

The astronomical Virtual Observatory : lessons learnt, looking forward



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



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- 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



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Interoperability: first steps



- January 2002 Strasbourg
OPTICON European WG but
international participation
First Interoperability meeting – >
VOTable

CDS/NVO > Pre-IVOA standard

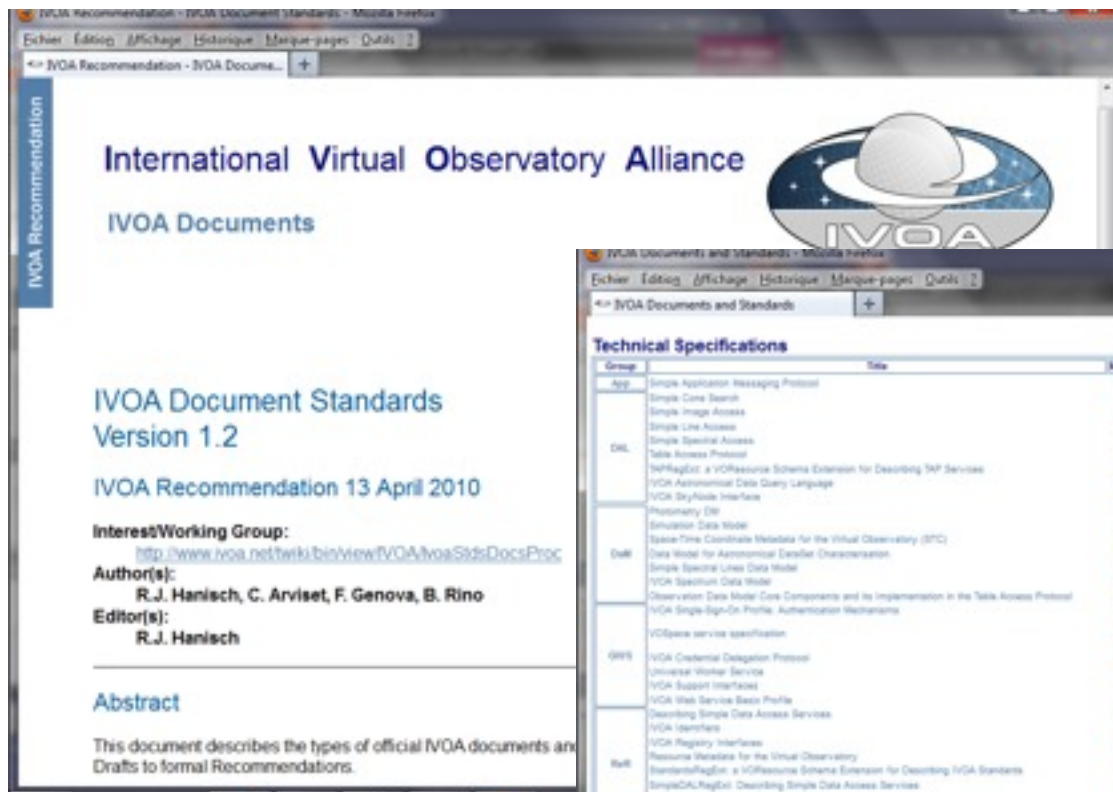
- June 2002 Garching
 - *Toward an International Virtual Observatory (ESO/ESA/NASA/NSF)*
 - Creation of IVOA



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Interoperability : IVOA standards




Group	Title	Most stable	In progress	Working Draft	Version history
APP	Simple Application Messaging Protocol	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	Simple Cone Search	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	Simple Image Access	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	Simple Line Access	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	Simple Spatial Access	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	Table Access Protocol	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	Table Access Protocol - a VOResource Schema Extension for Describing TAP Services	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	VOA Astronomical Data Query Language	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	VOA SkyNode Interface	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	Proximity DB	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
DEL	Simulation Data Model	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	Space-Time Coordinate Metadata for the Virtual Observatory (STC)	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	Data Model for Astronomical Datafile Characterization	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	Simple Spectral Lines Data Model	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	VOA Spectrum Data Model	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	Observation Data Model Core Components and its Implementation in the Table Access Protocol	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	VOA Single-Sign-On Profile: Authentication Mechanisms	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	VOData service specification	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	VOA Credential Delegation Protocol	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	Knowledge Worker Service	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
GWS	VOA Support Interfaces	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	VOA Web Service Basic Profile	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	Assembling Simple Data Access Services	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	VOA Identifiers	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	VOA Registry Interfaces	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	Resource Resolvers for the Virtual Observatory	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	StandardsRegistry - a VOResource Schema Extension for Describing IVOA Standards	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	SimpleCALRegistry - Describing Simple Data Access Services	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	VOResource - an XML Encoding Schema for Resource Metadata	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	VODataService - a VOResource Schema Extension for Describing Collections and Services	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
REG	An IVOA standard for Unified Content Descriptors	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	UCD1+ Controlled Vocabulary	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	Maintenance of the list of UCD words	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	Vocabularies in the Virtual Observatory	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	VOA Document Standards	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	VOA	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	Sky Event Reporting Standard (VOEvent)	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	VOT	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	VOTable Format Specification	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0
	VOTable	1.0.0			0.9.0 1.0.0 1.1.0 1.2.0

Procedure adapted from W3C



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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



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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



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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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2MASS
ESO-WFI
Chandra
VLT-ISAAC
HST-ACS
DSS
My Data

Data Tree

- K
- H
- Z
- 00000-WFI
- IC1897
- Y80
- DEEP2C-PT 0.1 *x2.5 * 0000-18-2
- DEEP2C-PT 0.2 *x2.5 * 2000-15-06
- B99
- PC142
- U38
- 00000-ACIS
- SR-1-10KEY
- AC11003 P1000 1.2 *x1.2 * 1999-10-14
- SR-1-10KEY
- 00000-ISAAC
- Z
- 00000-10 2.5 *x2.5 * 08/04/2002
- 00000-11 2.5 *x2.5 * 08/04/2002
- 00000-14 2.5 *x2.5 * 08/04/2002
- 00000-15 2.5 *x2.5 * 08/04/2002
- 00000-20 2.5 *x2.5 * 08/04/2002
- 00000-16 2.5 *x2.5 * 08/04/2002
- 00000-21 2.5 *x2.5 * 08/04/2002
- 00000-9 2.5 *x2.5 * 08/04/2002
- H
- K0
- 00000-BST-ACS
- F775W
- epoch2
- epoch3
- epoch4
- epoch5
- ve220001.0
- CDP-SOUTH-SECT23-VERSION1.0
- CDP-SOUTH-SECT23-VERSION1.0
- CDP-SOUTH-SECT23-VERSION1.0
- CDP-SOUTH-SECT21-VERSION1.0
- CDP-SOUTH-SECT44-VERSION1.0
- CDP-SOUTH-SECT14-VERSION1.0
- CDP-SOUTH-SECT42-VERSION1.0
- CDP-SOUTH-SECT12-VERSION1.0
- CDP-SOUTH-SECT35-VERSION1.0
- CDP-SOUTH-SECT33-VERSION1.0
- CDP-SOUTH-SECT31-VERSION1.0
- CDP-SOUTH-SECT24-VERSION1.0
- CDP-SOUTH-SECT22-VERSION1.0
- CDP-SOUTH-SECT43-VERSION1.0
- CDP-SOUTH-SECT43-VERSION1.0
- CDP-SOUTH-SECT43-VERSION1.0
- CDP-SOUTH-SECT13-VERSION1.0
- CDP-SOUTH-SECT11-VERSION1.0
- CDP-SOUTH-SECT34-VERSION1.0
- F606W
- F435W
- F555LP
- DEBC
- Z
- AA0

Data available at selected point are highlighted in tree

A.V.O demonstration prototype v1.0

Load... Save... Plugins... Print... Help... Quit

File: 03:32:25.77 -27:47:36.9

Field: 03:32:25.77 -27:47:36.9 38.89"x37.7

CDP - ESO - Acl1004 - ST-BCF - UMARJ04040 Base - CNR0001 - VO-104 - ST-501

Field of view outlines are plotted automatically

Info Frame

CDF-SOUTH-SECT23-VERSION1.0

Observation_Name	CDF-SOUTH-SECT23-VERSION1.0
ObservingProgram_Name	00000-HSTACS
FilterName	F775W
Size_alpha	4.1"
Size_delta	4.1"
Angular Pixel Size	0.829"
Origin	SIT1
OriginalCoding	FITS
CenterPoint_RA	03:32:38.72
CenterPoint_DEC	-27:48:18.3
DataAcqTime	2002-08-01
Position Angle	0.0°

Cutout Target: 03:32:33.50 -27:47:36.9

Stick Fov in stack LOAD Close

Image metadata

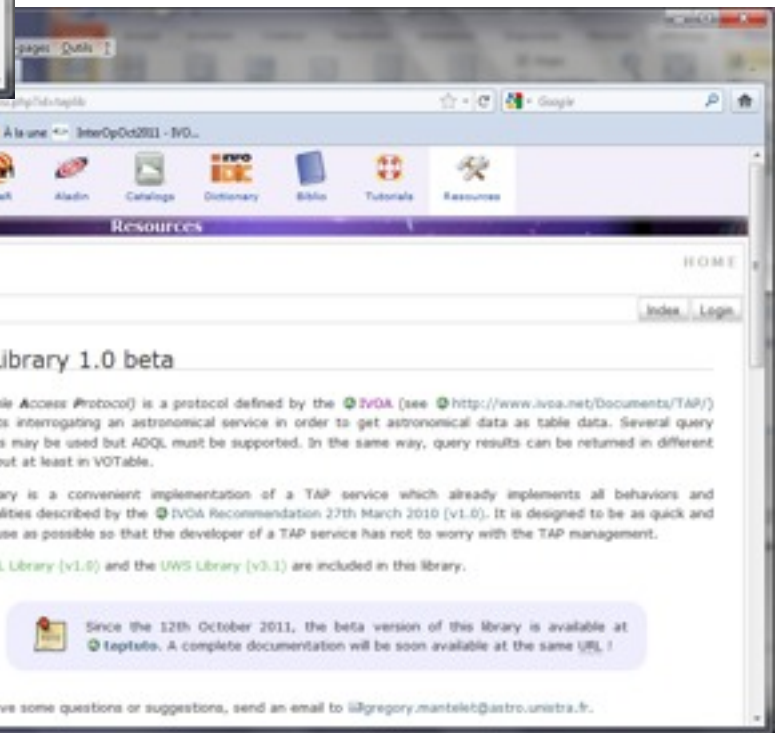
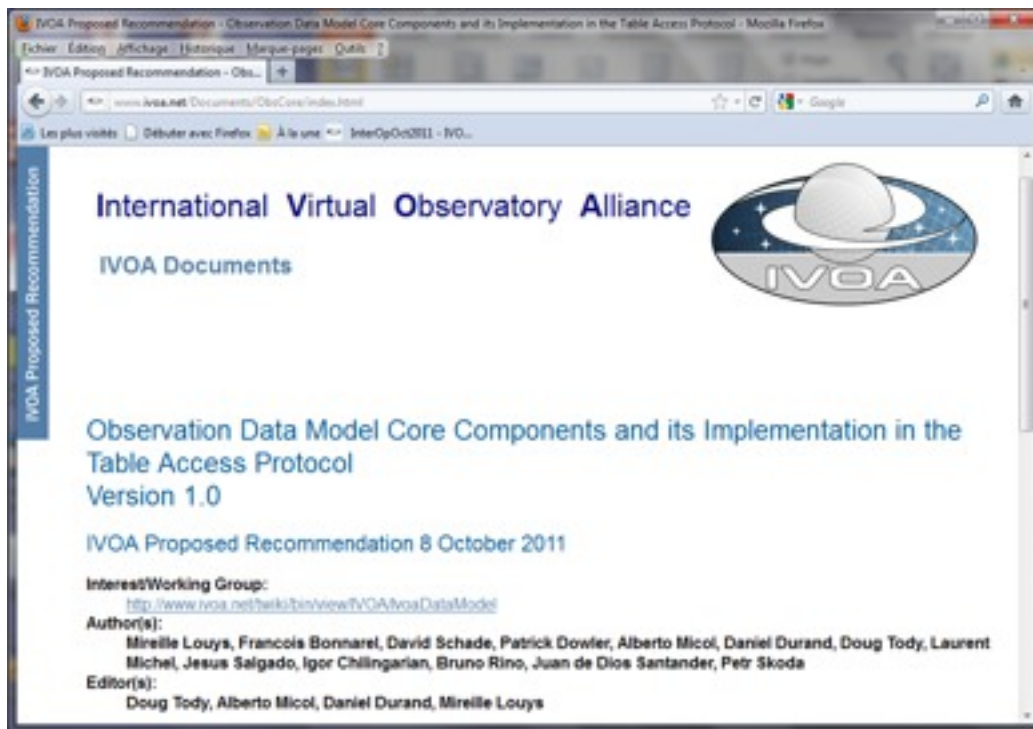
Science feedback and priorities

- 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



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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



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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 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



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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



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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)



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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?



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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



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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)



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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 policies



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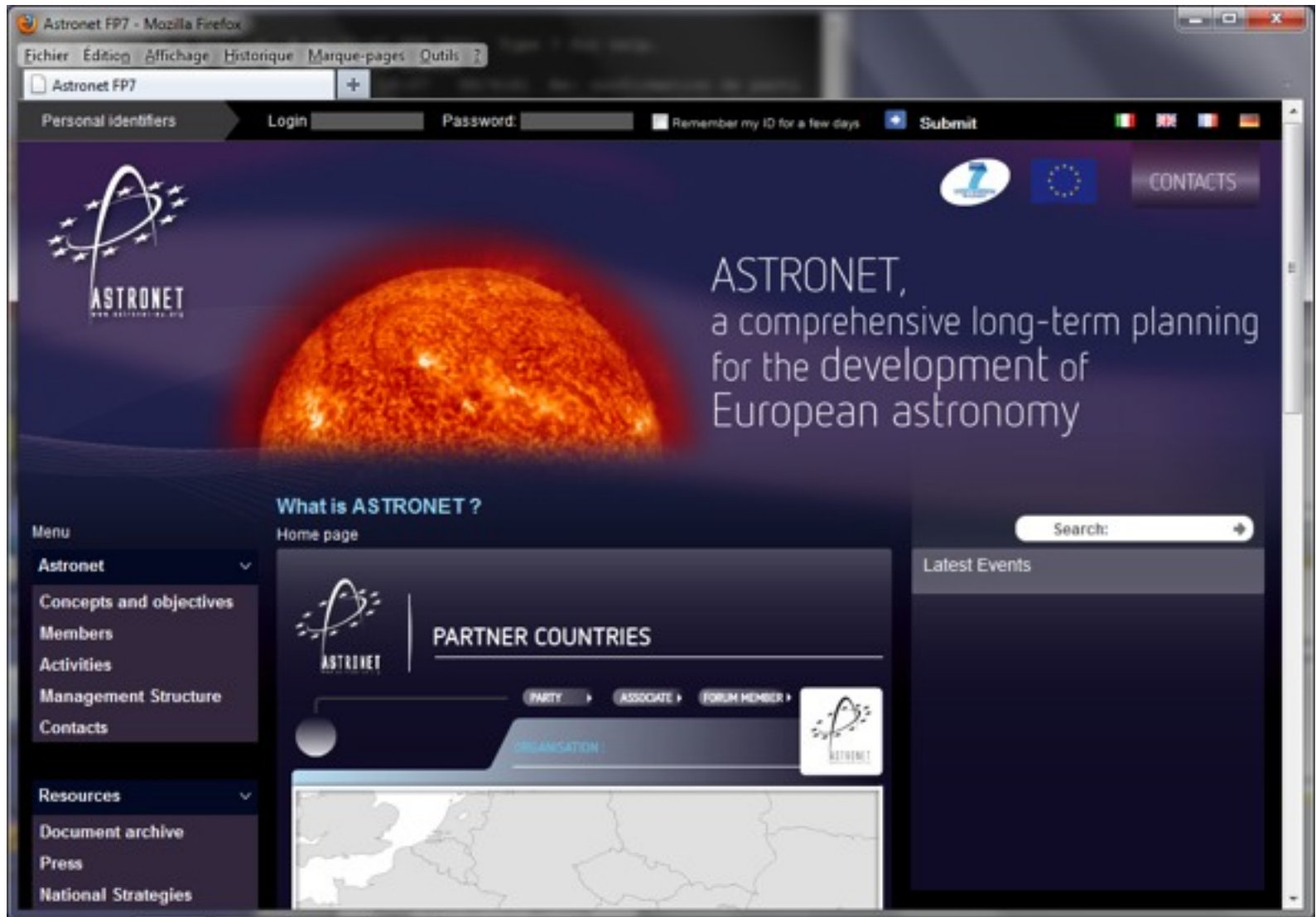
The European context

- 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’)



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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)



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Astronet Roadmap



High Level Expert Group on Scientific Data



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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...



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