This project proposes to develop and deploy the Dynamic Network System (DYNES), a nationwide cyber-instrument spanning 39 US universities and 16 Internet2 connectors. DYNES will support large, long-distance scientific data flows in the LHC, other leading programs in data intensive science (such as LIGO, Virtual Observatory, and other large scale sky surveys), and the broader scientific community. By integrating existing and emerging protocols and software for dynamic circuit provisioning and scheduling, in-depth end-to-end network path and end-system monitoring, and higher level services for management on a national scale, DYNES will allocate and schedule channels with bandwidth guarantees to several classes of prioritized data flows with known bandwidth requirements, and to the largest high priority data flows, enabling scientists to utilize and share network resources effectively. DYNES is dimensioned to support many data transfers which require aggregate network throughputs between sites of 1-20 Gbps, rising to the 40-100 Gbps range. This capacity will enhance researchers' ability to distribute, process, access, and collaboratively analyze 1 to 100 TB datasets at university-based Tier2 and Tier3 centers now, and PB-scale datasets once the LHC begins operation.

DYNES is based on a "hybrid" packet and circuit architecture composed of Internet2's ION service and extensions over regional and state networks to US campuses. It will connect with transoceanic (IRNC, USLHCNet), European (GÉANT), Asian (SINET3) and Latin American (RNP and ANSP) R&E networks. It will leverage the network infrastructures of the Internet2 community, as well as computing and storage facilities at participating sites, to enable data flows among US sites as well as overseas. It will build on existing key open source software components that have already been individually field-tested and hardened in part by the PIs: DCN Software Suite (OSCARS / DRAGON), perfSONAR, UltraLight Linux kernel, FDT, FDT/dCache, FDT/Hadoop, and PLaNeTs. DYNES deployment is essential for efficient use of available network resources and to enhance the efficiency of its users. This will be achieved by secure data transfer request APIs to communicate parameters characterizing the transfer attributes (size, level of priority, desired ETA, loss tolerance, etc); queues for tasks (transfers) of different lengths and levels of priority, coupled to dynamic (real or virtual) path-construction services for the most demanding, high-priority tasks, leveraging the work of the DOE-funded OSCARS, TeraPaths and LambdaStation projects; network path and topology discovery, path performance estimation, and tracking services; and policy-based network path-request and utilization services.

The DYNES team will partner with the LHC and astrophysics communities, OSG, and Worldwide LHC Computing Grid (WLCG) to deliver these capabilities to the LHC experiment as well as others such as LIGO, VO and eVLBI programs, broadening existing Grid computing systems by promoting the network to a reliable, high performance, actively managed component. It will enhance HEP applications by closely coupling to the Grid-based physics production and analysis systems that are now in use in ATLAS, CMS, ALICE and LHCb. Physicists will use DYNES, coupled with Internet2's ION, ESnet, US LHCNet, and the overseas partner networks, to help meet near-term data analysis milestones and greatly improve performance and robustness in data handling operations. Astrophysicists will enhance their ability to locate, extract and distribute and further process massive datasets.

Intellectual Merit: The deployment of DYNES, though its groundbreaking character as the first multidomain hybrid packet- and circuit production network system aimed at data intensive science, and its unprecedented level of network capability in handling large data flows and real-time data streams, will represent a watershed in the history of R&E networks.

Broader Impact: Future science programs in HEP, astrophysics and gravity wave physics, and other data intensive disciplines, will be facilitated by DYNES' technologies and worldwide network partnerships. Working with CHEPREO and similar E&O efforts targeting under-served communities both in the US and overseas, DYNES will reach a wide variety of students at collaborating institutes including underrepresented groups and minorities. This will lower the barriers, and enable individual graduate students, undergrads, postdocs and faculty to use DYNES to achieve high throughput in support of their research in many data intensive fields.