Enabling the Internal Organization to Support Lateral Alignment Across Stakeholders

A Case Study of the Office of Environment and Energy, Federal Aviation Administration

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Executive Summary

The Office of Environment and Energy in the FAA faces a fundamental challenge: How can it organize its efforts to fulfill existing, internal FAA goals and priorities while simultaneously serving as a catalyst to help re-align the efforts of all the stakeholders associated with aviation and the environment? The Office, known as AEE (for Aviation Environment and Energy), cannot focus only on transformation and change in the system, nor can it fulfill its existing mandates by operating in narrow, internally oriented ways. The purpose of this case study is to document the internal challenges and choices facing this organization – to help in its strategic planning, to illustrate the use of the lateral alignment framework, and to educate others on the process and substantive challenges.

The challenges concerning aviation and the environment are substantial. Noise and emissions issues represent a constraint on growth in airport and in-flight operations. Understanding the impacts of aviation on the atmosphere requires new scientific research and the development of new tools, models, and methods – all with important policy implications. On these and related issues, the Office of Environment and Energy must coordinate its efforts with other federal agencies, including NASA, EPA, DoD, DoI, NOAA, and others, as well as with local and regional authorities, private associations and organizations, and international bodies. Given that demand for air transportation is projected to continue increasing and that the very architecture of the system is changing (to shift from ground-based guidance, to incorporate new business models, to adjust to a changing mix of aircraft, and other major shifts), core questions are raised about the most effective structure and operation of AEE.

An effort was made to restructure the Office in 1999, which did introduce the concept of integrated, cross-functional team-based operations, but that effort was not focused on the full range of current challenges. Today, the Joint Planning and Development Office (JPDO) operates across federal agencies and has responsibility for advancing the Next Generation Air Transportation System (NGATS), which adds a new dimension to the alignment challenge facing this Office, which has a lead role concerning the environmental aspects of NGATS. As this case study will illustrate, there are no simple or quick answers to the challenges facing this organization – inevitably, the analysis will raise as many questions as it answers.

Guiding the analysis in this case study is a new framework for understanding what is termed "lateral alignment in complex systems," which involves the connections across stakeholders in complex systems that enable them to orient and connect their efforts to meet individual organizational goals and system-wide goals. In this process, the Office needs to sort skillfully though a number of challenging dilemmas, including:

- Supporting increasingly distributed work with a more diverse mix of stakeholders, while simultaneously speaking with one voice and responding rapidly to requests for input and action
- Building ever greater depth of expertise in many technical domains, while simultaneously operating in an integrated, cross-disciplinary fashion
- Maintaining clear overall strategic direction, while the many associated public and private sector organizations are independently making strategic choices that can undercut the strategic intent

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Although these and other related dilemmas facing this organization do not have easy answers, the new insights can be found by examining the case through the lens of out three-tiered framework, which involves behavioral alignment, functional/structural alignment, and strategy/systems/values alignment. The first part of the analysis focuses on "behavioral alignment," which includes findings along the following dimensions:

- **Communications & Information Sharing:** Current communications and information sharing efforts, including the use of web-based technologies, are an important enabler for AEE as it seeks to operate with increased alignment across other stakeholders. Such efforts help to build trust. However, there are still challenges in adjusting behaviors to utilize the new technologies. Moreover, there is still the potential for a much stronger "pull" for information and communication resources to drive knowledge-creation, collaborative problem-solving, and continuous improvement efforts.
- **Leadership & Decision Making:** Traditional chain-of-command models of leadership are not adequate when so many issues require coordinated effort across multiple independent stakeholders. New methods of leadership, rooted in influence more than authority, are crucial. At the same time, pressure for timely decision making and an increasing range of issues is increasing. Current senior leadership in AEE has been praised for emphasizing collaboration across stakeholders, but deeper culture change will be needed so a distributed form of leadership can be effective across many different panels, committees, working groups and other alignment activities. Rewards and reinforcement for leadership at every level will require calibration, along with other support policies.
- **Negotiations & Conflict Resolution:** Operating on a collaborative basis across stakeholders will require new forms of negotiation and conflict resolution. Mechanisms for mediation, problem-solving and other alternative dispute resolution methods will need to be integrated with existing processes for conflict resolution via formal hearings, litigation and other means. Cultivating increased awareness of the multiple interests and strategic motivations of the stakeholders is a critical skill at all levels.
- **Learning & Development:** There is a continual need to invest in the technical and process skills and capabilities of the staff in AEE. New frontiers in the development of technical models and methods require such investments, as well as the need for new leadership, communications, and conflict resolution process capabilities. Performance feedback and evaluation methods need to expand to include the spectrum of new skills and activities required for successful work, as well as inputs from many sources.

Overall, the various behavioral dimensions are not a major barrier to lateral alignment, though each of the above specific points can help enable the process. The second part of the analysis focuses on "functional/structural alignment," which involves the following findings:

- **Work Flow & Technical Coordination:** A range of specific structural choices confront the Office, each of which has advantages and limitations. These include:
    Option 1: Leave the current structure as it is, with a focus on strengthening the processes by which people operate in this structure;

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Option 2: Shift the structure to match the various integrated panels that have been established on the Environment Integrated Product Team (EIPT) that is part of the JPDO; and

Option 3: Organize the Office in a matrix structure – with core competencies along one dimension of the matrix and various projects and teams assignments along the other dimension.

Other options are also possible – the key point is that the work flow has to map to and accommodate the full range of mandated current-state government functions that currently reside in this Office, as well as the additional activities associated with serving as a catalyst for systems change. Note that there are functions within this Office that are involved in workplace health and safety and other matters that are in addition to aviation and the environment. Adjusting the structure to match to expanding and changing mix of work – particularly without additional staff resources is a priority issue.

- **Levels of Governance & Forums:** The need for new forums and governance mechanisms is illustrated by the creation of the EIPT, with meetings of the Steering Group twice a year and working sessions of the various panels in between Steering Group meetings. At present the forum is transitioning from a vehicle for information sharing and collaborative problem-solving into a coordinating body playing a leadership role on projects that involve resources from multiple organizations. In the FAA Office of Environment and Energy and in each of the other member organizations there is a mix of support and resistance to the EIPT playing this integrating role. If the new forums are to realize their full potential, they will need increased recognition within the respective organizations as valued forums, along with recognized leadership responsibility for certain domains or issues. In this sense, lateral alignment can and should involve periodic adjustment of the recognized mission and purpose of collaborative forums.

- **Functional Roles & Depth of Expertise:** The individuals in AEE who are serving in new leadership roles face a common dilemma – is the new role an additional set of tasks and activities to fit into an already full set of responsibilities *or* are the new roles now part of new ways of accomplishing their various responsibilities? Success in lateral alignment clearly depends on the second, integrated approach, but this requires virtually all roles in AEE to be redefined in these broader ways. Further, it requires development of associated depth of expertise – a key concern of many AEE employees.

- **Performance Metrics & Reward Systems:** Currently, reward systems in the federal government (including pay increases, career development, public recognition and other matters) are oriented around effort within each agency – so integration across agencies and with other stakeholders is incompletely valued. Of course, budgeting and other resource decisions are made on an agency-by-agency basis, which makes collaborate efforts by AEE (and others associated with EIPT) vulnerable to shifting priorities in other agencies.

- **Support Functions & Support Systems:** Support functions such as legal, human resources, information systems and others – as well as the associated support systems – must now orient their support activities to help enable the Office staff to operate in these new ways. This includes services that connect to stakeholders who are not in AEE, but helping to advance the goals of AEE. Negative views toward these organizations among some in AEE make this an even greater challenge.

Overall, these functional and structural aspects of lateral alignment represent much greater challenges than the behavioral aspects, but they also represent greater leverage in enabling new ways of operating. The third part of the analysis focuses on "overarching strategies and systems," as well as "underlying values and assumptions," which involves the following analysis and recommendations:

- **Overarching Systems Architectures:** There are many different systems architectures involved in the efforts of AEE, including: (1) the current state architecture of local, regional and national systems for managing noise and emissions issues in this country; (2) the current state architecture for advancing science and technology relevant to noise and emissions; (3) the international systems architecture associated with aviation and the environment; (4) the efforts to develop the next generation systems architecture for air transportation; and (5) the systems architectures associated with workplace health and safety and other domains relevant to this Office. The various properties of these systems are only partly understood and the dynamics of their interactions with one another are also only partly understood. System design and management is clearly a core competency that will be of ever increasing importance in the years to come.
- **Overarching Strategies & Goals:** The strategic intent for this Office is centered on balancing current responsibilities with service as a catalyst for systems change. There is tension in that this strategy is not fully embraced across the staff in AEE and it is vulnerable to shifts in priorities across the federal government. The decision, for example, to shift NASA resources away from atmospheric science research has major implications for the strategic direction being pursued in AEE
- **Underlying Values & Assumptions:** Within AEE, there is general consensus on high level values about the environment, safety and other matters, but a great deal of variation in views on how proactive the Office should be as a catalyst for change. Additionally, the values and assumptions vary considerably across different federal agencies with respect to their views on private sector industry, investments in science and technology, and other matters. While culture change is never quick, awareness of and attention to these underlying values and assumptions is essential for long-term re-alignment.

It is often said that structure drives behavior. It is also said that patterned behaviors create structure. In the effort to enable AEE to operate aligned across relevant stakeholders, it will take both structural change and appreciation for emergent patterns of interaction. Together, structure and behavior can be re-aligned to enable a new mode of operations – for AEE and others as they all work to address current challenges and future transformation. There are many areas that will need attention to enable such alignment – reflecting the reality that it is a systems challenge facing AEE. Simply put, systems challenges need systems solutions. It is hoped that this study helps in this process.

Introduction

On November 4, 2004, a group of more than 60 stakeholders from 38 public and private sector organizations reached a national consensus vision on aviation and the environment that would be transmitted to the U.S. Congress. This shared vision centered on addressing, in a balanced way, the environmental implications of a projected three-fold increase in demand on the U.S. air transportation system. Included in the vision was the unprecedented goal of reducing, in absolute terms, the health and welfare impacts of noise and local air quality emissions, as well as more fully understanding and addressing the implications for global climate change. This vision was the product of an intensive, nine-month process of research and consensus building.[1]

For Carl Burleson, Director of the Office of Environment and Energy, Lourdes Maurice, Chief Scientist for Environment and Energy, and other stakeholders, implementing the vision would require resources, scientific advances, and the ability to work together in ways that had never before been achieved. The report to Congress specifically called for a substantially greater capability to communicate and coordinate across stakeholders. Yet, experience working together on aviation and the environment was varied among the federal agencies (Federal Aviation Administration, National Aeronautics and Space Administration, Environmental Protection Agency,

> *A core principle guiding the research is that a measure of internal alignment is needed within each stakeholder so that it can constructively engage in alignment across stakeholders.*

Department of Defense, and others), as well as among key industry associations, such as the Air Transportation Association (ATA), the Aerospace Industries Association (AIA), and the numerous local, regional, national and international nongovernmental organizations. A recently established Joint Planning and Development Office (JPDO) held promise as a vehicle to build alignment among these many stakeholders, though it also surfaced fears around how it could also end up undercutting progress.[2]

This case study documents the internal alignment efforts of one key stakeholder – the FAA Office of Environment and Energy (which operates under the acronym AEE for "Aviation Environment and Energy") – so that it can effectively support and help lead alignment across the many relevant stakeholders. Although the AEE has historically been organized around separate functional "chimneys," a 1999 reorganization did seek to break down some of these barriers with the establishment of cross-functional teams. That change was not made, however, with the intention of enabling external alignment across a range of stakeholder organizations – it was focused more on internal cross-functional integration. As a visual representation of the external alignment challenge consider the following

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[1] Ian Waitz, Jessica Townsend, Joel Cutcher-Gershenfeld, Edward Greitzer, and Jack Kerrebrock, *Report to Congress, Aviation and the Environment: A National Vision Statement, Goals and Recommended Actions*, FAA/NASA (2004).

[2] The JPDO was launched in 2003, under the auspices of "VISION 100 - Century of Aviation Reauthorization Act" (P.L. 108-176). The JPDO follows from one of the core recommendations by the Commission on the Future of the United States Aerospace Industry, which issued its report to Congress in November, 2002.

chart, which features the logos of just some of the relevant stakeholder organizations, each of which is relevant to AEE's efforts:

Chart 1
Sample Stakeholder Organizations for Lateral Alignment

A proposition guiding the research is that a measure of internal alignment is needed within each of these stakeholder organizations so that each can constructively engage in alignment across the system. This case helps to illustrate the many dimensions along which such internal alignment could take place – within AEE and potentially elsewhere.

Background

Faced with the predicted three-fold increase in demand on the U.S. air transportation system by 2025, Congress requested the development of the Next Generation Air Transportation System (NGATS). Over the past 35 years, there has been a six-fold increase in the capacity of the system, during which time there has been a 60% improvement in aircraft fuel efficiency and a 95% reduction in the number of people impacted by aircraft noise[3]. The projected additional 300% increase in demand over the next two decades will depend on continued progress in addressing environmental impacts.

Mindful that environmental issues are among a number of potential constraints in the system,[4] Congress separately commissioned a special study on "Aviation and the Environment".[5] While separate from the NGATS initiative, the study of "Aviation and the Environment" confirmed that issues of noise, emissions, and water quality all could constrain growth in the air transportation system as a result of potential impacts on human health, the quality of life, and global climate change.

As part of the study, a consensus vision was forged among a broad range of stakeholders, which is:

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[3] Waitz, op. cit.
[4] Two other key constraints are safety and security.
[5] This was part of the FAA Reauthorization. For the report from the study, see Waitz, op. cit.

MIT Project on Lateral Alignment in Complex Systems

Chart 2
National Vision from Congressional Reauthorization Study

> **A National Vision for Aviation and the Environment**
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> *In 2025, significant health and welfare impacts of aviation community noise and local air quality emissions will be reduced in absolute terms, notwithstanding the anticipated growth in aviation. Uncertainties regarding both the contribution of aviation to climate change, and the impacts of aviation particulate matter and hazardous air pollutants, will be reduced to levels that enable appropriate action. Through broad inclusion and sustained commitment among all stakeholders, the US aerospace enterprise will be the global leader in researching, developing and implementing technological, operational and policy initiatives that jointly address mobility and environmental needs.[6]*

While the consensus vision is compelling in many respects, the study found that communication and coordination across governmental agencies, private industry, and other stakeholders would be essential in achieving the needed action on these environmental factors. A clear, shared vision would not be sufficient on its own, given the needed actions in terms of technology, science, regulation, and other dimensions.

In implementing the vision, the study pointed to the newly established Joint Planning and Development Office (JPDO), that is charged with coordinating the efforts of the public and private stakeholders associated with the next generation system.[7] The JPDO brings together the FAA/Department of Transportation, NASA, the Department of Homeland Security, the DoD, and others. While the specific structure and operation of the JPDO continues to evolve, it is presently organized around eight Integrated Product Teams (IPTs), one of which is focused on Environment. The full set of IPTs is as follows:

- Agile Air Traffic System IPT
- Environment IPT
- Global Harmonization IPT
- Airport IPT
- Safety IPT
- Security IPT
- Situational Awareness IPT
- Weather IPT

The draft systems architecture emerging at the JPDO contemplates GPS-linked navigation based on the aircraft, allowing (ideally) for more flexible and optimal flight profiles, while ending sole reliance on a ground-based air traffic control

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[6] Waitz, op. cit.
[7] For more information on the JPDO, see: http://www.jpdo.aero/site_content/ Note that the initial vision and focus of the JPDO builds on an earlier 1999 FAA Research, Engineering and Development (RE&D) initiative, that also contemplated a 3-4 fold increase in demand, new technology to support "free flight," and other advances. The RE&D was initially an FAA initiative that expanded to include NASA, but did not have the full breadth of stakeholder involvement as the JPDO.

system. The architecture also anticipates the emergence of new business models involving increased use of regional jets, micro-jets and future technology innovations. Overseeing the work of the JPDO is a Senior Policy Committee that includes the secretaries, administrators, and other senior leaders of the respective agencies and departments.

Within the FAA, the AEE is charged with addressing the environmental aspects of aviation and is the lead within the JPDO for environmental issues. The Director of AEE, Burleson, is the Director of the JPDO Environment IPT (EIPT). The Secretariat for the IPT also resides in AEE. Alignment to support the work of the EIPT is challenging, involving the work in divisions for "Noise," "Emissions," and "Environment, Energy and Employee Safety," as well as many other domestic and international activities.

Methods. In preparing this case study, the research team conducted more than a dozen individual interviews with leadership and staff in AEE, as well as additional interviews with external stakeholders. Concurrently, they provided direct technical assistance facilitating selected EIPT meetings, while observing the interactions and proceedings at the meetings. This is an "action research" approach – building additional insights while being directly engaged in the operational activities.[8] Key archival records were examined and incorporated where appropriate. A custom-designed internal alignment survey was administered to the AEE staff. The full size of the staff is small and not everyone completed the survey (the response rate was 37%),[9] so the data from this survey should be treated with caution. Too much meaning should not be read into small differences in responses, but strong views and large differences can at least be taken as suggestive of views across the full workforce.[10] The case study also draws on prior experience with the Reauthorization Study on Aviation and the Environment. The research is linked to an MIT Working Group on Lateral Alignment in Complex Systems. This case is the first in a planned series of case studies that will investigate various aspects of stakeholder alignment around aviation and the environment.

AEE and the EIPT

This case study serves as a baseline, documenting the current state for internal realignment efforts in AEE. Over time, it will be important to track emerging developments relative to this initial portrait. First, it will be helpful to review the structure and operation of AEE, as well as the nature of the Environment IPT, which this Office leads. Since the study was prompted by questions around AEE's alignment with respect to the EIPT, that is the primary focus of the analysis – though it is presented in the context of the full scope of AEE efforts.

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[8] The concept of "action research" was pioneered in the literature by Kurt Lewin in the 1940s and then further advanced by Chris Argyris in *Inner Contradictions of Rigorous Research* (New York: Academic Press, 1980), by Don Schön in *The Reflective Practitioner: How Professionals Think in Action* (New York: Basic Books, 1983), by Anselm Strauss in *Qualitative Analysis for Social Scientists* (Cambridge, Cambridge University Press, 1987), by Edgar Schein in *Process Consultation: Its Role in Organizational Development, 2nd Ed.* (Reading, MA: Addison-Wesley, 1988), and in other publications by these and other authors.

[9] A total of 41 surveys were distributed electronically and 15 surveys were returned. One survey was excluded from the analysis (all the answers were the same, including items that were stated in the reverse).

[10] Note that the responses were evenly distributed across the four major parts of the organization – with 3 from the 100 group, 4 from the 200 group, 3 from the 300 group, and 4 from the office of the director (and one excluded).

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AEE's Existing Structure and Operation. AEE develops, recommends, and coordinates national aviation policy relating to environmental and energy matters, including noise and emissions. It is organized into a division centered on noise issues (known as the 100 division); a division centered on environment, energy, and workplace health and safety (known as the 200 division); and a division centered on emissions issues (known as the 300 division). There are a total of 28 employees in all three of the divisions and approximately half a dozen senior advisors – covering science and technology, economics, policy, and modeling – who are direct reports to Director Burleson.

The current configuration of the AEE has emerged through various reorganizations, some relatively recent. For example, the workplace health and safety function was added in 1994. As well, there have been periodic restructurings within each group. For example, in 2000, the Noise Division shifted to a team-based structure, following a 1999 restructuring study. Before 1999, AEE-100 was the Technology Division, which included technical aspects of both noise and emissions. AEE-300 was the Policy Division, which included policy aspects of both noise and emissions. The reorganization to the current Noise Division involved combining the parts of the former AEE-100 and AEE-300 divisions that dealt with noise, as well as adopting a team structure. A similar combination led to the Emissions Division, though the very creation of this division sends a very important signal. As one interviewee noted, "Historically, AEE has been focused on technical noise without regard for emissions."   While the reorganization around separate, integrated teams on noise and emissions allows for more integration of technical and policy dimensions in each domain, it complicates the ability to address interdependencies between noise and emissions. For example, recent noise restrictions in London's Heathrow airport have the unintended consequence of requiring more fuel burn and thus increasing emissions.

Although the presence of a group focused on occupational health and safety may seem out of place in an office that is primarily focused on energy and environment, there is an increasing overlap between environmental and occupational safety and health issues, as reflected by recent conference agendas of the American Council of Government Industrial Hygienists, the Environmental Protection Agency, the Occupational Safety and Health Administration, and others. In this case and in others, it is clear that formerly distinct domains of expertise are increasingly interdependent.

The organization administers a wide range of regulations concerning aircraft noise and emissions,[11] airport operations, and related matters. This includes the development of highly sophisticated metrics and models, such as the Emissions and Dispersion Modeling System (EDMS), the Integrated Noise Model (INM), the System for Assessing Aviation's Global Emissions (SAGE), and others. AEE also has responsibility for noise and emissions certification regulation development, which builds on metrics and models that are developed.

Individuals from these various AEE groups are assigned to serve on cross-functional teams for special projects. Based on their expertise, they are also

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[11] The FAA has a direct regulatory role in setting standards on noise, while it relies on the EPA as the lead in setting standards on emissions.

assigned to represent the Office in international forums, such as the International Civil Aviation Organization (ICAO) and, within ICAO, on the Committee on Aviation Environmental Protection (CAEP).[12] Over the years, the work with CAEP has become as key integrating force for the AEE. The three year cadence by which working groups within CAEP surface issues and seek agreements has not only been a focus of the work efforts of many staff members, but it also has become an implicit rhythm on which AEE operations are organized. Note, however, that the shifting priorities in ICAO do not always match the particular skill mix of the employees and managers in AEE. So, added to the cadence must also be time for individuals to build the requisite knowledge and skills for a given assignment or (in rare cases) for the Office to be able to bring in people with the appropriate knowledge and skills.

In the last couple of years, AEE has initiated a number of major initiatives. First, it commenced an effort to develop the next generation of tools and models to provide an integrated assessment of aviation noise and emissions as well as the ability to evaluate the costs and benefits of a variety of potential actions.

Second, AEE fundamentally revamped its research endeavors, including a three-fold growth in R&D funding and established a research partnership organization with a broad network of stakeholders from universities and industry. Entitled the Partnership for

> *…the work of the IPT demands a high level of integration and coordination*

AiR Transportation Noise and Emissions Reduction (PARTNER), MIT leads this consortium which represents an additional, periodic set of conferences and projects that involve various AEE staff members. As well, there are non-PARTNER organizations, such as the Volpe National Air Transportation Systems Center, who also have research and technical support contracts with the AEE.

Third, AEE assumed leadership for developing and fostering implementation of the President's requirement that all federal agencies have an environmental management system in place by December 2005. As well, AEE has assumed a leadership role with respect to the EIPT in the NGATS plan. As we will see, the work of the IPT demands a high level of integration and coordination – which stands in contrast to the existing functional organization. Further, the pace of work within the JPDO is rapid – which stands in contrast with the experiences in ICAO and CAEP.[13] As well, the focus of the IPT is on action rather than research – which stands in contrast to the work taking place through PARTNER.

Finally, in addition to these new initiatives, there are periodic "crisis" events, such as an airport that needs immediate technical assistance around an environmental review. Referred to as "pop-ups" or "fire drills," these events pull numerous staff off their regular assignments to help resolve the crisis.

The range of different structural domains within AEE are presented in Chart 3, which conveys to full scope of the alignment challenge.

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[12] Individual skills and expertise can also fail to match the ever evolving technical focus of these efforts.
[13] Note, however, that the 1999 FAA Research, Engineering and Development (RE&D) had a similar sense of urgency.

Chart 3
Structural Domains to be Aligned Within the
FAA Office of Environment and Energy

Formal AEE Structure	ICAO/CAEP Structure	Environment IPT	Research Partnerships	Periodic "Crises"
Front Office • Chief Scientist • Senior Adv. for Environmental Policy • Special Asst. for Economic Environmental Analysis • International/ JPDO Liaison • Senior Adv. on Tools & Models AEE-100 Noise Division • Aircraft Integrated Support Team • Airports & Airspace Integrated Support Team AEE-200 Environment, Energy and Employee Safety Division • Environment & Energy • Safety AEE-300 Emissions Division • Aircraft • Modeling & Analysis	International Civil Aviation Organization (ICAO) Council ICAO Committee on Aviation Environmental Protection (CAEP) • Working Group 1- Noise Technical Issues • Working Group 2- Operations (includes Models) • Working Group 3- Emissions Technical Issues • FESG- Forecasts and Economics • Task Groups on Emissions Trading and Charges	• EIPT Secretariat • Analytical Tools Panel • Science/ Metrics Panel • Technology Panel • Operations Panel • Policy Panel	Volpe National Air Transportation Systems Center PARTNER research studies, including: • Low Frequency Noise Study • Measure- ments, Metrics and Health Effects of Noise • Continuous Descent Approach • Land Use and Airport Controls • Quiet Rotorcraft and Short-Field Operations • Supersonic Transport • Emissions Measurement s, Health Effects, and Atmospheric Impacts • Other topics (including the study of lateral alignment in complex systems)	• Immediate technical assistance for airport environmental certifications • Immediate technical assistance for engine and airframe manufacturers regarding environmental issues • Immediate technical assistance for airlines regarding environmental issues

EIPT Structure and Operation. Within the range of AEE activity, the EIPT has a broad mandate. It integrates aspects of the consensus vision from the Reauthorization Study on Aviation and the Environment, as well as the priorities of the JPDO. In a shared vision statement developed by the IPT, the scope was defined as follows:

- Developing a balanced environmental approach for aviation – at local, regional, national and international levels
- Defining appropriate issues and metrics for noise, air quality, water quality, and related matters
- Exploring metrics for global climate change
- Developing environmental models

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- Developing and promoting solutions and policies to address environmental issues
- Enabling communication and coordination across relevant stakeholders

While this mandate directly overlaps with the mission of AEE, it encompasses a much broader mix of stakeholders, with often varied time pressures and different cultures and ways of operating. For example, in a shared vision statement, the EIPT stated that it is committed to operating with an intensive, balanced approach that emphasizes alignment across stakeholders in developing needed business and technology architectures, as well as other relevant tools, metrics, and products.

> *While the work with the EIPT is central to the mission of AEE, it also represents additional assignments and tasks for a staff that has not increased.*

The EIPT is organized around a Steering Group and Secretariat, which support communication and coordination across the JPDO organization beyond the EIPT. Within the EIPT there are the following Panels:
- Analytical Tools Panel
- Operations Panel
- Policy Panel
- Science/Metrics Panel
- Technology Panel

Although the EIPT has populated the Steering Group with individuals who have expertise and relevant responsibilities in their respective agencies, none of the members have budgetary and policy authority in their organizations comparable to that of the EIPT Director, Burleson, in the FAA. The EIPT Panels have stated their intent to operate in a "badgeless" mode based on technical expertise, making technical and policy recommendations to the IPT Steering Group.[14]

The EIPT is not the only forum in which this Office is involved in stakeholder engagement. There is intensive participation in other consortia and public forums such as: ICAO/CAEP, SAE A-21, E-31, TRB committees, PARTNER Steering Group, EDS TAB, FICAN, INM DRG, EDMS DRG, and EASA.[15] As well, there are focused engagements around the certification of new aircraft or airport expansion plans. While the work with the EIPT is central to the mission of AEE, it also represents additional assignments and tasks for a staff that has not increased. This highlights a tension between regular AEE tasks and the additional work added for the EIPT. As one Panel Chair commented, "my goal is to run this Panel as a virtual team, so that it doesn't represent more than 5% of my time." However, he then added that, "the actual work, which falls under the overview of the Panel, is really 100% of my time since this is the work that I need to do." This is still an open question for many staff – is this effort an additional set of tasks to be kept to a minimum so as to not interfere with preexisting assignments or is this the new way that the work is to be accomplished? In some

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[14] The full EIPT and each Panel has developed a Shared Vision statement (all using a standardized format) and work plans for the Panels are organized around a common "four panel chart" format featuring 1) the Drivers/Rationale for the Work of the Panel under NGATS, 2) the Long-term Outcomes Anticipated, 3) the Specific FY07 Output, and 4) the Out Year Funding Requirements. The Panels all also identify anticipated roadblocks/chokepoints

[15] See the list of acronyms in the appendix for more information on these organizations.

respects, the tasks imposed by the JPDO are just that – new, additional tasks and, in the viewpoint of some, tasks without clear direction. In other regards, it is clear that the executive leadership of AEE seeks to make this the new way that work is done (regardless of the long-term viability of the JPDO).

A Vision and a Framework for Alignment

In exploring ways to achieve the needed internal alignment within AEE, Burleson has said that he is committed to supporting the efforts of the JPDO, but that he would orient the efforts of his office in a more collaborative approach with other public and private stakeholders, whether through the JPDO or by other means if the JPDO does not endure. Thus, the future vision for AEE is to be appropriately aligned internally to operate effectively in the context of a long-term systems change in the approach to aviation and the environment. This vision includes anticipating and addressing the environmental implications of a system where there will be increased traffic density, with a potentially more diverse mix of aircraft, and changing patterns of use among regional as well as international airports.

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density, with a potentially more diverse mix of aircraft, and changing patterns of use among regional as well as international airports. All the modeling and metrics functions, the scientific research, and the regulatory aspects of the AEE must maintain their current high quality performance levels, with greater adaptability and in close partnership with numerous other government agencies, industry, and non-governmental groups. A partial list of this coalition will include; NASA, DoD, EPA, the National Park Service, National Oceanic and Atmospheric Administration - U.S. Department of Commerce, (NOAA), the airlines, air freight lines, universities, state and local airports, international aviation and environment bodies, and others.

Another part of a vision involves being able to work in close partnership with local airports and community organizations to conduct pilot experiments followed by broad scale adoption of innovations related to noise and emissions reduction. The collaborative work with international organizations would certainly continue as part of a future vision. There is also potential for conflict, especially with the European Union, given differing views and political pressures on how to deal with aviation's environmental issues on either side of the Atlantic. Further, the growing importance of developing countries' aviation markets in the international system (China, India, Brazil, etc.) will likely make international collaboration both more vital and more complex.

The potential for unilateral adoption of new standards and approaches in many parts of the world could undermine the interests of U.S. stakeholders and place serious constraints on the development of NGATS. While it is possible that a more fragmented approach to standards might serve to advance some aspects of environmental protection, this is certainly something that is a concern to many in industry and government. For these stakeholders, lateral alignment is

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the primary alternative to fragmentation and independent action (since unilateral, top-down regulation is not within the control of any stakeholder).

A Framework for Studying Alignment Within and Across Stakeholders. The complexity and importance of the alignment challenge led to a working relationship with the MIT research team that had initially provided facilitation support in forging the consensus vision. While the reauthorization study pointed to communication and coordination, it was clear that a more enduring form of alignment was needed. In the past, there has not been a great deal of positive experience with alignment across government agencies, let alone between the public and private sectors. More is known about alignment within a given organization for internal purposes – such as top-down alignment through restructuring/re-engineering or bottom-up alignment through employee participation and feedback processes. The focus here, however, is on long-term alignment across stakeholders (each with their own internal hierarchies) and between levels in a multi-stakeholder system – an aspect of complex systems that is less well understood. It was agreed that MIT would play a dual role, helping to facilitate aspects of the alignment efforts and conducting research to document and learn from the process.

> *Another part of a vision involves being able to work in close partnership with local airports and community organizations to conduct pilot experiments followed by broad scale adoption of innovations related to noise and emissions reduction.*

In support of this research and related research in other organizations, an MIT working group has been formed on "Lateral Alignment in Complex Systems" (for more detail on this project, see the appendix to this case study). This group defines lateral alignment as:

> *Formal and informal patterns of interaction that orient and connect inter-dependent stakeholders so as to advance both their internal, separate interests and their shared, system-wide interests.*

Building on this definition, the emerging lateral alignment framework focuses on three levels of analysis where there are distinct patterns of interaction.[16] The first tier of this framework focuses on "Behavioral" patterns of interaction, which would include alignment or misalignment with respect to communications, information sharing, decision making, negotiations, leadership, and other behavioral interactions. Second, there are "Functional/Structural" patterns of interaction, which would include alignment or misalignment around functionally interdependent work, support functions, and other such interactions. Third, there are "Underlying Values" and "Overarching Strategies and Systems Architectures" where there again can be alignment or misalignment.

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[16] This framework builds on the concepts of strategy, structure and process as developed in *Strategic Negotiations: A Theory of Change in Labor-Management Relations* (Cambridge, Harvard Business School Press, 1994) by Richard Walton, Joel Cutcher-Gershenfeld, and Robert McKersie. The particular focus on internal alignment corresponds to the concept of "intraorganizational bargaining" in the predecessor book by Walton and McKersie, *A Behavioral Theory of Labor Negotiations* (New York: McGraw-Hill, 1965). The concept of transformation being enabled by alignment across levels has roots in *The Transformation of American Industrial Relations* by Thomas Kochan, Harry Katz, and Robert McKersie (New York: Basic Books, 1984). There are separate literatures on standards, protocols, and transformation in technical systems that are also relevant and will be incorporated into the research.

Data collected for this AEE case study are organized using this framework, focusing on selected dimensions/elements. A key hypothesis guiding the research is that transformation in a complex, engineered system is not possible without sufficient alignment across multiple levels or dimensions. For example, just aligning communications or information flow is not sufficient; functional/structural alignment and some degree of alignment around underlying values and overarching strategies and systems architectures is also needed. It should also be noted that alignment may or may not be seen in the self-interest of all stakeholders and it is understood that some forms of alignment can be rigid and stultifying, while others can be flexible and enabling. Because this is a base line case study, the focus is on assessing the current range of alignment challenges since it would be premature to assess if the needed alignment for transformation has yet taken place. A visual representation of the lateral alignment framework is as follows:

Chart 4
A Preliminary Framework for Lateral Alignment in Complex Systems
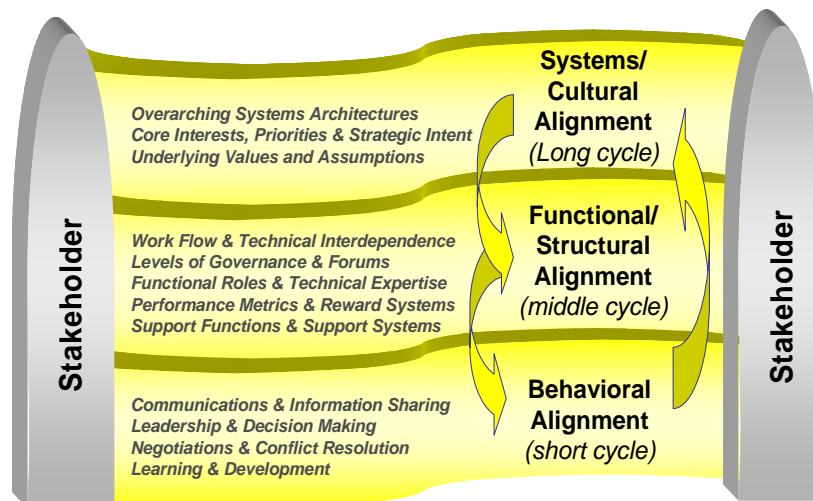
Source: MIT Working Group on Lateral Alignment – Joel Cutcher-Gershenfeld and Joel Moses, co-chairs

Behavioral Alignment

The behavioral aspects of alignment are, perhaps, the most visible. They are certainly the initial focus of many alignment efforts – in the form of communications training, building common websites, and the like. While the development of behavior skills or communications tools alone will not achieve the needed internal or lateral alignment, these are certainly a necessary aspect of alignment. A closer look at several behavioral dimensions of alignment within the AEE suggests that achieving alignment at the behavioral level is a much deeper challenge than might immediately be apparent.

Chart 5 presents the responses on various behavioral dimensions of alignment from the internal alignment survey. We will refer to the data in this chart at various points in this section of the case study. In interpreting the data, an average response that is a 5 or above could be interpreted as representing strong enabler of alignment, while a response that is below a 4 would suggest a

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possible barrier to alignment. Caution must be exercised with these data, however, since the responses are from just over a third of the workforce in AEE.

Chart 5
AEE Staff Views on Behavioral Enablers and Barriers to Alignment
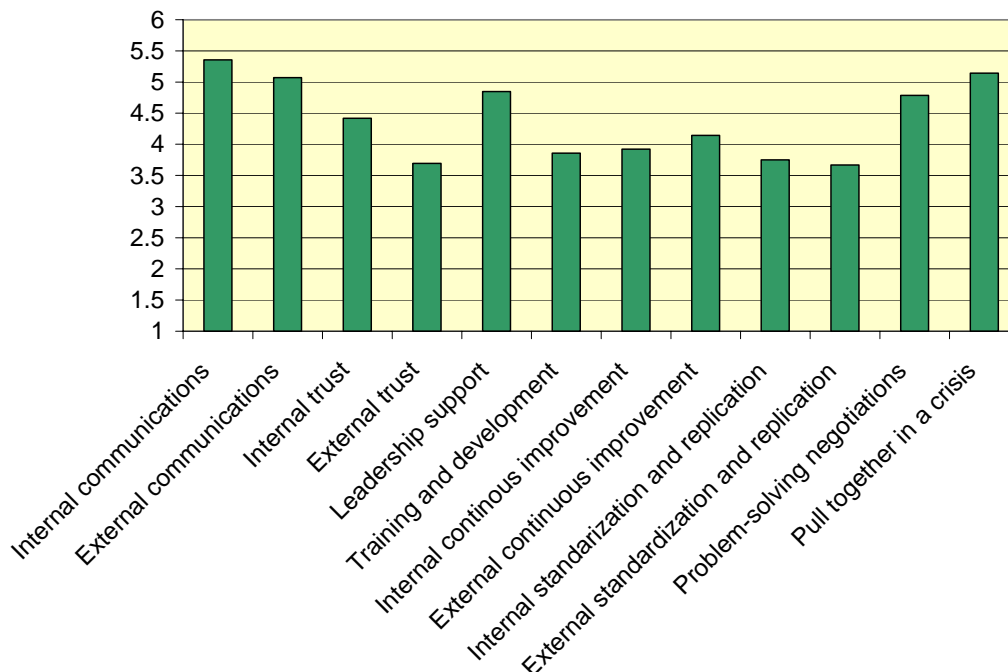
Key: All items were presented as statements on each of these dimensions, with the following possible responses: 1=Strongly Disagree; 2=Disagree; 3=Somewhat Disagree; 4=Somewhat Agree; 5=Agree; and 6=Strongly Agree.

Communications & Information Sharing: Aligning communications within AEE to enable lateral alignment goes far beyond one-to-one listening and presentation skills. It involves formal and informal communications among people operating on different floors in the FAA building, in different offices around the country, and international communications. Communications, of course, includes many media: telephone, email, teleconferences, videoconferences, off-site events, common use of shared websites, and other means. People meet face-to-face as well as in a variety of distributed, geographic combinations.

Overall, the views of the respondents to the internal alignment survey suggest that communications is seen favorably. Although one senior manager expressed concern in an interview that the AEE does a better job of

> ***Issues around communications often boil down … to underlying issues of trust.***

communicating externally than it does internally, the survey data would suggest that internal communications is not a barrier to lateral alignment.

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One aspect of communications not visible via the survey, but highlighted in various interviews, concerns the impact on communications of the short cycle times that the JPDO has imposed for responses on policy and other matters. These tight deadlines are compounded by the lack of subsequent feedback. AS one panel member noted, "Each Panel rushed around to get the budgets done [for the JPDO], but we never get feedback. They forget to let you know. Am I wasting my time, spinning my wheels, falling into a black hole?"

Issues around communications often boil down, as one individual commented, to underlying issues of trust. He stated that, "the communications may be agency-to-agency, but it boils down to person-to-person." He added that "there has to be trust and confidence from various interests – from the public, to states, to industry, to regulators (EPA, FAA Aircraft Certification, etc.), to airports." In the context of lateral alignment, the importance of these issues is magnified. The survey data further supports these comments, highlighting that external trust is a potential barrier to lateral alignment (much more so than internal trust). As the interactions among these various parties move beyond time-bound initiatives and into ongoing working relationships, the importance of this issue will intensify. Individuals are becoming more interdependent with others who are not part of the same authority structure, so trust and confidence – internal and external – become even more central to how (and even whether) work gets done.

In addition to the communication challenges, the exchange of information and knowledge has always been an important part of FAA/AEE operations. In order to support operations that span many organizations, AEE has established a website called the KSN (Knowledge Sharing Network), which is a common repository for posting presentations, meeting notes, and various forms of exchange. The use of KSN has not yet been fully integrated into AEE operations, which may reflect ingrained habits and simple technological problems. For example, KSN was initially set up on one platform within AEE and then migrated to another under the JPDO – creating a series of temporary access problems. A more challenging issue is that there are a wide range of websites intended for knowledge sharing that are associated with different projects and initiatives. The sheer number of websites adds confusion as people seek new patterns of use. Additionally, the users of these websites may have deeper issues, such as questions around the accuracy and use of information

The traditional "chimney" structure within AEE (and within the FAA and the Federal Government) is a further constraint on information sharing. In this structure, information tends to flow vertically rather than horizontally, just as smoke flows up a chimney. Moving away from that structure into the IPT format will open up channels, but it also adds new forms of ambiguity. Motivations and incentives to share information across chimneys are not always clear as efforts to change patterns of behavior begin. Each individual has his or her own channels of information flow and these have developed over time based on their effectiveness. It takes greater effort to use new channels – they must prove their credibility and trustworthiness. As one interviewee commented, "The key is being more proactive in attending meetings, conferences, briefings up through the chain of command (up to administrator), meeting with lobbyist, up to committees in congress – being more far reaching." There is, however, the issue of saturation – that is, the problem of information overload. The answer does not involve making all information and knowledge freely available to all, but rather,

the judicious management of information and knowledge – assuring that each stakeholder has appropriate access to necessary information and knowledge.

A key additional dimension of information sharing is that much of the relevant information and knowledge to be shared comes from research, models, and technical activities that face budgetary as well as other pressures. For example, the current cuts in the NASA Aeronautics budget represent breaks in the flow of key sources of information that people in AEE depend on in their work.

The IPT structure and the larger JPDO structure bring together stakeholders without a common history of working together (and hence having trust in each other) and with few preexisting channels of communication. This means there are many additional ways in which information sharing can break down. As one individual commented, "There is a risk that one group may interpret things differently from another – if one group is looking at the Environment IPT for an answer, but they don't clarify the form in which the data is needed, it could be a failure. One group will produce what isn't needed." Thus, information and knowledge sharing are key dimensions of internal alignment for AEE, but both involve challenges that cannot be quickly or easily resolved.

Looking ahead, the communications requirements facing this office will increase, requiring additional resources and expertise. Additionally, the need to share information across federal agencies and among other stakeholders will increase and there will be the need for continued and expanded use of new, web-based technologies to facilitate this process. Progress is already being made along these lines, but there are still challenges concerning the scope of these systems and the new behavioral patterns needed. Since all the stakeholders are in a process of building trust, the open communications and information sharing is an essential foundation for these lateral relationships.

Leadership & Decision Making: New forms of leadership are required in the context of lateral alignment. There is a connection between structure and leadership – as the structure changes, leadership changes in a number of ways.

> ***Leadership in this context happens by influence more than authority***.

On the one hand, leadership in this context happens by influence more than authority. On the other hand, decisive action is needed – often with very tight time constraints. This points to a delicate balance in leadership that has to co-evolve as the structure changes.

Within AEE, the senior leadership has embraced the EIPT under the JPDO as a key vehicle for fostering the increased alignment needed across stakeholders. One individual commented that the Director of AEE "is the kind of leader who has a strong commitment and makes it clear that people are an integral part. His championship will make people want to help." Another individual commented, "Top leadership is doing everything he can. His team is also working to enable alignment, but a lot more are working against it." The survey results in Chart 5 above are consistent with these comments, with most respondents generally agreeing that they do have the leadership support that they need.

In the context of lateral alignment, a key challenge centers on leadership turnover. So much of the initial alignment process builds on personal interactions and relationships, all of which have to be reestablished when leaders change. This means that leadership hand-off protocols and other methods of managing these transitions are essential. These challenges are relevant in the context of the JPDO, ICAO (particularly the CAEP working groups), PARTNER, and other cross-cutting forums. As one individual commented, a key driver for sustained alignment will be "unwavering, totally committed leaders that sustain this effort with continuity as people come and go so new people are brought into this new system and understand their role."

The bottom line is that there is no one leader who has authority over all the stakeholders in this initiative, and new forms of leadership are essential. Traditional chain-of-command models of leadership will not be adequate given that many issues require coordinated effort on the part of many independent stakeholders. An increasing number of individuals will need to be able to provide a distributed form of leadership while serving on integrated, cross-organizational teams and working groups. At the same time, overarching goals must continually

> *… there is no one leader who has authority over all the stakeholders in this initiative, and new forms of leadership are essential.*

be articulated by leaders. Mechanisms will be needed to balance accountability with the increased complexity and accelerated pace of decision making. When organizations such as the JPDO call for rapid decisions on complex issues, there are leadership dilemmas in that neither this Office nor any other parties have the overriding authority to mandate a response. Thus, beyond traditional leadership development training, lateral alignment requires more explicit agreements on the approach to leadership across the various stakeholder organizations.

Negotiations & Conflict Resolution: Traditional processes for negotiations and conflict resolution must adapt to handle an increasingly diverse set of contracting relationships and a broader mix of conflicts. Mechanisms for mediation, problem-solving and other alternative dispute resolution methods will need to be integrated with existing processes for resolution via formal hearings, litigation and other means. The survey data suggest that people somewhat agree that the approach to negotiations is more of a problem-solving one, which does not suggest a fundamentally different model for interactions. New approaches to negotiations build on formal analysis of stakeholder interest, structured brainstorming of options (during the negotiations), use of third part facilitators and mediators, and other such interventions. While some alternatives to litigation are widely used in the federal sectors (under the banner of alternative dispute resolution methods), it is not clear from these data that new interactive approaches are deeply embedded in the organization.

In many respects, the operation of AEE in coordination with other stakeholder organizations is still in a forming stage. Looking ahead, it is predictable that there will be important conflicts and disagreements among these parties, even though they have not yet clearly surfaced. At this stage of the effort it would be timely to establish the protocols or procedures for resolving such conflicts – since it is much harder to do so when embroiled in difficult issues.

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Learning & Development: There is a continual need to invest in the technical and process skills and capabilities of the staff in the Office, which is of increased importance given the AEE focus on enabling the next generation air transportation system. New frontiers in the development of technical models and methods will require such investments, as well as the new leadership, communications, and conflict resolution, and process improvement capabilities. As one interviewee commented, "The capabilities of the workforce do not match vision that leader has in mind – people not trained or selected for this." The survey data in Chart 5 above also suggest that technical and process skills and capabilities are indeed a potential barrier to alignment. Respondents reported that they did not have all the needed skills and that mechanisms for continuous improvement, standardization and replication are all limited within AEE – an issue addressed in more detail below in the section on technical expertise.

Functional and Structural Alignment

The functional and structural aspects of alignment are less visible than the behavioral. For example, when the JPDO wanted to foster better working relations among the IPTs, the first step was to schedule communications and leadership training for the IPT Directors. While this sort of behavioral intervention may well have been helpful, it does not address functional interdependencies among the IPTs. Chart 6 provides survey results on a range of structural matters that will be addressed throughout this section of the case study. Again, caution is urged with these data – they come from all parts of AEE, but only from a portion of the workforce – so they can be taken as suggestive, but not definitive.

Chart 6
AEE Staff Views on Functional/Structural Aspects of Alignment
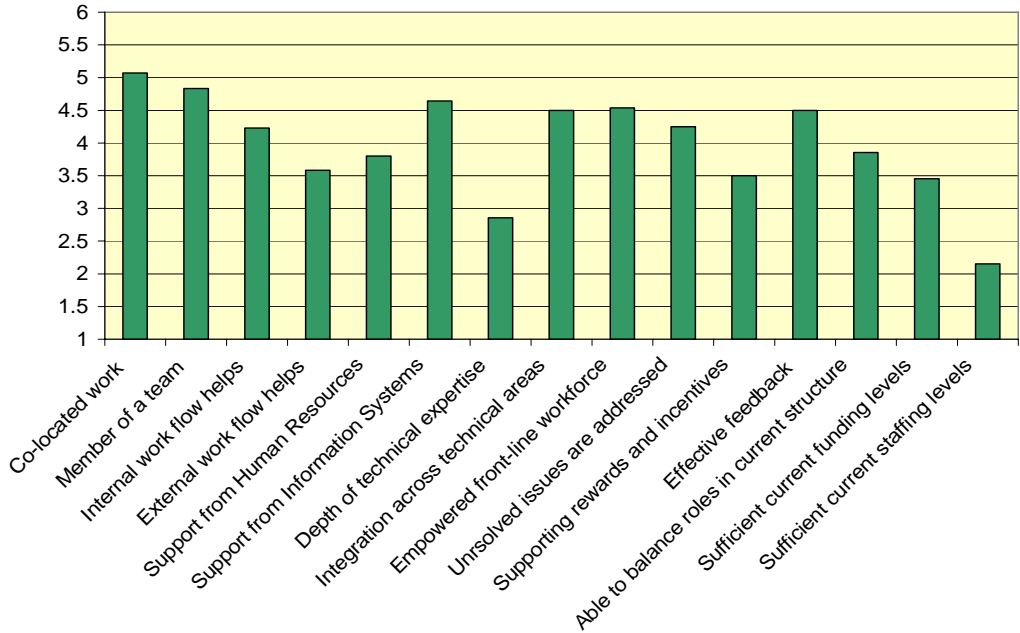
Key: All items were presented as statements on each of these dimensions, with the following possible responses: 1=Strongly Disagree; 2=Disagree; 3=Somewhat Disagree; 4=Somewhat Agree; 5=Agree; and 6=Strongly Agree.

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Work Flow and Technical Coordination. A core issue on work flow and technical coordination was summed up by one interviewee who asked, "Can the science deliver the results in the time and will it stand out and be believable?" If lateral alignment doesn't help to deliver such results, then it will not be worth the effort. Across the Divisions in AEE (the 100, 200 and 300 groups), there are various flows of work. In some cases, it is a work flow around the development of specific metrics. In other cases, it is a work flow around development of various models and tools. In still other cases, it is a work flow around the development and promulgation of standards or regulations and the certification of new aircraft or airport expansions. There is also basic science research that is coordinated from AEE. Even before the establishment of the EIPT, some of this work was conducted in coordination with other agencies. Some of the science research, for example, was coordinated with NASA. Some of the regulatory enforcement – especially emissions standards for aircraft – was coordinated with the EPA. Still, most of these interagency efforts were specific projects, programs or otherwise bounded efforts. Similarly, there were cases where there was close collaboration with industry, such as occurred in the phase out of Stage II engines (to be replaced with a new generation of Stage III engines that were more fuel efficient and quieter). Here too the efforts were time bound.[17]

As Chart 6 suggests, many of the people in AEE report being co-located with others relevant to their work. A key barrier that stands out from the data is the external work flow.   The respondents are more positive about the internal work flow than the external flow of work, although even the average responses on internal work flow point to a potential barrier.

As the Office shifts to operate in a more interdependent fashion under the auspices of the EIPT, the work flow changes in many ways. Existing projects and programs – such as the development of a suite of integrated tools for environmental analysis – migrate to become the work of EIPT Panels. This was viewed favorably by many interviewees, who cited "cross-functional mechanisms and teams to look at tools, research on health and atmospheric impacts" as a positive move. In these efforts, the work is initially the same, but it now takes place under the auspices of the IPT Panels and the JPDO, which adds resources and complexity. Over time, some work flow from other agencies moves into the purview of the EIPT and more directly becomes part of the work of AEE staff. The coordination of the work becomes interwoven with the way the Panels operate. In this context, all of the internal alignment challenges faced within AEE have parallel dynamics in other offices, agencies, and organizations.

An example of these challenges with work flow is evident in the following draft chart, which was produced at a meeting of the EIPT Steering Group. As this chart illustrates, both the Technology Panel and the Operations Panel anticipate having inputs around emissions and noise. Along with the Science/Metrics Panel, these represent potential inputs into the Analytic Tools Panel, which may involve feedback around metrics, but will then go to the Policy Panel. This is illustrative of the possible work flow associated with Analytic Tools. Other interdependencies exist for the work of other Panels – all within the IPT. There is
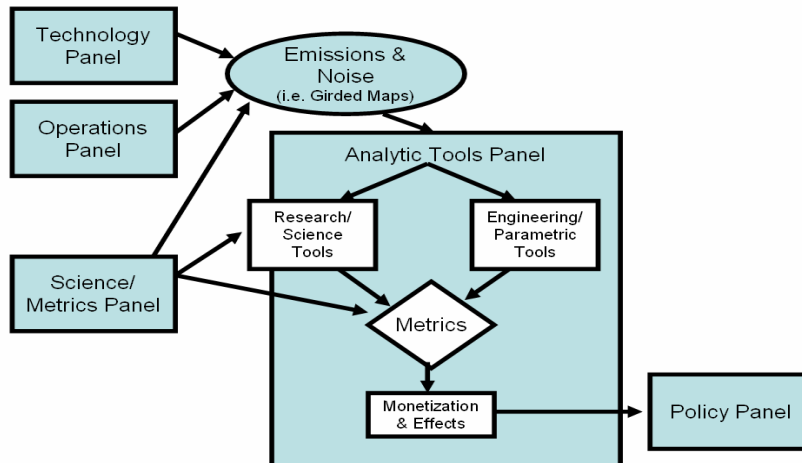
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[17] In fact, this was not only a time-bound effort, but the use of what are called "hush kits" to improve some Stage II engines, rather than to replace them, hastened the collapse of collaborative efforts.

a further set of functional interdependencies involving other IPTs and the respective home organizations.

Chart 7
Draft Process Flow Map

To address the interdependencies across the Panels, the research team conducted an exercise at the second meeting of the IPT Steering Group where each Panel was given a large-sized pad of "post-it" paper (each of a different color). They were then able to post the notes at flipcharts on easels by each of the other Panels – indicating on whom they were dependent or for whom they were an input. Here is a sample chart with some of the data that were generated by this exercise for the Analytic Tools Panel:

Chart 8
Environment IPT Analytic Tools Panel Interdependencies with other Panels

Other IPT Panels	Interdependencies
Metrics/Science	• We fully anticipate an iterative relationship with you (with a smiley face) • What current tools evaluate metrics today? • What analytic tools do you see as a priority for development with the advent of next generation technology (from the Technology Panel)?
Technology	• Trade-offs between technologies • Cost/benefit analysis
Operations	• How can real time operations incorporate environmental analytic tools into real-time flow management, tactical separation, and procedures – designed tools/decisions?

Policy	• Need:
	     o The problems that you are working on
	     o The goals, milestones and work program
	     o The policy needs

International Liaison[18]	• Two-way feedback on what you are doing

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[18] Note that the International Panel was subsequently disbanded in favor of international coordination via each of the other five panels.

These are just some of sample aspects of work flow among the IPT Panels that will have to be managed.

Complicating the move to a work flow around interdependent Panels, is the chimney structure within the present 100, 200 and 300 divisions, across other parts of the FAA, and at different levels in the system. For example, one staff member reflected that "we were making progress in getting every line of business on the latest directive on NEPA procedures for FAA – all aligned in one document. But once it was completed, the airports' line of business went back to the titanium stovepipe to do their own thing by revising their own directive (duplicative to what is coming out of this office or, in the areas that are not duplicative, it should have been integrated)." Although these "stovepipes" are clearly a barrier, there is also a risk to moving to the other extreme, which would be a structure just composed of cross-functional teams (or even constantly changing teams). The risk is that depth of technical expertise would suffer.

Thus, it will be essential for the organization to have both a logical structure (whether based on functional expertise or cross-functional teams), with a concurrent ability to reconfigure. That is, if the office remains organized by technical function (though in a way that is more coherent than present), there needs to be effective mechanisms to manage assignments to work on cross-functional teams. Conversely, if the office is reorganized around cross-functional teams, there needs to be effective mechanisms to maintain depth of technical expertise within functional domains. It may be that the IPT Panels provide an appropriate structural framework, but that remains to be seen. Whatever structure is chosen, however, it is clear that it will have additional, matrix dimensions.

Whatever structure is chosen … it is clear that it will have additional, matrix dimensions.

Beyond the work flow issues within AEE and the FAA, there are work flow issues across the IPTs in the JPDO. One AEE staff member captured this complication by saying, "It is not a lack of concern or a disagreement around whether the environment is important – the biggest challenge will be the structure of the JPDO and the inertia that the other IPTs have and the priorities that will be set separately from the environment IPT." At present, each IPT has some common operating procedures, but the level of standardization is not high – complicating what will already be divergence as a result of only partly resolved priorities.

Ultimately, a range of specific structural choices confront the Office, each of which has advantages and limitations. These include:

> **Option 1:** Leave the current structure as it is, with a focus on strengthening the processes by which people operate in this structure;

> **Option 2:** Shift the structure to match the various integrated panels that have been established on the Environment Integrated Product Team (EIPT) that is part of the JPDO; and

Option 3: Organize the Office in a matrix structure – with core competencies along one dimension of the matrix and various projects and teams assignments along the other dimension.

Of these three options, the first one is problematic in that the many additional linkages are all seen as a claim against their current roles. Still, there is merit in Option 1 in that the cross-functional teams that were set up under the last reorganization have not had the full range of support needed. Helping the teams to realize their potential would be very helpful. This might include more detailed current state assessments with each team using various team effectiveness metrics and facilitated improvement processes where appropriate.

The second one is problematic in that the JPDO and the EIPT may or may not endure. To restructure a federal agency in order to align with a newly formed organization that is still establishing its ongoing institutional role would likely be premature. Linking the structure of AEE to the JPDO has many unknowns. As one interviewee commented, "It is not a lack of concern or a disagreement around whether the environment is important – the biggest challenge will be the structure of the JPDO and the inertia that the other IPTs have and the priorities that will be set separately from the environment IPT." Still, there is merit in Option 2 in that these groupings do correspond to key tasks relevant to the next generation air transportation system and these are all channels for collaboration with other public and private organizations. As one individual commented in the open-ended portion of the survey: "Diminish JPDO activity to the extent possible and concentrate on building EIPT. The two may seem at odds -- but what I mean is AEE should be starting to strategize for a future without the JPDO umbrella." In this sense, the EIPT panels may well represent an appropriate structure to organize work.

The third option may be the most promising, though it is also the most challenging to execute. A matrix structure under Option 3 would begin with each employee having as a home unit their primary domain of technical expertise. These could be organized as they are now – with the Front Office, the 100, 200 and 300 groups – although these home units for technical expertise may be configured in other ways as well. These domains of technical expertise could be substantive, such as "emissions," or oriented around applications, such as "modeling." A second, related way to define the home units, would be around what industry terms "value streams." Thus, one value stream in the present operation involves the suite of models and tools. Another involves basic science on climate effects of aviation. Option three could end up as a combination of the current structure and the EIPT Panel structure in order to define the home unit.

Once the home units of technical expertise are defined, then the people in each would also have certain assigned roles with respect to internal cross-functional teams, ICAO/CAEP, the Environment IPT, the Research Partnerships, and the handling of Periodic "Crises." Under this set up, each employee would have a set of roles and responsibilities associated with the internal AEE structure and additional defined roles relative to each of these other initiatives. The additional roles assignments would be assignments not to an activity, but to a formal team (some ongoing and some formed for a short period of time). Although this matrix does exist to some degree now (under Option 1), it happens on a case-by-case basis rather than an explicitly designated range of activities that are all connected to the overall strategy and goals of the agency. Ultimately, this would

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allow for a relatively flat organizational structure with three levels – team members, team leaders, and cross-team (executive) leadership. A key to effective matrix operation is that it is understood (and even expected) that there will be tension in the matrix, with formal time allocated to surface and address the interdependencies.   Support for this notion of a core structure with the ability to form additional teams on a matrix basis is reflected in the following open-ended comment from the survey on a recommended structure: "Whatever it is -- don't have it be rigid. Understand that projects need teams that cross organizations. Have no more than 3 Divisions. Avoid the temptation to create more 'special assistants'." Visually, the matrix might look as follows for each employee:

Names	Technical Depth (Primary Assign-ment)	Internal Cross-Functional Team(s)	ICAO/ CAEP Role(s)	EIPT Role(s)	Research Partnership Role(s)	"Crisis" Response Role(s)
XXXX						
XXXX						
XXXX						

Of course, many variations are possible. The key point comes back to the definition of lateral alignment cited earlier. Each stakeholder has to be able to "orient and connect" their efforts to others in way that advance each of their separate interests and their shared system interest. The structure of AEE has been moving toward an increased capability to orient and connect in these ways, but additional structural change would further enable this capability.

Levels of Governance & Forums: The need for new forums and governance mechanisms is illustrated by the creation of the EIPT, with meetings of the Steering Group twice a year and working sessions of the various panels in between Steering Group meetings. Note that we use the term "forums" as an overarching label for the way panels, IPTs, committees and other efforts bring together stakeholders for regular dialogue and action.

At present the IPT as a forum is in the process of transitioning from a vehicle for information sharing and collaborative problem-solving into a coordinating body playing a leadership role on projects that involve resources from multiple organizations. In the FAA Office of Environment and Energy and in each of the other member organizations there is a mix of support and resistance to the EIPT playing this integrating role. If the new forums are to realized their full potential, they will need increased recognition within the respective organizations as valued forums with recognized influence over certain domains or issues

Overall, the survey responses in Chart 5 above suggests that the workforce does feel somewhat empowered at the front-lines (at least in comparison to other factors). Similarly, there is also moderately strong agreement (4.5 on a 6 point scale) around unresolved issues being addressed at higher levels. In neither case do these data suggest a high performance team-based work system, but nor do they suggest one that is dysfunctional. Thus, these are two key dimensions of governance that are not major barriers to lateral alignment, but where improvements are possible.

At the same time, there are parts of the governance process and forums that have been a source of frustration for participants. For example, private sector (e.g., industry) representatives were invited to serve on the EIPT panels, names were submitted to the NGATS Institute, and then there were delays of more than six months while the legal status of these representatives had to be sorted out. Similarly, one staff member commented that "the panels are asked to produce material without clear directions." The experience across the panels has been mixed, with one leader noting that the EIPT has been more effective in its work on operations than on other areas.

Overall, as Chart 9 suggests, the survey respondents do report moderately high levels of coordination with many additional stakeholder organizations. There are two exceptions to the overall pattern in Chart 9 – coordination with EPA and NOAA. The stories in these two cases are, however, very different. In the case of NOAA, there were relatively few past instances of collaborative work between AEE and NOAA, but the EIPT has brought a key staff member from NOAA into an active working relationship with AEE such that we would anticipate increased alignment over time as a relatively easy outcome. By contrast, recent years saw a withdrawal by the EPA from participation in a number of activities concerning aviation and the environment – so the data in Chart 9 reflects not an absence of interaction, but historic tensions. It is of note, however, that there are signs of increased EPA engagement in the EIPT, which may lead to a shift in these views over time.

Chart 9
AEE Staff Views on Coordination with Internal and External Stakeholders
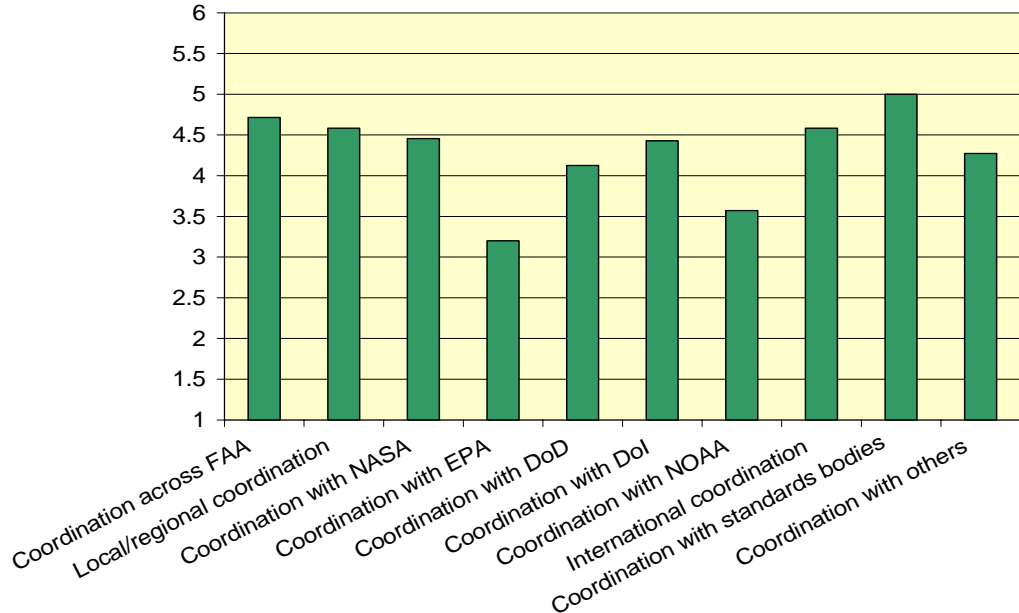
Key: All items were presented as statements on each of these dimensions, with the following possible responses: 1=Strongly Disagree; 2=Disagree; 3=Somewhat Disagree; 4=Somewhat Agree; 5=Agree; and 6=Strongly Agree.

Functional Roles & Technical Expertise: In AEE, the staff is relatively small and has not grown as the scope of work has grown. This is by far the greatest

MIT Project on Lateral Alignment in Complex Systems

barrier reflected in Chart 5 above – the current staffing levels. As one staff member commented, "The big challenge for the office is major and ambitious goals, but with the same workforce that we had at the outset."   Another commented, "We are short-staffed in general, and in certain critical areas. In addition, there are some people who do not "pull their weight". This impacts our ability to complete tasks and complete them satisfactorily. It also definitely impacts morale, and peoples' attitudes. . . . At the same time, we have some of the best, hardest working, knowledgeable, experienced staff that I have ever had the pleasure of working with…and the public is fortunate to have them as public servants." This directly connects to the alignment efforts, as one person noted: "We are trying to pull together enough resources from different agencies and the private sector. We've never done it this way before and we're overstressed with no time to figure things out." A further comment is that "the challenge for the organizations directly involved is to have people dedicated to the IPTs and their own organizations' missions."[19]

The expanding scope of work is a critical issue because people will be asked to fill roles they have never had to fill before. They will be asked to interact with close colleagues and new people from other groups in unfamiliar ways. Historically, when the Noise Division shifted to a team structure, it was felt (at least according to one AEE staff member) that the reorganization created better communication within the Division but resulted in things being "more stove-piped than ever." Others, however, challenged this view – seeing a greater degree of communication across the agency since the reorganization. Certainly, respondents to the survey had a moderately strong agreement that there was integration across technical areas. A far greater concern reflected in Chart 5 is around the needed depth of technical expertise, which emerges along with staffing levels as a clear issue to be addressed.

Issues of technical depth will become even more pressing as the amount of work that AEE is asked to complete grows. As one individual commented in the open-ended portion of the survey, "Our current challenges require more than the usual Environment and Energy

> *… not only are the work flows and the technical interdependencies changing, but formal roles are shifting as well.*

expertise and we should implement a system to prepare and train our personnel for those new challenges. For example Continuous Descent Approach (CDA) requires knowledge of aircraft procedures for landing, landing spacing between different size of aircraft and many other things that I am not familiar with." As well, the changing roles are also reflected in the shift that one staff member expressed in this way, "Historically [the relationship between FAA and other stakeholders] has been solely reactive and focused on the technical detailed

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[19] The connection between staffing and mission accomplishment is reflected in the following comment about the safety efforts: "When AEE agreed to provide policy, oversight, reporting and liaison for FAA employee safety issues, we did so only on the condition that adequate resources would be provided. Those were defined as 6 FTE plus $1.4 M in contract funds. That resource level lasted approximately one year. Over the succeding years, a combination of budget shortages and hiring freezes reduced the resource level to 2 FTE and $400 K. As a result, policy development was stretched out greatly, and the oversight function was essentially put on hold for several years. Last year, we got authorization to hire a third person, and our progress has been drammatic. For example, we have completed employee safety and health program evaluation visits for fifteen FAA organizations."

problem of the day – instead of managing the challenges of tomorrow from a systems perspective."

Some structural tensions are predictable as a result of the integrative approach within the EIPT. The emphasis on operating "badgeless," for example, will facilitate problem solving and collaborative efforts within the IPT. At the same time, this approach can create tensions within the respective organizations – who will accuse their representatives of having "forgotten where they came from." As one interviewee commented, "we are trying to pull together resources from different agencies and from the private sector -- we haven't done it this way before; we are over stressed; we have no time to figure out new things; and some of our bosses don't have this as primary concern."

Thus, not only are the work flows and the technical interdependencies changing, but formal roles are shifting as well. A similar shift can be anticipated in the various support functions. Already, there is evidence of new issues concerning Human Resource Management and Labor Relations. Interactions with the unions representing FAA workers are usually reserved for this support function, but there are now questions around how early to have unions involved in the work of the Operations Panel and other Panels that may generate changes in bargaining unit work. Issues around funding have had implications for the Financial Services functions. These arise, for example, with the many contractual arrangements under PARTNER for university research. The Agency's Office of Chief Counsel and the Office of Government and Industry Affairs will have new roles as a result of the network of stakeholders being brought into the JPDO process. Consider that performance evaluations must also value work done for another set of objectives such as that work that people do in the EIPT. Human resources policies must be flexible to allow for appropriate rewards and recognition when people take on these new tasks.

At present, the individuals in this Office who are serving in some of the new leadership roles face a common dilemma – is the new role an additional set of tasks and activities to fit into an already full set of responsibilities or are the new roles now part of new ways of accomplishing their various responsibilities? Clearly, the later approach will be the key to success, but the structure and process needs to support the new roles – along with the requisite technical depth.

Performance Metrics & Reward Systems: The design of many reward and reinforcement systems are rooted in classical economic assumptions, aimed at aligning incentives around organizational objectives. While it might make sense to ask if the reward and reinforcement systems at AEE are aligned with the work of the EIPT, there is a more basic consideration when it comes to these sorts of shifts in a complex system. That is, legacy reward systems can (and often are) antithetical to new systems. Thus, the first challenge in lateral alignment is not to seek supporting incentives so much as to address existing disincentives.

In the case of AEE, there are federal policies and procedures that emphasize individual performance reviews and competitive assessments that may or may not drive behavior in ways that are consistent with lateral alignment. As one AEE staff member commented, "I don't know if the structure we have would feed into lateral alignment. People are taken away from their normal responsibilities and asked to take on a second full time job. Sometimes there is resentment because

my boss's work isn't getting done. People are supportive, but there is still that issue of working long hours and not being fully compensated . . . we need to do something."

Rewards and reinforcement do not just operate at the level of individual employment relationships. In the federal government, the merit of organizational endeavors is determined through the allocation of budget and resources. This aspect of a reward system is relevant not just in terms of having the budget to accomplish a task, but also as a signal that drives morale, career planning, and concentration of effort. This is particularly relevant in the context of systems change – when budgets take on symbolic as well as practical importance, signaling priorities with respect to the new initiatives. As one individual commented, the problem is finding the resources, not "just giving the program lip service." Another stated, "put your money where your mouth is – commitment from the federal government means dollars and our problem is funding basic research." Another commented, "If you lost the research budget [in FAA], morale would sink much as it has at NASA [where there have been major cuts in aeronautics research]."

Of course, the rewards and reinforcements can become positive as well. One individual commented on the possibility of the EIPT helping to legitimize support for research on aviation and the environment: "NASA resources were cut. But if this work forwards NASA's budget, then NASA will play. There has to be some reason that they can point to." In further support of such a scenario, one manager cited an example of a multi-agency initiative where individual effort and initiative was not necessarily valued in the home organization, but was valued in the collaborative forum. In this case, the individual was able to bring back opportunities for the organization that may not have been anticipated going in.

Thus, where operations involve increasing lateral alignment, there are likely to be tensions around reward and reinforcement systems that give contrary incentives. At the same time, success that builds on the collaborative approach can foster a positive, self-reinforcing dynamic. Ultimately, the reward systems in the federal government (including pay increases, career development, public recognition and other matters) are oriented around effort within each agency. Integration across agencies and with other stakeholders is incompletely reinforced. Budgeting and other resource decisions are made on an agency-by-agency basis, which makes collaborate efforts by this Office vulnerable to shifting priorities in other agencies.

Support Functions & Support Systems: Support functions such as finance, human resources, information systems, legal, and others must now orient their support activities to help enable the Office staff to operate in new ways. In some cases, these are just additional incremental tasks, such as supporting additional training or adjusting hiring practices. In other cases, it represents a fundamental cultural change. For the legal function, for example, contracting practices that assume an arm's length, customer-supplier relationship do not match the more collaborative activities. For the HR function, there are a growing number of government, industry and university stakeholders and others who are serving on teams, panels and committees in order to advance the mission of the agency, but who are not on staff in AEE. These support functions are generally seen as barriers, as the following strongly worded comment suggests: "The support [from Legal] is horrible and renders a lot of actions useless. It is worse than personnel

-- which is awful." Clearly, lateral alignment elevates the importance of support from functions that are not necessarily held in high esteem – a key challenge.

Architectural, Strategic, and Cultural Alignment

Least visible of all are deep, underlying values and assumptions, which may or may not be aligned internally and across stakeholders. These underlying values and assumptions are reflected in what scholars term the "organizational culture."[20] It is of note that issues around cultural values are among the hardest to change in organizations, but core values and assumptions have some of the greatest leverage. There are also overarching considerations around strategic direction on the part of each stakeholder, as well as the overarching issues associated with various system architectures. It is these key overarching and underlying factors that are the focus of this last section of the case study.

Underlying Values & Assumptions. A focus in core values and assumptions as a dimension of alignment is essential, though it requires a long-term horizon in terms of change. The internal AEE survey included questions on eight matters that might or might not be seen as core values by the AEE staff. As Chart 10 indicates, there is broad consensus on the importance of these values and minimal distinctions to be made among seven of the matters. It is perhaps noteworthy that protecting the environment had the second to lowest degree of agreement, though again the differences with the higher agreement items are small. The notable exception, is with respect to enabling competition, which is not a strongly shared value among AEE staff. In general, this suggests a high degree of internal alignment around core values.

Chart 10
AEE Staff Views on Core Values in AEE
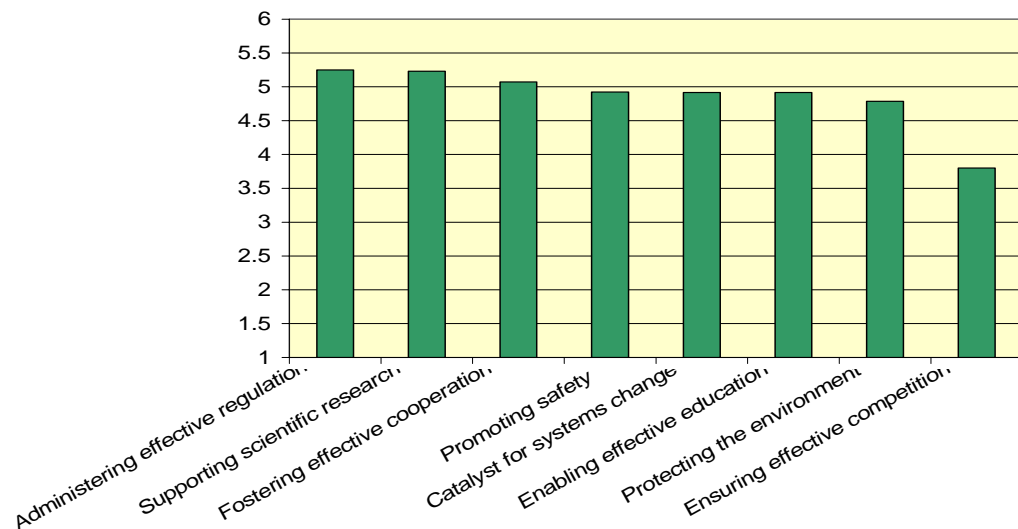
Key: All items were presented as statements on each of these dimensions, with the following possible responses: 1=Strongly Disagree; 2=Disagree; 3=Somewhat Disagree; 4=Somewhat Agree; 5=Agree; and 6=Strongly Agree.

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[20] Ed Schein, *Organizational Culture and Leadership,* San Francisco, Jossey-Bass (1988).

Beyond the internal alignment on values, a number of the AEE participants in the EIPT commented on the contrasting cultures of various federal agencies, as well as the contrasts between public and private sectors. For example, some commented that the culture in NASA Aeronautics is oriented around research, which contrasts with the culture in the EPA that is more oriented around regulation, which further contrasts with the culture in the FAA that gives more emphasis to operations. As one interviewee commented, "The Administrator is committed to the environment, but the culture of FAA has not always favored environment. It is a technical and regulatory organization – safe and efficient air transportation system has been the focus – with environment only now being elevated. It will take a while to overcome the culture."   It is beyond the scope of this case study to confirm broad generalizations around the respective cultures of these agencies. Indeed, the survey data certainly suggests that regulation is also a core value in AEE. Further, each organization is not a single, monolithic culture. Still, to the extent that there are such cultural tendencies, it is important to be mindful of them when attempting to operate with increased alignment.

Government members of the IPT will have regulatory roles that are likely, at times, to put these members of the IPT into conflict with members of the IPT from the aviation industry. In some cases, the conflict may reach to core, underlying values and assumptions – such as whether to unambiguously value growth in the aviation sector. Clearly, the survey data does suggest that ensuring competition is not highly valued within AEE. This may even be an issue for the EIPT with respect to other IPTs that are much more focused on increasing system capacity. Working through these issues and maintaining momentum on the environmental priorities of AEE will take skill and awareness. It may also require the establishment of issue resolution processes and channels for appeals when issues cannot be resolved at the Panel or IPT level.

In some cases, the values and assumptions may shift to favor collaboration. As one interviewee commented, "Teamwork is helping. We are all working toward a common goal – addressing the environmental issues. Everyone has a piece and can take it back to their management. It is not just an FAA initiative – we all can own a piece of that." Similarly, parts of NASA Aeronautics might have operated relatively independently from the FAA in the past. Now, however, one AEE staff person reported that, "NASA is in survival mode – our relationship has improved recently." This statement reflects the reality that the budget for NASA Aeronautics has been slashed and they need to reach out to insure ongoing funding. It is an opportunity to build deeper relationships between two groups. The research expertise at NASA is vital to the work that AEE needs to accomplish. Awareness of this interdependency can open up dialogue and build increased appreciation for working together.

Perhaps not surprisingly, the culture change within agencies may be harder than the culture change among representatives operating across agencies. As one interviewee commented, "It is more difficult bringing along others in FAA than counterparts in NASA and elsewhere. Others in FAA just see this as just another government initiative (airports, traffic, etc.). Others on the EIPT are having a similar experience with their counterparts – they are all just focused on the problem of the day." These comments just begin to suggest the many dimensions on which culture change is on the agenda – change within and across agencies, both with regard to regular operations and future perspectives.

Overarching Strategies & Goals. Within the AEE, there are norms and an organizational culture that can put a damper on announced new strategies and goals. The organization has experienced change in the past with various internal reorganizations that are still recalled by people in the organization. Couple this with the types of change that happen as administrations come and go through the political process and it is not surprising to hear a mix of reactions about any new initiative. On one hand, there was stated excitement by some about the leadership in a new, more collaborative direction, but, as one AEE staff member commented, "It is more difficult bringing along others in FAA than counterparts in NASA and elsewhere. Others in FAA see this as just another government initiative." There is also ambiguity around goals. One staff member expressed it this way, "It is not clear what will bring about these goals – it's hard to see since there are so many degrees of freedom."

Beyond skepticism and caution, there are more basic issues around strategic priorities. As one staffer put it, "We all need to agree on what is important with respect to aviation and the environment – agree on the problems themselves and the relative severity of the problems – and what we are realistically capable of doing about the problems." Another staff member commented on issues reaching beyond AEE, "Another barrier is lack of high-level FAA management acceptance of environmental issues as a potential major constraint." Beyond FAA, there are parallel priority issues among different agencies. For example, when the legislation establishing the JPDO was written, the EPA was not included (most of the focus in establishing the JPDO was on issues other than the environment). Getting the EPA to participate in the work of the AEE and the Environment IPT is complicated by the fact that the leadership of the EPA is therefore not aligned with the work of the JPDO.

In order to understand the strategic orientation within AEE, it is helpful first look at how people focus their energies. When asked about how much of their time is focused internally as compared to external interactions, the respondents to the internal alignment survey reported that about 60% of their time is internally focused, with about 30% focused externally on other government agencies and 10% externally with the private sector. When asked what the mix might be in a year, there is a very slight shift (on average) toward increased external interactions. This is presented on the next page in Chart 11.

Chart 11
AEE Staff Time Allocation

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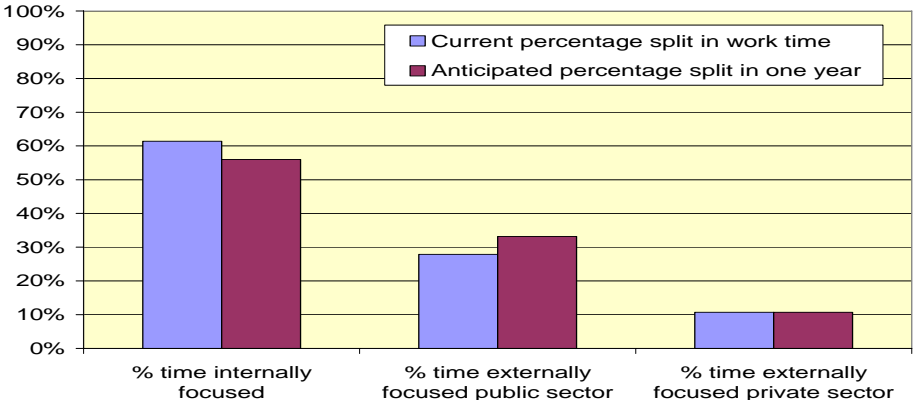
There is no benchmark against which to assess these percentages – Is 60% too much of an inward focus for an agency seeking to increase its lateral alignment? Or is 40% of time focused outside of the agency a substantial degree of engagement? Ultimately, there is is a core strategic challenge for AEE, which involves balancing current responsibilities with service as a catalyst for systems change. There is tension in that this strategy is not fully embraced across the staff in the Office and it is vulnerable to shifts in priorities across the federal government. The decision, for example, to shift NASA resources away from atmospheric science research has major implications for the strategic direction being pursued in this Office.

Overarching Systems Architectures. Much of the work of the JPDO centers on the development of a next generation architecture for the U.S. air transportation system. In this respect, there are challenges in transitioning to a new architecture from the current systems architecture (which is actually a legacy collection of many separate systems architectures, such as for air traffic control, airport operations, weather tracking, etc.). Because the development of the future architecture is an iterative process, it means that alignment within AEE, as well as across the IPT, will be at risk of constantly being disrupted with each new iteration.

Compounding the alignment challenges at this level are the many separate, but interdependent systems architectures. First, the DoD has its own overlapping, independent systems architecture for air traffic control, defense base operations, environmental management, and so on. Second, there are separate systems architectures in the European Union (EU) and other parts of the world. Indeed, there are periodic claims in both the EU and the United States of bias in favor of civil aviation aircraft from either Airbus or Boeing that, regardless of the merits, add further tension to international alignment efforts. Third, there are social systems architectures, such as the Civil Service System and other government employment relations systems that can impact alignment efforts. As one individual commented, "Civil service is often seen as a nice safe job that won't infringe on personal time, but to do what we need to do, we need people who can stay with an issue as needed."

The various properties of the various interdependent systems are only partly understood and the dynamics of their interactions with one another are also only partly understood. As one interviewee commented, "With each new Director, AEE has been moving toward more of a systems perspective." Looking ahead, system design and management is clearly a core competency that will be of ever increasing importance – at all leadership levels.

Conclusion

The work and roles in the AEE would be simpler and clearer were this office to choose to operate on an insular basis, with collaboration limited to periodic projects or initiatives, selected university research projects, and various international collaborations. It is also likely, however, that the impact of the organization and the broader ability of all parties to constructively engage issues of aviation and the environment would diminish. Instead, by building an

increased ability to operate with alignment – across government agencies and among other stakeholders – the potential impact is expanded. As we have seen, however, the challenges in accomplishing this task are many.

First, the overall cadence of work within AEE is driven by five very different sources – the existing, internal functionally organized work; the long-term, deliberative ICAO/CAEP process; the university research process; periodic crisis events; and now the JPDO/EIPT process. Internal alignment of AEE with the JPDO/EIPT process represents a key opportunity to forge a more integrated and collaborative approach to aviation and the environment, but it will have to be reconciled with the other, parallel cadences in AEE. A key finding in this regard is that the JPDO may or may not endure as an integrating mechanisms for the development of the next generation air transportation system, but the EIPT structure should be sustained in any case. As such, the internal alignment of AEE in support of the work of the EIPT is important regardless of the future of the JPDO.

Second, various behavioral aspects of alignment, trust and communications emerged as key themes. As well, leaders have to operate more on the basis of influence than authority and interactive skills are essential. Beyond interactive skills, systematic enablers need special attention, including developing new norms around the use of web-based interactive tools, enabling the effectiveness of the existing cross-functional teams, developing protocols for leadership transitions, and other such innovations.

> *… fundamental systems change is not possible without a significant measure of alignment within and across the relevant stakeholders.*

Third, beyond the behavioral alignment, there are aspects of work flow, technical interdependency, functional roles, and support functions that all need attention. These issues are, if anything, more pressing than the behavioral matters. In these cases, the existing "chimney" structures will limit the needed collaboration. At the same time, there does need to be a way to ensure continued depth of technical expertise. Ultimately, experts in given technical domains will need to be able to focus some portion of their effort within the technical domain and some portion of their effort in cross-functional teams, projects, and initiatives. This likely points to a matrix structure where people have a home base in some version of the current 100, 200, and 300 structure, but where there are formal roles and duties in an array of panels, committees, working groups and other such assignments. Restructuring within AEE is important, but it has to be integrated across all dimensions of the alignment framework.

Finally, issues of values and assumptions, strategy, and systems architectures all loom large as matters that cannot be easily or quickly resolved, but that will impact the collaborative efforts in many ways. As one interviewee commented, "It is partly structural, but even more it is a mindset. The top third of the resources in the office are dedicated to the integrated mission, but the other 2/3 are in a government job – punch the clock. What will it take to get out of that mindset? Maybe we need more education on the mission to have more ownership -- some intervention is needed." The challenge here is a mix of

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anticipating and mitigating the immediate challenges, combined with a constructive engagement of culture change. It is possible that the Senior Policy Committee of the JPDO is a forum where overall systems barriers could be surfaced and addressed, but that prospect will need to be balanced against what are sure to be concerns about taking issues through internal channels in each respective agency. This is a key issue for the EIPT on environmental matters – will issues be addressed through this forum or in the separate chain of command in the respective agencies? The way that AEE operates internally on such matters will send a strong signal to other organizations.

Motivating this study has been the proposition that fundamental systems change is not possible without a significant measure of alignment within and across the relevant stakeholders. While this case study documents many relevant dimensions on which alignment will be needed, it remains to be seen how much internal alignment is needed to enable lateral alignment. There are many key questions to be addressed along these lines, which are reflected in the planning worksheet included in Appendix I.

For the FAA Office of Environment and Energy, this is a strategic crossroads. In seeking alignment within AEE, with other parts of FAA, with other federal agencies, and across other stakeholders, new ways of addressing aviation and the environment are being forged. There are inevitable tensions in the process, but there are also early signs of what is possible and there is cautious engagement of a growing array of stakeholders in working toward the vision. Because the challenges are complex and multi-dimensional, there will not be a single-point solution. Although there are important areas of behavioral alignment needed, the analysis here points to functional/structural dimensions as more pressing and, ultimately, to strategic, systems and cultural dimensions. In systematically working through these challenges, however, AEE will be learning valuable lessons for other stakeholders associated with aviation and the environment, all of whom will also have to build internal alignment in various ways. Further, there are lessons around the internal alignment needed for other aspects of the United States aviation system and, indeed, for stakeholders in a broad range of complex, engineered systems.

APPENDIX I

Lateral Alignment Planning Worksheet

Three Levels of Alignment	*Key Dimensions at Each Level*	*Selected Questions on Functional Requirements*
Behavioral Alignment	**Communications & Information Sharing**	• *Is there easy and open access to general information relevant to people in the organization and collaborators in laterally aligned organizations – web-based or otherwise?* • *Are there periodic face-to-face meeting opportunities, along with other synchronous and asynchronous communications?* • *Are there protocols for information exchange where appropriate – for suppliers, customers and collaborators?*
	Leadership & Decision Making	• *Have clear roles and responsibilities been specified for senior leaders and "distributed" leaders at all levels?* • *Are skills in coaching and mentoring, consensus decision making and situational leadership broadly distributed?* • *Are leadership hand-off protocols established for leadership changes?* • *Are decision making protocols established as appropriate?*
	Negotiations & Dispute Resolution	• *Are there established internal and lateral processes for dispute resolution?* • *Have skills in constructive, problem-solving negotiations been established internally and laterally?*
	Learning & Development	• *Have defined and supported learning plans been developed for all employees, focusing on technical skills and process capability?* • *Are there opportunities for shared formal learning activities across individuals from different stakeholder organizations?*
Functional/ Structural Alignment	**Work Flow & Technical Coordination**	• *Are "value streams" and process flows mapped?* • *Are there disconnects in the flow of work – internally and laterally?*
	Levels of Governance & Forums	• *Do forums have clear charters, specifying mission/ purpose, roles/responsibilities, and operating procedures?* • *Is there a clear scope of issues to be resolved in new, lateral forums and clarity on what goes to hierarchical channels?*
	Functional Roles & Depth of Expertise	• *Have gaps in technical expertise been identified, with resources allocated and mechanisms to see and close future gaps?* • *Have roles been redefined to enable lateral alignment?*
	Performance Metrics & Reward System	• *Are there mechanisms to assess new forms of work – in terms of performance metrics?* • *Have rewards that are antithetical to lateral alignment been eliminated?*
	Support Functions & Support Systems	• *Are support functions engaged in strategic dialogue to re-orient operations to support lateral alignment?*
Overarching/ Underlying Alignment	**Overarching Systems Architectures**	• *Are there useful visual representations of concurrent systems architectures that help to reveal potential connections and disconnects?*
	Overarching Strategies & Goals	• *Is the strategy of lateral alignment clearly understood and valued as a way of operating?*
	Underlying Values & Assumptions	• *Are core values that enable alignment efforts reinforced?* • *Have core values that undercut alignment efforts been examined?*

APPENDIX II

Guide to Acronyms

AEE	Office of Environment and Energy, (Federal Aviation Administration)
AIA	Aerospace Industries Association
ATA	Air Transportation Association
CAEP	Committee on Aviation Environmental Protection
DHS	Department of Homeland Security
DoD	Department of Defense
EASA	European Aviation Safety Agency
EDMS DRG	Emissions and Dispersion Modeling System Design Review Group
EIPT	Environment IPT
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FICAN	Federal Interagency Committee on Aviation Noise (FICAN)
ICAO	International Civil Aviation Organization
INM DRG	Integrated Noise Model Design Review Group
IPT	Integrated Product Team
JPDO	Joint Planning and Development Office
KSN	Knowledge Sharing Network
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration (U.S. Department of Commerce)
NGATS	Next Generation Air Transportation System
PARTNER	Partnership for AiR Transportation Noise and Emissions Reduction
RE&D	(FAA) Research, Engineering and Development
SAGE	System for Assessing Aviation's Global Emissions
SAE A-21	Society of Automotive Engineers (SAE) Committee A-21 on aircraft noise
SAE E-31	Society of Automobile Engineers (SAE) E-31 Aircraft Exhaust Emission Committee
TRB	Transportation Research Board

Appendix III

Effectively Addressing the Challenges of Aviation and the Environment

Introduction: As the AEE addresses aviation and the environment, including current and future challenges, it faces many strategic choices. This survey has been developed by researchers at MIT. The MIT research began with selected interviews and has now expanded (based on feedback from AEE) to include this survey. The focus is on potential enablers and barriers facing AEE as it seeks to align its work with three new developments: 1) The Next Generation Air Transportation System (NGATS) plan; 2) the integrated environmental approach to AEE models and analysis; and 3) the Center of Excellence research.

Participation in this survey is voluntary. All responses will be tabulated by MIT and no individual responses will be identified outside of MIT – only aggregate results will be reported. Your participation is deeply appreciated. Analysis of data from this survey will contribute to current planning efforts by AEE management, as well as potential restructuring of the organization, given the advent of NGATS and other new developments. If you have any questions or comments on the survey, you can contact Dr. Joel Cutcher-Gershenfeld at 617-253-5777 or joelcg@mit.edu or Dr. Betty Barrett at 617-258-7202 or barrett@mit.edu.

The survey has been set up as an electronic form. Please complete the survey, save the file, and then send the completed survey as an attachment to: joelcg@mit.edu. It can also be printed, completed as paper copy and mailed to Joel Cutcher-Gershenfeld at E40-251, 1 Amherst Street, Cambridge, MA 02139). Note to preserve confidentiality, all surveys will be separated from the e-mails with which they were sent.

PART I: BEHAVIORAL ENABLERS AND BARRIERS

*Note: Please Indicate whether you agree or disagree with the following statements, each of which concerns factors that could be enablers or barriers to your efforts at AEE. Using the scale to the right, check just **one** response to each statement – indicating the degree to which you agree or disagree with the statement. Please read each question carefully as some are worded in the positive and some in the negative.*

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Don't Know/Not Applicable
1. The way my job is presently set up, I am able to easily communicate <u>internally</u> (within AEE) with all the people necessary to do my job	☐	☐	☐	☐	☐	☐	☐
2. The way my job is presently set up, I am able to easily communicate <u>externally</u> (across stakeholders) with everyone necessary to do my job	☐	☐	☐	☐	☐	☐	☐
3. There is currently a high level of trust across <u>internal</u> groups within AEE.	☐	☐	☐	☐	☐	☐	☐
4. There is currently a high level of trust across <u>external</u> agencies and organizations relevant to my work in AEE	☐	☐	☐	☐	☐	☐	☐
5. The current leadership within AEE helps me to do my job	☐	☐	☐	☐	☐	☐	☐
6. I have received all the needed training and development to best fulfill my roles and responsibilities in AEE	☐	☐	☐	☐	☐	☐	☐
7. Mechanisms exist to help me make continuous improvements in the way that I do my job at AEE	☐	☐	☐	☐	☐	☐	☐

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PART I: BEHAVIORAL ENABLERS AND BARRIERS (cont.)

Note: Please Indicate whether you agree or disagree with the following statements, each of which concerns factors that could be enablers or barriers to your efforts at AEE. Using the scale to the right, check just **one** response to each statement – indicating the degree to which you agree or disagree with the statement. Please read each question carefully as some are worded in the positive and some in the negative.

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Don't Know/Not Applicable
8. When we are working with external stakeholders, there are effective mechanisms to support continuous improvements in the way we work	☐	☐	☐	☐	☐	☐	☐
9. There are <u>no</u> consistent tools and methods for us to use in making improvements in the way we operate as an organization	☐	☐	☐	☐	☐	☐	☐
10. When there are innovations in the way we work in AEE, mechanisms exist to help standardize and replicate the innovations for broader use	☐	☐	☐	☐	☐	☐	☐
11. When there are innovations in our work with external stakeholders, mechanisms exist to help standardize and replicate the innovations	☐	☐	☐	☐	☐	☐	☐
12. When I am involved in formal negotiations in my role in AEE, I always take a problem-solving approach that emphasizes mutual gains	☐	☐	☐	☐	☐	☐	☐
13. We all pull together when it comes to a short-term crises here at AEE	☐	☐	☐	☐	☐	☐	☐

14. Please provide a <u>story or example</u> in space below about how behavioral factors such as *communications, trust, leadership, training, continuous improvement, and negotiations* impact AEE's work with others – internally and externally: *(note: begin typing in the grey area and the form will expand as needed)*

PART II: FUNCTIONAL/STRUCTURAL ENABLERS AND BARRIERS

Note: Please Indicate whether you agree or disagree with the following statements, each of which concerns factors that could be enablers or barriers to your efforts at AEE. Using the scale to the right, check just **one** response to each statement – indicating the degree to which you agree or disagree with the statement. Please read each question carefully as some are worded in the positive and some in the negative.

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Don't Know/Not Applicable
15. I am currently co-located with the people in AEE who are most relevant to my work.	☐	☐	☐	☐	☐	☐	☐
16. I am part of a formal work team within AEE.	☐	☐	☐	☐	☐	☐	☐
17. The current work flow across different <u>internal </u>parts of AEE provides all the support that I need for the work I do in AEE	☐	☐	☐	☐	☐	☐	☐
18. The current work flow across <u>external</u> public and private sector organizations provides all the support I need for the work I do in AEE	☐	☐	☐	☐	☐	☐	☐
19. The Human Resource/Personnel function in FAA provides all the support I need for the work I do in AEE	☐	☐	☐	☐	☐	☐	☐
20. The Information Systems function in FAA provides all the support I need for the work I do in AEE (computer support, DAMS/FAMS, KSN)	☐	☐	☐	☐	☐	☐	☐

Note: *Please Indicate whether you agree or disagree with the following statements, each of which concerns factors that could be enablers or barriers to your efforts at AEE. Using the scale to the right, check just **one** response to each statement – indicating the degree to which you agree or disagree with the statement. Please read each question carefully as some are worded in the positive and some in the negative.*

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Don't Know/Not Applicable
21. Within AEE, we have the depth of technical expertise in all relevant topic areas to support all of our roles and responsibilities	☐	☐	☐	☐	☐	☐	☐
22. Within AEE, we have the capability to integrate/collaborate across areas of technical expertise	☐	☐	☐	☐	☐	☐	☐
23. There are certain technical skills essential to addressing the future challenges facing this organization that are <u>not</u> present in AEE	☐	☐	☐	☐	☐	☐	☐
24. Front-line individuals and groups in AEE are empowered to address issues and problems as they emerge	☐	☐	☐	☐	☐	☐	☐
25. Issues or problems that cannot be resolved by front-line individuals and groups in AEE are promptly resolved at higher levels	☐	☐	☐	☐	☐	☐	☐
26. The current internal reward and incentive systems at AEE reinforce and support the work I do	☐	☐	☐	☐	☐	☐	☐
27. Effective feedback mechanisms exist to help me to know how well I am performing my job at AEE	☐	☐	☐	☐	☐	☐	☐
28. The current level of funding is sufficient for AEE to effectively address its goals and objectives	☐	☐	☐	☐	☐	☐	☐
29. The current level of staffing is sufficient for AEE to effectively address its goals and objectives	☐	☐	☐	☐	☐	☐	☐

30. Please provide a <u>story or example</u> in space below about how functional/structural factors such as *work flow, depth technical expertise, front-line empowerment, reward and incentive systems, feedback mechanisms, funding and staffing* impact AEE's work with others – internally or externally: *(note: begin typing in the grey area and the form will expand as needed)*

PART III: SYSTEMS/STRATEGY/VALUES ENABLERS AND BARRIERS

Note: *Please Indicate whether you agree or disagree with the following statements, each of which concerns factors that could be enablers or barriers to your efforts at AEE. Using the scale to the right, check just **one** response to each statement – indicating the degree to which you agree or disagree with the statement. Please read each question carefully as some are worded in the positive and some in the negative.*

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Don't Know/Not Applicable
31. There is a clear and compelling *overall* strategic direction guiding my work at AEE	☐	☐	☐	☐	☐	☐	☐
32. Where appropriate, my work at AEE is well coordinated with other FAA offices	☐	☐	☐	☐	☐	☐	☐
33. Where appropriate, my work at AEE is well coordinated with stakeholders at local and regional levels (such as airports and NGOs)	☐	☐	☐	☐	☐	☐	☐

PART III: SYSTEMS/STRATEGY/VALUES ENABLERS AND BARRIERS (cont.) *Note:* Please Indicate whether you agree or disagree with the following statements, each of which concerns factors that could be enablers or barriers to your efforts at AEE. Using the scale to the right, check just __one__ response to each statement – indicating the degree to which you agree or disagree with the statement. Please read each question carefully as some are worded in the positive and some in the negative.	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Don't Know/Not Applicable
34. Where appropriate, my work at AEE is well coordinated with stakeholders at NASA	☐	☐	☐	☐	☐	☐	☐
35. Where appropriate, my work at AEE is well coordinated with stakeholders at EPA	☐	☐	☐	☐	☐	☐	☐
36. Where appropriate, my work at AEE is well coordinated with stakeholders at the Department of Defense	☐	☐	☐	☐	☐	☐	☐
37. Where appropriate, my work at AEE is well coordinated with stakeholders at the Department of the Interior	☐	☐	☐	☐	☐	☐	☐
38. Where appropriate, my work at AEE is well coordinated with stakeholders at NOAA	☐	☐	☐	☐	☐	☐	☐
39. Where appropriate, my work at AEE is well coordinated with stakeholders at federal agencies other than the ones listed above	☐	☐	☐	☐	☐	☐	☐
40. Where appropriate, my work at AEE is well coordinated with stakeholders at international levels	☐	☐	☐	☐	☐	☐	☐
41. Where appropriate, my work at AEE is well coordinated with standard setting and formal stakeholders (such as SAE-21, E-31, FICAN, etc.)	☐	☐	☐	☐	☐	☐	☐
42. Protecting the environment is a core value that is essential to AEE's Success	☐	☐	☐	☐	☐	☐	☐
43. Promoting safety is a core value that is essential to AEE's success	☐	☐	☐	☐	☐	☐	☐
44. Fostering effective cooperation is a core value that is essential to AEE's success	☐	☐	☐	☐	☐	☐	☐
45. Ensuring effective competition is a core value that is essential to AEE's success	☐	☐	☐	☐	☐	☐	☐
46. Administering effective regulation is a core value that is essential to AEE's success	☐	☐	☐	☐	☐	☐	☐
47. Enabling effective education is a core value that is essential to AEE's success	☐	☐	☐	☐	☐	☐	☐
48. Supporting effective scientific research is a core value that is essential to AEE's success	☐	☐	☐	☐	☐	☐	☐
49. Serving as an effective catalyst for systems change is a core value that is essential to AEE's success	☐	☐	☐	☐	☐	☐	☐
50. AEE is playing an appropriate leadership role in the development of environmental aspects of the next generation air transportation system	☐	☐	☐	☐	☐	☐	☐
51. Environment and energy issues represent a fundamental constraint on growth in the US air transportation system	☐	☐	☐	☐	☐	☐	☐
52. AEE is putting the right amount of effort into international alignment through the ICAO process *Note: If you believe AEE should put more or less effort, please specify in the grey space (it will expand as needed):*	☐	☐	☐	☐	☐	☐	☐

53. AEE is putting the right amount of effort into US alignment under the Joint Planning and Development Office (JPDO) **_Note:_** _If you believe AEE should put more or less effort, please specify in the grey space (it will expand as needed):_	☐	☐	☐	☐	☐	☐	☐

54. Please provide a <u>story or example</u> in space below about how systems/strategy/values factors such as _strategic direction, connections across levels, values about competition and cooperation_ impact AEE's work with others – internally and externally: _(note: begin typing in the grey area and the form will expand as needed)_

PART IV. ADDITIONAL QUESTIONS

Note: _Please Indicate whether you agree or disagree with the following statements, each of which concerns factors that could be enablers or barriers to your efforts at AEE. Using the scale to the right, check just **one** response to each statement – indicating the degree to which you agree or disagree with the statement. Please read each question carefully as some are worded in the positive and some in the negative._

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Don't Know/Not Applicable
55. _(Please answer this question only if you were in the organization during the 1998-1999 reorganization)_ — The 1998-1999 reorganization helped AEE to meet the challenges it has faced since that time	☐	☐	☐	☐	☐	☐	☐
56. _(Please answer this question only if you were in the organization during the 1998-1999 reorganization)_ — I have found an improved level of communication and teamwork since the 1998-1999 AEE reorganization	☐	☐	☐	☐	☐	☐	☐
57. I am able to effectively balance competing roles and responsibilities under the current AEE structure	☐	☐	☐	☐	☐	☐	☐
58. People working as members of formal teams in AEE get the support that the teams need to be effective	☐	☐	☐	☐	☐	☐	☐
59. The current reward system in AEE is a barrier to the effective operation of formal teams in AEE	☐	☐	☐	☐	☐	☐	☐

60. _The development of the Next Generation Air Transportation System (NGATS) and the creation of the Environment IPT (EIPT) may have impacted your work. Please estimate the approximate percentage of your time associated with NGATS/EIPT and the approximate percentage of time in other roles and activities. Please make sure the total adds up to 100%._	_Percentage of time on NGATS/EIPT:_	**%**
	Percentage of time on other activities: **100%**	**%**

	Current percentage split across internal and external work	_Percentage split as you believe it will be by the end of next year_
61. _Please indicate the degree to which your work is focused internally within FAA or externally across public and private sectors. Again, please be sure that the responses add up to 100%_		
Internally focused efforts – working within the FAA	**%**	**%**
Externally focused **public sector** efforts – working with other government agencies (local, national, and international)	**%**	**%**
Externally focused **private sector** efforts – working with private sector organizations, associations and representatives	**%** **100%**	**%** **100%**

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62. With respect to regular AEE operations, please indicate your primary work location:

- ☐ 100 Group – Noise Division
- ☐ 200 Group – Environment, Energy and Employee Safety Division
- ☐ 300 Group – Emissions Division
- ☐ Office of the Director and Central Administrative staff
- ☐ Other (Please specify:)

63. With respect to the current work with the Joint Planning and Development Office (JPDO), please indicate the IPT groups or panels for which you are a member: *(please check all that apply)*

- ☐ IPT Steering Group
- ☐ IPT Secretariat
- ☐ IPT Analytical Tools Panel
- ☐ IPT Science/Metrics Panel
- ☐ IPT Technology Panel
- ☐ IPT Operations Panel
- ☐ IPT Policy Panel
- ☐ Not Applicable

64. What specific recommendations would you make regarding the future structure and direction of AEE: *(note: begin typing in the grey area and the form will expand as needed)*

65. What specific recommendations would you make regarding any activity or area AEE should consider adding into its work or dropping from its current set of activities – and why? *(note: begin typing in the grey area and the form will expand as needed)*

66. If you could provide one lesson or bit of guidance to a new employee in AEE, what would you tell him or her? *(note: begin typing in the grey area and the form will expand as needed)*

67. Please list at least one deeply held, shared value in the AEE organization: *(note: begin typing in the grey area and the form will expand as needed)*

68. Please use the space below for any additional comments: *(note: begin typing in the grey area and the form will expand as needed)*

– Thank you for taking the time to complete this survey –

Appendix IV

Lateral Alignment in Complex Systems
Project Overview and Prospectus

A Core Challenge in Society. . .

Many of our society's most important, complex engineered systems depend on alignment across many organizational and institutional stakeholders. Whether it is the next generation air transportation system, the stability of the electrical power grid, new frontiers in space exploration, net-centric models for military operations, extended supply chains, new manufacturing and service delivery systems, effective research and development operations . . . all involve a growing set of stakeholders that will not and mostly cannot operate together on purely the basis of top-down command and control. It takes a unique kind of influence and more . . . including attention to functional interdependencies, systems architectures, core values and assumptions. It takes what we are terming "lateral alignment" – a critical challenge in a time of accelerating technological change and increased complexity.

The Consequences of Failure Can Be Large. . .

Following the tragic failure of the Columbia space shuttle, the Columbia Accident Investigation Board (CAIB) concluded that "the foam debris hit was not the single cause of the Columbia accident, just as the failure of the joint seal that permitted O-ring erosion was not the single cause of Challenger. Both Columbia and Challenger were lost also because of the failure of NASA's organizational system." (CAIB, August 2003, p. 195). Similar social systems failures have been revealed by catastrophic events such as the Katrina Hurricane, various power grid failures and others. Perhaps more pernicious are the complex systems where misalignment is manifest in gridlock – preventing much needed systems change and transformation. This is may be the case, for example, when it comes to the many embedded systems associated with US health care or global warming. There are real and even tragic costs when there is lateral misalignment across organizational and institutional stakeholders.

The Project on Lateral Alignment in Complex Systems. . .

Begun at MIT and now expanding to include the University of Illinois and additional partners, the Project on Lateral Alignment in Complex Systems has a simultaneous commitment to applied research and basic science. We are pioneering new tools and methods to facilitate lateral alignment in field settings and we are advancing core underlying theory at the frontiers of network theory, game theory, graph theory, negotiations theory, institutional theory and related domains.

An Emerging Definition and Framework. . .

As scholars, we know that definitions are important. Here is our present working definition of "lateral alignment in complex systems:"

> "Formal and informal patterns of interaction that orient and connect inter-dependent stakeholders over time so as to advance both their internal, separate interests and their combined, system-wide interests."

Our focus is on three distinct types of alignment, which are: I. Behavioral Alignment, II. Structural/Functional Alignment, and III. Values/Strategy/Systems Alignment – all three of which are essential for systems change or transformation. These three types of alignment (examples of sub-elements for each) are reflected in the following framework:
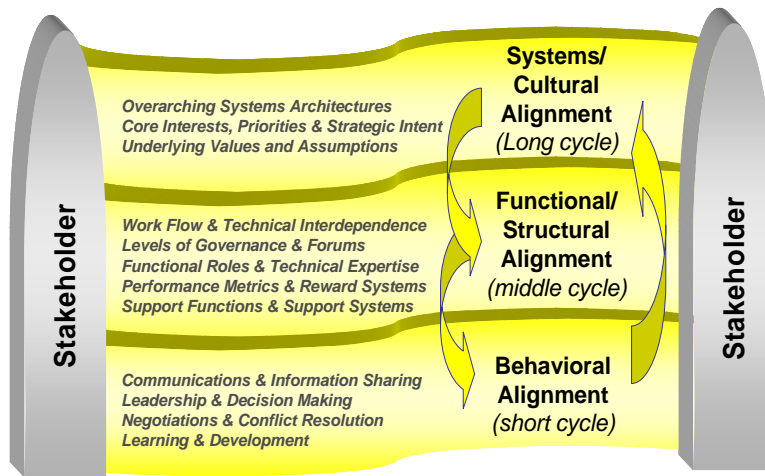
In this framework, the Behavioral Alignment is labeled as a "short cycle" in that behavioral patterns of interaction may shift toward increased or decreased alignment within relatively short time frames. This is where many alignment efforts primarily focus – such as increasing communications. By contrast, Functional/Structural Alignment is on a longer time horizon. Alignment or misalignment of cultures, systems architectures, and core interests operate with very long time horizons. The research and applications are all designed to understand and address dynamics for all three types of alignment, as well as the interconnections among them.

Current Research Focus. . .

This project utilizes what is termed an "action research" approach – using tools and methods to help parties better orient and connect in complex systems, while concurrently using data collected and lessons learned to advance underlying theory. Examples of tools and methods that are simultaneously practical and deeply informative, include:

- Mapping network connections among stakeholders in complex systems
- Establishing charters, shared visions and interdependency matrices for new or revitalized forums that bring stakeholders together in new ways
- Developing protocols and standards to guide new patterns of interaction
- Surfacing potential misalignments at the level of underlying cultural values and assumptions, and overall systems architectures

Working Group on Lateral Alignment. . .

A working group of leading scholars engaged in inductive and deductive theory development around the concept of "lateral alignment in complex systems" serves as a sounding board for the research. Individuals associated with the Working Group include: Joel Cutcher-Gershenfeld (UIUC ILIR/IESE) and Joel Moses (MIT EECS/ESD) (co-chairs), Betty Barrett (MIT CTPID/ESD), Jason Bartolomei (MIT ESD, Ph.D. student), Joanna Brooks (MITRE), John Carroll (MIT Sloan/ESD), Dietrich Falkenthal (MIT ESD Ph.D. student), John Hansman (MIT Aero-Astro/ESD), David Hartzband (MIT ESD Visiting Scholar), Chris Lawson (MIT ESD Ph.D. student), Don Lessard (MIT Sloan), Nancy Leveson (MIT Aero-Astro/ESD), Chris Magee (MIT Mech/ESD), Karen Marais (MIT Aero/Astro Ph.D. student), Nick McKenna (MIT ESD Ph.D. student), Aleksandra L. Mozdzanowska (MIT Aero-Astro Ph.D. student), Kate Parrot (MIT Sloan Ph.D. student), Eric Rebentisch (MIT CTPID/ESD), George Roth (MIT CTPID/ESD), Ian Waitz (MIT Aero/Astro), Annalisa Weigel (MIT Aero-Astro/ESD), and others to be added from MIT, UIUC and other locations.[21]

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[21] Note: ESD stands for MIT's Engineering Systems Division, EECS stands for MIT's Electrical Engineering and Computer Science Department, Aero-Astro stands for MIT's Aeronautics and Astronautics Department, CTPIT stands for MIT's Center for Technology, Policy, and Industrial Development, ILIR stands for the Institute of Labor and Industrial Relations at the University of Illinois, Sloan stands for MIT's Sloan School of Management, and UIUC stands for the University of Illinois at Urbana-Champaign.