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**THE OPEN SCIENCE GRID – The Next Five Years:**

**Distributed Computing for the Nation’s Scientists, Researchers, Educators, and Students**

DRAFT V0.9

# Vision for OSG’ – 1 page – Miron, Ruth, all

# Big picture

OSG is a recognized key component of the US national cyberinfrastructure enabling scientific discovery through advanced distributed high throughput computing.

OSG is committed to promoting the adoption and to advancing the state of the art of distributed high throughput computing technologies.

OSG is providing the services that underpin the distributed high throughput computing capabilities of US-Atlas and US-CMS.

OSG promotes, enables and facilitates sharing of computing resources across administrative and organizational boundaries in support of high throughput applications.

OSG is pioneering distributed high throughput computing frameworks and technologies.

OSG provides an anchor for the US distributed high throughput computing community.

**Accomplishment phase I**

Enable US-Atlas and US-CMS to build and operate effective distribute high throughput computing infrastructures that are fully integrated into the WLCG.

Offer a high quality distributed high throughput computing software stack that is used by LIGO as well as other organizations (TeraGrid, NYGrid) and campuses (Clamson).

Operate services that facilitate effective and secure sharing of computing resources across administrative and organizational boundary. Major users of these capabilities have been LIGO (Einstein@home) and CDF.

Provide a ‘home’ to the distributed high throughput computing community through technical leadership (pioneered the concept of federated national grids) adoption of advanced technologies (distributed resource management overlays – glideIns/pilots) rigorous approach (blue print activities and technical and operational principals) joint activities with science groups/projects (NEES, SBGrid) engagement with end users (xxxx) and education (OSG summer school).

Develop a technical network of projects and activities (CI-team, high throughput parallel computing, and Advance network laboratory) in the area of distribute high throughput computing.

Conceptual framework: DTHC is good for science. Here is an example of how moving forward under these principles is changing the way LHC is doing science. To implement these principles needs:

Any job, anywhere, any time. Gotten so far: What are the other things we need to get this far and how do we get there:

Why the concepts leads to the successes.

Achieved a game changing shift in the ability of the experiments to publish results. An expectation that the paradigm of having data distributed to Tier-2s all over the planet and having the data immediately available, is a paradigm shift from traditional host based computing that people did not expect to succeed. Expectation that analysis done at the host lab, CERN, and that the distributed computing would not work. In practice the data being available at the Tier-2s has allowed access with a turnaround time never seen before, able to fully utilize all these resources transparently without manual effort being assigned. Noone worries anymore who gets what data because it is “Taken care off”. Previously had to spend lots of time being sensitive as to who gets which data. People worried if they don’t’ get the data themselves they wont’ have access to it. This is no longer talked about.

The fact is that results are submitted for publication from LHC data a few days to weeks after the data is acquired, compared to 6 months for the predecessor Run II.

Single signon feature is very important. Has underpinning of transparency. Ability for trust across the DTHC system has enabled the transparency.

Ability to redirect resources.

Ability of the local deployment and use of resources. Enables the autonomy of the US to be competitive. Coherent contribution to the WLCG from the US community. Some fundamental policies that concern the VOs. We find ways to implement the policies and make them accepted between the Federations we are able to able to move forward. Local autonomy. Common reporting saves effort. Allows us to be innovative locally by having a productive team across the VO and middleware groups.

Distributed computing is a part of the eco-system. Intellectual entity and who values this and a set of services.

**Plans for phase II**

Strengthen and expand the role of the OSG as the cornerstone of the distributed high throughput computing community in the US and as an international authority in this field.

Continue to improve the cost effectiveness of the services we provide while addressing the growing need for high throughput capabilities.

Lower adoption barriers of OSG services and expand the technology network anchored by the OSG.

One of the directions we are going to take in the future is dealing with the increased complexity of the node – more complexity, GPU, multicore, different storage paradigms. Satellites have already shown value here and we will continue with this model.

* Support and evolve usable, robust, secure software technologies for the distributed computing communities.
* Foster an excellent workforce through providing practical training and hands-on education.
* Federation

Positioning within the broader eco-system:

We consider OSG to be the Distributed High Throughput Computing arm of the NSF XD program, as well as providing the DOE Science Program with DHTC services and infrastructure.

In the next five years of OSG our vision is to sustain the current accomplishments in science and research enabled by distributed high throughput computing, expand the capacities into a new realm of computational resources and environments, and extend the benefits of the services offered to multiplicative factors more scientists and researchers.

OSG’s **intellectual merit** is its leadership in the practical application of high-throughput computing. OSG serves as the common point for software providers (such as Condor or glideinWMS) to see their middleware in production. OSG serves as a pool of expertise for developing and deploying future production-quality high-throughput applications.

Innovation: Tight integration between the application community and the software/middleware community teams. Evolution from pre-staging of data to data caching will be perturbative. This will be a major undertaking as we move forward. Experience that all major HEP experiments have had major capabiiity changes in their analysis over the years of data taking. The continuation of the collaborative project will enable this change in happen coherently and managed without perturbation of production and strengthen and extend the common services and software. Without the continuation of the common program the advances made risk being lost and the experiments systems to once again diverge. E.g. Virtualized environment.

Innovation: stable operational stage.

Helped them

In practice Ability to run any job anywhere. Has enabled science to be done differently

Reprioritize the work being done across the ensemble with less effort and agro.

Ability of the community to trust a single sign-on. Reliable platform to enable the trust and institutionalized into practice.

OSG’s **broader impact** is that we represent an important part of the computing landscape, which is important for us as a nation to keep presence in it. Believe other communities that will become more and more dependent on these methods.

Mission statement: “*The Open Science Grid (OSG) advances science through open distributed computing. The OSG is a multi-disciplinary partnership to federate local, regional, community and national cyberinfrastructures to meet the needs of research and academic communities at all scales.”*

## Challenges Identified during Phase I

* Longevity of the Engagement process.
* CS research based on OSG lab
* Adoption by another large, emerging science community
* Use of “unowned” resources by large communities.
* Benefit of OSG dependent on distributed computing model of the specific community.Not well suited when there is fundamentally a centralized model.
* Tier-3s are different, and must adjust our models and thinking in order to provide them with significant benefit.
* Defining scientific impact and its quality from an infrastructure. Signifcant benefit is defined as “if OSG does not exist the community has pain”.
* Value of users being anchored into a community rather than as individual researchers.
* Maintaining energetic interest of excellent skilled professionals in an operations and support heavy activity.

## Out of Scope

OSG continues with the policy of not owning resources, not developing software, not providing web based portals and not directly supporting HPC system use.

# Benefits to Science– 1.5 pages – Frank

The vision of OSG centers around enabling Scientific Research and Discovery through distributed high throughput computing. We aspire to be “Open” towards the broadest possible range of stakeholders in terms of diversity of science. For the purpose of the discussion here, we distinguish three types of Scientific beneficiaries of OSG, the core constituencies comprised by the LHC experiments and LIGO, other domain science communities, and Campus and Regional Cyberinfrastructures. We define as “core constituencies” those who either are the major resource consumers (LHC) or benefit from “embedded user support” to port their applications (LIGO).

In the following, we briefly describe the scientific goals of each of these core constituencies, but restrict ourselves to examples only, when elaborating on the Science benefits derived by other customers.

The scientific program of the LHC with its four experiments, three of which, ALICE, ATLAS, and CMS, participate in OSG, is probably the largest scientific endeavor ever attempted. Each of these three are global collaborations across close to 200 institutions in roughly 40 countries, comprising a total of roughly 5000 physicists and engineers. ATLAS and CMS are scientific competitors with a mission to address some of the most profound questions in particle physics today: what is the physical origin of mass, and does the Higgs boson exist? Do supersymmetric particles exist and do they explain the origin of the dark matter observed in the Universe? Does space-time have extra spatial dimensions? Answers to these questions would provide a major advance toward completing a unified view of the particles in nature, the forces with which particles interact, and their role in the past and future of our universe. ALICE, ATLAS, and CMS compete in Nuclear Physics on understanding the quark-gluon plasma produced in heavy ion collisions.

This is a time when we have unusually compelling indications that the Large Hadron Collider (LHC) at CERN, with collision energies three to seven times beyond those available at previous facilities, will lead to important discoveries within the next 5 years, with implications over a broad field of fundamental science.

The LHC scientific community has chosen distributed HTC as their computing paradigm because it fits most naturally both the technical and sociological boundary conditions for getting the science done. Technically, the data from colliders like the LHC has individual beam crossings as “atomic unit” of computation. These atomic units, sorted into datasets of well defined provenance, are analyzed sequentially without any requirements on parallelism. HTC has thus a long history in nuclear and particle physics. Sociologically, the LHC has reached a scale where the host laboratory, CERN, can no longer physically host even the majority of the personnel required to accomplish the scientific mission. Nor is it viable for the participating countries to send the majority of participating human resources to CERN. Remote operations is thus a necessity. Globally distributed HTC is thus a design choice to match the distribution of computing resources to the distribution of human resources, thus maximizing the productivity of the cost driver, human effort, in the LHC scientific program.

In 2010, the LHC experiments transitioned from commissioning their detectors to producing their first physics publications. Already in its first year of operation, discoveries were made [1][2], previously uncharted territory has been explored [3][4], and the cross sections of the dominant backgrounds for many of the upcoming searches has been measured [5]. In the process, Computing has proven to be the enabling technology scientists were hoping for, providing an agile environment for scientific discovery. Over the next 5 years, the LHC is scheduled to reach its design energy and luminosity, providing the once in a lifetime discovery opportunities it was designed for. Scientifically, we expect to either discover the Standard Model Higgs boson, or conclusively rule out its existence. The latter would rattle the foundations of modern particle physics. In the area of dark matter, we expect to probe supersymmetry at the TeV scale within the next 5 years. Non-observation of supersymmetric particles at that scale will start to render supersymmetry an “unnatural” explanation for some of the phenomena it was invented for, begging for alternate explanations.

To derive scientific results from the tens of Petabytes of data expected over the next 5 years, ALICE, ATLAS and CMS depend on the Open Science Grid to deliver the operational services, and intellectual community to sustain and enhance their National Cyberinfrastructures, and to guarantee its seamless integration into the evolving global computing landscape. Much of what is presently taken for granted by the LHC science community when analyzing Petascale datasets was bleeding edge technology research only a few years ago. The experiments are at the beginning of major transitions of their computing models, from static to dynamic data placement, from single-core to small-scale parallel applications, from LAN to WAN data access by the applications, from physical to virtual compute environments. All of these transitions require bleeding edge technology research, and the LHC experiments expect OSG, and the computer science and engineering ecosystem it has created to help them find viable solutions for the challenges ahead.

Within the next 5 years, Gravitational Wave Physics is expected to go through a revolution in sensitivity via the start of data taking of Advanced LIGO, Advanced VIRGO, LCGT, and possibly AIGO [12]. Advanced LIGO alone marks a transition from a 1/6 chance of observing a gravitational wave from known sources with the data taken up to the end of 2010, to daily observations with data to be taken starting around 2014. The search for gravitational waves is thus transitioning from the quest for “first observation” to becoming a standard tool of astronomy. Quoting the 30 year roadmap document: “an inter-continental scale network made up of advanced interferometers in the US, Europe, Asia, and Australia would provide an all-sky array that could detect, decode and point to the sky-position of gravitational wave sources in the audio bandwidth where many of the most interesting sources are located”.

Over the last 5 years, LIGO benefited from OSG software and opportunistic computing [13], with the OSG project providing the “embedded user support” effort to port LIGO applications to benefit from distributed HTC. For the next 5 years, we expect LIGO to benefit in addition from OSG’s knowledge, processes, and services with regard to the global integration of gravitational wave physics.

Apart from these core constituencies in Particle, Nuclear, and Astrophysics, there are a number of other stakeholders from physics, biology, chemistry, mathematics, medicine, computer science, and engineering.

Achieved progress in terms of the sociology: Global systems, global partnerships, local vs global cohesion.

Compute with a center – domain specific.

Among them is the Structural Biology community (SBGrid) with its headquarter at Harvard Medical School. The SBGrid Consortium is a computing collaboration of more than 140 X-ray crystallography, NMR and electron microscopy laboratories. Participating laboratories include groups at more than 50 academic institutions in 12 countries. Structural biology focuses primarily on the study of molecular structure of proteins and nucleic acids and the association of structure and function. The community has significant data and processing requirements originating from large data sets resulting from various forms of macromolecular imaging techniques (X-ray cyrstallography, electron-microscopy, and NMR), as well as simulation and modeling algorithms for protein folding, docking, structure determination, and dynamics. SBGrid is still a new community to OSG, consuming 6 Million CPU hours in 2010 across more than 20 different sites, leading to their first scientific publication [6] derived solely from opportunistic computing on OSG.

Some of the most active communities today precede the OSG (CDF, CDMS, D0, MiniBooNE, MINOS, STAR, Geant4), and adapted technologies from OSG into their operations, or even moved their operations onto OSG as their primary Cyberinfrastructure (CDF, D0). Others have started their large scale distributed computing operations from the beginning with OSG in mind (Minerva, NEBioGrid, SBGrid) or are exploring OSG as part of their preparations for future operations (DES, GlueX, IceCube, Mu2e, NEES, Nova, …).

Over the first 5 years of OSG operations, we found that bringing in new Science is most effective and sustainable via Campus and Regional affiliation. The original model preceding OSG was GLOW [7], followed by FermiGrid [8] and NYStateGrid [9] showing that the model can be successfully implemented at Universities, National Laboratories, and even at the State or Regional level. OSG offers software, services, and a production Cyberinfrastructure to interface with. The Campus or Regional institutions provide a support organization for their Scientists, as well as access to their hardware resources on an opportunistic basis. Education and training of the Scientific user community is decentralized, and thus scalable. OSG’s education and training role in this context is in providing knowledge and learning opportunities for the local support teams.

An excellent example of a more recent Campus Grid is the Holland Computing Center (HCC) at the University of Nebraska. HCC provides the research computational resources for the University of Nebraska system, including high-performance computers, storage, and networking. In 2010, HCC began offering high-throughput computing based upon the OSG, and were able to utilize 11 million CPU hours on non-HCC resources. Six research groups from multiple campuses (largest users were mathematics and biochemistry) utilize the OSG. HCC traditionally hires 2 graduate students; one was sent to the 2010 OSG Summer School, and the other has begun his CS PhD work based on OSG technologies. This year, OSG resources have contributed to four publications [10], three of which would have been impossible without OSG given their tight schedule. For the next 5 years, HCC wants to expand its use of OSG by adding a new EPSCoR collaboration with nanotechnology researchers in Puerto Rico. Their workflows will be challenging in terms of specialized node requirements and large (10s of GB) outputs that must be transferred between sites, as well as large numbers of small scale parallel jobs commonly referred to as High Throughput Parallel Computing (HTPC).

HCC is an unusually ideal example, as it combines many areas of potential benefit from and to OSG. It combines hardware resources distributed across multiple locations within the University system, and Scientific Computing support for domain science researchers across all the sciences, performed by a central campus IT organization that is engaged in Computer Science and Engineering Research with one of the core OSG constituencies.

One of the challenges for OSG for the next 5 years is to apply the lessons learned from the work with GLOW, FermiGrid, NYStateGrid, and HCC to other, less ideal examples. There are several known opportunities, and probably many more as yet unknown. The former include leveraging the LHC Tier-2 and Tier-3 programs into support communities that span multiple disciplines on these campuses. These two programs alone include more than 50 Universities, some of which have well established IT organizations with similar characteristics as HCC. For others, the particle physics groups themselves [11] have become the nucleus of scientific support organizations that span multiple domain sciences.

*User Support Contribution to Accomplishments section*

In the past 5 years, OSG User Support has increased the velocity of scientific discovery by enabling additional science communities (D0 MonteCarlo, LIGO E@H, SBGrid, CHARMM, Engage VO Researchers, NEES) to access the OSG cyber-infrastructure and by better positioning other communities (CDF, LSST, ALICE, GlueX) for future use of OSG.

# Organization and Management

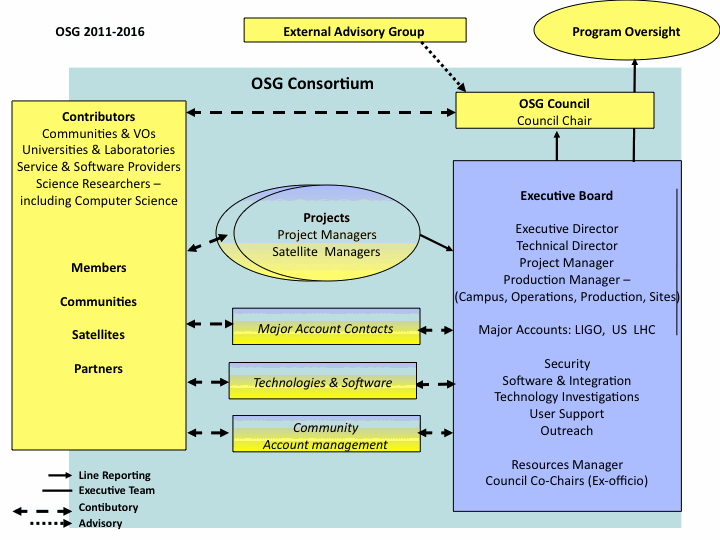
The Consortium (see Figure x) is the overarching organizational unit of the OSG, with the Council being it’s governing body. Its primary function is to ensure effective benefit to the scientific mission of the stakeholders through endorsement of the program of work and contributing to the strategic planning. The program of work of the Consortium is managed and executed through the directly funded core project, independent (collaborative) satellite projects, and the contributions of the consortium members. The strength of the organization is in the team spirit across the contributors and staff of the projects, and individuals whose understanding and expertise crosses administrative boundaries. The management structure of OSG project has an Executive Team providing the overall management, leadership a small number of well-defined Areas of responsibility and authority, and cross-cutting support activities provided by the program office.

Figure 1: OSG Organization

The project areas are: **Production** that oversees the production usage, operations, and campus grid activities; **User Support** that provides support for the science communities and users; **Software** that supports all aspects of the OSG software including interactions with software providers, user requirements, and oversight of software developed within OSG; **Security** that covers operational security, the trust infrastructure, security training and assessment; **Technology** that documents, plans and manages the OSG software architecture and technology changes requested by the stakeholders; and the **Program Office** that provides the cross-cutting leadership, management and outreach for the program.

We will continue endorsement of Satellite projects as a means to have independent developments of new capabilities. The existence of OSG as a “collaboratory” allows the science communities to advance their use of new technologies more cost effectively and with more chance of success and adoption.

# The Program – 10 pages

Science communities and resource providers adopt OSG technology, services, and capabilities largely because of the stability, reliability, and economy of scale that the OSG offers. To maximize the scientific benefit, communities need to know that the OSG DHTC services will be there when they need them and that the interfaces they expect will continue to work. This allows scientists to focus their energy on science instead of the complexities of cyberinfrastructure.

Complex jobs submitted by OSG Science Communities (henceforth referred to as Virtual Organizations or VOs) such as Atlas, CMS, HCC, LIGO, and SBGrid are routinely distributed over 10, 20, 30, or even 40+ sites across the US, often without the end user even realizing it. Enabling science jobs to transparently scale in this manner is highly non-trivial and requires regular pushing at the frontiers of DHTC capability.

Reliably delivering DHTC cycles requires that OSG provide a coordinated and dependable capability that includes all the Program areas: Production, Operations, Software, Security, User Support, Technology Architecture, and the Program Office.

## Production – 2 page (covers production, operations, sites, campus grids)

OSG Production is the culmination of many OSG efforts including testing, integration, services, support, operations, hardware, software, and security. These efforts make up the DHTC fabric that enables VO and Resource Providers to interact and benefit each other. Production occurs as VOs get their jobs run and data analyzed across the DHTC fabric, and in so doing enable the advancement of science. The Production team of OSG is focused on the quality, operations, and throughput of the DHTC fabric that underpins the ability of jobs and data to execute and move.

The primary goal of the Production team is thus to ensure the stability, reliability, and economy of the DHTC fabric. In particular, the OSG fabric must scale as each of the VOs are continuously scaling their workloads to reach their science needs. Scaling also occurs as new resources are added to the OSG. As the OSG collective usage graph demonstrates [!!! Need to insert a graph or a reference here], OSG job throughput alone is increasing at approximately 1.5x per year. Also data movement has tripled in the past two years to nearly 1 Pbyte of data now being moved every day on the OSG. Scaling stresses the DHTC fabric in many non-obvious ways (e.g. in areas of discovery, monitoring, and accounting that are described below in the Operations subsection).

To ensure that the DHTC fabric keeps up with demand, the Production team is responsible for managing all changes across the fabric that have the potential to affect production. The Production team is continuously monitoring fabric activity and communicating between stakeholders to help guide and ensure successful improvements and problem resolutions. The weekly Production meeting is thus central to OSG where representatives from all the stakeholders (VO Support, Operations, Security, Resource Providers, Software, and Production) meet to manage and resolve issues. With its DHTC fabric overview perspective, the Production team is also involved in identifying, extracting, and socializing best practices with the OSG community, both on the VO as well as the resource provider side. Best practices not only help make production jobs run more efficiently but are key to securing the economy of scale in a distributed heterogeneous environment.

Over the last 5 years, the OSG has developed many needed components for VOs to run and monitor the health of their workflows through the fabric. A current limitation on the scalability and use of the DHTC fabric however is the lack of a more global view of the health of the resources. We currently have RSV for monitoring the health of services, but in this generation of OSG prime, we plan on deploying better monitoring to provide a global view of job monitoring as well as to understand dynamically how sites are responding to and handling user jobs.  Pushing the state of the art further in this area will enable OSG Production to scale both by providing an insightful picture of problem areas within the fabric and enabling the dynamic feedback necessary for sites and VOs to understand and fix their weaknesses.

Another lesson learned concerns the increased robustness that can be obtained via dynamic resource management. In this model resources are dynamically acquired before committing to their use. OSG then commits only those resources that work "well enough" for the job at hand. Better dynamic selection leads to dramatically improved robustness as experienced by the end user. As an example, after struggling for the better part of a year to achieve scaling levels of ~1000 sustained, concurrent jobs on the OSG, the SBGRID VO switched over to the newly recommended model and were able to scale up by another factor of 5 with minimal additional effort in just a few weeks. As results like this have become more broadly recognized VO demand for this service is increasing and the existing dynamic resource allocation services in production will need to be scaled.

As many of the DHTC fabric services have been recognized as being generally applicable to distributed architectures, a secondary goal of the OSG Production (and Operation) team is to utilize the OSG developed production expertise in external communities’ distributed architectures. For example some Operation hosted services have been demonstrated to be applicable to Future Grid and Cloud computing architectures and will be discussed further in the Operations subsection. Another excellent example of this is in the support and advancement of Campus Infrastructures that is included in subsection 4.1.2.

### Operations

OSG Operations is responsible for a suite of production and support services that underpin the DHTC Fabric. These services are defined by stakeholder agreed upon service level agreements (SLAs) and include:

- **Service Desk** contributions are important for both usability and dependability of the DHTC fabric.

a) The service desk is the mechanism for both VOs and RPs to connect themselves (register) to the DHTC fabric.

b) Frontline support to operators, resource providers and VOs help build dependability into the fabric by assisting with problem tracking and resolution, including round the clock response for critical services.

- **Discovery and Information services** are a critical part of the DHTC fabric since they provide the topology of the OSG and allow the community to dynamically determine where and when DHTC resources are available, so they can be utilized. As critical components, several of these services are maintained in failover environments since even a short interruption demonstrably impacts data movement and processing.

- **Monitoring services** operate on different levels and contribute to DHTC dependability in two main ways:

a) Service monitoring capabilities identify and alarm/alert when certain production problems are detected thereby facilitating the resolution of these issues. Atlas and CMS receive alarms directly when critical problems are detected.

b) General health monitoring displays are used by the Production team both to assess health as well as understand trends and patterns of DHTC usage on the fabric.

- **Accounting services** provide accounting abilities on the DHTC fabric for all VOs and RPs including specialized metrics used by Atlas and CMS to demonstrate their contributions to the WLCG. Currently the OSG accounting system (Gratia) handles upwards of 2 million job and data transactions per day with peaks a factor of two higher.

- **Dynamic resource allocation** services contribute to DHTC fabric dependability by creating an overlay that a) provides a uniform interface for interacting with heterogeneous resources and b) automatically implements best practices that shelter users from many potential pitfalls. This is an important area in OSG that needs to be expanded to make this available to more communities in the OSG.

- **Communication, Documentation, and Software Cache services** are essential for code and information sharing and community building across the geographically and scientifically diverse OSG community.

Each of these is essential if the DHTC community is to maintain the reliability needed to attract and sustain scientific research communities. In sum, they form a crucial part of the state-of-the-art DHTC fabric. Hosting these services means that VOs and Resource Providers do not need to each set up and maintain their own services. This is part of the economy of scale that OSG provides.

Over the next five years, state of the art DHTC Operations will be advanced on multiple fronts:

* OSG Operations will host additional production quality services and continue to scale existing services to meet the steadily increasing demand of the stakeholders. It will also add new services such as a top-level BDII that will enable US CMS and US Atlas to access global WLCG site data locally. Continuous improvement of the reliability of existing services is also of high priority.
* In addition to providing more services, OSG will improve DHTC management capabilities that enable sites and VOs to collect and aggregate data they are interested in, not just for site monitoring, but also for detailed job monitoring. These services will provide real time feedback on how resources are responding to workloads. The goal is that problems and bottlenecks can be understood before they effect production.
* Real time data of this caliber will enable monitoring tools that inform the Production team, VOs, resource providers and OSG operators of problems and status issues affecting inter-site job flow, not just site status. Operators and coordinators will be empowered to assume more active roles in debugging inter-site issues.
* While these services, monitoring, and accounting capabilities will be operated for OSG stakeholders, they will also be readily usable by other communities that are developing distributed software infrastructures. Operations will also provide virtualized resources (OSG Operations Cloud) to provide stakeholders and campus grids with off site resources to provide testing, monitoring, and other important operational services.
* The current standalone communication systems (TWiki, DocDB, Web Portal) used for documentation and presentation will be merged into a single collaborative environment using advances in social networking technologies and documentation environments to provide a single point of interaction for all collaborators.

### Campus Infrastructure

The relative ease with which new resources can be integrated into the OSG DHTC fabric and leverage the full capabilities of OSG make it a natural pattern to follow for providing campus infrastructures. The foothold that OSG has on over 80 campuses makes extending this capability a natural choice for campuses such as UConn and LTU that are looking to adopt campus grids. There is a considerable amount of local expertise available and some infrastructure building blocks already in place especially at Atlas and CMS Tier-2 and Tier-3 sites. Of course any campus that is looking to create a campus grid can benefit from this activity.  
  
The extension of the OSG DHTC fabric onto campuses carries a strong value proposition for both the Campus as well as the OSG. Aside from the campus benefits of utilizing a larger resource pool, improved (policy driven) resource utilization, higher fault tolerance, and reduced costs, campus grids make researchers more competitive by giving them access to more resources, allowing them to get more science done faster. Researchers trained to use campus grids can readily extend their research to the OSG, thereby accessing an even larger pool of resources and bringing new science to the OSG. Success on the campus level is a success for the OSG, but the OSG benefits in other ways as well. Sites that utilize campus grids may eventually choose to make a portion of their resources available as part of the OSG thereby enriching all the DHTC researchers on the OSG. Enabling campuses also fits the OSG model of focusing its limited resources on science communities as opposed to individual researchers.  
  
To accomplish all this, OSG will provide a downloadable software stack, documentation, and training for the campus organization, both to learn how to deploy and operate the software, as well as to learn how to support their scientific community to operate on their campus as well as the larger national DHTC infrastructure. An initial prototype of this software stack exists, and is in production at the University of Nebraska, connecting clusters in two cities (Lincoln and Omaha). As a result, scientists in Nebraska compute transparently across the two cites, as well as OSG at large, deriving Science Benefits as described in Section XXX (XXX = Science Benefit Section).

The components of the Campus HTC program including the security, data and jobs. For the first year we will work on glidein that are ready for a campus. Packaging, technologies, documentation, user support. Next year working closely with the s/w providers to support remote access via SSH. ATLAS and CMS are looking to OSG to work with the Tier-3s to enable them to benefit from additional local campus HTC. There will be constraints on working with sites that do not allow wide area connectivity to the worker nodes.

Model is that you have a login platform. On that platform have a multiplexor that says whether jobs go locally only or on the entire universe or to the cloud. The profile determines how the job gets submitted. Each campus runs some services (e.g.glidein factory). OSG is open to delegation of running or hosting of those services initially until the campus is able to run it.

Designed to enable the campus to work within the campus only: technology integration, some glue tools, need support from VDT for software collection support, may need to add components, documentation, qualified deployment support. Primary output is in engaging with the campus, following up with the Tier-3s where there may be a foothold. Include testing of the software collection in the integration process. Document and demonstrate patterns for new entrants to follow. Institutionalize and commodotize implementation of OSG campus HTC. Transition from the prototype to make this an institutionalized, integrated part of the OSG. Plan to move from an “engagement” style program transitioning to an institutionalized part of OSG. Goal to try in a few more places and then transition. 1st release of a Campus Factory by the end of Year 1 etc. Toolkit allows them to egress to the rest of national, international, cloud and other resources as they need.

We will work closely with the rest of the XD program on interfacing and integrating this activity with other campus activities in XD. Kim Dillman of Purdue University is expected to work with us on this area of work.

Once campus is used to using HTC locally we also help them bridge to remote resources.

The model for supporting the application users: the campus activity will work with early adopters directly, and then transition them to the regular OSG operations support processes.

## Software Infrastructure – 2 page (includes integration, scalability/validation/)

In order to provide this software infrastructure, the group provides three services: creation of software distributions, support, and software evaluations.

*1. Creation of Software Distributions*

We create the software distributions used by OSG users. The creation process is the entire end-to-end pipeline that begins with discussing software requirements with OSG users and results in deployable software tools. It includes prioritization, planning, building, testing, configuration, documentation, and packaging software tools to integrate them into the software distributions. We rely on the University of Wisconsin-Madison NMI Build and Test Lab to build all of our software, and we plan expand our usage of the lab by moving our test infrastructure to it.

An essential part of the creation of a software distribution is testing the software in a realistic wide-area DHTC environment. Our software distributions are tested in an “Integration Test Bed” (ITB), which includes resources from various VOs in a variety of configurations. While the Software Infrastructure Area coordinates the testing, people not directly involved with the creation of the software distribution perform the testing. They provide important feedback on whether or not the software really work for the scientific workflows in use by the VOs. Will elaborate in the supplements, and upon further discussion with Rob Gardner and Suchandra Thapa, during the week of January 10th

Once software has been added to our support software distribution, we will continue to support that software as long as our stakeholders need it, even if the original software provider discontinues support. This is essential because the long-term reliability demanded by a DHTC infrastructure requires the sustaining of software used by the infrastructure. Of course, we may need to obtain extra effort to do provide this sustainment, or we may maintain the software on “basic life support”, as appropriate. We may also look for alternative solutions while maintaining the software.

2. *Support*

We will provide the first-level of support for OSG users. When they have problems with any portion of the software distributions, they can ask the software infrastructure team, and we will provide assistance in determining which software component is the problem and either solutions/workarounds for the problem or assistance in contacting the appropriate software developers for deeper help. We coordinate this work with the User Support group by … This needs fleshing out in discussion with Chander, will happen January 11 or 12.

*3. Software Evaluations*

We will provide fair evaluations of software tools to meet OSG stakeholder needs. Unlike the Technology Investigation Area, which evaluates software before it has been decided to be in an OSG software distribution, we provide ongoing evaluations of software tools that are currently in use within OSG. Software needs to be regularly evaluated to understand if it meets the expected needs of stakeholders: will it meet the scaling requirements as the stakeholders expand their work? Is it sufficiently reliable? Does a new version of a software tool present any new problems that need to be addressed?

Software will be evaluated on the basis of scalability, reliability, and usability. Usability includes ease of use, completeness of the feature set and documentation. This is expected to be an occasional activity, but one that requires significant effort for short periods of time. The exact timing will be driven by the stakeholder requests. If we are asked to do more evaluations than our effort profile can support, we will prioritize the evaluations in consultation with the Executive Team. This is an ongoing effort for three reasons: (1) the needs of our stakeholders increase over time, (2) new software releases add new features that may adversely affect the software’s behavior, and (3) hardware improvements over time potentially enable new levels of scale.

### Value of the Software Infrastructure

The software infrastructure distributed by OSG provides value in several ways:

* It fulfills the targeted needs of our stakeholders. It allows these stakeholders to offload their individual effort to a group of specialists and therefore provide economy of scale. We have found through experience that significant portions of software we provide are shared between OSG users.
* Scientific users have a more robust and easy-to-use software infrastructure because of our testing, integration, configuration, and documentation,
* We provide a toolkit that is a starting point for users to build their HTC infrastructure and join it to the OSG.
* We provide mechanisms to manage change and evolution of the software technologies over the long-term.
* We provide a center of excellence for software infrastructure for distributed computing.
* For software that is no longer maintained but is needed by our stakeholders, the software infrastructure group will maintain the software.

### Specific Software Goals

During the lifetime of OSG, we expect to address many software needs. However, these needs are difficult to predict now because we are driven by the needs of our users, and those needs change over time. That said, we have several needs that we plan to provide, and others that are possibilities. These are described briefly here, but in more detail in the Software Infrastructure Supplement.

1) Community-appropriate packaging mechanisms

We will significantly evolve our distribution mechanism. Historically we have used a little-known software packaging and distribution mechanism called Pacman [ref]. While it provided many significant benefits, users have always grudgingly accepted it because it does not integrate well with their operating system packaging mechanisms. While we have been moving towards these so-called “native packaging” mechanisms, we will convert our packaging efforts to fully adopt the existing OS native packaging mechanisms. The result is that we will be able to significantly leverage a wider community to building our software for two reasons. First, we will use well-understood methods of packaging software and people will be able to more easily contribute software to the OSG software distribution. Second, we will be able to contribute software that is of interest to a wider community into existing, third party software distributions. Together these will have three significant results:

* This will make OSG more effective by leveraging outside effort
* The work produced by OSG will be useful to a wider community
* It will allow better reuse of existing software
* This will simplify our infrastructure and aid our ability to supply multiple software distributions (next).

2) *Multiple Software Distributions*

Currently, we primarily provide a single software distribution. It is a high-quality, well-documented, stable software distribution. However, it has become clear that not all of our users have the same requirements (e.g. the LHC users do not have the same needs as the LIGO users or the structural biology users.) In a way similar to Linux distributions (like Red Hat or Ubuntu) have split their distributions into stable and “bleeding edge”, we plan to support multiple software distributions, including community specific distributions. For example, we have a prototype of a separate software distribution for deploying a storage element based on Hadoop, where the requirements are focused on quickly reacting to recent software releases and meeting a single stakeholder’s needs (as opposed to all stakeholders). While this may sound like considerable extra work, we believe the extra work is partially addressed by our improvements to creating software distributions (above). In particular, because of our move to standard native packaging systems, it becomes easier to include software packages created by external people.

3) *Changes to Platform Support*

As of this writing, the OSG software stack supports a wide variety of platforms, but they haven’t quite kept pace with the changing needs of our stakeholders. We will be adjusting our platform support in reaction to user needs. Likely changes include adding support for Ubuntu and recent versions of Mac OS X.

4) *Support for Campus Infrastructures*

To support the campus infrastructure effort (above), we will provide a software distribution (or perhaps a set of distributions) that support the specific needs of this effort.

5) *Packaging as Virtual Machines*

We have seen interest from our stakeholders in using virtual machines and external cloud systems such as Amazon’s Elastic Compute Cloud. We think there is a significant opportunity for us to assist our users by supplying some portion of our software distributions via pre-installed virtual machines that can be easily configured and deployed.

6) *Configuration management*

Recently we have been improving the OSG software distribution’s configuration management infrastructure. An important benefit of the distribution is our ability to simplify the configuration of a complex set of software and thereby help users quickly and correctly get the software running. We have been evolving the configuration management system to support native packaging, and during the first year of OSG Prime, we will need to provide documentation and features to make it easy for users to integrate the configuration with their existing site configuration management systems.

7) *Mirroring*

With more move to native packaging, we will be able to easily provide mirrors of our software distributions, something that was challenging with our Pacman distribution method. We will provide at least one complete mirror of software distributions.

### Assessment

Assessment of a software distribution is challenging, and our goal is to significantly improve our ability to assess whether we are meeting our goals or not. We plan to do 100 things:

1) We will do a yearly survey of our stakeholders to understand their changing needs and what they would like for us to provide. For example, we will ask what new software or technologies they need, what software they no longer needs, what new platforms they need, and what platforms they no longer need.

2) As part of this survey, we will ask our stakeholders to evaluate our performance.

3) We will collect statistics, including (1) download statistics from our supported software repositories and (2) statistics on ticket handling such as number of tickets, speed of initial response, and average time to resolution.

The Software portion of the deliverables is rough and needs revision. However, the basic list of tasks are the ones I know about.

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| **Milestone** | **S /D** | **Deliverable** | **Area Section** | **Measures of Success** | **Communities Benefited** |
| Years 1-5 | S | User Support, ongoing | Software | % tickets resolved  time to resolution | All |
| Years 1-2 | D | Add source native packaging | Software | % of packages provided as source packages | All |
| Years 1-5 | S | Perform 1-2 Software Evaluations per year | Software | ? | Requesting communities |
| Years 1-5 | S | Perform 1-2 scalability/usability tests/year | Software | ? | Requesting communities |
| Year 2? | D | Add one software distribution based on source native packaging | Software | ? | Requesting communities |
| Year N?? | D | Add campus infrastructure software distribution | Software | ? | Campus Infrastructure effort |
| Year 1 | D | Extend configuration management to simplify integration with site configuration management | Software | ? | All |
| Year 2 | D | Provide mirroring of VDT software repository @ GOC | Software | ? | All |

## Security – 1.5  page

DHTC environments are unique in that the trust between the participants and the willingness to collaborate – which is affected by the trust as well – are what binds disparate domains to work together. In DHTC, the trust is voluntary and formed throughout the collaboration lifecycle based on participants ongoing interactions, all the while the resulting trust also transforms these interactions. This is different from homogeneous environments such as TeraGrid/HPC, where each participant has the same security model and trust is formed top-downThe security infrastructure of the OSG consists of operational security (incident response, vulnerability assessment, security ticket resolution), identity and access management services, software vulnerability assessment, and risk assessment of the overall system. In every part of our work, OSG depends on contributions from OSG participants, and with those contributions, OSG builds many-many trust relationships among them.

During incident discovery, we trust a participant to monitor, detect, and report a local incident that may affect others. OSG members trust OSG security team to understand whether a resource's local monitoring and detection capabilities measure up to other participants' security requirements. During incident response, all OSG members trust one another to follow the OSG incident response process faithfully and mitigate the reported vulnerabilities.

During software analysis, OSG trusts our software providers to provide vulnerability-free software and to fix the problems once they are reported. Software providers trust one another that any assumptions made in one component is honored by an interacting component. For example, a resource gatekeeper trusts the VO job submission client that the credential accompanying the job request indeed belongs to the requesting user.

During identity and access management, the resource owners trust OSG to provide scientists with truthful credentials that accurately transforms scientists' local identities into the global space. The resources trust that these global credentials are equivalent to the local credentials used in-house and hence suffice local access requirements. OSG trusts the scientists to provide truthful declarations about their identities and access privileges given by their VOs. During risk assessment, we culminate all of the activities above and search for the places where the trust assumptions have been violated.

Underpinning principle of all the OSG security activities is to identify, understand and preserve the trust assumptions/requirements between all parties. The OSG participants trust OSG security team to spell out these assumptions and verify that they are not violated.

Violation of above trust assumptions compromises the security of OSG infrastructure. Yet, all of these relationships are currently implicit and are not captured in any formal representation. There have been research in requirements engineering that defines and studies trust assumptions [1, 2] that is similar to what we want to achieve in the security of DHTC environments. However, existing research focuses on expressing the assumptions at the initial system design and then studies how to build systems meeting these assumptions. Our challenge in DHTC is that OSG participants have already built their own systems with these assumptions in mind yet without explicitly representing them. Therefore, we have to extract this information from existing systems, and then find a design solution that meets everyone's needs and capabilities. For example, while bridging campuses with OSG, we have seen that access requirements and underlying trust models at universities are significantly different than that of existing OSG resources such as DOE National Labs. We also realize that universities cannot significantly change their domain models in order to fit into OSG. Therefore, our work has been to understand the reasoning behind the domain models and find a feasible and secure solution for all the participants.

Trust relationships provide the foundations for OSG security. As part of our proposed program of work, we plan to develop a generalized framework of trust flows, that captures the flow of trust between the entities as a result of the interactions between them. Such a framework can reveal how seemingly independent security assumptions in fact affect one another. Our future goals are to understand how to extract trust assumptions from an existing system; how to express them in an easily understandable format; how to identify the places those assumptions break; how to find out the consequences of trust violations (i.e. vulnerabilities in the system); and how to mitigate these vulnerabilities based on the understood consequences. Our overall goal is to bring a general framework of trust into the DHTC environments, and to guide our work in every area of security based on this framework. The benefit of this work is bringing a methodology to distributed system security, where security assessments will be based on facts drawn from the system, and as a result, the system security will be improved based on rigorous evaluation.

Over the next 5 years, we will see the benefits of our approach most notably in the following areas:

* Over the past five years, the access and identity management needs of our community have continued to diverge. VO sizes (order of 20 vs 1000), computational models (web-portal based vs command-line vs cloud computing), and VO cultures constantly evolve. Likewise, OSG resources gets more diverse in their security models (universities vs. national labs vs bridging to TeraGrid resources). Instead of continuing to provide a single certificate service and expecting that it will meet everyone's needs, we will adopt and provide a diverse set of identity services including federation-enabled identity services, which is essential to leverage Shibboleth-InCommon framework in the campuses, and short-lived web token services for easy web access, which will allow certificate-less user experience over the desktop. We will provide the classic certificate service in OSG and enhance it as necessary to integrate with the new services. Our goal is to create a menu of identity services that can be mixed and matched, and helping OSG communities create their specialized identity infrastructures out of these services.
* Initial incident discovery and detection is a key area that affects the operational security directly. So far, we have observed that between the OSG participants the time it takes to detect a security compromise vastly differs up to the order of weeks. Because each participant has varying security capabilities, tools, human effort and expertise. For example, an LHC-Tier 3 site running a few storage services with a part-time system admin has different needs than a site hosting hundreds of compute and storage services with a dedicated security team and a suite of security tools. Our goal is to define a common level for OSG participants, where everyone possess a set of minimum operational skills and tools to maintain the overall operational security. Defining this common level will be an outcome of the risk assessment based on the trust framework we will develop. We will advise and help adoption of appropriate monitoring and detection tools. We will develop a tiered monitoring framework: at the user-level, we will help a user to monitor and detect unexpected behavior with their grid credentials (e.g. sending weekly usage statements to users similar to the monthly bank credit-card statements); at the VO level, we will help VO managers to monitor the jobs submitted under the VO credentials and track the resources these jobs have accessed to; at the resource-level, we will help resource owners to detect an ongoing attack and mitigate the vulnerabilities; at the infrastructure-level, we will monitor the aggregate behavior in OSG.
* The software distributed by OSG is a core asset of our project and vulnerabilities in the software stack pose high-level risks to our community. We will assess the security of our software stack by identifying the trust assumptions between the disparate components, users and resources. Fully evaluating the security of a software stack as big as VDT is a hard problem. To overcome this, we will focus our work on the areas that we have knowledge and control over. During software integration, VDT team determines the configuration variables that would tie the components together. We will check whether our configuration choices violate any of the assumptions made by the software developers. We will seek ways to provide a non-root installation of VDT stack. This will prevent propagating root privileges to components that do not need them.

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| **Milestone** | **S or D** | **Deliverable** | **Area Section** | **Measures of Success** | **Communities Benefited** |
| Each year until FY14 | D | Design and provide a diverse set of identity services. | ID Management | Successful integration and adoption by the user community. | All |
| Each year | S | Evaluate the security needs as computing techniques change, such as cloud computing | ID Management | Successful and secure bridging to cloud resources | All |
| Each year | S | Incident Response, Vulnerability and Risk Assessment | Operational Security | Preventing | All |
| FY13 Develop the monitoring framework. Identify a list of minimum monitoring capabilities. FY-15 Identify existing tools and help adoption in OSG | D | Help OSG community acquire proactive monitoring and detection capabilities. Develop a 3-tiered monitoring framework: user-level, site-level and infrastructure-level. | Operational Security | Decreased time to detect a security attack at an OSG resource. Reduction in number of incidents. | All |
| FY 15 | D | Develop a trust flow diagram of VDT stack. Identify the effect of configuration parameters on the security of the software | Software security | Reduction in number of software vulnerabilities | All |

## User Support

The User Support team’s mission is to support science communities that use OSG and increase the velocity of their scientific discovery by improved access to computational resources. As science communities, especially outside the HEP community, continue to leverage OSG, the User Support function in OSG provides a one-stop mechanism to understand their needs, provide technical guidance on how to adapt their applications to run in a DHTC environment, and help resolve issues and technical problems. The User Support team also actively supports the existing community of VOs in effectively using OSG by providing support systems that enable shared learning and serving as an anchor point for resolving complex technical problems.

OSG provides a highly developed and complex software framework for enabling computation and data management at very large scales. This framework is rich with many capabilities and options that provide a broad set of choices in technical methods for structuring simulation, analysis, and data management. As new communities seek to join and leverage the OSG capabilities, they typically require guidance in making appropriate choices from the technology “toolkit” and support in transitioning their applications from a dedicated resource model to the DHTC environment.

Over the next five years, the User Support functions will be advanced in the areas of support for new communities and existing communities who want to change and expand their use of OSG; and we will continue and refine the support for the existing OSG stakeholder communities.

In support of existing OSG Science Communities, we plan to continue and refine the current work program:

1. User support plans and conducts periodic forums that build collaborative communities between the VOs to enable shared learning and mutual support. A key principle in OSG is the advancement of the cyber-infrastructure via innovation by the VOs; the user support team enables sharing of these advancements in technology and methods within the broader OSG stakeholder community.
2. As OSG integrates and deploys new technologies (e.g. new job submission methods, storage discovery tools, etc.) that advance the capabilities of the shared cyber-infrastructure, the User Support team, with support from the developer community, will develop and deploy tutorials and documentation to help the broader OSG communities understand and potentially adopt such new capabilities.
3. The user support team serves as the anchor point for complex technical problems seen by VOs that cannot directly be attributed a technical component of OSG or may span multiple components. The user support team helps the VO conduct analysis and triage and helps refer the issue to the appropriate agent for resolution; in the case of multi-disciplinary issues, the user support team provides ownership and pulls together ad hoc teams to understand and resolve the problems.
4. The OSG currently “owns” two VOs that provide an environment for individual researchers who use OSG. These serve individual researchers who do not have a critical mass to invest in creating and operating their own VO; the “osg” VO serves researchers experienced in the use of OSG and the “engage” VO host new researchers who require substantial assistance in using the OSG. Continued operation of these VOs requires certain common services (e.g. VOMS, OSG-MM, etc.) which will continue to be supported by the user support team (while the actual hosting of these services will be handled by the OSG operations team).

In support of new science communities, we intend to develop and deploy new processes and additional staff effort to improve the speed with which new science communities are able to adapt their applications to use OSG. In the past five years, we have helped several (~10) new science communities in using OSG or planning for future use of OSG and have learned that this is long process which it often under-estimated in term of schedule, effort, and technical complexity. For 2-3 new science communities per year, User Support will develop and deploy a consulting and assistance framework that accelerates the time-to-production. By conducting a technical review of their computational approach by a panel of experts within OSG, we will provide guidance and technical recommendation to the VO on how best to adapt their applications for execution in OSG. By embedding a member of the User Support team with each new community, we plan to accelerate the process of grid-adaptation, integration, and deployment as these communities work to adapt their software to run on OSG and ramp-up to production.

A key challenge in this effort is the in-depth expertise needed in the many technical facets of the OSG framework; and it is unlikely that a small team can have expertise in all the needed areas. Thus, the User Support team will develop expertise in certain core technologies (e.g. Condor, glideinWMS, PanDA, etc.) and reach out to other technical resources within OSG to help address the needs of the Science stakeholders. Thus we accelerate the access to technical expertise for new entrants to OSG.

Deliverables

1. Bring 2 new science communities per year to effective utilization of OSG
2. Support the existing VOs in resolving issues that affect their effective use of OSG
3. Provide the common services for the Engage & OSG-VO communities per SLAs

Enabling effective use of a shared resource model requires communities to adopt various complex and new technologies and adopt a new set of societal frameworks that govern this eco-system. Although the benefits of these investments have been shown to be substantial, there is an upfront learning curve and cost threshold that must be overcome; and part of the challenge is overcoming the cultural changes in migrating from dedicated computing resources to a shared computing resources framework. In our first five years of OSG we have achieved experience in this transition and now propose to provide more structured initial support so as to facilitate the adoption of OSG by providing increased direct support to new science communities or existing communities who look to change how they use the OSG.

## Technology Architecture and Investigation – 1.5 pages

The technology architecture and investigations area provides the OSG with the mechanism for long-term technology planning and short-term execution of plans. The program of work includes collaborations between the user communities and OSG on investigations, prototyping and understanding of new capabilities in the OSG environment.

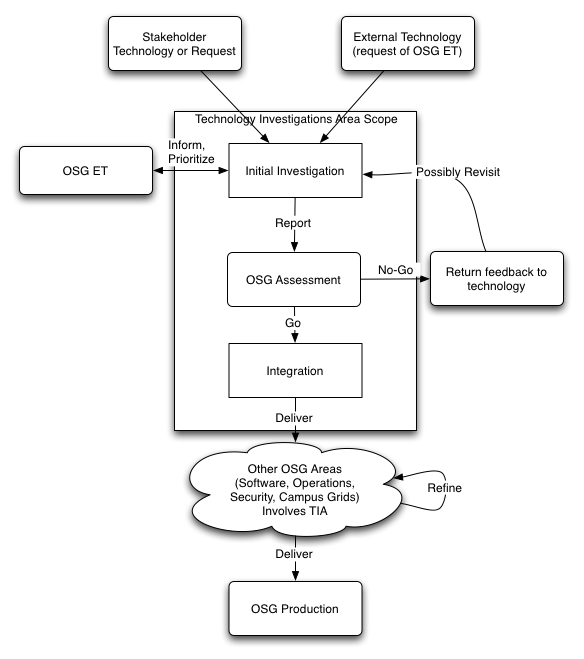
### Technology Architecture

The technology architecture program of work is the evolution of the current Blueprints area. Its primary duty is to advise the OSG Technical Director. It is responsible for:

* (DOCUMENT) Maintaining the conceptual principles of the OSG as captured in the OSG Blueprint document.
* (PLAN) Organizing face-to-face “Blueprint” meetings with the OSG Technical Director and a small group of staff members to focus at a conceptual and foundational level on specific aspects of the OSG infrastructure, technologies, operations, architectures and designs. Blueprint meetings occur approximately 3 times a year.
* (ASSIST) Assisting the OSG Technical Director and OSG area teams in executing the OSG’s long-term technology vision of a coherent, consistent end-to-end system.

The architecture group has evolved to its current state over the last 5 years, and is effective at planning. However, its impact is limited to planning for changes that can be executed by other OSG software areas. It has no effort to assist the OSG area teams. Thus, it’s been more effective at changing technology already being worked on by OSG.

### Technology Investigations

For OSG’, we include a “technology investigations” program of work, to provide a more direct mechanism for managing the technology landscape and assisting OSG areas in making changes. While the architecture group is an advisory board for the technical director, the investigations group is designed to be a tool that can be strategically applied by the technical director.

We will focus on collaborating with OSG stakeholders to identify those topics that are most suitable and may be potentially disruptive medium-term. The group’s work will be organized as investigations into a specific topic. We will focus on finding *existing* technologies that can be deployed in the next 6-24 months. The investigations will be driven by the architectural work. Together with OSG staff, the technology investigation’s effort will additionally utilize students at the University of Nebraska-Lincoln; UNL students have contributed positively to the current OSG project.

If the technology will be adopted, the investigation team will do further “major integration” and will output the technology (which may not be software) to one of the other OSG areas. The other area may choose to do further refinement, with final output to production. For accepted technologies, we will collaborate closely with the OSG-Software area. See the attached diagram for an overview of the workflow.

The Software area and Technology areas have several apparent overlaps; we envision the two areas will work closely to avoid duplicate work. One criterion we will use in order to avoid duplicate work is that if the investigation/evaluation is used to inform decision about software adoption, it is in the technology group. If the decision has already been made, it is part of the software area.

The user communities drive the evolution in OSG capabilities. Invariably the user communities and software developers are ahead of the OSG in exploring new ideas for their applications and environments; invariably, there is significant overlap in the activities of the communities. OSG benefits from a close and early collaboration as we can influence and learn from the communities. This helps us “center” ourselves as the common, reusable, shared infrastructure and ensure the technologies are operationally robust and usable. The technology group provides an anchor for this collaboration.

We believe our external collaborations will both extend (users with evolving needs will require evolving existing technologies) and expand (new users bringing new disruptive technologies to the OSG) the technology portfolio. Based on the current inputs from the OSG stakeholders, we have identified the following areas as initial targets:

* + **Many-core processor support**: Many-core processing techniques are a necessary evil for today’s processor architectures where core count increases but core speed does not. These techniques are beginning to move out of R&D and “traditional HPC” arenas and intersecting with DHTC. In 2010, the High Throughput Parallel Computing (HTPC) satellite began the technical work required for integrating many-core jobs into the OSG. We will continue to collaborate with and empower their efforts throughout OSG’, especially as this becomes critical for stakeholders such as LHC
  + Science stakeholders depend on this now. And who.
  + LHC schedule – starting in 2011 the Tier-1s and later the Tier-2s will need these capabilities.
  + If ATLAS and CMS push then it will be an easy transition. Some work being done through GlideinWMS and Panda. Biggest pieces missing – accounting (PBS, Condor exist) and launch through the Glidein framework. This has been delivered. Sociological underpinning of providing the capability at the sites, the submission side and the delivery site has been accomplished,
  + Dynamic reservation to reserve a node rather than static allocation of full nodes at a time.
  + New capability put into place by the collaboration between the Satellite and the OSG.
  + Fills a “niche”.
  + Managing the increasing complexity of a single CPU. Need a convention of number of cores needed and available once one arrives. The fact that there is a mixed environment – some jobs need single core and some many.
    - CMS will find over next 2-3 years that won’t schedule the whole node (Current strategy) and will need to have the flexibility of sub-node scheduling at Tier-1s and Tier-2s. Given that the Tier-1 and Tier-2s use Condor. Need more work in Condor to support this. Commitment from Condor to work with us on this.
    - ATLAS is already needing dynamic scheduling of the partitioning of the nodes for different applications.
    - Need scheduling prediction capabilities for node reservation, draining and allocation. Finishing of a whole workflow rather than a single job in the workflow management system. E.g. Panda knows about job sets.
  + Fraction of accessible resources will flip to all be many core on a CPU over the next 2-5 years.

GPUs also as a Satellite. For the LHC this is an interesting technology and they are exploring the potential. There is no roadmap for deloying into production in OSG at this time. OSG is committed to work on this through Satellites in collaboration with the communities.

* **Clouds/virtualization**: Several communities have expressed interest in cloud/VM technologies. This interest has been focused on expanding the OSG’s DHTC technologies to include cloud resources, and to provide smaller VOs a more comprehensive means to package a uniform job execution environment. We collaborate with the ExTENCi and glideinWMS projects for both interests, and believe they will deliver technology that the OSG will need to integrate.
* **Monitoring**: While OSG VOs may have excellent monitoring for their own activities, OSG-wide job monitoring is a current deficiency. Better monitoring is a frequent request from the OSG Production area and smaller VOs. This was unsuccessfully addressed early on in the OSG project. We believe the underlying technologies have matured in recent years and merit re-evaluation.
* **Data management**: Throughout the OSG, there has been a focus in storage management. We package reliable, scalable storage solutions for sites that meet the WLCG’s needs. The individual VOs then take these “storage resource islands” and combine them into a coherent system. The influx of small VOs and small WLCG T3 sites has put an emphasis to rethink data management. The WLCG is exploring using cache-based data distribution as a simpler alternative to today’s pre-placement model. The OSG is interested in advising and following the WLCG efforts in order to generalize the approach to the entire OSG.
* **Campus Infrastructure**: There has been recent awareness that campuses have a unique set of challenges and requirements; the technology of a well-funded nation-wide grid cannot be simply grafted to the smaller scope. In OSG’, we plan on having a clear set of campus-oriented technologies for building a campus grid and bridging campus users to the national grid.

These will be the immediate major focuses, but we envision there will be more to come over the next five years.

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| **Milestone** | **S or D** | **Deliverable** | **Area Section** | **Measures of Success** | **Communities Benefited** |
| End of each calendar year | S | Updated Architectural document; | Architecture | Acceptance by OSG-ET | All |
| Three times a year | S | Blueprint meeting | Architecture | Advise TD and motivate investigations | All |
| 2011 | D | Integrate HTPC into OSG | Investigation | Acceptance by WLCG and two other VOs | WLCG and campus science communities (GLOW & HCC). |
| 2011 | D | Integrate cloud resources | Investigation | Number of cloud resources added | WLCG; small VOs |
| 2012 | D | OSG-wide monitoring | Investigation | Percentage of OSG jobs monitored | Small VOs; OSG production |
| 2012 | D | Simplified data management; support new WLCG models | Investigation | Adoption. | Small VOs and WLCG. |
| 2013 | D | Campus Grids Technology | Investigation | Adoption by campuses; number of researchers bridged to OSG | New Campus Communities |

## Program Office – 1 page

The activities in the program office cover: education, outreach, project management and assessment, and internal and external communication (including oversight of documentation).

### OSG Education

The OSG educational offering will comprise two annual schools, a weeklong school for students and researchers interested in learning more about grid computing, particularly as it is used in OSG, and one for new and potential OSG site administrators. Each one will follow the overall format of the successful 2010 OSG Summer School: an in-person training event that has a strong emphasis on practical, hands-on experience and that is taught by OSG staff who actively use the technologies being discussed. This effort will include the ongoing development and refinement of the curricula and materials; preparation for and delivery of the schools themselves; and analysis of during- and post-event feedback and evaluations.

To support the school trainees after each school, we will continue the mentoring program started with the 2010 Summer School. Each trainee is paired with an OSG staff mentor, based on geography, shared interests, and availability. Mentors will stay in contact with their trainees, be a first point-of-contact for questions and issues that arise, and will encourage their trainees to increase their participation in the scientific grid computing community. Each mentor will be limited to a few trainees, so that they can provide adequate mentoring without taxing their other duties. This effort will include the careful management and development of the mentoring program as a whole. In the OSG 2010 summer school, we found the mentoring program useful because it helped to keep the students engaged after the school ended.

### Council

The OSG Council is the governing body of the OSG Consortium and is responsible for assessing that the program of work outlined by the OSG Executive Team and OSG Executive Director. The OSG Council is composed of those members of the OSG Consortium that contribute in a significant way to the OSG. The OSG Council endorses all strategic decisions, whether they are recommended by the Executive Team or derived through OSG Council Forum. The procedural rules for the OSG Council operations are described in the OSG By-Laws. The OSG Council Chairperson is assisted in the day-to-day operational needs of the OSG Council by an OSG Council Administrator.

### Project Management and Assessment

The program of work for OSG is established annually through a high-level articulation of the stakeholder needs, a more detailed WBS of the deliverables and milestones and a staff assignment breakdown. During each year decisions are taken by the Executive Team on any re-prioritization of tasks and reassignments of effort. For this next phase of OSG we will programmatically divide the work into “operations” and “new capabilities”. For Operations tasks there will be a set of measurements and goals; for the new capabilities a traditional WBS structure. We will make more systematic use of standardized surveys to be able to assess trends in user satisfaction, needs and responses. We want to maintain and improve our ability to make decisions flexibly, quickly and clearly, and to be able to make timely reactions to changes in, or new, user needs, new opportunities and available technologies.

To ensure successful education and documentation programs that are developed by OSG staff experts, we will require a minimum allocation of staff time to education, documentation and assessment activities. To that end, the statements of work will include specific requests for small percentages of individual staff members’ effort for education, documentation and assessment.

Add assessment paragraph in here – Rob G

Ruth;s thoughts: in Phase I of OSG we collected lots of information. In Phase II we will focus on understanding this information and presenting it in meaningful forms.

### Communications

Administrative and communications support ensure good communication internal to the Consortium including support for the work of the OSG Council, the OSG main web pages and monthly newsletter. We will consolidate the tools to make one communications space across the existing 3 services. The documentation “tsar” works to ensure a consistent, complete documentation set for use by all Consortium members. The external relations staff provide outreach to partners and peers, the weekly e-publication “The Digital Scientist” in collaboration with TeraGrid/XD and the European Grid Infrastructure program. We will focus our attention on continuation of the Research Highlights – science and/or research stories where the research has benefited from the OSG.

### Federating with Europe

Many of the OSG user communities have community systems and users that span Europe as well as the USA. OSG pays particular attention throughout our program on technical interoperation of the infrastructures, bi-directional access to (bridging) of the services, and collaboration with our European partners. These are covered in the particular areas responsibilities: Interoperability testing of new components and software by each side through regular coordination with the EGI project; Security incident response, trust relationships and consisten policies; Coordination in software adoption and release, including regular coordination with the EMI project; Acting on behalf of the US LHC community in reporting to and operations of the World Wide LHC Computing Grid; And Participating in the OGF related “Infrastructure Policy Group”, IGTF and other worldwide coordination bodies.

### Central and South America

Since 2008, OSG has had a recognized program of collaboration with groups in Central and South America to help and support in the establishment of local (federated) distributed infrasructures. The nature of this support changes as the maturity of the local organizations evolve. Activities include: educational schools (through the Outreach effort), support for operational services and resources before the local organization can host them (through the Operations effort) and support for users in those areas to use existing OSG resources (through the User Support/Engagement effort). We are including a minimum of effort to continue these activities through the core OSG program, at the same time as exploring means to promote a Satellite program in this area in order to make faster progress and increase the impact and value.

### Effort and Institutions

# Conclusion 0.1 pages

**References**

From Science Benefits:

[1] the “ridge” from cms

[2] jet quenching from ATLAS and ALICE

[3] [4] pick a few search papers from both. E.g. the dijet resonance searches, maybe the black hole paper, for fun. The first susy paper if it is out by then.

[5] top cross section paper

[6] Sliz, Protein structure determination by exhaustive search of Protein Data Bank derived databases, Proc. Nat’l Academy of Sciences doi:10.1073/pnas.1012095107

[7] reference for GLOW

[8] reference for FermiGrid

[9] reference for NYStategrid

[10] the 4 publications from HCC work on OSG.

[11] This could be a place for a reference to the UCSDGrid website.