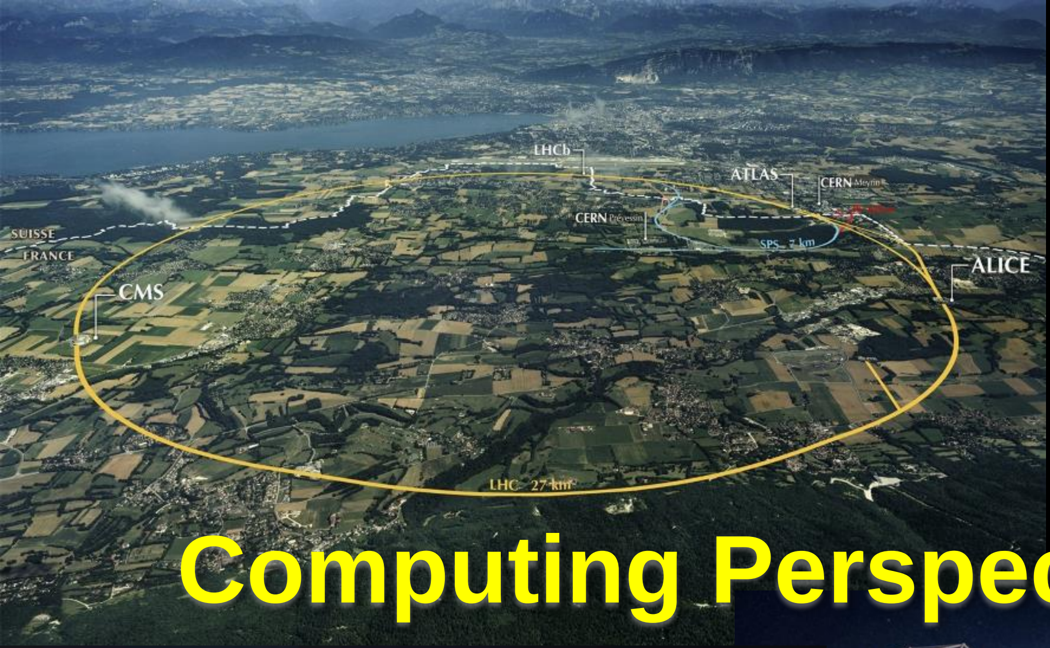
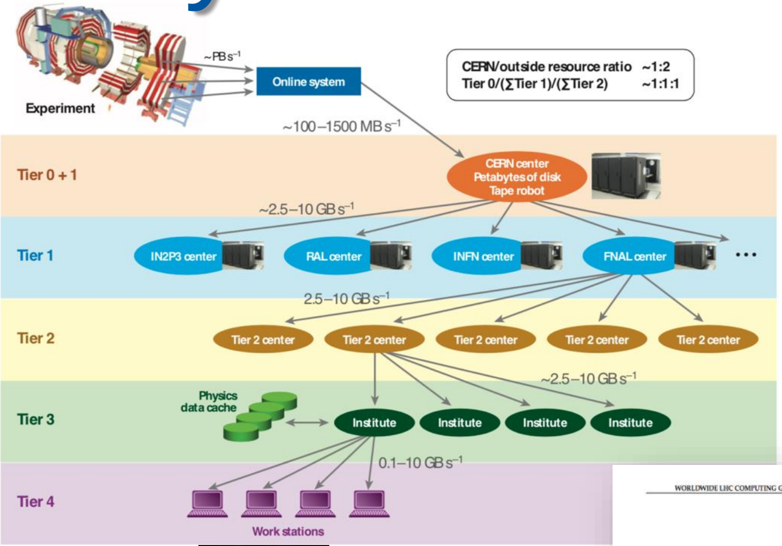


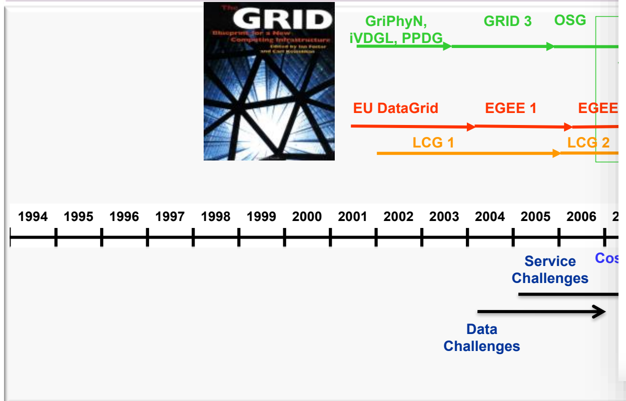
Ian Bird
LAPP/ESCAPE

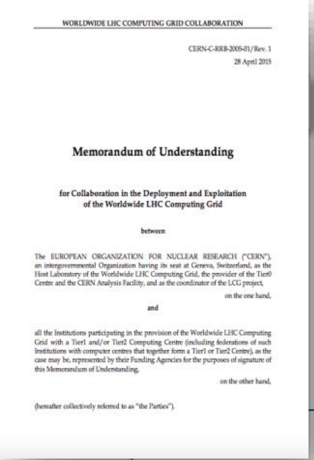
vCHEP21
17th May 2021

Computing Perspectives

20 years of federated infrastructure







WORLDWIDE LHC COMPUTING GRID COLLABORATION

CERN-C-RRB-2005-01/Rev. 1
28 April 2015

Memorandum of Understanding

for Collaboration in the Deployment and Exploitation of the Worldwide LHC Computing Grid

between

The EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH ("CERN"), an intergovernmental Organization having its seat at Geneva, Switzerland, as the Host Laboratory of the Worldwide LHC Computing Grid, the provider of the Tier0 Centre and the CERN Analysis Facility, and as the coordinator of the LCG project,

on the one hand,

and

all the Institutions participating in the provision of the Worldwide LHC Computing Grid with a Tier1 and/or Tier2 Computing Centre (including federations of such Institutions with computer centres that together form a Tier1 or Tier2 Centre), as the case may be, represented by their Funding Agencies for the purposes of signature of this Memorandum of Understanding,

on the other hand,

(hereafter collectively referred to as "the Parties").

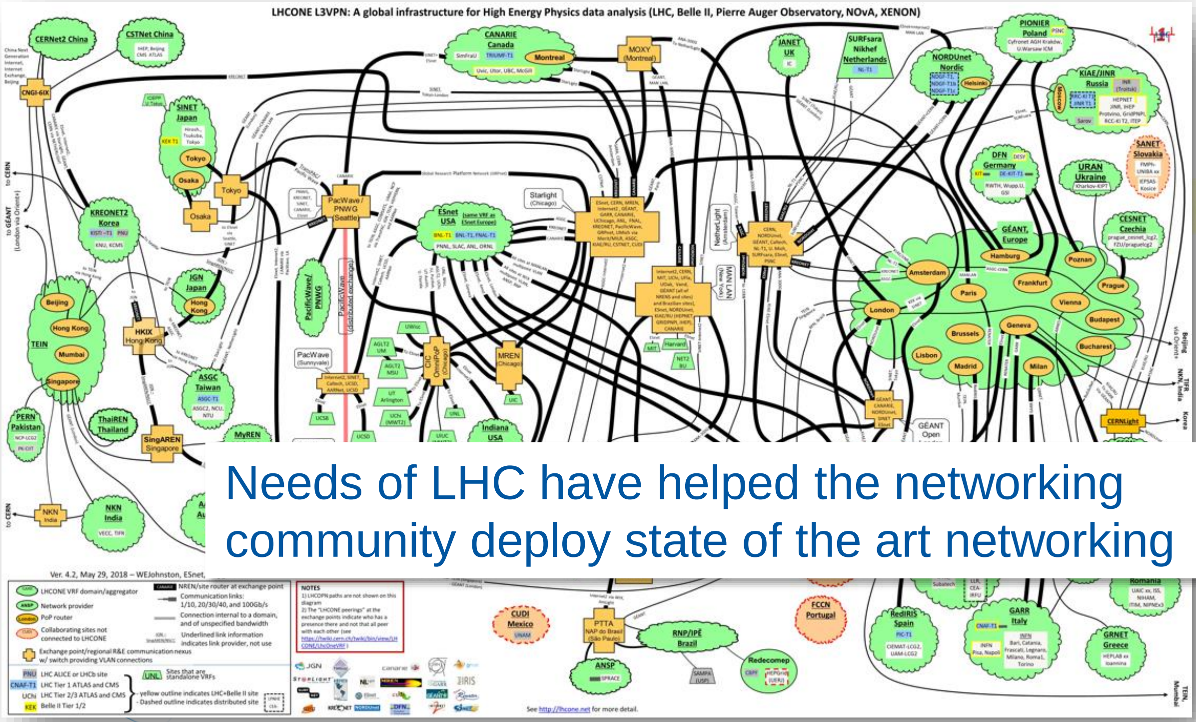
- ❑ Model designed in 1999
- ❑ Uncertainty over network performance, reliability
- ❑ Focus on distributing data *globally* to compute resources
- ❑ No concept of data remote from compute
- ❑ Quickly evolved

Major features and capabilities of todays HEP computing infrastructures:

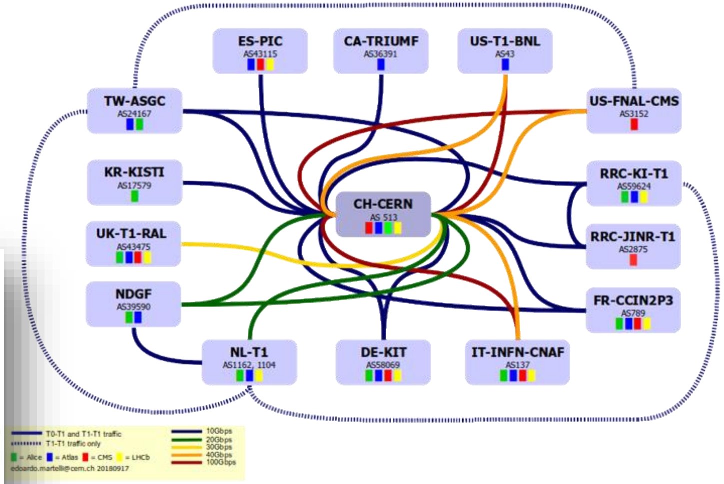
- Networks – international and national, private and public
- Data management – key to success, data transfers, storage systems, data management tools and data organization
- Compute – provisioning of resources and workload scheduling; evolution of types of resources
- AAI (Authentication, Authorization Infrastructure) - the mechanism of federation, single sign on, etc.
- Operations support – security, incident response, problem tracking, daily operations, upgrade campaigns
- Other common services – software delivery, databases and db replication/caching, etc.
- Diverse experiment-specific services and tools – applications

Networks

- OPN – private connections – managed by WLCG
- LHCOne – Virtual Overlay on national academic networks – managed by NRENs
  - Also used by many other "HEP & related" experiments

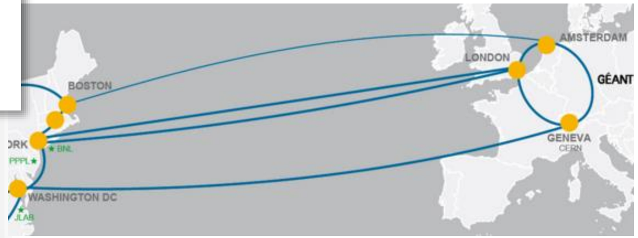


Needs of LHC have helped the networking community deploy state of the art networking



WAN bandwidth increased x10 in 10 years

Significant transatlantic capacity



Some lessons and comments

- A *trusted* federated infrastructure is of tremendous value and importance
  - This is the *key* feature that identifies our collaborative distributed infrastructure
  - Even though the X.509 model was difficult to use and manage
  - Security coordination; policies, incident response, vulnerability & threat intelligence is of huge value
  - Sociological – inclusivity

- The network is a fundamental resource and opportunity, not a problem to be solved
  - Redundancy and distribution of services as originally foreseen was unnecessary, complex, and expensive
  - Today service model is much simplified and streamlined

- Today's operational structure is very simple – coordination at a high level, no need for the heavyweight operations centres

- Distributed data management and storage is expensive – hardware and operations
  - Data pre-placement is not an optimal strategy (it is a complex problem)

- Hardware and cost evolution is becoming a serious concern –
  - "Moore's law" as we assumed it is broken
  - Future of storage technology is a concern – tape and disk
  - The future computational resources are very heterogenous

Some lessons and comments

- Relationship with network providers has been very important – bi-directional

- Relationship with e-infrastructures has gone through phases
  - Their need to serve a broad community means often less responsive to more rapidly changing needs and computing models of specific communities like HEP
  - There is a low-level layer that can be common across communities (e.g. AAI, procurement models, policies), most other aspects today in the domain of the science communities
    - Important to remember when we discuss e.g. EOSC

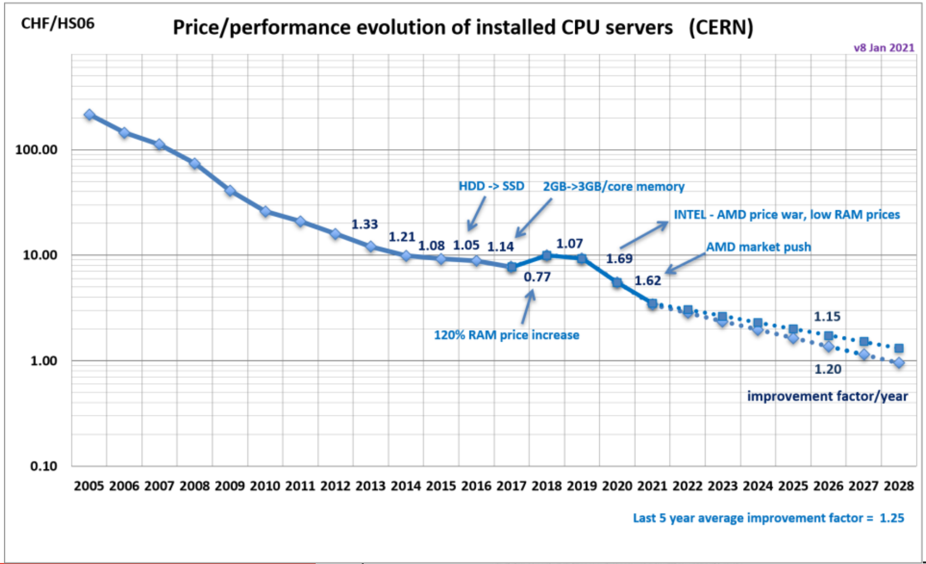
Challenges & drivers of change

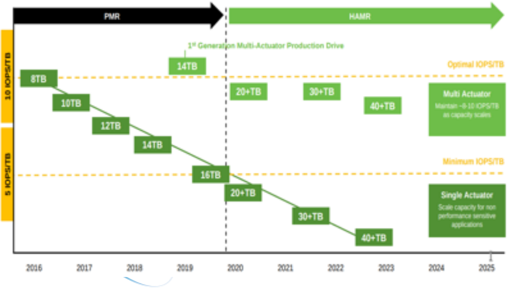
- HL-LHC scale and timeline
  - Cost-effective computing and sustainability essential
  - No expectation of increased budgets despite scale of computing needed
- Other sciences reaching similar scales
  - Especially in related domains we must co-exist e.g. in data centres
  - Cooperation and collaboration is beneficial and natural
- New initiatives for Open Science oblige us to work differently
  - Pre-requisite for some funding
  - To our advantage long term
- Hardware price/performance has stagnated / flattened. ➔
- Hardware evolution has accelerated
  - For many years we had single architecture, similar cluster-based resources, well defined storage models
  - Pressure to include HPC, cloud into our computing models
  - Network-based computing is ubiquitous – not just for science

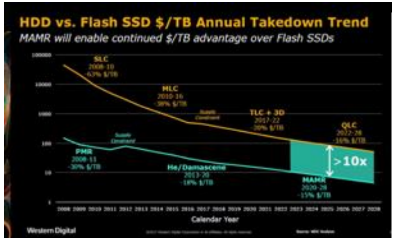
Hardware cost evolution

- Previous assumptions of ~20%/year effective cost improvement for CPU & storage no longer true
- *Market-driven* rather than technology
- Science has no influence on these markets

- We have serious risks:
- Our budget outlooks are constrained
- Risk of technologies disappearing
  - e.g. tape due to market forces
  - disk technology future not clear – costs not obvious








The Register
Biting the hand that feeds IT

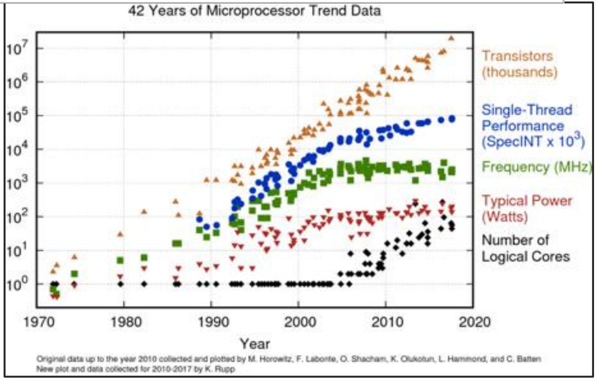
Data Centre › Storage

Did Oracle just sign tape's death warrant? Depends what 'no comment' means

Big Red keeps schtum over the status of StreamLine

By Chris Mellor 17 Feb 2017 at 10:44

Oracle's StorageTek (StreamLine) tape library product range will be end-of-lifed, *El Reg* has learned.



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➢ All point towards an evolved strategy for the future

Evolution of HEP computing

HSF-CWP-2017-01
December 15, 2017

arXiv:1712.06982v5 [physics.comp-ph] 19 Dec 2018

A Roadmap for HEP Software and Computing R&D for the 2020s

HEP Software Foundation[1]

ABSTRACT: Particle physics has an ambitious and broad experimental programme for the coming decades. This programme requires large investments in detector hardware, either to build new facilities and experiments, or to upgrade existing ones. Similarly, it requires commensurate investment in the R&D of software to acquire, manage, process, and analyse the shear amounts of data to be recorded. In planning for the HL-LHC in particular, it is critical that all of the collaborating stakeholders agree on the software goals and priorities, and that the efforts complement each other. In this spirit, this white paper describes the R&D activities required to prepare for this software upgrade.

[1] Authors are listed at the end of this report.

https://doi.org/10.1007/s41781-018-0018-8

WLCG-LHCC-2018-001
05 April 2018

WLCG Strategy towards HL-LHC

Executive Summary

The goal of this document is to set out the path towards computing for HL-LHC in 2026/7. Initial estimates of the data volumes and computing requirements show that this will be a major step up from the current needs, even those anticipated at the end of Run 3. There is a strong desire to maximise the physics possibilities with HL-LHC, while at the same time maintaining a realistic and affordable budget envelope. The past 15 years of WLCG operation, from initial prototyping through to the significant requirements of Run 2, show that the community is very capable of building an adaptable and performant service, building on and integrating national and international structures. The WLCG and its stakeholders have continually delivered to the needs of the LHC during that time, such that computing has not been a limiting factor. However, in the HL-LHC era that could be very different unless there are some significant changes that will help to moderate computing and storage needs, while maintaining physics goals. The aim of this document is to point out where we see the main opportunities for improvement and the work that will be necessary to achieve them.

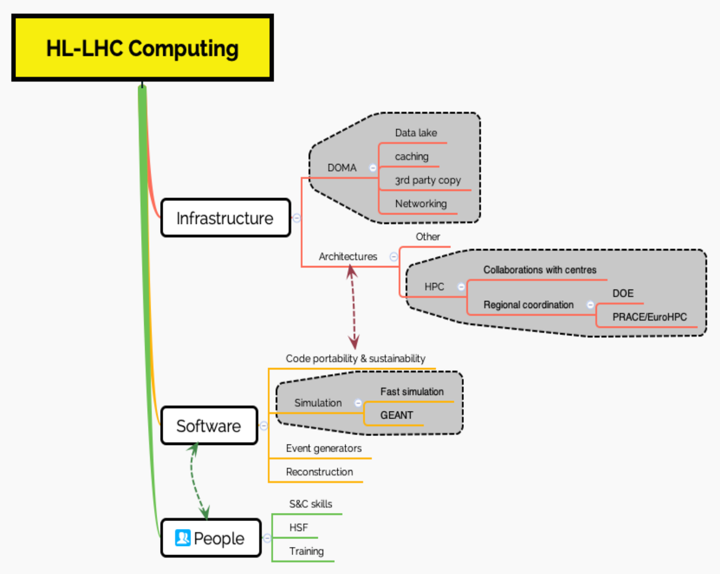
During 2017, the global HEP community has produced a white paper - the Community White Paper (CWP), under the aegis of the HEP Software Foundation (HSF). The CWP is a ground-up gathering of input from the HEP community on opportunities for improving computing models, computing and storage infrastructures, software, and technologies. It covers the entire spectrum of activities that are part of HEP computing. While not specific to LHC, the WLCG gave a charge to the CWP activity to address the needs for HL-LHC along the lines noted above. The CWP is a compendium of ideas that can help to address the concerns for HL-LHC, but by construction the directions set out are not all mutually consistent, not are they prioritised. That is the role of the present document - to prioritise a program of work from the WLCG point of view, with a focus on HL-LHC, building on all of the background work provided in the CWP, and the experience of the past.

At a high level there are a few areas that clearly must be addressed, that we believe will improve the performance and cost effectiveness of the WLCG and experiments:

- **Software:** With today's code the performance is often very far from what modern CPUs can deliver. This is due to a number of factors, ranging from the construction of the code, not being able to use vector or other hardware units, layout of data in memory, and end-end I/O performance. With some level of code re-engineering, it might be expected to gain a moderate factor (x2) in overall performance. This activity was the driver behind setting up the HSF, and remains one of the highest priority activities. It also requires the appropriate support and tools, for example to satisfy the need to fully automate the ability to often perform physics validation of software. This is essential as we must be adaptable to many hardware types and frequent changes and optimisations to make the best use of opportunities. It also requires that the community develops a level of understanding of how to best write code for performance, again a function of the HSF.

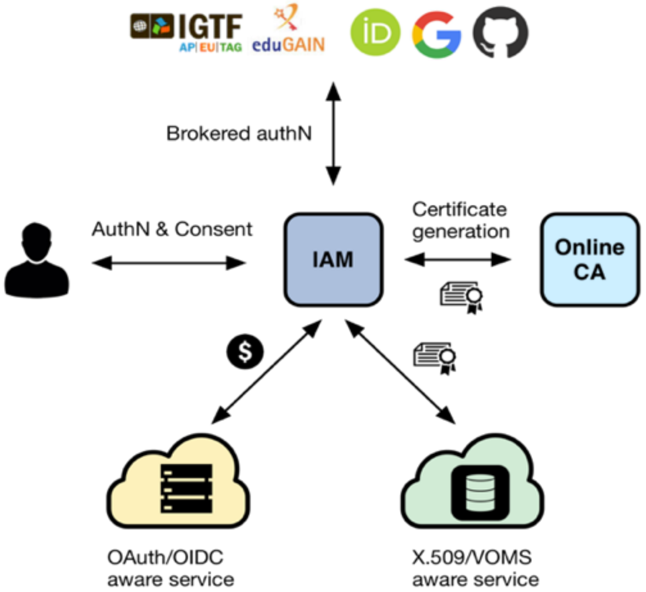
1

https://cds.cern.ch/record/2621698



Authentication, Authorization, Identity

- AAI follows the blueprint of the FIM4R working group
  - **being implemented across e-infrastructures globally**
- Migration to token-based AAI
- Migration will take time; translation will be needed for some time
- EOSC/EOSC-Future will integrate the same model (as do other cyber- and e-infrastructures)
- Important to maintain the existing trust networks



Data Infrastructure

DOMA project in WLCG ➔ ESCAPE

Ideas picked up in many regions and collaborations

Idea is to **localize bulk data** in a cloud service
(Tier 1's ➔ data lake):
minimize replication, assure availability; policy driven

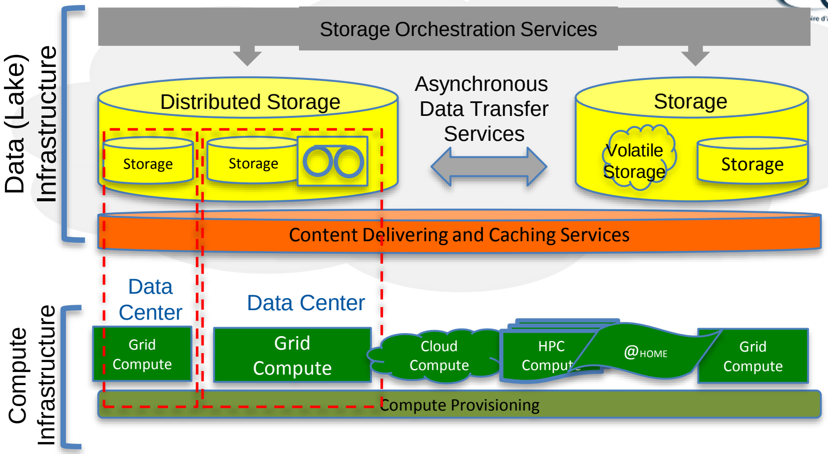
Serve data to remote (or local) compute – grid, cloud, HPC, etc.
Simple caching is all that is needed at compute site

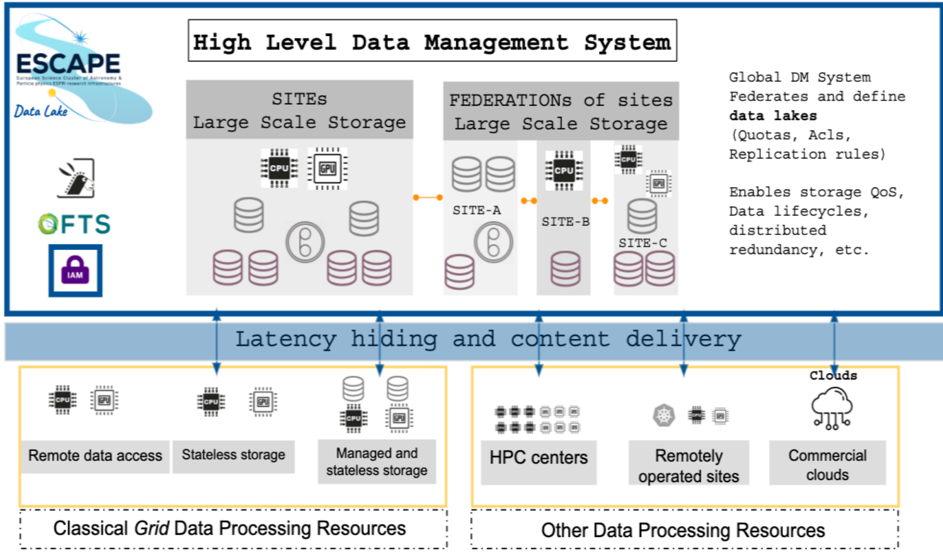
Works at national, regional, global scales

Model to **integrate** private and commercial storage – in a "RAID" configuration across sites

Solid **demonstrations** happening, e.g. in ESCAPE and others
shown to work for many experiments not just LHC

➔ Can ensure **FAIR**ness of scientific data





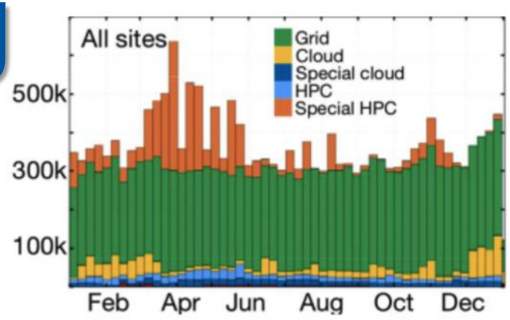
Heterogeneous computing

- Heterogeneity will be the norm in future
  - Use of HPC, encouraged or obliged
    - many policy, and practical issues to address
  - Use of accelerators or co-processors for specific tasks
  - Incorporation of commercial cloud resources (which may include the above)
    - Cost is still an issue
- In addition new models of compute and storage provisioning may be arriving

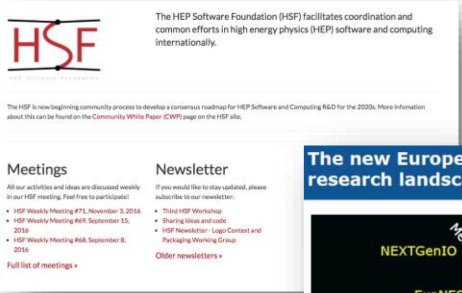
  e.g. dynamic composability of hardware and software systems, cluster co-processors etc., storage in the network

  Not forgetting quantum computing …
- All of this requires significant investment in software and training, as well as policy, scheduling, infrastructure and service adaptations
  - Maintain flexibility and adaptability
- Close collaboration with other sciences with different/complementary needs may help to offset the costs
- NB: collaborate to avoid other communities re-inventing existing solutions

  e.g. HPC inventing data management solutions



New Summit HPC @ ORNL:
9.96 Pflops in CPU (**non X86_64**)
215.7 Pflops in GPUs


HSF

The HEP Software Foundation (HSF) facilitates coordination and common efforts in high energy physics (HEP) software and computing internationally.

The HSF is now beginning community process to develop a consensus roadmap for HEP Software and Computing R&D for the 2020s. More infomation about this can be found on the Community White Paper (CWP) page on the HSF site.

Meetings

All our activities and ideas are discussed weekly in our HSF meeting. Feel free to participate!

- HSF Weekly Meeting #71, November 3, 2016
- HSF Weekly Meeting #69, September 15, 2016
- HSF Weekly Meeting #68, September 8, 2016

Full list of meetings »

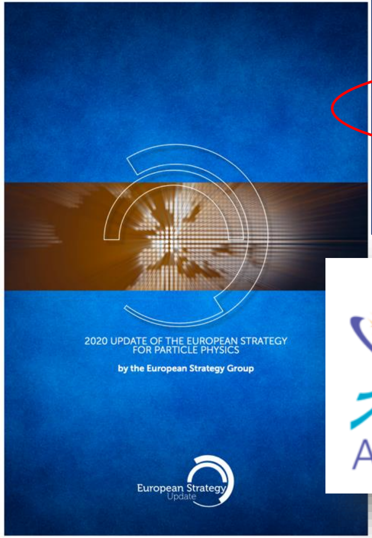
Newsletter

If you would like to stay updated, please subscribe to our newsletter:

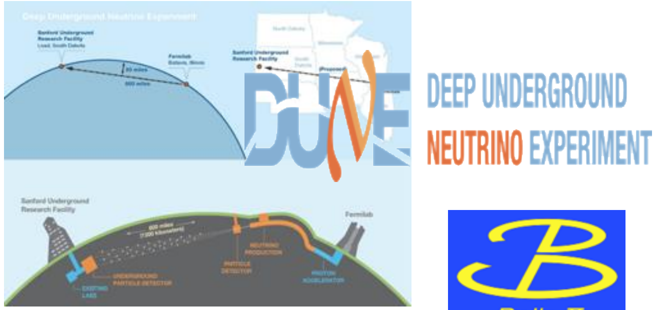
- Third HSF Workshop
- Sharing ideas and code
- HSF Newsletter - Logo Contest and Packaging Working Group

Older newsletters »

The 2020 European Strategy



D. Large-scale data-intensive software and computing infrastructures are an essential ingredient to particle physics research programmes. The community faces major challenges in this area, notably with a view to the HL-LHC. As a result, the software and computing models used in particle physics research must evolve to meet the future needs of the field. ***The community must vigorously pursue common, coordinated R&D efforts in collaboration with other fields of science and industry, to develop software and computing infrastructures that exploit recent advances in information technology and data science. Further development of internal policies on open data and data preservation should be encouraged, and an adequate level of resources invested in their implementation.***



Belle II

Astroparticle Physics European Consortium (APPEC)

APPEC

APPEC Contribution to the European Particle Physics Strategy

December 17, 2018

Editorial Board:
S. Katsanevas, A. Masiero, T. Montaruli, J. de Kleuver, A. Haungs

Contact Person:
T. Montaruli (APPEC Chair from Jan. 1, 2019)
Email: teresa.montaruli@unige.ch

Website: http://www.appec.org

The scientific outcomes of particle physics experiments are made possible by the development of an efficient computing and software infrastructure. Computing and software are profound R&D topics in their own right and are essential to sustain and enhance particle physics research capabilities. There is a need for strong community-wide coordination for computing and software R&D activities, and for the development of common coordinating structures that will promote coherence in these activities, long-term planning and effective means of exploiting synergies with other disciplines and industry. Some recently initiated examples are the HEP Software Foundation addressing the common computing and software challenges related to particle physics, and ESCAPE (European Science Cluster of Astronomy & Particle physics ESFRI research infrastructures) exploring the synergies in the areas of astronomy, astroparticle and accelerator-based particle physics.

APS Division of Particles and Fields Response to European Strategy Group Call for White Papers:
Tools for Particle Physics

DPF Executive Committee and Strategy Whitepaper Editing Group
dpfstrategy@fnal.gov

December 18, 2018

Abstract

The U.S. particle physics strategy process is summarized in a companion white paper that also describes U.S. activities related to the five P5 science drivers. Additional activities within the U.S. particle physics program that are critical to progress in our field are described here.

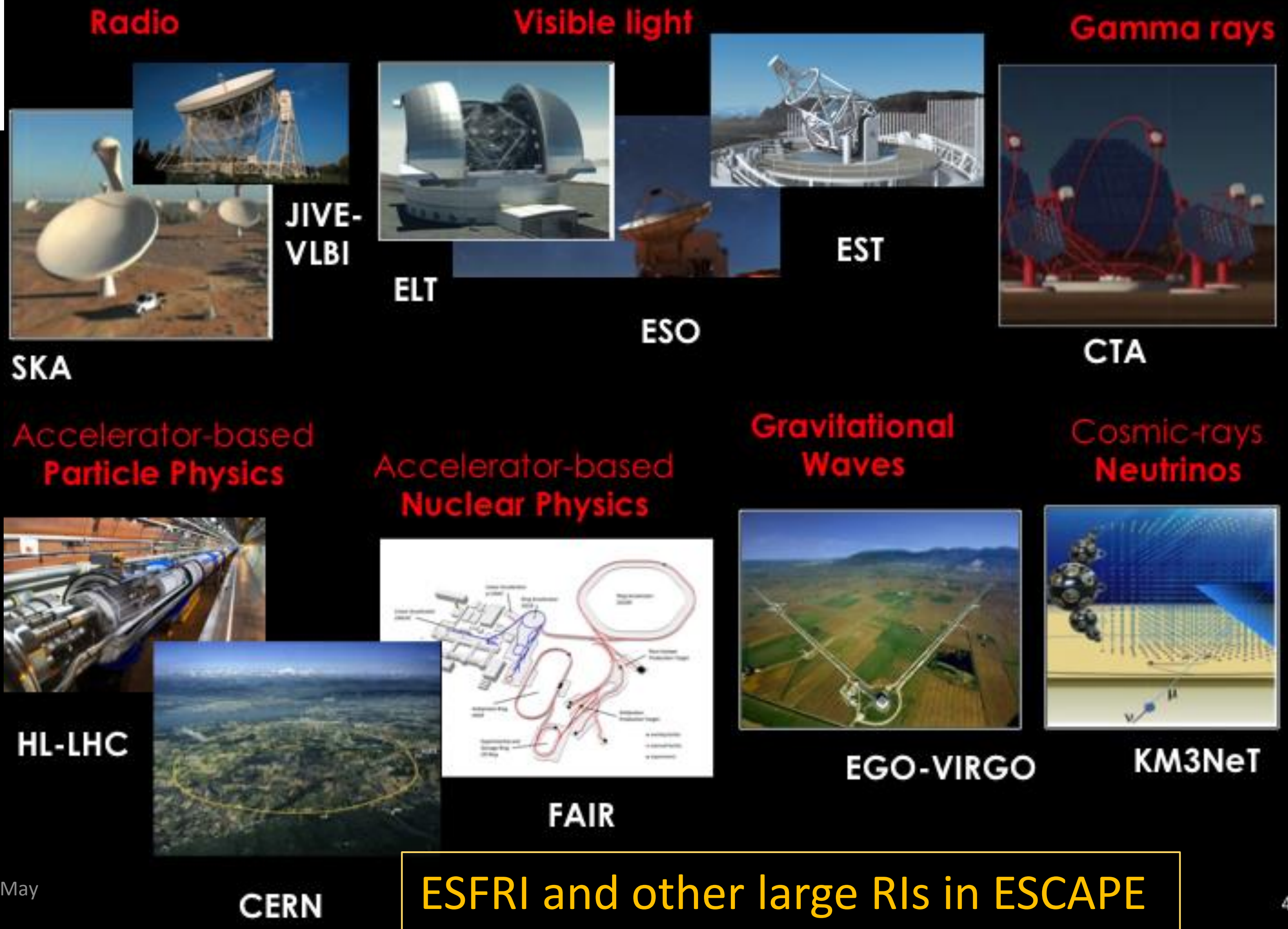
B. The particle physics community and the European Commission have a strong record of collaboration. ***The relationship between the particle physics community and the European Commission should be further strengthened, exploring funding-mechanism opportunities for the realisation of infrastructure projects and R&D programmes in cooperation with other fields of science and industry.***

C. European science policy is quickly moving towards Open Science, which promotes and accelerates the sharing of scientific knowledge with the community at large. Particle physics has been a pioneer in several aspects of Open Science. ***The particle physics community should work with the relevant authorities to help shape the emerging consensus on Open Science to be adopted for publicly-funded research, and should then implement a policy of Open Science for the field.***

Common challenges

- Management of Exabyte- scale science data
  - And associated tools, networks, infrastructure
- Move from “simple” x86-like clusters to very heterogenous resources
  - Use of HPC and Exascale computing resources
- Infrastructures & centres likely to be common between HEP & Astronomy, Astroparticle, GW, etc.
- Software challenge – associated with the above
  - How to easily move code between various compute resources, validate correctness, adapt to new architectures, etc.
  - HSF as a collaborative mechanism – lots of interest
- Develop and retain skills in software and computing
  - In the scientific community – as well as with specialists
  - Issue of recognition in academic environments

ESCAPE
European Science Cluster of Astronomy & Particle physics ESFRI research Infrastructures



ESFRI and other large RIs in ESCAPE

ESCAPE: Astronomy and Particle Physics ESFRIs

- **Aligned expectations**:
  - **Large volume data** generators (up to multi-Exabyte scale level)
  - **“Observatory” and “Facility”** type of operation require global open access and long-term sustainability of research data
  - The **astrophysics** and the **accelerator-based** particle/nuclear physics **ESFRI** facilities join in a **multi-probe approach** towards the understanding of the Universe
    - Addressing expectations of new generation of researchers for a **“virtual space” -** sharing workflows and interoperatable data
    - Acknowledge commitment of scientists (on transversal research)
  - Engage with society and citizens

- **Enhance coordination**:
  - leveraging two major complementary excellences in data stewardship:
    - the astronomy **Virtual Observatory** infrastructure;
    - long-standing expertise of the **HEP** community in large-scale distributed computing and big-data management
  - operating a shared open innovation environment, adopting and enhancing FAIR/Open-Science principles

Funded by the European Union’s Horizon 2020 - Grant N° 824064

ESCAPE in a nutshell

- **31** partners (including 2 SMEs)
- **7** ESFRI projects & landmarks: **CTA, ELT, EST, FAIR, HL-LHC, KM3NeT, SKA**
- **2** pan-European International Organizations: **CERN, ESO** (with their world-class established infrastructures, experiments and observatories).
- **2** European research infrastructures: **EGO** and **JIV-ERIC**

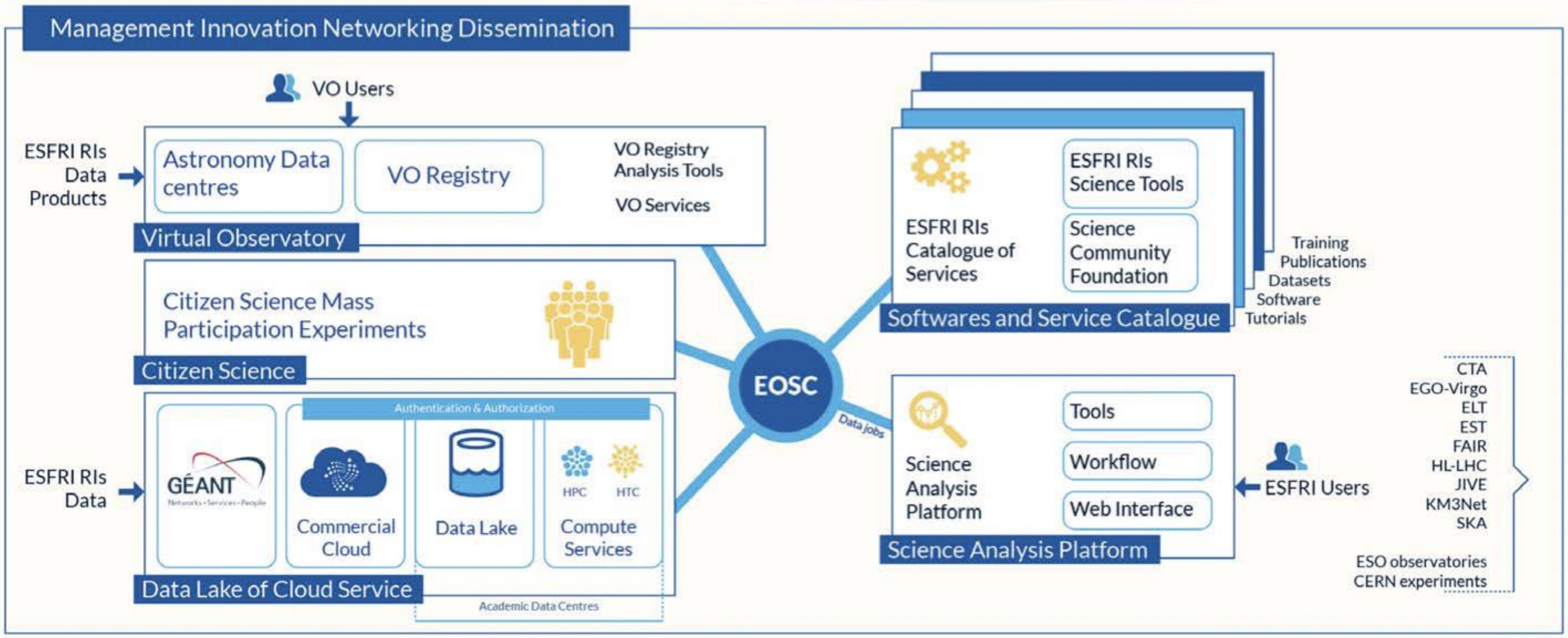
Formal commitment of their legal entities and management boards required by EC

- **1** involved initiative/infrastructure: EURO-VO
- **4** supporting European consortia: APPEC, ASTRONET, ECFA and NuPECC.

- Budget: **15.98 M€**
- Started: **1/2/2019**
- Duration: **48** months (end date 31/1/2023)
- Coordinator: **CNRS-LAPP**

Funded by the European Union's Horizon 2020 - Grant N° 824064

ESCAPE contributions to EOSC



Funded by the European Union's Horizon 2020 - Grant N° 824064

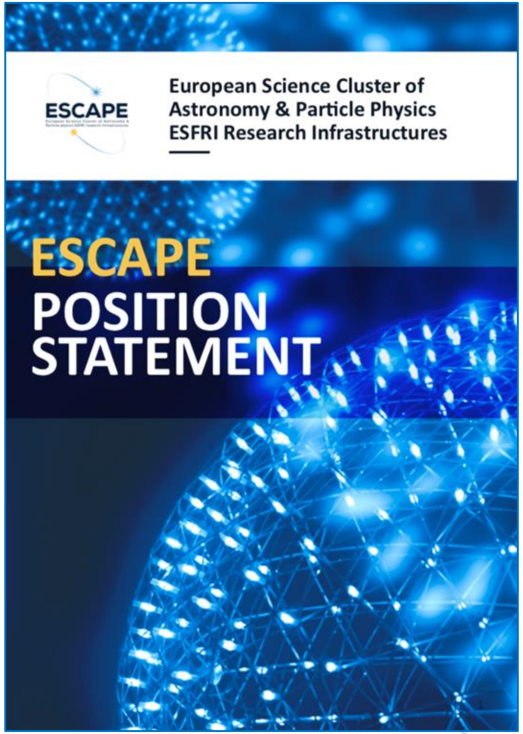
Synergies

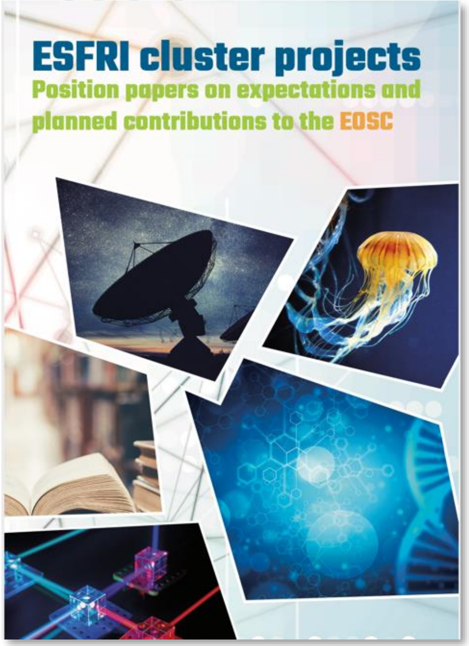
- The cluster concept (like ESCAPE) is a very successful (network) tool proposed by the European Commission
  - Key ingredients: **network + funding + focus + high-level commitment + coherence with European policy + multi-disciplines + bottom-up researchers' involvement + training.**
  - Science clusters (within the EOSC Association) to build a coordinating structure;
  - Physicists together with data-scientists, researchers in computer science and digital SMEs
  - Virtual Research Space for open science, R&D and open data uptake.

Funded by the European Union's Horizon 2020 - Grant N° 824064

Broader synergies with other research clusters

Gathering the contributions from all RIs Directors (E-SC)





ENVRI FAIR
SSHOC
EOSC-Life
panosc
ESCAPE

Five thematic Science Clusters founded under INFRAEOSC-04-2018 (80% of ESFRI RIs)

https://zenodo.org/record/4044010#.X2oaYtaxVcs

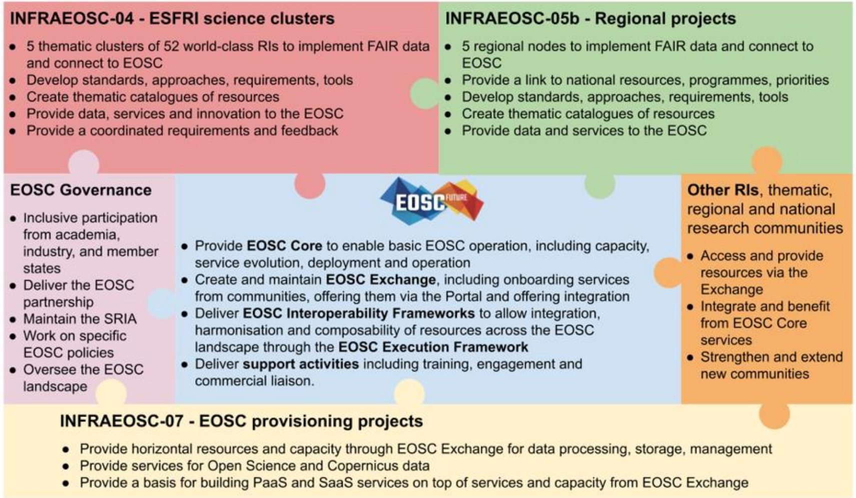
https://zenodo.org/record/3675081#.X2R2PJNLhTY

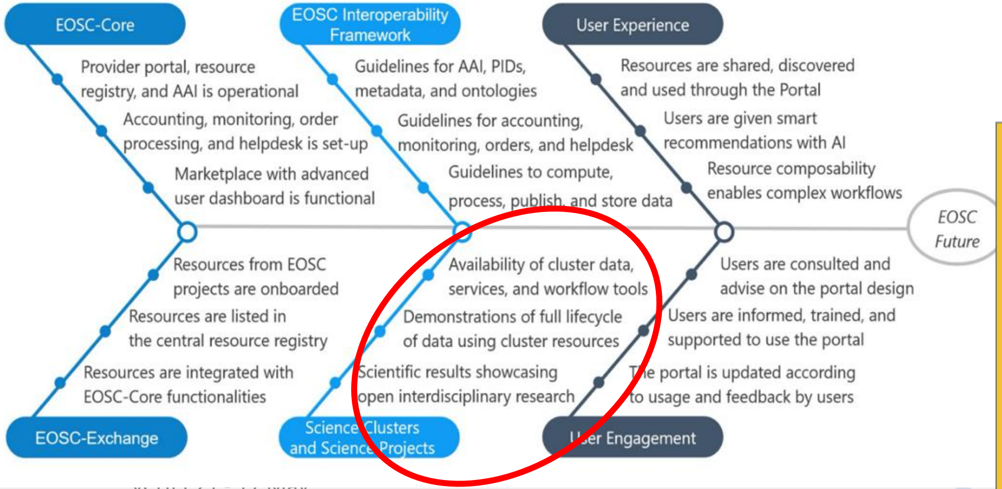
https://www.projectescape.eu/sites/default/files/Escape_position_statement_web.pdf

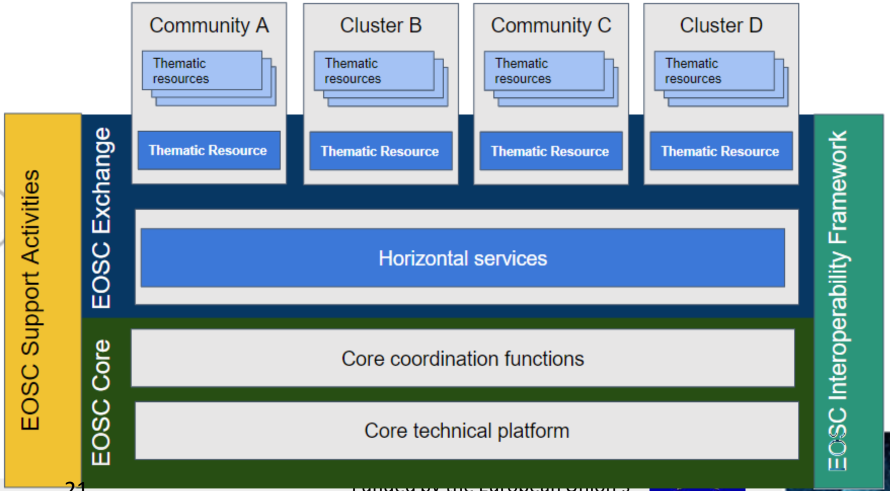
Funded by the European Union's Horizon 2020 - Grant N° 824064

EOSC-Future

- ❑ A new project – started 1st April;
- ❑ Responding to EU H2020 funding call, (INFRAEOSC-03-2020): 30 months, 40 M euros
- ➢ ***EOSC-Future is a prototype of an integrated EOSC***







Funded by the European Union's Horizon 2020 - Grant N° 824064

Integrators: Cross-cutting Science Projects

Dark Matter:

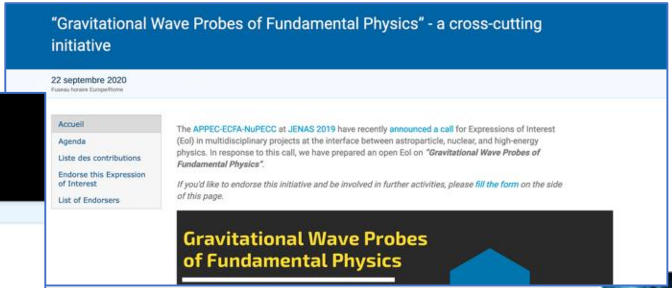
- understand the nature of dark matter by collecting data, analysis pipelines and results from complementary astronomy, particle and nuclear physics sources on a broad platform that will be ultimately be hosted on the EOSC Portal
- exploit synergies and complementarities across different communities, creating a unique link between dark matter as a fundamental science question and the ESCAPE Open Science services needed to answer it

Extreme Universe:

- do ‘frontier’ multi-messenger science to understand extreme matter and particle processes in strongly curved space-time
- combine astronomy and e-infrastructures and focus on data organisation
- organise data from different wavelengths/messengers - and different types of extreme astrophysical transients (SNe, GRBs, FRBs, TDEs) - so that they can be easily gathered, analysed and modelled holistically, and not remain fragmented as present

Linked to two corresponding JENAA EoIs
(with already about 1000 subscribed scientists)

JENAA
Joint ECFA-NuPECC-APPEC Activities



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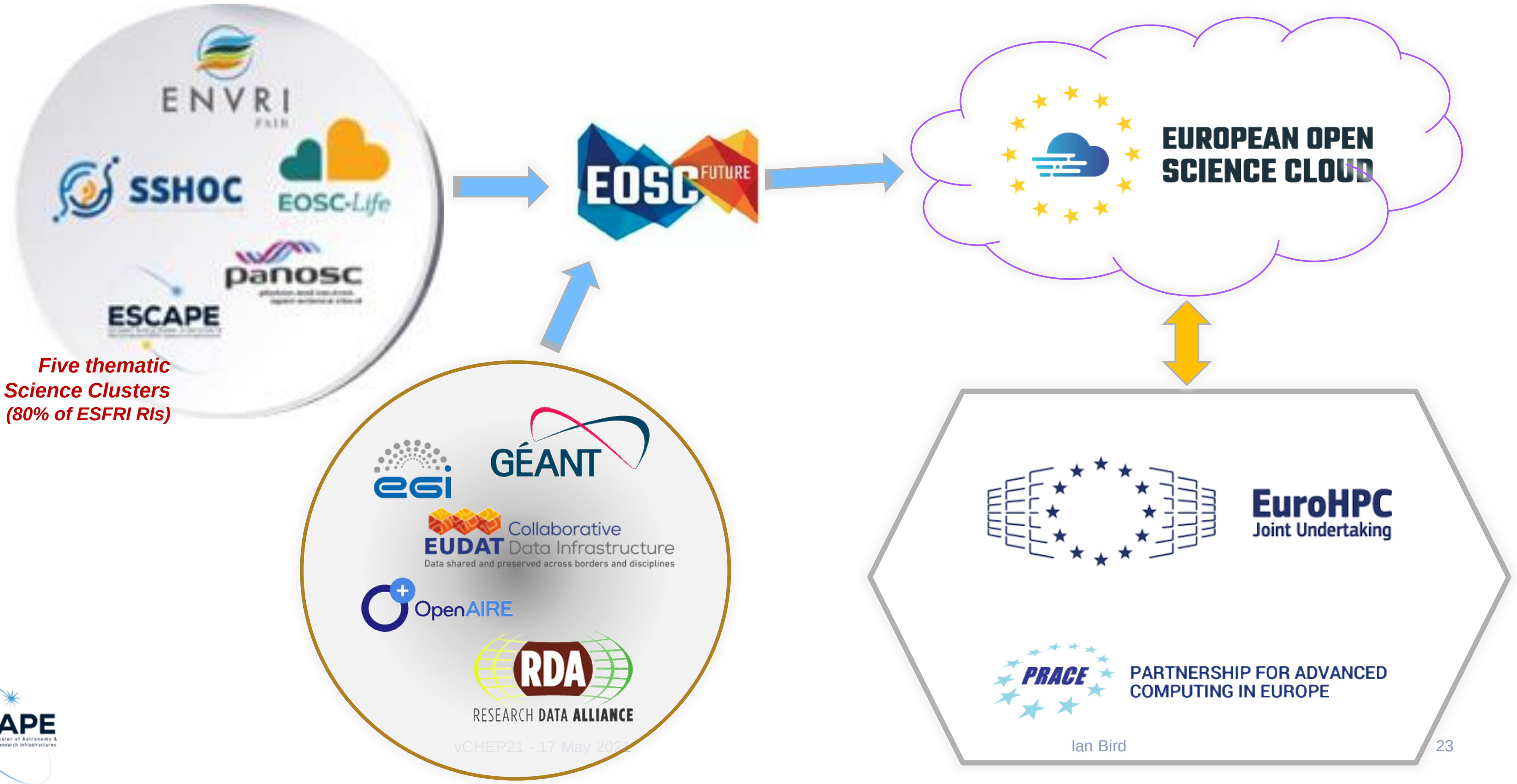
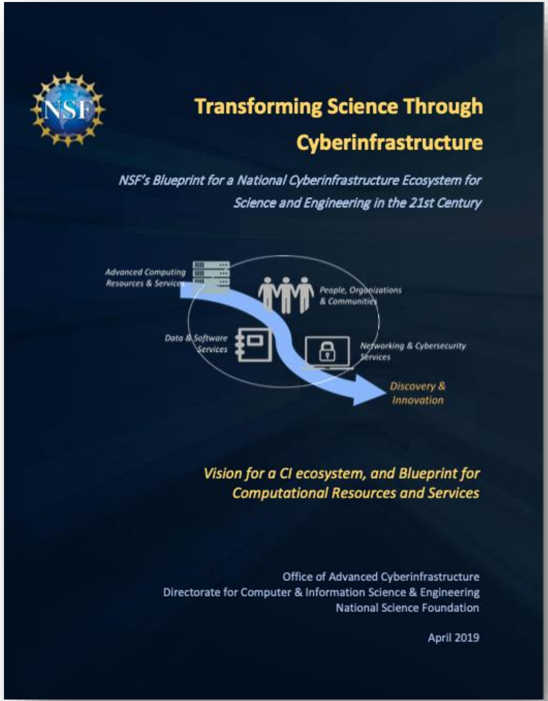
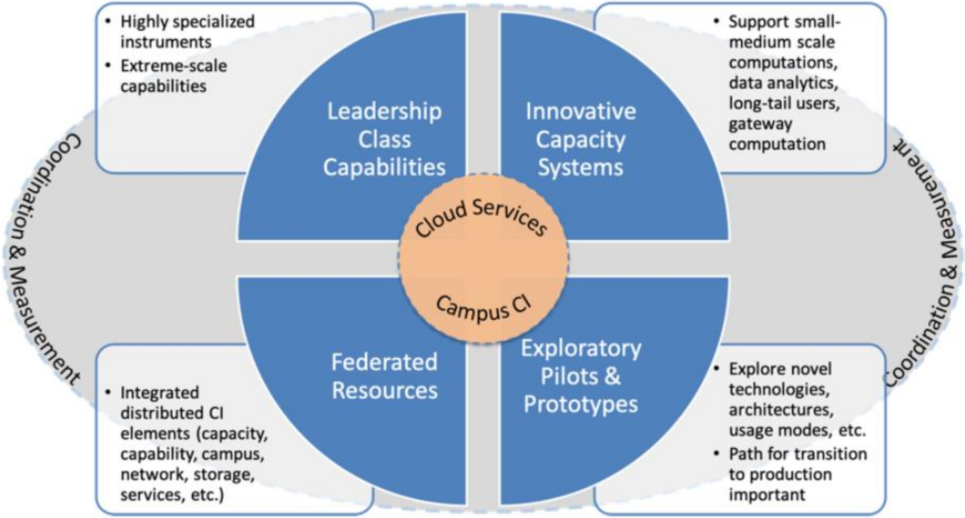
European Landscape



NSF vision of Cyberinfrastructure





Other similar, integrated visions for many national infrastructures

Outlook

- Federated, network-centric computing is even more important for the future
  - Hardware and software will evolve significantly
  - Lots of opportunities arising for efficiency (but also complexity)
- Synergies and collaborations across disciplines and domains is important and positive – will contribute to sustainability
- HEP should keep at the forefront – and share our experience