AIAA Space Architecture Symposium
10-11 October 2002, Houston, Texas

AIAA 2002-6103

DESIGNING A THINK TANK TO STUDY DESIGN

dedicated to the memory of Arthur L. Loeb (1923-2002), founder of the design science program at Harvard University

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ABSTRACT

The reflexive challenge of designing a think tank to study and support collaborative design of space architecture can be inspired by evolution bootstrapping its own advancement. Design teams need ways to observe their design methods, assess their effectiveness and feed back assessment results into ongoing design development. This paper describes a think tank to study design, and its associated webtank (think tank on the web). Four applications needing this capability are illustrated: coordination and integration, distributed visualization, software design, and design education.

INTRODUCTION

NASA needs better capacity to coordinate and integrate complex design tasks. The design and construction of the International Space Station (ISS) is a project of vast complexity, not only technical and scientific, but also managerial, because of the participation of many stakeholders. One cause of the many obstacles to ISS integration and operation is NASA's need for methodologies to handle participatory complexity.

A second example of design coordination and integration is Mars mission design. As NASA plans future missions, such as the first human mission to Mars, it is readily apparent that NASA will need such methodologies not only to conceive, design, and build the mission, but also to operate it. Here scientists and technologists must integrate their skills and objectives to produce a coordinated strategy (Figure 1).

Beyond coordination and integration, a second application is distributed visualization. David Olynick, while working at NASA Ames Research Center, proposed how a think tank with such capability could be used for automated shape prototyping through integrated rapid simulation of different morphologies for reusable launch vehicles. Through low fidelity simulations of many alternatives early in the design process new hypersonic vehicle shapes could be designed at lower cost and in less time (Figure 2).

A third application for a design think tank is software development. Mark Shirley of NASA Ames Research Center has proposed how a high cost, labor-intensive software project, such as the design of spacecraft control for Deep Space I Remote Agent, might enable review and re-conception of the software design process. Mission-specific software products could provide case studies for engineering practice.

Engineering practice change would in turn lead to smaller design teams and to the development of reusable modular software design components (Figure 3).

FIGURE 1: Design coordination and integration in the conception of Mars missions.

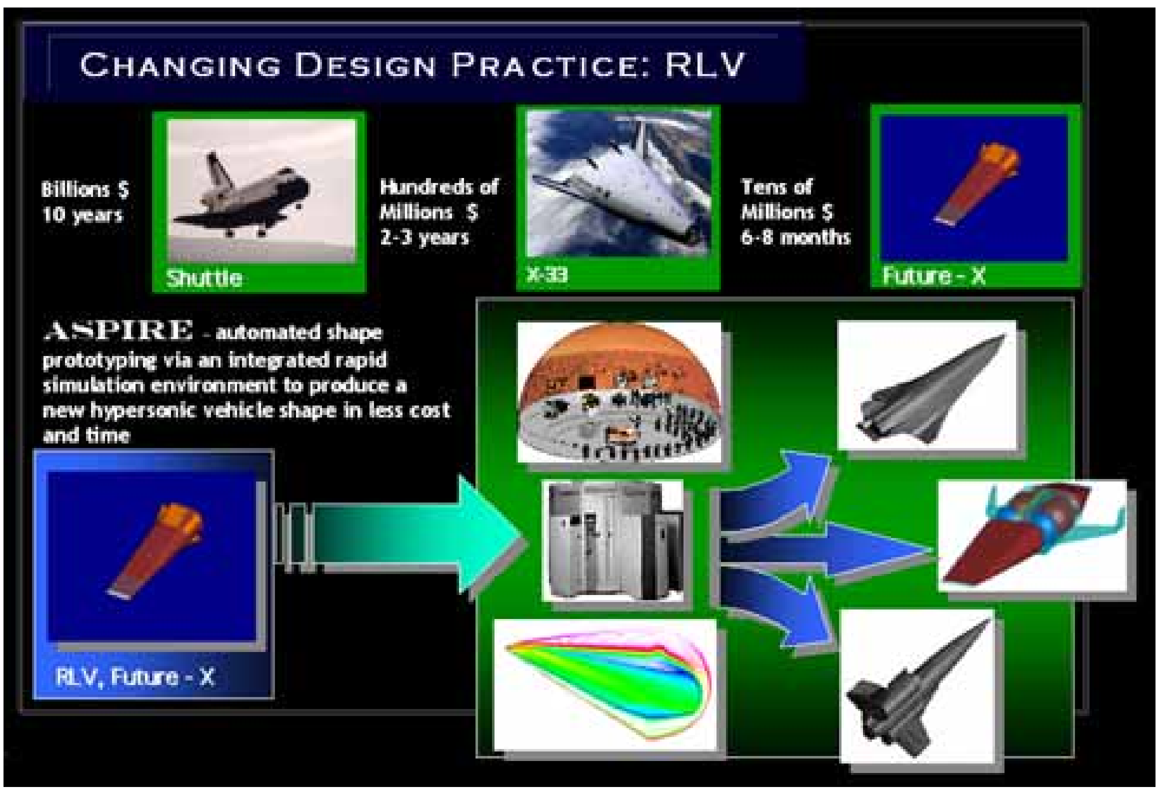

FIGURE 2: How a Think Tank could study design morphology (David Olynick).

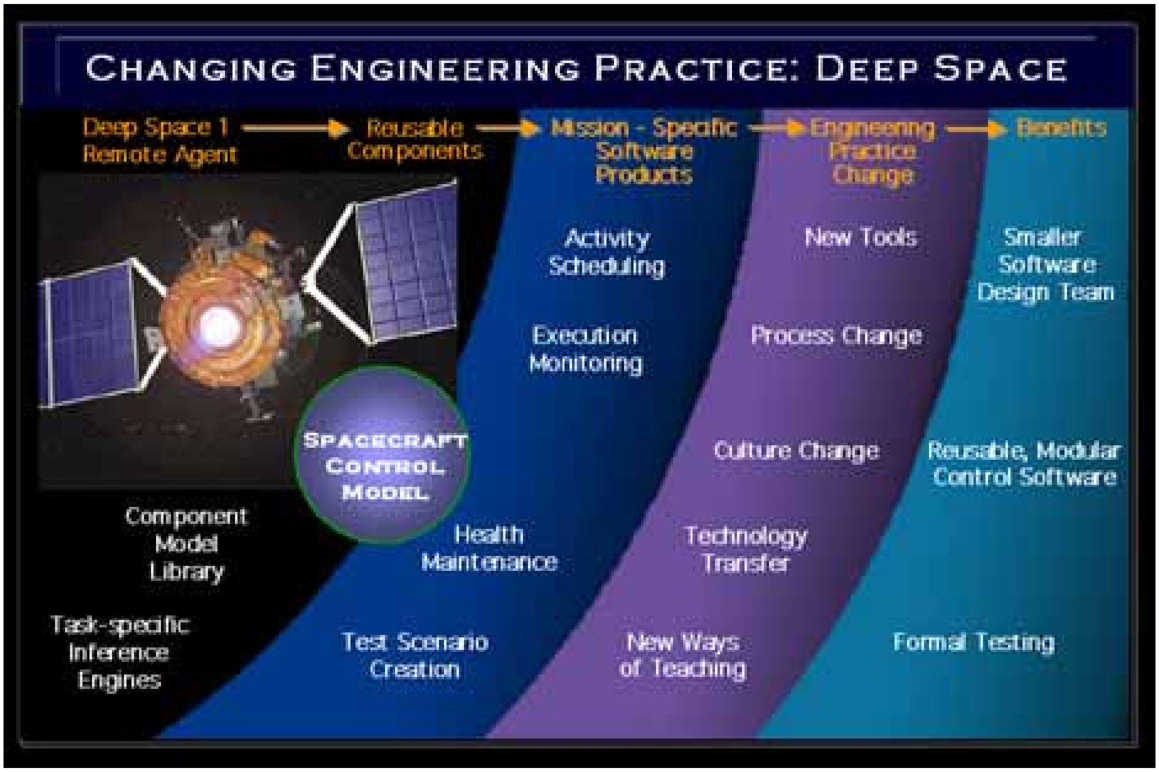

FIGURE 3: How a think tank could study the software design process (Mark Shirley).

A fourth application is design education. The SETI Institute has developed a cross-disciplinary web-enabled high school science curriculum (physics, chemistry, biology, evolution of technology) called Voyages Through Time in which students explore how the concept of evolution underpins and integrates these disciplines. The requirements of the last curriculum module, the Evolution of Technology, will be supported by a Collaborative Web Environment or "webtank." Two key components of this web-based support infrastructure are the TRACE Cognitive Process Model (pat. pend.) and webtank collaborative functionality.

Before implementing a webtank in a NASA mission-critical environment, I sought an application with "captive users" to test the effectiveness of the prototype. So I chose to initiate development of the webtank to support the SETI curriculum high school student teams as they designed their final projects in teams. I also wanted to explore, with free-wheeling younger users, how the webtank can be a vehicle to enable a bottom-up, bio-inspired methods for space design.

The term *webtank* connotes a web environment to support think tank and collaborative design activities. Webtanks enable distributed design teams and can use available internet technologies and bandwidth. Figure 4 shows the webtank graphical user interface designed for the SETI Institute curriculum. Figure 5 shows user flexibility to choose the ordering of the stages of the TRACE cycle.

This webtank is designed to support collaborative design tasks. The webtank offers guides, frameworks to facilitate design collaboration, and knowledge management repositories, providing designers feedback for "learning by design." The webtank can be a petri dish in which to culture and study design, and so complement traditional work process modeling. Since tools based on modeling existing work processes cannot enable users to conceive how a new generation of tools could lead to work process change, the webtank provides a testbed to study the design process.

FIGURE 4: WebTank Graphical User Interface.

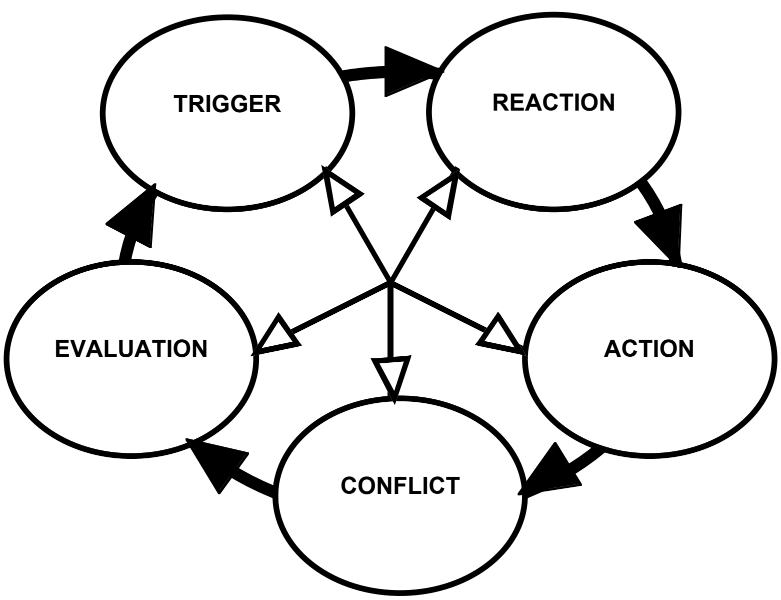

FIGURE 5: Cyclic interaction of the five stages of the TRACE model.

The capacity to design a webtank to evolve its functionality in response to its users will not only be critical to support think tanks of the future; it is also a “terrestrial analog” for intelligent systems capabilities needed on space missions. Documentation of webtank collaborative problem-solving sessions, self-assessment of performance, and adaptive response will together support emergent intelligence in this distributed system.

The SETI Institute established a systematic method, using external contractors for pilot testing, and later field testing, all elements of the *Voyages Though Time (VTT)* curriculum. Pilot testing of the SETI curriculum and Version 1.0 of the webtank was completed in 2001. This input is being used to design the webtank field test. Anticipated future functionality includes:

- knowledge management across projects and disciplines and through time;
- gathering process data that can be archived and retrieved, by humans and/or intelligent agents;
- cross-disciplinary design innovation through collaborative scenario-building;
- design through low fidelity simulation and comparison of alternatives;
- simulation of the impact of technology insertion into an integrated design project; and
- rapid response where collective action by diversely skilled human/ agent teams is needed to address complex design problems.

TRACE COGNITIVE MODEL [PAT. PEND.] AND KNOWLEDGE PROCESSOR

The five stage TRACE cognitive process model provides a system framework for discovering, developing, exchanging, applying, and integrating design knowledge in individual or group design tasks. The user interacts with the system in a question prompt and response mode via the user interface, which is coupled to the TRACE Knowledge Processor.

This framework provides a system and method for individually adapted learning, project design development and knowledge management, enabling asynchronous collaboration among users of its knowledge processor.

The TRACE cognitive process model can be embedded in software or web-based systems that supply a general template with prompts to aid the user in complex creative tasks, such as preparing a plan or designing a project. The process model enables users to generate and organize ideas, and to present their results in a format that is easily searchable and accessible as a resource for future users of the system. The process model also enables users to organize ideas for innovation and communication with collaborators or for assessment by team leaders or instructors. It provides a system and method for individually adapted learning, project development and knowledge management, as well as enabling asynchronous collaboration among users of its knowledge processor.

As the face / vase toggle button in the GUI shows, the webtank will serve two complementary functions. It offers process support for invention and collaborative problem-solving (active mode), and provides a knowledge management framework for information resources and project archives (passive mode). Users can click back and forth between active and passive modes (Figure 6).

Imagine having the capability to easily toggle between information resources and speculative design experiments. For example, Peter Gage an aeronautical engineer at NASA Ames Research Center, is designing reusable launch vehicles for space probes. To avoid the great cost of building a full scale prototype for testing, design engineers aim first to narrow the field of best options. Through many low fidelity simulations of alternative shapes, they select the few best, which are then simulated at high fidelity. Thus cost is reduced and the likelihood of an optimal design increased by first simulating many

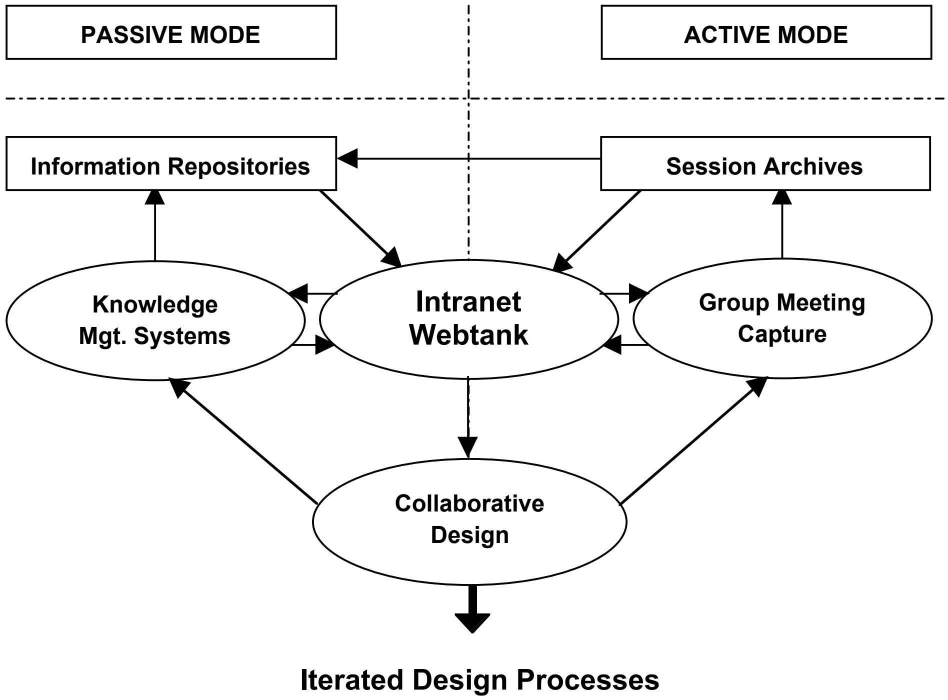

FIGURE 6: Webtank structure: passive / active modes.

alternatives at low fidelity, then a few at high fidelity before building a physical prototype.

Gage noted "the important change to me is that designs are less static and more reconfigurable, both while being designed and after they are in service. If we don't finish preliminary design years before production, but keep re-evaluating decisions in the light of new information, we can retain flexibility. We abandon the idea that design is ever finished; we can reconsider requirements throughout the life cycle and make design changes when necessary. To do this, we certainly need to archive the full history of the design and exploit simulation to capture the important effects. We don't need perfect simulation before construction, we need adequate simulation throughout the life cycle."

Figure 9 is an architectural block diagram illustrating the five stages of the TRACE cognitive process model and its associated knowledge processor.

The five functions of the knowledge processor are very basic and pragmatic. We need to record changes and when they were made, a way to filter or rate their importance relative to the completion of the overall design task, a way to cross-reference how one change impacts other design features, and finally the capacity to optimize through integration.

Having discussed applications and functions for a think tank to study design, let's move from pragmatic considerations of *what?* and *how?* to consider *why?* a design think tank is important and why it could change the way we do science and the way we think about design, bringing these two ways of thinking closer together.

This link gives new meaning to the term coined by Buckminster Fuller – design science. Design simulation complements traditional scientific method, offering another way to generate new hypotheses.

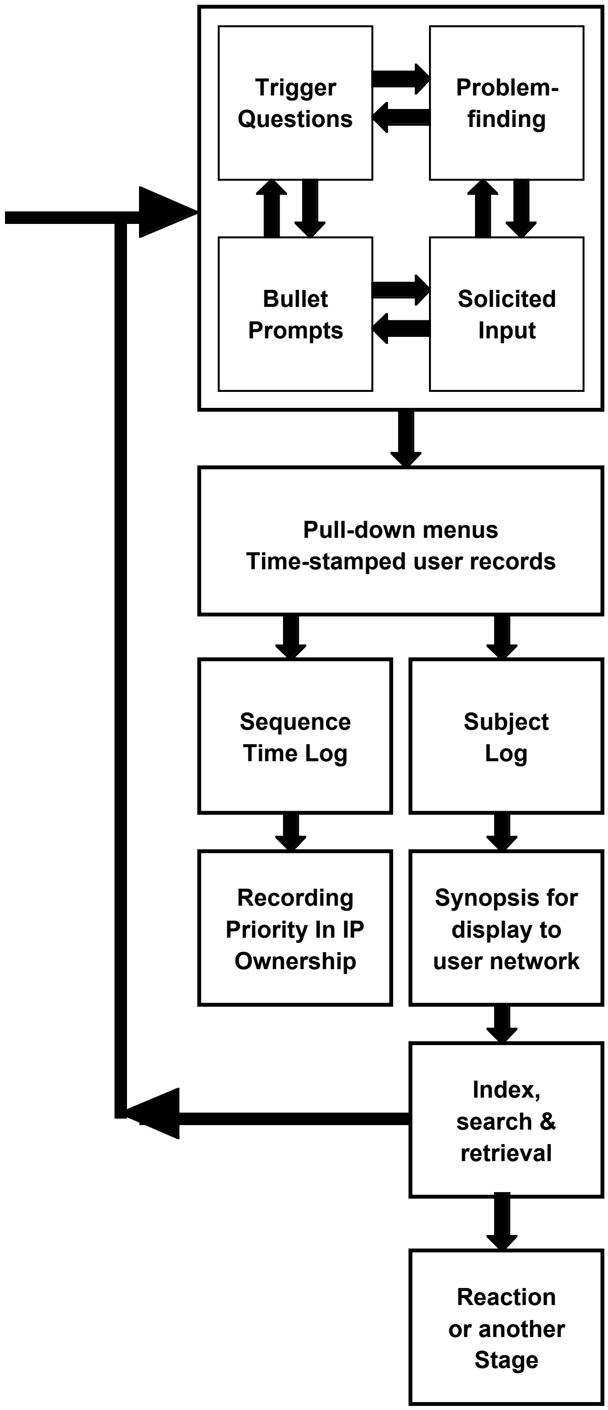

Figure 7: Flow diagram illustrating stage one, Trigger, of the five-stage TRACE cognitive process model.

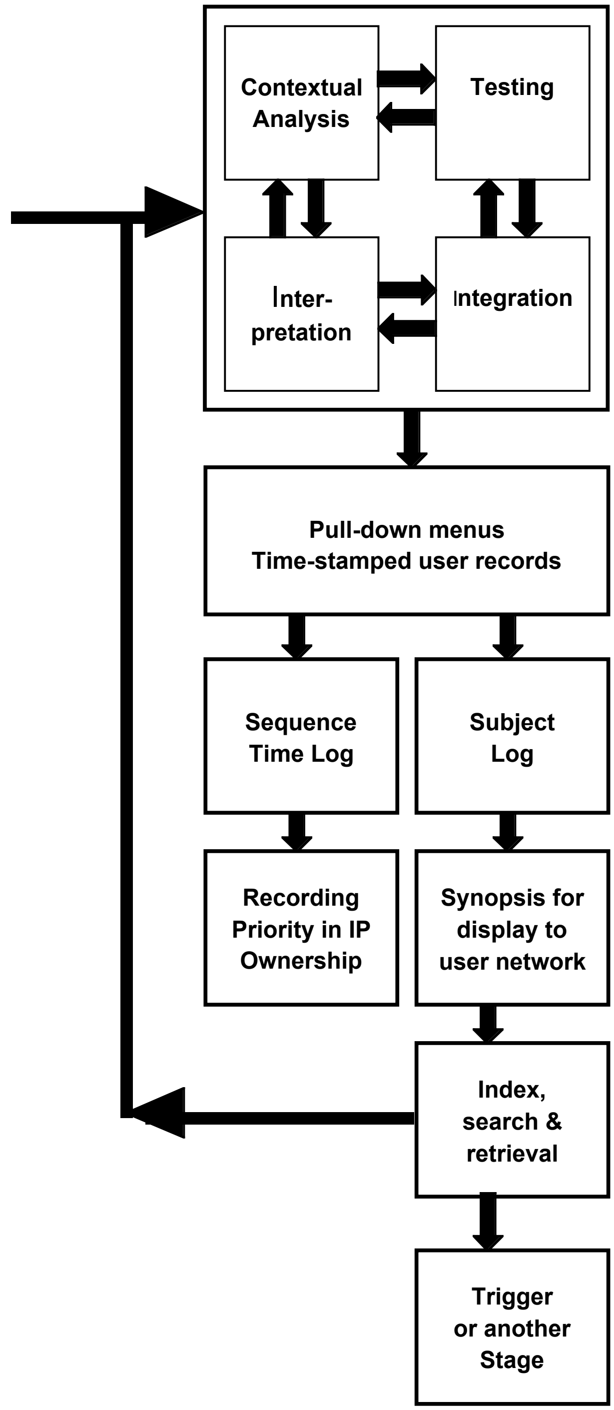

Figure 8: Flow diagram illustrating stage five, Evaluation, of the five-stage TRACE cognitive process model.

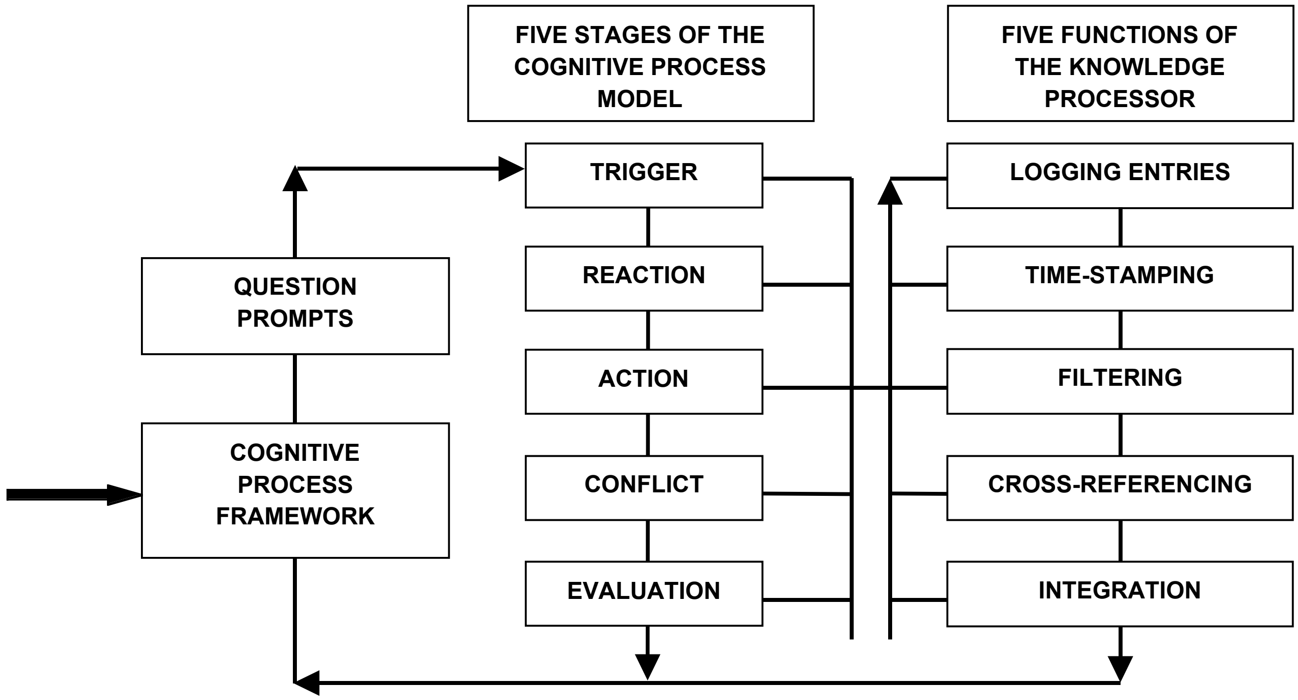

FIGURE 9: TRACE cognitive model and associated webtank functionality.

Whether a scientist is looking for turbulent airflow around a new design for an aircraft, or for anomalies in visualized star patterns, the scientist is using his/her visual recognition capabilities to identify patterns in visualized data, working more like a designer than ever before.

As we rely more and more on simulation we face a question: Through simulation can we construct, and so gain knowledge of, reality? How do we prove that our hypotheses are correct and that what we think we have discovered corresponds to the external reality that we have tried to simulate? How can design be a tool for thinking and speculating about the future?

COMPUTING AND SPECULATION

Designing a think tank and associated webtank to study design has potential broad implications. What if you could say "what if?" and see the idea you imagine? The art of speculation is today enhanced by advanced visualization and simulation tools that can take our hypotheses and play out scenarios based on them. More than twenty-five years ago Heinz von Foerster defined *cognition* as "computing descriptions of a reality." (Von Foerster, 1973) *Computing* (from the Latin com-putare) means *to contemplate things* (putare) *together* (com). Von Foerster, with uncanny accuracy, predicted the potential future role of computer-supported Collaborative Problem-Solving Environments (CPSEs) in design.

When computer scientist Dan Cooke joined NASA to head up the Intelligent Systems Program, he said that what attracted him to the job was that NASA had the grand challenges that can motivate the next generation of computer scientists.

The problems he referred to are not the ones generally associated with journeys into space: propulsion, navigation, food, processing, waste and recycling resources, living in microgravity, establishing bases in hostile conditions. The problems Cooke referred to lie on the intellectual frontier of sending unmanned missions into space. If manned exploration is pushed forward to, say, 2020, the next twenty years of exploration will be undertaken by semi-intelligent, semi-autonomous creatures that we design. How will we design them?

Creating intelligence capable of solving the problems that space travel poses will force us to sharpen our design tools and hone our understanding of what intelligence is by looking at what it does. On future unmanned missions into space will tiny, dumb robots, each with a single skill, collaborate like ants to accomplish complex tasks requiring higher intelligence than any robot alone can muster? Like cells, will they form a community and specialize? Will collapsible robots self-erect in space? Will dumb robots "get input" and start to learn? Will there be conflict, struggles for domination? How will these robot communities coordinate their activities? And, as they encounter new design challenges, how will they evolve? Given the right kit of parts and rules, will they be able to design themselves?

Computer scientist Jordan Pollack pushes the boundaries between non-life and life through artificial life robotic simulations that experiment with design as a process of non-goal-directed evolution, showing how life might evolve itself: "We first define life as a dynamical process, far from equilibrium, which creates a local reversal of entropy. Life dissipates energy and creates informational structures." Pollack maintains that, "electronic life is a new scientific field of critical importance to understanding life, as it has been, and as it could be, here and on other planets and inside virtual worlds. E-life will allow us to engineer systems that can adapt, reconfigure, and autonomously operate as cost-effectively as human labor." (Pollack, 2001)

This implies designing a creature that, once born, will learn from us but eventually grow to adolescence, rebel, and thereafter insist on making its own decisions. What will we learn by trying to design robots that can make their own decisions on the fly and learn from their mistakes? This is a much more difficult design challenge than if the robot is given a goal and simply preprogrammed to carry out its task. As designers, we cannot predict the future; the act of predicting creates its own paradox. (Gill, 1986)

So we need new design strategies, modeled on biological evolution. Yet there are hazards in modeling evolution. For biologists, replication, and evolution arising from the ability to replicate, underpins all the wonders of life. But as computer scientists speculate on the future, fears arise that this same foundation of all life could also lead to our extinction. In "computer networking … the sending and receiving of messages creates the opportunity for out-of-control replication … The 21st century technologies – genetics, nanotechnology, and robotics (GNR) – are so powerful that they can spawn whole new classes of accidents and abuses. Most dangerously, for the first time, these accidents and abuses are widely within the range of individuals or small groups. They will not require large facilities or rare raw materials. Knowledge alone will enable use of them.

"Thus we have the possibility, not just of weapons of mass destruction but of knowledge-enabled mass destruction (KMD), this destructiveness hugely amplified by the power of self replication."

This prospect leads Bill Joy to a sobering reflection: "Failing to understand the consequences of our inventions while in the rapture of discovery and innovation seems to be a common fault of scientists and technologists … As this enormous computing power is combined with the manipulative advances of the physical sciences and the new, deep understanding in genetics, enormous transformative power is being unleashed … But now, with the prospect of human-level computing power in about 30 years, a new idea suggests itself: that I may be working to create tools which will enable the construction of the technology that may replace our species. How do I feel about this?" (Joy, May 3, 2000)

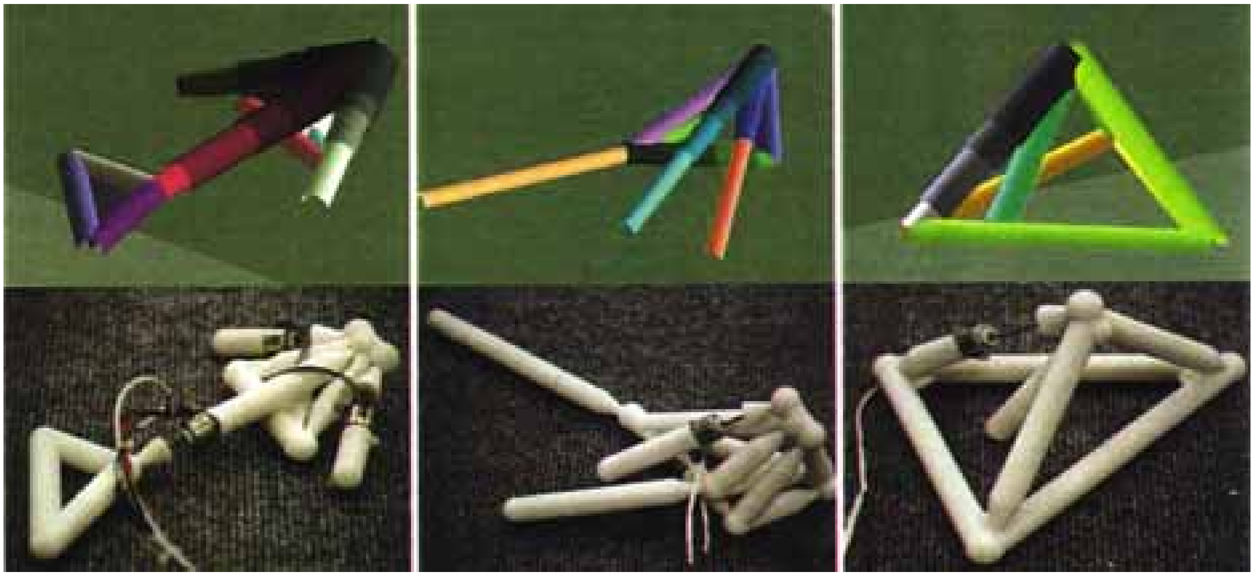

FIGURE 10: Lipson and Pollack. Simulations of self-designing robot strategies for locomotion. Dynamic and Evolutionary Machine Organization Lab, Brandeis University

FROM SPECULATION TO CHOICE: DESIGNING OUR FUTURES

What if our design hypotheses about the future affect our behavior and so determine how the future actually unfolds? This question generally divides people into roughly into three camps. Some think our opinions don't matter. Our planet is following its course in an objective universe, regardless of what we think. Others think that our opinions matter only relative to human issues, the outcome of an election for example.

But the third camp takes the really risky position. This third camp believes that our opinions matter a lot – that they matter outside the realm of human issues and can have a profound effect on the physical future of our planet and all of its lifeforms. Will we discover that any of the 10,000 stars within 100 light years of us are other suns with other life-filled planets? If we don't believe it's worth looking, discovery is less likely. The problems we believe are important determine how we explore new frontiers, whether in space or in the search for understanding. So then our opinions matter.

This third camp argues that if we don't believe global warming is a threat, we will do nothing to combat that non-threat. If we believe (or don't believe) that humankind has a future elsewhere in the universe, these beliefs will determine how we expend resources and channel our design talent, and in turn determine our future. (Gill, 1986)

So turning opinions into speculative design acts can play a role in creating real futures. For example, if we believe that Mars could become a habitable planet, scientists and engineers will conduct research on how to make it habitable, exploring ways to terraform Mars. If we don't believe it, we won't conduct the research that could make it a reality. And if we don't conduct this research on how to terraform Mars, we may not appreciate the elegant intricacy of our present habitat on Earth. Trying to make Mars into a pleasant, livable place like Earth could teach us a lot. Possibly we will only understand our Earth when we try to copy it on Mars.

How will we identify life and intelligence in other worlds? Will we know what it is by recognizing it, by communicating with it, or will we only know what it is when we can design it?

On July 4th,1997, the day the Pathfinder mission landed on Mars, the NASA Mars website had

100 million hits. The Pathfinder landed in a water runoff channel using its experimental bounce-and-tumble air-bag landing system. Its little (10kg) robot Sojourner wandered about the landing site looking at rocks with its camera and chemical analysis spectrometer. But when the Pathfinder's communication system failed, poor little Sojourner was programmed to circle, waiting for new instructions that never came. How can we design a smarter robot that can revise its plans in such an emergency?

Fifty years before Sojourner began to circle, awaiting her next instruction, Alan Turing anticipated the need to develop fallible machines that could learn from their mistakes. He proposed incorporating a random element into their design as a prerequisite for "a learning machine" and as a way to avoid having to specify all contingencies in advance. This would allow the computer to take a wild guess and then (in good evolutionary form) to reinforce or discard the guess based upon how the guess played out. Turing saw intelligence as analogous to "the genetical or evolutionary search by which a combination of genes is looked for, the criterion being survival value." (Dyson, 1998)

A hundred and fifty years before Sojourner began to circle, Charles Babbage, (1792-1871), designer of the Analytical Engine, the forerunner of the modern computer, anticipated the role of singular anomalies when he described how the design of intelligence required something wholly new (a rule not implied by anything preprogrammed) to be created out of the rules-action-feedback cycle. Babbage alluded to "miracles" and similar unpredictabilities in his *Ninth Bridgewater Treatise* : "The engine . . . may be set, so as to obey any given law; and at any periods, however remote, to make one or more seeming exceptions to that law." (Babbage, 1899)

The fact that Charles Babbage, a century before the technology to realize his concept, could have "out of his mind" designed the concept of the computer illustrates the power of conceptual thinking. The computer was an idea, a "what if" speculation, before it ever existed as an operating machine.

The design of intelligent robots demands a whole new way of thinking about thinking, and a new paradigm for design. It forces us to question what intelligence is and why it is coupled with life.

We've now come full circle, back to our original challenge: How do we design the think tank and webtank environments through which constructive innovation can be supported and through which desirable futures can evolve? NASA (the U.S. National Aeronautics and Space Administration) is now exploring the design of new contexts for cross-disciplinary collaboration. (Gill, 2001) The goal is to facilitate the design process, rather than predicting outcomes. In a "think tank" environment cross-disciplinary groups brainstorm new ideas for NASA research, technology, and mission design.

Webtanks (think tanks on the web) and other forms for Collaborative Problem-Solving Environments (CPSEs) will extend the application of new visualization and simulation tools to support speculation. CPSEs can be petri dishes in which to explore future directions for research and technology development and to capture and analyze those design sessions in order to refine the tools that support them. CPSEs must co-evolve with their users, adapting to and learning from, each problem-solving challenge. (Gill, 1999)

What if individual design (which we can't observe) has its parallel in group design, where the design process can be observed? Where we cannot see into the individual creative mind, webtanks and CPSEs enable "invisible observers" to capture collaborative design in action in order to study these process dynamics as we build new contexts to support them. (Hutchins, 1999)

When Werner Heisenberg recounted a series of conversations that revolved around discoveries in atomic physics in his time, he noted that in transcribing these conversations "careful attention has been paid to the precise atmosphere in which the conversations took place. For in [this context] the creative process of science is made manifest." (Heisenberg, 1972) Perhaps, if careful attention is paid to the context in a web / CPSE situation when a pivotal “conversation” occurs, we may generate new hypotheses about how the design process operates and how to cultivate new contexts to support it.

Eddington once asked: "Who will observe the observers?" (Eddington, 1939) Today we might push his question one step further to ask: Who will interpret what the observers observe? Each simulation is itself an interpretation of the “reality” it models.

Today, CPSEs demand that we revise von Foerster’s dictum: “If you desire to see, learn how to act” to “If you desire to see, learn how to simulate.” You then *see* your design in a visualized simulation, which *acts* out a scenario based on your set of hypotheses.

For example, biophysicists at NASA Ames are studying the origin of life by observing computer simulations of how simple proteins, peptides, organize themselves to perform basic functions required for life. To study how these molecules can organize themselves, the team used the oil/ water interface as an analog to the environment of a cell membrane. The simulation started from a description of the forces acting between atoms; Newton's Laws of Motion were then used to follow the movements of the atoms that resulted from these forces. The movements of the many atoms were then visualized to enable the team to see, qualitatively, the results of the simulation.

The combination of advanced computer simulation and visualization offers a new perspective on the scientific method, which makes scientists more akin to designers and transcends the traditional dichotomy between theory and experiment:

First, as in traditional scientific method, hypotheses drive simulations. However, here the simulations are completely specified by their underlying hypotheses. By acting as an interface between scientists and their hypotheses, simulations allow scientists to propagate their hypotheses forward in time, exploring the causal relations they induce. So, for example, micro-scale hypotheses made about how atomic forces vary at different distances nest within macroscopic hypotheses about the overall behavior of the system. While it may not be possible to verify micro-scale details through experiment, macroscale behaviors usually can be checked experimentally; in this way simulations can validate hypotheses.

Second, visualization enlists scientists’ pattern recognition capabilities, revealing structural characteristics that the scientists could not see in the data alone. Humans have evolved exquisitely complex capability to identify and analyze visual patterns. Visualization harnesses these capabilities to analyze complex, multi-variate data sets, e.g. for the movements of atoms. Since the outcome of a scientific simulation is by no means a foregone conclusion, the ability to discern structure is essential. So visualization (i.e. the representation of the simulation) is a discovery tool.

Finally, the results of simulations sometimes surprise scientists, triggering ideas they might not have recognized were implied by their hypotheses. Simulation of peptides at the interface between water and oil led the scientists to break out of their traditional mindset that a protein is a crystal structure frozen in time; the simulation characterized proteins as highly flexible, adaptable structures. Scientists had assumed that proteins fold like a zipper from one end to the other. Instead, after a false start, in the simulation the protein folded from both ends. Once folded, the protein did not stay in an alpha helix; it shifted back and forth between an alpha helix and a 3-10 helix, equally in equilibrium in both structures.(Michael New, Andrew Pohorille, 1999-2002)

Computer scientist Chris Henze has developed software that makes it possible to visualize in virtual reality on an immersive workbench how atoms form themselves into molecules. His design tool for developing new nano-structures, Virtual Mechanosynthesis (VMS), couples molecular dynamics simulation to an immersive display. “Mechanosynthesis” refers to the challenge in nanotechnology to develop mechanisms capable of placing individual atoms in precisely defined positions (nanoassemblers).

FIGURE 11: Chris Henze. Virtual Mechanosynthesis, a tool for design visualization.

The user points the wand at the atoms, moving and combining them into complex structures, where the software constrains the field of possibilities to those theoretically possible in the real world.

VMS, by enabling researchers to try out and debug complex assemblies, allows simulated experiments for the creation of plausible atomic designs. (Henze, 1999 – 2002)

Another computer scientist, Chuck Jorgensen, has developed an Intelligent Flight Controller (IFC) neural network software that can rapidly adapt flight control to a changed aircraft configuration. This tool can be used to design controllers for pre-prototyped aircraft, making it possible to fly those simulated devices on simulated terrain, so designers can test new designs before actually building or flying them. (Jorgensen, 1999 – 2002)

Can we also try to simulate our possible futures? Nobel laureate Christian de Duve reflects: "There is no reason why we should view ourselves as the pinnacle of a process that still has another five billion years to go. What form the next step will take, even what extant species will be involved, are unanswerable questions.

"What will be recognized tomorrow as a fork organism is a mere terminal twig on the tree of life today. de Duve arrives finally at the metaphysical view that the universe is profoundly meaningful, in that its structure epitomizes thought and the ability to reflect upon itself." (de Duve, 1995)

Marine biologist and former Chief Scientist of NOAA (U.S. National Oceanographic and Atmospheric Administration) Sylvia Earle asks: "Could certain microbes, now occupying highly specialized, restricted niches, find the conditions we are creating more favorable — and enjoy population explosions that trigger other events inhospitable to us? Changes in the sea in the past few decades should command our rapt attention -- the sort of interest one might take in, say, the life-support system of a spacecraft housing all of the past, present, and future of humankind." (Earle, 1995)

And Chief Scientist of Sun Microsystems Bill Joy muses: "People who know about the dangers still seem strangely silent. When pressed, they trot out the 'this is nothing new' riposte — as if awareness of what could happen is response enough. . . . They complain, 'Your worries and your arguments are already old hat.'" (Joy, May 3, 2000)

Perhaps, then, it is not new arguments but a whole new design approach that we need. Speculation and simulation may support that approach.

Late in life the great animal behaviorist Konrad Lorenz offered an optimistic vision: there were in his view definite signs that a self-recognition of all cultural humanity, a collective self-knowledge derived from natural science, was beginning to spring up. He believed that if this movement grows, human intellectual aspirations and energies will be raised to a higher level of integration, a "creative flash" of reflection and meditation. And he noted that a reflecting, self-investigating culture has never yet come into being on this planet, just as objective science did not exist before the time of Galileo. (Lorenz 1977)

How can we begin to speculate about our many possible futures from a new perspective, a perspective that is more than an argument, more than the marshaling of evidence, the designer's perspective, which can produce new concepts and integrated, cross-disciplinary innovation?

Whether or not laws of science are invariant, as in the rules of chess, there is certainly the uncertainty of the changing style and opinions of the designer, which contributes to the outcome of the game.

As Werner Heisenberg said, "Natural science does not simply describe and explain nature; it is part of the interplay between nature and ourselves; it describes nature as exposed to our method of questioning. This was a possibility Descartes could not have thought, but it makes the sharp separation between the world and the I impossible." (Heisenberg 1958)

Physicist James Jeans, more than seventy years ago, wrote: "The universe begins to look more like a great thought than a great machine. Mind no longer appears as an accidental intruder into the realm of matter. . . . the old dualism of mind and matter seems likely to disappear. . . through substantial matter resolving itself into a creation and manifestation of mind." (Jeans, 1930)

Why, in a paper about designing a think tank to study design, do I quote these grand old giants of science and technology, who spoke decades ago? I am making a case for the role of design in conceiving and simulating our futures. Charles Babbage, Arthur Eddington, Werner Heisenberg, James Jeans, Alan Turing and others were conceptual designers with uncanny insight far ahead of their time. They saw the problems and possibilities we now face. If today we all have our noses to the grindstone, doing the next scientific experiment or designing the next space habitat or tool, we may miss the chance to see the future realities that our experiments could support and that our tools could be designed to sculpt.

If as a society, we accept uncertainty, we will worry less about defining the future as a goal. Instead we will examine carefully the criteria by which we are designing our way from the present into the future. What are our values? How do these values affect our design actions? What "moral imperatives" have we perhaps taken for granted as defining our possible futures? What "singular anomalies" that could trigger great change have we perhaps ignored?

Our journey into what de Duve has called "the Age of the unknown" will be driven by our innate curiosity, our unique ability as designers to speculate, and by thought itself evolving.

So we must respect prediction as an attempt to interpret the present in full awareness that our interpretation will have an impact on future possibility. And we must acknowledge prediction's uncertainty: the future does not yet exist for us to observe or predict; it awaits our design …

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ACKNOWLEDGMENTS

I would like to acknowledge the very helpful comments of Dr. Marc Cohen, Advanced Space Projects, Center for Mars Exploration, NASA Ames Research Center on several early drafts of this paper. Also Dr. David Olynick for Figure 2 and Dr. Mark Shirley of NASA Ames Research Center for Figure 3. Dr. Jordan Pollack of Brandeis University for Figure 10.

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DEFINITIONS AND TERMS

TRACE Cognitive Model (pat. pend.) — a model to support the design process consisting of five phases: Trigger, Reaction, Action, Conflict, and Evaluation.

Webtank — collaborative web environment (think tank on the web).