Developing spaceborne imaging sensors

Look in the past and in the future

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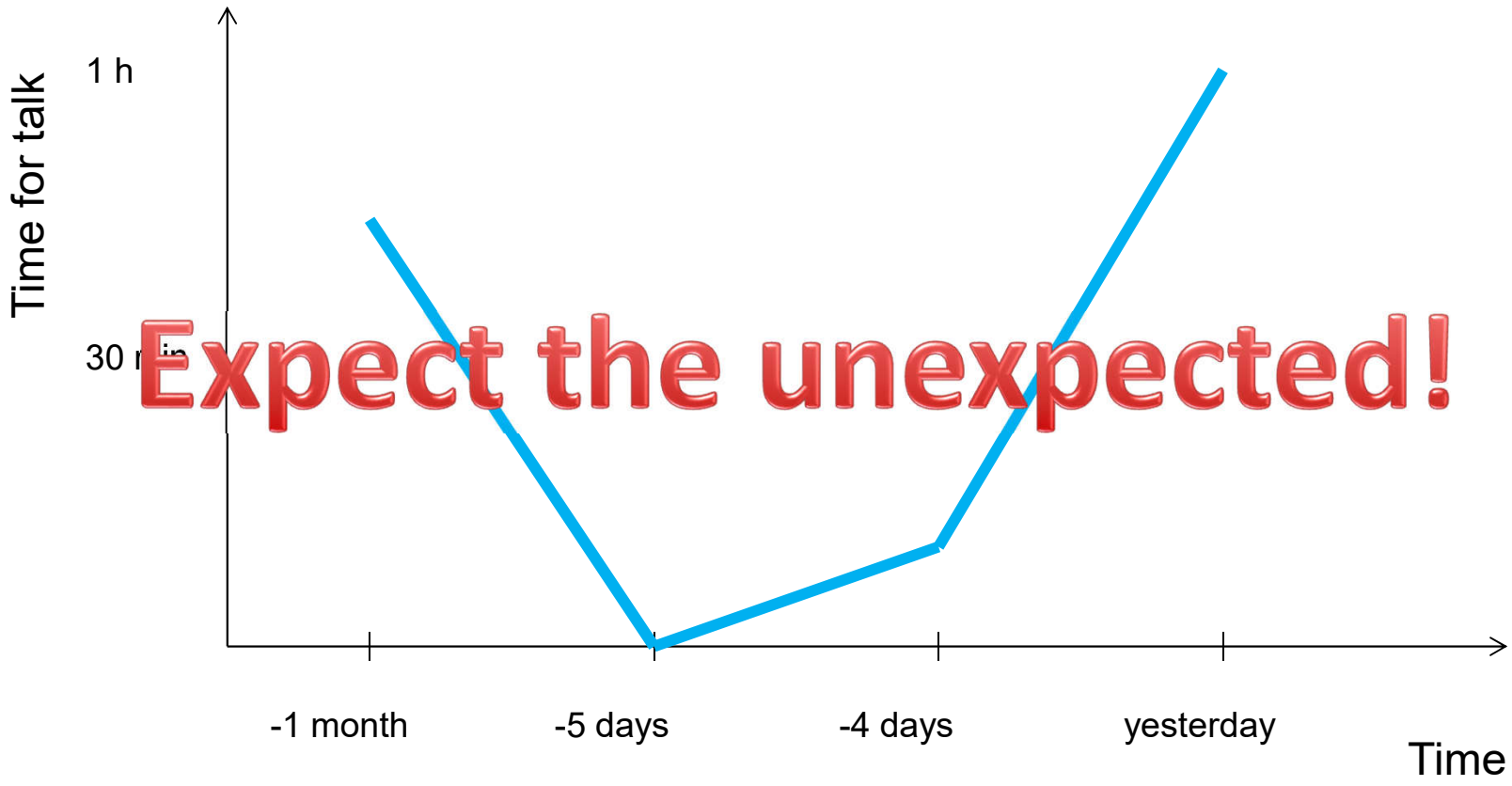
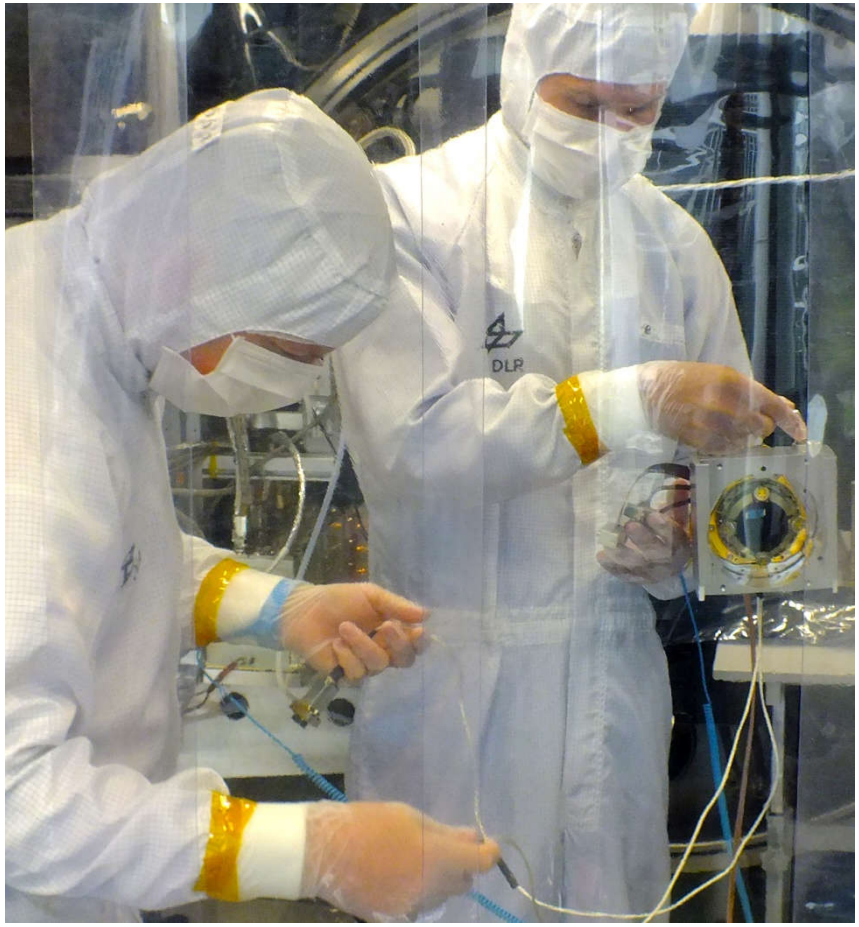
PSIVT 2019, Sydney

Intro


Time for talk
1 h
30 min
Expect the unexpected!
-1 month
-5 days
-4 days
yesterday
Time

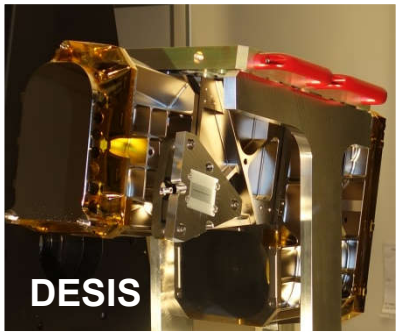
DLR's Institute of Optical Sensor Systems

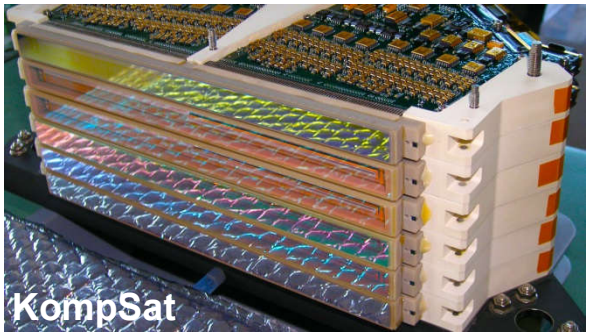
- Mission:
  Research and development of optical sensor systems (UV, VIS, IR, THz) in analogy and extension of the human visual perception.
- Research areas:
  - Focal plane units and camera systems
  - Spectrometers
  - Modelling & data processing
- Applications:
  - Earth observation
  - Planetary research
  - Security
  - Transport

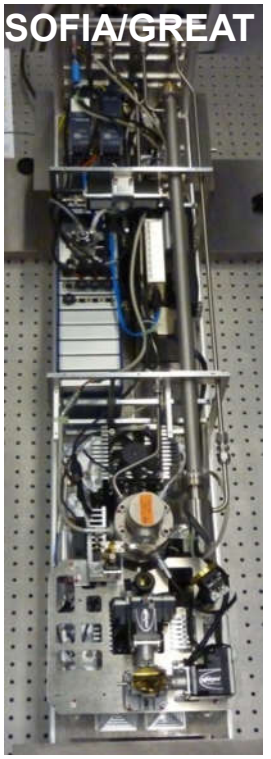


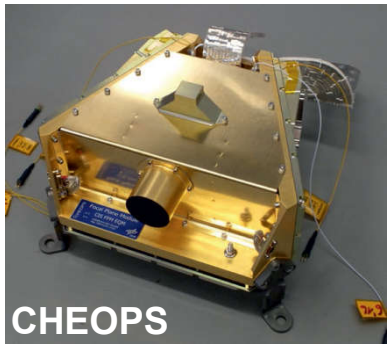
Actual Contributions to Space Missions

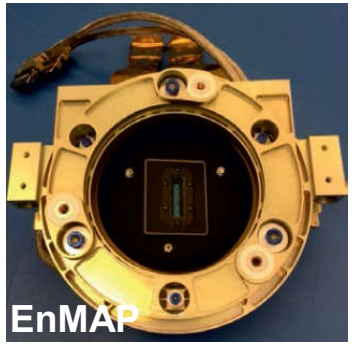
- MERTIS
- InSight
- CHEOPS
- PLATO
- SOFIA: GREAT
- GRACE follow-on
- FireBIRD: TET & BIROS
- DESIS
- EnMAP
- KompSat

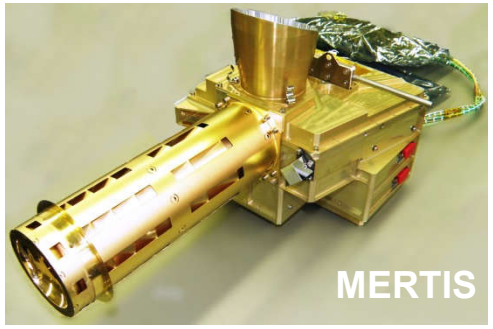


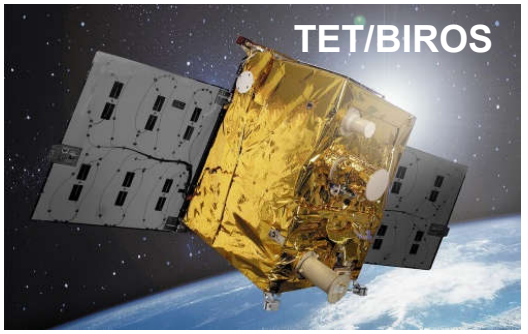






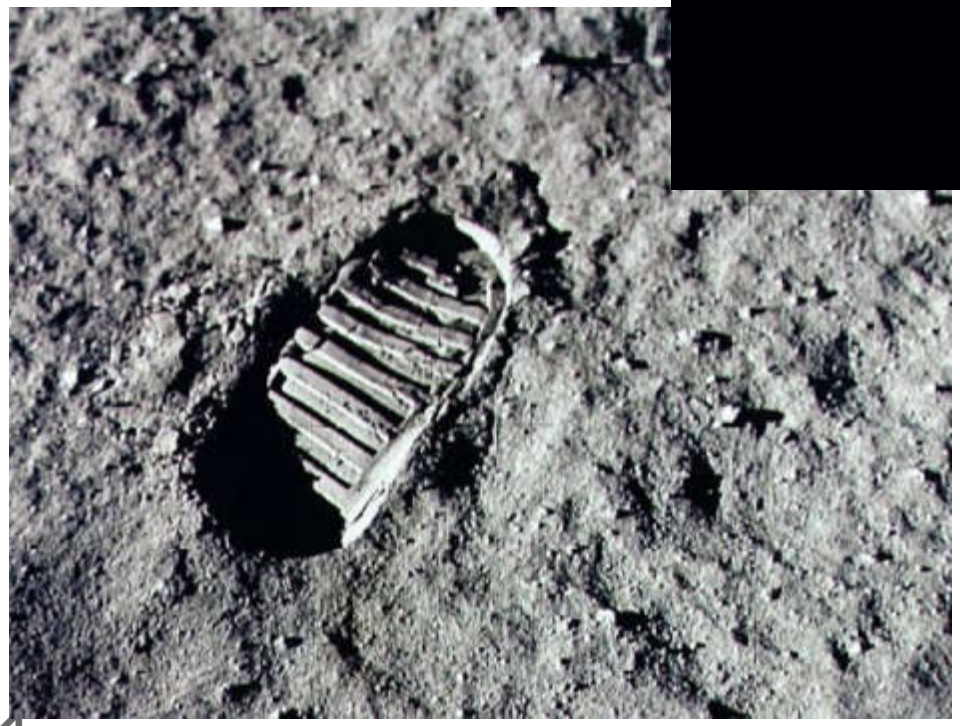






Space missions…

… are fascinating & motivating



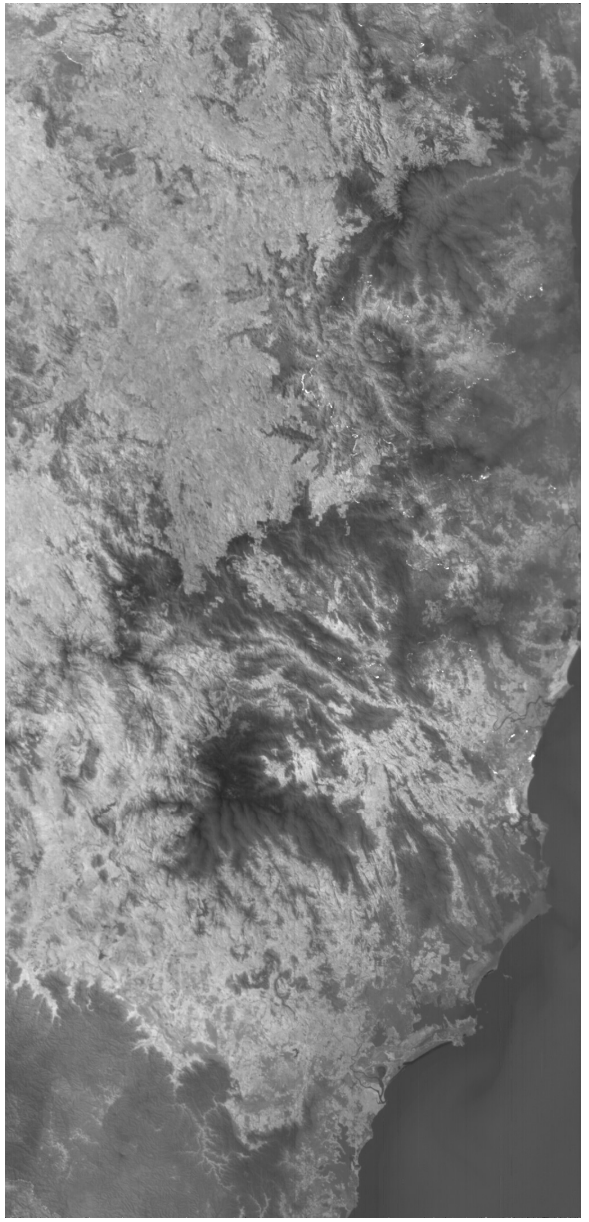
… are expensive

Content

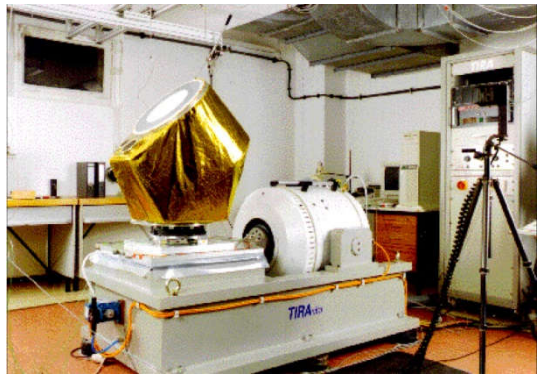
- Is aerospace useful and why?
- What makes aerospace difficult?
- Who is doing aerospace?
- New Space
- Comparison 1978 vs. 2018
- Quo vadis?

Is aerospace useful and why?

- Three examples (daily in use)
  - Navigation (GPS, …)
  - Communication (phone, TV, …)
  - Mapping (military/ intelligence … private) -> optical sensors
- Advantages for doing things from space
  - Excess to global coverage
  - No (national) restrictions
  - No maintenance



What makes aerospace difficult?



- (Normally) one way missions
- Space physics
  - Mechanical loads during launch and separation
  - Temperature
  - Radiation, e.g. limiting the electronic components
  - Vacuum
  - Zero g (Hubble)
- Operations
  - Timing constraints (90min orbits, long travels)
  - Data rates (delays, storage)
- Management & Engineering
  - large (international) teams
  - many standards and interfaces
  - Extensive testing
  - Quality (requirements comparable to automotive and medical industry)
- This all makes aerospace expensive in time and resources

Who is doing aerospace?

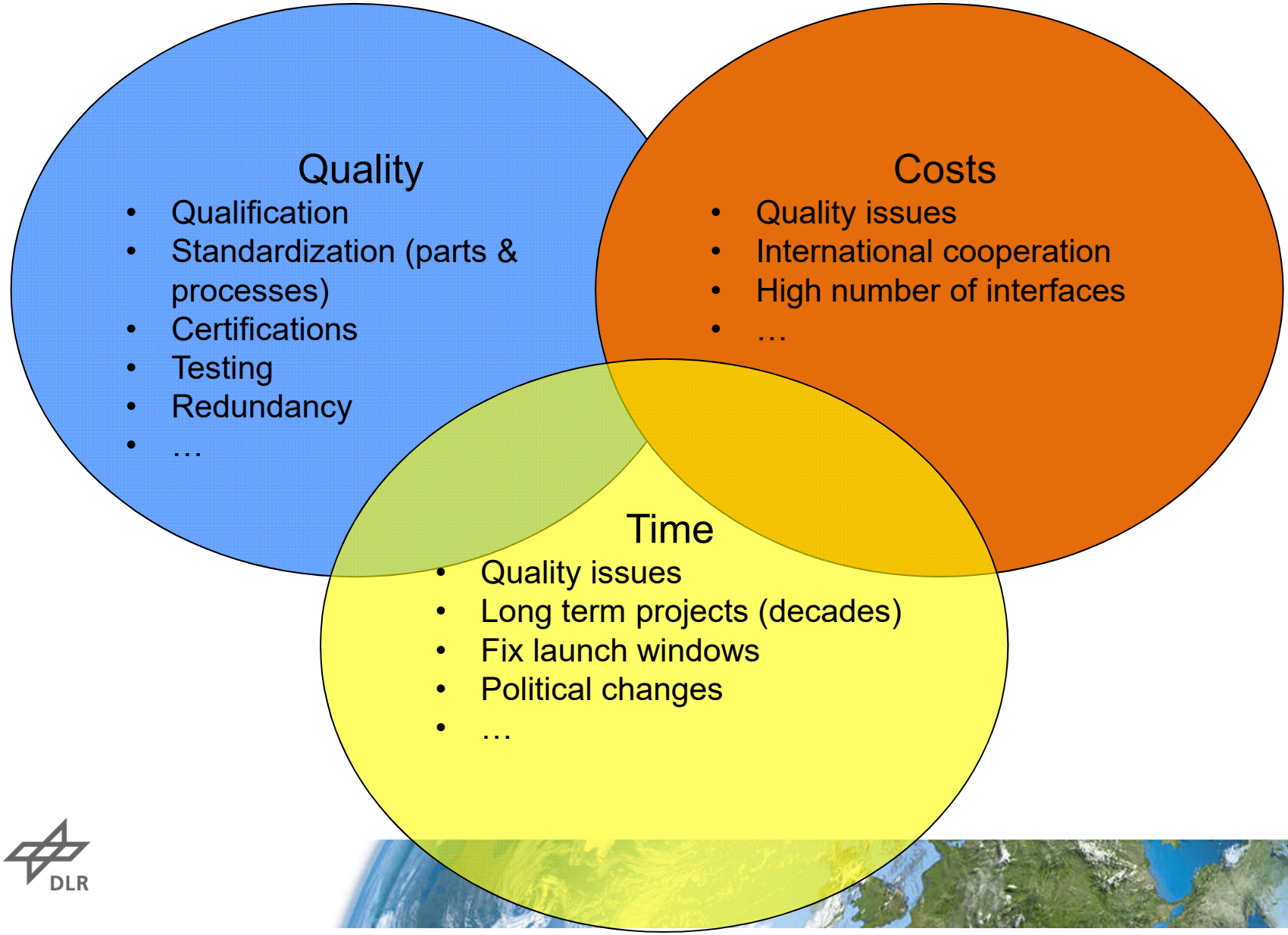
- Governments (Soviet Union, USA, …)
  - Driven from military/ intelligence requests
- Space agencies (NASA, ESA, JAXA, …)
  - Research driven
- Universities
  - Research
- Companies
  - Commercial products and services
  - “New space”
  - Space tourism?
  - Elon Musk & SpaceX

New Space

- https://www.youtube.com/watch?v=sYKRQh5Jx04
- A SpaceX rocket failed to land on an ocean platform, after delivering groceries to the International Space Station. The booster rocket apparently landed too hard and tipped over in the Atlantic east of Jacksonville, Florida on Tuesday. (April, 2015)

What will change?

Space projects (metrics)

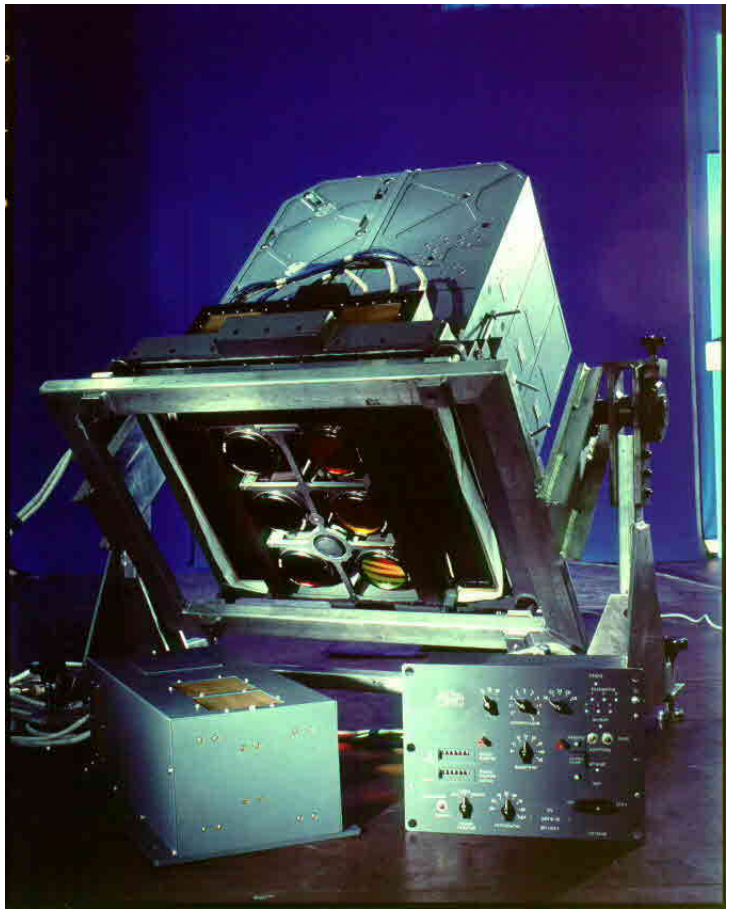


New Space

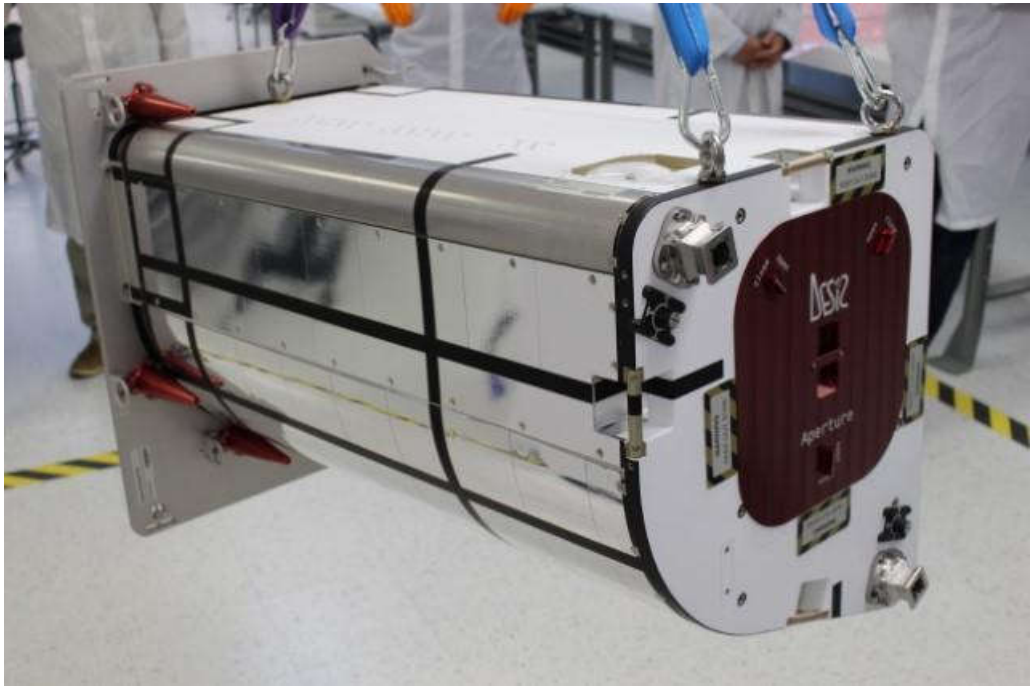
- When industry comes into play
  - There must be a business model!
  - There will be competition!
  - The number of missions will increase!
  - Prices will go down!
  - Maybe compromises on quality!?
  - Other redundancy concepts

	Past	Future
Who	Government, Agencies	Industry (+ Universities, Agencies)
Cost	Did not play a (big) role	Decrease
Time	Did not play a (big) role	Decrease
Quality	most important	negotiable
Quantity	unique items	mass production

Comparison



MKF-6, 1978



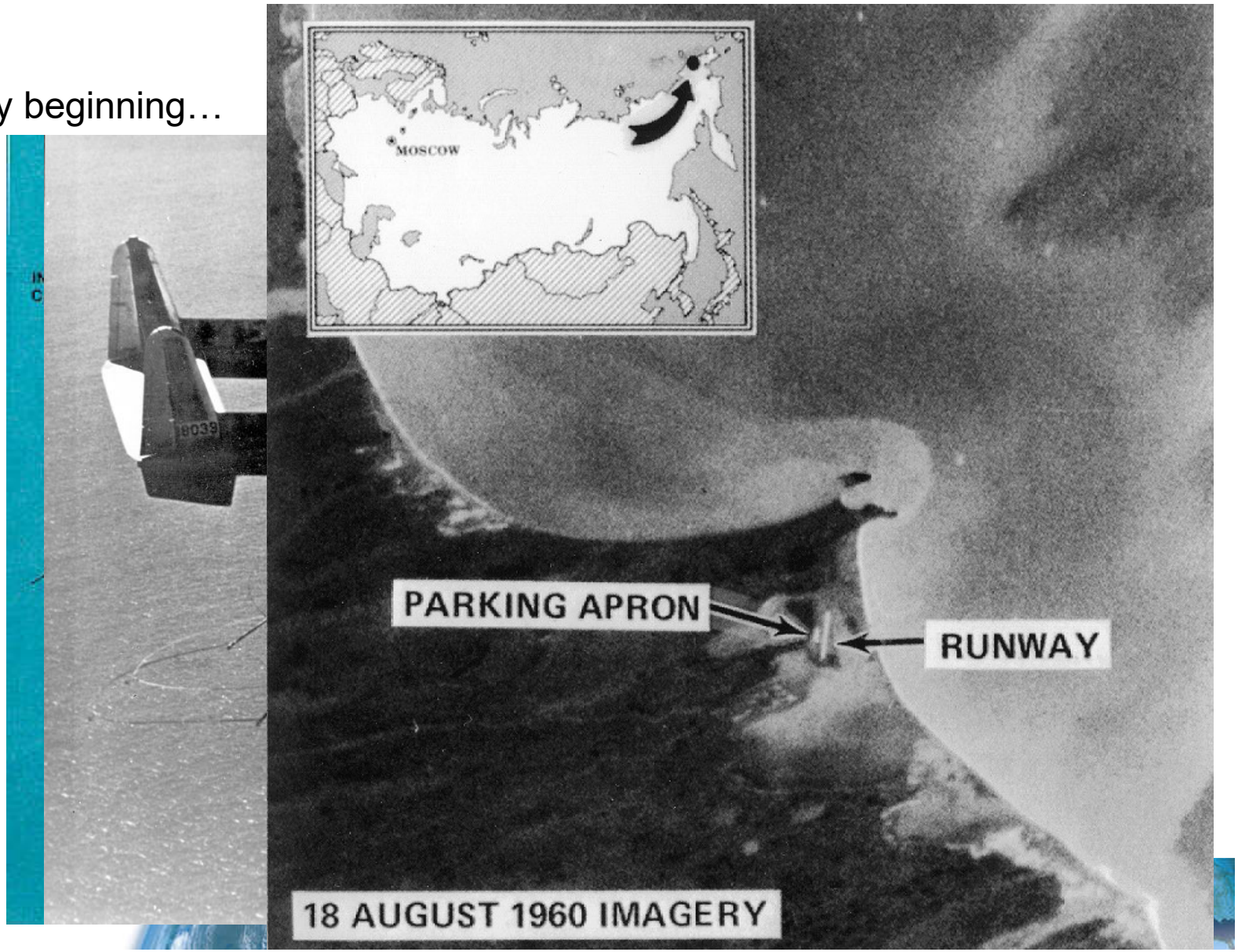
DESIS, 2018

Comparison

MKF-6	Parameter	DESIS
Saljut 6	**Space station**	ISS
1978	**Year of deployment**	2018
800 x 600 x 600mm³ (est.)	**Size**	900 x 600 x 500mm³
175kg	**Mass**	95kg
200 - 400km	**Orbit height**	400km
125mm	**Focal length**	320mm
55 x 81 mm (film)	**Size of dector**	6 x 25mm (CMOS), 24µm Pixel
225km	**Swath width**	30km
10 - 20m	**Spatial resolution**	30m
6	**Number of bands**	235
1/20 - 1/200 s	**Exposure time**	< 4ms
VEB Carl Zeiss Jena & AdW	**Instrument‘s primes**	DLR & TBE
82Mio DDR-Mark	**Costs**	< 10Mio Euro

Comparison

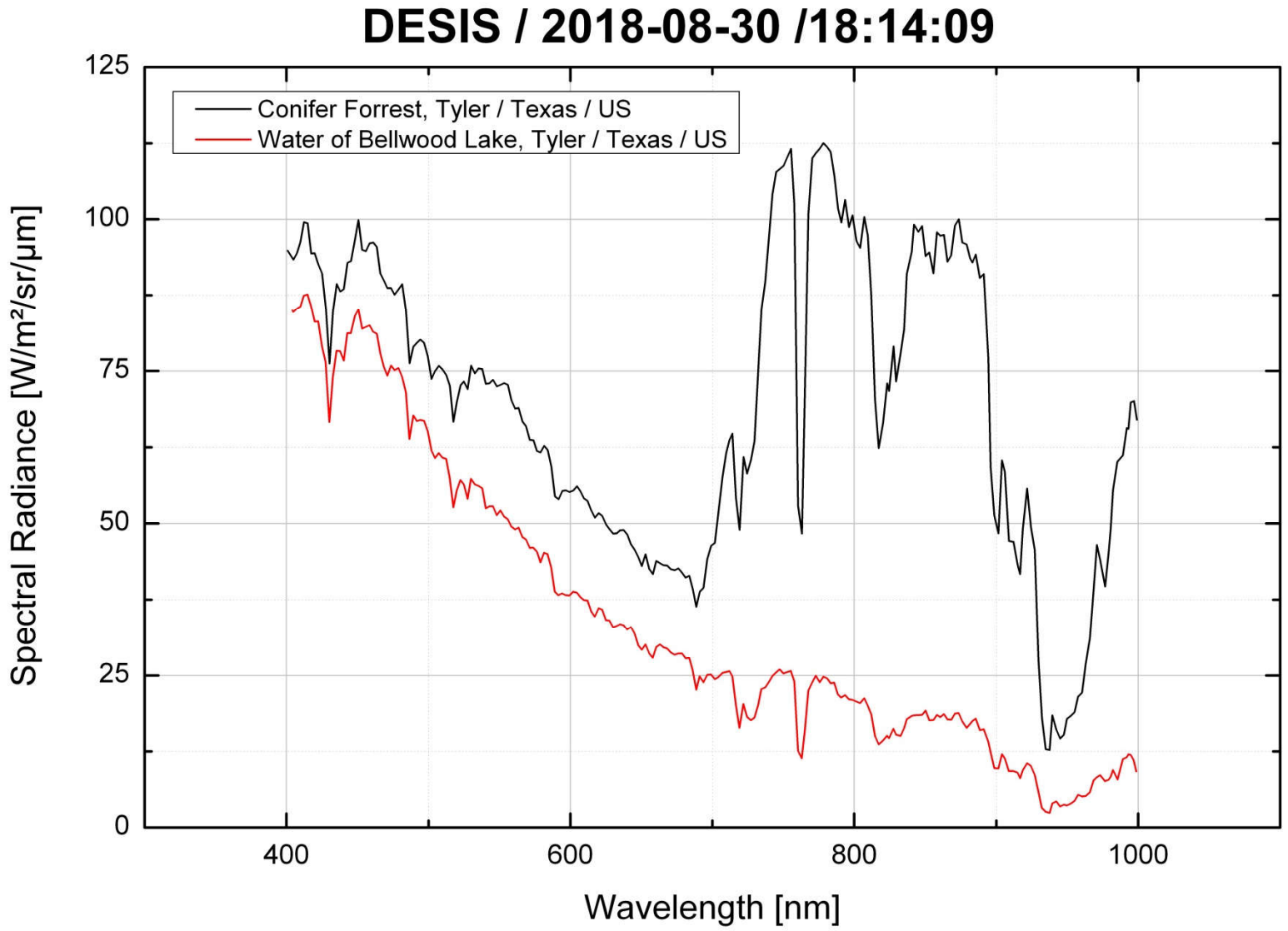
- In the very beginning…



Comparison

Imagery MKF-6

Comparison


DESIS / 2018-08-30 /18:14:09
Conifer Forrest, Tyler / Texas / US
Water of Bellwood Lake, Tyler / Texas / US
Spectral Radiance [W/m²/sr/µm]
125
100
75
50
25
0
400
600
800
1000
Wavelength [nm]

DESIS

- DESIS is a measuring device
- Data products
  - Radiance [W/ sr / nm / m²] in 235 bands
  - Reflectance [-] in 235 bands
- Applications
  - Environmental monitoring
  - Resource management
  - Precise farming/ forestry
  - Urban development
    -> computer vision, geosciences, …
- Operational since September 2019
- Data for scientific applications via DLR

- Highlight: Robotic installation (video)

Space and research institutions?

- Three main fields will stay in governmental/ agencies/ universities hands
    - Basic research
        - Where are we coming from?
        - How did the Earth evolve?
        - How life got started?
    - Protection of the planet Earth
        - Asteroids & comets
        - Earth sciences
    - Exploration & exploitation & utilization
        - How to make use of the resources of other planets/ bodies?
        - Big commercial interest, but…
- Because they are no business cases (yet)

Final statement

- Mission Insight (NASA, CNES, DLR)