National Research Council
Meeting of Experts on NASA Plans for System-Level Research to Mitigate the Impact of Aviation on the Environment

May 14-15, 2009
National Harbor, MD

Summary of Comments from the Meeting and NASA Feedback/Response/Disposition

August 15, 2009

Disposition of NRC MoE Comments

Vehicle Breakout Session:

Comment Themes

- **Implementation**
- **Goals/Objectives/Metrics**
- **Configuration/System studies**
- **Technologies**
- **System level experiments versus X-plane demos**
- **Managing expectations**

Comments from NRC MoE – Vehicle Implementation (1 of 4)

Comment	Disposition
Re-introduction of integrated system-level research into NASA program very important and positive step.	NASA will continue to pursue additional system-level research as technologies mature in the foundational base programs and external drivers exist.
Exciting program -- looking forward to hearing more.	ISRP and ERA will continue to take advantage of outreach opportunities. AIAA Meetings (ATIO in Hilton Head), SAE Meetings (WAC in Seattle), FAP Annual Meeting (Atlanta), etc. In the past few weeks, we have continued to spread the word at AIAA APA in San Antonio, and SFW Aerothermodynamics TWG at IGTE in Orlando.
CO2 emissions from aviation: 2% is a low estimate. The important thing is that it is a growing number and will be more significant in the future, which Jai pointed out correctly. One thing to remember is that the impact on global climate from aviation.	The statistic and source are being checked.
American Recovery Act and FY09 Congressional augmentation. Details? How are these funds being invested and how do they relate to the topic of discussion, priming ERA? Front-loading efforts? *(Note: it was later clarified that this cannot be shared yet).*	Congress approved the NASA Operating Plan, including details of spending plans of the American Recovery Act funds, and those details are to be shared with the NAC Aeronautics Committee at the July meeting.

Comments from NRC MoE – Vehicle Implementation (2 of 4)

Comment	Disposition
When saying that there are "compelling reasons" to choose ERA as the first project in ISRP, one should mention what are/were the alternatives. Were other things considered? Why was ERA decided on? Jai left himself open to that question.	At the AIAA Aerospace Sciences Meeting and Exhibit in January 2009, Dr. Jaiwon Shin gave a presentation on NASA Aeronautics, and it included a chart showing possible "game changers" for the industry in the future. Included in that chart was the notion of ERA, Supersonic Flight testing, UAVs in the NAS, and V&V of Complex Systems. These areas were included as possible areas for future funding augmentation in the NASA Aeronautics portfolio, and thus were alternatives to ERA. ERA was decided upon based on ARMD's own assessment of technologies from the fundamental base program that were ready to be integrated, matured and tested in a relevant environment. In addition, Congressional language provided guidance for investment in system-level research in "green aviation."
While it is "only" $60-$65M / year, what matters is the distribution of it…much of this money is being asked to be invested out of house, I imagine. None of this was clarified. *(Note: I was surprised that the industry reps were polite enough not to ask!)*	Due to the nature of the work, NASA's new investment in integrated system-level research will require a significant amount of collaboration with industry. In contrast to the fundamental base programs, it is expected that more than half of the Program funds will go to out-of-house procurements through vehicles such as the NASA Research Announcements (NRAs), Space Act Agreements (SAAs), on-site contractors and other procurement mechanisms.

Comments from NRC MoE – Vehicle Implementation (3 of 4)

Comment	Disposition
While not “dipping” into the existing fundamental research base to start additional (to those budgeted) system-level research, does anything preclude the existing programs from continuing to do system-level research? Will it all be moved to the new ISRP?	The research conducted in the fundamental base programs extends from foundational base research, to single discipline research, to multi-discipline research, to system-level research. When warranted, certain system-level research will be considered for additional projects to the Integrated Systems Research Program. The criteria used to determine whether or not such work is appropriate for ISRP includes the following: Technologies have attained enough maturity in the foundational research program that they merit more in-depth research at a system level in a relevant environment; Technologies which systems-analysis indicates have the most potential for contributing to the simultaneous achievement of various goals; technologies identified by stakeholder input as having potential for simultaneous achievement of various goals; and Research not currently being done by other government agencies and is appropriate for NASA to conduct.

Comments from NRC MoE – Vehicle Implementation (4 of 4)

Comment	Disposition
What is the best way to accomplish the work that ERA needs to do? In-house? Out-of-house? What is the ideal blend? For out-of-house work, does this mean NRAs? Other procurement mechanisms? How do you more constructively engage industry without being unduly influenced? *(Note: this was somewhat clarified later on, but more details should be provided, particularly to industrial partners, once they are available).*	NASA's overall Aeronautics program achieves its expected role and contributions within the current budget by focusing on NASA's unique capabilities and by maximizing coordination and collaborations with industry, academia, and other government agencies. We are able to fund a workforce at the four NASA Research Centers (Ames, Dryden, Glenn, and Langley) that allows for robust implementation of our research programs in such a manner that our workforce is sustained as a premier technical organization and a true national asset. NASA has put many mechanisms in place to engage academia and industry, including industry technical working groups and technical interchange meetings at the program and project level, Space Act Agreements (SAAs) for cooperative partnerships, and the NASA Research Announcement (NRA) process that provides for full and open competition for the best and most promising research ideas. It is anticipated that these mechanisms, as well as other competitive procurements, will be utilized to involve the private sector in ISRP and ERA. NASA plans to allocate ~$15M towards NRA in FY2010, which equates to roughly 24% of the program budget, which is greater than the amount allocated by the other research programs. In addition to the NRA, it is anticipated that a significant amount of the remaining funds within the program will be used for out-of-house procurements on advanced concepts and testing. An acquisition strategy plan will be developed in FY09 to identify and outline the strategy for the larger procurements and collaborative efforts of the project.

Comments from NRC MoE – Vehicle Goals/Objectives/Metrics (1 of 2)

Comment	Disposition
Goals of program include development/validation of tools but also maintain focus on achieving environmental objectives.	Actually, ERA is more focused on experimentally maturing technology concepts and studying the integration of them into unconventional vehicle concepts that can meet the N+2 noise, fuel burn, and LTO NOx metrics, and SFW will be focused on disciplinary, and multi-disciplinary tool set. The ERA approach will provide data for validation of the tools developed in SFW, which in turn provides focus for further tool development/improvement within SFW.
N+2 metrics are a good start. ERA will continue to refine most important environmental metrics.	Agreed. In addition to fuel burned, aircraft system noise, and LTO NOx, ERA will examine the benefits of N+2 technologies integrated into unconventional vehicle concepts on cruise NOx, as well as, particulate matter (PM) emissions. In this regard, ERA is planning a test campaign focused on fuel-flexible combustor designs. It has been shown that alternative fuel blends may emit less PM, and we plan to investigate how to take advantage this recent finding in the design of advanced combustors, and their integration into propulsor systems to result in less fuel burned and less NOx and lower PM emissions.

Comments from NRC MoE – Vehicle Goals/Objectives/Metrics (2 of 2)

Comment	Disposition
One should talk about containing "objectionable noise" within airport boundaries. That may mean 55 DNL or 65 DNL. This is so that the audience does not leave with the impression that the aircraft will be silent by N+3.	Agreed. 55 DNL is the current metric describing the situation where noise is contained within an average airport boundary. 55 DNL is not silent, but is essentially characteristic of non-objectionable noise. DNL is a computed measure essentially characterizing the noise contours at and around airports over the course of 24 hours with penalties for night flights; the metric is dependent of the fleet mix at a given airport. On an individual aircraft basis, and in approximate terms, if the entire fleet could meet Stage 4 minus 71 EPNdB cum, we would achieve 55 DNL. This is how we now talk about our N+3 goal. Our N+2 noise goal – Stage 4 minus 42 EPNdb cum, is consistent with 65 DNL and is a strong, challenging move towards keeping objectionable noise within the average airport boundary.
What are the high-level goals for ISRP? What should they be?	The high level goal for ISRP is to conduct research at an integrated system-level on promising concepts and technologies and explore/assess/demonstrate the benefits in a relevant environment.

Comments from NRC MoE – Vehicle Configuration/Systems Studies (1 of 3)

Comment	Disposition
A key central issue is whether NASA has zoomed into a particular concept for N+2. It is good that you are clear on the fact that HWB is not necessarily the solution.	ERA phase 1 does significantly leverage past NASA investment in the promising HWB configuration concept. Why? Our system studies, and those of the MIT/Cambridge Silent Aircraft Initiative show very impressive potential for noise and fuel burn goals. However, early in the project, NASA will fund an NRA entitled "N+2 Advanced Vehicle Concept Study." In this study, we will seek advanced vehicle concepts that can achieve the N+2 goals. In this study, industry and academia will have a chance to propose alternative advanced vehicle configurations, define technology roadmaps associated with the vehicle, as well as development timelines and ROM cost estimates for an array of system and subsystem level experiments. In this way, NASA plans to explore the design space for alternatives that can simultaneously achieve the N+2 noise, NOx and fuel burn goals. It is envisioned that the bidders conference will occur very near to program start. It is expected that aircraft and engine companies will team, perhaps with universities and other entities to propose. These studies will be scoped for two years of effort and serve to inform key decisions for ERA phase 2.

Comments from NRC MoE – Vehicle Configurations/Systems Studies (2 of 3)

Comment	Disposition
HWB system analysis charts: how certain are you of those results? What are the uncertainties? Particularly in aircraft weight estimates. If the uncertainty bands are large, does that warrant pursuing HWB?	NASA system study experts have been methodically refining system studies that compare "apples-to-apples" technology benefit assessments on advanced N+2 tube and wing and advanced N+2 hybrid wing body vehicle concepts. The methodology has been carefully calibrated against tube and wing certification data, and published physical data associated with the B777/GE90 design mission (the latest twin aisle configuration with published payload/range data), and therefore we are fairly confident of the benefits predicted for an advanced N+2 tube and wing. For the case of the N+2 hybrid wing body configuration, as published in an AIAA 2009 paper by Nickol and McCuller's, we are not confident in the following two areas: compressibility drag and weight estimation of the various aircraft system components. In fact, as stated in the referenced paper, we believe we have over predicted both the weight and drag, and therefore we expect the fuel burn results to be conservative. In order to improve the tools, we are conducting an additional "industrial strength" study with the AFRL and Boeing Research and Technology using aircraft company configurations to establish a better weight estimation procedure and to better understand the compressibility drag of the hybrid wing body configuration. We will incorporate this knowledge gained, and continue to refine our analysis and predictive capability.

Comments from NRC MoE – Vehicle Configurations/Systems Studies (3 of 3)

Comment	Disposition
No shielding potential is shown for the conventional aircraft, but clearly there is some. May want to give the "conventional" configuration that benefit to be fair and compare apples to apples.	The conventional configuration analysis includes what shielding benefit exists. The conventional configuration is a low wing with engines mounted below the wings. It is acknowledged that conventional configurations with aft-fuselage mounted engines, such as MD-80, do provide a shielding benefit not included here. There are other emerging system studies (by Andy Hahn) will assess optimal shielding for advanced N+2 tube and wing configurations. These studies may lead to some additional focus by ERA project. Finally, the N+2 Advanced Vehicle Concept Study NRA may shed additional light on the shielding potential of advanced tube and wing configurations.

Comments from NRC MoE – Vehicle Technologies and Interactions with Other Programs (1 of 2)

Comment	Disposition
Important to highlight new elements in ERA -- concepts and approaches that were not part of previous NASA programs, and to deliver intermediate results.	Agreed. Examples include open rotor engine concept integrated with a hybrid wing body to exploit shielding, and integration of bypass ratio 15-20 advanced turbofan engines onto a high wing configuration. These advanced unconventional vehicle concepts will be further developed and explored in ERA to gage their potential for simultaneously meeting aggressive N+2 noise, LTO NOx and fuel burn goals. While natural laminar flow is not a new idea we are taking on additional barriers, like ground test capability for NLF at flight Rn, and we will take advantage of technology advances in to overcome previous barriers, such new super-hydrophobic materials/coating technology to protect leading edges from contamination. FAA certification challenges will be addressed.
Close interaction with Airspace Systems Program important to exploit some new ideas (e.g. multiple aircraft ops, speed changes).	Agreed. An FY10 task will closely examine the positive (and, potentially negative) impact of the most promising advanced vehicle concepts at the air transportation system level. For example, in this task, wake vortex characteristics of the most promising advanced vehicle concepts will be established and impacts predicted. In addition, we will simulate flight profiles in and out of the top US airports and calculate integrated noise profiles for the most promising vehicle concepts.

Comments from NRC MoE – Vehicle Technologies and Interactions with Other Programs (2 of 2)

Comment	Disposition
Is it the case that technologies in ERA will be chosen for their N+2 (simultaneous) potential and not N+1 directly? Meaning: when you get to choose only a few of the things you want to do, will N+2 be the primary driver or will you be forced become more N+1ish?	Yes. Technologies and concepts will be chosen for their N+2 simultaneous potential to meet the goals, and not N+1 directly. However, as described in the discussion distinguishing ERA and CLEEN, advances in ERA may indeed directly benefit N+1 – it is all about the trades, integration, and generally broadly applicable technologies.
Are you open to technologies not developed at NASA that are ready for system-level experimentation?	Yes, and the primary initial entry point for such ideas will be through the initial NRA activities.
Structural Technologies: In addition to PRSEUS, materials, EBF manufacturing, load control.	PRSEUS is focus of phase 1 investigations. Other concepts will be incorporated as they mature, or as they emerge via initial NRA studies.

Comments from NRC MoE – Vehicle System-level Experiment vs X Plane

Comment	Disposition
There is no vehicle yet here. Will there ever be a vehicle that can be used as a system-level technology demonstrator? Can there be partnerships with the other government agencies to leverage their funding?	The question of a system-level vehicle technology demonstrator will be addressed in initial NRA studies. The initial vision for such an experimental vehicle tested was for a government owned asset – implying partnership with other government organizations as a viable approach if common, or at least compatible, goals and requirements could be defined.

Comments from NRC MoE – Vehicle Managing Expectations (1 of 2)

Comment	Disposition
NASA's plan describes a program that will make an impact on environmentally-responsible aviation. It provides a flexible approach with multiple paths to achieve more ambitious goals in the future, but NASA must manage expectations (TRL level, scope) in the current budget environment.	Agreed. We view the FAA's CLEEN program as a program to rapidly mature very-promising, N+1 technology to higher TRLs (6-7) - technologies by 2015 that appear to be suitable for integration in conventional tube-and-wing commercial aircraft for entry-into-service (EIS) dates around 2020. The ERA project will mature very promising N+2 technology concepts by 2015 to be ready to be INTEGRATED into advanced unconventional vehicle concepts that appear to be suitable for EIS around 2025-2030 AND focus on a balanced, integrated approach that attacks noise, LTO NOx and fuel burn goals simultaneously. In many cases, the technology concepts may be broadly applicable, it is the integrated, balanced approach into N+2 unconventional vehicle concepts that distinguishes ERA from CLEEN.

Comments from NRC MoE – Vehicle Managing Expectations (2 of 2)

Comment	Disposition
How is the IP going to be handled here (in the new NRAs) when industry brings its own ideas to the table? Are there compromises? How about cost sharing? Is NASA willing to compromise a bit? It may be necessary.	IP and cost sharing will be determined on a case by case basis, first in the definition of a given solicitation or partnership agreement, and secondly in negotiation of specific agreements. Though the starting point is open, public disclosure of all results, it is recognized that ERA's focus at the subsystem/system level and is thus closer to competitive product development than is foundational research; as such more compromise is anticipating. An example would include open documentation of results, but results that may be sanitized or normalize to protect proprietary interests of partners, yet still convey important lessons learned in the research. We will not require public disclosure of proprietary information.
What does NASA need? What does industry need? What is a happy medium? Is a platform to demonstrate technologies sufficient?	We believe we have spent a lot of time and effort with other government agencies and industry through our interactions on national and international committees and working groups to understand the needs of the subsonic transport community. We believe these needs have been captured well in the National Aeronautics Policy and Planning Documents, and we have constructed the ERA project to be in alignment with these needs as described.

Disposition of NRC MoE Comments

Operations Breakout Session

Comments from NRC MoE - Operations

Comment	Disposition
The demand case is getting much, much weaker these days. 3x is long gone. 2x is not towards the end of the century. John should change that tune or he may get into trouble in the future. But even long-term research standards (2030-2040), large increases in capacity are not the driver anymore. Certainly not by 2025. Must emphasize the benefits, if they exist: weather sensitivity/insensitivity, delay/congestion reduction, etc.	Throughput and efficiency are key. Addressing uncertainties due to weather and delay factors have been long recognized as the critical items. ASP is doing just that. Capacity is not a dead issue. Addressing efficiencies will not be sufficient in numerous specific choke points in the system. Aggregate demand may not double or triple for quite some time, but capacity will exceed 2x and even 3x at specific metroplex, terminal areas, or sectors. NASA has an obligation to develop tools to allow system performance through these congested corridors.
Slide 9: so the NAS is a complex system. OK, I buy that. But it has to have a more natural functional decomposition that is not that complicated. Can you provide such a functional diagram and explain to an audience where NASA technologies will be integrated and how (and how much) they will have an impact?	See the current complex NAS architecture vs. the envisioned NextGen architecture (much simpler). Evident is the functional decomposition of FAA capabilities roadmap and ASP technology insertion at key decision points. Also, the current NAS architecture does indicate the NASA technologies already deployed by the FAA,, such as Traffic Management Advisor (TMA) at each of the individual ARTCCs.

Comments from NRC MoE - Operations

Comment	Disposition
Will the system-level activities currently in ASP be moved to a new project in ISRP? (Note: it was later made clear that they go into the new ASP project . . . Questions remain whether this is the best way of doing things, especially if some interactions are needed between FAP and ASP.	ASP is restructuring the Program, in part, to develop a new project focused on systems analysis, integration and evaluation. It is considered essential that ASP ensure that key skills are available within the program to effectively transition technologies from the lab to application. Note that the system-level implementation activities are conducted by the FAA. This is considered the most rationale present course of action. As our technology development and transition process matures, we will take the opportunity to reconsider project location. The necessary actions with FAP will be enabled regardless of the projects location in ASP or ISRP.
What is being lost in the re-alignment of the ASP projects? Was the separation between airspace and airportal so unnatural that it did not work? Will the driver to fully integrate work make some fundamental technologies lose out? (Note: from the outbreak session at the end, it was clear that the second group had probably discussed this, but I was not present.	Nothing is being lost in the re-alignment. The former structure was not unnatural, but rather inefficient. The success of the new structure will be measured by how well both technology development and transition take place without sacrificing either.

Comments from NRC MoE - Operations

Comment	Disposition
Is there any substance to the RTTs? What would be FAA's opinion of these? Are they an effective research transition tool? Is FAA invested?	The RTTs are well supported by both the FAA and ASP. Both the FAA and JPDO have been publically supportive of the RTT activities and recent products. Numerous FAA organizations are invested in RTT formulation both with personnel and resources. This has also been echoed through FAA testimonies to the responsible Congressional oversight committees.
Barry, what is new here that was not being done before? Is this repackaging? Are there some nuggets that we could not do before, but we can do now? Are there foundational research enablers that allow for new system-level research that will provide solutions?	The ASP restructuring is not simply repackaging. It is being redesigned and focused to provide enhanced modeling, analysis, and testing capabilities enabling opportunities to mature, integrate, and evaluate advanced ATM technologies in relevant operational environments whether through high fidelity simulations or field tests in collaboration with service providers and/or stakeholders. Foundational research enablers will emerge as they have done through the concept and technology development project.
Are there plans for additional budget requests in the future to ensure that these system-level activities can be pursued? If so, what is the target date? Does it match up with NextGen timelines?	Future budget requests will follow the success and identified needs of new technology development and technology transition efforts.

Comments from NRC MoE - Operations

Comment	Disposition
Is capacity the driving constraint? Why is it always first if it is not anymore?	See above.