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The Italian balloon launch facility and its role in the frame of ASI stratospheric activities

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Abstract. Stratospheric balloon launch base Luigi Broglio was set up in 1975 and now it represents the only access to space for Italy. The stratospheric balloon activities need continuous update in technology and continuous going after scientists requests. It is important to undersign agreements of cooperation with others space agencies offering technology, sites, trained personnel, in order to assure the success of the missions. Trapani Milo Base is going to direct its energies towards these goals through the upgrading of its technological equipment and through cooperation in Italy and in the world to test new sites and new technology.

1. Introduction

Scientific ballooning activity in Italy is managed by Italian Space Agency (ASI: Agenzia Spaziale Italiana), that owns and runs the balloon launch facility Luigi Broglio located in Trapani Milo, on the western part of Sicily in Italy. Thanks to a sound expertise based on several years of experiences on field operations, ASI personnel can provide know how and technology to the all scientific groups interested in stratospheric experiments but not directly involved in ballooning. Expertise embraces all fields of mission design as: probe development involving thermal, mechanical, power and electronics issues, probe integration, communication and data handling, ascent and descent trajectory estimation, launch, tracking and recovery for either local launches or transmediterranean launches. ASI encourages collaboration with scientific institutions as research centers and universities in order to achieve execellence with consistent background, which provide competence on specific fields and that are actively involved in projects and eventually used as on site support.

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2. Historical and statistical data

Stratospheric balloon launch base Luigi Broglio was set up in 1975, on an area used during the 2nd world war as military airport by Italian aviation, as a consequence of a memorandum of understanding with United Kingdom and USA to launch a stratospheric balloon. The launch success, for the first time a 600 Kg payload run through Mediterranean sea and Atlantic ocean and was recovered in USA territory, paved the way for Italian stratospheric activities. Italian and foreign scientists interests opened a collaboration agreement between CNES and CNR for launch activities. When in 1988 Italian Space

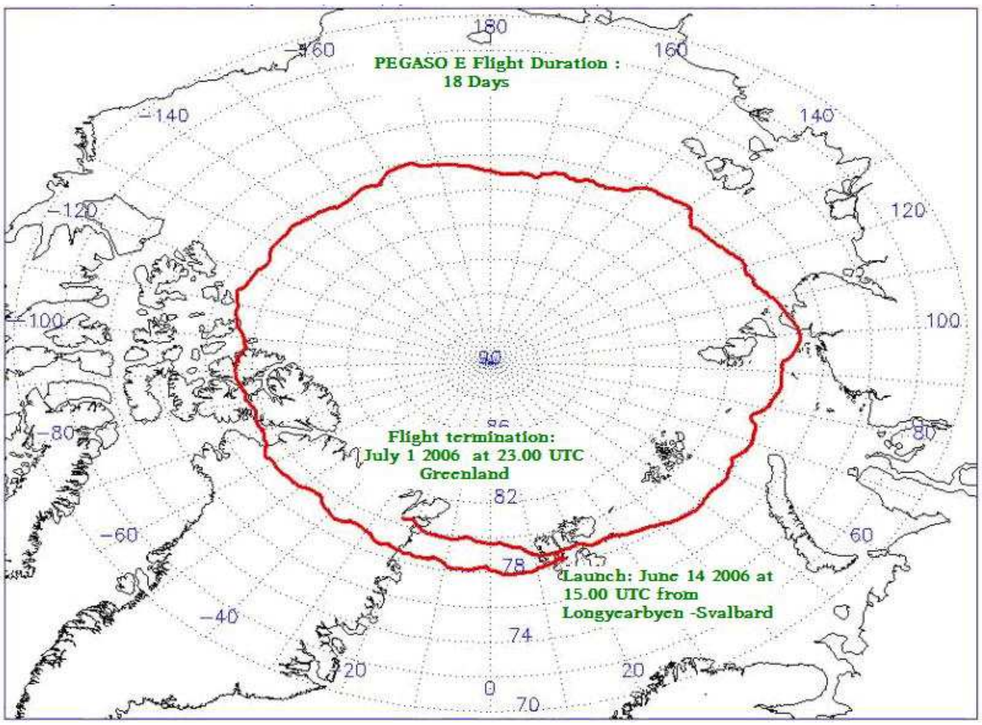

Fig. 1. The PEGASO-E trajectory around the North Pole.

Agency (A.S.I.) was set up it was A.S.I. run base and since 1992 it was able to manage entirely a stratospheric balloon mission by own means. Nowadays it is one of the few facilities in the world that can guarantee a balloon flight in all its phase (planning, procurement, integration, trajectories prediction, weather forecast, launch, flight control, scientific data acquisition, recovery).

The base has been the set of over 120 launches, 85% of which successfully concluded.

Their typical features were:

– The capability to launch heavy payload: typically up to 3.5 ton with a 30 Km altitude and up to 2.5 ton with a 42 Km altitude.
– Flight duration: over 20 Hours (Transmediterranean)

Many others launches were carried out after planning and support of Trapani staff in various sites around the world. Among these the last in time are listed in Table 2.

3. Activity fields

Many experiments regarding astrophysics have been launched from Luigi Broglio balloon launch facility, most important relating:

– X Ray
– IR radiation
– Strange Quark matter
– Cosmic Ray effect on biological structure
– Biological experiments carried out by means of on-board dedicated platform

Others technological programs have been carried out:

– Preliminary test of satellite equipment and sub systems
– A.R.D. Atmospheric Reentry Demonstrator (capsule rescue qualification)

Table 1. The most important experiments launched from MILO BLF

Milo1	Cosmic particles	Bristol University
Milo2	X Sources and C.B.R.	CNR and Washington University
Milo3	γ Astronomy	IFCTR (CNR) and Max Plank nst.
Odissea1	Cosmic particles	CONIE SPAIN
Odissea2	γ Astronomy	IFCTR - GIFCO - ITESRE (CNR)
PAF	Radio Astronomy	IROE - GIFCO (CNR)
CAESAR	γ Astronomy	CERS/CEN CNES
CELIMENE	X Astronomy	IAS (CNR)
AGLE	IR Astronomy	CERS - CEN (CNES)
CIRCE	X Astronomy	IAS (CNR)
ULISSE	IR Astronomy	IROE (CNR)
ENEA	X Astronomy	IAS (CNR)
POKER	X Astronomy	IAS (CNR)
TELEMACO	IR Astronomy	IROE (CNR)
ELENA	γ Astronomy	ITESRE (CNR)
FIGARO	γ Astronomy	CERS(CNES) IFCAI/IAS (CNR)
PALLAS	X Astronomy	IAF/IAS (CNR) -Southampton Univ.
ARGO	IR Astronomy	IROE/IFA (CNR)
MINITIR	IR Astronomy	ROME UNIV. IRE/CAISMI/IAS (CNR)
MINIZEBRA	X Astronomy	- Southampton Univ.
PHOSWICH	X Astronomy	ITESRE(CNR) - Univ.
AROME	IR Astronomy	CNES
LAPEX	X Astronomy	ITESRE/IAS (CNR) CERS (FR)
ARD	Technologic	ESA
S.Q.M.	Nuclear research	CNR(TO) TOKIO University
HASI	Huygens Atmospheric Structure Instr.	Padova Univ.
BIRBA	Collection of biological exp.	Italian Labs & Univ.
BABY	UV Observation BAckgroundBY-pass	IASF-CNR (PA)
SAFIRE -B	Atmospheric study - Envisat	IFAC-CNR (FI)

– Flight control technique: balloon guidance using wind altitude dependency.

The most important experiments launched from Trapani Milo Launch Facility are listed in Table 1.

4. Trapani Milo Launch Facility - The site peculiarities

Stratospheric balloon launch base Luigi Broglio is located in Trapani, contrada Milo, on the western part of Sicily, Italy, 38 01 N - 12 35 E, on a vast area of about 95 Ha on the south side of Monte San Giuliano. Being sheltered on the north by the steep rock of Erice it has excellent wind conditions in low altitude during launch fase while its proximity of the sea and high altitude wind direction during flight window (summer time) can guarantee a trajectory over the mediterranea sea, far from highly populated areas, and let to plan the recovery of payload in Spain territory after a 20 hours average Trans-Mediterranean flight. Thanks to the former utilization, the base presents a very large launch pad (600 meters of diameter) with direct visibility from control tower, and a full equipped integration and control center area consisting of: Control Center & Offices, Integration & Workshop and Helium recovery and stock building. Control Center & Offices is the headquarters of the facility where, apart from offices, is the Control Center with a meteo forecasting and Vaisala sounding station, high bit rate real time data acquisition system, real time flight data Digital/Analogical recording, flight control and balloon tracking system and the whole equipment need to

Table 2. Flights from other sites.

Year	Launches	In co-operation with
2008	DUSTER flight from Svalbard	ARR, Ph. Dept. University La Sapienza, CNR/ISTI , Naples University
2007	a) USV-DTFT0 (2006 Summer Local Flight ready to fly postponed to February 2007 due to meteo conditions)	a) CIRA
2006	a) 1 Flight from Antarctica	a) PNRA, INGV,Ph. DeptUniversity La sapienza, CNR/ISTI
	b) 1 Flight from Svalbard	b) ARR, INGV,Ph. DeptLa Sapienza, CNR/ISTI
2005	a) 2 Flights from Svalbard (PEGASO B & C)	a) ARR, INGV,Ph. DeptLa Sapienza, CNR/ISTI
2004	a) 1 Flight from Svalbard (PEGASO)	a) ARR, INGV,Ph. DeptLa Sapienza, CNR/ISTI
2003	a) 4 Flights Trailblazer from Svalbard	b) ARR, INGV,Ph. DeptLa Sapienza, CNR/ISTI

TM/TC (UHF ground station and on board equipment, S band ground station and on board equipment, IRIDIUM based system for LDB flight). Integration & Workshop consist of four integration hangars each of them provided with direct line access, air conditioning, electric and mechanic equipment as well as an electronic laboratory, a thermo and vacuum test equipment and overhead travelling cranes. All these are able to accommodate up to 5 scientific payloads. Moreover systems and vehicles necessary for balloon launch and payload recovery are provided in Helium recovery & stock building (launch vehicle with a capability up to 2.500 Kg., launch spool machine, UHF mobile station, S band mobile station). All equipments and facilities in Trapani base, bound with the strategic position of launch pad and site allow scientific teams to test their experiments in laboratory and in flight directly. The presence of main infrastructures and commerce nearby (Airport, Harbour, Highway) makes Trapani Base an excellent site for supplies and communications as well. The proximity of huge stretch of sea and low population density of territory around Trapani, guarantee acceptable levels and a safety recovery in case of emergency landing. Trapani Milo balloon facility can boast the following advantages:

- location
- safety
- trajectory
- facilities

5. New developments and perspectives

Following science requirements ASI has developed a modern technology in order to reach scientific goals for LDB flights. Among these, the development of a new TM/TC system has a great importance. Three different projects have been funding to improve Trapani base capability to offer a whole mission direction for Trans-Mediterranean and extra muro flights as well. IRIASI (supplied by ELTA - FRANCE) offers science and housekeeping TM/TC capability using IRIDIUM communication system. The new system was already delivered to Trapani base, and all tests for acceptance have had positive outcomes. It was used for the first time during DUSTER experiment launched last June from Svalbard Islands with great success. IRILASI (supplied by ELTA - FRANCE) offers high performance science and housekeeping TM/TC capability using IRIDIUM communication system and a line of sight L band link to obtain high rate of downlink. The new system was already delivered to Trapani base, and all tests for acceptance have had positive outcomes.

STRADIUM (supplied by an Italian pool formed by IASF/INAF INGV LEN U. Of Rome La Sapienza, Telespazio) is the domestic effort to offer an high performance TM/TC system using IRIDIUM communication system. The new system was already delivered to Trapani base, and all tests for acceptance

Fig. 2. The balloon launch facility "Luigi Broglio".

have had positive outcomes. Another important project is HIPEG. It consists in developing of an advanced gondola azimuth pointing system (pivot) and it has as prime contractor IASF/INAF of Bologna). Many other projects have already started and are in progress, all of these addressed to give science community upgrated technology for stratospheric missions. We can recall: Development of on board power supply system based on fuel cells to give a long duration power supply during arctic night when it is not possible to use solar array. Development of non dynamic launch systems . Development of non conventional parachutes. Upgrading of flight dynamic and trajectories forecast tools. Stratospheric balloon activities are always in in evolution and need an uninterrupted work of technologic upgrading. ASI pursues this purpose through Trapani team and cooperation with the most important Italian laboratories, universities and companies. The prospect of these cooperations is to make Trapani Milo base the excellency center in Europe and in the world for stratospheric balloon missions giving a wider opportunity to science community and guaranteeing a whole support to stratospheric missions required by customers. This will be reached improving the base capability to plan, develop and manage a mission. In perspective Trapani Milo launch facility functions and role will be: to carry out indipendently stratospheric missions, to carry out technological tests through local or tranmediterranean flights, to manage technical coordination and feasibility of missions required, to be center of integration of extra muros payloads, to manage maintenance and calibration of equipments, to manage shipping of goods and travels, to be center of permanent and operational team, to be MOCC and permanent warning station for LDB flights, to study the improvement of stratospheric services, to manage engineering, research and technological development of stratospheric missions, to manage agreements, cooperations and supports.

6. The ASI ROAD MAP of Stratospheric activities

New developments and prospects will be prosecuted through activities scheduled by ASI team to be carried out in Trapani Milo base as well in others launch sites in the world (extra muros activities). The local missions, planned, developed and integrated in Trapani, will be launched from Milo base and they will be: Trans Mediterranean missions Consolidated activities will be carried out in the frame of ASI INTA (Spain) MoU with stable uses in technological and scientific fields; Local missions consolidated activities with perspectives of increase for interplanetary and re-enter missions (USV, AURORA); Educational missions activities with increase perspectives but to ver-

Fig. 3. The balloon launch facility "Luigi Broglio"
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ify also based on the costs; possibility of development in the student formation. The so called extra muros activities will be planned, developed and integrated in Trapani Milo base, but they will be launched from others sites that ASI has already tested or has scheduled to test through agreements with partners in the world. The most important program is the actuation of the agreement between ASI and ARR (Andoya Rocket Range Norway) to use Longyearbean airport in Svalbard to make summer and winter LDB launches and to realize the new Italian / Norwegian Nobile/Amundsen Stratospheric balloon Center in Longyearbean. This future base will be the north-est stratospheric balloon facility (78 14 N, 15 30 E) and from there will be possible westward flights in summer time, or eastward flights during winter. The duration of the flight could be a long one, arriving up to 1 month and over. This location, easier to get to than South Pole and therefore with minor logistic problems, offers to science a part of sky never explored before. The scheduled experiments already funded which will be launched from Svalbard are: OLIMPO 1 (U.of Rome La Sapienza + Fr + UK); SORA (CISAS U. Of Padova + Fr + UK); OLIMPO 2 (U.of Rome + Fr + UK) and BOOMERANG (U.of Rome + Fr + UK): Others extra muros activities see launches from Antarctica BTN, PISQ Sardinia, BSC Malindi Kenya. The first site, M. Zucchelli Base Terra Nova Bay, will be the set of LDB flights under PNRA organization in winter time but as already said, requires many efforts to resolve logistic problems. The PISQ is a military polygon located in Sardinia Island and it has the great advantage to have a huge area in the sea where it is possible to forbid the navigation, so it comes out to be a safety site for launch as drop tower as USV program is. The site of Malindi in Kenya is the historic base where San Marco Project took place. Studies and verification are in progress to verify the feasibility of local and LDB flights which, as its location close to Equator (2 99 S, 40 19 E), could be circumequatorial flights westward or eastward. If preliminary activities will give positive outcomes, some stratospheric flights (Pathfinders) will be performed to start up a permanent facility in Broglio Space Center in Malindi. This base is also considered the best site for the last two propelled USV flights (SRT-HFT) because of previous experiences done in the site and its safe location.

7. Trapani base role in the frame of ASI stratospheric activities

The ASI stratospheric activities will be managed from Trapani Milo Base because is the historical site for these activities and is the facility to integrate experiments, to test in laboratory or in flight every kind of equipment, to store equipments and machines need to the launch, to store and prepare all equipment to be shipped. All these activities can be carried out through technological upgrading and through agreements of cooperations and support.