ERAS

EUROPEAN MARS ANALOG STATION

Python on Mars

EuroPython, Florence, 03 July 2013

The Italian Mars Society

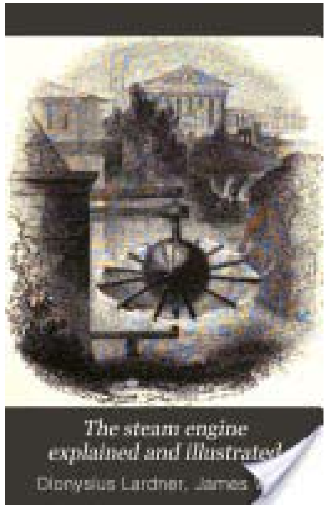
Franco Carbognani, Ezio Melotti

Some 19th Century predictions…

Boston Daily Journal

1830 : “Bumps produced by trains traveling at 15 or 20 miles an hour would lead to many cases of concussion of the brain“

1830: “Rail travel at high speeds is not possible because passengers, unable to breathe, would die of asphyxia”



Some 20th Century predictions…

THE TIMES

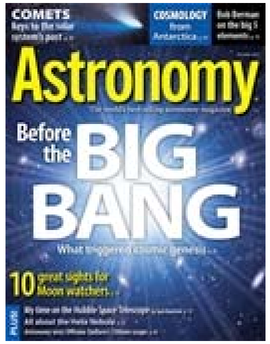
1906: "All attempts at artificial aviation are not only dangerous to human life, but foredoomed to failure from the engineering standpoint"

The New York Times

1936: "A rocket will never be able to leave the earth's atmosphere"

And some 21st Century predictions…

2006: "Biologists estimate that during a 2-year Mars mission, an astronaut may lose between 13 and 40% of her or his brain!"



Booksie

2007: "inter-planetary manned space travel is virtually impossible"

Mars showstoppers

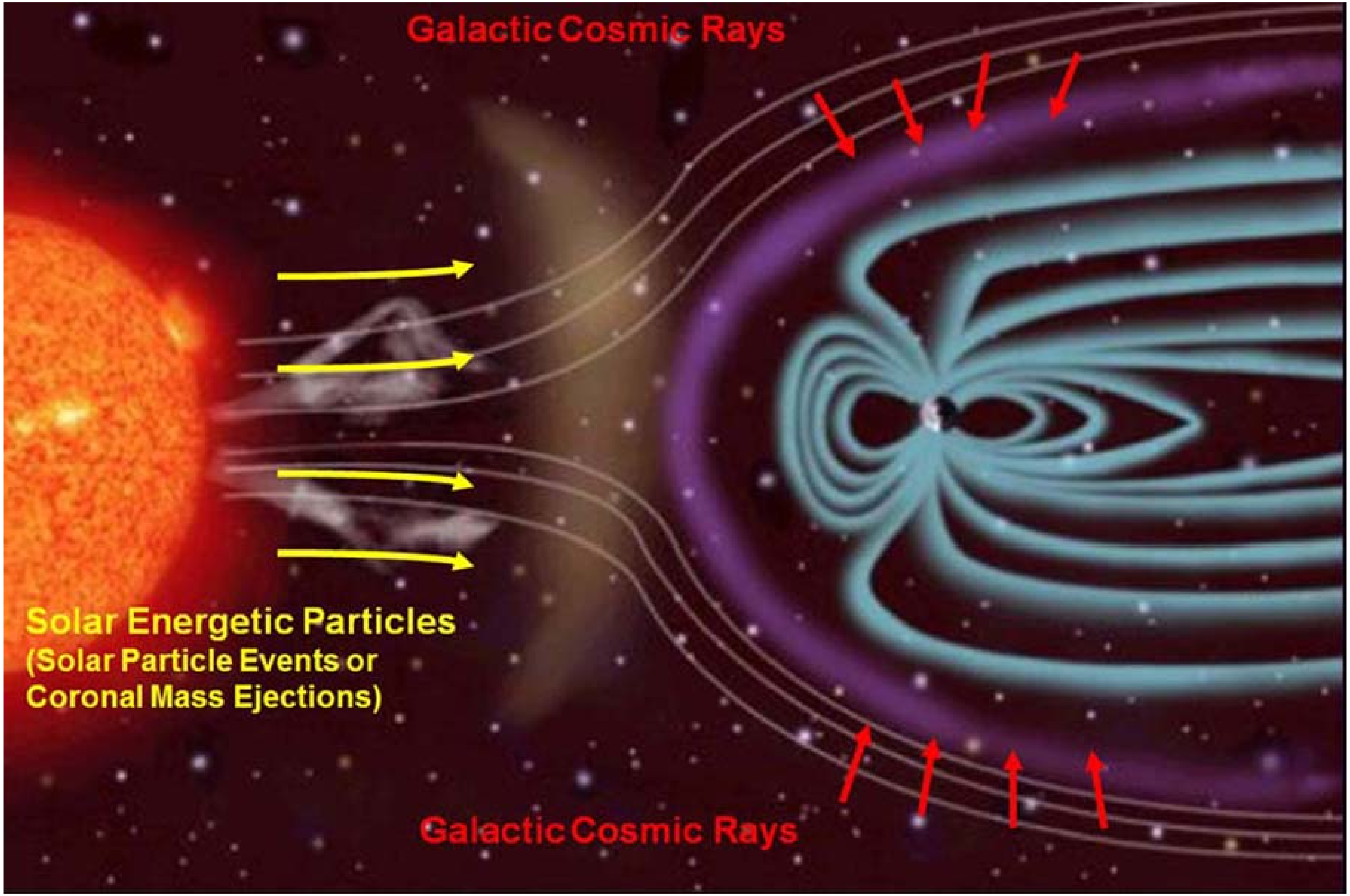
Threats to human health and safety which can prevent a human Mars mission from succeeding or even starting.

1. Hypogravity
2. Radiation
3. Need for Regenerative & Bioregenerative Life Support
4. Mars Dust
5. Planetary Protection (Forward-contamination and Back-contamination)

Hypogravity

* not an actual image from Mars

Radiation



Source: http://www.jpl.nasa.gov/

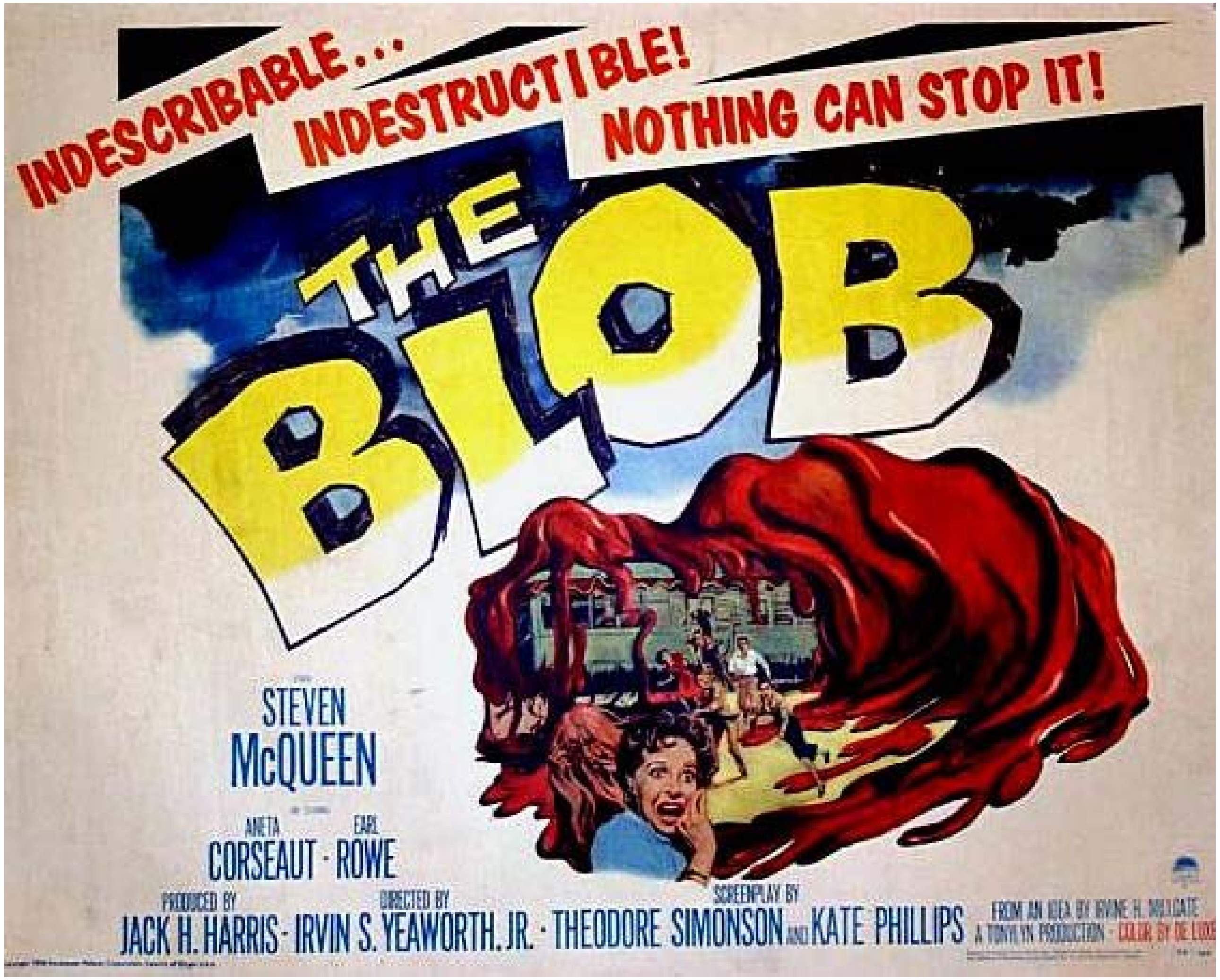
Need for Regenerative & Bioregenerative Life Support

Source: http://www.space.com/

Mars Dust

Source: http://commons.wikimedia.org

Planetary Protection



Source: www.midnight-buffet.com

Limitations of existing analog stations

- HABITAT SHIELDING

The existing terrestrial analog stations do not simulate shielding as part of their missions.

- HABITAT SEALING

Existing Stations are not sealed structures:

1. closed life cycle environment cannot be simulated
2. dust control practically impossible

- HABITAT LOCATION

Located in remote areas. Such locations imply:

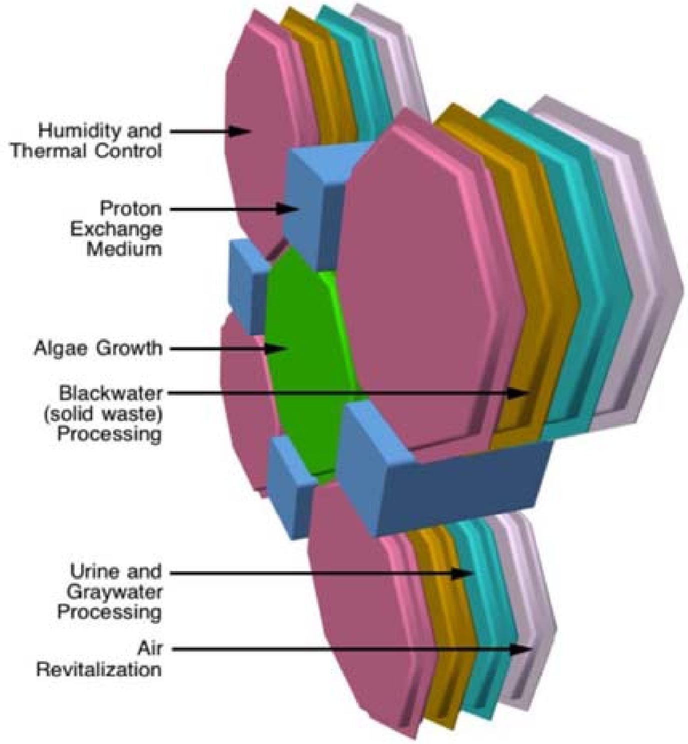
1. Elevated costs of logistics: transportation and supplies.
2. Only short seasonal use. A facility not used full-time is very expensive per man-hour of use
3. Simulations implying advanced technologies are avoided because too difficult to be supported and maintained remotely

Limitations of existing analog stations

ERAS main innovations

- HABITAT SHIELDING

Provide radiation shielding and thermal mass using the membrane Water Wall concept.



ERAS main innovations

- HABITAT SEALING

Provide habitat sealing relying on air-exchangers, filters, plants and proper design of entrances (airlock). This will allow for the validation of mission critical technologies as dust filtration and a full environmental control and life support system.

- HABITAT LOCATION

A suitable location where:

  - Logistical costs are minimized
  - The facility could be fully supported by a local Engineering Crew
  - Full time use the entire year would be possible
  - Proximity to touristic areas could be exploited for public outreach and education
  - Advanced Technologies such as photovoltaic power-generation system long term performances verified
  - The habitat could be placed into an enclosed area (hangar), were some features of the Martian environment will be reproduced, particularly lighting conditions and the Martian dust environment

ERAS main innovations

- HABITAT SEALING

Provide habitat sealing relying on air-exchangers, filters, plants and proper design of entrances (airlock). This will allow for the validation of mission critical technologies as dust filtration and a full environmental control and life support system.

- HABITAT LOCATION

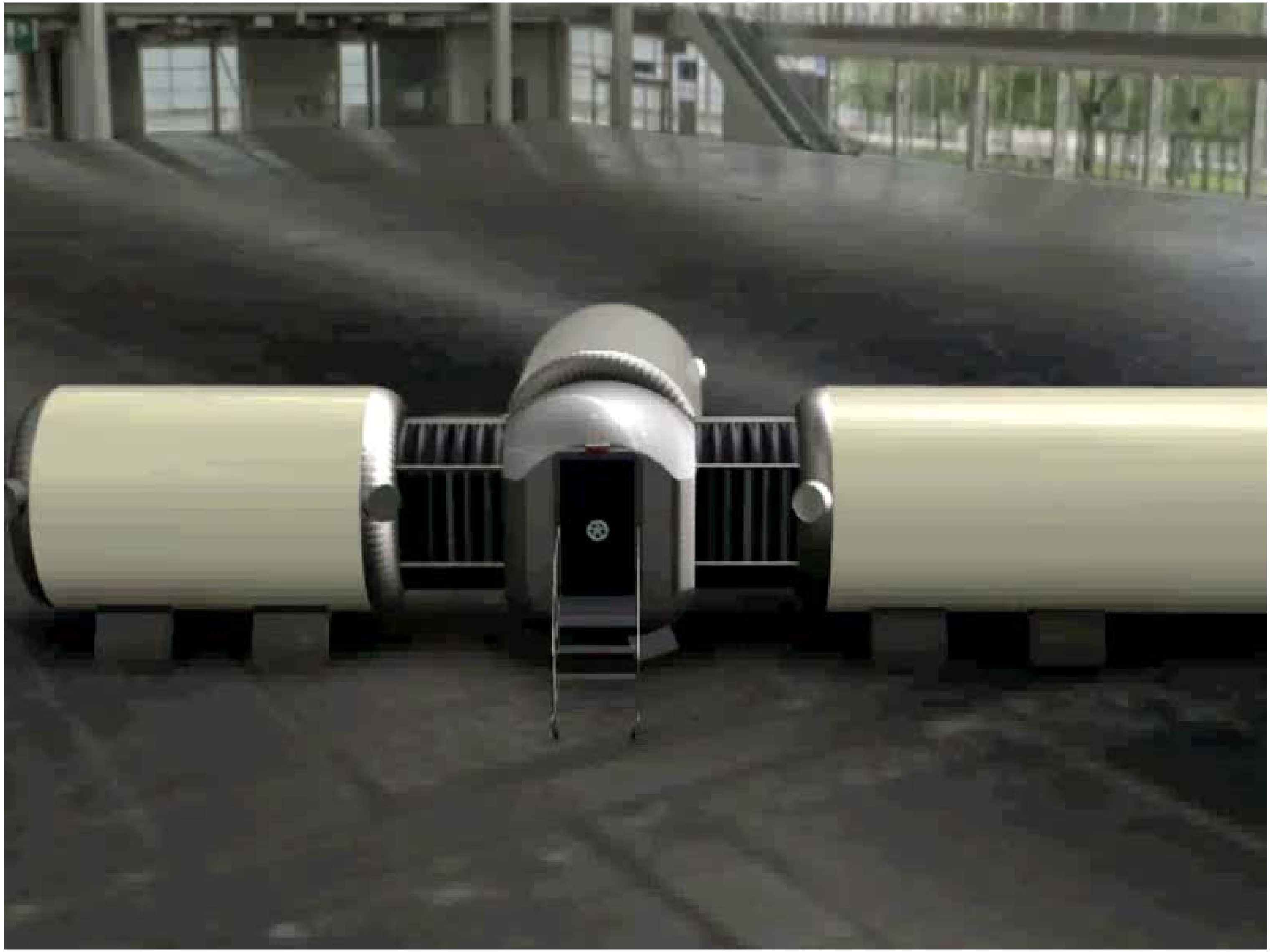
A suitable location where:

- Logistical costs are minimized
- The facility could be fully supported by a local Engineering Crew
- Full time use the entire year would be possible
- Proximity to touristic areas could be exploited for public outreach and education
- Advanced Technologies such as photovoltaic power-generation system long term performances verified
- The habitat could be placed into an enclosed area (hangar), were some features of the Martian environment will be reproduced, particularly lighting conditions and the Martian dust environment

ERAS habitat typology

- The existing Mars Research Stations are examples of pre-integrated, hard shell modules.
- Latest developments in the field have introduced the concept of pre-fabricated, inflatable structures (TransHab)
- Main advantages of advanced inflatable structures:
  - Larger usable/habitable volume
  - Lower mass
  - Higher crew productivity
  - Higher crew morale and quality of life (Lower stress)
  - High reliability & easy to repair

ERAS habitat typology



Project Objectives

- Provide full in-field assessment of hybrid/inflatable habitat technologies
  - Assess long term effectiveness of adopted dust control and mitigation technologies
  - .....
- Provide effective testbed for key enabling technologies
  - Include simulation of most relevant physical-chemical regenerative and bioregenerative life support systems.
  - Equip the astrobiology laboratory in order to effectively validate procedures which incorporate Planetary Protection in sample collection and handling
  - .....

Project Objectives

- Effectively implement Human Factors advanced research into Habitat Design
- Provide an environment able to maximize scientific productivity of researchers
- Ensure effective transfer of results to the scientific community
- Ensure effective outreach
- Inspire the next generation of scientists, engineers, and entrepreneurs to pioneer the space frontier

The ERAS first steps: The C3 System

The Command, Control, and Communication (C3) system must provide the data processing and communications functionalities required to:

- monitor and control the planetary habitat's environment and subsystems
- monitor and maintain crew health and safety
- communicate with mission support, robots and EVA crew members
- support data processing related to the mission objectives
- host the core part of the Crew Mission Assistant

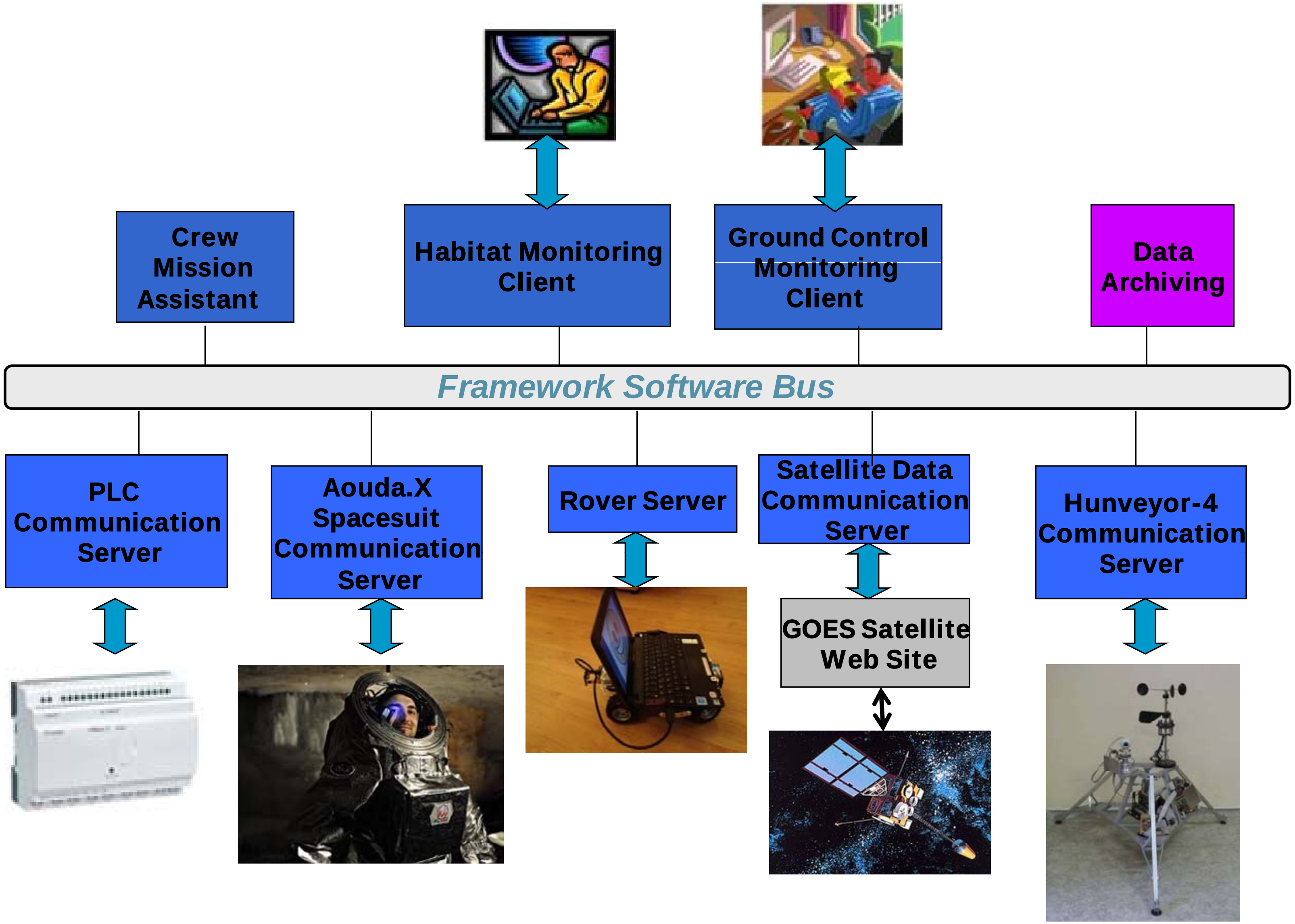
ERAS C3 as a Distributed Control System

- The ERAS C3 Subsystem could be classified as an heterogeneous Distributed Control System (DCS).
- The DCS fundamental services are:
  - Communication: allows that the components (control servers and clients) of the distributed system communicate among them
  - Online database: refers to the possibility to access online any data point of the DCS
  - Configuration database: keeps and manages the configuration data
  - Logging: collects the logs from all over the system and presents it to the operator
- DCS common services and tools are usually grouped into a Framework. The specific applications are then built on top of it by using and/or configuring its available tools.
- Frameworks pros:
  - the development time can be decreased
  - maintenance can be facilitated
  - more time can be spent on the project specific control solutions (i.e. the functional part)

Control Framework Selection

- One of the main technical choice needed for the C3 prototyping is the one of the Framework. The selection criteria to be applied are including:
  - Required services
  - Performance needs
  - Desired operating systems
  - Real-time requirement
  - Provided hardware integration support
  - Software engineering tools & development support.
- Various options have been considered were and the TANGO DCS Framework (http://www.tango-controls.org) selected

ERAS C3 Functional Diagram



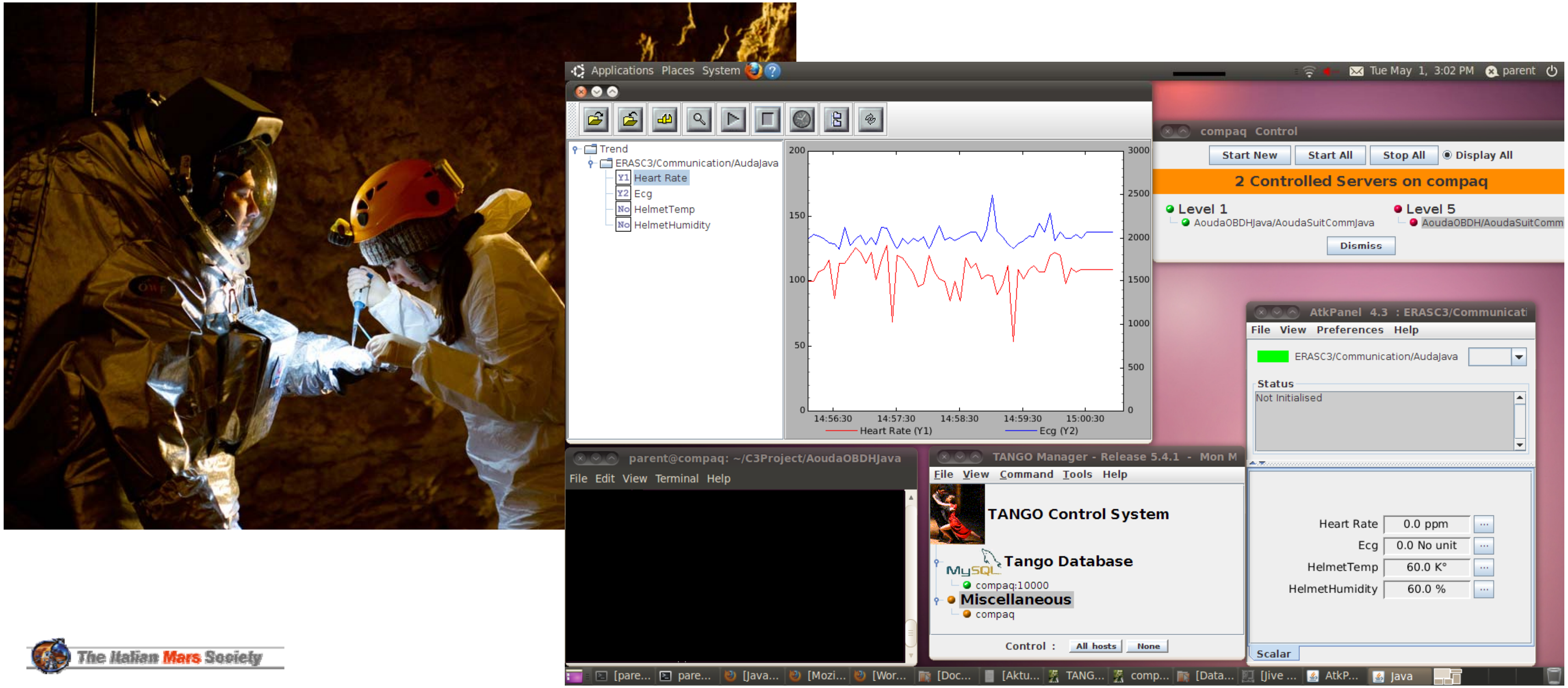
The C3 System Prototype Functionalities

Of the planned C3 functionalities those are the ones we have or will implement for the C3 prototype:

- Habitat Environment Monitoring
- Monitoring of parameters relevant to crew health and safety
- Use of advanced Human Machine Interface (HMI) technologies for interaction with rovers
- Communication with space probes
- Crew Mission Assistant Components. Use of Machine Learning technologies for:
  - detection of anomalous situations from space suit biomedical data
  - predicting solar energetic proton events

C3 Prototype field tests

During Dachstein2012 and MARS2013 Morocco field tests the communication between the ERAS C3 prototype and the Aouda.X Spacesuit (in particular for main biomedical and engineering telemetry data) has been successfully tested.



C3 Prototype field tests - AoudaX

C3 Prototype field tests

- Detection of anomalous situations from space suit biomedical data

  A draft Neural Network has been implemented as a *python TANGO server* able to grab needed data from the TANGO software bus provided by the AoudaOBDH Device Server.

  For the purpose the *Feed-forward neural network for python (ffnet, http://ffnet.sourceforge.net)* has been used.

  The prediction of heart rate (HR) from physical activity (PA, represented by the AccelerationBody signal) has been implemented.

C3 Prototype field tests - Hunveyor

C3 Prototype field tests

- Communication with space probes

HUNVEYOR-4 is an advanced space probe model that was engineered by the students at the Alba Regia University Centre, a campus of Óbuda University. The communication with Unveyor-4 implied the development of a dedicated *python TANGO Communication Device Server*

Data has been retrieved via the *Redis (http://www.redis.io/)* data structure server.

During the Morocco MARS2013 tests it has been possible to collect data from HUNVEYOR-4 but only from the provided test data queue with simulated data.

A Google Summer of Code on Mars

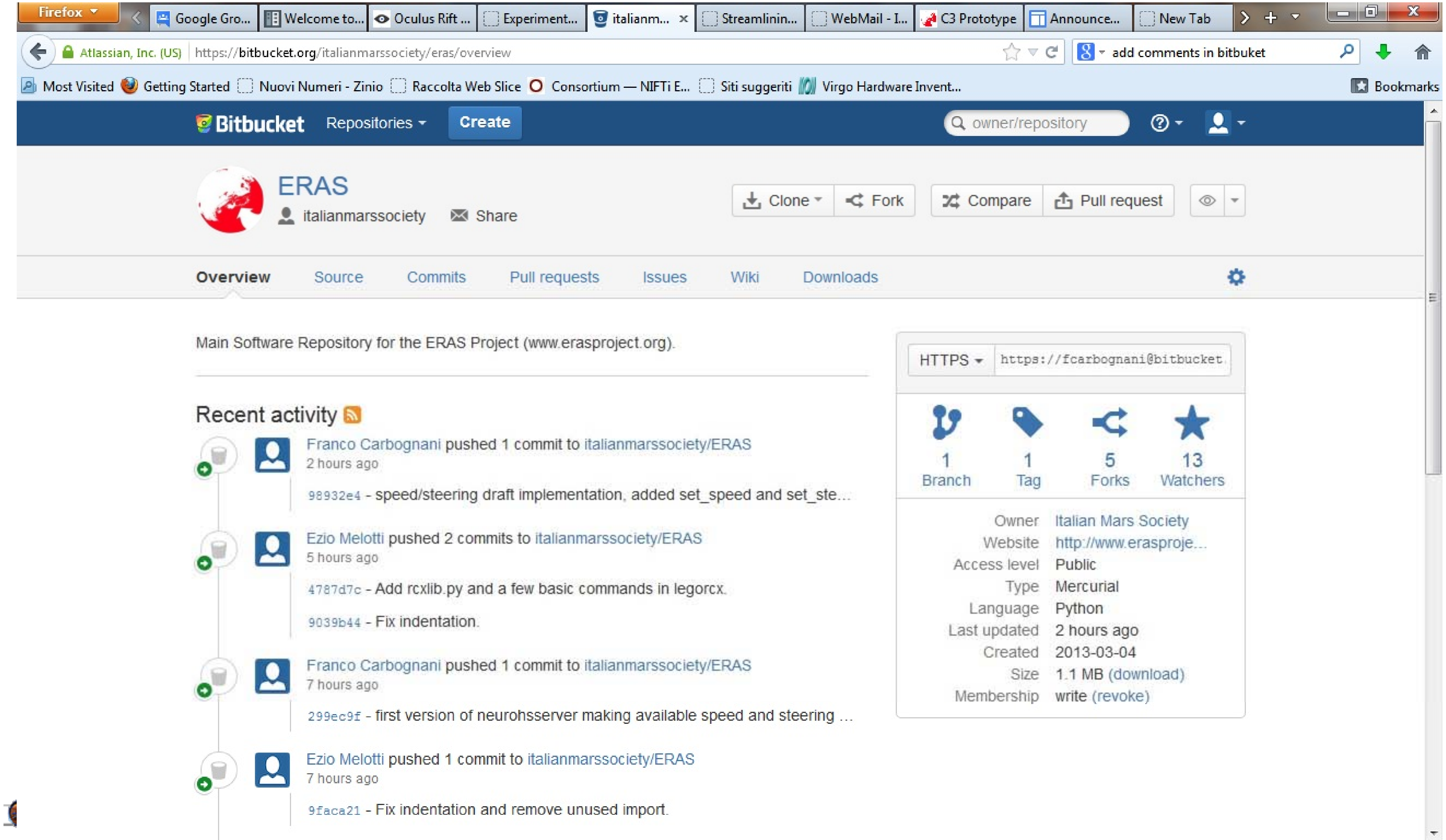
- Italian Mars Society (IMS) is partecipating to GSoC2013
- Four students working on ERAS C3 projects focusing on advanced Human Machine Interface (HMI) and Machine Learning technologies
  - Ezio Melotti: rover control via an EEG neuroheadset
  - Eric Meinhardt: speech recognition for rover control
  - Simar Preet Singh: solar energetic proton events prediction
  - Mario Tambos: detection of anomalous situations from space suit biomedical data.
- More details on those projects can be found on the ERAS web site dedicated page

ERAS 2013 GSoC Strategic Plan

- June 20 User Requirements Review completed, Tango up and running in stand alone mode
- June 27 Draft Design Study ready, Start of Coding, Implementation of Use Cases one by one in Test Driven Development mode (repository updates at least every 2 weeks)
- July 5 First software push into the archive and then from there every two weeks on Friday evenings (July 19, Aug 2, etc.)
- July 29 Design Study Review completed: Design Study doc frozen on repository, Server prototype up and running in Tango
- Aug 2 Mid-term evaluation
- Aug 15 "GSoC on Mars" paper and presentation for 2013 Mars Society Convention in Boulder ready
- Sep 16 Final server version up and running, All validation tests OK with satisfactory coverage
- Sep 23 User/Maintenance Manual frozen on repository
- Sep 27 Final Evaluation
- Oct 2013 Projects integration on Bergamo C3 prototype
- Whithin 2013? Field testing in collaboration with Austrian Space Forum (TBD)

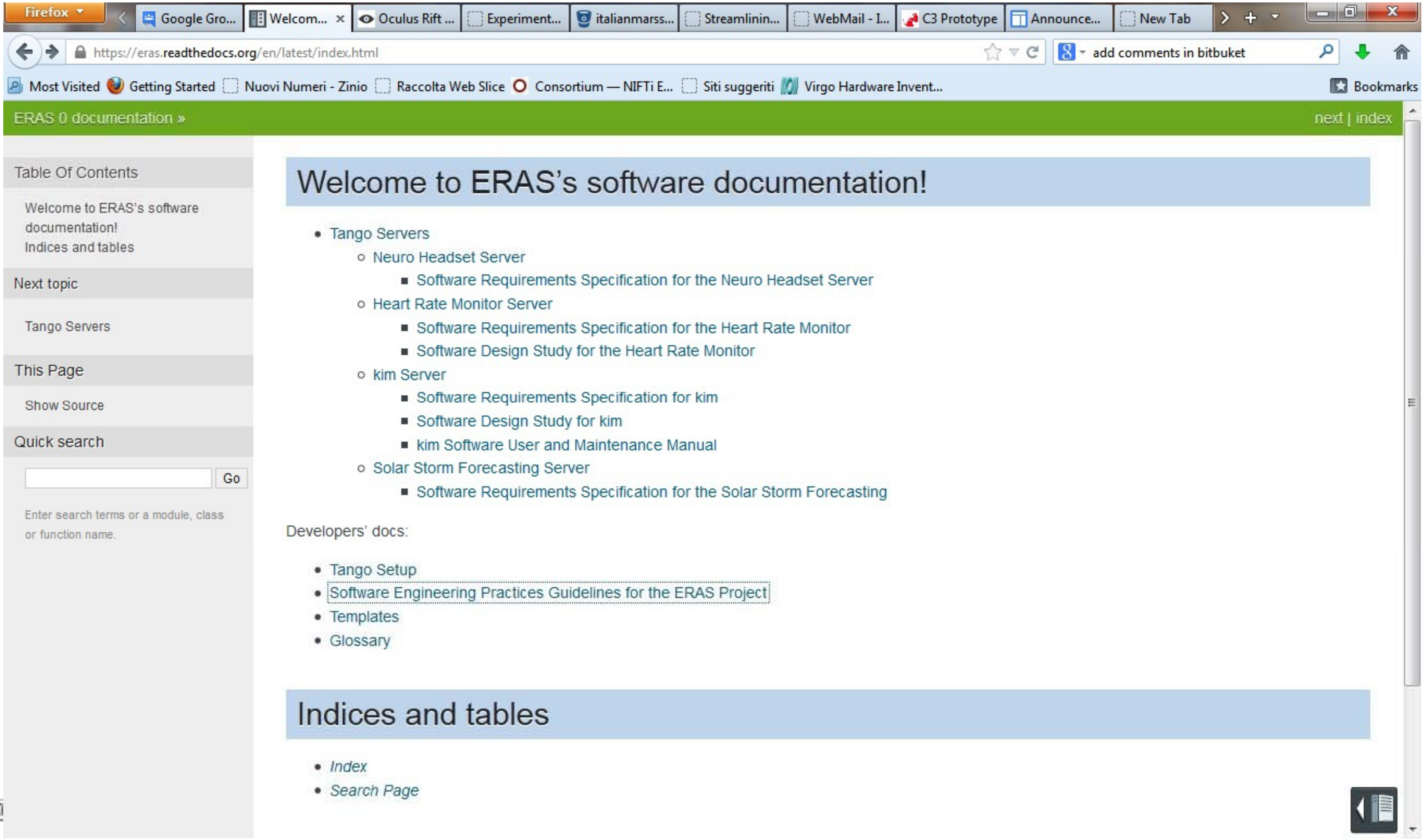
ERAS C3 projects setup

- Projects central repository on bitbucket



ERAS C3 projects setup

- Software documentation in rst format, built via Sphinx and made available on readthedoc
- Provided "pythoncentric" Software Engineering Guidelines



A Google Summer of Code on Mars

- Python libraries we are using or planning to use
  - PyTango
  - ffnet
  - NeuroLab
  - PyBrain
  - Emokit
  - Rcxlib
  - ...

Thanks for your attention!

For more information and for staying up to date on the ERAS project:

http://www.erasproject.org