# The astronomical Virtual Observatory : lessons learnt, looking forward

*Examples taken from the European view, but other projects have followed similar paths*

- The VO aim

  *Enable seamless access to the wealth of astronomical resources*

  An ambitious goal and no pre-existing organisational model to follow
- We had to invent a way of building the VO
- Pragmatic approach with a few basic principles
  - –A global VO
  - –Keep in mind science usage and implementation by data centres
  - –Fullfil astronomy's needs but when possible use generic building blocks to allow wider interoperability

# A global VO

- The VO has been thought from the very beginning as a fully global endeavour
- Neither a French (or Alsacian – Strasbourg region) nor a US nor a Japanese VO, but the astronomical Virtual Observatory
- The basis of the VO is Interoperability
- Global interoperability requires international agreement

# Interoperability: first steps

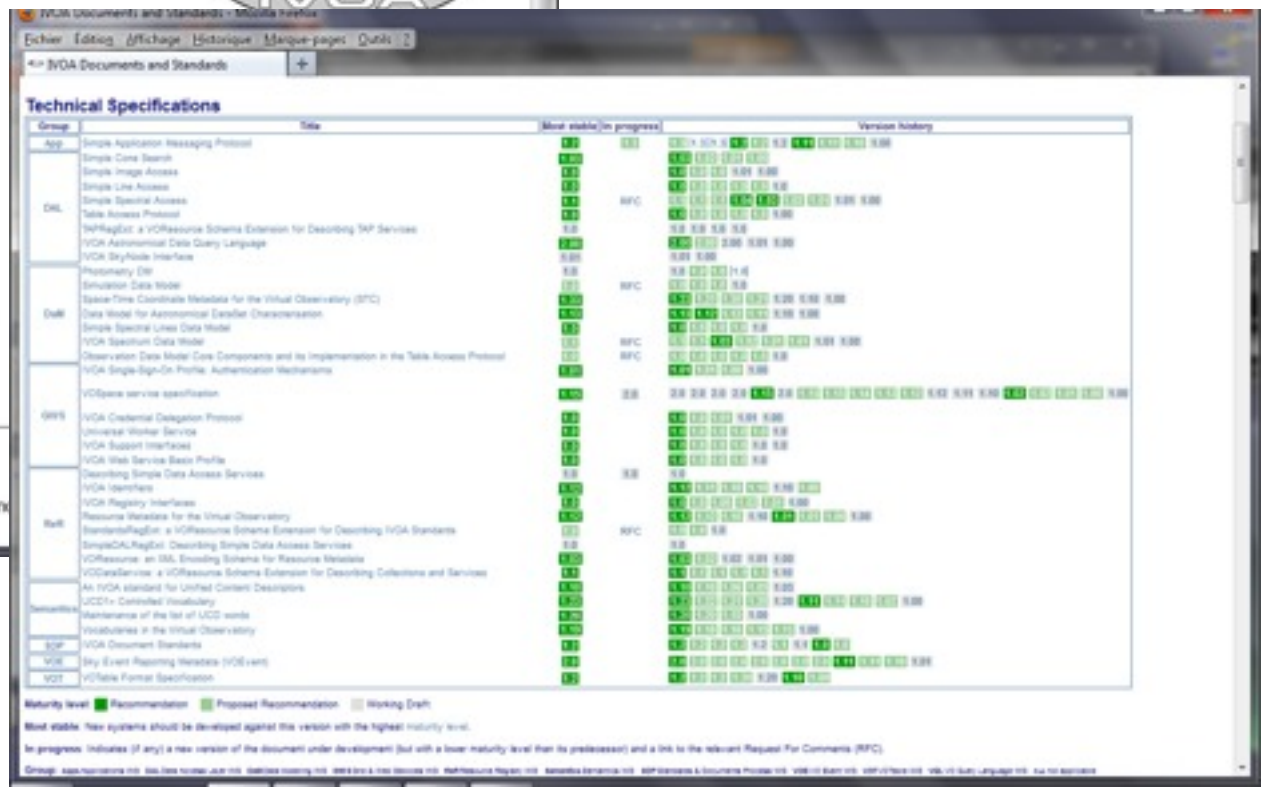

- January 2002 Strasbourg

  OPTICON European WG but international participation

  First Interoperability meeting – > VOTable

  CDS/NVO > Pre-IVOA standard
- June 2002 Garching
  - *Toward an International Virtual Observatory* (ESO/ESA/NASA/NSF)
  - Creation of IVOA

# Interoperability : IVOA standards


*Procedure adapted from W3C*

# Interoperability: current status

Passage to maintenance mode for many standards


*From C. Arviset*

Continuing to work on standards remains mandatory

–Feedback from implementation and scientific usage

–Evolution of astronomy – new facilities, new science

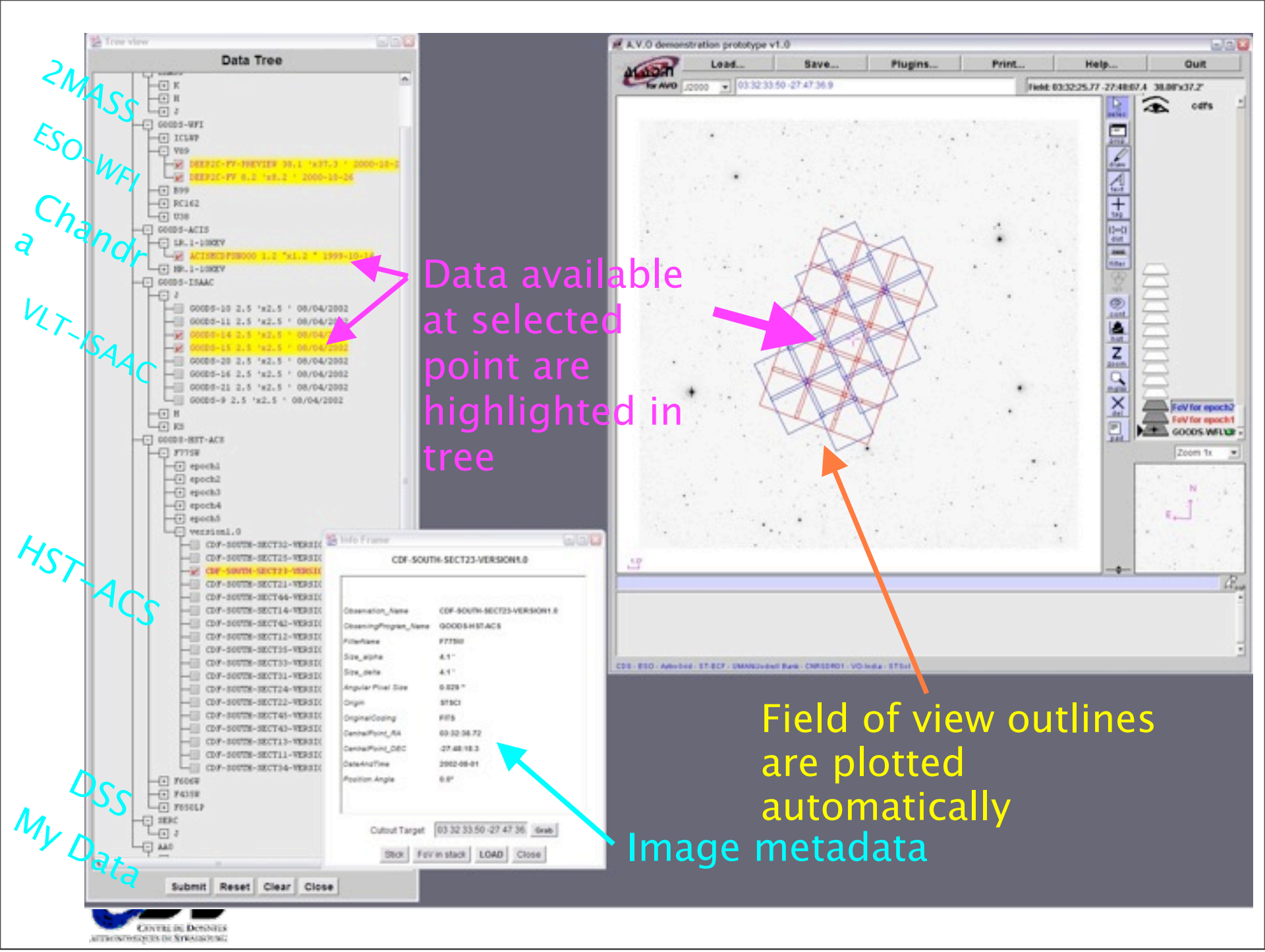
–Evolution of the technological context

# VO evolution

- The VO has never been solely a technology development
- Scientists and data providers participated from the beginning in the VO development
- Things had to be made in the proper order
- The basic building blocks (standards and tools) had to be – and have been – built, with in mind take-up by data centres and science users
- Now towards operational phase
- The focus is moving towards more support to take-up by scientists and data providers, plus outreach towards education

# VO Science requirements

- Science requirements have been present from the beginning
  - Scientists in VO projects
  - Science Advisory Committees or equivalent
  - Science demos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Data available at selected point are highlighted in tree
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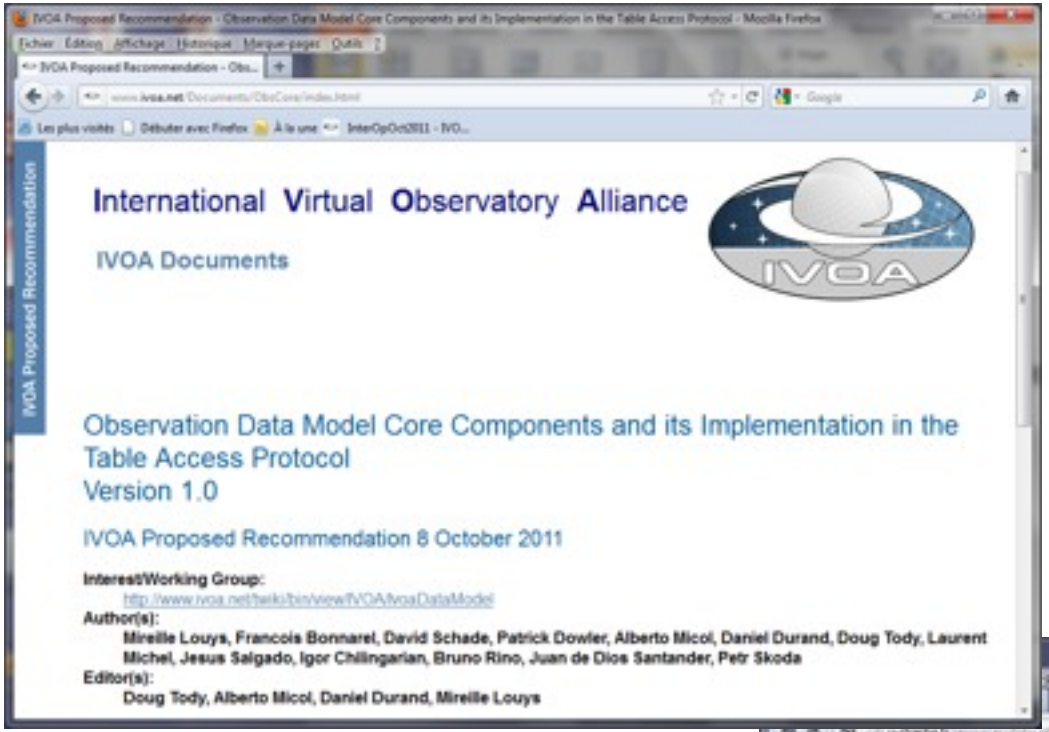
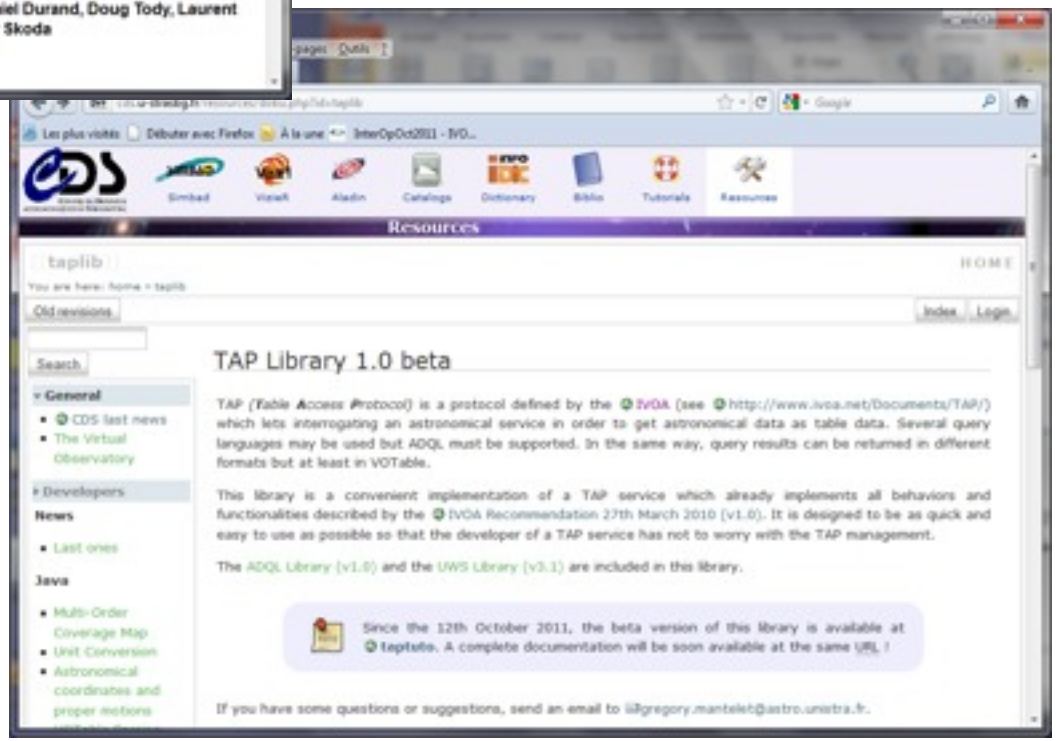
# Science feedback and priorities

- IVOA has set up a Committee, then a Standing Committee for Science Priorities to identify in high priority science cases, then gap analysis to identify the lacking standards
- First example: help implementation by data providers > the ObsDM metadata subset
- SED building, Search by object class/list
- Work more closely with the VO projects' Science Advisory Committees to gather 'global' requirements and feedback




TAP Library
with documentation
and tutorials

# Take-up by data providers

- A major action of IVOA during the last years has been to define a ‘simple’ subset of metadata to be provided by data providers to facilitate implementation, good enough for data discovery and access tools
- Huge diversity of possible data providers – the VO aims at giving access to the wealth of astronomical knowledge

# The Euro-VO census of data providers

- Census of European Data Centres (EuroVO-DCA, EuroVO-AIDA, 2009, 2010)
- Inclusive definition : Data Centres populate the VO with data and services, service to the community, added-value, sustainability, quality
- 69 ‘data centres’ answered
  - Data archives, services, theory data and services
- Some of these services are are widely used by scientists to access to bibliography, data and tools
- The provision of data and services has clearly been strongly encouraged by the development of the VO

# Data centres in Europe (and elsewhere!)

- A huge diversity in aims
  - large services provided by international agencies, with archives of the large ground-based and space instruments
  - large systematic surveys of the sky, results of large simulations
  - generalist data bases and services
  - smaller contributions of scientific teams which share their expertise
- Huge diversity in size and organisations
- An *ecosystem* of data and service providers willing to share data and knowledge - a distributed, heterogeneous system with no a central point nor hierarchical organisation

# Strands of work during operational phase

- Support to take-up by data providers
- Support to take-up by the scientific community
- Continuous technical development
  - Standards (update of existing standards and new standards because of feedback/evolutions) – VO teams + IVOA
  - Tools
- Outreach towards education and the general public (appeared in IVOA meeting in May 2011)

# Support to take-up

- Scientists
  - Topical ‘Community feedback’ workshop
  - Calls for proposals for advanced usage
  - Schools
  - Tutorial
- Data providers
  - Implementation tools
  - Tutorials
  - Data Centre Schools
  - Data Centre Forum to discuss requirements and feedback?

# IVOA evolution

- Better connection to get science requirements
- Implementation feedback
- Development of the information sharing role: on take-up activities, implementation tools, outreach activities, etc, although all these activities are not under IVOA responsibility

# VO status

- The strands of work necessary during operational phase are well understood
- The basic building blocks are here
- Major challenge: sustainability
- Interdisciplinary usage can appear as a must in many « political » contexts

# Interdisciplinary aspects

- IVOA had in mind to use generic components when possible. e.g. for two critical components for « wide » interoperability
  - Registry of Resources: OAI-PMH, Dublin Core
  - Vocabulary: RDF + SKOS (semantic web)
- Re-use/adaptation by other disciplines: pragmatic approach  through dissemination of knowledge through staff (HELIO et al., VAMDC)

# European VO specific challenge

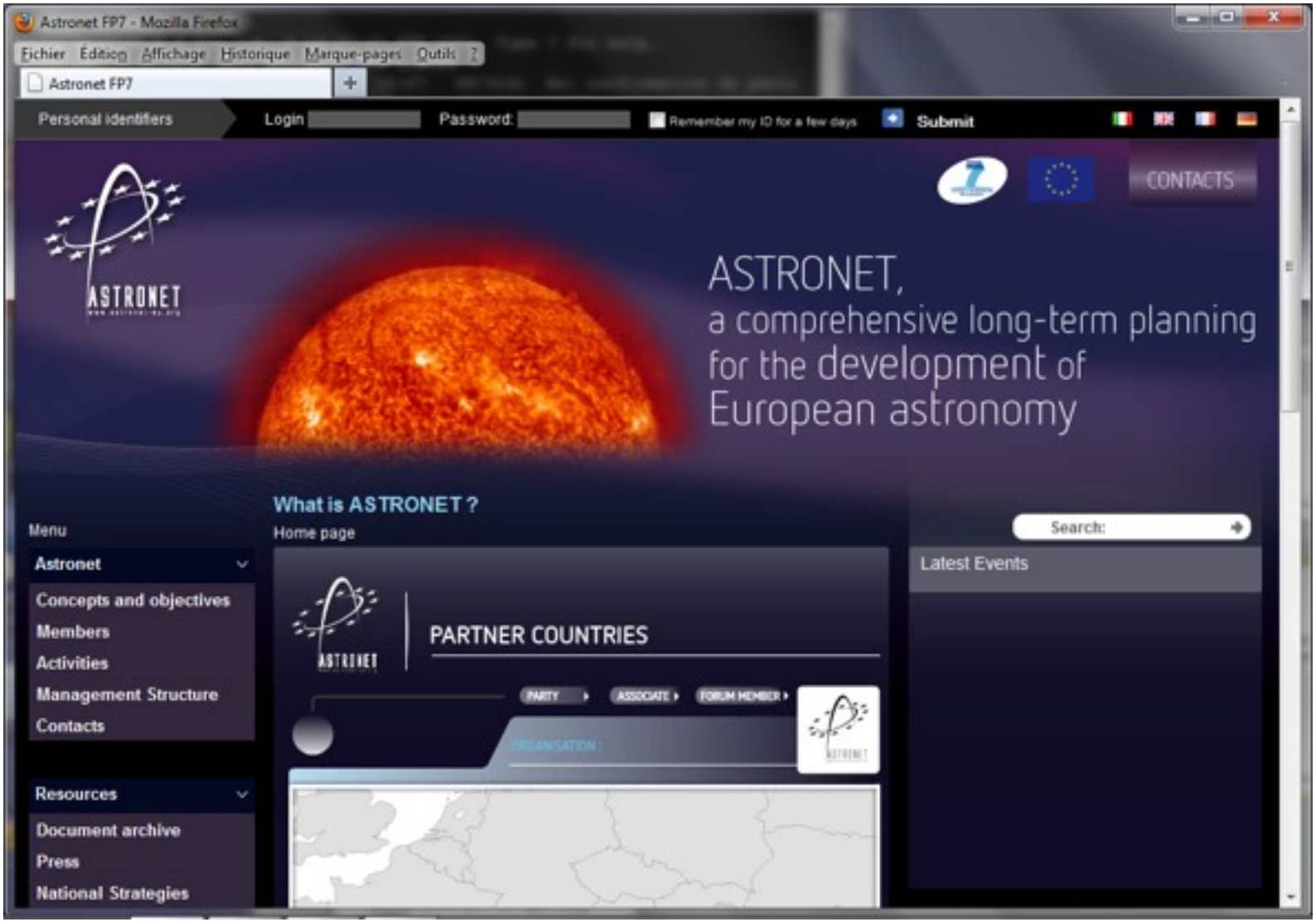
- A rich landscape including the two European Agencies, ESA and ESO, and national programmes
- Several of the founding parents of the astronomical VO
- *Challenge*: coordinate/federate VO projects
  - Different research/funding systems
  - Different projects
- Euro-VO: the European 'glue'
  - coordinate activities (e.g. regular Technology Forums)
  - reach all EU countries including those with no organised VO project
  - critical mass for Science Advisory Committee, support to take-up and outreach (templates re-used in the national context)

# Euro-VO Results

- A very significant increase in collaboration
  - Technical collaboration, e.g. on the definition of standards and tools but also on R&D
  - Different kinds of meetings which have shaped the collaborations and relations with data centres and users
- Attention given to non-partner European countries to support their communities and to help them shape their own politicies

# The European context

- Strategy for astronomy discussed and set-up by AstroNet ERA-NET, which includes ~all funding agencies from ~all EU countries
- Science Vision (2008) and Infrastructure Roadmap (2009)
- The VO is recognized as an important infrastructure of astronomy
- But the recommendations are not easy to implement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# European funding system

- European funding: a complex system which evolves continuously
  - Organized into successive Framework Programmes
  - Calls and « instruments »
- Euro-VO: a series of projects which progressively built the landscape
- Structured in phases in three successive Framework Programmes
  - Phase A (FP5): AVO, OPTICON Interoperability WG
  - Development (FP6): VO-TECH, EuroVO-DCA
  - Transition to operations (FP7): EuroVO-AIDA, EuroVO-ICE (on-going, 'bridging')

# The future for Euro-VO

- How to implement Astronet recommendation?
- Define articulation/balance between national/ Agency level and European level
- Sustainability of national/Agency projects
- Sustainability of the European layer
  - Strongly dependent on European funding opportunities
  - Continuing European/international coordination is mandatory
- Projects on-going in 'neighboring' disciplines (HELIO, Europlanet, VAMDC)


Astronet Roadmap


High Level Expert Group on Scientific Data

# The VO in the general context of scientific data policies

- The general context in which we work is rapidly evolving
  - High Level Expert Group: Collaborative Data Infrastructure
  - Requirement that data obtained on public funds are made publicly available
- Astronomy at the forefront: a global, heterogeneous, interoperable, OPEN, widely used, data infrastructure
- WE HAVE USERS: on-line services are everyday tools for the astronomical community
- Interdisciplinary usage is seen as the basis, but disciplinary pillars are necessary in a Collaborative Data Infrastructure
- Astronomy can be seen as an interesting use case! Let's convince our funding Agencies…