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FUNCTIONS OF GEOENGINEERING RESEARCH GOVERNANCE

Background Paper, Workshop on Geoengineering Research Governance in California

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Introduction:

When a research area addresses a compelling social need, yet also raises serious concerns and controversies, often the appropriate response is to pursue the research, but to do so in the context of a governance framework that adequately addresses the associated concerns. In this way, society has conducted research and advanced knowledge in various challenging areas, such as early recombinant DNA research, stem cells, research on human subjects, radioactive or biohazardous materials, etc.

Society now faces a similar challenge for geoengineering research. Research is needed because geoengineering might be an important, valuable, or even necessary part of effective strategies to limit climate change risks, and governments are likely to face future decisions over what to do about it. Yet, geoengineering could turn out to be a dangerous course even under conditions of severe climate change, and it raises deep concerns about the appropriateness of tinkering with the only planet humanity can currently inhabit. Experiments now proposed can improve our understanding of the potential impacts of geoengineering and involve virtually no climate perturbation or direct risk. However, by proceeding with experimentation, they raise concerns the door is then open for possible future deployment. Thus, such experiments require effective governance. Considering governance issues at this early stage also provides a valuable starting point to inform processes likely to be needed to address potential future developments in geoengineering and climate policy more broadly.

This note, and the related discussions in the morning session of our workshop, address the foundational question of what geoengineering research governance must accomplish, *i.e.* the *functions* of governance. The workshop will spend most of the afternoon discussing specific approaches to developing governance for geoengineering research.

Governance Functions

We propose that governance needs can be usefully grouped into three basic functions, as illustrated in the figure below:

1. **Enable Reliable Research:** Provide the authorization, resources and management necessary for research to proceed, in conjunction with guidance and quality controls to help ensure that research results are useful and relevant to inform societal choices.
2. **Legitimize Research:** Ensure that research topics, methods, and conduct are compatible with basic moral, democratic, and legal principles, and broadly acceptable to relevant citizens.
3. **Control Research Impacts:** Ensure that potential harms or risks from research activities are recognized and appropriately managed.

Many proposals in the current debate about governance target one or another of these functions. Few address all three. The functions also overlap and interact. Many concrete governance decisions affect more than one function, and effective governance requires coordinated pursuit of all three. In this note, we first discuss each function and potential ways to advance it separately, then consider overlaps, interactions, and the need for coordination across the three functions.

Enabling Reliable Research

Most discourse on governance of climate engineering research does not include functions that enable research, not to mention reliable research. But this often-overlooked action provides an important foundation in that the research directions and management of that research underlie the reliability of information society will need to make wise decisions. Many would say that research is simply enabled by funding it. But the function of providing resources has to be coupled with functions that manage the research to ensure that the research results in trustworthy information.

These linked functions – providing resources to enable research, and imposing quality and reliability controls – are common to all fields of scientific research. Normal research has program management, peer review, and dissemination and criticism of results in scientific fora in order to ensure research projects meet high standards of scientific and technical quality – e.g., that they reflect understanding of prior relevant work, use appropriate methods, are demonstrably feasible and competently executed, take appropriate account of uncertainty – and thus are expected to produce reliable outputs.

Advanced climate engineering research will require upping the game in all these areas because the goals of research will be in debate, the system being investigated will be complicated and complicated in unexpected ways, and most importantly the impact of any possible deployment could be very large and planetary in scope. The problem warrants particular attention to the culture, structure and management of climate engineering research. Governance functions to address these issues include:

- Providing research program funding
- Design of mission driven research
- Systematic evaluation
- Communicating the meaning of research results
- Tracking the increase in understanding

Providing research program funding

Research fields need access to a variety of societal resources to make progress and contribute to informing decisions. In addition to the obvious need for financial resources, researchers need viable career paths to attract them, people trained in the right skills, channels to disseminate their work, access to collaborators and (for field research) research sites, and various other resources. Research fields gain support and validation from programs that fund them, provide guidance to researchers, and signal that the research area is socially valued and acceptable. Government-funded research programs are not the only source of such support and validation but government funding provides a powerful signal that researchers can confidently invest in the area.

Design of mission driven research

Trends in research management over the last decades have favored “investigator-driven research” whereby research programs name topical areas and researchers propose specific questions and methods to investigate these questions. To the extent geoengineering research has gained any support thus far, it has been within this model. But, as climate engineering topics gain traction, the requirements of research will differ from much scientific research. Climate engineering research will aim to develop a set of technical capabilities to mitigate an identified problem, and to understand the potential efficacy, limitations, and risks of those capabilities. Climate engineering is thus fundamentally an area of *engineering* research, and thus requires more extensive and clearer effort to define its goal, and to align and implement specific research projects relative to that goal. It is mission-driven research, and is likely to become more strongly mission-driven as the urgency to find viable climate-change strategies strengthens and as specific methods and their potential benefits, limitations, and risks, become clearer. Geoengineering responses, if viable at all, will be pieces of a complex system of responses, including both human and natural elements. Research will have to define these systems and management will have to insure they receive systematic investigation.

Governance of mission-driven research differs from governance of investigator-initiated research. But if geoengineering research must have top-down, mission-driven management, what is the mission and how (and by whom) is it defined? The mission cannot be as simple as “put a man on the moon” because the goal of this research should not be to deploy a climate engineering technology. The appropriate mission is more likely to be understanding the potential efficacy, advisability, and practicality of various geoengineering approaches in the context of broader climate actions, rather than advancing and making any particular approach work.

Keeping this focus can be challenging. Once an institution or group of researchers has funding to pursue a climate engineering topic, they will become identified and vested in that topic. Governance will have to function to keep clarity on the goal of providing societal choices rather than just getting intervention done. For example, research that identifies unanticipated problems, or that shows a particular approach or engineering concept does not work, would represent a valuable contribution to this mission. Appropriately rewarding and motivating such work requires a carefully designed reward structure that reflects the societal goal of informing future

decisions, whether these are to develop and use, or not to pursue, particular paths.

Much of the research community today would like to avoid mission-driven research. Past mission-driven research programs have had various widely recognized shortcomings, such as inappropriate mission definition, narrow control and poor communication, disregard for collateral damage, discouragement of creativity, and lack of public engagement. Governance of geoengineering should aim to learn from and avoid these.

Systematic Review

Normal scientific peer review does well at ensuring the reliability and veracity of individual projects. Climate engineering research will require review and evaluation processes at a broader level than stand-alone research papers. Review must also consider broader criteria such as completeness of the study and relevance and impact for the broader mission, which may require novel approaches, such as tasking a group of researchers with identifying what might be missing or wrong.

Research Communication and Discourse

The research program will need the capacity for effective communication of research choices and results. This requires more than releasing research plans and data, to communicate and inform discussion of intentions, methods, results, and their significance. What is the experiment trying to achieve and why is it the best way to do this? What is the quality of the information forming the basis of the experiment? How did the actual results differ from the hypotheses? What was learned from the differences and what could be done next and why? What went wrong and why? Scientists may discuss these issues freely among themselves but often lack the practical skills to discuss these for societal consumption. Governance needs to insure research communicators can explain the purpose and meaning of the research.

Tracking the increase in understanding

In addition, research directions will have to adapt to new information. A clear process for doing this should involve pre-determined and information-driven assessment points. Critically, investigators should be asked to predict what they think they will learn from each next step in the research. As a phase completes, investigators should be asked to formally evaluate what they have learned in the previous steps compared to what they expected to learn. We almost surely cannot achieve perfect knowledge of any climate engineering technology, but we can develop more skill in predicting the outcomes. Evaluation of the increase in prediction skill requires the discipline of *a priori* prediction and *post facto* comparison. Governance should facilitate the process of prediction and evaluation at regular points in the research plan.

Legitimizing Research

Legitimizing climate engineering research means ensuring that research topics, methods, and

conduct are compatible with basic moral, democratic, and legal principles and broadly acceptable to citizens. The functions of governance should help to build the societal capacity to use information about these methods wisely, including whether to continue or stop research and decisions around eventual deployment or eschewing deployment. The need to legitimize climate engineering research derives from a sense among relevant publics, that the research endeavor should not violate basic societal norms, that people and institutions involved in it can be trusted, that the research falls under democratic control and that the risks imposed by research compare acceptably to the benefits gained. Not surprisingly, various publics contest these factors as they involve values and vested interests as well as (hopefully) facts. Legitimizing functions include:

- Public engagement
- Technology assessment
- Staged Process
- Horizon scanning and policy analysis

Public Engagement

Legitimization of research requires providing opportunities for public deliberation of the research plans and results in the context of societal values. Public concerns need to be addressed seriously and respectfully. Governance will need to provide a forum for discussion of concerns about direction and implications of the endeavor, and potential future policy choices. This engagement should both build trust and increase the capacity of publics to address tough future choices and risks.

Public deliberation of climate engineering faces the challenge that everyone on Earth is a potential stakeholder, as are future generations. The challenge will be to design public deliberation so it is perceived as fair and representative. Ideally, the deliberations should involve a wide spectrum of society in some way and be inclusive of different points of view. As much as there seems to be consensus on the need for public deliberation, there is less agreement about how to do it. Consequently, governance should function to explore various methods for public engagement. Questions also remain about whose job it is to do public engagement and at what level. At what point should deliberation involve specific experiments? Early deliberation might focus on the research program at a high level. If and when risky experiments are proposed, a more detailed deliberation of specific plans may be in order.

Technology Assessment

Governance should provide for assessment of climate engineering research in the context of panoply of other risks and benefits. Such assessment will require learning of the state of knowledge, the potential for benefits, and the risks associated with reaching for that benefit and evaluating these risks and benefits compared to other related risks and benefits. For example, a common assessment of climate engineering places this choice in the context of today's climate. Governance should insure that the context for evaluating these choices is the future climate and global wellbeing.

Staged Process

Based on experience to date, research may meet with some level of resistance, even when risks are low. Research governance has tried to deal with differing opinions through a staged process where engagement on each proposed step of research passes through a societal approval process, prescribed requirements, and a choice of outcomes. Such staged processes have been developed to shepherd new innovations through development, and to ensure that the process pauses at defined points so that managers can review progress and prognosis, risks and benefits, and decide whether the project proceeds or ends. For example, an early outdoor geoengineering experimental proposal, the SPICE project in the UK, used a stage gate process and, in the end, the experiment was cancelled. Although, in the end the path to canceling the project was more convoluted than just the stage gate process, the concept of refining and using stage gates processes remains favorable.

Horizon scanning and policy analysis

Public concerns about climate engineering center on what will happen in the future. Governance should include provisions to scan the horizon for upcoming events, possible tipping points, and discoveries and provide policy analysis related to preparing for these possibilities.

Controlling Research

Activities undertaken for research purposes can generate harmful impacts or risks – to health and safety, to the environment, or to other values. Like all other activities, research must comply with applicable regulations protecting environment, health, and safety, for workers and the general public. In the United States, research activities in principle fall under the major environmental statutes, for air, water, toxic materials, and environmental assessment, but in practice they usually fall under exemptions or below statutes' *de minimus* thresholds.

But regulation usually limits known mechanisms of harm to recognized values, whereas research focused on new ways of manipulating the world raises new forms or mechanisms of risk, or new values or forms of harm not previously recognized. Examples include early recombinant DNA to modern synthetic biology, as well as research on radioisotopes, biohazards, stem cells, human subjects, and animals. Such fast-moving research areas and newly recognized, or newly valued, dimensions of harm and risk call for more precisely targeted responses informed by cutting-edge expertise.

Digging in a little more detail into what is required to control impacts and risks of research suggests there are four separate sub-processes:

- Identifying and assessing risks
- Developing capacity to respond to these risks, including identifying and assessing specific risk-control measures, identifying key decision-makers, and disseminating information
- Enacting risk-control measures, via norms, guidelines, standards, or rules
- Observing responses and evaluating effectiveness, which may in turn lead to revising prior risk assessments, response assessments, or control measures.

Risk-control functions for research raising novel risk concerns have mostly not involved formal regulation, at least not initially. Sometimes researchers who first identified the concerns their

research posed have acted collectively to develop and implement controls, limit or slow the research, or even stop certain lines of research judged especially high-risk, pending assessment and enactment of controls. Alternatively, funders, universities or other research host organizations have implemented additional requirements on their researchers through statements of best practices, work-plans, codes of conduct, or similar instruments to exhort and guide their members. As research proceeds and understanding of risks and control measures advances, these initial control steps tend to be institutionalized, in the form of new bodies (such as Institutional Review Boards), standardized requirements of funders, hosts, journals, and others, and stably convergent expectations, whether or not the controls are eventually enacted in formal laws or regulations.

How do these approaches apply to controlling risks of solar geoengineering research? Early commentary on geoengineering research considered the possibility of destructive or risky experiments, sometimes in dramatic scenarios involving rogue actors. These concerns were reinforced because quantitative climate response at continental to global scale cannot confidently be known without doing experiments at a similarly huge scale and this would indeed have serious trans-boundary impacts and serious risks considerations. The obvious response to such a scenario was to attempt to prohibit such interventions, initially by some form of international moratorium. Such a step poses its own serious political and legal challenges in view of the absence of any current international institutions or treaties with the relevant authority and administrative capacity.

But this approach has little to do with the current situation. Geoengineering research now being done or proposed lies at the opposite extreme from some potential future global-scale interventions: it involves either no manipulation of the environment at all (as with computer-modeling or lab-bench studies, or passive environmental observations), or manipulations so tiny that they are confidently recognized as effectively zero risk. Regarding controlling risks posed by this research, the answer appears clear: there are none.

However, the scale of research and associated risks may change. That currently proposed geoengineering experiments pose no risks requiring assessment and control does not necessarily imply that this will remain the case. Today's proposed experiments target atmospheric processes that have important consequences for the design, efficacy, and risk of potential future interventions and can be studied at small scales. Information gained from these experiments may improve the physical realism and accuracy of climate models, allowing some further advances in understanding the effects and risks of geoengineering through model studies alone. It is also possible that early field experiments will lead to identification of other interventions, at larger scale or using different methods, which appear to offer further high-value advances in knowledge. If future field research expands in scale or intensity, at some point the environmental impacts will cease to be negligible – either because their potential intensity increases to the point of requiring more serious assessment and control, or because their spatial scale expands to the point that they have detectable trans-boundary effects and so become matters of international concern. Such future expansion might also bring geoengineering research within the scope of existing state or federal laws. For example, it has been suggested that even relatively small experiments might fall under the scope of California's expansive Environmental Quality Act (CEQA).

Preferred control frameworks might take a cue from other controversial research areas and develop through consultation among researchers, funders, universities, and others. Because it is uncertain when, or whether, future thresholds of research impact will be passed, there is value in starting to develop assessment and control processes early – even if they are clearly not needed and yield obvious answers – to learn how to do this, build public confidence and trust, and ensure capability is in place for if and when it is needed.

The second reason that the minimal scale of present direct risks does not obviate the need for assessment and control processes is that people are worried about how the knowledge gained from early research might influence later decisions or actions, and how capabilities enabled by that knowledge might be used. (In terms of our three governance functions, these combine elements of control and legitimation.) They worry that this research will lead to bad consequences. These are not necessarily principled objections --that the geoengineering is just wrong-- but they tend to overlap with these. But because they focus on the possibility of future (bad) human decisions and these concerns are not subject to technical risk assessment and control, these concerns have significantly contributed to the slow, contentious progress of research, and effectively addressing them poses a quandary.

Notably, geoengineering is not the first research area for which concerns of this character have been prominent. Such concerns have been raised repeatedly over multiple new areas of scientific research and technology development, extending at least from 1970s concerns over early recombinant DNA research to current synthetic biology research supercharged by CRISPR-Cas9. But while such risk concerns have been repeatedly raised, there has been no past research controversy for which it is clear these issues have been satisfactorily addressed – or even, for that matter, what it would mean for them to be satisfactorily addressed. Perhaps geoengineering will be the test case, the first controversial research area for which institutions and processes are developed that give adequate consideration to such risks.

Overlapping Governance Functions and the Need for Coordination

The three types of governance functions overlap, and these intersections hold some of the most innovative and interesting aspects of governance. An overarching function of governance will be to coordinate and enhance communication among governing functions that enable, legitimize and control research.

An early and important overarching issue is aligning funding with the public interest. Concerns about accountability have led to suggestions that outdoor experiments should only be conducted with public funding. However, investigators find themselves conflicted between accepting funding from an administration that denies climate change-- a position widely perceived to be out of alignment with the public interest-- and the sense of urgency to begin research to advance the state of knowledge. The choice of government agency to fund research has also engendered examination of the reliability and trustworthiness of the funding agency. Can the agency define and meet research goals while maintaining the ability to collect and respond appropriately to information negative to those goals? Do they have a history of transparency in their operations? Do they have a history of poor or reckless decisions based on the fear of losing funding? A function of governance is to address the question of whether the funding source and the public interest are aligned.

All assessments of climate engineering research governance have named transparency as a key principle. However, the functional meaning of transparency will be a matter of judgment and utility that cuts across the three functional areas. A governance structure should provide mechanisms for ensuring that the research community has done due diligence in explaining their research and that societal concerns are addressed in that communication. The principle of transparency obliges researchers to be candid with concerned citizens about what they are doing, why they are doing it, what and whose aims the research serves. Transparency requires being open about both favorable and unfavorable information. The governance function of coordinating transparency norms has the purpose of enabling good science, and building and sustaining trust.

Governance of the scientific review process should take into account the fact that reviews do not only evaluate the science, but also serve to inform societal confidence in the research results. A scientifically-based process of adaptive management, that is adapting research direction based on new information, should be coordinated with a stage-gate process designed to obtain societal buy-in for research choices. The adaptive management of the scientific enterprise requires coordination with any staged process used for purpose of maintaining legitimacy. As new research results come in, regular scientific review governance can coordinate this review with public deliberation about the next set of research choices.

Governance activities will need to coordinate research questions among scientists and publics. Not only do citizens and policy makers need to understand the context and meaning of the research defined by the scientific establishment, they also need to have research respond to the questions they have. Defining the goals of research should be a shared endeavor between researchers and those involved in legitimacy to insure research remains in the public interest. As well, the development of defensible and wise controls involves risk assessment that may drive a different set of research questions.

Some other intersecting governance functions might include quality controls integrated into research program management that often have parallel requirements for risk control. Successful completion of these processes also tends to help advance legitimacy.

Looking Forward to the Discussion of Governance Structures

Our morning session will focus on discussion of the governance functions described above, and whether they are necessary and sufficient. The afternoon will be devoted to discussing how to achieve governance functions for early research. Two prominent suggestions include the development of a broadly based, independent advisory board that could advance all three sets of governance functions and the development of a “code of conduct” that would provide voluntary guidelines to those involved in the research enterprise. We are also leaving room to discuss other ideas that have surfaced or those that you as participants wish to bring forward. We look forward to this discussion and hope it will result in a concrete recommendation to the state of California.