Il futuro della tecnologia Astronomica

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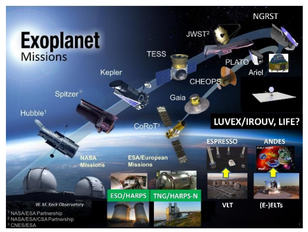
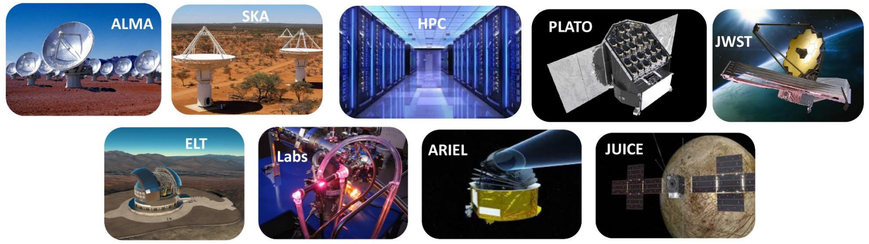
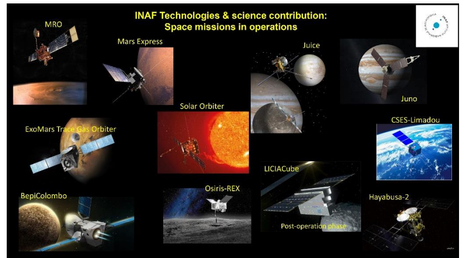
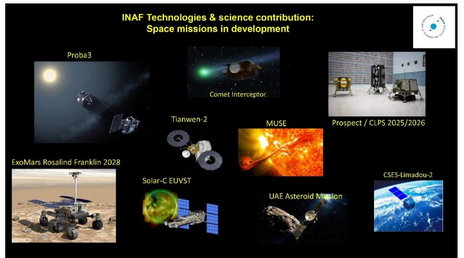
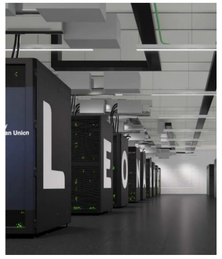










Top Priority from INAF DVS

INAF DVS (2019-2029) identify the following priority:

- Participation to the large international facilities of the future
- The exploration of the Solar System
- Life beyond our Solar System
- Multimessenger Astrophysics
- Fundamental (Astro)physics

Key points (extracted from Astronet RM)

Current and upcoming facilities will open up exciting opportunities for discovery. Examples of areas of future science discovery are:

- The origins of the Universe, inflation, and the emergence of cosmic structure
- New tests of physics in extreme conditions
- The first stars, galaxies, and the epoch of reionisation:
- The formation of planets, stars and galaxies:
- The origins of our Solar System and the characterisation of other worlds

Area to be updated

To address previous point following area should be addressed in medium / long term

- (New) Ground Based Facilities
- New Instruments and facilities upgrade
- Technology development for facilities
- Space Based Facilities
- Laboratory astrophysics
- Computing and data management
- Sustainability and accessibility

(New) Ground Based Facilities

Completion of the construction and commissioning of the ESO Extremely Large Telescope (ELT) and its first generation instruments, as well as that of the Square Kilometre Array (SKA) and its Regional Centres are of key strategic importance. Amongst new ground-based infrastructure projects four emerge as priorities: CTA, EST, wide-field spectroscopic facility for a 8-10m class telescope and Einstein Telescope aimed to GW detection.

- Cherenkov Telescope Array (CTA) is an array of telescopes located across two sites on both hemispheres to detect very high energy gamma rays from black holes and other extreme phenomena. As the first true large-scale observatory targeting these energies, it is expected to lead to breakthroughs in our understanding of the origins and production of non thermal particles in the Universe.

- The European Solar Telescope (EST), a 4m solar telescope to be built in the Canary Islands with first light expected after 2030. The EST will significantly increase our understanding of the solar magnetic field and its relations with the heliosphere and the Earth..

- A general-purpose, wide-field, high multiplex spectroscopic facility, for a telescope of the 8-10m class. Such a facility will enable a broad range of science investigations and help capitalise on other large investments by providing follow-up capabilities for facilities such as JWST, VRO and Euclid.

- Einstein Telescope (ET) will follow LIGO and VIRGO in the GW detection. Together with LISA from Space will open a new era in the astronomy.

New Instruments and facilities upgrade

Europe operates many astronomical facilities that will continue to do cutting edge science in the coming decade, both via existing functionality and continued upgrades to their capabilities. It is important to strengthen the ability of these successful facilities to secure the funding needed to continue their excellent scientific work, especially in a landscape of increased operations costs.

- An upgrade of the Atacama Large Millimeter/submillimeter Array (ALMA), as explored for example in the ALMA 2030 Vision, and including extending the frequency coverage with Band 1 and 2 receivers, longer baselines, wider bandwidths, and improved VLBI capabilities;

- The Very Large Telescope (VLT) and the VLT-Interferometer (VLTI) will remain the workhorse of European ground-based optical Astronomy even in the era of the ELT, and should therefore continue being supported and new instruments developed. Particular priorities to high-contrast, high angular resolution instrumentation for e.g., exoplanetary system observations.

- While the ESO Extremely Large Telescope(ELT) and its first generation of instruments will see first light by the end of this decade, the immediate funding and development of second-generation instruments is recommended.

Technology development for facilities

Long-term scientific ambitions can however only be met if crucial technological developments are anticipated and carefully planned well in advance. Most of the technologies that will be needed for the next generation of facilities are cutting-edge, and their emergence and maturation usually require a decade or more. The following technologies are priorities that need development now, if we are to build the facilities seen as priorities by the European Astronomy community for the next decades.

- Receiver technology and dish development for Radio Astronomy;
- Cryogenics and detector technology for far-infrared space telescope;
- Space-qualified UV-optimised optical elements and detectors;
- High-contrast imaging systems for exoplanet observations;
- Optical / infrared interferometry technologies;
- Space- and lunar-based radio technologies

Space Based Facilities

The major European space-based missions are coordinated by ESA, who has just completed its own scientific perspective exercise Voyage 2050, and is also currently defining its programme for human and robotic exploration, Terrae Novae 2030+, mainly targeting the Moon and Mars..

- The two future ESA L-class missions, NewAthena and LISA, are presently undergoing new studies, with the goal of cutting their costs, it is recommended that both missions preserve their initially-planned scientific return.
- The nearest M-class missions PLATO, a mission to detect and characterise exoplanets and study their host stars via asteroseismology, is expected to be launched in a couple of years. It will be followed by ARIEL aimed to study the planetary atmosphere.
- The ExoMars mission was a priority of the astronomical community but it has been put in severe jeopardy by the geopolitical situation. The exploration of Mars remains of major interest to the European scientific community, and the rapid implementation of this new strategy therefore a priority to preserve the scientific goals of the mission and minimise additional delays.
- NOT only BIG mission, CubeSat are very attractive to check new space aimed technology and do space science at low cost (e.g. Hermes).

Computing and data management

Astronomy has entered the era of ‘Big Science - Big Data’. Major current and upcoming facilities provide astronomical data at rates never seen before across the entire electromagnetic spectrum and beyond:

- Developing and investing in a professional software engineering / computational skills base in Astronomy. This has many implications and requirements, including career development with clear progression pathways in academia and improving the diversity of the workforce. Such careers have to be promoted and considered as an integral part of our science/research portfolio. Traditional metrics for academic performance are often inappropriate for measuring the impact and usefulness of computationally focussed outputs. New assessment criteria, for example based on industrial models, should be adopted by the astronomy community to give proper credit to essential contributions that technicians and software engineers provide.

- Missions and facilities should plan an integrated approach for data products and software tools: their design, delivery, maintenance and development should be sufficiently planned for and resourced already at the onset and for the lifetime of the mission/facility. That initiatives should be supported for the long term preservation and scientific use of data. F.A.I.R approach.

- Fully collaborative, open and synergistic view is recommended, when it comes to the astronomy-computing ecosystem, encompassing data, software, processing, analysing and modelling. Open science, data and software sharing, archives, cloud computing, platforms and service infrastructure represent various facets of an integrated view of computing in astronomy: this should be acknowledged and acted upon.

- Stimulate simulations environment to be well defined and financed in each project from the beginning.

- Use of IA and machine learning in the astronomical Data analysis.

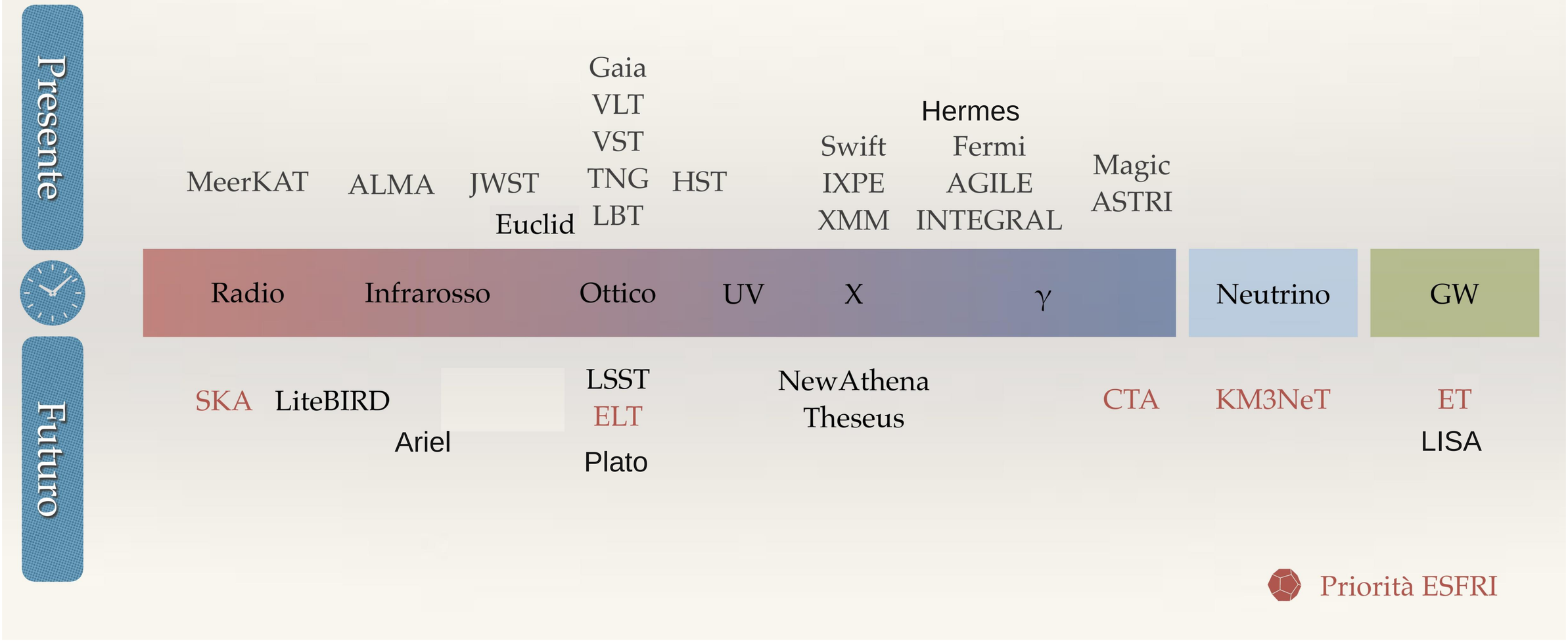
- Quantum computing ??? Application to astronomical data analysis.

Sustainability and accessibility

A strong priority of the European Astronomy community is to see questions of sustainability, ethics, equality and diversity considered as part of decision making processes. The key recommendations are:

- Astronomy projects should include environmental footprint assessments and reduction plans regarding construction and management of facilities, travel and computing, to follow (at the least) the European timeline towards carbon neutrality.;
- Diversity and inclusion should be central to funding strategies and plans. Data collection efforts should be standardised with suitable metrics to make meaningful comparisons and take action.
- The Astronomy community needs to work with national and international regulatory and policy bodies and with industry to ensure the protection of the dark, radio quiet skies for the benefit of both the research communities and the general public.

Facilities and international instruments (INAF)



Conclusions

- INAF is involved in a lot of project of different size and I think is a good sign. Small project are the base for new technology development / test on ground and in Space.

- Laboratory astrophysics, in addition to observational facilities, aimed to calculations, laboratory measurements and experiments are strongly suggested to update our technical skills.

- SGS development. SGS is a key element in each space mission and is a mix of management / Software skills / Instrument knowledge. INAF has already a lot of experience on such field.

- Improving our system approach to project management , this really needed in each project involving international party.