

**PUBLISH ON DEMAND**

**Decision Products and Long Term Integrity**

**FALL 2013**

**UPDATE**

**mediaX**  
**STANFORD UNIVERSITY**



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## Decision Products and Long Term Integrity

Publish On Demand Project Update October 2013

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### Background

This project assesses the human and technical infrastructure required to support the systematic construction of complex group-decision products and the procedures necessary to ensure their long-term integrity.

It actively addressed two interdisciplinary research questions:

- 1) What infrastructure requirements would support the systematic construction of *decision products* designed with explicit requirements, grounded by open and well-documented research, subject to systematic review and quality control, and communicated persuasively to relevant constituents?
- 2) Given the explosion of ephemeral digital media, what criteria for educational, technical, and institutional mechanisms will ensure the long-term integrity of decision products and intellectual work?

The accelerating velocity and complexity of decision-making in industry, government and nonprofit organizations is making ‘business-as-usual’ methods for situation assessment and decision-making untenable. Information of uncertain quality and accountability is exploding on the web. Our methods for deliberation in government agencies, board rooms and non-profit groups need to change to meet these accelerating information challenges.

Specifically, the human brain evolved under very different linear and local event- selection pressures than the exponential and global events in today’s business environment. Further, the brain has a well documented set of hard-wired or built-in heuristics, such as overgeneralization, saliency and sunk-cost biases that were once adaptive to keep us safe from predators but are maladaptive distortions of judgment in the complex modern world. Even well educated decision makers are subject to these and other systematic errors in judgment. However, explicit anti-biasing decision support can be provided that decreases the likelihood of systematic decision errors.

What is needed is software infrastructure for developing a culture that makes high-quality decision products a priority - as if facts, logic, future consequences, and preserving the integrity of those decisions matters.

### **Objectives – The Phase 1 Project Had Six Objectives:**

- 1. We developed a decision-products methodology and initial virtual- decision support environment.** Following the workshop, we selected the most frequently cited required augmentation applications and built access to them into a prototype virtual-reality environment for demonstration and testing. The initial ADE (Augmented Decision Environment) was prototyped for demonstration in the Turf3D virtual environment. The decision-products methodology was adapted from Rick Hayes-Roth at the Naval Postgraduate School and Richards Heurer of the CIA.
- 2. We prototyped a cloud-based course that can be used to evaluate educational, technical and institutional mechanisms** required to ensure the long-term integrity of intellectual work products, including decision products. Professor Laughlin has taken a first pass at developing an educational course to test these ideas. The high-quality results have demonstrated the effectiveness of the process. See <http://large.stanford.edu/courses/2013/ph241/>. We have identified several potential project-specific improvements, particularly with respect to integrating with other systems.
- 3. We specified that we would have open interfaces to a hybrid electronic- storage and print-on-demand system** for documenting decision products and student-developed course work.
- 4. We organized a Media X Workshop on Decision Products and Information Integrity.** In fact, we designed two Augmented Decision Environment (ADE) workshops. The first workshop, held on March 2, 2013, helped us to understand what works currently, what doesn't, and what else is needed. We gleaned additional insights from the second workshop held on May 22, 2013 with Sabia, Petrobras, and CNI from Brazil. That workshop focused on Zero Preventable Accidents in the Oil and Gas Industry.
- 5. We conducted two Media X Workshops on Augmented Decision Systems.** This has been accomplished in the two workshops mentioned above.
- 6. Project Report.** This Phase 1 report documents our Phase 1 findings, lessons learned, a walk-through of current and proposed software environments and next steps for future research. This report specifically addresses exciting areas of new opportunity to provide seamless and operationally functional decision augmentation that could be a game changer for early-adopter organizations.

## Results

We researched potential mechanisms for augmenting our limited processing capabilities for integrating vast amounts of data, making sense of it, producing decision products that persist and feeding back the results of our decisions into our future decisions. We also investigated the economic incentives necessary to preserve the quality, accountability and longevity of these decisions.

The mediaX Augmented Decision Systems workshop on **Concepts, Incentives, and Requirements** was held on March 2, 2013. We invited distinguished technical, corporate and government leaders to help us think through system use and requirements.

We made good use of the new and innovative Stanford Peter Wallenberg Learning Theater (PWLT). The specifications of this extraordinary environment are:

The PWLT has a 8-foot high by 32-foot wide, seamless, curvilinear video wall, composed of an 8 x 24 array of Christie MicroTiles. The system is used as one massive display with 16 separate channels of display activity.

Each 306 x 408mm (~12”x 16”) MicroTile is composed of a 540 x 720-pixel display with .56mm pixels. Each MicroTile is driven by its own graphics controllers. The gaps between tiles are only 1.3mm.

The entire 258-sq. ft., life-size display is fully addressable and scalable in whole or in part. The resolution of the combined display system as it is used in the PWLT is 3904 x 15,840 pixels, or 61,839 megapixels.

Each MicroTile has a color-reproduction capability that is 115 percent of the NTSC color gamut, and exceeds standard LCD flat panels by more than 50 percent. The MicroTiles have 70x more pixels than the most popular 4mm surface-mount display LEDs.

The system has 16 channels of graphics input, driven by a Jupiter Fusion Catalyst 4000 controller. Each channel addresses 1600 x 2560 pixels.

The 5.2-channel audio system can localize sound, and synchronize sounds to the images on display. For example, the system is capable of locating acoustically each stereo source with its specific image in the full field of view. Thus, a video of two couples with each starting from opposite ends of the screen, could show them walking past each other across the field of view, fully synchronized with the stereo sound of their localized conversation.

The workshop exceeded our expectations and generated many new and exciting ideas. Several participants are interested in pursuing these ideas.

### March 2, 2013 Workshop Results

1. **Workshop participants agreed that technology alone would not solve the complex decision-quality problems** in corporations, government and non-profit organizations. However, **a principled combination of innovative decision**

**methodology, human-incentives engineering, and decision-support software and hardware technology could make a significant difference in decision product quality.**

2. One of the needs identified by workshop participants was to **provide a decision team with support for communication, visualization and touch-based manipulation of complex decision products.** For example, one of the breakout groups explored a use case that addressed the needs of a Rapid Issue Response Team that could be charged by a corporate executive or government agency to rapidly gather the relevant information about an urgent or critical issue, test facts and identify misinformation, assemble a balanced and coherent representation of n sides of the issue, develop recommendations and work products to explain the recommendations to relevant audiences in clear and compelling ways. This recommendation dovetails well with new research that Dr. Michael Bernstein is conducting at Stanford on rapidly crowd sourced Flash Teams of experts.
3. Providing **resilient infrastructure for decision-making under crisis conditions and uncertainty** was another theme. The use case for this need was providing effective emergency response to a massive earthquake, in spite of the absence of grid electricity and cell-phone communications. There were many very useful ideas knit together into one powerful and surprisingly resilient emergency response decision system.
4. **Addressing dysfunctional government decision making was another use case that focused on the problems associated with government and corporate decision-making systems that were once functional but have become slow, self-serving, simplistic and non competitive with best practices.** Many excellent ideas were generated under this theme. One in particular that stuck and has already produced a team that wants to pursue it is the idea of a **“People’s Accountability Engine”** that could analyze complex reports and policies, and reduce the text to a set of key assertions, assumptions and additional action items not directly related to the purpose of the legislation or report (otherwise known as “pork” or favors for special interest groups). Information gleaned from the report could be utilized to simulate probable outcomes under varying conditions and assumptions. **Stanford Professor Jim Fishkin participated in this session and has conducted more than 70 large-scale deliberative, decision-making workshops in over 15 countries. He thinks that an augmentation system like the “Accountability Engine” discussed in our workshop would be a transformative technology for government and business decision-making.**
5. The workshop highlighted the **utility of sophisticated visualization displays and software tools.** Rather than have a special visualization cave, which is the only place to experience substantial intellectual augmentation, the participants expressed an interest in having a seamless augmentation environment – from smart phones, to wearable displays such as Google’s monocle “Glass” product, to slates and laptops, to wall- sized and 320-degree immersive 3D displays. The participants stressed their preference for an intuitive and easy-to-use toolset vs. a complex toolset with many features. Operationally, in the tradeoff between features and ease of use, ease of use must prevail.

6. All three groups in the March ADS workshop pursuing different application use cases identified the usefulness of having a system that could do semi-automatic fact checking, by searching the web for counterfactuals to assertions made. In addition, **a system that in its simplest form could be a checklist for avoiding known bugs and biases in cognition**, such as those identified by Tversky and Khaneman, could be enormously valuable if implemented rigorously and delivered through a simple interface. However, AI techniques such as the Deep Learning algorithm enable us to recognize these pathological patterns with much greater fidelity than simple checklists.
7. **Once a high-quality decision product has been produced, there is still the matter of ensuring its integrity and longevity.** One of the techniques for ensuring integrity is to score the information sources used to produce the product. Another method is to enforce the constraint that all references either be backed up in multiple places or available on paper.

### May 21-22, 2013 Sabia “Zero Preventable Accidents” Workshop Briefing

The Sabia workshop on Zero Preventable Accidents took place on May 22, 2013. The workshop theme evolved in almost real time from the May 21<sup>st</sup> ADS presentation and interactions with workshop participants. Participants included members of the Sabia organization, CRM and X from Brazil. In addition, we presented a briefing on augmentation rationale, technology and applications.

#### Augmentation Rationale

Today we are surfing on a tsunami wave of information. Our brains did not evolve for this level of information flow. This wave of information is indigestible, and doubling every 18 months (Moore’s Law). Our human information architecture, the brain, has not had a major upgrade in 50,000 years. In addition, as information doubles, technologies other than computers, such as nanotechnology, synthetic biology and robotics, double at an exponential rate. One option is to use technology to augment our brains and this ongoing augmentation can be incremental.

Biases in human cognition often results in bad decision making. Examples of biases include:

Anchoring bias - Fixating on first impressions

Status quo bias - Failure to consider alternatives to what is

Sunk-cost bias - Protecting earlier bad choices

Confirming-evidence bias - Selective data collection

Framing bias - Posing the wrong question

Overconfidence bias – Failure to challenge assumptions

Saliency bias – Focus on dramatic events vs. whole picture

Base-rate bias – Neglecting relevant baseline information

Pattern-behavior bias – Imposing patterns on events

Prudence bias – Slanting probabilities and estimates

In some companies and organizations, “information fog” prevents decision makers from making the right calls. Some biases that contribute to this fog could be addressed with Artificial Intelligence tools and augmented decision systems.

Another example of poor decision-making is the ‘legalized influence-peddling’ now permitted in the US in the form of campaign-finance contributions. This process warps rational decision-making in government and can be tracked by looking at risk signals of corruption. Larry Lessig, a Harvard professor of law and previous mediaX grant recipient at Stanford, has been working on changing the influence of money in the U.S. Congress by using citizen crowd-sourcing, data-mining tools and hyper transparency.

So what could be done to avoid disasters such as the Deep Water Horizon oil spill in the Gulf of Mexico? Zero-defect goals in oil well design could be operationalized via an augmented decision-making system that monitors and enforces oil well design constraints. Improving learning speed and quality is a key path to solving this problem and can be accomplished by using the augmented-decision system as a training tool. To avoid conflicts of interest, guidelines to avoid conflicts of interest need to be established and enforced on the web.

Some companies have built hybrid knowledge systems to improve or alter decision-making. For example, CALO was an Artificial Intelligence project that attempted to integrate numerous Artificial Intelligence technologies into a cognitive assistant. The project started in 2003 and ran for five years. The CALO project was funded by the Defense Advanced Research Projects Agency (DARPA) and eventually merged with the Personalized Assistant that Learns (PAL) project. The CALO effort has had many major spin-offs, most notably the Siri intelligent software assistant now part of the Apple iOS since iOS5 - in the iPhone 4S, iPhone 5, iPod Touch5 and the iPad. Siri allows users to speak to a computer and delegate work to it. Siri potentially changes the relationship users have with their devices. Devices become a computer associate - users can delegate simple tasks and work to their devices. Siri is just the tip of the iceberg of what this technology can do. One of the things it will eventually be able to do is to aid in everyday decision-making via error prevention and correction.

Richards J. Heuer, Jr. has written about common errors in intelligence analysis in his book *Psychology of Intelligence Analysis*, developed through his work with the CIA Directorate of Intelligence. The identified error patterns are applicable to corporations as well as government agencies and are directly relevant to the never-ending quest for better analysis and continuously improving decision processes.

## Table on Errors in Intelligence Analysis

Based on Heuer, summarized by Neil Jacobstein

<b>SOURCES OF ERROR</b>	<b>SAFEGUARDS</b>
Defining problem incorrectly	Frame questions in multiple ways
Narrow consideration of alternatives	Generate maximum alternative hypotheses
Closed and limited set of information sources	Open and diversify information sources
Attachment to a specific hypothesis judged as "most likely".	Develop arguments against each hypothesis rather than trying to confirm hypotheses.
Situation may change, or new information may alter understanding of status quo	Specify things to look for that, if observed, would suggest a significant change in situation probabilities
Analytical process not systematic	Manage for process quality excellence
Cognitive limitations and error	Simple tools to guard against biases

Setting up quality and safety indicators in the use of technology is important in augmented-decision control groups. This helps to enable world-class safety performance. If an error using technology occurs, decision makers won't be able to say that they "had no idea" that a disaster was possible – accountability is created.

Zero-defect decision-making means improving learning speed and quality with deeper pattern recognition, faster situation assessment, less error and distortion, higher quality prediction, less rework and improvement on safety and security metrics.

Technologies are available to improve decision-making and prevent crises. To use these well, it is important also to widen the circle of inclusion in workplace decisions. Training programs are important in dealing with this issue.

Some tools available for augmenting decision systems include:

- 3D visualization tools: Flare, AVS, GGObi, VTK, OpenDX
- Argumentation maps: DebateMapper, C-TOOLS, Horn
- Big data predictive analysis: R system and add-ons
- Ontologies: Cyc, OWL+, SUMO, IEEE
- Task and domain specific knowledge repositories: RDF, object lib, domain rule sets, LinkedData, logical spreadsheets
- Knowledge processing: Python, R, NLP, NuPIC
- Modeling and simulation: Stella, SimPy, JavaSIM, XLSIM
- Sense and respond systems: ActionWeb, BPR, Palantir
- Social media tools: Twitter, Collaboratory, Cave2, Google+, NodeXL
- Gaming frameworks: World of Warcraft, WorldGame, MP
- Personal and group agents: Siri, Now, Electric Elves, Java IAL.

Key sources of value added for decision system augmentation using Artificial intelligence include:

- Augmenting human skills
- Improving accuracy of predictions
- Accelerating process timing
- Solving complex problems
- Improving quality
- Increasing productivity
- Decreasing costs
- Managing knowledge
- Expanding the range of possibilities

Sustainable human intelligence requires mathematical, ecological and ethical literacy. The cost of getting the technology and maintenance right for proper decision-making is only a fraction of what it costs to deal with the consequences of a disaster. Zero preventable accidents means transforming decision-making with continuous situation assessment and adaptive intelligent response.

### Sabia Workshop Results

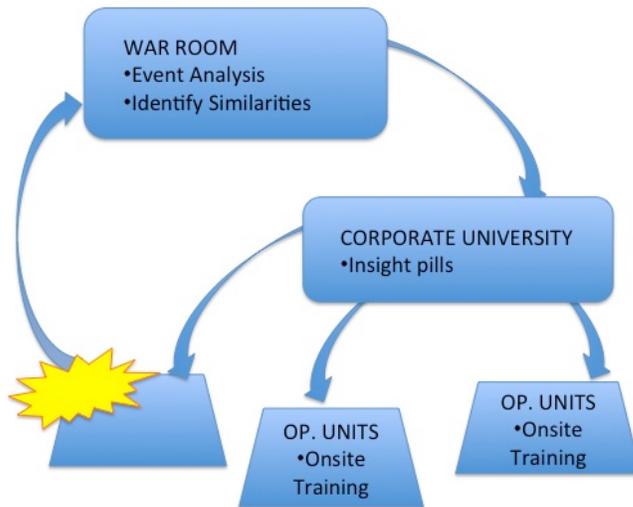
The workshop participants discussed the applications that would be most relevant to their particular situations. These discussions became the application foci for the next day's workshop.

### Specific Workshop Results

The key theme of the Sabia workshop was "Zero Preventable Accidents". The group divided into three teams.

1. **Provide Services to the 250 Biggest Brazilian Enterprises on a National and Network Basis.** This team sees a problem in excessive autonomy of state-level actors and wanted to provide a collaborative problem-solving mechanism for integrated programs and feedback. The team wanted to also include integrated learning and a gaming system for total engagement.
2. **Amplify the Crisis Management Room with an Augmented Decision Laboratory** that gives users integrated access to information, decision tools and simulation. Elements include: an augmented decision checklist, database event-trigger monitoring tools and a virtual-reality training laboratory.
3. **War Room for Planning and Deploying Oil Platforms.** The concept was to provide tools for safety-event detection and analysis, identifying similarities, developing university level safety programs, and creating distributed safety programs.

## PROPOSED SOLUTION



### Phase 1 Findings

**Summary:** It appears that in the 10-year forecast most organizational decision-making will be significantly augmented to enhance decision-product quality, including considerable information integrity checking and persistence assurance. Moving proactively to develop and, especially, adopt products and service that could accomplish this will confer significant competitive advantage.

### Lessons Learned

Many lessons were learned on this Phase 1 project. We summarize six specific ones below. The sixth insight came from interactions with a Chinese delegation from the Hong Kong University of Science and Technology that came to mediaX for a workshop in September. They were exposed to the prototype ADE and provided answers to the question "Would you actually use this augmentation system?" Their feedback is summarized in item 6.

1. Potential users of Augmented Decision Systems require specific use cases and demonstrations to understand the basic value proposition. They simply cannot make the transition from abstract requirements and specifications to comprehending the ways that this technology could empower them. They have no other examples, beyond immersive virtual or theme-park environments designed specifically for entertainment. We found increasing enthusiasm and engagement with every step beyond abstract specifications towards a prototype that they could experience and a use case that was motivating and vital to them.
2. The real power of Augmented Decision Systems does not require super advanced AI or computing hardware, though it could be amplified through both. Its primary value derives from the simple recognition that the velocity and complexity of the accelerating information environment requires the systematic adoption and utilization of explicit decision-support tools. Once that information-velocity threshold has been achieved, the tools will evolve in concert with user needs.

3. Treating decisions as products is a dangerous proposition in most organizations. People are rewarded for good outcomes but often punished for bad outcomes caused by poor decisions. They want to take credit for good decisions and obscure the source of bad ones. An explicit process that ensures the long-term integrity of speech acts, positions, votes and budget decisions allows leaders to be second-guessed downstream. In failure-resilient Silicon Valley culture, this is a risk worth taking in exchange for faster and higher quality decisions, and a system of reliable continuous improvement.
4. Adoption will have to pass cultural filters. In failure-intolerant cultures, the last thing leaders want is full accountability—for the bad decisions as well as the good ones. This suggests two somewhat counterintuitive possibilities. First, American business culture, to the extent it can truly embrace failure and fast feedback on continuously improving decision processes, may have a powerful competitive advantage over more traditional technological competitors such as China, Korea and Japan. Second, technology companies embedded in more traditional, closed- decision, failure-intolerant cultures, have a real opportunity for breakthrough performance if they adopt augmented-decision processes with long-term information integrity. In fact, as exponential technologies progress and compound acceleration causes everyday events to become a blur, these may be the only companies in their cultural matrix that survive.
5. Augmented-decision environments will necessarily undergo a process of continuous improvement and evolution. We see a large competitive advantage for open-source application-integration frameworks, tools and data. This is not a political position but rather a technological one. In a hypercompetitive world with rapidly changing software technology, it makes little sense to get locked into specific software packages – particularly those a company develops internally. As Bill Joy observed, “most of the world’s smartest people work outside of your company”. So, the strategy that seems most competitive and resilient is to have an open augmented-decision systems-integration platform with an abstract software as a service (SaaS) API for every key function. This way, the decision to include a particular function or tool—argumentation maps, for example—is not tied to any particular argumentation-map application brand or software system. This allows the framework to track the Darwinian competition within each application class and have a low switching cost to adopting the best-in-class component in each category.
6. People who are not software engineers tend to be quite sensitive to an application’s immediate sensory, haptic and latency feedback. It has long been the case that software engineers tend to care more about the underlying power of the tools they build and tend to think of the ‘user experience’ as an afterthought to be optimized by others. Based primarily on feedback from a Chinese delegation’s participation in a mediaX workshop, in ADEs the high complexity of the underlying tools clearly ensures that the systems will not be used without a lot of attention to user experience and training, as well as simplification engineering. Thus, the focus of the next round of research will be a duel thrust on integration, and a seamless and intuitive user experience.

## Phase 1 Prototype Augmented Decision Environment

The Phase 1 Augmented Decision Environment prototype is implemented inside the Turf3D virtual-reality environment. One key strength of this system is that it provides users with an immersive virtual world for problem-solving and decision-making. Tools are posted in various types of web-browser screens and multiple tools can be invoked at once by users. The tools currently available are:

Argumentation maps from Bob Horn

Debategraph – dynamic argumentation map web service from

The R machine learning and statistical tool package

Web site of R Studio IDE

NodeXL for data visualization

A checklist of anti-biasing questions for decision groups

An active Stella simulation system web link and demo

A link to the Long Term Information Integrity Class site

Several images posters directly relevant the problem space

## Phase 2 Augmented Decision Environment

Some additional tools and deeper integration of current tools are needed. The additional tools include:

AI Planning Engine – EUROPA Platform for Planning, Scheduling, Constraint Programming, and Optimization

Assertion Representation – open format Horn clause triples in XML

Direct two-way linkage to the Long Term Information Integrity Database

Factual and Counterfactual Causal algorithms – based on work by J. Pearl

In addition to these tools, we need to provide an intuitive workflow interface and integrate the information flows via a unified data store to allow the toolset to share inputs, outputs and coordinated semi-automated execution.



## **Additional Reading:**

Statement of the Publish On Demand Research Theme

*<http://mediax.stanford.edu/POD/concept>*

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