CENTRE NATIONAL D'ÉTUDES SPATIALES

CNES's Titan Montgolfiere Studies
Planetary Science Decadal Survey
Satellites Panel Meeting

September 22, 2009

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The Role of CNES in Stratospheric Ballooning

- **CNES has established competency in stratospheric balloons in Europe since 1962, recognized internationally**
  - **Balloon Department : R & D in technology of aerostatic systems, modeling, envelops & gondolas developments, telemetry & command systems, operations…**
  - **Development of envelops, and fabrication in cooperation with Zodiac International in Ayguesvives, nearby Toulouse**
  - **Operational capability : 30 to 40 stratospheric balloon launches each year from France, Sweden, Brazil and other foreign sites**
  - **Large international community of scientific users : about 15 French groups and German, British, Japanese teams, etc.**

Stratospheric Balloons on the Shelve

- **Zero Pressure Balloon (BSO)**

Mass Payload : up to **2.7 tons**
Altitude : 17 to 44 km
Flight duration : up to **48 hours**
Volume : 3 000 – 1 200 000 m^3

- **Superpressurized Ballons (BPS)**

Mass Payload: up to **40 kg**
Altitude : up to 20 km
Flight dur. : up to **3 months**
Diameter : from 3.7 to 12 m

- **InfraRed Montgolfieres (MIR)**

Mass Payload : up to **50 kg**
Altitude day : 28-30 km
Altitude night : 18-22 km
Flight dur. : up to **3 months**
Volume : 45 000 m^3

Scientific use of Stratospheric Balloon

- **Balloons are the only vehicles allowing :**
  - **In-situ measurements in the mean stratosphere (20-45 km)**
  - **Time evolution of a measure within a mass of air in displacement and tracking of its trajectory**
  - **Experimentation within the stratospheric environment (stratospheric crane for drop of entry systems)**
- **Balloon campaigns play a major role in :**
  - **Large European programs for the study on the arctic ozone layer (EASOE, SESAME, SABINE, THESEO)**
  - **Validation of satellite products : UARS, POAM, ILAS, ODIN project, ENVISAT, IASI, …**
  - **Study of the atmospheric circulation : VASCO, INDOEX, BOA, MA, ESCOMPTE, …**
  - **Specific studies on atmosphere dynamics (turbulence, waves, …)**
  - **Experimentation in astronomy with stabilized and pointed gondolas**

Launch sites in France : Aire sur l'Adour & Gap

Fixed and Mobile TT &C Stations

- P Band TM/TC Station for the command and control of the balloon and for the standard users requirements
- L Band Station for high data-link users' requirements
- Checkout shelter for the users

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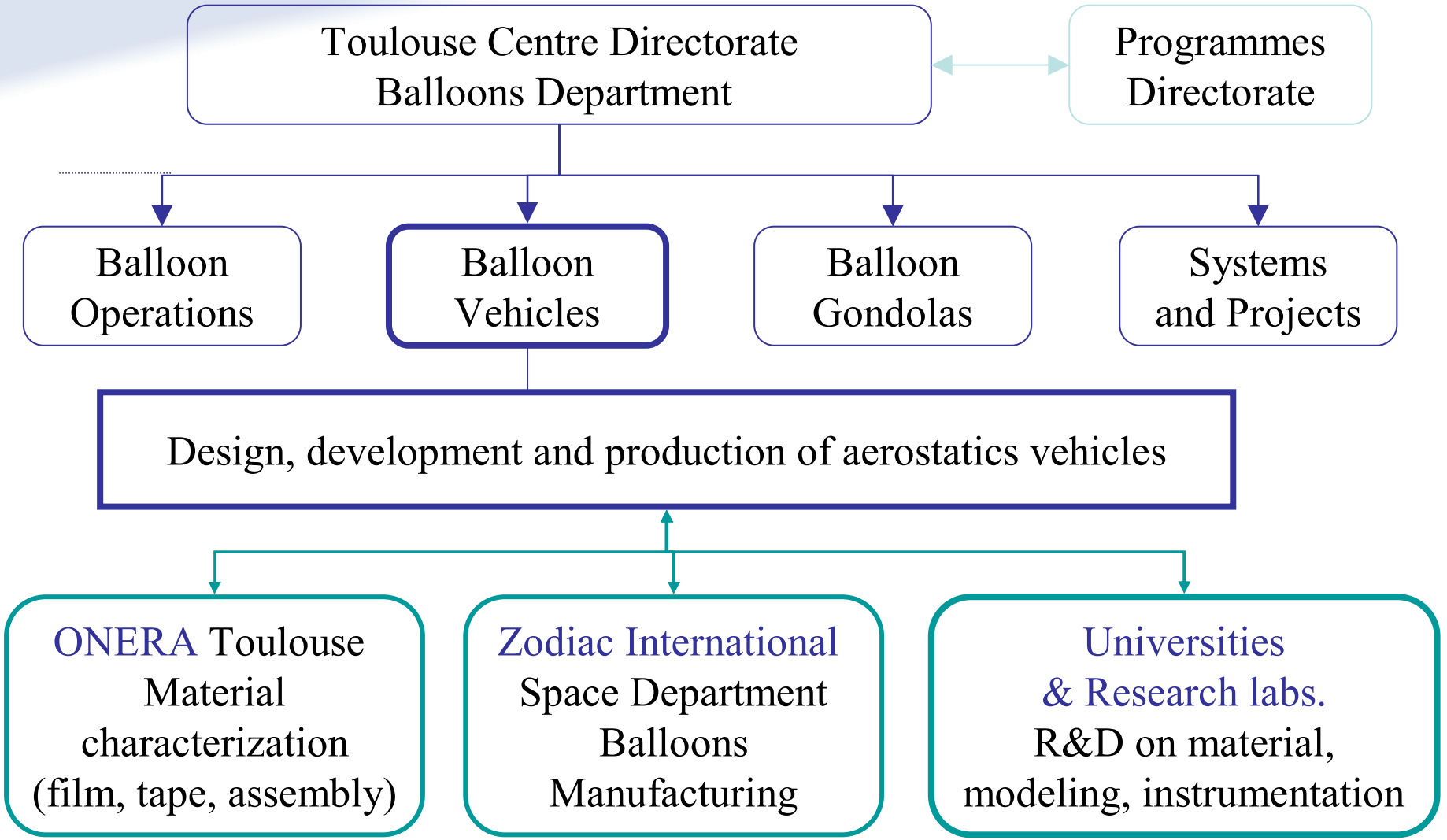
Organization of Development Activities



Fabrication of Zero Pressure and Super-Pressure Balloons

- **Quality control throughout the whole process of fabrication of the balloons:**
  - **During fabrication of polymeric film**
  - **At reception : specification verification of material used**
  - **During fabrication : control points and validation of samples**

- **Improvement of the balloon fabrication & control machines:**
  - **Gore cutting machine with on line control for the polymeric film defaults and gore size**
  - **Improvement / replacement of gore assembling machines**
  - **Improvement of the control laboratory capabilities**
  - **Computerized acquisition in a database of all data produced during the fabrication process**

Fabrication Hall for Super Pressure Balloons

Gore Cutting Machine

Inlet with the roll of polymeric film

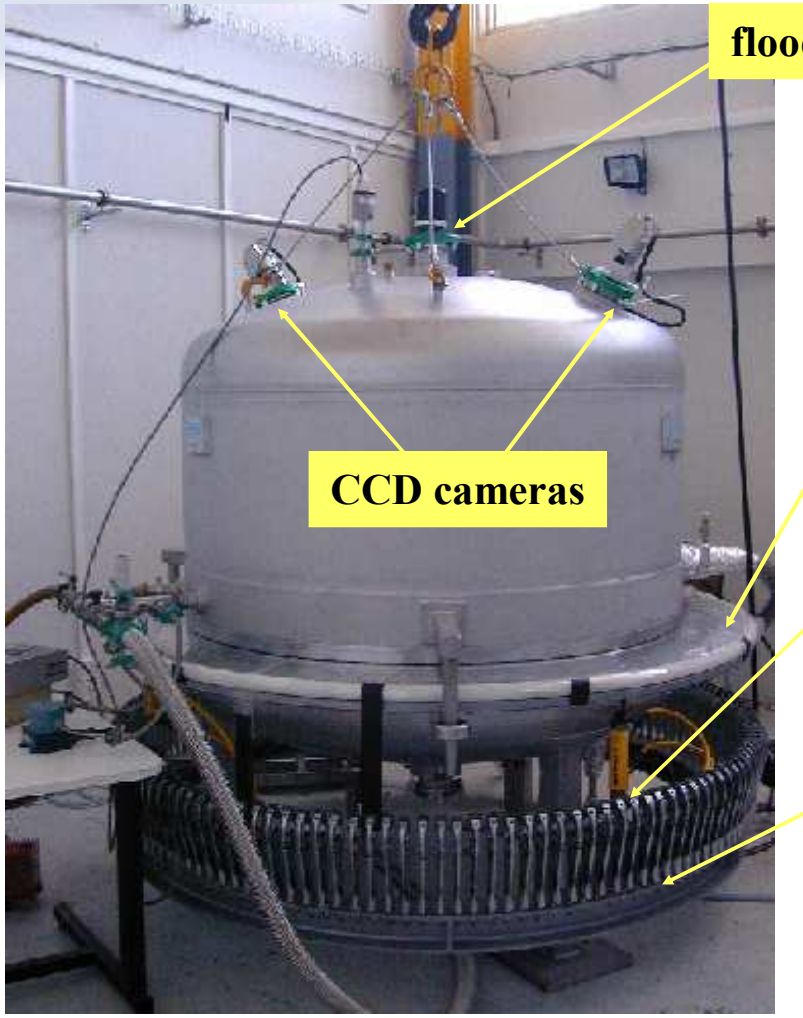
Gore cutting zone

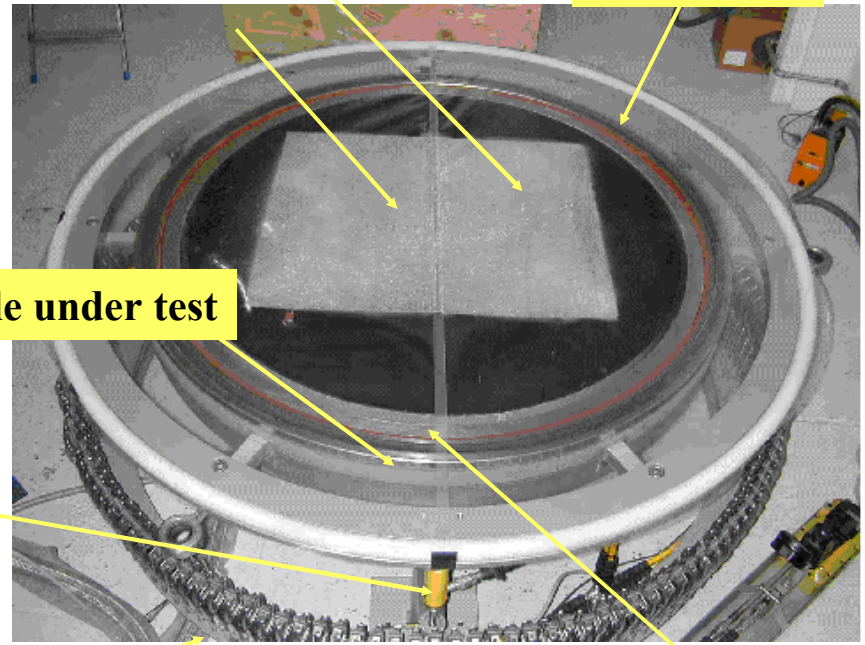
Gore Assembly Machines

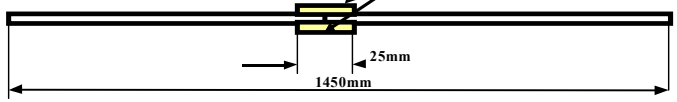
Super Pressure Balloon

Zero Pressure Balloon

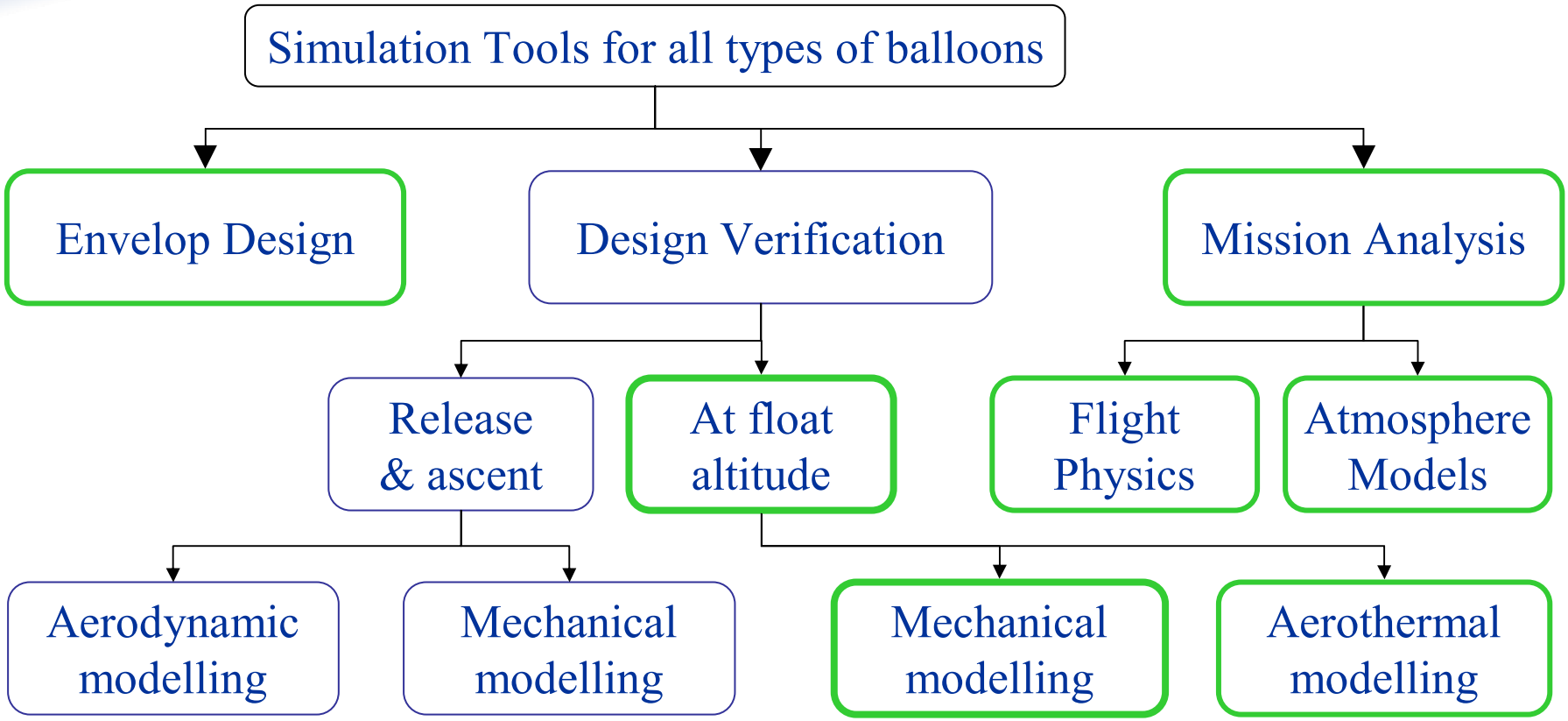
Verification Facility Nirvana



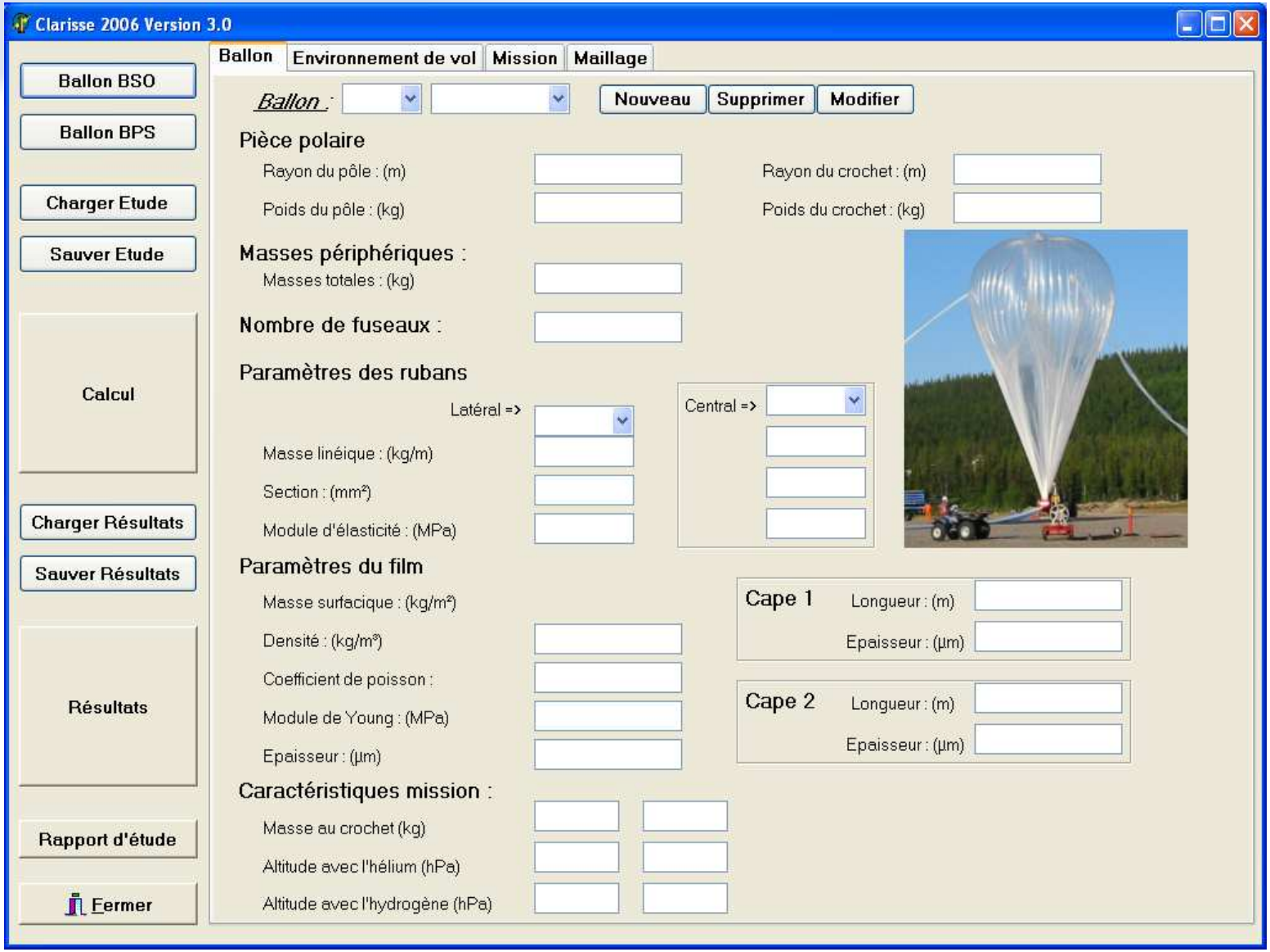




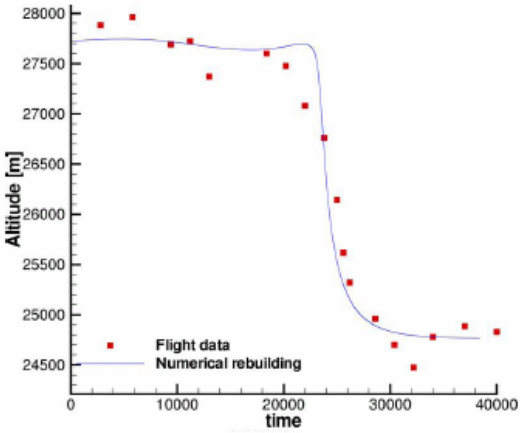
Balloon Design and Verification Tools

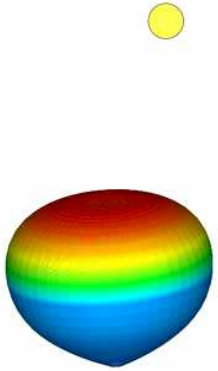


Tailored Finite Element Tool

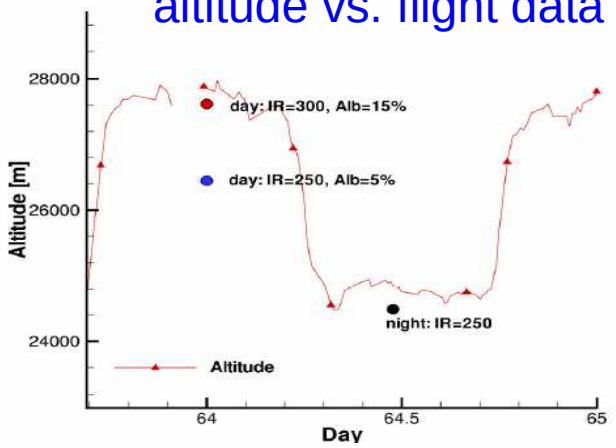


Unsteady CFD and Thermal Modeling of a MIR

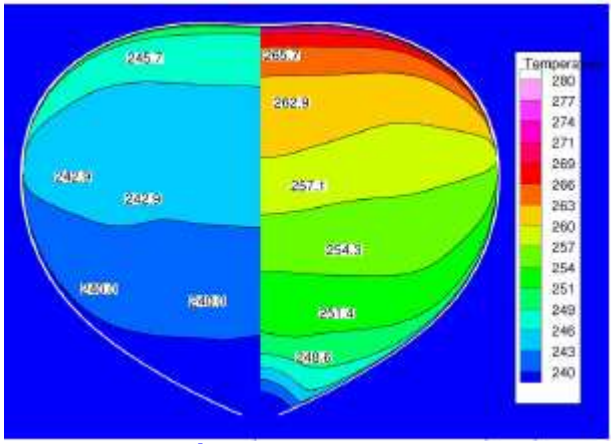




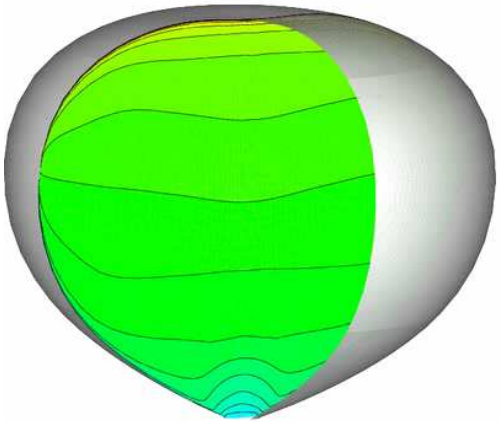
Simulated float
altitude vs. flight data



night day



Internal gas temperature



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Day to night transition (unsteady)

Day & night float conditions (permanent)

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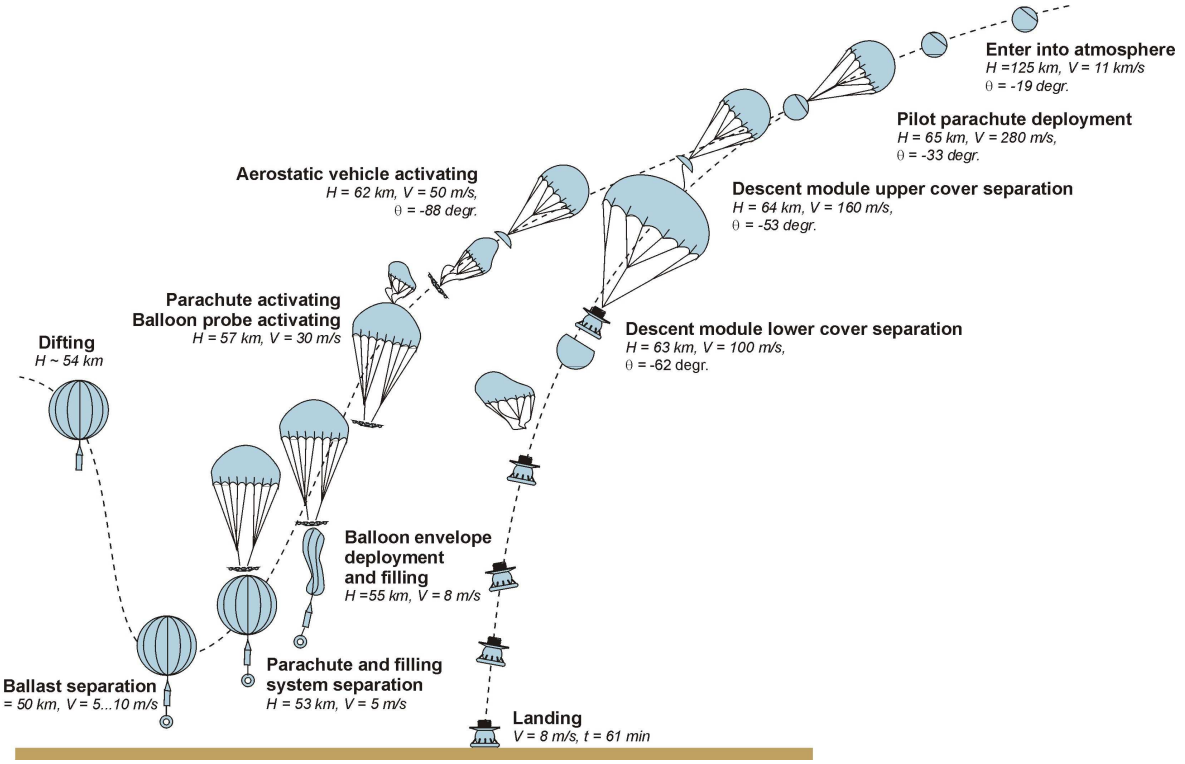
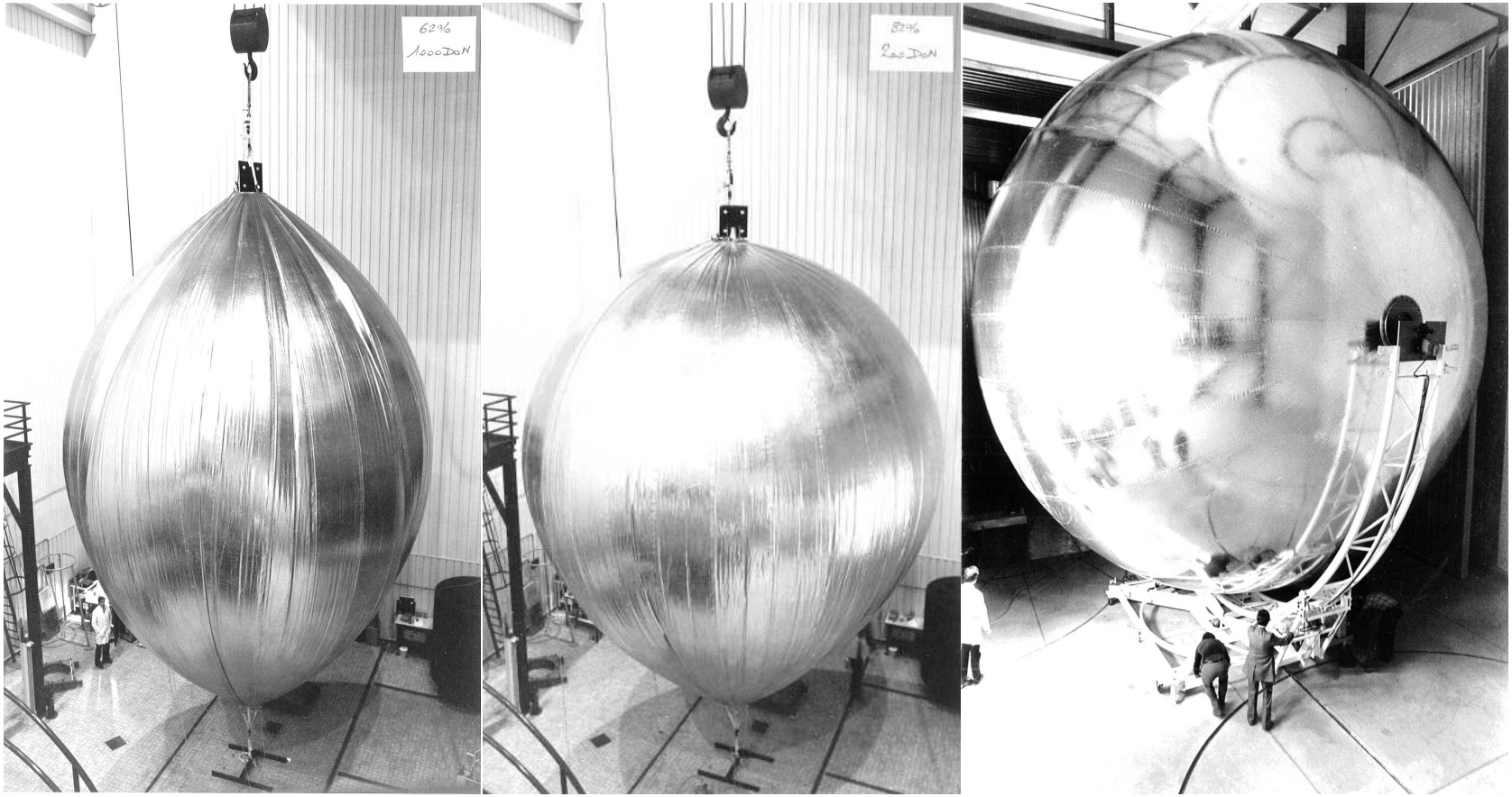
Venera : Russian – French Collaboration for a Venus Super Pressure Balloon

- Developed in 1985 balloons of automatic interplanetary stations "VEGA-1, 2" carried out a drift in Venusian atmosphere and researches of dynamics of cloud layer of the Venus atmosphere.

- **Basic characteristics**
  - Spherical shape
  - Diameter : 9 m
  - Balloon volume : 21 m^3
- Filling gas : helium
- Lift force : 20 kgf
- Envelope mass : 12 kg
- Lifetime : 10 days



Inflation of the Venera Balloon on Ground Indoor



Deployment of the Venera Balloon on Ground Outdoor