Finland’s space science instruments

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The starting projects defined the present technological capabilities and science fields in instrument projects

From one Earth ionosphere mission in the 1990’s to space weather

From 1990’s Mars ionosphere missions to Mars weather studies on NASA Landers

From industrial X-ray measuring equipment to X-ray astronomy instrumentation

From space science microwave instrument that never flew to SAR-radars

Finnish share in space science missions listed in separate file: Finnish participation.xls
Finns in experimental space science

Science institute
- Aalto university
- Helsinki university
- Oulu university
- Turku university
- Finnish Meteorological Institute

Instrument technology
- microwaves
- X-ray, plasma physics, cosmology
- electric fields and waves
- particle detectors (Sun)

Company
- DA Design
- Oxford
- --
- ASRO
- Vaisala

Space astronomy

Solar system research, planetology
Stratospheric balloons in 1965-79

- Oulu university within SBARMO-organisation made balloon tests in 1965-1979 and has participated in sounding rocket tests with USA
- In many countries these activities have preceded making instruments for spacecraft – in Finland the effect was small
Late start with the neighbours

- Finland started to co-operate with the Soviet space science programmes in the mid-1980’s. This was done through Sweden. Swedish ASPERA plasma spectrometer flew onboard Soviet Mars probes Phobos 1 and 2 and onboard magnetospheric research mission Interball.
- Soviet Phobos-1 was launched on 7 July 1988 carrying first Finnish space hardware.
- Finland joined ESA in 1987.

- Lots of effort to Russian spacecraft until 21st century: SRG, Radioastron, Mars-96, and still ongoing: MetNet. (FMI)
- Collaboration continued also in Sweden’s national (small) satellites Freja, Astrid and Odin. (FMI, Univ. of Oulu)
- ESA is main forum but FMI takes part into NASA’s missions, especially Mars landers.
ESA space science - Finnish instruments

Instrument project funding cancelled in 2012

Science/Archive participation
Start 1: Mars

Mars probes
Phobos 1, 2 (CCCP)
- minor part in
**ASPERA** plasma spectrometer
(1985-1988)

Mars **landers**: Mars-96
(Russia)

**AD ASTRA PER ASPERA**
FMI and 1) plasma physics,
2) Mars landers and
3) pressure, temperature and
humidity measurements
(based on Vaisala’s sensors)
on Mars and Titan

Mars **landers**:
Intermarsnet
(ESA study), Netlander
(CNES, Metnet (Russia))

Mars **landers weather**
**instruments**: ESA Beagle and
Exomars, several NASA landers plus
ESA’s Huygens on Titan; (ESA
Rosetta lander on a comet)
Russian Mars-96 and future Metnet, NASA’s Mars Polar Lander, Phoenix, MSL, and future InSight, ESA’s Mars Express (Beagle-2), future Exomars.

Weather sensors

Metegg lander (60 kg), Finnish computer, power distribution, weather sensors

Sources: NASA, FMI, Wikipedia

Landers

MetNet
ESA’s Huygens, 2005

Italian HASI instrument’s Pressure Profile Instrument by FMI on Titan lander

Sources: Yle, FMI
Participation to Swedish ASPERA plasma spectrometer on Phobos and Interball spacecraft (1985-96)

ASPERA flew on Phobos, Interball, Mars Express, Venus Express, Rosetta. Kiruna Space Research Institute and FMI collaboration.

ESA SOHO

SWAN: solar wind, FMI and French Service d’Aeronomie

ERNE: Sun’s particles, Univ. of Turku

FMI: large space weather simulations

Univ. of Oulu: electric field instruments for NASA Polar and ESA Cluster; VTT: scanning mechanisms for SOHO, Cassini, TWINS
START 3: Spectrum-X-Gamma to ESA INTEGRAL, SMART-1, BepiColombo, ISRO Chandrayaan-1

SIXA for Spectrum-X-Gamma (2014 w/o SIXA) Silicon detectors.

X-ray spectrometers to measure the Sun X-rays and Moon and Mercury surface

Gas filled proportional counter, X-ray windows

Commercially delivered proportional counters
Commercial X-ray instruments

Italian SAX, NASA RXTE, HETE, NEAR and Messenger, JAXA MAXI (on ISS) - Oxford company (Outokumpu Electronics) delivered X-ray instruments

Sources: ASI, NASA, Wikipedia

SAR-radar components for German TerraSAR-X, Tandem-X and Spanish Paz and EU’s Sentinel 1A, 1B and 1C.
Unique capability in Europe: Tuorla

Made of Silicon Carbide - Opteon Oy polished test mirrio (dia 1,35 m) in 1998.

The polishing came soon after – biggest space mirror. For transportation to Turku the Airbus Beluga cargo aircraft was used in 2004. Polishing took 8 months – ready in April 2005.

Source: ESA
Aalto and Turku universities were in small technical roles in the huge NASA instrument project.

Source: NASA
ESA’s X-ray Multi Mirror Mission

Patria has developed composite structures for decades. XMM-Newton’s X-ray telescope require 7 metre long tubular structure, largest composite structure in space. This one example of industrial capability enabling science.
Annex: The process of selection to space science instruments
How to get your science experiment onboard a spacecraft?

- Finland is a member of European Space Agency, ESA. ESA’s Directorate of Science and Robotic Exploration has a systematic way to select payloads for scientific spacecraft.
  - To get one’s experiment into a space science mission of CNES, ASI, DLR, NASA, JAXA, Roscosmos, ISRO or Chinese Space Administration (and Brazil, Argentina, Ukraine, South-Korea etc.), the key scientists in Finland need to know someone important on the “other side” or find someone with similar science interests in Europe or the USA (etc.) through whom to proceed.
    - The selection process is similar to ESA’s, but the systems work on a national level and a Finn can’t usually make a direct proposal to their missions, only be a part in someone else’s proposal for an instrument.

- Some small countries have developed small satellites on their own, the leading example is Sweden.
  - Nowadays, Cubesats have made building own satellites cheaper – Aalto university is building Aalto-1 and Aalto-2 satellites that carry instruments. Both make scientific measurements in space.
How ESA selects what science it does?

Payload and Mission Definition in Space Sciences
Cambridge university press, 2005
The selection of a Science mission

Payload and Mission Definition in Space Sciences
Cambridge university press, 2005
ESA’s process for a space science mission

- ESA has a long time plan of based on high level priorities of space science. Its current long time plan is **Cosmic Vision**
  - Cosmic Vision is a ESA’s space science long term plan. It was preceded by Horizon 2020 and Horizon2020+ programmes from early 1980’s to approximately to year 2005
    - COSMIC Vision [http://www.esa.int/Our_Activities/Space_Science/Defining_the_Cosmic_Vision](http://www.esa.int/Our_Activities/Space_Science/Defining_the_Cosmic_Vision)
    - Its missions [http://sci.esa.int/science-e/www/area/index.cfm?fareaid=100](http://sci.esa.int/science-e/www/area/index.cfm?fareaid=100)
    - The mission are Small (first such is starting, its cost is 150 M€, but ESA pays only 50 M€), Medium (circa 0,5 billion euro) and Large (over one billion euro). M and L missions are as ambitious as large NASA missions.

- Within Cosmic Vision (until next long time plan is started for the period after 2025) ESA runs competitions on
  - IDEAS ON THEMES TO RESEARCH (current call for mission ideas for L3)
  - MISSION IDEAS (current call for mission for L2)
  - MISSIONS (Cosmic Vision M2 call – this lead into Euclid to be the new mission; 4 mission candidates now compete on M3 mission – ESA makes internal and industrial studies of candidate mission to see if they are feasible)
  - PAYLOADS OF SELECTED MISSION

- Finns have proposed (as the leader in a proposal) a couple of Earth Observation missions and one Space Science mission
  - The Science mission proposal was STORMS - [http://esa-spaceweather.net/spweather/Alpbach2002/Koskinen-storms.pdf](http://esa-spaceweather.net/spweather/Alpbach2002/Koskinen-storms.pdf) - the VG’s are quite educational on the process in general!
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How ESA selects science payload?

Payload and Mission Definition in Space Sciences
Cambridge university press, 2005
Payload for an ESA space science mission

- Some of the very large instruments are ESA funded and industrially manufactured. Most **scientific instruments are nationally funded and developed by national or international teams** of space scientists. Technically the units are often designed and manufactured by national space industries. In e.g. Italy and France science institutions have capabilities of making themselves space science instruments.

  - **ORGANISING INSTRUMENT DEVELOPMENT PROJECT**
    - TEAM – NATIONAL OR MULTINATIONAL MAKES THE PROPOSAL – ESA DEMANDS THAT THE TEAM LEADERS’S FUNDING AGENCY MAKES A MULTILATERAL AGREEMENT (MLA) WITH ESA STATING THAT IT WILL FUND THE INSTRUMENT UNTIL IT IS READY.

- **Leader is called Principal Investigator (PI), rest in team are Co-Investigators**

- **IN MANY COUNTRIES HAVING THE FUNDING IS THE HARDEST TEST**
  - In Finland Tekes is the largest funding agency, while Academy of Finland and the science institutions, i.e. universities and Finnish Meteorological institute, also fund.
  - Aalto, Helsinki, Oulu and Turku universities and FMI have developed space instruments.
  - They have often used Patria, Space Systems Finland, DA-Design, ASRO, Oxford and VTT to make the engineering and manufacturing of the units. FMI often does most of its work (on Mars lander etc.) in-house on its own funding.
Payload for an ESA space science mission

• Technically the units are often designed and manufactured by national space industries.
  - REST IS WORK
    • DESIGN OF THE SENSOR UNIT AND ITS ELECTRONICS,
    • BUILDING PROTOTYPES AND TESTING THEM,
    • MOUNTING THE UNITS ON SPACECRAFT AND TESTING,
    • LAUNCH AND OPERATIONS OF THE SPACECRAFT, THE INSTRUMENT MAY NEED TO COMMANDS FROM THE GROUND (PASSED FROM SCIENTISTS TO ESA THAT THEN SENDS THE COMMANDS) OR SOFTWARE UPDATES OR SETTLING ANOMALIES IN OPERATION OF THE EXPERIMENT
    • DATA FROM THE INSTRUMENT COMES FIRST TO PI AND HIS/HER SCIENCE TEAM, THE PERIOD OF SOLE ACCESS TO THE DATA SIX MONTHS, THEN THE DATA IS OPEN TO ALL SCIENTISTS
    • SCIENTIFIC PAPERS ARE WRITTEN AND PUBLISHED, DATA IS ARCHIVED BY ESA, MORE PAPERS COME LATER ON, THERE ARE INCREMENTAL AND LARGE FINDINGS, NEW THEORIES MAY BE NEEDED AND NEW RESEARCH NEEDING NEW SPACECRAFT
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Cambridge university press, 2005