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Geotechnical Asset Management, Leadership, and Decision-Making

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14th Dialogue with Leaders in the Design and Construction of Transportation Facilities

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INTRODUCTION

Good afternoon everyone. I'll start with a preview of my talking points and then some acknowledgements before we start.

Preview

First: I didn't make a PowerPoint. I took the title of this "Dialogue with Leaders" session to heart - it's supposed to be a dialogue. That means I talk and you talk. That is not easy to do if all of you are staring intently at pictures of rock slopes on a wall screen, drinking coffee and ignoring me completely. Please feel free to interrupt me at any point and ask a question or tell me I'm wrong about something. If none of you want to talk, even with prompting, don't worry, I can talk for hours.

What does the title mean? What do **GAM**, **Leadership** and **Decision-Making** have in common? First, they are all related to the GAM R&D projects that have been underway for the last ten years. More importantly these topics all relate to **Implementation**. I'll get to each of these main story lines and the overall concept that I want to focus on. I could have called it "*Implementation for GAM*," but that sounds a little boring, doesn't it?

Let's get into this by first eliciting a little information from you:

- How many geologists do we have today?
- How many economists?
- Any psychologists?
- How about accountants/finance specialists?
- How many lawyers?
- How many engineers?

Why am I asking about accountants and psychologists and lawyers? Because, it may take all kinds of talents and abilities and all kinds of folks to drive a research result into an implemented program. If you take a look at the TRB committee structure you'll note the many diverse disciplines represented. All the disciplines and all the committee work can benefit from cross-pollination. For the GAM R&D projects, we certainly took advantage of a multi-discipline approach with engineers, data specialists, geologists, economists, risk managers, maintenance and operations specialists and others all working on the R&D issues.

I hope you will all listen, talk, and later take a look at the written version of this Dialogue, posted on GAM Joint Subcommittee webpage: https://trb-gam.weebly.com/ and in the TRB Annual Meeting Online website http://amonline.trb.org/?qr=1 . Then, please do some reading on the topics and thinking about how to be a better decision-maker and how to influence decision-makers in the service of improving decisions about research projects.

Acknowledgements

I want to thank the chairs and committee members of the AFP00 Section for selecting me for the honor of addressing all of you today. I also owe a huge debt to both **Nancy Whiting** our TRB Liaison, and our AFP00 Section Leader, **Erol Tutumluer,** for supporting today's Dialogue

and for their unrestrained and most welcome support of the Joint Section Subcommittee on Geotechnical Asset Management (AFP00 and AFS00 Sections).

I also want to thank **Anand Puppala** Section Leader and the AFS00 Section, the other parent of the GAM Joint Subcommittee. Anand has been enthusiastic about GAM since the beginning and I appreciate his support. Of course, I also want to express my deep gratitude to the dozens of people who have associated themselves with the GAM Subcommittee.

The concept of GAM in the US was first expressed by **Erik Loehr, Kristen Sanford Bernhardt and Daniel Huaco.** Although not much happened for a while, when TRB took an interest and we started the GAM Subcommittee, GAM was such an obviously good idea that it was easy to accept. People were ready from day one to move GAM into the "must do" category. I'm grateful to Erik and Kristen and Daniel for the great start on bringing GAM to fruition.

I believe I'm here today because of the successful launch of the GAM Subcommittee. I have enjoyed a pretty visible spot in the process as the first chair of the Subcommittee, but as I often say, this isn't about one person charging along – it has truly taken dozens of people over the last ten years or so to make this a success. I won't belabor the point, but I could stand here and throw out name after name and story after story for the next 45 minutes and still not mention every contributor. Speaking of which, I especially want to thank two important contributors, **Scott Anderson and Darren Beckstrand** who now co-chair the Subcommittee. Whatever success I have had **in the past** has been due in large part to their continuing participation on the Subcommittee. And, more importantly now, **the future** of the GAM Joint Subcommittee is now in their hands.

Last and certainly not least, I would be remiss if I did not point out that the two guys who got me into this in the beginning are both in this room today: **Larry Pierson and Jay Jayaprakash.**

Larry and I started talking about managing geotechnical assets almost ten years ago when I was still at Alaska DOT. I had an epiphany at a NW Geotechnical Workshop meeting after two presentations on "managing" retaining wall inventories. That begged the question in my mind of why not manage all geotechnical assets. I discovered the Loehr, et al. writings from the early 2000s and things got rolling in very quick succession. I talked to Larry (then Chair of the AFP10 Engineering Geology committee), Larry talked to Jay (then the TRB Liaison) and the next thing I knew, my body was on a plane to Oklahoma City to lead the first ever GAM TRB workshop at the Highway Geology Symposium while my brain was sitting stupidly at my desk in Anchorage going: "Huh? What?" At the end of the workshop, while I was still trying to catch my breath, Jay "suggested" that I write something for the TR News – and as many of you who know Jay will appreciate, there was no saying "no" to Jay's suggestions.

So, let's talk about GAM, leadership and exploring the characteristics of decision-making as their application to implementation.

GEOTECHNICAL ASSET MANAGEMENT (GAM)

In this segment, we'll address the technical subject that brought us here. Let's start with a question to you:

What is Geotechnical Asset Management and why have so few of you heard of GAM?

The recent rounds of federal legislation (MAP21 and the FAST Act) require state DOTs to develop risk-based performance management plans for pavements and bridges, but these statutes do not require DOTs to manage geotechnical assets in the same way. Can't really blame DOTs for that prioritization, especially when combined with a pervasive lack of understanding by executive managers in DOTs of what can be done to manage these "dirt" assets to good effect for a state's transportation system. No doubt this audience has a good understanding of the value and importance of geotechnical assets for a transportation system. Can you imagine a state DOT constructing a set of assets with a replacement value equivalent to all of its bridges without considering how or even if it should manage those assets?

GAM is performance management, risk management and transportation asset management applied to geotechnical assets like slopes, embankments and retaining walls or as I like to call it "*Asset Management in a World of Dirt.*" Stanley, 2011 TR News. TAM is defined in federal law as a: "strategic and systematic process of operating, maintaining, and improving physical assets, with a focus on engineering and economic analysis based upon quality information, to identify a structured sequence of maintenance, preservation, repair, rehabilitation, and replacement actions that will achieve and sustain a desired state of good repair over the lifecycle of the assets at minimum practicable cost." 23 USC 101(a)(2). GAM applies that definition to geotechnical assets.

State of GAM Practice

GAM was developed over the last ten years by research programs at Alaska DOT and several other states and in a federal land management agency study. Most of the initial research work was done in Alaska in a series of R&D projects that culminated in a comprehensive GAM Plan consistent with Transportation Asset Management (TAM) principles and processes. These concepts were then applied to Montana DOT's rockfall management program and to a GAM-based Unstable Slope Management Program for FHWA's Western Federal Lands Highway Division in cooperation with several other agencies including BLM, National Park Service, National Forest Service, etc. In the same time frame, several other state DOTs were all independently developing programs that adopted GAM principles. Notably, Colorado DOT has developed a Geohazard Asset Management Program and a GAM-based retaining wall management program as part of the state's TAM program.

There are two common threads that connect many of these programs: many of the key participants are TRB members; many of these folks are also participants in the annual FHWA-sponsored Northwest Geotechnical Workshop. These two annual meetings bring together dedicated practitioners in the geotechnical arts and sciences and GAM has become a frequent topic of discussion. Leaders from the participating state and federal agencies take home with them lessons learned and knowledge gained about GAM and how they can apply these findings in their states.

I'm not going to give you a bunch of detail about what a GAM program looks like. You can find research reports and documents for AKDOT, MDT, WSDOT, CODOT and Federal Land Management Agencies – some documents and links are listed in my reference list. You will see that AK, MT and a group of Federal Land Management Agencies have developed programs with a common cadre of consultants and thus share similar attributes. WSDOT has had an Unstable Slope Management Program for decades, and it has not been stagnant. WSDOT has expressed that they plan to move forward with a GAM Plan. Colorado DOT has its risk-based hazard management program that addresses their abundant unstable slopes and a separate GAM-based retaining wall management program.

There are other programs out there as well that can be discovered with a little searching. One thing you will discover if you do a little searching is there is no generally accepted method to implement a GAM program for a DOT. There is some hope on the horizon as we expect publication soon of the NCHRP report on a GAM Implementation Manual that will provide some guidance for state DOTs.

Thoughts on GAM

I want to leave the GAM topic with a few points:

1. The principal value of geotechnical assets is that they literally support an agency's other physical assets. "Virtually all structures are supported on soil or rock. Those that aren't either fly, float or fall over" - Richard L. Handy. As was demonstrated recently by the November 2018 magnitude 7.2 EQ in Alaska, the state transportation system grinds to a halt when numerous segments of the roads become impassable due to natural hazards such as earthquakes or extreme flood events. This same vulnerability is also demonstrated when less widespread events occur such as slope failures, post-wildfire debris flows, embankment collapse due to thawing permafrost, etc.

2. "Normal" deterioration of geotechnical assets is another concept that is still less than ideally understood. We know geotechnical assets deteriorate, but we do not yet have enough data to predict with certainly how long a service life will be for a slope or a retaining wall. "One problem with managing geotechnical assets is that they are almost always constructed and then forgotten until they "suddenly" fail. Geotechnical assets are too important in terms of their supporting role for agencies to leave their fate to the future in a 'build and forget' mindset." Stanley and Anderson, 2017. We do know that geotechnical assets do not have infinite service lives. Slopes and embankments deteriorate along recognizable time lines – the asset condition can be assessed at any time in the life cycle. The life cycle cost for geotechnical assets is also discoverable for maintenance, preservation and repair/replacement. It's also possible to determine the risk cost and to set performance targets and monitor performance over time using the same kinds of methods used for other transportation assets. All of this is important because, so far, little attention has been paid to the intrinsic value of these assets and the enormous cost of managing geotechnical assets compared to other assets such as pavement and bridges.

   > ***AKDOT Geotechnical Assets:*** *The replacement value of AKDOT's geotechnical assets is about three times the value of the state's bridges. The replacement cost of geotechnical assets can be staggering. Alaska, e.g., has about $19B in replacement value for rock and soil slopes. A little less than 1/3 of these slope assets are in "poor" condition and will need infusions of funding in the next, say ten years if the condition and*

> *performance of these assets is to remain adequate. Billions of dollars will be needed for repair and replacement. The cost to simply maintain geotechnical assets in their current condition is estimated at $200M/year. Thompson, 2017.*

3. So, bottom line, **there is a gathering storm for geotechnical assets across the country**. They are aging and deteriorating at a faster pace and failing with greater frequency. We do not currently seem to have either the determination or the funding to keep up with the deterioration rates. Stanley, 2017, 3rd NASL Keynote Speech, Roanoke, VA.
4. What will it take to improve the future for agencies and their geotechnical assets?
    - ***Greater understanding*** *of what geotechnical assets are and their value to DOTs and the performance of transportation systems.* ***Implementation of GAM programs.***
5. What will it take to implement GAM programs?
    - ***Leadership, advocacy and understanding*** *of the decision-making process* and the courageous patience to drive implementation forward.

With this basic understanding of the role of geotechnical assets, let's move on to talk about the role of leadership.

LEADERSHIP

Audience Question

How many of you are either an executive decision-maker or are in a position close enough to influence those decision-makers? This next section will be about you. Don't hesitate to speak up and challenge anything I might have to say.

This session is not about the latest leadership techniques and theories. However, since this is supposed to be a Dialogue with Leaders, and it is not, I suspect, necessarily evident why I am perceived as a leader, other than by virtue of having been chair of the GAM Subcommittee. I feel obliged to mention a few things about what has lead me to some conclusions about what makes a "leader."

Like all of you, I have seen many, many popular books on how to become a "leader in one minute a day" or touting the "seven most effective what-evers of leaders". We all have a wealth of examples from our own careers. My own 50 year "career" took a lot of turns I would never have expected, from laborer, engineering technician, driller, engineering geologist, lawyer, engineering geologist again, DOT middle manager and, lately, agency "consultant". I won't bore you with details, but suffice to say I have had a lot of supervisors who knew nothing about leadership and a blessed few who did. Often, the best leaders I've been around, gave minimal instruction and guidance, set goals and then stepped back and let the result unfold. You all know that too much guidance and instruction can lead to mediocrity. Consider the following:

> ***Mary Barra at General Motors*** *When Barra became head of General Motors she had a huge job of ahead of her to manage restructuring the organization. Meeting with HR, she decided to begin with Human Resources - the first job she tackled was the dress code. Yes, the dress code. She looked at the ten page long code and announced she was changing the dress code to two words: "****Dress appropriately.****" The HR department fought back, wanting to put in specifics like "Don't*

wear T-shirts that say inappropriate things." Barra was perplexed and asked the HR people "What does inappropriate, in the context of a T-shirt, even mean?" Then she received a scathing email from a senior director complaining about the policy, so Barra surprised him by phoning him and asking directly what was wrong with her policy. The guy was troubled because his staff sometimes had to meet with government officials and had to look appropriate. Barra told the director to discuss it with his staff. He called back in minutes saying the staff agreed to keep some nice clothes in their lockers – problem solved. Two things occurred to Barra; 1) if managers cannot handle what "appropriate dress" means, what <u>else</u> can they not handle, and 2) let people own the company policies and police themselves and they'll find solutions.

Leadership Qualities and Characteristics

Briefly, here are a few leadership qualities or characteristics I've noticed over the years and more I've read about and thought about in the last few months:

Takes the Opportunities

- When I was practicing law, I got a referral to do some pro bono work for a non-profit group of adult survivors of childhood sexual abuse. We got a favorable result in some pretty routine planning and zoning issues, and the group then asked me to preside over their Board of Directors to help them become better organized. The years spent with the group were the most rewarding time I spent as a lawyer and one of the very few memorable accomplishments out of seven years of practice.

- A couple of times over the years, I came into leadership roles as a result of a singular opportunity, e.g., my final position as an employee - for AKDOT - which came to me when our Chief Geologist was forced to retire early due to health issues, and I won a competitive appointment to his position, probably far earlier than I would otherwise have had a chance, if ever.

- I also got lucky when I stumbled onto Geotechnical Asset Management, which has dominated the last ten years of my career. The first inkling I had that managing geotechnical assets would be possible came at a NW Geotechnical Workshop when two different speakers from Utah (Blaine Leonard) and Oregon (Don Turner) DOTs talked about "managing" retaining walls. I wondered, why not "manage" all geotechnical assets? I did some research and found that Loehr, Sandford Bernhardt and Huaco had already written about this in the early 2000s, but that not much had happened since. Then, through sheer happenstance, I attended an NHI training course on maintenance of slopes in Anchorage and Erik Loehr was one of the presenters. That encounter lit a fire under me and I was off and running.

- Then, the biggest opportunity of my career knocked on the door and led to funding for the AKDOT GAM research program. I answered the door and we'll discuss that whimsical process a little later.

Desire

- If you are to be a leader, you have to want to make things happen. If you want to effect change in your organization, you have to be prepared to fight against those who are fine with status quo. If you want your design project to move successfully out of CAD and onto the highway, you have to want to do your best work to make it happen. If you really want a research project to go forward, you have to believe in it and be prepared to advocate for it. If you do have the desire, you should make (and keep) the commitments that will keep you in the game until the end is reached.

Ability

- Many of us have invested considerable time, effort and money into becoming expert in our area of practice, whether in science, engineering or business disciplines. Some of us are highly specialized, others are generalists. I asked you earlier to identify your area of specialty – most of you are engineers, but I imagine there are a significant number of you who have studied and practiced in two or more disciplines.

- However you come to a research project, if you are to have a leadership role, you should have abilities that align with leadership needs and that will serve the project. That doesn't mean you need to be an expert in every aspect of the research – rather, you should have the "leadership ability" to direct the work without necessarily performing the work. Recognize the abilities of others on the team and let them do the work. For the GAM R&D project, I was most definitely a "generalist" – my knowledge about much of the subject matter was like the Platte River: "a mile wide and an inch deep . . . ." But I picked a great team of several consultants plus our own DOT staff, so the "ability" that paid off for me was the ability to take a thin understanding and (at least in my mind) synthesize a lot of ideas to both lead and follow our team.

- Another "ability" characteristic is what I call "associative-ness" – openness to disparate and apparently un-related ideas that might have some connection to or usefulness for a project. The ability to collect these ideas and apply them to the current work helped my understanding of the limits of the project. My constant pestering of the team members with all these ideas also tested their limits of patience!

- My best example of this is my association with TRB over the past ten years or so. My weekly reading of the TRB newsletter and scanning project updates and announcements of work products for items that might relate to GAM and my attendance at a wide variety of committee meetings over the years provided numerous new avenues of thought. Several of the people I met influenced the directions I took the GAM R&D. This was particularly true of the TRB meetings for the Transportation Asset Management Committee. Many of the ideas I tested for inclusion in the GAM research came from those sources and many of the people I met eventually came to AKDOT under contract. Chief among those was Paul Thompson, without whose knowledge and experience, the GAM R&D would certainly have foundered.

It is all too easy to stay in your silo and focus on a research problem to the exclusion of all else. I encourage you to stay open to and actively seek out information and ideas from outside your specific project. There can be no better place to look than at TRB and the annual meeting. The continuing infusion of new ideas will help keep your thoughts fresh. Something to remember when your project starts to far exceed the time budget and the years just keep on rolling by.

Commitment

- Not long after I launched the GAM R&D projects from my DOT section, I prepared a **list of commitments** for my various programs, projects and assignments. Because I knew the GAM R&D would take a significant amount of my time and Department resources, I wanted to show my immediate boss and his boss, the Chief Engineer, that I was serious about my job and the activities in which I was engaged. I wrote a paragraph about the GAM program and my nine other significant commitments and sent the list up the chain. The response was underwhelming, to say the least. As I basked in the deafening silence, I knew that it was up to me to make this happen, so I re-doubled my efforts, **learned to say yes** to everything that supported GAM, and launched a ten-year long research.

  ***Commitment**: I learned about commitment from a Starbuck's Cup. The cup had this quote printed on the side: "The irony of Commitment is that it's deeply liberating . . . the act frees you from . . . your internal critic, from . . . rational hesitation. To commit is to remove your head as the barrier to your life," - Anne Morris. For me, once I made a commitment to develop GAM, I no longer had to engage in a lot of wasteful decision-making. If something came up related to GAM, I could and did automatically say yes to it.*

The specific qualities and characteristics of leadership are different in each of us, as are the circumstances to which we are exposed that can nudge us toward a leadership role. I do think that all of us have the latent ability to lead given the right set of circumstances. Our literature is replete with examples. For a recent non-fiction treatment, take a look at Doris Kearns Goodwin's "Leadership in Turbulent Times" that looks closely at the presidencies of Abraham Lincoln, Theodore and Franklin Roosevelt and Lyndon Johnson.

DECISION-MAKING

What is a decision in the research context?

It's a choice between two or more paths in the research/implementation process. Examples of potential decisions:

- Approve or not approve initial idea?
- Approve research, but defer approval of implementation until after research is completed?
- Allow research to go forward, but at reduced funding?
- Approve more funding and more time?

What is the Approval Process that leads to a Decision about Research and about Implementation?

In my experience researchers simply assume that there will be implementation. But how many of you are aware of projects that went through the research phase and then died before implementation? Why did these projects die?

If a research effort is to be implemented, somewhere in the research and implementing agency process, some one person has to say "Yes, this project is approved through research and implementation. You may proceed." OR someone will say "OK, nice research report, but we are not going to implement this research." OR, the funding for implementation will dry up and you may never know why. Or any number of other scenarios can result in failure to implement. Hadn't we better consider these possibilities before proceeding with an idea?

My own experience in these matters for the GAM R&D may be instructive. When I started proposing and advocating for research, I was as naïve as a newborn kitten about the process, the timelines, the cost, how to shepherd a project along, who I needed to impress, basically all of it. I had an "Idea" I was excited about and didn't think much farther along than the next step at any particular point in the process. After the fact, I have become aware of how capricious decision-making has been by my agency and by TRB/AASHTO/NCHRP as I have worked on several research ideas with TRB committees over the last ten years. The idea that decision-making is capricious is doubly true for agency executives and managers in my DOT experience.

> ***GAM Research & Development Funding:*** *From 2002 - 2007 I applied every year for research funding to get a start on an Unstable Slope Management Program for AKDOT – without success. Applying for funding was a bureaucratic exercise of filling out forms and trying (without guidance) to find the right language to catch attention of the Research Committee that allocated a few $M each year of federal funds designated for the state DOT Research Section. Finally after five years of frustration, I wangled an invite to the 20007 Research Committee meeting to give a presentation. I put together a ten slide show of dangerous rockfalls and landslides, describing each site. Then I said: "Any one of these sites could have killed someone," and sat down. After a moment of silence, the executive planning manager who had discretion in allocating federal funds to our programs spoke and said they would not give me all the research funds I asked for, but would give me $50,000 in startup funding for a literature search . . . and then he said he would also give me a federally funded research stand-alone STIP project for $600K for a three year period from 2008 – 2010.*
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> *Soon, at my request, the funding grew and grew and grew. For 2010, I was approved for $1.2M/year funding to start pioneering research into GAM. Between 2012 and 2016 there was over $6.5 million directed to GAM research. In addition there were other STIP road project-specific funds added for GAM research and data collection. The USMP research eventually grew into a combined set of R&D projects ten years long and over $10M that resulted in the first (and thus far only) comprehensive, multi-asset Geotechnical Asset Management program.*

Agency decision-making always comes down to one person

If you are trying with courageous patience to get a program implemented, you need to advocate for the program, and I firmly believe that you have to know who that one person is and tailor your approach accordingly. It may be your immediate supervisor or two or three levels up. It might be out of your chain of command. It might look like a committee decides, but remember

there is always one person to him you must address your request and you should know who that person is and how they can best be convinced to decide in favor of your project.

To be an effective advocate and champion for your objectives, you should understand something about the mechanics and psychology of the decision-making process generally; and specifically, for the person you need to impress. I found my guy, then I found the staff members who had the guy's ear and were willing to tell me a few hints about getting to "yes." Then, I took shameless advantage of them for as much funding as I could get and for as long as I could. In my case, from the perspective of getting my program going and growing, the capricious nature of agency funding allocation was a benefit.

Capriciousness in Decision-Making

As a project/program manager I was ecstatic to be able to apply the significant research funding that I felt strongly is sorely needed. Now though, after some experience with state and federal agencies and studying the mechanics and psychology of decision-making for a few months I think I am a bit more pragmatic and not sanguine about the ability of agency management to make the "right" choices to implement GAM programs or principles. Even though I am forever grateful to the managers that provided the funding, I wonder at the wisdom of their decision-making process. Why? Because after ten years of serious R&D projects involving Consultants and many DOT staff members, the project was shelved instead of being implemented. I failed, despite having a detailed Communication Plan, including implementation, to consider the possibility of an end game that would leave the GAM Program un-implemented.

That's why I wanted to speak about decision making. That's why I want to understand how implementation can be driven forward to a better conclusion. I think you are all capable of a better result if you are armed with a little more knowledge of how the implementation process can work and should work.

So, with this section of the Dialogue I hope you will become interested in how to move your research projects forward from Idea to RNS to NCHRP Project to Implementation. In the case of my AKDOT GAM research project, there was no point at which a senior manager issued a memo or email or other message saying: "The GAM program R&D is approved." The funding just kept rolling in every time I asked for more. Managers did make the decisions to apply funds to the R&D phases, but the "notice" was the appearance of the funded project in the federal STIP updates each year. And then, when the project was finally finished and the final documents were completed, the project was shelved with a couple paragraphs in the Transportation Asset Management Plan.

> ***AKDOT's Decision not to implement GAM:*** *"DOT&PF has elected not to establish performance targets for these asset classes and include the GAM Plan in the initial TAMP submittal to FHWA. DOT&PF does not expect to pursue programmatic maintenance or preservation activities on geotechnical assets at this time. The data and reporting information in the GAM Program is being incorporated into new project selection criteria. The approach under this initial TAMP is to address geotechnical asset classes within the scopes of capital projects." AKDOT TAM Plan, April 2018, pg. 33*
> http://dot.alaska.gov/stwddes/asset_mgmt/assets/tamp_april_2018.pdf

Thus ended, for the foreseeable future, the implementation of Geotechnical Asset Management for AKDOT.

DECISION-MAKING SCIENCE

How Decision-making Science Can Help Researchers

If we accept the premise that decision-making is capricious, what are we to do to favorably affect the outcome of our research projects and successfully reach implementation of the results? By examining the decision-making process and taking a few steps we might not normally consider, we can nudge the decision-maker in the right direction. One of the steps we can take is to recognize that we can become **"choice architects"** who have the ability, position and authority to influence decision-makers. Thaler and Sunstein, 2008.

Before we get to what we might do to improve chances to reach implementation, let's look at a few points about the process of human decision-making. Psychologists, economists and practitioners in allied fields have been exploring decision-making for decades. There is an enormous volume of writings on the subject, ranging from professional scientific journal articles, books and research reports to popular writings in best-selling non-fiction markets. No attempt will be made here to summarize the work of thousands. Four names stand out:

> ***Danny Kahneman and Amos Tversky****: (see "Thinking, Fast and Slow") Kahneman received a Nobel Prize in economics for their joint work that set the stage for decades of research in the area of decision-making. Tversky would likely have shared the Nobel Prize with Kahneman, but died before the award. [Also worth reading is "The Undoing Project," about Kahneman and Tversky, written by Michael Lewis, who also wrote "Moneyball."].*
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> ***Richard Thaler*** *("Nudge") Thaler also has a Nobel Prize in Economics. Thaler was a co-founder of an asset management firm that applies "behavioral finance" principles for their clients. Interestingly, Kahneman is also with the firm.*
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> ***Gary Klein*** *("Streetlights and Shadows") is senior scientist at a research and consulting firm working with commercial and government clients in the area of "applied cognition." Streetlights and Shadows is a very accessible and relatable book suitable for lay readers interested in decision-making. Unlike others in this field, Klein opines that cognitive biases don't distort our thinking, but instead reflect our thinking. Klein also thinks that the cognitive biases that have been studied in the laboratory don't have as great an effect on decision-making in the "real world" as has been demonstrated in controlled laboratory experiments.*

System 1 and System 2 Thinking

Kahneman and Tversky exploded the classical economics concept that humans are rational and make reasoned economic decisions. Starting in the 1970s, they explored the widely-accepted concept of two kinds of thinking; System 1 and System 2. System 1 is intuitive, automatic, effortless and quick. System 2 is analytical, reflective and requires effort and reasoning. Kahneman, 2011; Thaler, 2008.

Below are two stories that illustrate something about the two types of thinking processes.

> ***Hudson River Landing****. On climb-out shortly after takeoff, an airliner struck a flock of birds, causing the loss of both engines. 208 seconds later, the airliner touchdown in the Hudson River with no loss of life. During that few minutes the pilot, Capt. Sully Sullenberger, had to control the aircraft, communicate with traffic control and the cabin crew, decide which headings to steer,*

consider and then reject three possible runways that he decided they could not reach, and ultimately decide on a water landing. He made numerous life and death decisions and got every one of them right. Ask yourself if this was System 1 intuitive thinking or System 2, analytical and reasoned thought as Sully rode the airplane down to the water. Adapted from Klein, 2009. See also the movie "Sully."

***The Gimli Glider**. Through a series of unfortunate events, both engines of an airliner quit at cruising height during a night flight across Canada. This caused loss of electrical power, robbing the pilots of their modern instruments and left them with a few battery-powered basic instruments and seriously degraded use of the flight controls. The pilot, Captain Pearson, and copilot had about 20-30 minutes to land. They had to decide where to go, repeatedly ask air traffic control for steering directions and reports on their location. They had to consider how to land the powerless plane at a higher than normal speed, with no flaps, no normal braking, no reverse thrust, and without full instruments or controls. They pretty quickly located a former RCAF military airstrip, with which the copilot was familiar, at the town of "Gimli" located north of Winnipeg. The runway had been converted to a racetrack and was in use at the time of the landing. Captain Pearson had to use an unusual procedure to side-slip the plane onto the former runway, but landed the plane safely with only minor injuries to passengers and crew. After this incident, the plane continued in service for 25 years, and was forever known as "The Gimli Glider." Again, ask yourself whether the pilot utilized intuitive thinking or reasoned analytical thought as the airplane descended out of the night sky. Adapted from Klein, 2009.*

INTERESTING NOTE: Both Captain Sullenberger and Captain Pearson were experienced glider pilots.

Cognitive Biases and Heuristics

Kahneman and Tversky identified and studied numerous cognitive biases that affect our thinking processes. They collected numerous mental shortcuts or rules of thumb (heuristics) for how people conduct decision making. Many researchers followed them and there is now an abundance of literature in the "biases and heuristics" field and it remains an active area of study. In addition to the academic studies, there are many lively and very relatable popular books and magazine/journal articles addressing the minutiae of cognitive biases and heuristics.

The literature and research has shown that human decisions are fraught with hundreds of biases that affect the decision-making process. These systematic "errors" affect humans in business, the sciences, personal decisions and every aspect of human life. There are now several decades of research and analysis into these cognitive biases – journal articles, research reports, popular magazines and books. There's even a "Journal of Behavioral Decision Making!" Below is a very small illustrative sample of biases. It is easy to recognize many of these in one's self and others. Kahneman and Tversky (and now a host of others) have explored these with experiments under laboratory conditions and in the "real world."

Some of the heuristics and biases that may be useful to us in research. First consider whether your important decision-maker is likely to decide an issue quickly, decisively and intuitively in System 1 thinking or take time in reflecting on the "right" choice based on analysis of System 2 thinking.

Below are a few of the hundreds of identified biases and heuristics. We'll examine a couple of these in more detail. (https://en.wikipedia.org/wiki/List_of_cognitive_biases)

> ***Planning fallacy*** *– projects are always underestimated for time and cost and overestimated for project value. Kahneman, 2011, Ch. 23. "Over budget, over time, over and over." Regarding mega-projects. Flyvbjerg (2011)*
> ***Framing effects*** *– people will more often choose outcomes that are couched in positive terms than in negative terms, even though the options are of equal economic value.*
> ***Anchoring and Adjustment heuristic –*** *Anchoring is the human tendency to rely more heavily on the first evidence discovered relating to a decision. The decision maker considers more evidence and adjusts the answer to arrive at an estimated answer that is adequate to solve the problem.*
> ***Gambler's fallacy*** *– belief that a certain outcome is "due" in a series of events, where each event has an equal chance of occurrence (coin toss, e.g.). People tend to believe after a string of the same outcomes (say heads occurring in a coin toss ten times in a row), that the "odds are in favor of" a different result for the next event.*
> ***Status quo bias*** *– people have a preference for the current state of affairs. Implementing a GAM program in any state DOT represents a major change in the way executives managers look at geotechnical assets. Making that change happen is a monstrous hurdle. See "endowment effect" below.*
> ***The endowment effect*** *– people ascribe more value to things merely because they own them and would pay more to keep something than to purchase it or a replacement.*
> ***Loss aversion*** *– preference for avoiding losses versus acquiring an equivalent gain.*

The principal message about "cognitive biases" or "systematic errors" is that decision-making generally is affected by hundreds of biases that, depending on your viewpoint, either distort the decision-makers thinking or reflect his or her thinking. Recognizing this about decision-making and making use of an understanding of the biases and some key heuristics can improve the chances of getting a favorable decision for implementing research products.

It is not enough to have an elegant engineering solution that speaks for itself as the "right" answer to a problem addressed by research. There is too much competition for research funding to rest on the technical attributes. The data, analysis and conclusions must be relevant, meaningful and convincing to a decision-maker. Knowing that R&D and Implementation have a poor track record for success should lead to the conclusion that maximum effort is needed to win through to the goal.

> *"The challenge, however, does not stop with simply identifying the critical assumptions for analysis. It is here where the most important and least asked question in business becomes paramount. Whether comprised of data collection or proactive pilots or experiments, analysis must not only be targeted at the right issues, but actually capable of changing someone's mind. A sophisticated, "correct" analysis is of no use in this regard if the consumers of the results - the decision-makers - do not buy into the appropriateness and interpretation of the analysis. Carraway, 2015. https://ideas.darden.virginia.edu/2015/10/the-most-important-and-least-asked-question-in-business/*

Danny Kahneman agreed with the idea that data and numerical analysis do not a story make. As he famously said: "No one ever made a decision based on a number. They need a story." Kahneman, 2011. As researchers working toward implementation, we have to get the right technical answers **and** tell a story that "resonates" with and convinces the decision-makers. Decision-making characteristics, cognitive biases and decision-making heuristics can be used as tools to frame our interactions with decision-makers in ways that could improve the odds of

getting approval for implementation programs. When we use the tools available to us to influence decision-makers, we become the "Choice Architects" that Thaler and Sunstein (2008) described. Each of you can play an important role as a choice architect in getting research programs from Research & Development into Implementation.

The Planning Fallacy

It is axiomatic that few infrastructure projects are built to the original schedule and budget. It is actually much worse than you might think. As Bent Flyvbjerg said it: "Over budget, over time, over and over." Flyvbjerg (2011). He was referring to mega-projects like the Channel Tunnel, but the principles apply to a wide variety of projects. Flyvbjerg said that three models explain underperformance; bad luck, the "Optimism" cognitive bias (aka systematic error) and "Strategic Misrepresentation." The last mentioned model can be thought of as simply lying to gain an advantage in the quest for approval and funding for a project. This was characterized as reverse Darwinism or the survival of the "un-fittest."

In the US, one does not need to look far to find numerous projects of smaller proportions than the mega-projects that Flyvbjerg studied that suffer from the planning fallacy. The Big Dig and Seattle's Big Bertha tunnel borer come immediately to mind. The NYC 2nd Avenue Subway project was started in 1972 and finished in 2016. The Phase I cost was $4.5 B with an overrun of $700M and the project completed two miles of subway, vs. the planned eight miles. Phase II is planned for another 1.5 miles at a cost of $6 B and planned completion date of 2027-29. https://en.wikipedia.org/wiki/Second_Avenue_Subway

Whatever the scale, I am certain that very nearly everyone in the room has experienced a project or several that have been subject to the planning fallacy. For researchers starting out with a new idea, consideration of the planning fallacy might be worthwhile if only to moderate a tendency to under estimate cost and time frames. For decision-makers, the planning fallacy should tell you to evaluate competing proposals carefully in light of the effects of the bias. Perhaps both research proposers and evaluators will benefit from in-depth looks and even negotiation as to the scope of projects.

Interestingly, Danny Khaneman has commented that projects don't get anywhere without some degree of overpromising (i.e., strategic misrepresentation).

> ***Daniel Kahneman Textbook project.*** *Kahneman took part in a project to create a textbook about judgment and decision-making for the Israeli Ministry of Education. After a year of weekly meetings and some writing of outlines and chapters, the team met and Kahneman asked each of the members to write down an estimate of how long it would take to finish the text. The average estimate was two years. Kahneman then asked a team member who had worked on several similar projects how long they had taken to finish. The person responded that many of the projects failed – around 40% and that they had taken 7-10 years for those that were completed to finish. The team was stunned to hear how far off their estimates were, but even in the face of this bad news, they carried on as if nothing had happened. The finished the book eight years later! By the time they finished, the Ministry had lost interest in the project and the text book was never used. Adapted from Kahneman, Chapter 23, 2011.*
>
> ***AKDOT Geotechnical Asset Management Research & Development Project.*** *As I re-read the above Kahneman example a few months ago, I recalled when I first found his book, "Thinking, Fast and Slow," in 2011, not long after starting on the GAM development work. I read through*

> *parts of the book, then put it away. Then in 2010, I started up the GAM project and had to make some estimates about cost and timeline. My guesses then were in the neighborhood of $500K and I wrote the first contracts for a three year period. The final reports were published last year, eight years after project kick-off. Total cost was in excess of $10M. When I re-read Kahneman as I was studying for this speech and came to the text book example, I had a pretty good laugh.*

The planning fallacy is not as much a tool for convincing decision-makers to approve the back end of the project as it is for affecting the process during the front end. If the research understands the planning fallacy she can nudge estimates with strategic misrepresentation until the numbers about costs and benefits comport with her understanding about the decision-maker's expectations and likely response. So when a researcher estimates a little high and the decision-maker decides to scale the funding back a little and if everything else works right the researcher gets what she needs to perform the research.

Framing Heuristic

Now think about a research project and consider how best to frame your request for funding. Let's say you want funding for a GAM-based rockfall management program. You want to put together a presentation to make your case for implementing a program. Do you want to show several PowerPoint slides with spreadsheets and graphs showing the investment of funds over time and the expected improvement to system performance over 5–10 years? Do you want to show a lot of slides that have photographs of rockfall blocking roadways or debris flows washing away cars?

Is your decision-maker a Planner with the ability to dispense funds to your project? Is your decision maker an economist in the administrative section? Is your decision-maker an experienced civil engineer? The choice architect will "frame" the question in terms that appeal to the nature of the one person making the decision. An engineer/manager will likely be seen as a System 2 thinker, carefully deliberating about the analysis. A planner may be seen as likely to act intuitively in response to the photos illustrating high risk and demanding quick action to address funds to solve the problems. The economist might make a decision based on the long term benefits and costs of implementing the program in the context of many other programs in the Department. You may have to show all three kinds of presentations at different times to build enough forward motion to get the decision-maker to approve the funding.

But even with all the information you have passed on to stakeholders and other interested parties about the proposed project, you may still get the opportunity to make the "ask" for funding approval. One way for choice architects to effect favorable decision-making is to frame the questions about a research project at the beginning of the project. Example for GAM:

> *"Mr. Executive, if we are able to show you with our research and analysis that managing geotechnical assets using TAM processes will result in improved performance, reduced risk, reduced life cycle cost and a positive rate of return, what reasons would impede approval of funding for conduct of the R&D and for implementation of the program?"*

This framing puts the onus on the decision-maker to say no against a compelling argument and asks the decision-maker to provide reasons for his or her answer. This kind of framing may lead to a "yes" as the easier path than a "no."

IMPLEMENTATION

One reason I'm here talking today is to promote the idea that IMPLEMENTATION is a critical part of research that is all too often given short shrift, resulting in even thought out and well-conducted research projects with excellent products that end up on a shelf gathering dust. **All of us, as researchers, should be thinking about and planning implementation, from day one of our R&D projects and programs.** We are still barely starting GAM implementation at a handful of agencies, so talking about Implementation is an appropriate focus for a discussion of the future of GAM. The Dialogues with Leaders have often addressed both past and future of the subject areas in which we work. Today though I want to interest you in learning how to **SHAPE THE FUTURE**.

Implementation is an essential characteristic of completed research projects. Research reports stacked on a shelf are of little use. Actively promoting, advocating for and "selling" the results of a research project are the bare minimum necessary to effect the innovations and changes made possible by the research. As said by no less a personage than Adm. Hyman Rickover, Father of the Nuclear Navy, "Good ideas and innovations must be driven into existence by courageous patience."

> ***NCHRP Active Implementation System.*** *NCHRP's Active Implementation process is highly detailed, and apparently comprehensive.*
>
> *(http://www.trb.org/NCHRP/NCHRPImplementationSupportProgram.aspx).*
>
> *The program is a roadmap to implementation on a national scale. It addresses the gap between research and implementation, recognizes the present ad hoc nature of implementation and provides solutions to those issues. There is a sidebar in a TR News article, "Active Implementation at the National Cooperative Highway Research Program" noting the requirements for NCHRP Problem Statements that include listing the "key decision-makers who can approve, influence or champion the implementation of the research products." Dekelbab, et al., 2017. This at least acknowledges that there are decision-makers in the process, but does not the decision-making process. The NCHRP Active Implementation System does not address the issue of approval. Someone has to make a decision to approve the start of the project and the implementation of the results of the research.*

How do we proceed with that courageous patience to convince our agencies to adopt an innovative GAM program that will improve performance, extend asset service life and reduce the risk and cost of owning geotechnical assets in our transportation systems?

First, you need something to implement

That part is "easy" – For me, it just took eight years, about ten people and north of $10M worth of R&D at Alaska DOT to create the first comprehensive multi-asset GAM Plan.

Second, driving ideas forward with courageous patience requires leaders

Leadership is required to move GAM forward at the project level, the management level and at the executive level. And what does "forward" mean? It means having one or more champions ("leaders") advocating for and pushing along a program and working to secure a place at the table at transportation agencies to implement the concepts of GAM. I was that champion for GAM for several years, and so I speak with some authority on this. "Forward" also means that

some leader in senior management at transportation agencies has to reach down and make the decision to pull geotechnical assets along as part of asset/performance/risk management programs that are required under federal law. The necessity for convincing that person to decide in favor of a research project is why decision-making is part of this discussion we're having today.

Third, successfully driving research to implementation will be facilitated by understanding some concepts of decision-making

If we understand the way that humans, and especially for our purposes, senior managers, make decisions, and we can access the lessons from decision-making science, that may give all of us a new ability to effect change and successfully implement important research projects that are moving through NCHRP and other research programs.

As I've pointed out, one of the lessons about decision-making science is that all of us can use these concepts to become "choice architects." Thaler, et al., 2012. You can learn the ability to affect decision-making inside your organization and for funding sources outside. Effective messaging and careful framing of the issues for decision-makers can give them a Nudge (Thaler and Sunstein, 2008) in the right direction for approval of the research and implementation of an idea.

CONCLUSION

Recap

In this Dialogue we have touched the surface of a number of interrelated topics that could be of interest and of use to researchers with TRB and other endeavors. We've talked about how to get a project going, find approval for funding, and have shared some insights in how to reach implementation of the project.

We've talked about Geotechnical Asset Management and used the GAM R&D project at Alaska DOT to illustrate some of the points we've made.

We've shared understanding of the role leadership can take in progressing to implementation for research.

We have also taken a shallow dive into the deep pool of decision-making analysis and the human characteristics and cognitive biases that can guide us to using heuristics to aid us in pursuing fruitful decision-making for transportation agencies.

I hope we have all recognized by now that **IMPLEMENTATION is the last, best activity to complete every transportation research project**. It's up to all of us to start on day one thinking about how to IMPLEMENT our research products. As much as I have enjoyed the R&D phase of geotechnical asset management, I am frustrated and unhappy that we do not yet have even one comprehensive multiple asset GAM program implemented. We do now have a handful of GAM-based programs dealing with unstable slopes, but that is not enough. We have one fully developed GAM program at my former employer Alaska DOT, sitting on the shelf.

For everyone here, you can improve on research decision-making from the inception of an idea through implementation of a completed research project. If you are an agency decision-maker, with responsibilities regarding research R&D projects and implementation of research products,

be aware that your decisions are impacted by cognitive biases and that your thinking regarding research and implementation may be impacted by the systematic errors in thought that we all share. Let your inner Mr. Spock allow you to reflect on the value of R&D and Implementation, but let your inner Homer Simpson guide your dreaming and scheming on funding.

If you are in a position to influence decision-makers in the research business, study decision-making theory and learn to frame your requests to decision-makers in ways most likely to yield favorable outcomes.

If you are a practitioner with a research idea, what can YOU do to avoid seeing your projects completed, but then shelved instead of being implemented?

- **Commit** – make a commitment to an idea for research. Think big about your idea; let your inner Homer Simpson loose to take advantage of your intuitive thinking process. Talk it over with decision-makers above you and get their express approval to start a project.
- **Commence** – Get a formal start of the project and as quickly as possible find funding to support the project. Find the right decision-maker who holds the power to distribute funding. Find out what is needed to get her approval and make a well thought-out "ask" for the money using knowledge about decision-making, cognitive biases and those useful heuristics like "Framing" and the "Planning Fallacy".
- **Convince** – Convince the decision-makers and end-users of the project that this is a good idea and tell them what the costs and benefits will be. Don't fall prey to the "planning fallacy," instead using your knowledge of it to select an appropriate time frame and budget.
- **Complete** – Finish the project as close to budget and selected end date as possible.
- **Communicate** – From the earliest stages, communicate your ideas and the steps you are taking. Celebrate the successes as you progress and don't hesitate to explain failures. Make sure you keep in touch with the funding provider to update on progress and talk about the positive outcomes that the funds have paid for. Don't be shy about patting yourself on the back (with some veneer of humility, of course) in a forthright way, to assure decision-makers they have taken the right path in approving the project.

Forecast and Shaping the Future of GAM

In the future, we'll begin to see wide acceptance of management of geotechnical assets. This will occur:

- When the federally funded transportation statutes and codes for performance and risk management inevitably expand beyond pavement and bridges to include geotechnical assets and,
- Regrettably, and also inevitably, as more and more geotechnical assets fail more and more frequently, and
- Something over which we can exercise some control, as more GAM champions and leaders rise to push and pull the concept of managing geotechnical assets into the light of day. Every new GAM-based program influences more people at DOTs to consider developing their own programs.

This acceptance will be fueled by rising costs and reductions in performance; by the courageous patience of researchers in moving ideas forward to implementation; and by committed workers exercising their best efforts to conduct excellent research projects and move them to

implementation. This requires researchers to understand that doing excellent research and writing a report is not enough. Researchers must take the initiative in moving their projects to implementation.

We need not wait for the future to come to us. We can shape the future if we understand and use knowledge of decision-making processes and human cognitive biases to become "choice architects." We can frame decision-making toward favorable outcomes throughout the research process, from scoping, to funding, to conducting the work and eventually to implementation. We have to be lucky and take advantage of opportunities, we have to have the desire and ability to conduct a research project and we have to make a commitment.

Thank you all for your attention and participation!

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