The LANL-Sandia Axis: Mapping the Core of the U.S. Magneto-Inertial Fusion Community (2010-2016)

Executive Summary

This report provides a comprehensive intelligence assessment of the collaborative network between Los Alamos National Laboratory (LANL) and Sandia National Laboratories (SNL) in the fields of High Energy Density Physics (HEDP) and Magnetized Inertial Fusion (MIF) during the period of 2010-2016. The analysis reveals a deeply integrated, mission-driven ecosystem operating at the core of the U.S. nuclear weapons complex. The collaboration was not primarily focused on developing fusion as an energy source, but was a cornerstone of the National Nuclear Security Administration's (NNSA) Stockpile Stewardship Program (SSP), providing the fundamental experimental data required to validate the advanced simulation codes used to certify the U.S. nuclear arsenal.

This investigation provides the following high-confidence answers to the Core Intelligence Questions (CIQs):

- **CIQ 1: Formal Collaborative Structures.** The primary formal, tri-lab collaborative body governing advanced diagnostic development for HEDP facilities was the **National Diagnostics Working Group (NDWG)**, established in 2013. This group, comprising over 100 scientists from LANL, SNL, Lawrence Livermore National Laboratory (LLNL), and key academic partners, was chartered to develop and implement multi-year plans for the advanced diagnostics required by NNSA's major experimental facilities, including Sandia's Z-Machine. Key representatives during this period included Dr. Stephen Batha of LANL and Dr. G. A. Rochau of Sandia.
- **CIQ 2: Key Personnel Beyond Known Leadership.** Beyond the senior leadership, the MagLIF program at Sandia involved a broad cadre of staff scientists, engineers, and computational physicists. Key contributors identified through an extensive co-authorship analysis include **Dr. Kyle J. Peterson**, **Dr. Ryan D. McBride**, **Dr. Matthew R. Gomez**, **Dr. Adam B. Sefkow**, **Dr. Roger A. Vesey**, **Dr. Thomas J. Awe**, **Dr. M.E. Cuneo**, **Dr. Mark H. Herrmann**, **Dr. Christopher A. Jennings**, and **Dr. Edmund P. Yu**. At LANL, key personnel involved in related HEDP and MIF research included **Dr. Glen A. Wurden**, **Dr. Thomas P. Intrator**, and **Dr. Toru E. Weber**.
- **CIQ 3: LANL FRC/MTF and Sandia MagLIF Collaboration.** The relationship between LANL's Field-Reversed Configuration (FRC)/Magnetized Target Fusion (MTF) programs

and Sandia's MagLIF program is best characterized as one of **parallel, risk-mitigating development rather than direct programmatic integration**. No joint publications on the core fusion concepts were identified. However, the laboratories maintained a robust institutional partnership, including a formal Memorandum of Understanding for LANL to conduct plutonium physics experiments on the Z-Machine and extensive informal collaboration through shared conferences and the NDWG.

- **CIQ 4: Personnel Transitions.** The most significant and strategic personnel transfer during this timeframe was the career trajectory of **Dr. Charles W. Nakhleh**. He transitioned from LANL's X-Theoretical Design Division to become the leader of Sandia's Inertial Confinement Fusion (ICF) Target Design Department (c. 2007-2013), where he led the theoretical design for MagLIF. In 2013, he returned to LANL to assume leadership of the entire X-Theoretical Design Division. This career path represents a deliberate NNSA investment to cultivate a leader with integrated expertise across the nation's premier nuclear design and pulsed-power laboratories. No other personnel transfers of this nature between the specified divisions were identified.

Strategic Context: The Stockpile Stewardship Imperative

The extensive collaboration between Los Alamos National Laboratory and Sandia National Laboratories in High Energy Density Physics (HEDP) and Magneto-Inertial Fusion (MIF) between 2010 and 2016 was not an academic exercise in pursuit of fusion energy. It was a mission-critical component of the National Nuclear Security Administration's (NNSA) Stockpile Stewardship Program (SSP), the science-based approach established after the 1992 moratorium on underground nuclear testing to ensure the safety, security, and reliability of the U.S. nuclear arsenal.[1] The research conducted on Sandia's Z Pulsed Power Facility, the world's most powerful pulsed-power driver, provided the only accessible, real-world data in certain HEDP regimes needed to validate and improve the physics models within the nation's most secret weapons simulation codes.[1]

The fundamental purpose of this work was to use HEDP experiments as scientific surrogates for studying the physics of a nuclear weapon primary.[1] The implosion of a cylindrical or spherical metal "pusher" (a liner) onto a fuel core is the basic mechanism of the primary stage of a modern thermonuclear weapon. The hydrodynamic instabilities that arise during this process, particularly the Rayleigh-Taylor instability and its magnetic counterpart, the Magneto-Rayleigh-Taylor (MRT) instability, are the most critical failure modes that can disrupt the symmetric compression required for an efficient nuclear detonation.[1] In the absence of full-scale testing, the SSP relies entirely on these advanced simulation codes to certify the performance and reliability of these weapon systems. Therefore, experiments studying the implosion of beryllium liners under extreme magnetic pressure on the Z-Machine are a direct physical analogue to a critical failure mode in a modern device, providing indispensable data for code validation.[1] This research directly supports the annual assessment and certification of the specific weapon systems for which LANL has stewardship responsibility, including the B61, W76, W78, and W88 warheads.[1] A 2006 Memorandum of Understanding between LANL and Sandia formalized this collaboration, defining a series of plutonium experiments to be conducted on the Z-Machine through 2016 to support this mission.[4]

This mission context reframes the entire collaborative network. The personnel, funding streams, and security posture are all dictated by the requirements of the nuclear weapons complex, not by the Department of Energy's civilian fusion energy programs. The scientific output from this collaboration, including numerous publications in open, peer-reviewed journals and presentations at major international conferences, serves a dual purpose. Publicly, it advances the global scientific understanding of HEDP and MIF. Programmatically, it establishes a rigorously peer-reviewed, unclassified foundation for the highly classified work of code validation. The unclassified papers validate the fundamental physics models—such as magnetohydrodynamics and instability growth rates—that are common to both the open experiments and the secret weapons codes. This allows the NNSA to leverage the global scientific community for peer review of the underlying physics without revealing classified applications or specific weapon design parameters. The classified "black world" of stockpile stewardship builds directly upon the scientific foundation laid in the unclassified "white world" of academic research.

The Experimental Hub: Sandia's Pulsed Power Directorate and the MagLIF Program

As the host of the Z-Machine, Sandia National Laboratories' Pulsed Power Directorate served as the undisputed operational hub for the joint HEDP and MIF research during the 2010-2016 period. The Magnetized Liner Inertial Fusion (MagLIF) program, a novel approach to achieving controlled fusion, was the directorate's flagship experimental campaign, marshaling a broad team of theorists, experimentalists, and engineers from across the NNSA complex.

Program Leadership and Core Scientific Cadre

The MagLIF program was led by a small group of highly experienced senior scientists who represented the core intellectual leadership of the effort. Their roles and expertise defined the program's structure as a classic triad of foundational theory, experimental execution, and advanced diagnostics—a tight feedback loop essential for progress in high-risk physics.

- **Dr. Stephen A. Slutz:** A Distinguished Member of Technical Staff at Sandia, Dr. Slutz is widely credited as the original inventor of the MagLIF concept.[1] His foundational 2010 *Physics of Plasmas* paper laid out the theoretical basis for the program, proposing the use of axial pre-magnetization and laser pre-heating to relax the extreme implosion velocity requirements of traditional inertial confinement fusion.[1] His direct co-authorship on subsequent experimental papers demonstrates his central role in translating this theory into physical reality.
- **Dr. Daniel B. Sinars:** As the lead experimentalist and diagnostic expert, Dr. Sinars was a constant presence on nearly all key MagLIF publications.[1] A recipient of the Presidential Early Career Award for Scientists and Engineers (PECASE), his primary expertise was in developing the novel, high-resolution X-ray radiography systems that made the quantitative measurement of MRT instability growth possible.[1] This diagnostic capability was the critical link that allowed the experimental results to be directly compared to simulation predictions. He later became the Director of the entire Pulsed Power Sciences Center at Sandia and was the lead for a major ARPA-E funded collaboration with the University of Rochester's Laboratory for Laser Energetics (LLE) to study MagLIF scaling principles.[1]
- **Dr. Charles W. Nakhleh:** During his tenure at Sandia from approximately 2007 to 2013, Dr. Nakhleh served as the leader of the Inertial Confinement Fusion (ICF) Target Design Department. This strategically important position placed him in charge of the theoretical and computational design for all MagLIF experiments. His department was responsible for using simulation codes like LASNEX to model the entire process from laser absorption to final stagnation, providing the specific target designs for the first successful neutron-producing MagLIF experiments.[1]
- **Dr. Thomas A. Mehlhorn:** A senior manager and physicist within the pulsed-power center, Dr. Mehlhorn's work prior to and during this period focused on Z-pinch physics, fusion-fission hybrids, and the broader application of pulsed power for dynamic material properties research, providing senior-level expertise and programmatic guidance.[9]

The Broader MagLIF Team: An Expanded Network Analysis (CIQ 2)

Beyond the core leadership, the execution of the MagLIF program required a large, multi-disciplinary team of staff scientists, engineers, computational physicists, and technicians. A systematic co-authorship analysis of key publications and conference proceedings from 2010 to 2016 reveals the full roster of this working-level network, directly addressing the second Core Intelligence Question. The team was dominated by personnel from Sandia's Pulsed Power Sciences Center, with crucial contributions from other laboratories and industrial partners.

Table 1: Key Personnel in the LANL-Sandia HEDP/MIF Network (2010-2016)

Name	Primary Institution & Division/Directorate	Key Role & Program Focus
Sandia National Laboratories		
Dr. Daniel B. Sinars	Pulsed Power Sciences Center	Lead Experimentalist; Advanced Diagnostics (X-ray Radiography)
Dr. Stephen A. Slutz	Pulsed Power Sciences Center	Lead Theorist; Inventor of the MagLIF concept
Dr. Charles W. Nakhleh	Pulsed Power Sciences Center	Leader, ICF Target Design Department (c. 2007-2013)
Dr. Thomas A. Mehlhorn	Pulsed Power Sciences Center	Senior Manager; Pulsed Power Physics
Dr. Kyle J. Peterson	Pulsed Power Sciences Center	Staff Scientist/Manager; MRT Instability, Beryllium Liners
Dr. Ryan D. McBride	Pulsed Power Sciences Center	Staff Scientist; Beryllium Liner Implosions, Integrated Experiments
Dr. Matthew R. Gomez	Pulsed Power Sciences Center	Staff Scientist; Integrated MagLIF Experiments, Performance Scaling
Dr. Adam B. Sefkow	Pulsed Power Sciences Center	Staff Scientist; Integrated Target Design and

		Simulation
Dr. Roger A. Vesey	Pulsed Power Sciences Center	Staff Scientist; Target Design, Instability Mitigation
Dr. Thomas J. Awe	Pulsed Power Sciences Center	Staff Scientist; Instability Growth, Premagnetized Liners
Dr. M. E. Cuneo	Pulsed Power Sciences Center	Senior Scientist; Z-pinch Physics, Power Flow
Dr. Mark H. Herrmann	Pulsed Power Sciences Center	Senior Manager; HEDP and ICF Physics
Dr. Christopher A. Jennings	Pulsed Power Sciences Center	Staff Scientist; Experimental Execution, Diagnostics
Dr. Matthias G. Geissel	Pulsed Power Sciences Center	Staff Scientist; Laser Pre-heating, Laser-Plasma Interactions
Dr. Edmund P. Yu	Pulsed Power Sciences Center	Staff Scientist; Computational Modeling (Electrothermal Instabilities)
Los Alamos National Laboratory		
Dr. Stephen H. Batha	Physics (P) Division	Senior Scientist; ICF/HEDP Diagnostics, National Diagnostics WG
Dr. Glen A. Wurden	Physics (P) Division, P-24	Lead Researcher; FRC/MTF Experiments, Plasma Diagnostics

Dr. Thomas P. Intrator	Physics (P) Division, P-24	Senior Scientist/Mentor; FRC/MTF Program
Dr. Toru E. Weber	Physics (P) Division, P-24	Staff Scientist; MSX Experiment, FRC Formation
Dr. Scott C. Hsu	Physics (P) Division, P-24	Staff Scientist; FRX-L Experiment, Plasma Liner Physics
Dr. William Daughton	Theoretical (T) Division	Staff Scientist; Magnetic Reconnection Theory & Simulation

Essential Support: The Role of Industrial Partners

The complex and first-of-their-kind experiments conducted on the Z-Machine could not have been executed by the national laboratories alone. They required a close partnership with specialized industrial contractors capable of fabricating the unique components needed for the targets and diagnostics. Analysis of co-author affiliations on experimental papers reveals that **General Atomics** was the primary industrial partner for the MagLIF program.[1] Personnel from General Atomics, including

Diana Schroen, **Korbie Killebrew**, and **B.E. Blue**, are frequently listed as co-authors on key experimental papers.[1] Their role was critical, encompassing the precision manufacturing of the experimental targets, such as the solid beryllium and aluminum liners machined with microscopic, sinusoidal perturbations used to seed and measure the growth of the MRT instability.[1] This industrial partnership highlights the broader ecosystem required to execute high-consequence national security science.

The Design Agency Contribution: Los Alamos National Laboratory's Multi-faceted Role

While Sandia provided the primary experimental platform, Los Alamos National Laboratory served as a critical partner, bringing its unique and historical expertise as the nation's premier nuclear weapons design agency to the collaboration. LANL's contributions were multi-faceted, ranging from direct support to the MagLIF experiments from its X-Theoretical Design Division to parallel, independent research into related MIF concepts within its P-24 Thermonuclear Plasma Physics group. This deep, independent knowledge base meant LANL was not merely a consultant but an equal partner in advancing the science of magneto-inertial fusion.

Weapons Physics and Target Design (X-Division)

LANL's X-Theoretical Design (XTD) Division is the historical and current center for the physics design, assessment, and certification of the U.S. nuclear arsenal.[1] Its involvement in the joint HEDP research provided a direct link between the experimental work on Z and the core mission of the SSP. Dr. Charles Nakhleh's career exemplifies this connection. Before his pivotal tenure at Sandia, his early work at LANL (1996-c.2007) was as a technical staff member in X-Division, where he served as a "weapon system point-of-contact" and developed methods for uncertainty quantification in simulation codes.[1] His return to LANL in 2013 to lead the entire XTD division placed him in direct charge of the scientists responsible for applying the data and physical understanding gained from experiments like MagLIF to the annual certification of the stockpile.[1]

Another key figure from LANL was Dr. Stephen Batha, a senior scientist in the Physics (P) Division with extensive expertise in ICF and HEDP diagnostics.[12] His work focused heavily on developing and fielding diagnostics for major facilities like the National Ignition Facility (NIF) and Z, and he was a key LANL representative on the National Diagnostics Working Group, the primary formal collaborative body for this enabling technology.[15]

Parallel Expertise: The LANL FRC and MTF Programs (P-24 Group)

Concurrently with the MagLIF experiments at Sandia, LANL's P-24 Thermonuclear Plasma Physics group was pursuing a related but distinct approach to MIF known as Magnetized Target Fusion (MTF).[1] This research track, which has a long history at LANL, focused on using a Field-Reversed Configuration (FRC) as the magnetized plasma target. An FRC is a high-beta plasma torus with purely poloidal magnetic fields, offering potential advantages in stability and confinement.

During the 2010-2013 period, the culmination of this effort was the Field-Reversed Configuration Heating Experiment (FRCHX), a joint project with the Air Force Research Laboratory (AFRL) that used AFRL's Shiva Star pulsed-power driver to implode a solid aluminum liner onto an FRC target formed and translated from a LANL-designed source.[1] The key LANL personnel leading this independent but parallel research track were

Dr. Glen A. Wurden, **Dr. Thomas P. Intrator** (deceased in 2014), **Dr. Toru E. Weber**, and **Dr. Scott C. Hsu**.[1] Their work on FRC formation, stability, and translation provided LANL with a deep, hands-on knowledge base in magnetized plasma targets that was highly complementary to the work being done on MagLIF at Sandia. This independent expertise was crucial, as it meant the NNSA was pursuing a portfolio of MIF approaches, hedging against the significant scientific risk inherent in any single concept.

The Connective Tissue: Mapping Collaborative Structures and Personnel Flows

The collaboration between LANL and Sandia was managed through a combination of formal, NNSA-chartered working groups, direct institutional agreements for facility use, and informal but highly effective interactions at major scientific conferences. The flow of personnel, while limited, was strategically significant, highlighted by the career of Dr. Charles Nakhleh, which served as a human bridge between the two institutions.

The National Diagnostics Working Group (CIQ 1)

The most significant formal collaborative structure identified is the **National Diagnostics Working Group (NDWG)**. The user query referenced an "ADEC Working Group," but analysis of NNSA programmatic documents reveals that the NDWG was the correct and primary entity for this function.[15] Established in 2013, the NDWG's charter is to identify, prioritize, and coordinate the development of transformational diagnostics to support NNSA's HED experimental facilities: the National Ignition Facility at LLNL, the Z-Machine at Sandia, and the Omega/OmegaEP laser facility at the University of Rochester's LLE.[21] This tri-lab group, comprising over 100 scientists, was created to ensure that the expensive, complex instrumentation needed to measure HEDP experiments was developed collaboratively, avoiding duplication of effort and ensuring the best tools were available across the complex.[19] The existence of this group indicates a deliberate NNSA strategy to foster competition on the physics concepts (e.g., MagLIF vs. MTF) while mandating collaboration on the enabling technologies (diagnostics).

Table 2: Profile of the National Diagnostics Working Group (NDWG)

Field	Description
Official Title	National Diagnostics Working Group (NDWG)
Charter/Purpose	To identify, prioritize, and implement multi-year plans for the development of advanced diagnostics for NNSA's High Energy Density (HED) experimental facilities (NIF, Z-Machine, Omega).[19]
Key Institutional Members	Sandia National Laboratories (SNL), Los Alamos National Laboratory (LANL), Lawrence Livermore National Laboratory (LLNL), Laboratory for Laser Energetics (LLE), Massachusetts Institute of Technology (MIT), General Atomics.[15]
Key LANL Representative (2010-2016)	Dr. Stephen H. Batha [15]
Key Sandia Representative (2010-2016)	Dr. G. A. Rochau [15]

Joint Publications and Shared Platforms (CIQ 3)

While no direct, formal collaboration on the MagLIF and FRCHX fusion concepts was found, the labs maintained a robust partnership through other channels. A high-level Memorandum of Understanding governed LANL's use of the Z-Machine for critical SSP experiments on plutonium, demonstrating a formal framework for LANL to operate as a user on Sandia's flagship facility.[4]

The primary venues for informal collaboration and knowledge exchange were the major annual scientific conferences, particularly the IEEE Pulsed Power Conference (PPC) and the APS Division of Plasma Physics (DPP) meeting. These events served as the de facto working group meetings for the entire HEDP community. For example, the 2013 IEEE Pulsed Power and Plasma Science (PPPS) conference was chaired by Dr. Bryan Oliver of Sandia, with Dr. Mark Crawford of LANL serving as a technical program co-chair, indicating close coordination at the leadership level.[23] Both laboratories consistently presented dozens of papers at these meetings, with sessions on Z-pinch physics, HEDP, and diagnostics providing a sanctioned forum for scientists from both institutions to share results, debate physics, and plan future experiments outside of formal programmatic channels.[24]

The Human Bridge: Personnel Transitions (CIQ 4)

The most direct and strategically significant link between LANL's X-Division and Sandia's Pulsed Power directorate is embodied in the career of **Dr. Charles W. Nakhleh**.[1] His transition from a theoretical weapons physicist at LANL to the head of experimental target design for MagLIF at Sandia, followed by his return to lead LANL's entire theoretical weapons design division, is a clear example of a deliberate, long-term investment by the NNSA. This career path created a leader with an unparalleled, integrated understanding of both the theoretical design codes at LANL and the experimental platforms at Sandia that validate them. This cross-pollination of expertise at the highest level is a far more effective mechanism for knowledge transfer than formal reports or workshops, ensuring that the lessons learned from the complex reality of HEDP experiments were directly infused back into the core of the nation's nuclear design agency.[1] No other personnel transfers of a similar nature or seniority between the specified divisions were identified during the 2010-2016 timeframe.[28]

Intelligence Synthesis and Network Assessment

The synthesis of programmatic, personnel, and publication data reveals a mature, robust, and highly interconnected collaborative ecosystem between Los Alamos and Sandia National Laboratories dedicated to advancing HEDP and MIF science for the Stockpile Stewardship Program. This network is not a loose academic affiliation but a professionally managed, mission-focused enterprise operating at the heart of the U.S. national security complex.

The core of this network is defined by a shared mission (SSP), a primary experimental facility (the Z-Machine), and a fluid, interconnected community of experts. Leadership is concentrated in a small cadre of senior scientists and managers—**Sinars, Slutz, Gomez, and**

McBride at Sandia, and **Batha and Nakhleh** at LANL—who served as the central nodes of the network. They were supported by a broad base of dozens of staff scientists, engineers, and computational physicists who formed the working-level backbone of the research effort.

The collaborative architecture was sophisticated, employing formal structures like the National Diagnostics Working Group for enabling technologies where cooperation was most efficient, while allowing for parallel, competitive development of the primary fusion concepts (MagLIF and MTF) to foster innovation. This portfolio approach allowed the NNSA to hedge against the immense technical uncertainty of MIF research. The entire enterprise was supported by critical industrial partners like General Atomics for target fabrication and was deeply integrated with the wider academic community through partnerships with institutions like the University of Rochester and MIT.

Ultimately, the core of the U.S. "black world" plasma physics community is not defined by a single, secret project but by this dynamic ecosystem. The key personnel are those with the clearances, access to the primary facilities, and, most importantly, the specialized expertise in HEDP relevant to nuclear weapons physics. The network map reveals that individuals like Sinars, Batha, and Nakhleh are central nodes precisely because their work and influence spanned multiple projects and institutions, all in service of the same underlying national security mission: to provide the scientific foundation that ensures the credibility of the U.S. nuclear deterrent.

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