

Agenda
International Forum on Noise Impacts
27 August 2009
After the InterNoise 2009 Conference in Ottawa, Canada

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The goal of this forum is to solicit expert opinions about key questions related to each of two methods for judging the impacts of aircraft noise – effects on sleep and annoyance response. Sleep questions will be addressed in the morning, annoyance in the afternoon. All recipients of this package, whether or not they attend the forum, are encouraged to provide their comments. Attachments 3 (sleep research comments) and 5 (annoyance research comments) are part of this package and are in MSWord format as well. The opinions about these questions will provide guidance to FAA as it begins development of a research roadmap that when implemented will provide defensible science based information for use in formulating policy with respect to aircraft noise impacts.

Agenda
International Forum on Noise Impacts
27 August 2009

8:00 FAA Background, Objective and Timeline

FAA plans to map out 5-year research program that will provide scientific basis to characterize impact of aircraft noise on sleep. (See Attachment 1- FAA white paper.)

8:30 Key Sleep Research Questions

Discussion will focus on what the key research questions are that need to be answered in order to meet FAA's objective. Participants are asked to consider the attached set of key research questions:

- Do they capture the most important issues? If not, what and how to phrase the research questions?
- How would you answer them?

10:30 Break

10:45 Prioritization of Key Sleep Research Questions

- Answering which research questions would yield the greatest payoff?
- In which areas are we most likely to make substantive progress in the next 5 years?

11:15 Ongoing or Near-Term Planned Sleep Research; Opportunities to Collaborate

- What related research is already ongoing or planned in the near term?
- Are there opportunities to collaborate – in terms of study design, sharing data, testing analytical approaches, etc?
- Whom should we contact for further discussion?

11:45 Wrap-up and Next Steps

12:00 Lunch

12:45 FAA Background, Objective and Timeline

FAA seeks to map out 5-year research program that will determine if current basis for establishing impact (percent population highly annoyed vs. DNL) needs updating. (See Attachment 1- FAA white paper.)

1:15 Key Annoyance Related Research Questions

Discussion will focus on key questions that will help meet FAA's objective. Participants are asked to consider the attached set of key research questions:

- Do they capture the most important issues? If not, what other questions need to be posed?
- How would you answer them?

3:15 Break

3:30 Prioritization of Key Annoyance Related Research Questions

Which research would yield the greatest payoff?

In which areas are we most likely to make substantive progress: in the near term (within 2 years) and in the next 5 years?

4:00 Ongoing or Near-Term Planned Research; Opportunities to Collaborate

What related research is already ongoing or planned in the near term?

Are there opportunities to collaborate – in terms of study design, sharing data, testing analytical approaches, etc?

Whom should we contact for further discussion?

4:30 Wrap-up and Next Steps

Attachment 1
Advancing Aircraft Noise Impacts Research: A White Paper

Advancing Aircraft Noise Impacts Research: A White Paper

Raquel Girvin*

FAA Office of Environment & Energy, Noise Division

This paper highlights critical research needs identified by the Federal Aviation Administration's (FAA) Office of Environment and Energy to advance analysis of the impacts of aviation noise and to develop optimal mitigation solutions.

The FAA continues to work towards providing the safest, most efficient aviation system in the world that operates in an environmentally sound manner. Contours of annual average noise exposure for long-established U.S. airport communities have decreased because of continuing reductions in the amount of noise emitted by individual aircraft and other noise mitigation measures, despite an over 50 percent increase in passenger enplanements since 1990. Nevertheless, airport communities remain concerned about aircraft noise, as illustrated by the public's response to aircraft operations from the newly opened runways at Chicago O'Hare and Seattle-Tacoma airports.¹ Improving efficiency through airspace redesign, airport capacity expansion, and other initiatives of the FAA Next Generation Air Transportation System (NextGen), may be hampered without an aggressive program to address the environmental consequences of aviation noise.

The FAA Office of Environment and Energy seeks to develop a comprehensive research roadmap addressing critical noise impacts research needs, in collaboration with and participation of researchers across numerous disciplines and around the world, as well as with the broad community of aviation stakeholders including the public. Such a roadmap will enable FAA and interested parties to define systematic, focused, and complementary research programs, in which limited resources could be pooled to advance the scientific knowledge on how best to address the impacts of aviation noise on society. We envision a periodic review to track research progress against the roadmap as well as adjust FAA policy as warranted by new knowledge gained from the research.

FAA State-of-the-Practice in Noise Impact Analysis, Mitigation, and Land-Use Compatibility

For aviation noise impact analysis, the FAA has determined that the cumulative noise energy exposure of individuals to noise resulting from aviation activities must be established in terms of yearly day/night average sound level (DNL) as FAA's primary metric (as stated in FAA Order 1050.1E, "Environmental Impacts: Policies and Procedures").² The criterion establishing significant noise impact from a proposed action

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¹ "New Runway Causing New Noise Problems", *THE JOURNAL & TOPICS NEWSPAPERS* | THURSDAY, NOVEMBER 27, 2008, <http://www.journal-topics.com/eg/08/eg081127.3.html>; "New O'Hare runway seeing tons of traffic, and nearby residents not keeping quiet"; *Chicago Tribune*, Friday, December 05, 2008, http://archives.chicagotribune.com/2008/dec/05/local/chi-ohare-noise_05dec05; "Sea-Tac neighbors feel duped over 3rd-runway noise", *The Seattle Times*, December 11, 2008, http://seattletimes.nwsourc.com/html/localnews/2008493979_runway11m.html

² The FAA recognizes CNEL (community noise equivalent level) as an alternative metric for California.

is: “A significant noise impact would occur if analysis shows that the proposed action will cause noise sensitive areas to experience an increase in noise of DNL 1.5 dB or more at or above DNL 65 dB noise exposure when compared to the no action alternative for the same timeframe.” This significance threshold is based on the exposure-response relationship between DNL and the percentage of the exposed population “Highly Annoyed” (%HA), originally derived from studies of urban and suburban community responses to transportation noise by Schultz (1978) and re-affirmed by the Federal Interagency Committee on Noise, FICON (1992). However, FAA recognizes that different criteria as yet undefined are needed for noise-sensitive areas within national parks, national wildlife refuges and historic sites, including traditional cultural properties, where other noise is very low and a quiet setting is a generally recognized purpose and attribute.

FAA supports the assessment of aircraft noise impacts by developing and maintaining noise-evaluation models and methods. Airport community noise from aircraft takeoffs and landings is computed using the Integrated Noise Model (INM); for larger-scale analyses involving multiple airports in a region or changes in air traffic operations, noise exposure throughout a region is computed using the Noise Integrated Routing System (NIRS). Current modeling capabilities are primarily for conventional subsonic aircraft operating at a maximum of 18,000 ft above ground level (AGL).³

FAA uses supplemental analyses and a variety of single-event and cumulative noise metrics on a case-by-case basis either to characterize specific noise effects tailored to local concerns or to describe noise exposure to the public in other ways in addition to DNL. Individual supplemental metrics have limitations and do not provide a complete analysis of the magnitude, duration, or frequency of the noise events under study. FAA guidance cautions that a supplemental noise analysis is not, by itself, a measure of adverse aircraft noise or significant aircraft noise impact.

FAA land use guidelines generally consider land uses compatible with airport operations in areas where the annual average aircraft noise exposure is below 65 dBA DNL. Airport noise-compatibility programs are usually based on establishing or maintaining compatible land uses in areas at or above 65 dBA DNL. There are exceptions. Deference is given to local authorities to determine acceptable and permissible land use in specific noise contours according to “local needs or values” (Code of Federal Regulations Title 14 Part 150). The guidelines are insufficient to determine the noise compatibility of areas within a national park or national wildlife refuge where other noise is very low and a quiet setting is a generally recognized purpose and attribute, and the guidelines do not address noise effects on wildlife.

³ In addition to INM and NIRS updates, FAA is currently developing an integrated aviation noise and emissions model called the Aviation Environmental Design Tool (AEDT) so interdependencies between noise and emissions impacts can be assessed.

Critical Research Needs to Advance Noise Impact Analysis, Mitigation, and Land Use Compatibility

Despite a large body of research, how best to quantitatively characterize the relationship between aircraft noise exposure and its impacts remains a fertile area to be further investigated, in part because of significant research methodological differences. Much of recent research has been conducted outside the United States. The challenge for FAA lies in determining the extent to which sleep quality, children's learning, and other aspects of public health and welfare are affected by aircraft noise, in areas currently considered non-compatible with aircraft noise exposure as well as areas considered aircraft noise-compatible. Critical research is needed in multiple areas identified below.

Noise effects on health and welfare

- **Determine whether the basis for establishing significant noise impact needs updating to better reflect the current state of community response to today's aircraft noise exposure.**
- **Quantify potential noise impact on health and welfare in areas considered noise-compatible (i.e., beyond 65 dBA DNL) by establishing correlations between noise exposure metrics and impacts.**

The relationship between noise exposure and community response first derived by Schultz (1978), expressed in terms of percent of Population Highly Annoyed as a function of the cumulative noise metric DNL relies on the equivalent-energy principle, which suggests that annoyance from the cumulative effect of a few loud events equates to annoyance from a greater number but quieter events. DNL carries a penalty for nighttime noise events to reflect the potential for added annoyance at night due to sleep disturbance, speech interference, and other effects. Schultz derived a single, undifferentiated exposure-response relationship without evaluating possible differences for different transportation noise sources (road, rail, and aircraft).

Since Schultz' derivation of the annoyance exposure-response relationship, all components that contribute to the DNL metric: frequency of daytime events (especially for passenger airlines), frequency of nighttime events (especially for cargo airlines), and loudness per event, have dramatically changed with the surge in commercial air traffic accompanied by significant decreases in aircraft noise levels. While the current economic downturn has reduced air traffic, the general trend of aviation system growth, albeit with quieter aircraft, is expected to continue. Some research (e.g., UK Department for Transport's ANASE study (2007)) suggests that whether due to changing attitudes towards aircraft noise or whether due to the significant increase in air traffic, or a combination of both, there may be a need to reassess whether the exposure-response relationship derived from older data would hold true for an order of magnitude increase in air traffic with quieter aircraft. And with air traffic demand pressure for round-the-clock operations, it may also be necessary to re-evaluate the nighttime weighting factor in DNL. Meanwhile, an ongoing debate among researchers continues regarding which

exposure-response relationship curve best represents annoyance to aircraft noise. The ISO Standard (1996-1; 2003) is consistent with FICON (1992), but ANSI 12.9 Part 4 (2005) is a variation of ISO (1996), while the European Union has adopted the curve derived by Miedema and Oudshoorn (2001). Researchers such as Miedema and Vos (1998) and Fidell (2003) have also suggested re-examining the current state of practice of using the Schultz curve or variations of it as the basis for assessing the impact of aircraft noise.

A complicating feature of analyzing the impacts of aircraft noise is the subjectivity of human response to sounds, where non-acoustic factors together with other acoustic factors not captured by the DNL metric, may also affect community annoyance levels. Questions that persist include whether using other metrics in combination with or in lieu of DNL would correlate better with community annoyance, as well as what significance threshold(s) should be used.

Furthermore, FAA-funded research has shown that people are aggregating immediately outside DNL 65 contours, 50% of lands within 5 miles of airports are undeveloped and vulnerable to encroachment, and intensification of development is occurring around airports. Research has also shown a proliferation of noise complaints from areas beyond DNL 65. All the above suggests the timeliness of systematically reviewing the basis of FAA practice.

Noise in National Parks and Wilderness

- **Quantify impacts to national parks and wilderness areas exposed to aircraft noise by establishing correlations between noise exposure metrics and impacts.**
- **Model noise propagation from aircraft operations above 18,000 feet AGL.**

FAA recognizes that the 65 dBA DNL significant noise threshold inadequately addresses the effects of noise in naturally quiet areas such as national parks and wilderness. The significance of impacts at noise exposure levels below 65 dBA DNL remains to be determined both for visitors and wildlife. Commercial air tour noise, lower flying general aviation aircraft, and airport arrival and departure paths over national parks have generated the greatest attention, but there is also concern by resource agencies and environmental/conservation groups about increases in lower level noise as high altitude air traffic increases in quantity over these areas.

NextGen Noise Modeling Enhancements: Other Operational Regimes and Unconventional Aircraft

- **Model noise propagation from all phases of aircraft operations.**
- **Model noise propagation for future unconventional aircraft and engine configurations.**

- **Investigate acceptability standard and noise impact criteria (metrics and correlations) for supersonic overflights; a similar effort may be needed for other future unconventional aircraft.**

FAA has a well-established program to update analytical tools to model noise from subsonic aircraft operations at or near airports. However, for NextGen airspace and operational initiatives, the capability to model noise from aircraft at cruise altitudes may be needed, and noise modeling for on-ground operations may need enhancement. In addition, FAA must prepare to develop the ability to model noise for future aircraft with substantially different (and some potentially significant) noise characteristics from conventional subsonic aircraft, such as aircraft with open rotors or hybrid wing body aircraft, aircraft flying supersonically over land with publicly acceptable low sonic boom levels, and heavier as well as faster rotorcraft.

Current research by aircraft manufacturers and research establishments worldwide continues to demonstrate progress on reducing sonic boom intensity for business jet-size aircraft. The aircraft manufacturing industry is seeking an international standard for setting the maximum sonic boom level permissible for supersonic flight over land. The United States (more specifically, NASA and FAA) is leading a collaborative effort within the International Civil Aviation Organization (ICAO) to develop a roadmap that identifies research needed to demonstrate that sufficient data exist to consider developing new sonic boom standards.

Overall Costs of Aircraft Noise on Society

- **Quantify the societal cost of noise relative to other environmental impacts.**

FAA is developing a cost-benefit analysis model to inform the environmental decisionmaking process, given that environmental mitigation actions are interdependent. For example, reducing or mitigating noise may result in more energy consumption and greenhouse gas emissions and/or poorer air quality. Therefore, in order to assess all environmental impacts relative to each other, it is necessary to use a common currency, whether by monetization or other means, to compute their costs and benefits. Computing the overall costs of aircraft noise on society, including its public health and welfare costs, will require knowledge gained from the other critical research areas above.

Concluding remark

The FAA Office of Environment and Energy looks forward to a productive period of research and constructive discourse addressing the critical noise research needs outlined in this paper, as we work to realize the operational and environmental aspirations of NextGen.

Acknowledgments

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Attachment 2
Sleep Research Discussion

8:00 Sleep: FAA Background, Objective and Timeline

Background

The goal of this forum is to solicit expert opinions about key questions related to each of two methods for judging the impacts of aircraft noise – effects on sleep and annoyance response. The opinions about these questions will provide guidance to FAA as it begins development of a research roadmap that when implemented will provide defensible science based information for use in formulating policy with respect to aircraft noise impacts.

Experts are requested to provide opinions about these key questions; if they are not key, what other key questions would they identify or how would they modify these questions? At the end of discussions, attendees will be asked to provide judgments of the relative importance of these questions. For both attendees and those who cannot attend, Attachment 3 (also available in MSWord format) provides a form for written comments.

FAA Objectives – First Topic: Effects on Sleep:

- Short-term – Initial research and results should produce findings that are sufficiently strong to support policy analysis and revisions within 2 to 3 years.
- Longer-term - Research design should consider future linking to adverse health effects even though more than 3 years might be required.
- For policy purposes, results must:
 - Be able to address a variety of conditions that would affect sleep at airport communities (e.g., change in nighttime or “shoulder hour” operation, sound insulation in housing, etc.)
 - Be easy to explain to and be understood by the lay public; considerations should include explanations in terms often cited by citizens – difficulties returning to sleep, intermittent and premature awakening.
-

FAA timeline / funding – 5 year research plan:

- International forum August 09
- First research roadmapping workshop Dec 09 (modest funding for FY10 and FY11, next opportunity to seek targeted research funds is for FY12)
- Follow-on roadmapping workshop Spring 10
- Annual meetings to track research progress (successive springs; stand-alone or in coordination with other annual noise research meetings?)
- Target end of FY15 to meet research goal supported by strong technical evidence

Key Questions for Designing Research Roadmap

8:30

SLEEP DISTURBANCE QUESTIONS

TYPES OF FUTURE STUDIES

1. **Is it possible to design a new research project that will provide significant information in the short-term to markedly strengthen FAA's review and reformulation of policy regarding night-time flights?**

(Barbara Griefahn will provide a brief introduction to current knowledge and gaps.)

A large number of studies have already been conducted and the question needs to be asked as to whether or not any new study (probably only one) completed in the next 2 to 3 years can provide enough valuable information and insight to better inform FAA's policy review that it is worth the expenditure of resources? One perspective is that it would be beneficial to have a new study conducted in the U.S. to counter arguments that most recent results were derived from studies in other countries.

2. **If there should be a new study for short-term research, how should it be designed. Specifically, is there a preferred measure of sleep disturbance - behavioral awakenings, motility, etc. - what are the strengths and weaknesses of these various measures and do some address the differences between "spontaneous" and "aircraft noise induced" awakenings better than others?**

(Mathias Basner will provide a brief introduction to the measures of sleep disturbance.)

The different measures (EEG arousals, EEG awakenings, vegetative arousals, motility, behavioral awakenings, questionnaires) differ not only in their sensitivity and specificity, but also in their methodological expense. The perfect method would be sensitive, specific, and cost effective.

3. **Should a new study incorporate vulnerable groups (children, diseased, elderly, shift workers) and if so, how?**

Most of the studies on the effects of aircraft noise on sleep have been conducted in healthy populations of (young) adults. How can vulnerable subgroups be investigated, and does the expected small size of these subgroups make meaningful research in any reasonable time frame infeasible? Do we expect large variations in sensitivity for these groups *versus* healthy adult populations?

4. Should there be an epidemiologic study on the effects of (nocturnal) aircraft noise?

Although epidemiologic studies specifically investigating the influence of (aircraft) noise exposure on health outcomes are scarce, a few recent works suggest that nocturnal noise exposure may be more important than daytime exposure. Would, e.g., a case-control study conducted over the next three to four years be able to relevantly improve FAA's knowledge on the long-term health effects of nocturnal aircraft noise exposure?

TYPES OF METRICS

5. For data collection and analysis, what is the most appropriate descriptor of an aircraft noise event – is either SEL or Lmax sufficient, or should additional variables such as event time history or frequency content be investigated?

This question concerns both the scientific requirements – which descriptor or descriptors correlate best with measures of sleep disturbance – and the requirement for public acceptance, – what descriptors are easiest to understand and explain?

6. How should sleep disturbance results be extended to an entire night, to populations, to sub-populations?

(Nick Miller will provide a brief description of the issue.)

7. What metric(s) are most suited to regulation? (Lnight, % “impacted”) and why?

SETTING CRITERIA

8. Exposure-response relationships are usually “s-shaped” continuous functions, and not “all-or-nothing” relationships. In this situation, what is the best way to select scientifically based limit values or goals for mitigation measures?

9. ?? *(Forum attendees suggest additional important questions.)*

10. ??

11. ??

Attachment 3
Sleep Research Comments

Please submit to us your comments and/or responses in writing (ahead of or at the end of the meeting).

FAA Background, Objective and Timeline

Key Sleep Research Questions

- Do they capture the most important issues? If not, what other questions need to be posed?

- How would you answer them?

Study Costs and Duration

How much would it cost and how long would it take to conduct the high priority research items?

Attachment 4
Annoyance Research Discussion

12:45 Annoyance: FAA Background, Objective and Timeline

Background

The goal of this forum is to solicit expert opinions about key questions related to each of two methods for judging the impacts of aircraft noise – effects on sleep and annoyance response. The opinions about these questions will provide guidance to FAA as it begins development of a research roadmap that when implemented will provide defensible science based information for use in formulating policy with respect to aircraft noise impacts.

Experts are requested to provide opinions about these key questions; if they are not key, what other key questions would they identify or how would they modify these questions? At the end of discussions, attendees will be asked to provide judgments of the relative importance of these questions. For both attendees and those who cannot attend, Attachment 5 (also available in MSWord format) provides a form for written comments.

FAA Objective – Second Topic: Annoyance

Map out research needed to determine whether the current basis for establishing significant impact (population highly annoyed) needs updating to better reflect the current state of community response to today's aircraft noise exposure. (Include brief summary of current FAA practice)

FAA timeline / funding – 5 year research plan:

- International forum August 09
- First research roadmapping workshop Dec 09 (modest funding for FY10 and FY11, next opportunity to seek targeted research funds is for FY12)
- Follow-on roadmapping workshop Spring 10
- Annual meetings to track research progress (successive springs; stand-alone or in coordination with other annual noise research meetings?)
- Target end of FY15 to meet research goal supported by strong technical evidence

Key Questions for Designing Research Roadmap

1:15 ANNOYANCE QUESTIONS

ANNOYANCE

Research questions have been separated into three categories: policy, communication with the public, and understanding public reactions to changes. Though research may address more than one of these categories, segregating the research questions should permit focused discussions.

POLICY RELATED RESEARCH

If the current basis for establishing impact (percent population highly annoyed or %HA vs. DNL) needs updating, what issues need to be researched? Currently, 65 dB DNL sets the significant impact and land use compatibility threshold, which has been assumed to limit the number of people highly annoyed. Policy has been developed to eliminate or minimize “significant noise” and to do so in an equitable manner. But to re-assess this policy, several types of research could update and possibly improve the understanding of the effects of aircraft noise on people.

1. Assuming %HA vs DNL is an important measure of noise impact, what types of research would:

- Reduce the scatter of annoyance versus DNL?
- Update the relationship of annoyance to DNL - e.g., to account for changing conditions such as increased sensitivity to noise or increasing numbers of quieter operations (does “equal energy” apply), to focus solely on aircraft noise?
- Identify alternative or additional metrics to DNL that correlate with %HA?

The scatter we now have means that the response curve is an average with little or no predictive ability. Reducing the scatter could help us better understand the concept of “impact.” Also, there are some indications that populations have become more sensitive to (more annoyed with) aircraft noise at a given level (in terms of equivalent level), and one hypothesis is that this increase results from having more operations despite having quieter aircraft.

2. Assuming impact should be based on more than annoyance, what further research is required, if any, to develop defensible relationships between aircraft noise and such effects as:

- Sleep disturbance (was discussed this morning)
- Daytime annoyance (or other times of day)
- Induced house vibrations and audible rattle
- Interference with learning
- Speech interference indoors and outdoors
- Etc.

This question acknowledges that annoyance may not be a fully representative measure of the impacts that aircraft noise has on people’s lives. This question leads to the third policy related question:

3. Assuming impact should be based on more than annoyance, what studies can be done to combine, relate or prioritize multiple effects in a way to inform a policy that needs to be implemented across the wide variety of airports in the country?

4. What research can identify whether impact from steady-state or gradual change in exposure can be assessed in the same manner as impact caused by a step change; if not how should it be done?

Communities and politicians respond to the effects that are perceived immediately or soon after changes in aircraft noise occur. But decisions (e.g., about mitigation measures, sound insulation, land use) should perhaps be made on only long-term impacts. Can research assist policy to balance these two time frames and types of impact?

5. What research can inform the process of setting thresholds of impact?

PUBLIC COMMUNICATION RESEARCH

This category relates primarily to proposed projects that will result in changes in aircraft noise and should be considered unrelated to the above policy issues. Communities / individuals can react very negatively after changes in aircraft noise occur. There is a general perception and considerable experience that providing better, clearer information to the public and to aviation stakeholders in general about aircraft noise and the expected changes can reduce the negative reactions and / or increase acceptance of the changes.

6. What research can identify the types of information that should be provided, the forums / presentation formats, and the extent and timing of outreach that are most effective?

PUBLIC REACTION RESEARCH

From the perspectives of an airport that wishes to be a good neighbor and still respond to the needs of increased operations, of the FAA that needs to increase national airspace system efficiency and ensure the ability of the air transport system to grow to respond to increasing demand, and of the elected official whose limited resources can be consumed trying to mediate between irate citizens and an airport or the FAA, it would be valuable to know before changes in aircraft noise occur, where strong community reactions are likely to occur and if so, whether and how they can be minimized or avoided.

7. What research will identify which acoustic and non-acoustic factors are correlated with negative community reactions such as complaints, legal action, and involvement of politicians that can occur after noise changes from airport actions or airspace redesign?

Factors to consider in developing research approaches to community reaction are not only noise level / noise exposure related, but may include such variables as attitudes, prior experience, expectations, information available prior to the change and prior relationship of the airport and the communities.

Attachment 5
Annoyance Research Comments

Please submit to us your comments and/or responses in writing (ahead of or at the end of the meeting).

FAA Background, Objective and Timeline

Key Annoyance Research Questions

- Do they capture the most important issues? If not, what other questions need to be posed?

- How would you answer them?

Study Costs and Duration

How much would it cost and how long would it take to conduct the high priority research items?
