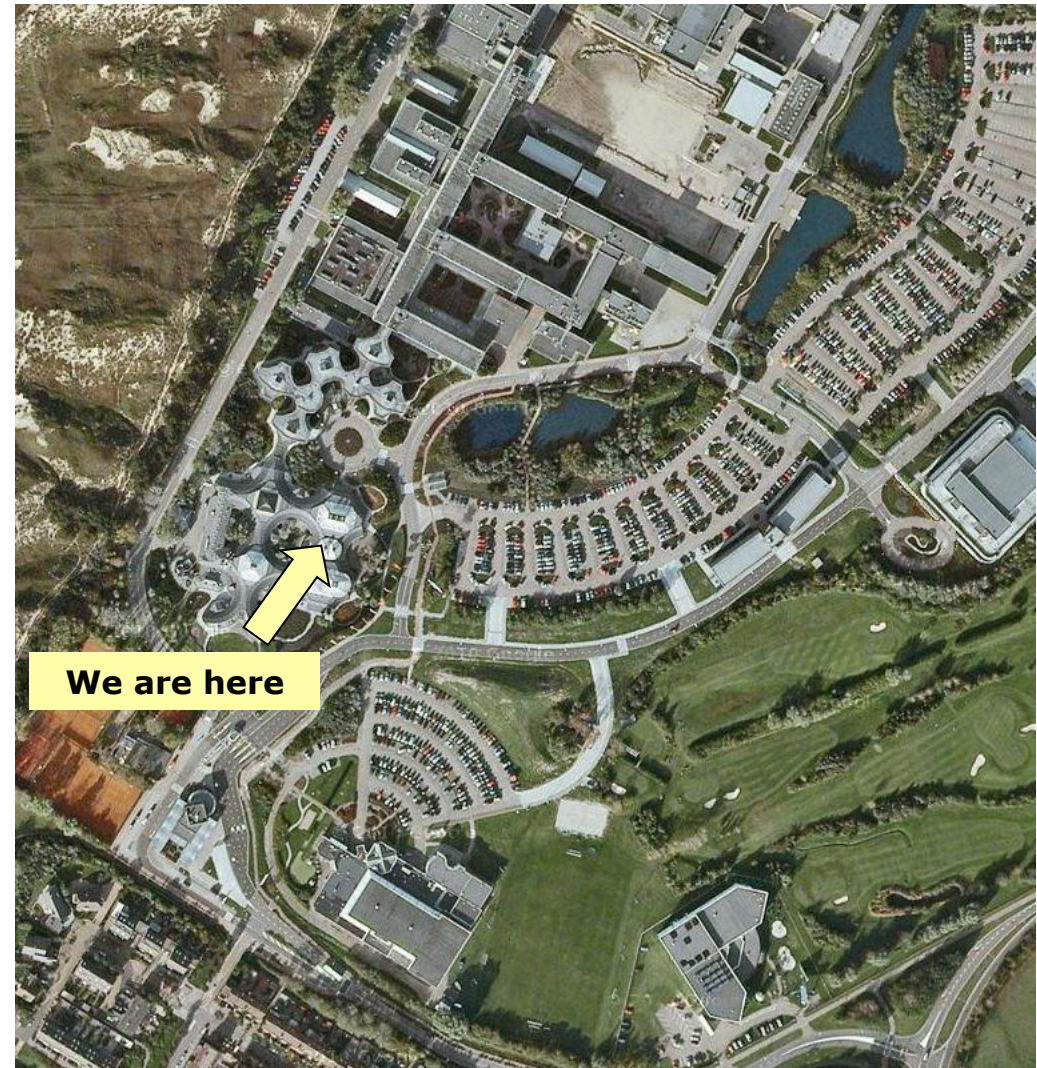 - Almost all wavelength ranges

Summer 92

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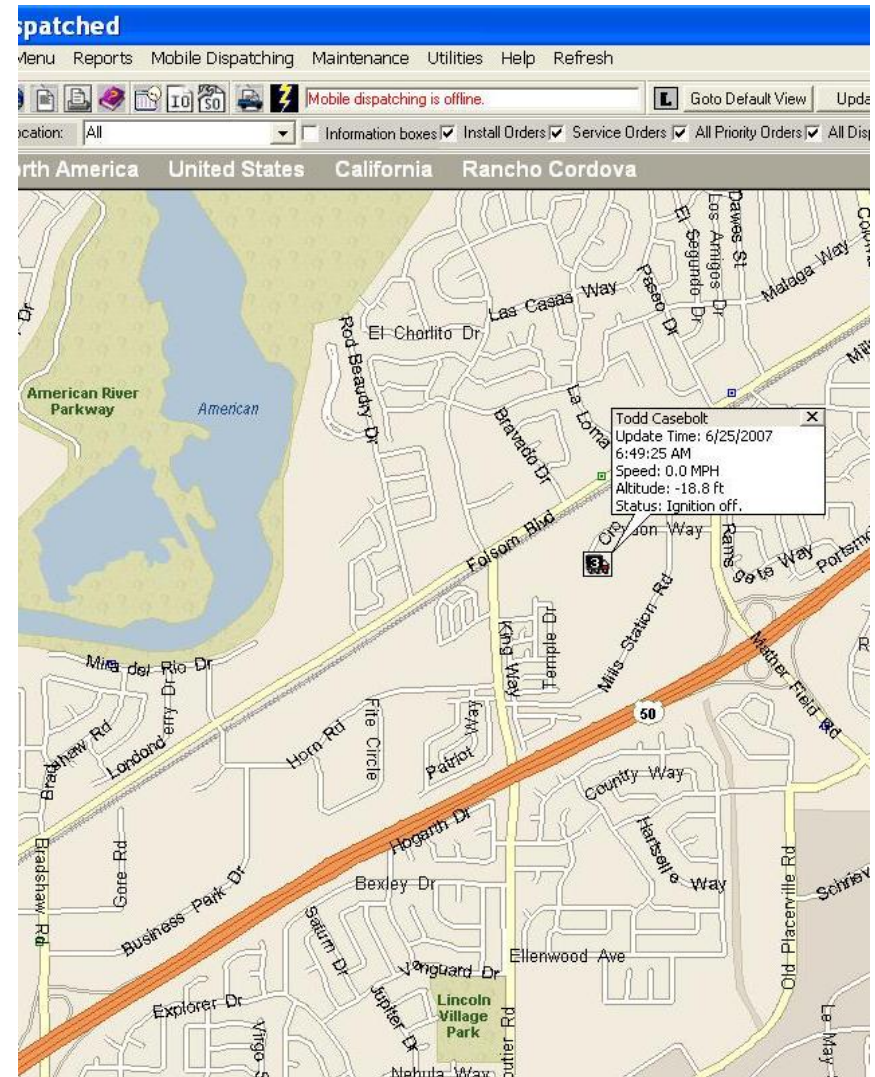# Operating *WHAT* ? Satellites in different "disciplines"...

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600-02264465 [RF] © www.visualphotos.com

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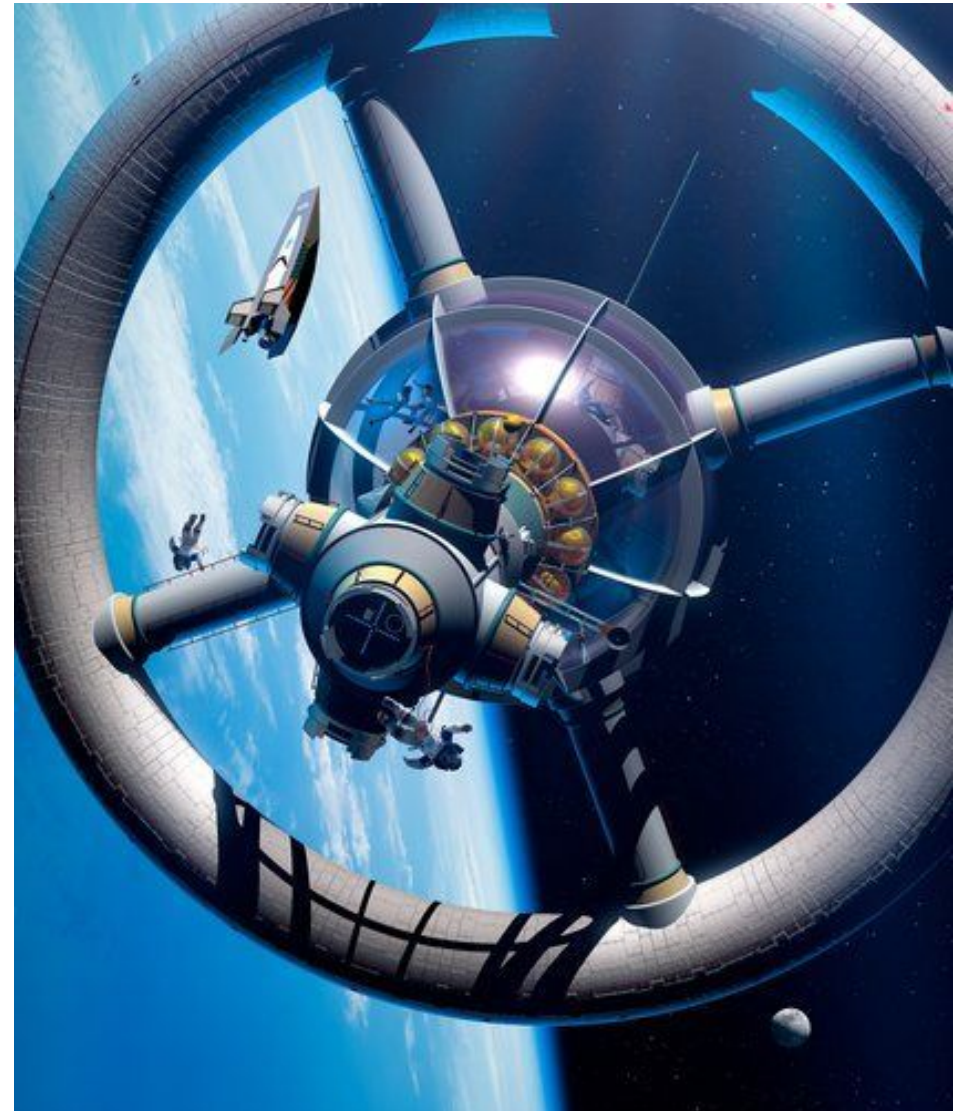- ➤ Astrophysics Missions
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NEAR — 433 Eros

March 22 2000 00:00:29   30° 286°

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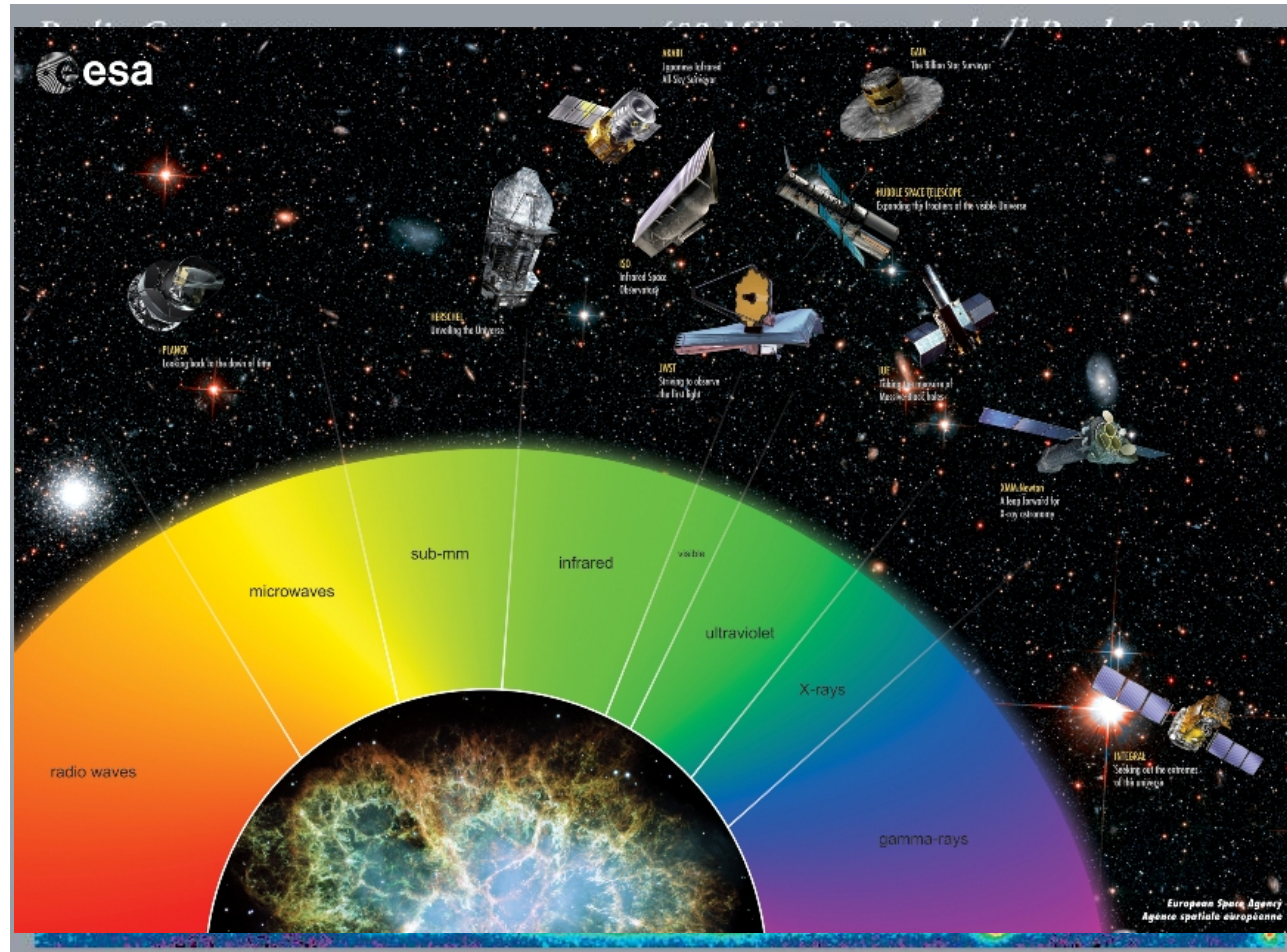
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"Common" Infrastructure Across Mission Types: Ground Station and its Infrastructure

- ➢ Size of antenna: Typically 12–35 m (ESA), up to 70 m (NASA Deep Space Network)
- ➢ Antenna size needs to increase with
  - Distance satellite-Earth (few hundred km for Low Earth Orbit, Voyager 1 spacecraft currently at $17.4 \cdot 10^9$ km (~115 AU) ➔ light round trip time > 32^h)
  - Decrease in spacecraft transmitter power (typically a few to a few hundred Watts)
  - Increase in data rate (e.g. Herschel 1.5 Mbit s^{-1} in downlink, 4 kbps in uplink)
- ➢ Ground Station provides electrical (10s of kW transmission power), mechanical (move tons of mass reasonably quickly, point with high precision and stability), thermal, computer & network infrastructure
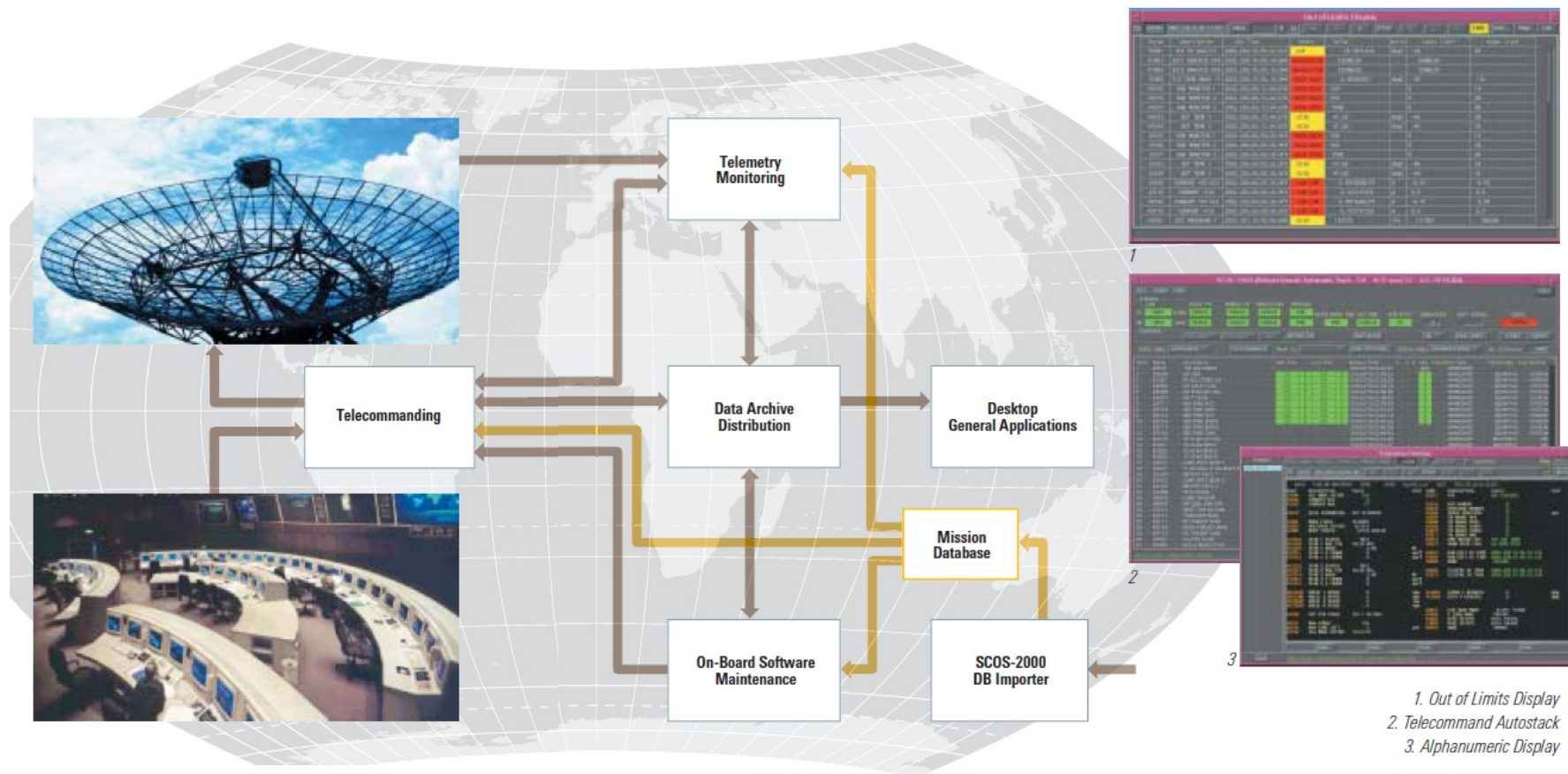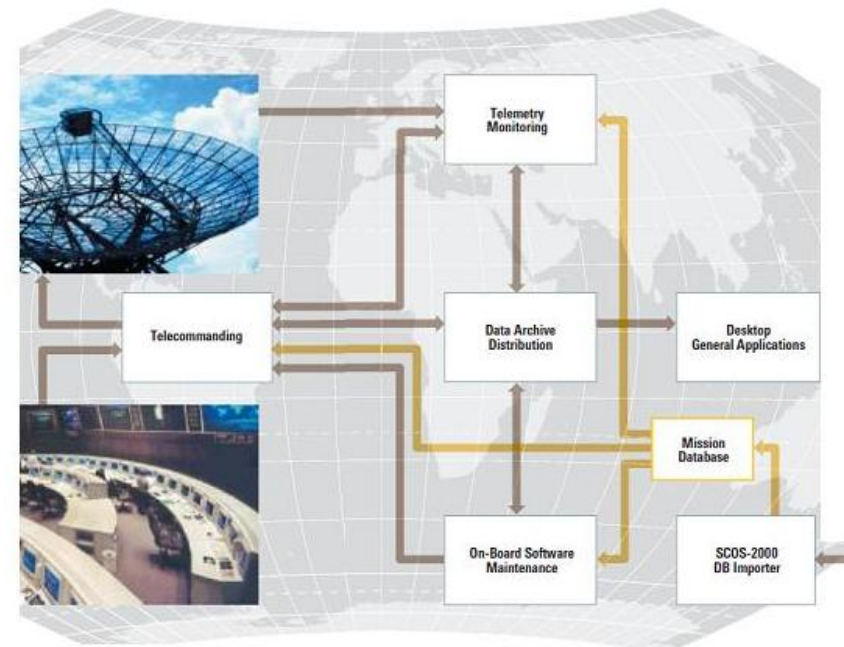
1. Out of Limits Display
2. Telecommand Autostack
3. Alphanumeric Display

"Common" Infrastructure Across Mission Types: Mission Control System

- ➤ ESA has developed its own Mission Control Systems starting in 1974
- ➤ Most recent offspring in this family is SCOS-2000, used by ESA and its partners
- ➤ SCOS-2000 is a generic, database driven application with mission-specific customisation
- ➤ SCOS-2000 DB Importer: Most projects maintain the DB in a commercial system (e.g. MS-Access)
- ➤ Mission Database: Contains all parameters needed for commanding (command mnemonics, their parameters, their translation to bit patterns, etc.) and for interpreting telemetry (parameter location in TM stream & length in bits, calibration curves for conversion to physical units, safety limits, parameter position on screen); mission specific
- ➤ On-Board S/W Maintenance: Conceptually, this extends telecommands (change/add functionality)
- ➤ Data Archive Distribution: Raw data archive, distribution to internal & external users
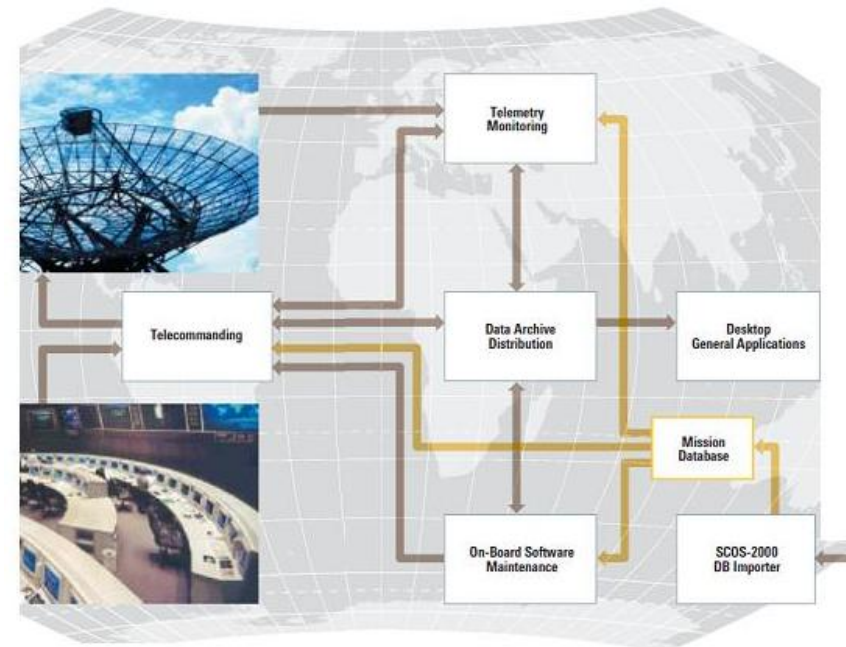- ➤ Desktop general applications (e.g. graphical displays of parameters, trend analysis, etc)

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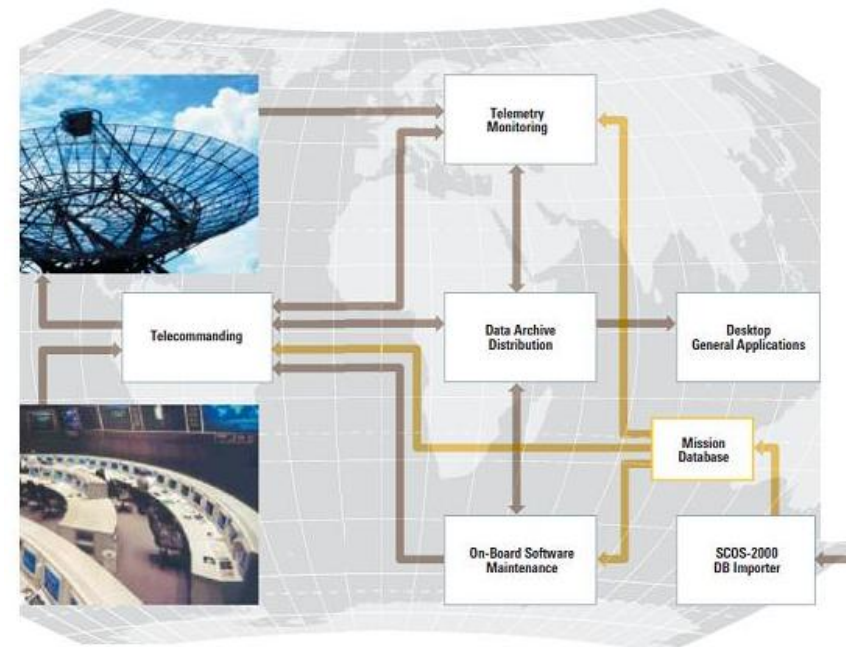➢ Desktop general applications (e.g. graphical displays of parameters, trend analysis, etc)

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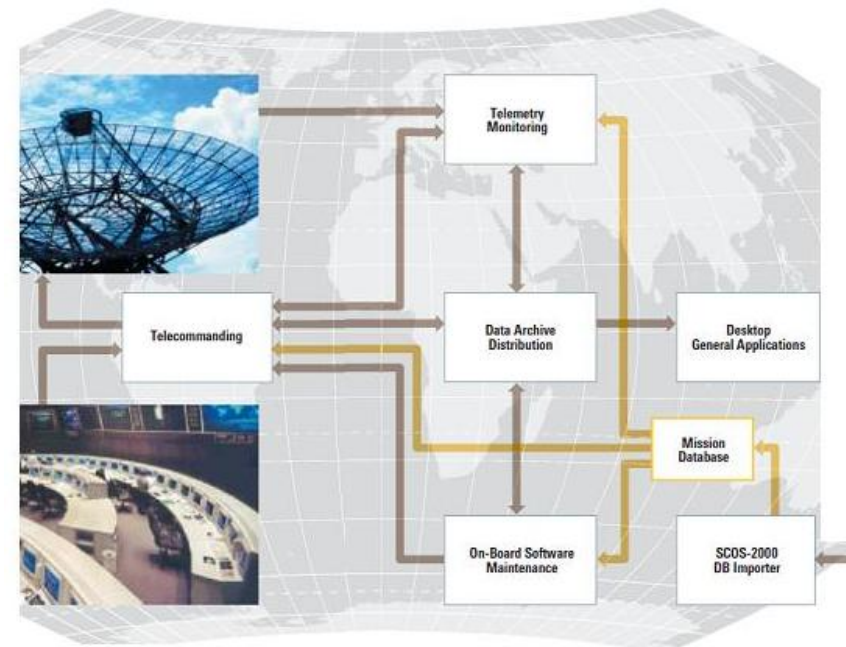- ➤ Desktop general applications (e.g. graphical displays of parameters, trend analysis, etc)

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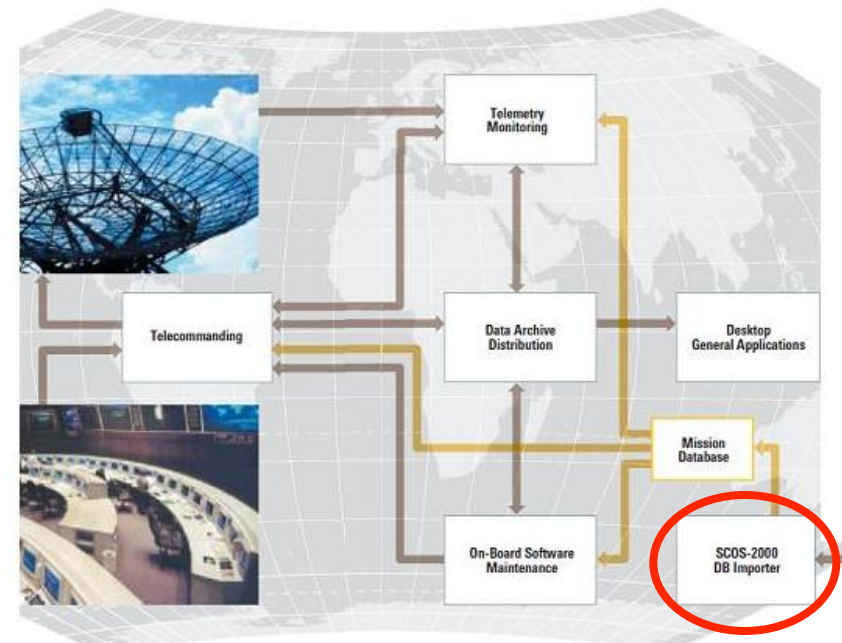➢ Desktop general applications (e.g. graphical displays of parameters, trend analysis, etc)

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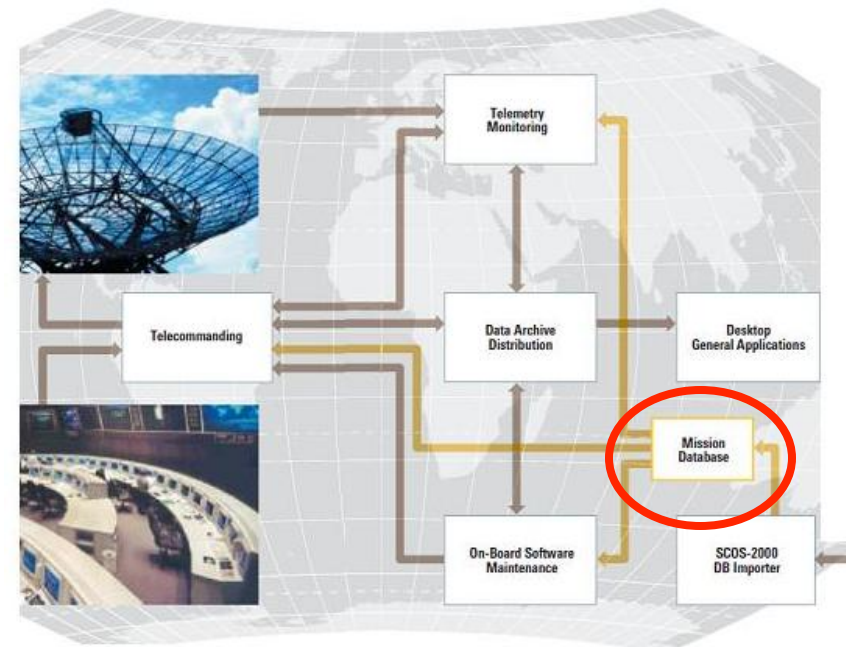➢ Desktop general applications (e.g. graphical displays of parameters, trend analysis, etc)

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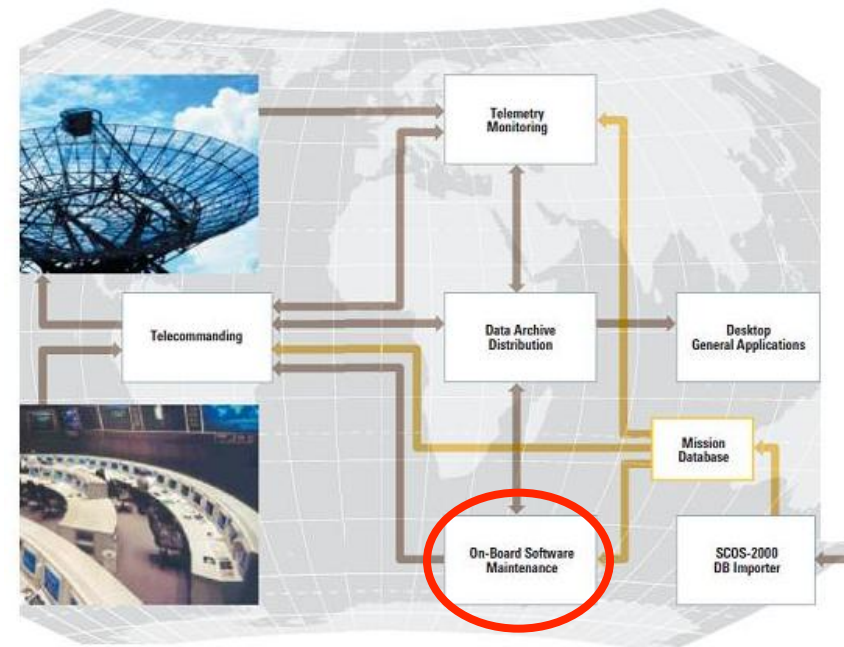- ➤ Desktop general applications (e.g. graphical displays of parameters, trend analysis, etc)

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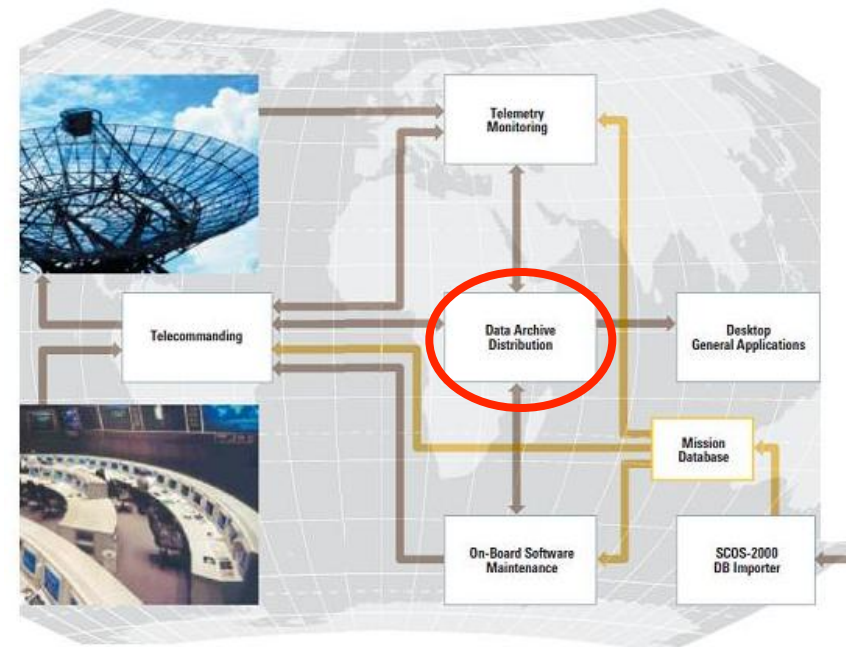- ➢ Desktop general applications (e.g. graphical displays of parameters, trend analysis, etc)

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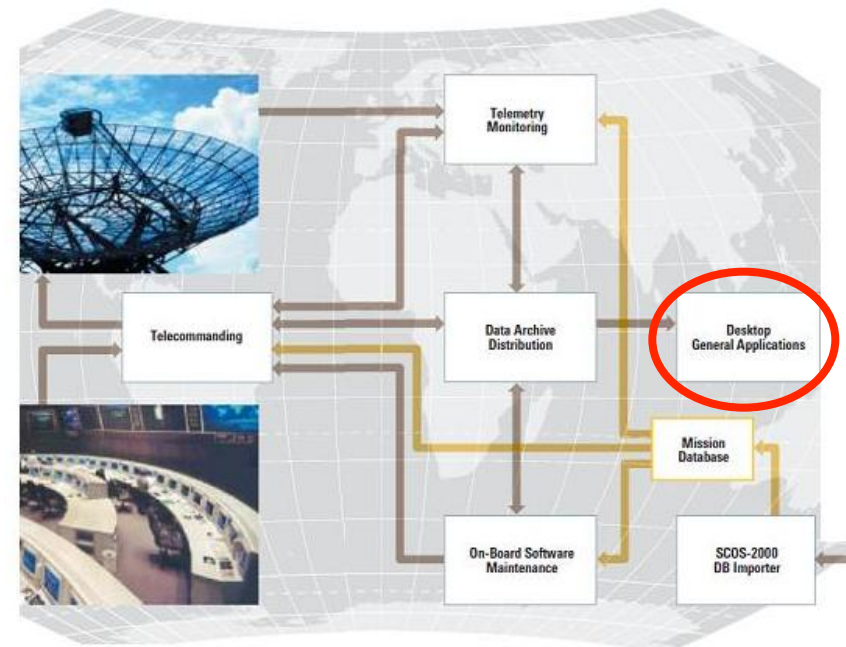
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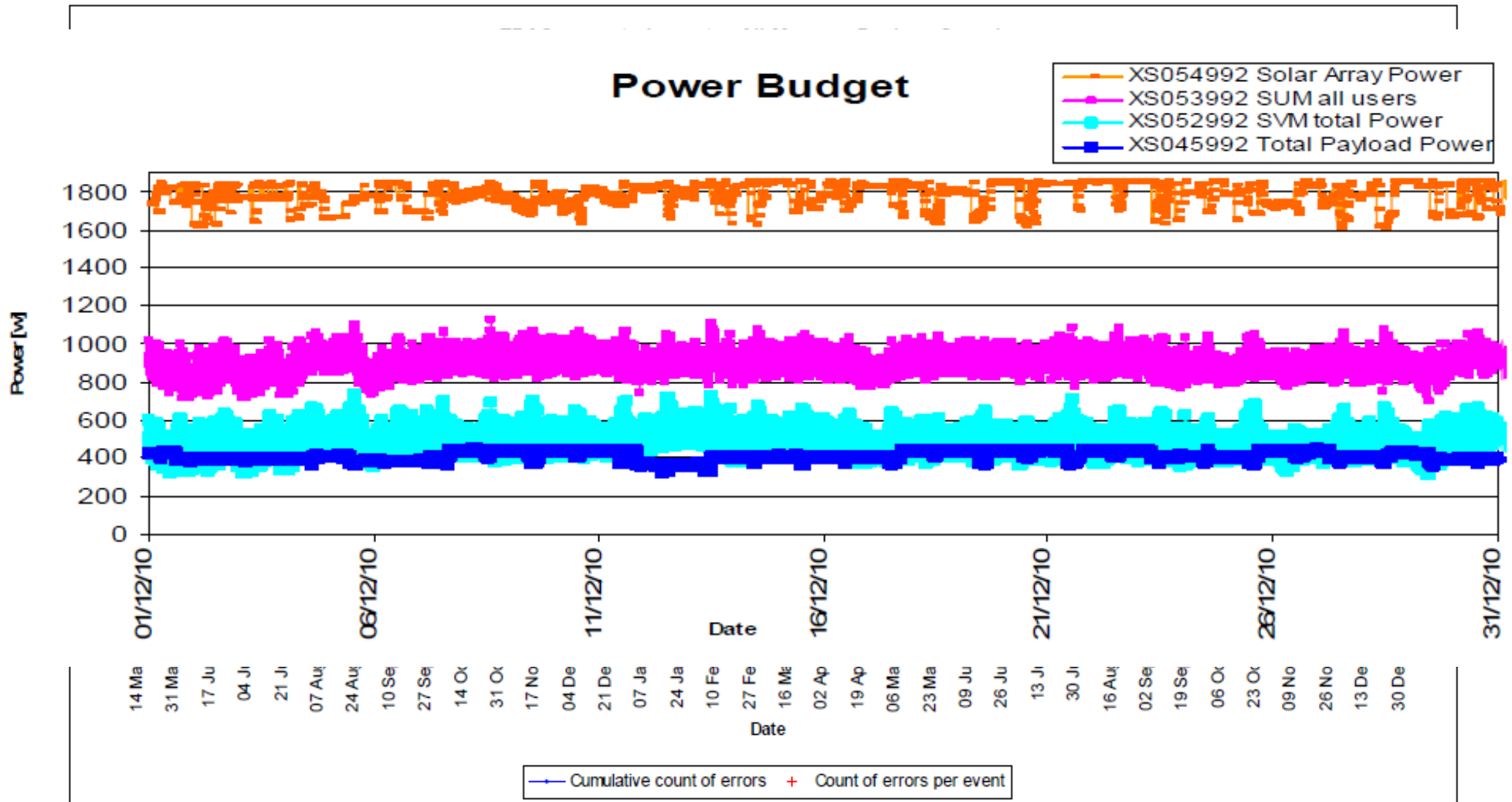- ➢ Desktop general applications (e.g. graphical displays of parameters, trend analysis, etc)

Power Budget

Common Infrastructure Across Mission Types: Teams and Activities Preparing A Mission

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- Flight Control Team
  - Responsible for user requirements on the Mission Control System
  - Preparing Flight Control Procedures
  - Close cooperation with industry
  - User testing of Mission Control System
  - Intense rehearsal of all mission phases
- Software Support
  - Supervising development of mission-specific extensions to the standard Mission Control System
  - Acceptance testing of software deliveries
- Simulator Development
  - Modelling behaviour of all spacecraft systems in software for use by the Flight Control Team in the development of procedures & for training purposes
- Mission Analysis
  - Calculation of Launch windows; numerous constraints arise from launch, separation & orbit evolution (e.g. eclipse durations, pointing constraints)
- Science Ground Segment preparation

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"Common" Infrastructure Across Mission Types: Teams in Operations

> **Flight Control Team**
> - **Size and location very much depends on mission phase**
> - **Around-the-clock shift work (24/7) during critical mission phases**
> - **Mostly engineers**

> Flight Dynamics Team
> - Separate room
> - Responsible for initial orbit determination
> - Responsible for calculating orbit maintenance manoevres
> - Responsible for satellite dynamical computations (attitude, reaction wheel speeds, gyro calibrations)
> - Mostly mathematicians

> Software Coordination Team
> - During critical mission phases physically present in the Main Control Room
> - Monitoring all computers, LAN traffic, etc.
> - Can switch to a hot-redundant systen without interruption of activities

Two big Flight Control Teams during Herschel/Planck launch in ESOC's Main Control Room

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Flight Dynamics Team during Herschel/Planck launch

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Software Coordination Team during Herschel/Planck launch

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"Common" Infrastructure Across Mission Types: Teams in Operations

➢ **Station Controllers**
  - **During launch and for satellites in Low Earth Orbit, several stations are required for continuous communication (time between launch in Kourou and Malindi signal acquisition is only ~30 min)**
  - **Most Ground Stations operated 7 days/ week, 24 hours/day**
➢ **Canteen services around the clock during critical mission phases**
➢ **Site Security (with extra guards to restrict access to certain areas during launches)**
➢ **Public Relations**

etc. etc.

ESA Tracking Network: Global Coverage

Core ESA Network
1 Kourou
2 Kiruna
3 Redu
4 Cebreros
5 Villafranca
6 Maspalomas
7 Perth
8 New Norcia
9 Santa Maria
10 Malargüe

Cooperative Network
1 Poker Flat
2 Goldstone
3 Madrid
4 Weilheim
5 ESRANGE
6 HBK
7 Kerguelen
8 Usuda
9 Masuda
10 Canberra
11 Malindi

Augmented Network
1 South Point
2 Santiago
3 Troll
4 Svalbard
5 Dongara

● Core ESA Network
● Cooperative Network
● Augmented Network

Tracking Stations & Station Controllers

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➢ **Site Security (with extra guards to restrict access to certain areas during launches)**

➢ **Public Relations**

etc. etc.

Canteen Services

"Common" Infrastructure Across Mission Types: Teams in Operations

- ➢ **Station Controllers**
  - **During launch and for satellites in Low Earth Orbit, several stations are required for continuous communication (time between launch in Kourou and Malindi signal acquisition is only ~30 min)**
  - **Most Ground Stations operated 7 days/ week, 24 hours/day**
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etc. etc.

Open Access

Herschel & Planck Launch

May 2009

Johannes RIEDINGER

ESA/ESTEC

Site Security

# "Common" Infrastructure Across Mission Types: Teams in Operations

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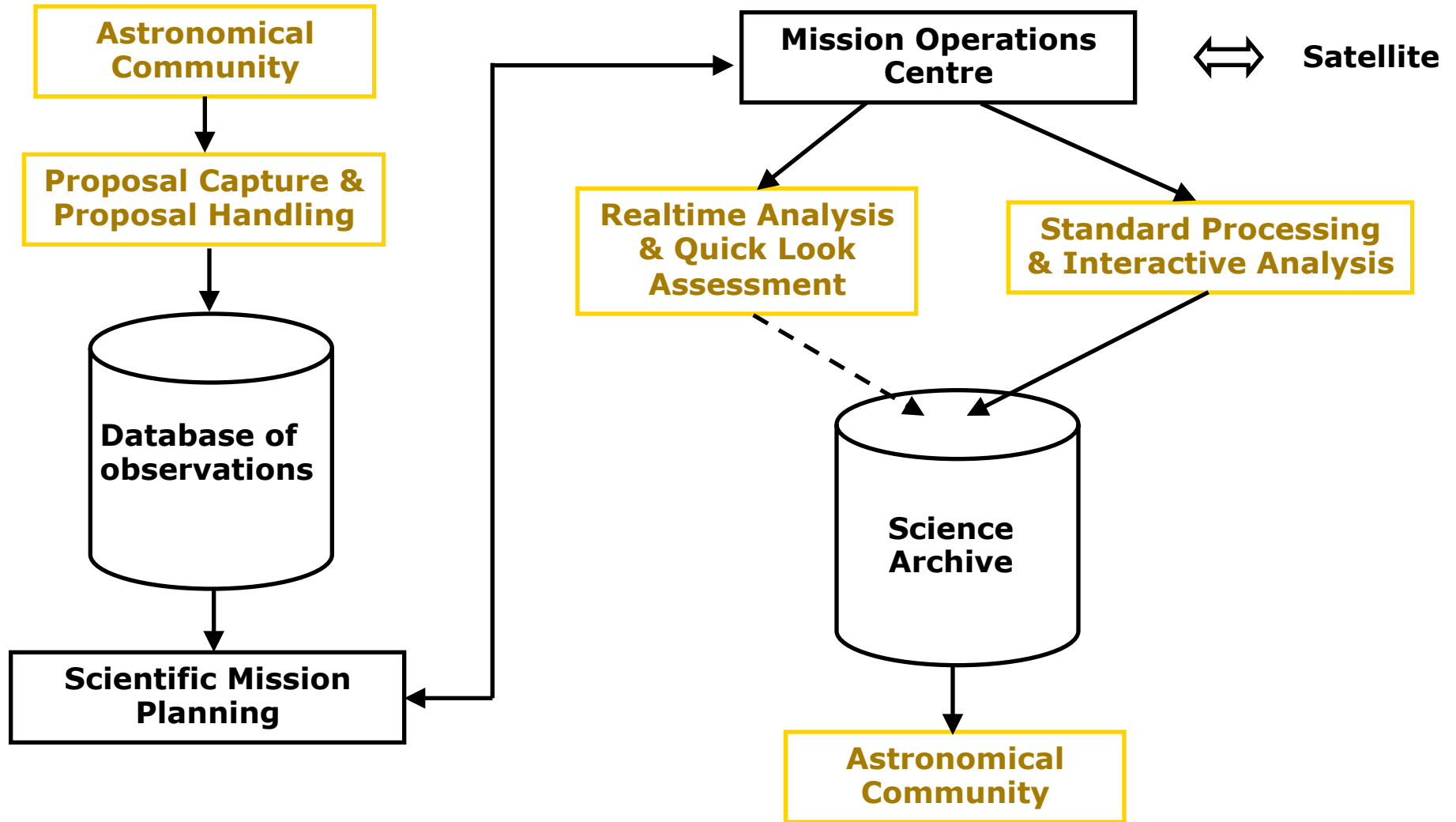
➢ **Public Relations**

etc. etc.
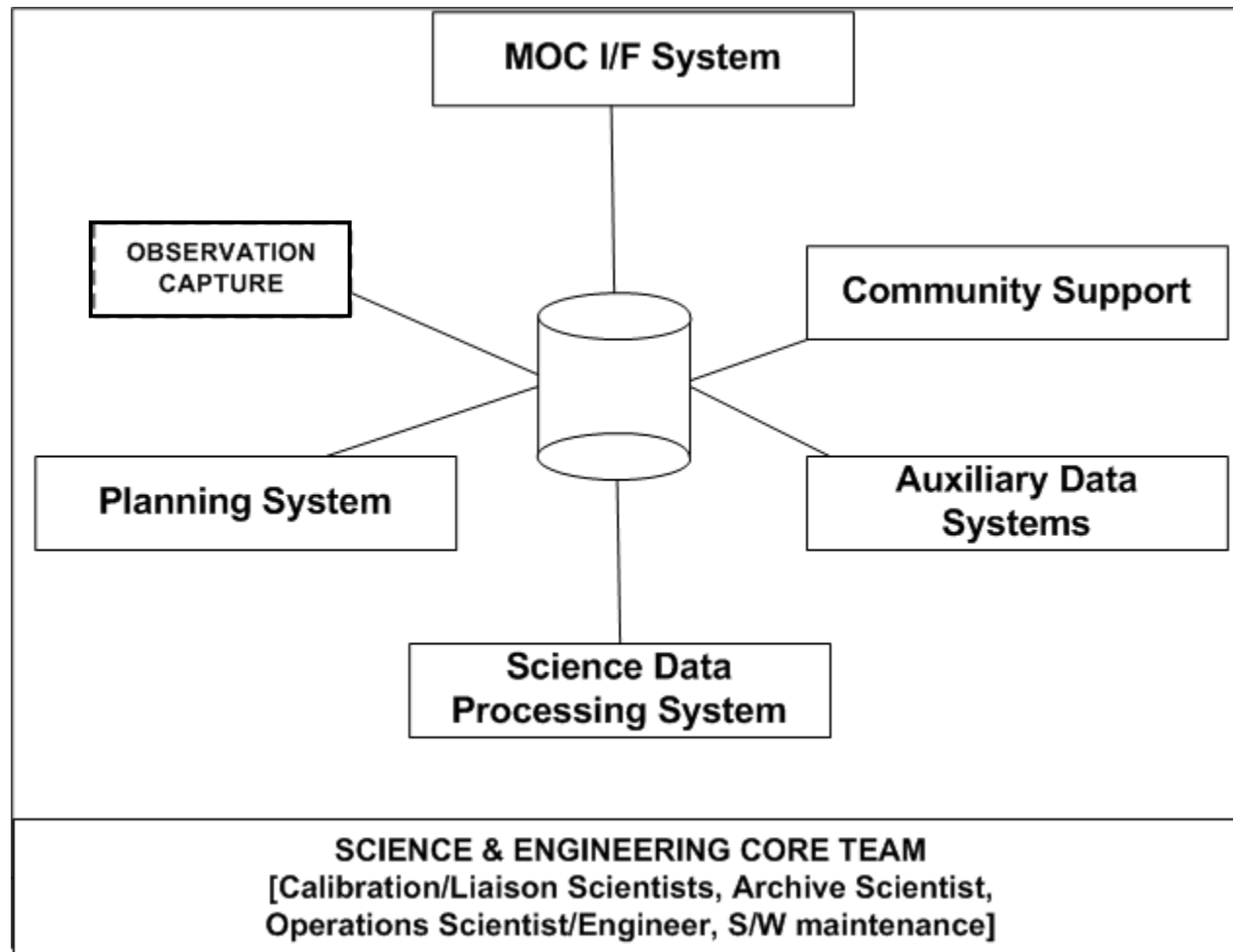

Public Relations Event Surrounding A Launch
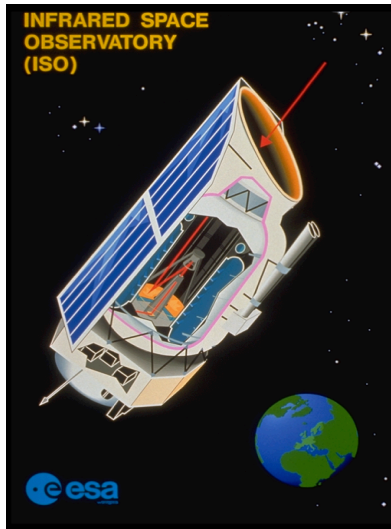
For the rest I will restrict myself to talking about operations of a typical astrophysics observatory

Ground Segment – Information Flow

Astronomical Community

Proposal Capture & Proposal Handling

Database of observations

Scientific Mission Planning

Mission Operations Centre

⟺ **Satellite**

Realtime Analysis & Quick Look Assessment

Standard Processing & Interactive Analysis

Science Archive

Astronomical Community

Ground Segment – SOC High Level Components
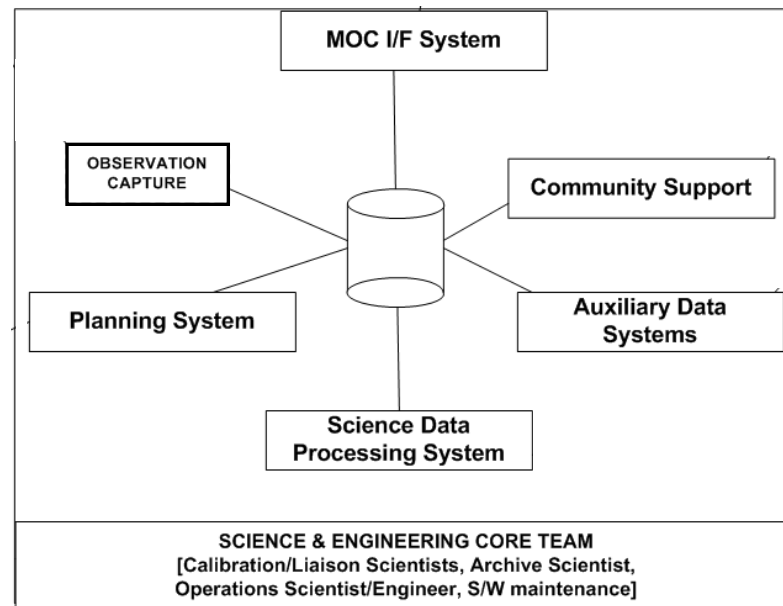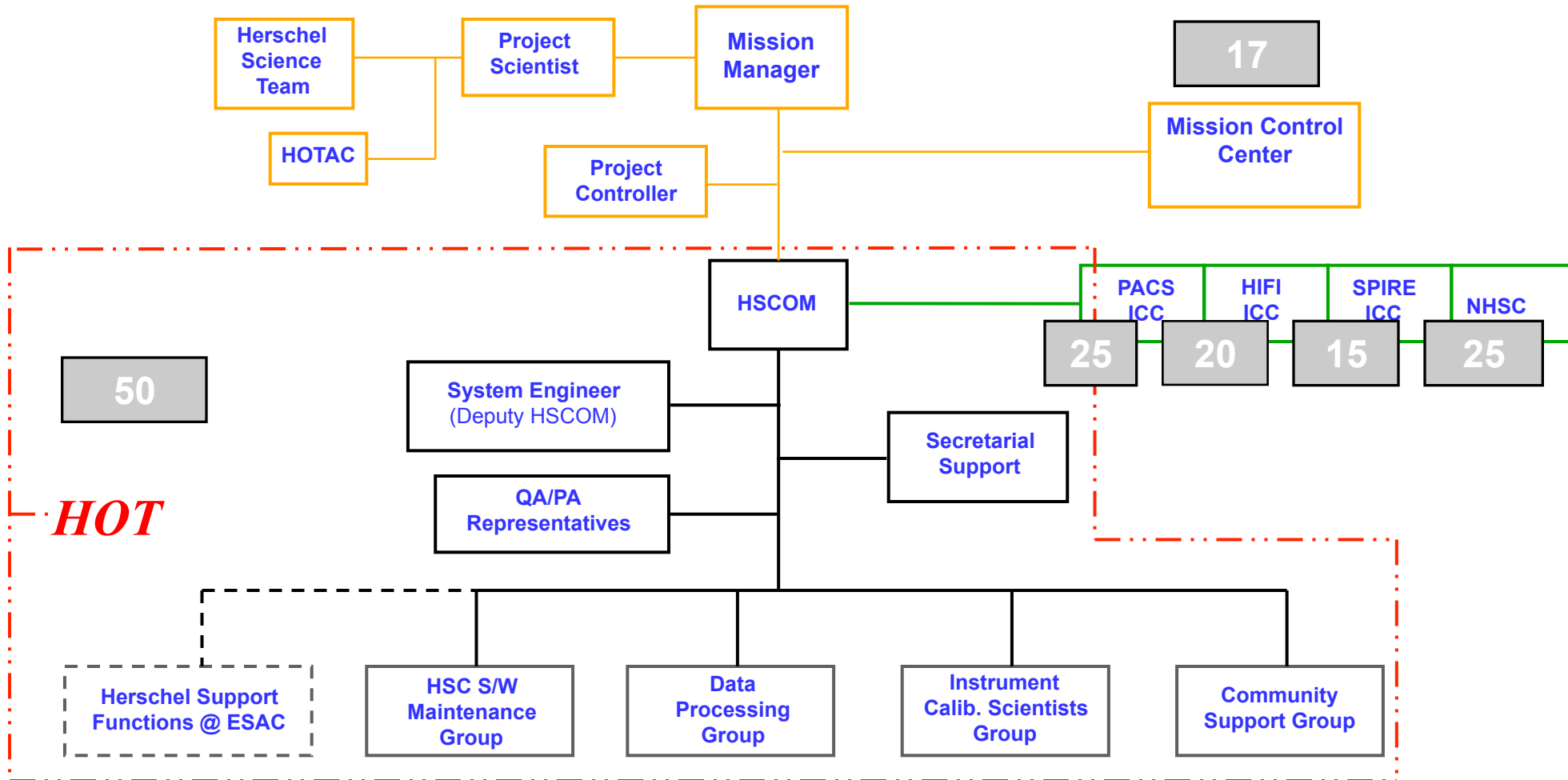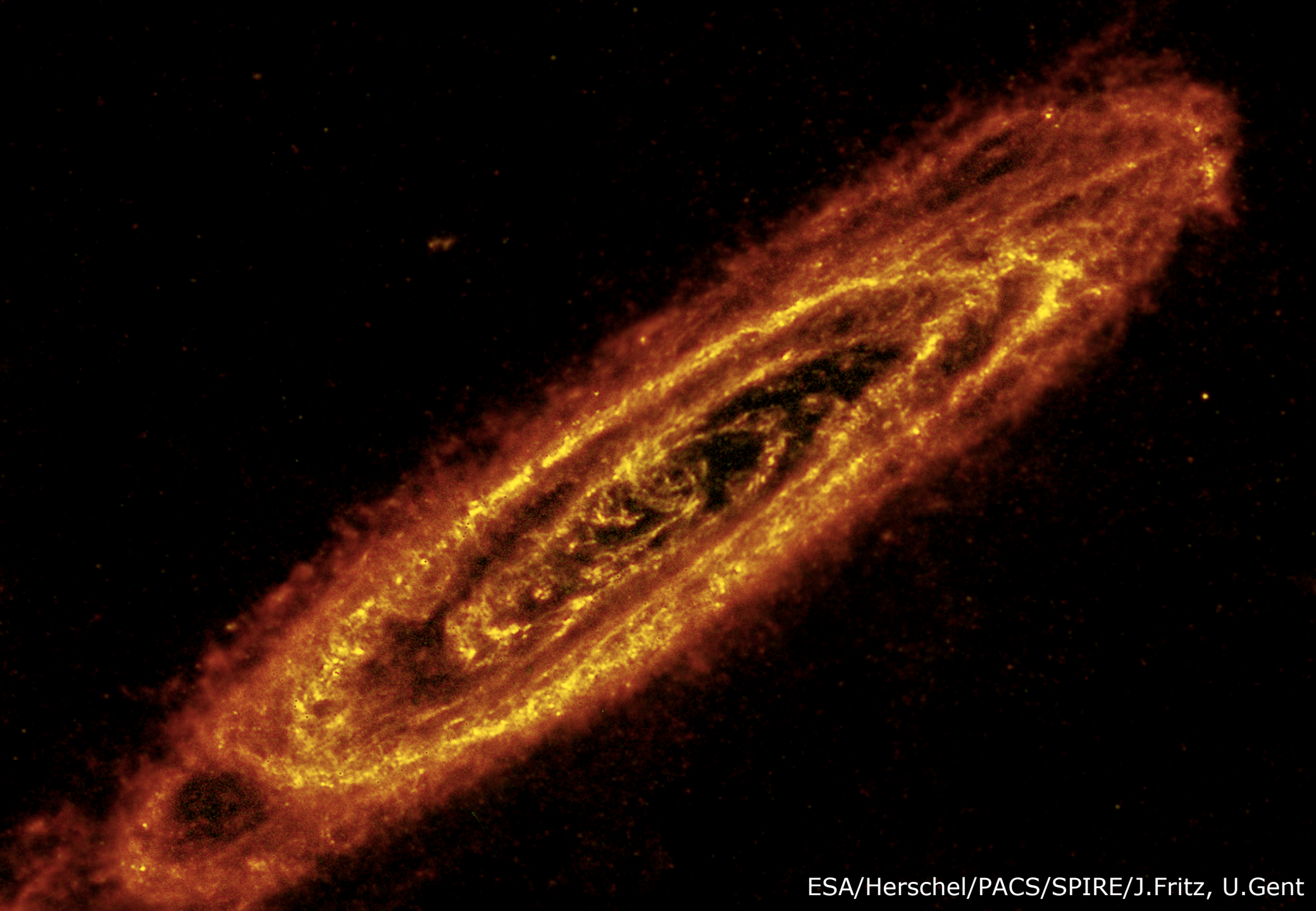
GENERIC SOC COMPONENTS

Organisation of the Herschel Ground Segment

Approximate number of full-time equivalents working in each area

- Herschel Science Team
- Project Scientist
- Mission Manager
- HOTAC
- Project Controller
- Mission Control Center — **17**
- HSCOM
- PACS ICC — **25**
- HIFI ICC — **20**
- SPIRE ICC — **15**
- NHSC — **25**
- System Engineer (Deputy HSCOM)
- QA/PA Representatives
- Secretarial Support
- *HOT* — **50**
- Herschel Support Functions @ ESAC
- HSC S/W Maintenance Group
- Data Processing Group
- Instrument Calib. Scientists Group
- Community Support Group

European Space Agency

ESA/Herschel/PACS/SPIRE/J.Fritz, U.Gent

Thank you !