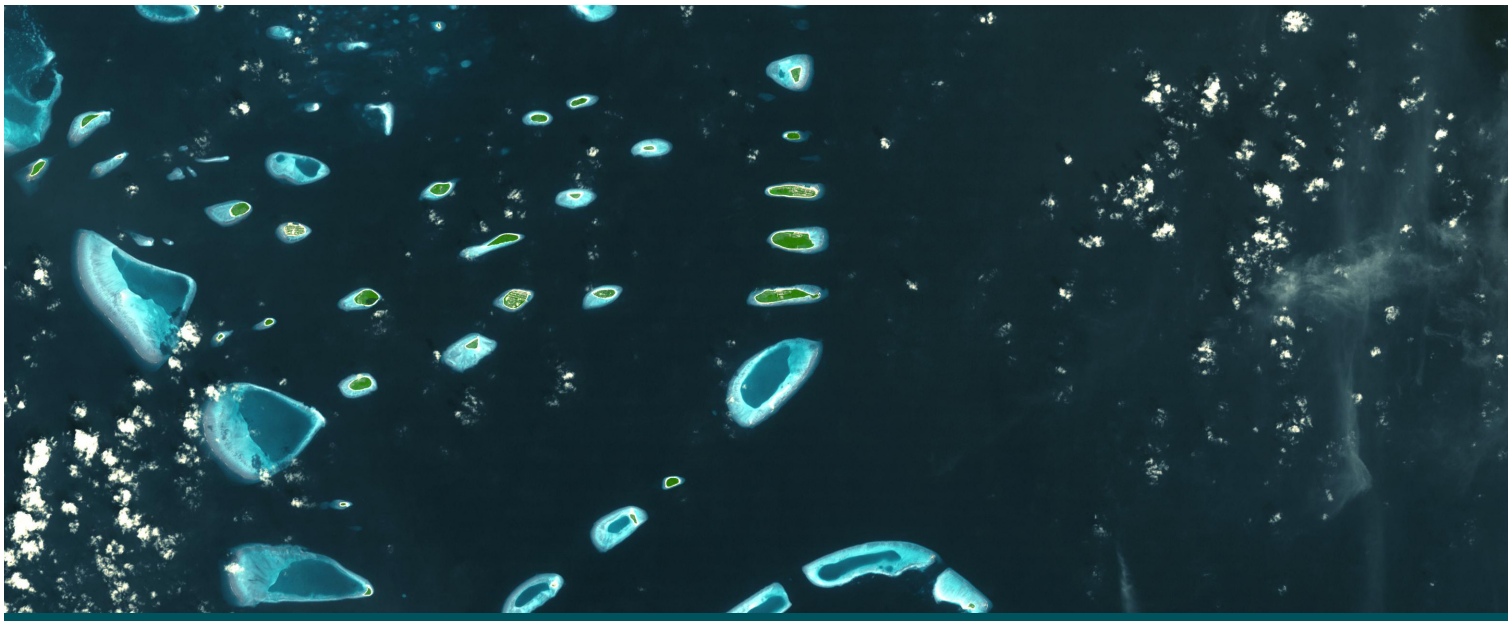
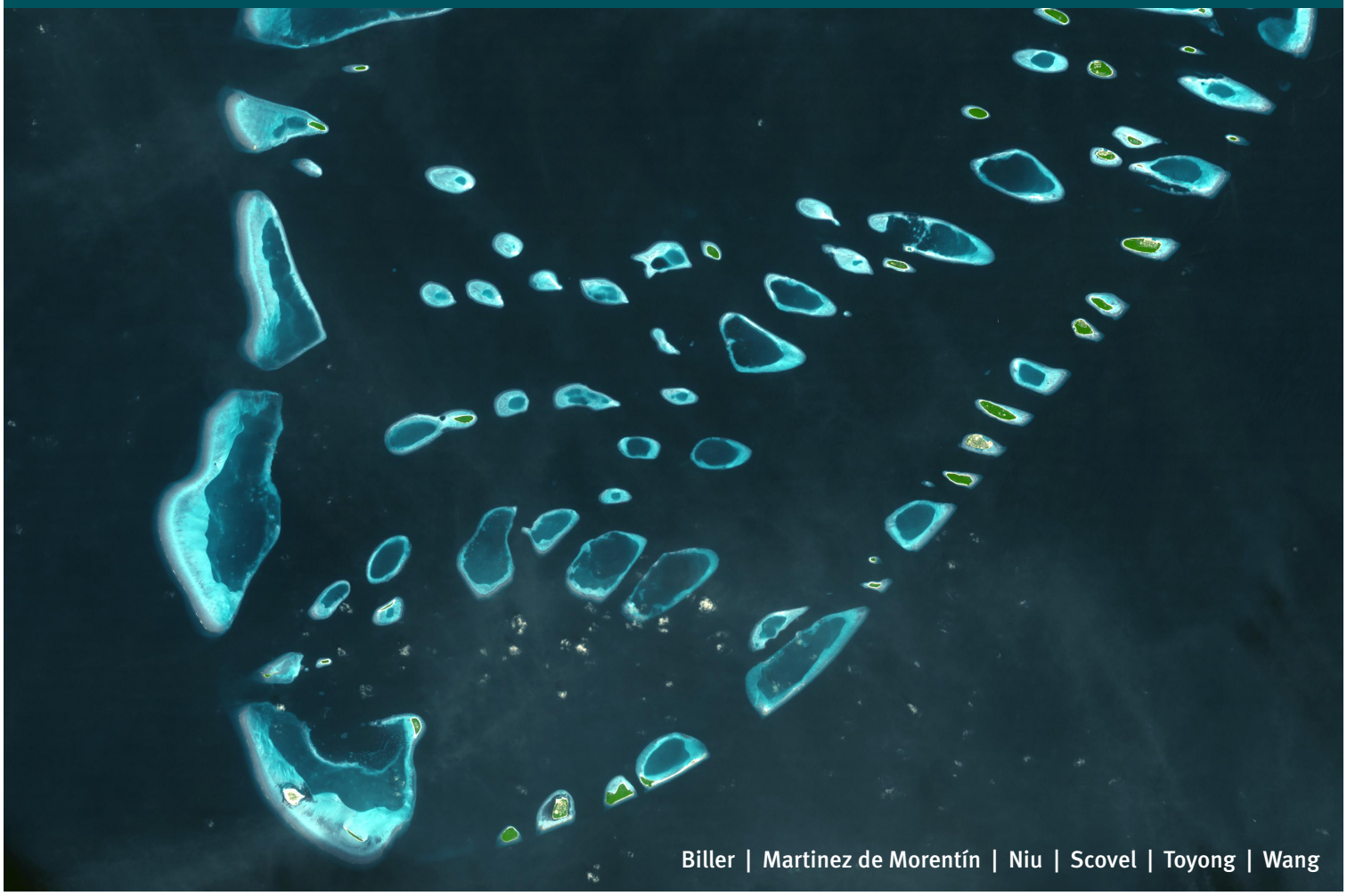


ID 589: Systems Workshop Fall 2006

Massive Change: Living in a World with Rising Seas



Biller | Martinez de Morentín | Niu | Scovel | Toyong | Wang

Cover photograph: **Malosmadulu Atolls, Maldives**
NASA/GSFC/METI/ERSDAC/JAROS, and U.S./Japan, ASTER Science Team
http://visibleearth.nasa.gov

Massive Change:
Living in a World with Rising Seas

Table of Contents

Photograph: **The Blue Marble**
Reto Stöckli and Robert Simmon, NASA Goddard Space Flight Center
http://visibleearth.nasa.gov

Preface

Background

Over the next century, it is expected that sea levels may rise as high as one meter, causing enormous damage to the environment, as well as debilitating the infrastructure of many coastal cities. Currently 15 of the world's 20 megacities (including Los Angeles, London, Karachi, and Tokyo) are located in coastal regions. As the seas rise, increased weather activity such as intensified hurricanes and more frequent tsunamis will threaten as many as 230 million people.

This "slow motion" disaster affects a variety of topographies. In addition to coastal megacities, low-lying nations such as the Maldives are in danger of being entirely engulfed. Countries such as Bangladesh, which are located on river deltas, are in danger of heavy flooding as the tides rise.

One of the major environmental factors responsible for the rise in sea levels is thermal expansion. As the ocean warms, the water expands, accounting for as much as a 1mm rise each year over the last several decades. Working in tandem with thermal expansion is the melting of glaciers, polar ice caps, and continental ice sheets. If the Greenland ice sheet should melt, for example, sea levels would rise by approximately seven meters. Add to that the melting of the Antarctic ice sheet, and we would be facing an even more disastrous scenario where sea levels could rise nearly 70m!

The impending rise in sea level leads to many issues and complications, including:

Loss of Ecosystems

Ecosystems are supported by delicate interactions among plants, animals, and microorganisms. These systems will fail if they do not remain in balance. As the sea level rises, fauna is forced to migrate to higher elevations, altering established ecosystem patterns. The ecosystem is further strained as salt from seawater mixes with the soil and encroaches on the land.

Damage to Infrastructure

The infrastructure of a city is under threat from rising seas in two ways. In the short term, natural disasters can ravage the buildings, transportation systems and internal structure. This damage extends beyond physical structures into economic hardship, loss of life and psychological trauma. Over the course of the next century, without proper measures, the rising seas will permanently invade dense human population centers.

Increased Threat from Tsunamis and Hurricanes

Warming ocean waters lead to increased intensity from extreme weather events. And as sea levels rise, storm surges increase exponentially in height. This same principle makes tsunamis even more deadly as well.

Preface

Salination of Soil
In a natural process, the soluble mineral salts near the surface of soil will push capillary flow of water from the ground. When sea levels start to rise, along with the general increase in land temperature, soil processes will undergo a massive transformation. The rate of surface evaporation causes water to be drawn from rising saline water table, resulting in accumulation of salt that is left behind. As the concentration increases, the land eventually becomes toxic to plants.

Damage to Agriculture
Damage from sea level rise will be devastating to agriculture as it impacts the industry both directly, through loss of land, and indirectly by changing the environment on which it subsists. Sea level rise contributes to agriculture land loss through inundation of low-lying lands particularly in the South East Asia region. Some, formerly fertile coastal land will need be surrendered with the intrusion of salt water into freshwater supplies normally used for irrigation.

Coastal Erosion
This form of erosion typically occurs due to the force of incoming tides and currents. It occurs when the amount of sediment deposited is less than the amount carried away. Coastal erosion reduces the natural beach buffer zones which help to dissipate tidal energy and protect communities against incoming storm activity.

Environmental Refugees
Current populations living in river valleys, levied flood plains, seaboard cities, and low plateau lands are at risk of being inundated as the sea levels rise. This would lead to the unparalleled relocation of entire populations. Without international cooperation, millions of people may end up homeless as environmental refugees. The United Nations predicts that 50 million people worldwide will be displaced by 2010 because of various environmental changes, a major factor being sea level rise.

Photograph: **Mekong Delta**
by Farl
http://www.flickr.com/photos/colloidfarl/148800272/

About Structured Planning

The Process

The semester-long Systems and Systematic Design course is a project-based course in which teams of graduate students, deliberately of mixed international origins and different academic backgrounds, apply the computer-supported Structured Planning process to complex design and planning problems. The goal for each project is to develop information thoroughly, propose innovative solutions that take maximum advantage of the information, and integrate these ideas into system concepts that can both be evaluated in their own right and (in a real situation) be the comprehensive project specifications for a follow-on detail design phase of development.

Course Issues

Complexity. What is the nature of "systems" concepts, where products, processes, services and settings are organized to act together to achieve multiple goals? What can be done to assure that a concept is as complete as possible, covering many functions and attaining a high degree of "wholeness" and organic reliability?

Design and Planning Methods. What is Structured Planning and how can its tool-kit of methods be used to collect, structure and handle information in projects of greater complexity than can be comfortably dealt with intuitively? How can such methods be used by a team to extend the effectiveness of all?

Teamwork. How do individuals with different cultural origins and different academic backgrounds work together successfully on teams? What roles are there to be played and what difficulties must be overcome?

Structured Planning

Structured Planning, the systematic planning process taught in the course, is a process for finding, structuring, using and communicating the information necessary for design and planning activities. It is a front-end process for developing concepts thoroughly and cohesively.

A number of projects have been undertaken with it and used to further its development. Among nearly 100 of these, an early published project for Chicago's transit authority (CTA) was Getting Around: Making the City Accessible to Its Residents (1972). In 1983, the House of the Future project won the Grand Prize in the Japan Design Foundation's First International Design Competition. In 1985, the design of a habitation module for Space Station was undertaken for NASA. In 1987, the Aquatecture project on the Grand Prize again in the Japan Design Foundation's Third International Design Competition. In 1991, Project Phoenix on global warming was honored as Environmental Category Grand Winner in Popular Science magazine's "100 Greatest Achievements in Science and Technology" for the year. In 1993, two award winning projects, NanoPlastics and Aerotecture, were widely publicized in Europe and Japan; in 1995, the National Parks project developed plans for the future of the U. S. National Park Service. In 2001, Access to Justice, a project sponsored by the National Center for State Courts, was

implemented for use in state courts across the United States, and in 2005, four projects on Home, Play, Work and Health were finalists in four of the five competition categories for Denmark's INDEX Awards, the world's richest design prizes. As the process has evolved, it has become an increasingly useful planning tool for products, systems, services, processes and organizations. It is now being used commercially.

A diagram of the process, shown in two figures on the following pages, outlines the activities that make up Structured Planning and the working documents and final products that are produced along the way. The following general description follows the diagram. Where products of the process are discussed here in the abstract, it is possible to see specific examples produced for this project in the appendices that accompany this report.

I. Project Definition

The Structured Planning process begins with Project Initiation and the production of a Charter. This is a "brief" that serves as an initial communication vehicle between client and planners. It contains background, context, basic goals, a project statement that cuts to the heart of the planning task, resources to be used, and an initial set of issues to be investigated.

Defining Statements are mini "white papers" produced in the Framework Development portion of Project Definition. They focus the project within the direction of the Charter, concentrating on the issues and arguing specific directions that the project should follow with regard to them. Together with the Charter, they define the project.

II. Action Analysis

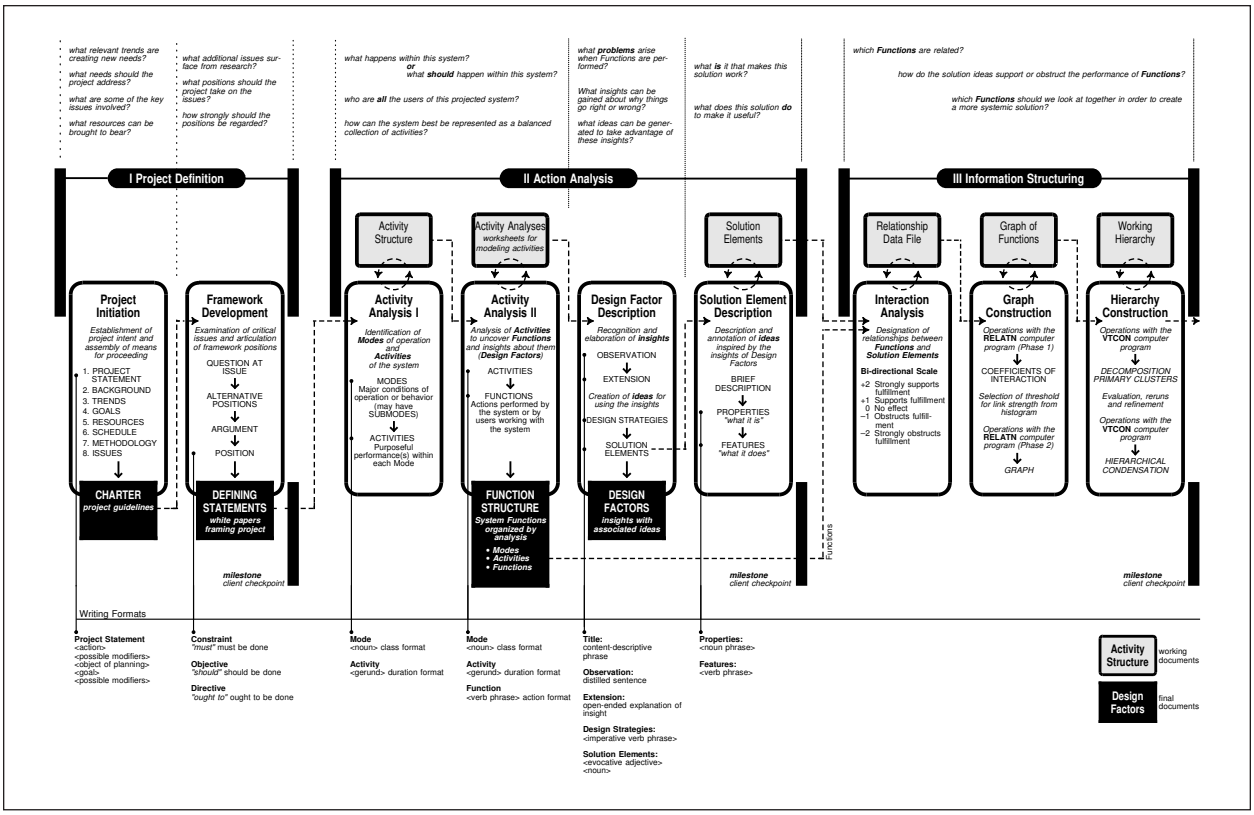
Any system can be viewed as a complex entity working with its users in different ways appropriate to its modes of operation. To plan effectively, a planning team must recognize these Modes, identify Activities that occur within them, and isolate the Functions that the users and system are intended to perform within each Activity. The result of the Activity Analyses conducted is a Function Structure.

Half of the purpose of Action Analysis is the enumeration of Functions. The other half is the development of information about these Functions that reveals insight about what happens as they are performed. During Action Analysis, insights are sought about why things go wrong in performing some Functions, and how other Functions manage to be performed well. These insights are uncovered in the Design Factor Description procedure and developed in documents that become part of a qualitative knowledge base. Activity Analyses record information at the Activity level; Design Factors document insights and ideas associated with Functions.

To capture as fully as possible the ideas suggested on Design Factors, Solution Element documents are written in the Solution Element Description portion of Action Analysis. These are one-page documents designed to capture enough detail about ideas to give

About Structured Planning

The Structured Planning process: phases I through III.



them substance when they are needed later. They have three important sections: "Description" — a short explanation, "Properties" — what the idea is, and Features — what the idea does. The Solution Element form is the tool used for committing ideas to paper.

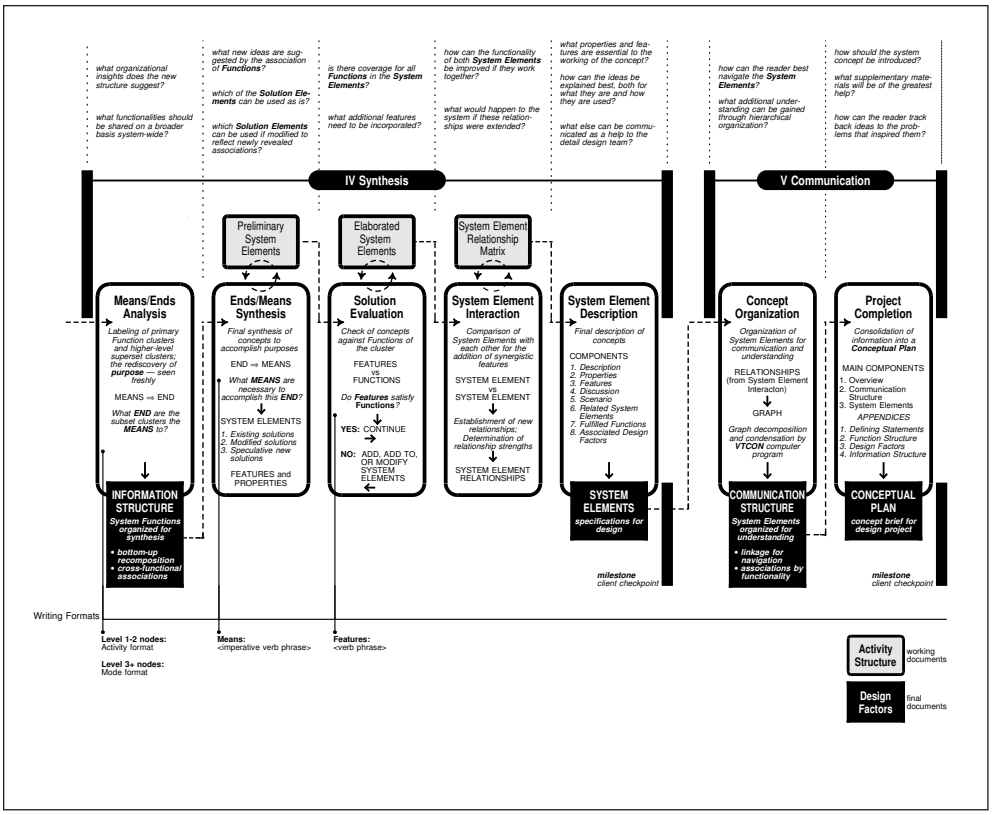
The product of Action Analysis is three sets of critical information: a set of Functions (the Function Structure), a set of insights (Design Factors) and a set of preliminary ideas (Solution Elements).

III. Information Structuring

Paradoxically, as useful as the Function Structure is for establishing coverage, it is not the best form of organization for developing concepts. Reorganizing information for use in concept development is the job of two computer programs, RELATN and VTCON.

The controlling factor for whether two Functions are associated from the planning standpoint is not whether they are categorically "related" in some manner, but whether a significant number of their potential solutions are of concern to both. Which Solution Elements are of concern to each Function is established in an Interaction Analysis procedure. The RELATN program then uses this information in a Graph Construction process to establish links between Functions.

The Structured Planning process: phases IV and V.



Another program, VTCON, completes the information structuring process. The graph establishes paths through the Functions by linking them when they are related, but, unlike a road map, a graph is not naturally arranged nicely for visual comprehension. In the Hierarchy Construction activity, VTCON finds clusters of highly interlinked Functions and organizes them into a semi-lattice hierarchy, a very general form of hierarchy most appropriate for planning. The hierarchy is called an Information Structure.

IV. Synthesis

In its form from the VTCON program, the Information Structure is simply a hierarchical organization. Nodal points do not have names. The task of Means/Ends Analysis is to create labels for all nodal points in the hierarchy. Moving bottom-up from the known Functions in the bottom level clusters, the question is asked, "To what end are these Functions means?" The answering purpose, in turn is grouped with its sibling nodes and viewed as means to a higher level end. The process continues to a completely labeled Information Structure.

The process is then reversed as a top-down, structured brainstorming procedure: Ends/Means Synthesis. In this process, the planning team asks of high level nodes, "what means do we need to meet this end?" As means are established, they are treated in turn as new ends for which means must be found, until the means become concrete enough to be described as final elements of the system (System Elements). Solution

Elements originally conceived for the Functions involved are constantly reviewed as possible end products. New ideas, however, are encouraged, and original ideas are modified or combined in the light of the means that evolve.

During Solution Evaluation, features of the System Elements are evaluated for their contribution to fulfillment of Functions in their part of the Information Structure. If there are unfulfilled Functions, this is the signal to return to the Ends/Means process for additional development.

System Element Interaction compares System Element with System Element in a search for additional synergies that can contribute to systemic qualities. More than simply recognizing relationships, the planning team proactively seeks out ways for System Elements to work together — to the extent of modifying one, the other, or both. Changes are incorporated in the properties and features of the individual System Elements.

The last task, System Element Description, completes the write-up of System Elements as specifications, including a succinct description, all relevant properties and features, and extensive Discussion and Scenario sections that contain detailed expositions of the ideas in both conceptual and operational terms.

V. Communication

Because the result of the Structured Planning process is a complex system, usually with a number of System Elements, a Communication Structure is frequently included as an aid to understanding. This is created during Concept Organization by the VTCON program from an assessment of how important the System Elements are to each other's operation. Using this structure, the reader can understand the system and navigate its concepts with greater efficiency.

The product of the Structured Planning process, assembled in the Project Completion section, is a Conceptual Plan, made up of an Overview that provides background and introduces the system, the System Elements that describe the ideas and their relationships, and Appendices that contain all relevant support information, including the Defining Statements, Design Factors, Function Structure and Information Structure.

Team Members

Student Team

Gabriel Biller
BA Applied Mathematics
Harvard University
(Cambridge, Massachusetts)

Elisabeth Martinez de Morentín
BA Industrial Design
Liotsa University
(Barcelona, Spain)

Eric Niu
BS Electrical Engineering
University of Texas, Austin
(Austin, Texas)

Kristy Scovel
BS Interactive Media
Columbia College
(Chicago, Illinois)

Natrina Toyong
BA Industrial Design
Universiti Teknologi Mara
(Kuala Lumpur, Malaysia)

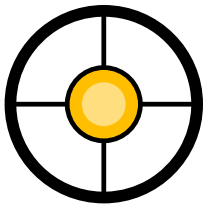
Albert Yu-Chen Wang
BE Industrial Design
National Cheng Kung University
(Tainan, Taiwan)

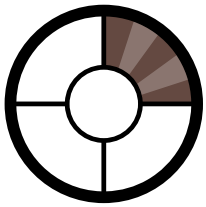
Faculty Advisors

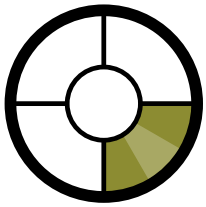
Charles L. Owen, Distinguished Professor Emeritus
John Pipino, Adjunct Professor

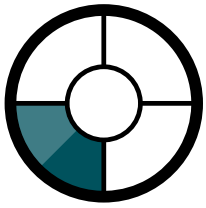
Teaching Assistants

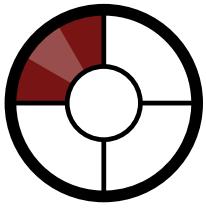
Derrick Kiker
Mark King

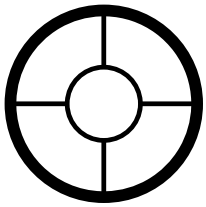










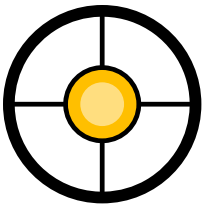


Portfolio Overview

The Intergovernmental Panel on Climate Change (IPCC) identifies three general strategies in response to rising sea levels: retreat, protection, and accommodation. Retreat is the only option available to the Tuvaluans who have begun relocating to New Zealand. Protection is exemplified by the incredible Dutch system of water management. The strategy of accommodation has been practiced for hundreds of years by the Venetians. In addition, we identify a fourth strategy we call assimilation, characterized by embracing the rising sea levels and taking advantage of the resulting opportunities.

The concepts we present are specific strategies for adaptation to rising sea levels. At the center of our portfolio lie **Data and Analysis**, the core of any sound decision-making process. Our concepts fall into four components: **Societal Adaptation**, **Resource Management**, **Physical Systems**, and **Emergency Management**. Our portfolio includes tools to clarify risks and trade-offs inherent to particular strategies, but each of these components must be addressed. Ultimately, choosing specific implementation strategies is left to the discretion of each community. The system presented here is held together by open and fair **Communication**, which enables the global community to collectively approach the issues that affect us all.

Introduction



Portfolio Component

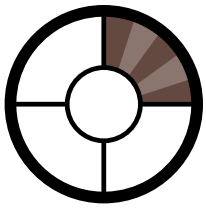
Data, Analysis, & Decision-Making

At the core of our system lie scientific and statistical data. The analyses of these data and the decisions dependent upon those analyses comprise the foundation upon which the rest of our system portfolio is built. To this end, we have incorporated several programs, organizations, and tools that are equipped to research, synthesize, and disseminate a unified and accurate message regarding the effects of climate change — on sea level rise in particular — to decision makers and the general public.

Climate change is now recognized as a fact almost without question. However, there is still much to be understood by the scientific community and others about the data we can measure and what it means to our future as a planet and as a civilization. In addition, the vastness of the data we can collect requires tools and processes for managing such seemingly infinite information. Leaders must be equipped with all available tools that can aid them in making decisions regarding the welfare of entire nations and peoples with the alacrity and confidence that such a grave situation requires.

The most important element of our system portfolio is the **human** element. This collection of initiatives and programs focuses on helping the general public to adjust to and embrace a future that involves adaptation and behavioral modifications. To aid this process we have chosen to involve some of the most basic and powerful human motivators including policy, economics, education, religion, culture, and public health — the cornerstone institutions of any society.

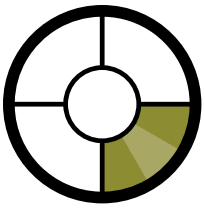
We recognize that people typically require prodding in order to change, particularly in the nearly imperceptible path of a "slow motion" disaster like sea level rise. In some cases, such as those affecting Small Island Developing States like the Maldives, Tuvalu, or Kiribati, the stakes are high, as entire cultures will be displaced. In other cases, the numbers of people potentially affected are in the tens of millions. The system elements we offer are intended to help eliminate the possibility of unimaginable human catastrophes.



Portfolio Component

Societal Adaptation

Introduction



Portfolio Component

Resource Management

Sustainability is the fundamental objective of every civilization, though only now are we beginning to understand this. To continue to function and propagate, a civilization must be capable of providing sustenance and other resources to all its members. Strategies for the continuous and reliable supply of food, water, and energy must be extensively planned for. Otherwise, civilizations are prone to follow a doomed trajectory of "overshoot and collapse," as eloquently described by Jared Diamond of previous failed civilizations.

With the accelerating pace of rising seas, many preconceived notions of how resources should be provided will be challenged. To support communities adapting to this environmental challenge, we have recommended strategies and programs to support resource harvesting, tools and methods for environmental protection, and systems for harnessing alternative energy sources.

With the world's population continuing to expand, and seas slowly consuming coastal areas, the pressures exerted on our limited supply of resources will only worsen, making resource management a vital component of any adaptation strategy.

Introduction

The altered environment caused by rising sea levels will necessitate the expenditure of human and material resources toward the goal of adapting our topography and physical structures. We believe that in order to exist in a world of rising seas, it will be important to implement both natural and human-made systems. Human-made modifications of natural systems have often led to unforeseen problems such as the destruction of coastal wetlands in Louisiana. These natural ecosystems already provided many of the protective benefits we must now restore artificially.

In the Netherlands, the dire necessity to protect human life resulted in the most sophisticated human-made defenses ever built against the sea. But, even the Dutch recognize that these protective measures are only temporary.

It is important that current and future cultures understand how to coexist with the earth's natural systems so that we may slow and eventually begin to reverse the damage caused by our current way of life.

Portfolio Component

Physical Systems

Introduction

Portfolio Component

Emergency Management

Although the threat of rising seas has an extremely long time horizon, we are already beginning to feel its effects in the form of increasingly deadly storm surge accompanying weather events such as hurricanes and seismic events like tsunamis. This sobering truth is evident in the recent calamities that befell New Orleans in 2005 and the many nations devastated by the Indian Ocean tsunami of 2004.

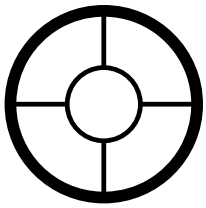
While sea level rise is a slow motion disaster, nations and communities at risk do not have decades or centuries to adapt to the inevitable emergency events which will continue to strike and cause merciless destruction to those in their wake. Disaster preparedness and management of recovery and rebuilding efforts are paramount.

As many coastal areas are extremely developed and populated, disaster preparedness must be at the forefront of city and community planning. We have constructed a combination of programs, tools, and devices to aid cities in their efforts to better plan for future emergencies.

Connecting and binding together all of the components in our system portfolio are communication and networking. Climate change-induced sea level rise is far too vast and ubiquitous a problem for any nation, large or small, to single-handedly solve.

Cooperation between nations, cities, and communities will be required to adapt to and overcome such a monumental challenge. Communication of information and needs between governments, corporations, and non-governmental organizations must be open and available.

To facilitate this process, we propose the formation of an alliance that will unite the nations that are at risk as a result of the threat of rising seas. By aligning agendas, knowledge, and resources, the network can be leveraged to foster synergy and facilitate negotiations between governing bodies.



Portfolio Component

Communication & Networking

System Elements:

Data, Analysis, & Decision- Making

Super System Element

Global Resource Information Database (GRID)

Sub-Elements

- Global Earth Observing System of Systems
- Global Environment Outlook
- Local Environmental Responses and Outcomes Database
- Global Environmental Threat Awareness Media & Information Campaign

A datum alone does not have a story. Each stream of data tells a piece of a story, and only by collecting them all together do patterns begin to emerge. And from those patterns emerge understanding. The **Global Resource Information Database (GRID)**, formed in 1985 by the United Nations Environment Programme (UNEP), is primarily concerned with gathering, analyzing, understanding, contextualizing, and sharing scientific data on the world's environment in order to understand the earth's environmental system. By collecting, handling, and interpreting this data, the **GRID** can inform decision makers on the current state of the planet as well as provide early warning of emerging environmental threats.

We propose a number of extensions to the current incarnation.

The **GRID** should take a more proactive approach to providing consultation to decision makers around the world. Collection of data and metadata is necessary to understand Earth's climate, but readily available analyses of prior implementation efforts will better inform leaders looking to implement adaptation strategies. Integrating these case studies with other global information resources will facilitate implementation of better-conceived measures by future decision makers.

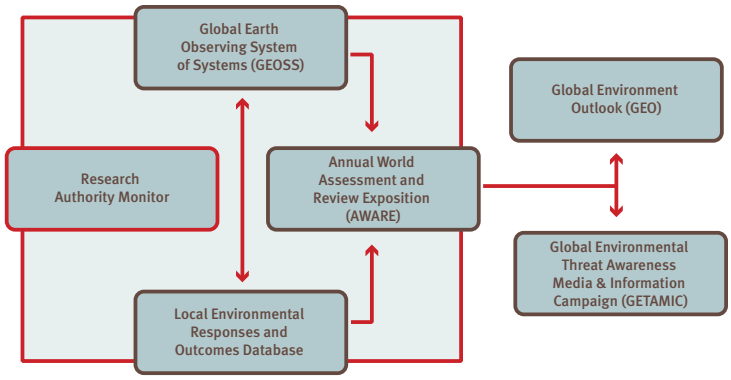
Properties

- Authoritative global database of scientific data
- Hub of a global network charged with understanding global environmental systems and the implications of their changes
- Team of scientists and policymakers dedicated to reviewing the global environment and assessing environmental trends
- Global array of climatic monitoring devices
- Computer and software systems for collecting, archiving, and analyzing environmental data
- Central database of climatic adaptation strategies, case studies, and best practices
- Interactive awareness installations

Global Resource Information Database (GRID)

Features

- Partners with organizations to install, upgrade, and monitor a system of remote environmental sensors
- Generates and acquires global scientific data pertaining to the world's environmental state
- Analyzes scientific data and assesses trends and implications
- Regularly publishes major concerns, trends, and emerging issues with inferred causes and social & economic impacts
- Broadcasts "early warning" of slow, but continuous, hazards
- Provides open access to authoritative metadata and data sets
- Advises decision makers on the implications of their activities
- Builds upon the peer-review foundation to discern which theories and data can be most trusted
- Partners with regional media and educational institutions to contextualize messages and raise awareness
- Empowers individuals to contribute to the international knowledge base
- Provides prediction scenarios of the future based on assessment of past trends and current understanding of climatic data
- Contextualizes trends and impacts to local communities and installs fun interactive dashboards to raise awareness



It is also important that the general public has a greater understanding of environmental threats, empowering them to take initiative on their own. Partnering with existing media channels to incorporate encouragement for adaptation into their programming will go a long way to increase public awareness.

Current programming is beset with negative alarmist messages, but future messages must change to adopt a more positive tone that focuses less on the ills of the current system but rather the innovative and progressive measures being adopted. Increasing awareness through more nontraditional means such as contextualized artistic installations in high traffic urban areas and interactive means of empowering individuals to actively contribute to the expanding knowledge base should be explored as well.

Cynthia and Bryant, a young couple, live in the East Village in Manhattan...

On their way home after seeing a new Broadway Musical, *Dr. Sublime or: How I Learned to Stop Worrying and Embrace the Intruding Ocean*, they notice a new addition to the Times Square billboards. The Jumbotron on the north face of One Times Square now hosts an interactive game where passersby can choose various strategies and measures to defend New York City against various environmental disasters. Cynthia can select from such options as building defensive walls, raising existing buildings, and erecting an enormous atmospheric tent around the city. Bryant can then unleash any of numerous disasters on the city, modeled on scientific data from the GRID. They find that the tent doesn't stand up well to Category 4 hurricanes.

After returning home with informational pamphlets picked up back at the interactive game, they decide to do some research into climate change and its implications to them. Searching through LEROD, they discover a number of strategies that would have worked better in the simulation. For instance, effective anticipation and evacuation systems coupled with strong defensive walls would be much more effective at mitigating the effects of a Category 4 hurricane. In order to better inform themselves, they download the latest GEO Year Book and share their new knowledge with some close friends.

One of these friends, Will, happens to design anemometers. Registering their newfound interest in environmental issues and seeking to encourage their participation, he gives them a new anemometer designed to link directly to the U.S. wing of the GEOSS over the Internet. Cynthia and Bryant now feel empowered to provide wind speed measurements from the roof of their home, contributing to the overall pattern of data that will be analyzed by scientists working off the data collected in the GRID.

Global Earth Observing System of Systems (GEOSS)

Findings are collected through the efforts of intrepid scientists while data will eventually be gathered through the **Global Earth Observing System of Systems (GEOSS)**. On February 16, 2005, 61 countries and over 40 international organizations agreed to a 10-year plan for establishing and supporting a global network of environmental monitoring organizations. For the purpose of collecting data and metadata, **GEOSS** will employ existing and new hardware including such things as a network of Earth Observation Satellites and infrasound monitoring stations, as well as seismic, hydroacoustic, and tidal sensors. Software among participants will play a key role in recording all data using uniform standards.

This enormous body of data and observations will support the **Global Resource Information Database (GRID)** in its efforts to inform decision makers on the current state of the planet as well as provide early warning of emerging environmental threats.

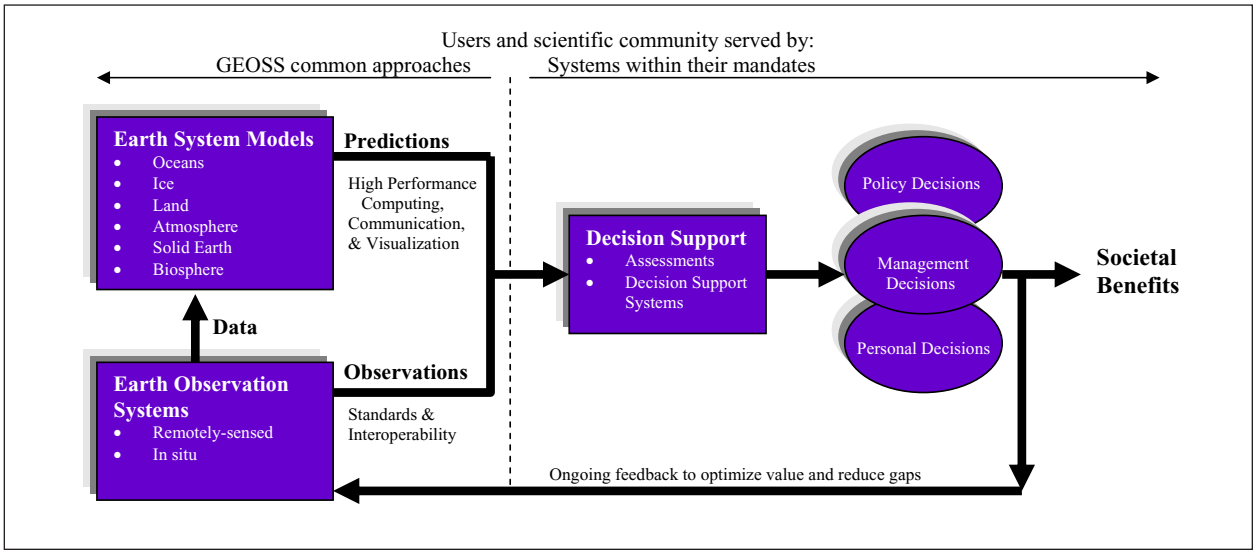
Properties

- Global network of Earth observing systems
- Conceptual and organizational framework for integrating observing systems
- Mechanism for coordinating specific user requirements
- Forum for discussion on common implementation issues and methods

Features

- Facilitates coordination among global Earth observation systems
- Ensures accessibility and understanding of observational data
- Provides a universal platform for recording observations, data, and measurements
- Engages and empowers a broad range of user communities to contribute
- Encourages adoption of data and information standards supporting usability
- Advocates and supports research in new and existing observation systems

Linking Earth observation to societal benefits *(Diagram by the U.S. EPA)*



Global Environment Outlook (GEO)

Properties

- Periodic, comprehensive report on the global state of the environment
- Annual assessment highlighting significant environmental events and achievements every year
- Regional, sub-regional and national integrated environmental assessments
- Forum for discussion on common implementation issues and methods
- System of regional collaboration centers

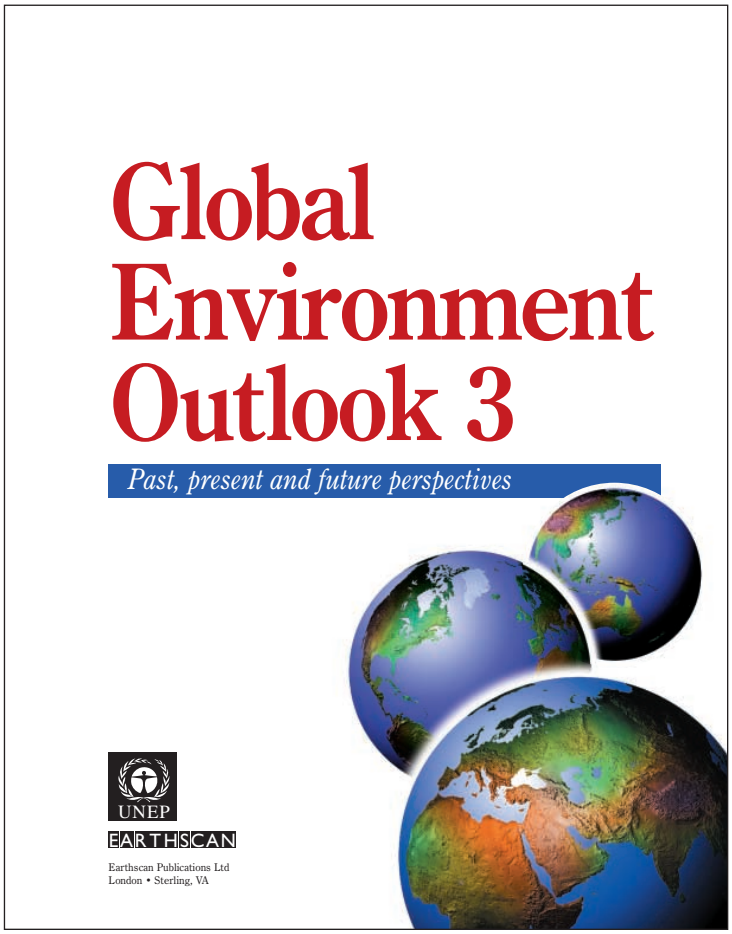
Features

- Collaborates with various sources to gather data and information
- Regularly analyzes and summarizes global environmental data
- Provides a participatory and consultative approach to assessment and reporting
- Solicits expert input and review of all major publications
- Publishes reports and assessments on significant events and the current environmental state
- Promotes youth education through a set of educational products and support of local action
- Informs decision-making and observation bodies, including the United Nations Environment Programme

The **Global Environment Outlook (GEO)** regularly publishes reports on the current state of the global environment as well as significant environmental events and achievements. Originally conceived in 1995, the first **GEO** report was published in 1997. Subsequent reports were issued in 2000 and 2002. Currently, the fourth edition is available for peer review. In 2003, the Governing Council of the United Nations Environment Programme (UNEP) instituted a supplemental annual report to keep global leaders abreast of significant events and achievements.

Fed by data, observations, and information assembled in regional collaboration centers around the world and having undergone rigorous and public peer review, the publications of **GEO** are intended to provide an authoritative bridge between science and policy, informing decision makers around the world.

GEO Comprehensive Report



Local Environmental Responses & Outcomes Database (LEROD)

The **Global Environment Outlook (GEO)** regularly publishes reports on the current state of the global environment as well as significant environmental events and achievements. Originally conceived in 1995, the first **GEO** report was published in 1997. Subsequent reports were issued in 2000 and 2002. Currently, the fourth edition is available for peer review. In 2003, the Governing Council of the United Nations Environment Programme (UNEP) instituted a supplemental annual report to keep global leaders abreast of significant events and achievements.

Fed by data, observations, and information assembled in regional collaboration centers around the world, the publications of **GEO** are intended to provide a bridge between science and policy, informing decision makers around the world.

While the collection of data and metadata is necessary to understand the systems underlying Earth's climate, leaders looking to implement adaptation strategies must also learn from the successes and failures of other local adaptation initiatives. The United Nations Framework Convention on Climate Change (UNFCCC) has currently implemented a system for cataloguing adaptation strategies, case studies, and best practices, but it is both difficult to find and poorly executed. Integrating these case studies and connecting them directly to the challenges that they are trying to address will provide decision makers with a better understanding of the implications inherent to the strategies they are considering.

Properties

- Central database of climatic adaptation strategies, case studies, and best practices
- Program for evaluating of a strategy's appropriateness to regional and/or local situations

Features

- Records instances where adaptation strategies are implemented
- Analyzes the implications and causalities associated with various adaptation strategies
- Compares proposed adaptation strategies against regional and local conditions
- Based on historical and scientific data, informs decision makers on the viability of proposed adaptation strategies

Global Environmental Threat Awareness Media & Information Campaign (GETAMIC)

Properties

- Strategy for raising public awareness and support of environmental issues
- Media programming that demonstrates successful methods of adaptation in popular shows
- Artistic installations in heavy traffic urban areas that contextualize environmental data

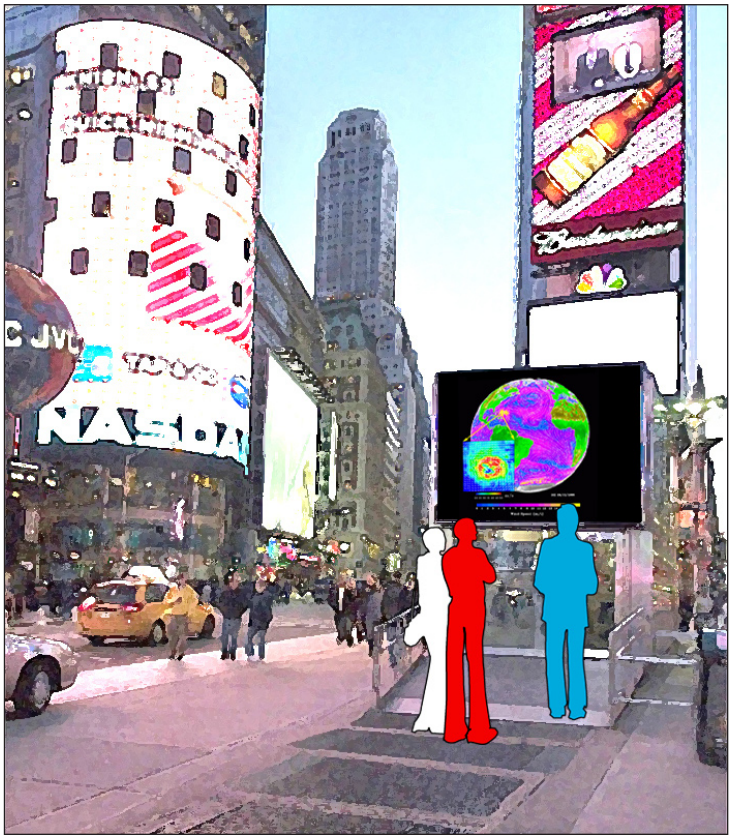
Features

- Partners with regional media centers to include adaptation strategies in popular programs
- Increases awareness and appeal of proactive measures
- Changes environmental message from alarmist cries to personal messages
- Provides interactive mediums for members of the general public to personalize and contextualize the implications of climatic change
- Turns environmental awareness into an inherent part of global culture

For any global transformation to occur, it is imperative that the general public gains a greater understanding of environmental threats and adaptation strategies that they can employ. Partnering with existing media channels to incorporate messages and story lines advocating adaptation into their programming will bring awareness to a media hungry public. Current programming is full of alarmist messages, often propagated by confrontational environmentalist groups. This is counterproductive as the public becomes both desensitized and defensive. Future media must integrate with all forms of programming and adopt a more positive tone that focuses less on the ills of the current system but rather the innovative and progressive measures being adopted.

More nontraditional means of increasing awareness should be explored as well. One such approach involves building contextualized, interactive artistic installations in high traffic urban areas through the general public can tangibly understand both the impact climate change will have on their lives and what

Contextualized, interactive climate change installation in Times Square



Super System Element

Analysis & Decision-Making Interactive Toolkit (ADMIT)

Properties

- Analytical processing software for understanding climatic and environmental data
- Extract, transform, and load (ETL) tools and process for linking data from **GRID** and other sources
- Vulnerability assessment tools
- Internet-based decision support tools
- Agent-based modeling and simulation software
- Scenario planning tools
- Querying and reporting tools
- Strategy assessment tools, highlighting potential benefits and trade-offs
- Database for tracking decisions and their results and impacts
- Dashboard tools for higher-level information access

ADMIT is a suite of software and other tools to help leaders, decision-makers, and resource managers understand:

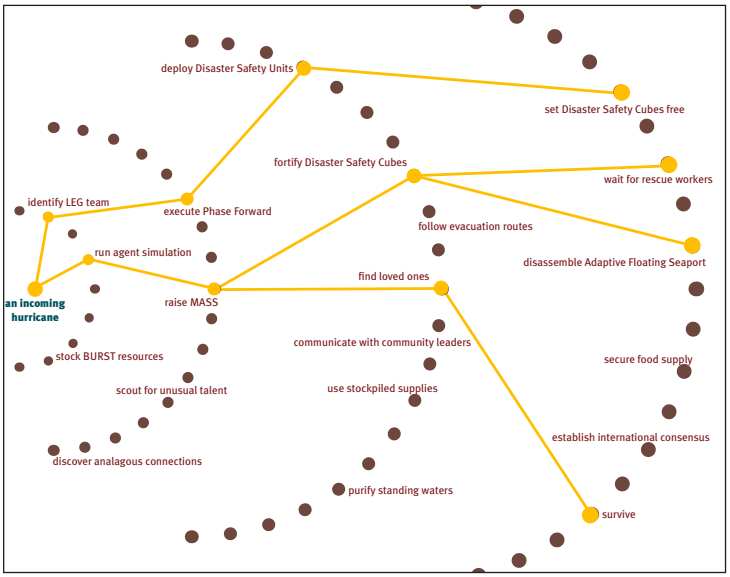
- the risks they are facing due to sea level rise (SLR)
- the potential costs and impacts on civil, economic, and political life from catastrophic events resulting from SLR
- the types of options/strategies available for managing risk, as well as their potential benefits and trade-offs
- the ability to track and analyze the effectiveness of decisions regarding adaptation to SLR

The primary questions facing a leader or decision-maker regarding the impact of sea level rise on communities, municipalities, regions, or states under one's jurisdiction are:

- what are the risks?
- what is the temporal latitude toward these risks?
- what are the options for mitigating or managing these risks?
- what would be the consequences or trade-offs of one strategy versus another in managing these risks?

Analysis & Decision-Making Interactive Toolkit (ADMIT)

Decision tree showing options and trade-offs in evacuation plan



These are not easy questions for anyone to answer, as there are so many variables and factors to consider, including impact on human life, impact on economic activity, disruptions to transportation and other systems, and even popular opinion.

To help with this challenge, **ADMIT** includes tools for analyzing data, running simulations to predict the outcomes of alternative strategies in alternative scenarios, and highlights the trade-offs inherent in each possible decision.

ADMIT's toolset uses visualization to help simplify complex information, making it easier for leaders to comprehend in more tangible terms the ramifications of today's decisions on future options. It also includes dashboards and reporting tools to give decision-makers higher-level access to information.

Features

- Adjusts mitigation and adaptation strategies based on new knowledge and information
- Fosters ecosystem stability and institutional flexibility
- Facilitates collaborative decision-making process
- Integrates data from GIS and GPS systems for specific areas of management
- Uses agent-based modeling to simulate impacts of environmental changes on selected indicators (able to integrate various third-party models simulating agricultural impacts, long-term changes in fuels, flood hazard, and other behaviors for different scenarios)
- Provides alternative decision criteria for evaluating mitigation and adaptation strategies
- Helps users identify best mitigation and adaptation strategies for their unique scenarios

System Elements:

Societal Adaptation

Super System Element

Pro-Active Risk Management Alliance (PARMA)

The **Pro-Active Risk Management Alliance (PARMA)** is an alliance of leaders from the insurance and reinsurance industries, scientists, policymakers, lawyers, and business and industry leaders. It brings together representatives from disparate disciplines who are all stakeholders in a common problem: that of adapting to climate change. At its core, **PARMA** is an education and knowledge-sharing network, a collective financial player capable of implementing and influencing large-scale changes in policy or public works projects, and a research collective pioneering new methods of risk assessment.

According to statistics on insured losses due to catastrophes during the period 1970-2005, 23 of the 40 most costly catastrophes occurred partially or entirely in the United States, with the top 8 most costly catastrophes all occurring on American soil. Hurricane Katrina has the highest cost in terms of total insured losses, totalling $45 billion.[1]

During this same period, of the 40 most deadly catastrophes in terms of loss of life, none occurred in the United States. In fact, the most deadly catastrophes during this period have almost all occurred in either Bangladesh, Indonesia, China, India, or Iran. To summarize, most of the greatest

Properties

- Multidisciplinary network of business, policy, and scientific leaders with a shared interest in addressing the issue of rising seas and other climate change-related challenges
- Research collective pioneering new methods and tools for risk assessment, management, and predictions of climate change impacts
- An authoritative body of knowledge on the economic and social consequences of climate change-induced catastrophic events
- Author and publisher of reports, books, electronic journals, blogs, newsletters, and educational courseware related to climate change challenges, including living in a world with rising sea levels

[1] "The 40 most costly insurance losses 1970-2005." Swiss Re. http://www.swissre.com/ (accessed 02 Dec, 2006).

Pro-Active Risk Management Alliance (PARMA)

Features

- Brings together subject matter experts from multidisciplinary fields to share ideas and collaborate on predictive modeling techniques and scenario forecasting methods to improve the insurance industry's ability to assess and manage risk related to catastrophes
- Develops curricula for educating business and industry leaders on how climate change can impact their business
- Provides financial support to scientific researchers on climate change
- Educates, informs, and influences policymakers
- Educates the public about insurance and climate change, including the risks associated with living in coastal areas prone to sea level rise and storm surge threats
- Pioneers new methods of risk assessment
- Promotes and participates in finding and financing adaptation projects
- Leverages collective power and influence to promote risk-reducing activities and programs
- Works in concert with stakeholders to create coordinated, integrated policies

catastrophes, financially speaking have occurred in nations of greater wealth, while most of the deadliest catastrophes have occurred in poorer, developing nations.[2]

Many of these catastrophes are weather-related events, which, due to increased frequency and ferocity as a result of climate change, has long been of concern to the insurance and reinsurance industries. According to Swiss Re's sigma insurance research, 2005 was the costliest year for property insurers ever, with total damage amounts at $230 billion (for both man-made and natural catastrophes).

These facts suggest that in wealthier nations that are at risk from sea level rise, perhaps the most effective form of motivation is a financial one. The disasters experienced first-hand in nations like the United States may not have been devastating enough in their human toll to truly spark change. On the other hand, developing nations are perhaps more likely to be motivated through a more "human" argument.

PARMA creates a forum for all major players in the financial, political, and scientific communities to address the problem of adaptation to climate change and sea level rise by creating incentivizing rewards, rules, and regulations. Insurance is in the business of spreading risk across time and place, and as such, plays a pivotal role in understanding the large scale macroeconomic effects of climate change.

Because a weather event can cause disruptions and damages to businesses, or raise the price of oil, the economic impacts can reverberate deeply through a global community. The insurance industry is well-equipped to protect businesses and individuals, including themselves, from calamity. They are truly on the front lines of this challenge because of their understanding of how to value and understand risk.

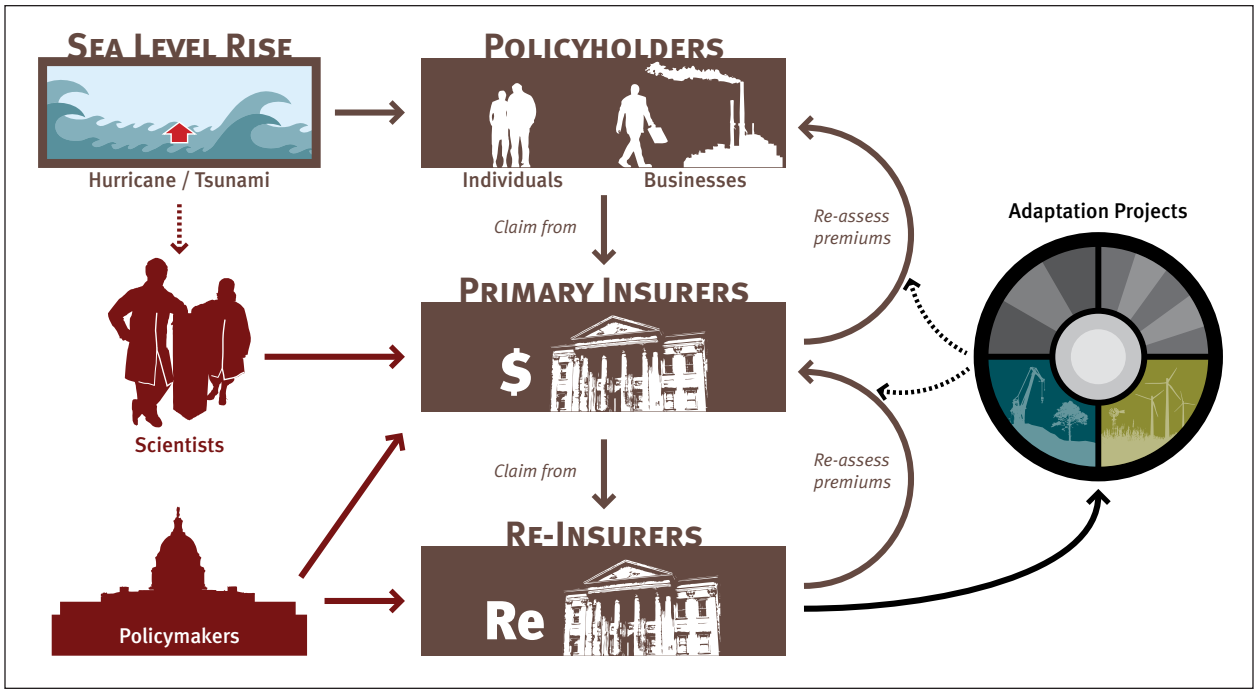
Scientists and policymakers are able to bring their subject matter expertise to the table, which can help result in better understanding of the science of climate change and, hence, better predictive ability on the part of insurers of future risk, as well as in new policies to promote and incent adaptation to a changing world.

[2] "The 40 worst catastrophes in terms of victims 1970-2005." Swiss Re. http://www.swissre.com/ (accessed 02 Dec, 2006).

Pro-Active Risk Management Alliance (PARMA)

Insurers can take this additional information into account to better assess the appropriate risk and premiums to charge their policyholders. In addition, insurers may find that they can help reduce the future likelihood of paying out large claims by proactively participating in adaptation projects, which in turn reduce the probability of disastrous events occurring.

Scientists and policymakers collaborating with the insurance industry



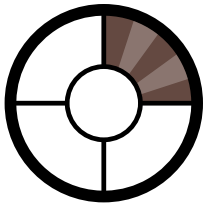
Juniper Insurance Agency, a small cap, publicly held company insuring homeowners in the mid-Atlantic coast region of the United States of America, is currently reassessing their premiums for coastal construction...

The impetus for this arose from several factors in the current economic environment. In the last six months, Juniper has been the subject of increased rates from their reinsurance company. In addition, there has been an increasing amount of litigation activity related to global warming, including a class-action lawsuit filed by shareholders against the Silo Corporation. The basis of the claim was misrepresentation of risk regarding the possible downturn of the stock as a result of consumer backlash to Silo's anti-environmental policies, which have directly contributed to global warming. Juniper has taken care to familiarize themselves with the reports provided by Pro-Active Risk Management Alliance (PARMA). These reports have been an excellent resource for information on risk analysis and relevant scientific data concerning the effects global warming will have on their company as a small business and, most importantly, as an insurance agency.

Over the last several years, PARMA has established itself as an integral part of the insurance industry. Having recently reviewed the published findings from a PARMA-initiated and funded scientific study involving the effects rising tides and increased storm surges on coastal construction, Juniper, like many insurance firms began to reassess their risk structure. Fortunately, PARMA provides companies like Juniper with the resources and educational materials to make calculated and forward thinking decisions. With PARMA's pioneering innovations in risk forecasting models, Juniper feels confident that they are accurately predicting their policyholder's risks, rather than relying on questionable historical data. In addition, PARMA's proactive funding of initiatives to improve the health of the environment — and thereby reduce the risk of catastrophic disaster — only strengthens the economic viability of Juniper and other small players in the insurance industry, giving the latter's policyholders more peace of mind.

Super System Element

Comprehensive Education System (CES)



The **Comprehensive Education System (CES)** is a thorough educational program providing tools to instill sustainability and adaptation habits starting in early childhood and continuing through adolescence. The long-term program is designed to foster communication among generations, from children to parents and grandparents.

Following are the **CES**'s program descriptions and applications by age group:

Babies (0-2): *"The two first years are the teaching years"*
"Emotional attachment: birth to 18 months. Recent research shows that a persons IQ predicts only a small part of career performance — emotional intelligence predicts about 80 percent of your career success. The part of the brain that regulates emotions, called the amygdala, learns very early how to be a good citizen. This means that emotions such as empathy, happiness, hopefulness, and sadness are shaped by how the infant is nurtured. The amygdala continues being shaped through adolescence, but early experiences (as well as inborn tendencies in temperament) are very important in regulating the brain's emotional wiring."[1]

Properties

- Learning toys to teach babies in their first two years
- Music for babies with nature sounds and disaster sounds
- Interactive toys that make respecting nature, recycling, and learning fun
- Extension of school programs with projects that can be applied at home
- Clothing program from natural materials waste
- Government-funded college courses that are part of the required curriculum
- Extension of PTA to inform parents about school activities and programs that focus on adaptation

[1] Bower, Don. "Building Baby's Brain: Prime Times for Learning." The University of Georgia, College of Family and Consumer Services. http://www.fcs.uga.edu/pubs/current/FACS01-3.html (accessed 01 Dec 2006).

Comprehensive Education System (CES)

Features

- Empowers children to take projects home and teach responsibilities to their parents
- Takes a psychological and emotional approach to reach adolescents
- Reinforces safe and healthy green habits in day-to-day school routines, not only on class
- Incorporates composing habits at school
- Partners with trendy and fashionable icons to apply a glamorous image to
- Taps knowledge from other generations by encouraging grandparents to instill habits in their grandchildren

Learning toys. Use primary colors to attract baby's attention and linking house colors directly with nature's colors.

Music. Start young with music to mimic natural sounds before, during and after a disaster.

Early Childhood (2-6)

Building Block Toys. Nature-inspired blocks, using recycled and natural materials that can later be composted or reused. Blocks are covered with natural textures, and can be assembled to play a simulation of the different stages of disasters. Playing with friends, children create scenarios illuminating the connections between natural and human environments by mapping their local urban or rural community and enacting scenes before, during and after a disaster.

Recycling Program at School. School curriculum teaches and monitors safe and healthy green habits in fun day-to-day school environments and routines, not only in class. Uses slogans like "Plastics dudes want to be with their plastics friends and party in the Recycling Party Bin. They can bring glass dudes and the metal dudettes too!"

Composting at school. A competition among classes will help the school garden to grow healthy and strong award sustainable prizes. Students are taught how to provide nutrients to plants, reduce the needs of fertilizers, improve the quality of soil, control weeds, and save water.

School Age (6-12)

Building Block Toys. Future versions will include software game application.

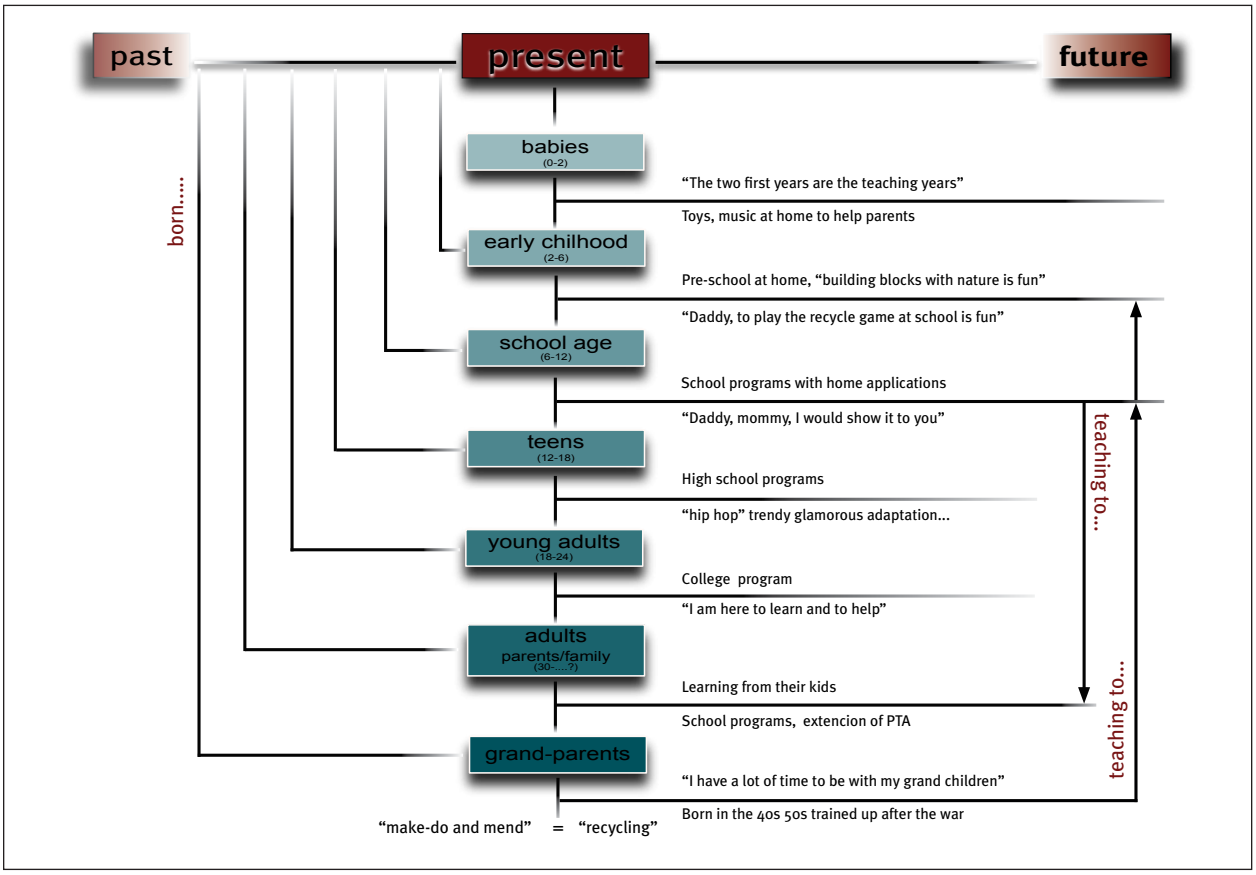
Recycling Program at School. The curriculum extends through home applications. Take home science projects boost awareness of parents who actively participate in their children's education.

Composting at school. Kids take home habits learned at school and teach to their parents.

Field trips. A step-by-step guide that enables students, teachers, parents and others to discover and explore all kinds of green sites. Field trips help visitors visualize nature's changes

Comprehensive Education System (CES)

Diagram of the Comprehensive Education System curriculum



and effects, promote and link eco- and cultural resources, guide curriculum to focus on encouragement, and promote controlled response in dangerous situations during and after a disaster.

Teenage High School (12-18)

Glamorous Adaptation. Psychological, emotional, and subliminal approaches will encourage understanding while incorporating sustainability and adaptation habits into adolescents' daily routines. One approach is to create clothing and school accessories sponsored by teen idols and made with organic and recycle materials.

Young adults (18-24)

College pre-fellowship. Government-funded college courses are made part of the requirement curriculum that extends awareness and preparation. Options of continuing on to a fellowship program will be created as well.

Comprehensive Education System (CES)

Adults/Parents

PTA School extension program. Parents will participate in school activities and programs. The focus will be on global warming activities, encouraging parents to support their children as they learn how to learn, prepare, and apply lessons to scenarios before, during and after to a disaster.

Grandparents

GPTA School extension program. A new association with the same philosophy as PTA, this program encourages grandparents (who have more time) to help their grandchildren adopt knowledge and habits from their generations. After all, grandparents born in the 40s and 50s were brought up after the war with such initiatives as "Make-Do and Mend," which is similar to today's recycling programs

India is almost late to class...

She forgot to dispose of her lunch leftovers. Inside of a plastic bag, she is carrying a soda can and an extra piece of her veggie sandwich wrapped in aluminum foil. Having grown up with sustainable habits, it is not even and option in her mind to go to class with that mess in her backpack. She runs to the school patio to throw the extra piece of sandwich into the compost bin. She knows that later on her contribution will provide a good appetizer for the plants. Then she skipped back down the hallway and went to the Recycling Party Bin where she deposited the metal soda can dude and aluminum foil dudette with all the other dudes already partying in the Bin. The plastic bag was invited to join the rest of its plastic friends on the other side. All of that only took her an extra two minutes, and India managed to get to class just in time

For India, having grown up with green habits, it was never in question where her waste should go.

Super System Element

Religious Environmental Action Program (REAP)

Properties

- Religious community leadership aligned around action on environmental and climatic issues
- Outreach programs for increasing awareness and calling for action

Features

- Applies new and relevant interpretations of traditional writings to support initiatives
- Lobbies at local, state, national, and international levels to influence policy debates
- Encourages constituents to participate in mitigation and adaptation initiatives
- Educates congregations on issues such as stewardship of the Earth and advocacy for the poor
- Brings moral clarity to climate change issues

Evangelical Climate Initiative. Operation Noah. Religion, especially institutionalized religion, is an incredible cultural mechanism capable of motivating large numbers of people. Religious organizations, especially in the U.S., wield significant influence in both personal and public arenas. They provide moral guidance to individuals and encourage behaviors aligned with promoting people's lives. In the public arena, religious institutions are extremely influential in policy making, partly through their ability to motivate the general population to participate.

By applying religious values to the issues at hand, we can more effectively create a culture where moral values and collective stewardship encourage action rather than reinforce the status quo. Rick Warren, founder of Saddleback Church and one of the original 86 members of the Evangelical Climate Initiative, stated at the Technology, Entertainment, and Design (TED) Conference that the highest form of existence lies in service. When you have been given influence, it is your responsibility to speak up for those who have no influence.

Religious Environmental Action Program (REAP)

Christian religious leaders that look closely enough will find moral alignment with environmental concerns. Even religious movements who prioritized human need above all others have realized that climate change will ultimately return to endanger human lives.

While the movement is fairly large, Western religious leaders are not unified around this common cause. In fact, many prominent evangelical leaders have directly opposed the Call to Action issued by the Evangelical Climate Initiative. Though many non-Western religions place more emphasis on individual spirituality and morality, there exists an opportunity to address climatic issues more forcefully and contribute to awareness of and adaptation to climate change.

Rick Warren of the Saddleback Church preaches stewardship of the Earth

Karen, a graphic arts student, is already aware of the growing concerns about the effects of climate change...

She attends church regularly, likes to dance, and drives an economical car. Having just moved to Los Angeles, she ends up in a sermon delivered by Bishop Charles E. Blake, Sr. of the West Angeles Church of God in Christ, a member of the Evangelical Climate Initiative. His sermon touches on a lot of different points, from family values to charity. But what sticks with her most is his discussion on how humans are failing their stewardship of the Earth, given to them by God.

Moved, she feels that she needs to take action. After talking privately with Bishop Blake, she decides on a few personal actions. Even though she lives in Los Angeles, she buys a bicycle and vows to ride to her destinations whenever possible. She has become more diligent in turning off the lights and has even begun buying credits to offset her carbon footprint.

Super System Element

Compact Anti-Vector System (CAVS)

In 1995 Alvin Wilbanks began research to understand how to eradicate mosquitoes without the use of pesticides. It was important to his work to get to the root cause of mosquitoes' attraction to their prey.

His first theory was that the mosquito was seeking blood, but this proved false. He then began to test other methods of attraction, such as moisture, body scents/pheromones, motion, and breathing. All of these experiments had poor results. He then discovered that mosquitoes were attracted to the heat emitting from a modified bug light.

He spent the next 3 years determining what temperature would be most effective and how big the unit should be in order to achieve the most efficient results. Other tests were performed to determine effectiveness, including air flow and wind design. The final analysis indicated that temperature, size, motion, and elevation were all determining factors in capturing and killing mosquitoes.

His research also indicated that the electrical fields emitting from his device were acting as warning signals to the insects, thus deterring them from investigating further. Wilbanks

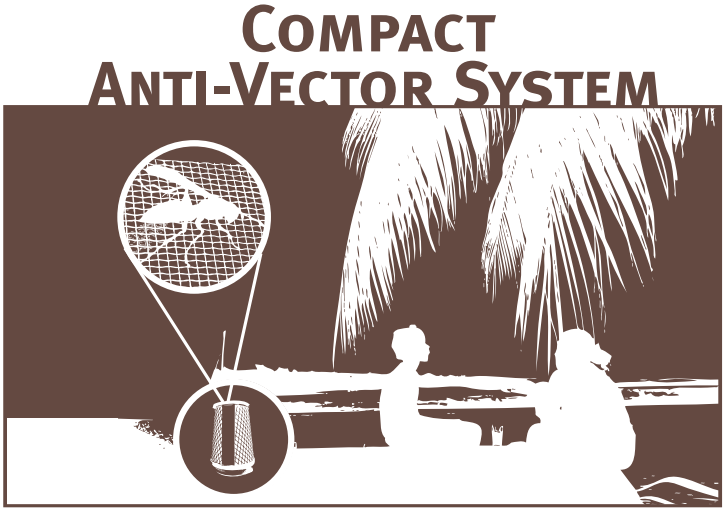
Properties

- Portable vector elimination device
- Carbon dioxide reservoir
- Heating mechanism
- Interface that allows for intensity adjustment
- Fan to create vacuum
- Electric grid
- Receptacle for vector waste

Features

- Eliminates disease spreading vectors from the environment
- Portable nature of device allows for protection in most situations
- Environmentally sound technology
- Utilizes current NASA developed technology
- Allows for adjustment of intensity
- Mimics the body temperature and carbon dioxide release cycle of humans and other warm blooded animals

Compact Anti-Vector System (CAVS)



decided to alter the unit in order to conceal the electrical fields but still attract and kill the mosquitoes. His technology simulates body heat and skin to attract the mosquitoes. Wilbanks was granted a patent for his innovation in 1997, followed by Underwriters Laboratories (UL) approval in 1999.[1]

We propose an extension to Wilbanks' invention, namely a reduction in size, making it compact and therefore portable. Reducing the size of this device allows for its use in a multitude of locations, such as an indoor environment or on a boat. In addition, the current model claims a one acre area of effectiveness. This intensity is not always needed or desired. The new model would allow for an adjustment in intensity, so that it would be relevant in a variety of situations.

[1] "Pesticide-Free Device a Fatal Attraction for Mosquitoes." Scientific and Technical Information (STI), NASA. http://www.sti.nasa.gov/tto/Spinoff2005/er_6.html (accessed 05 Dec 2006).

Lois was raised in Washington D.C., and like most inhabitants of the area, was a part of a political family...

With her father serving as a congressman and an environmental lobbyist for a mother, Lois had access to several intimate political social circles. In her second year in Law school at American University, Lois met Trenton, an ambitious and intelligent partner in a prestigious local law firm. They were married shortly after. Entering their marriage, Lois understood that Trenton had plans to become an ambassador and that relocation to less desirable locations would be inevitable early in his career. This knowledge, however, did not make Trenton's announcement that he had been positioned as the ambassador to Sri Lanka any less shocking. Her mother's work in Washington with GEO and GETAMIC helped Lois to understand the consequences of living in a world of rising seas.

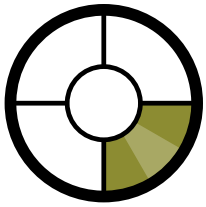
Sri Lanka, an island nation, has been suffering from both the direct and indirect effects of this global disaster for many years. Having heard that Malaria is an increasingly serious threat in this country, Lois began to research methods to protect her two small children from the possibility of contracting this disease. Lois logged onto the GRID website, where she learned about a product called Compact Anti-Vector System (CAVS), a portable device for controlling the number of vectors in the immediate environment. Since Malaria and other diseases are transmitted by vector agents like mosquitoes, Lois decided that this pesticide free device would be an excellent, sustainable way to keep her children safe anywhere they went. She ordered two devices from the GRID website, feeling confidant that they would provide a pest free environment for her family.

System Elements:

Resource Management

Super System Element

The Food Maker



Sub-Elements

- New-Land Farming
- Water Village Farming
- Hybrid Farming

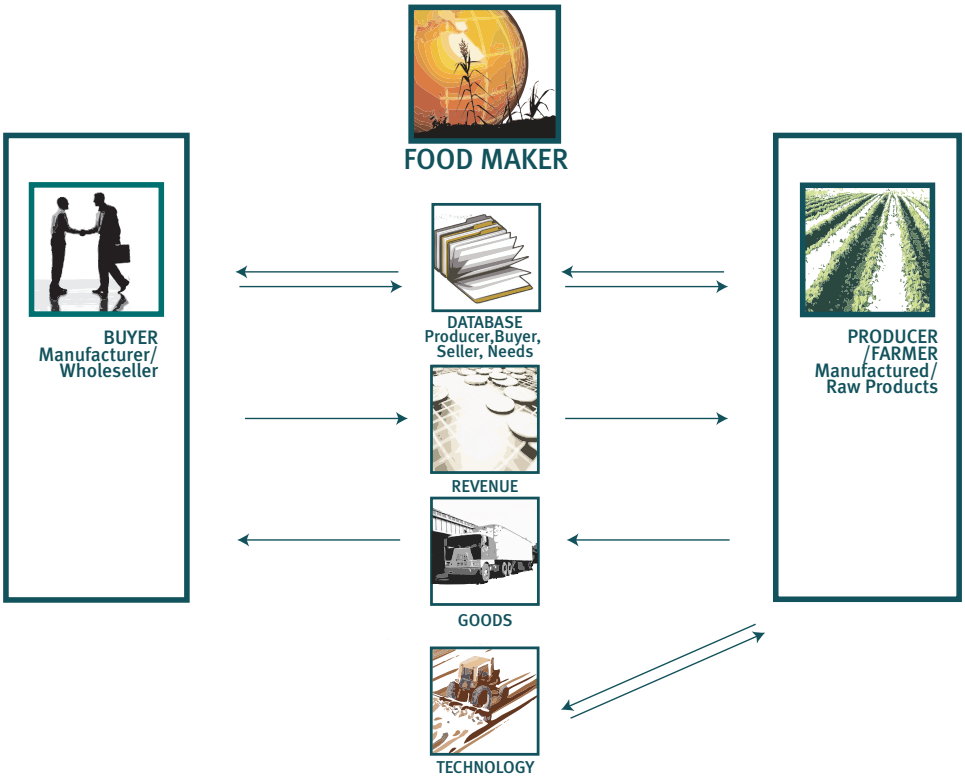
The Food Maker is collaborative program among communities at risk which supports various strategies for adaptive food production. The three strategies take into consideration the three possible conditions in dealing with a world of rising sea. Its adaptive attributes are highly related to the future population adaptation with high probability that as the signs of rising sea become more evident, the world will witness a massive change of habitual pattern along with obvious environment change.

The Food Maker program allows food exchange and acts as meeting point between seller (farmers, manufacturer) and buyer (manufacturer or wholesaler), while creating opportunities for transportation services and encourages **Expert Farming** methods. Playing the role of facilitator, **The Food Maker** helps set up a portal where buyers and sellers will be able to request for needs or offer to fill a need. On top of that, transportation and technology comes into play as a supporting role, not as an entity of the system but enablers, creating business opportunity along the way. Individual farmers will have a comprehensive business plan which is pre-determined before the food production begins. A central hub is provided via an I-Office link online with simple interfaces for farmers or their representative to keep track of the relationship with buyers.

Properties

- A consultancy program
- A food-chain program to assist farmers from participating communities to provide for local and international market
- Community of food producers participating in the resource development program
- An active center to collect and provide new or adaptive food making technique
- Database of Food-Making processes
- Situation evaluation software to analyze specific cases
- An online hub and I-Office for management
- A user kit for custom-tailored implementation plan
- A local management center

The Food Maker



Features

- Allows farmers to adapt to new environment with a custom tailored food production plan
- Provides farmers with a step by step guide to implement their personalized farming plan
- Support farmers by allocating dedicated consultant on case- to-case basis
- Provides a channel for contribution of new or adaptive farming techniques
- Offers scientist a ready supply of participants interested in agricultural scientific research
- Provides solution for farmers who choose to retreat and relocate from drowned farmlands
- Provides solution for farmers to accommodate to rising sea level
- Provides solution for farmers to adapt to high salinity land and water condition

Most coastal areas may be abandoned with preference towards the safer in-land areas where population will not be at mercy of unpredictable weather events. Currently, population development is by far the biggest known contributor to the decline of the coastal ecosystem. With a possible retreat of the population, slow re-evolution of some habitats crucial to food production may be possible. It will be the silver lining in the otherwise dark future that some may imagine. Due to the slow pattern of rising sea, natural habitat in abandoned coastal may gain the perfect slow process to evolve with the changing climate.

Some areas in the other hand may experience a change of salinity level. Higher water table will result in higher salinity count to soil. These are among the considerations that need to be taken into account when strategies for food production are created. On top of soil salinity, rising sea water may also be the cause of salt lakes, either by drowning lowland areas or intruding sea water mixing with existing lakes.

Research shows these environmental changes might occur due to rising sea levels. **The Food Maker** shapes its strategies based on the three areas of concern:

1. **New-Land Farming**; retreat from drowned surroundings and relocate to more sustainable environment
2. **Water Village Farming**; embrace the intrusive water and turn the vast coastal land into food producing environment
3. **Hybrid Farming**; using technology to adapt to high salinity in soil and water

The First Strategy

In the instant where impact and forces of the rising sea fares negatively on coastal environment or translate into persistent flooding of farm areas, the best option is to relocate to a more prosperous land. **The Food Maker**, working as the middle person will be able to sit through the process with a farmer and run through options for land, crops and method that best fit the new life that the evacuated farmer is capable of.

The Second Strategy

This strategy provides a solution for assimilating food-making processes to a rising sea environment. The methods allow farmers to embrace the situation by utilizing combination of technological and natural solution to continue producing food. Sea level rise, whether rapid or gradual, may cause populations to abandon coastal areas for fear of going underwater. This method embraces this scenario and uses the abandoned sea side for adaptive agriculture and aquaculture.

Aquaculture may also be initiated on emerging in-land lakes which may emerge as a result of flooding of low lands by rising sea level.

The Third Strategy

The strategy came to being due to the fact that sea level rise does not only paralyze all purposeful activities on coastal lands but may also impact the activities on adjacent in-land environment. A problem likely to occur is an increase of salinity level in both land and water. This threatens human uses of water and land especially for self sustenance.

The **Hybrid Farming** method will train and assist farmers in desalination for farming purposes using various techniques. The techniques are adaptation of existing solutions alongside scientifically engineered solution for crops and farming facilities.

The Kiran family lives off the land...

This family business is the source of living for their generations and many other families in Bangladesh. Over the decade their ancestors have managed to develop a strong chain of producers and marriage has expanded their farming life to all corners of Bay of Bengal. In November 1970, a cyclone hit the area and 500,000 people died. This tragedy was among the dark episode in the Kiran lives, with the lost of family members, there were hard times to rebuild their coastal agriculture. The source of economy was impaired and it sent many families at mercy of the government aid just to survive. Rebuilding the farming business took another five.

A few years before that, the Government decided to establish the embankment of the coastal islands through the predecessor of the Bangladesh Water Development Board (BWDB). The aim was to protect the people and their property from cyclonic surges and create better conditions for agricultural production by reducing intrusion of saline water and improving drainage of rainwater. The 1970 tragedy opened many eyes including those of the farmers. The embankment has failed and with the latest coverage of Global Warming and rising seas, Bangladesh has been put on the map among the at risk nations. Research were reporting that rural populations and farmland (especially rice) on some coasts will be wiped out. According to the UK Royal Society a one meter sea level rise could flood 17 percent of Bangladesh, displacing tens of millions of people and reducing its rice-farming land by 50 percent.

The Kirans realize that they can no longer rely on the embankment. The situation will worsen and there is no easy way to solve it. The Government has started calling on independent farmers to come

forward for a consultation to plan a new farming strategy. At first, the elders of the Kirans are very skeptical of getting outside help but later when they were explained the value of The Food Maker Program, they came to understand that the benefit will for them.

Sanjez Kiran has decided that his family will move away from coastal areas. The plan that was customized to fit his family will assist them in getting a land further in-land where there are large plain areas for him to start growing rice and potatoes. The land has been researched and tested and approved for the crops. Sanjez even managed to secure financing and buyer for the crops even before the seeds were planted. His family and the families of his worker will have a better life with the plan.

Sanjez's brother, Jamil, is more sentimental at heart. Despite persuasion from his wife and kids, he refused to leave the coastal area where his father first planted the seed for their agriculture heritage. Lucky for him, The Food Maker has a strategy that fits this need. He was allowed to remain on the safer part of the coastal where a wall was built further out towards the sea. This wall became a solid pen for a new adopted farming activity he had option for; fish farming. This met the need for a ready international market. On top of that, Jamil's sister in-law Reha, an aspiring business lady, wanted to fund a floating crops farm which will share the same space as the fish farm. The plan was very convincing that even a lady of little experience was willing to invest on such technology. Reha herself was assisted in the start up of the floating farm, she was able to see the report of potential income which will be generated even before harvest period comes.

New-Land Farming

In the instant where impact and forces of the rising sea fares negatively on coastal environment or translate into persistent flooding of farm areas, the best option is to relocate to a more prosperous land. **The Food Maker**, working as a consultant, will be able to sit through the process with a farmer and run through options for land, crops and method that best fits the new life that the evacuated farmer is capable of.

New-Land Farming is a practical way of retreating away from drowned farming areas and relocate in-land. Various existing procedures today can assist in the opening of new farm. In the case of **The Food Maker's New-Land Farming**, farmers will be assisted in a step by step process to acquire new land and suitable crops and funding to fill certain needs in the Food Maker program. The process allows farmers to go through the 10 steps of **New-Land Farming**:

1. Assigned to a personal **Farming Advisor**
2. Select suitable sites and soils
3. Select suitable crops
4. Understand the chemistry of the water
5. Condition soil and/or water to mitigate sodicity
6. Understand the water balance
7. Irrigate based on crop and leaching requirements
8. Prevent runoff
9. Monitor water, soil and vegetation
10. Plan for site closure

Properties

- Personal consultation on a case to case basis
- A database of crops options and its farming requirements
- A system of matching ability of land, financial, technicality with suitable crops to farm
- A collection of standard processes to evaluate the areas crucial understanding land ability to grow crops
- A procedural guide to acquiring land for farming processes
- A step-by-step start guide to opening a new farm

Features

- Minimize trial and error in farming
- Pre-determine the rate of success to fit individual farm
- Offers a cycle plan for crops to be farmed, harvested, sold and delivered
- Connects farmers with all related parties in a comprehensive business plan

Water Village Farming

Properties

- Three types of farming methods to accommodate rising sea levels
- Methods of turning abandoned coastal areas into adaptive agriculture and aquaculture sites
- A method of turning flooded low lands into lakes supporting aquaculture

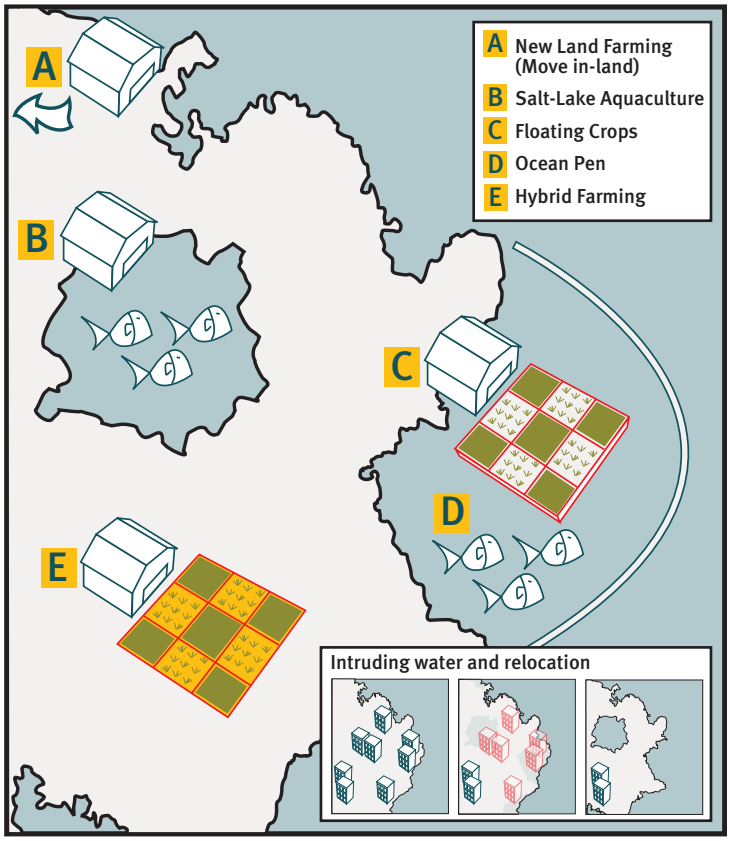
Features

- Provides farmers with the technology to continue producing food amidst the impact of sea level rise
- Offers a solution to mitigate the world's food shortages
- Supports the **Food Maker**'s food sharing and food chain system
- Makes a variety of food available to buyers in the **Food Maker** program
- Offers participating communities the means for self-sustenance

Water Village Farming, offers three technologies for dealing with the rising sea environment:

1. Crops in Containers
2. Marine Aquaculture
3. Salt Lake Aquaculture

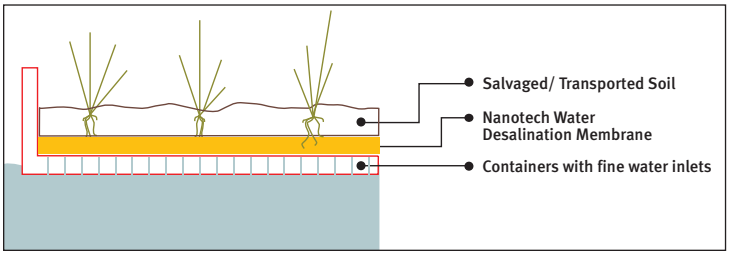
Food production strategy in a world of rising seas



Crops in Containers

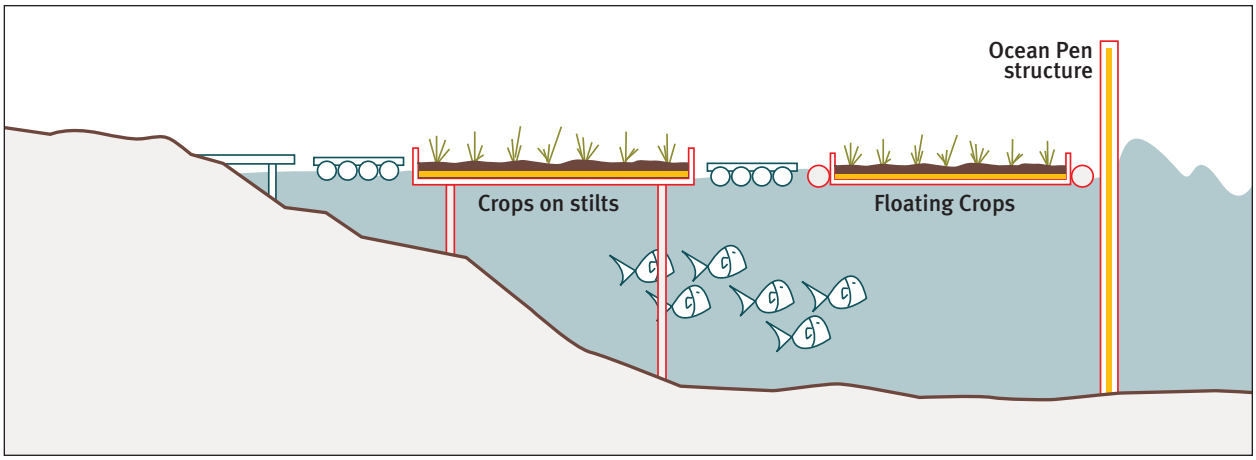
Crops in Containers may either be floating containers or containers on stilts. Soil used in container is acquired from land with rich soils or salvaged soils before original farming areas were drowned. The bottom half of the containers that touches the water will be layered with Nanotech Water Desalination Membrane which will irrigate crops passively by natural root penetration or actively by automated suction device powered by renewable kinetic energy.

Section through a Crops in Containers assembly



Water Village Farming

Aquaculture and crops growing on salt water



In other environments, a rise in sea level would enable saltwater to penetrate farther inland and upstream into rivers, bays, wetlands, and aquifers. This situation can be accommodated positively by two options: Marine Aquaculture and Salt Lake Aquaculture.

Marine aquaculture

Natural sedimentation and peat formation on wetlands (marsh) will no longer be possible with the rapid pace of sea level rise. If in the future, sea level rises faster than the ability of the marsh to keep pace, the marsh area will contract. Construction of bulkheads to protect economic development may prevent new marsh from forming and result in a total loss of marsh in some areas. The bulkheads will undeniably change the environment of future seasides in which development will start moving in-land, away from unpredictable sea rise and surges.

The less populated and abandoned sea side will be a perfect stage to build closed containment-system for Marine aquaculture. The sea wall will serve both as buffer for sea surges and a compromise to controversial issues of fish escapement and water disposal surrounding the current Marine aquaculture industry.

Salt Lake Aquaculture

Non-reversible penetration of salt water to inland waters sources can be repurposed to become salt water fish farms. The new salt lake will be equipped with marine aquaculture technology and enabling processes contrary to the current negative media attention on farmed fish.

Hybrid Farming

Properties

- *Leaching:* Using just a bit more water than the plants need to reduce salinity by leaching salts past the roots zone into aquifers
- *Drainage:* Ditches or underground pipes which takes saline water away
- *Flooding:* Badly salinized land that can no longer sustain agriculture can be rehabilitated by flooding and drainage. In cases where the land can still grow something, farmers can plant a rehabilitation crop that tolerates some salinity and uses a lot of irrigation water, such as rice.
- More efficient use of irrigation water: Drip irrigation, which involves delivering a metered amount to the area around the plant.
- Genetically engineered crops

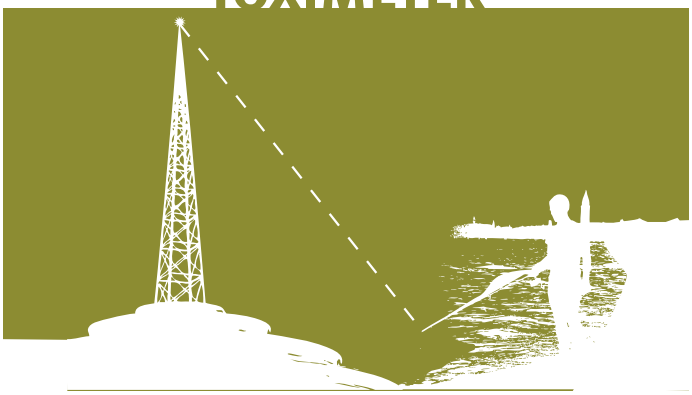
Features

- Provide farmers the technology to continue producing food in badly salinized soil
- Provide means of watering crops with salinized water source
- Support the **Food Maker**'s food sharing and food chain system
- Provide variety of food in production for the buyers in the **Food Maker** program
- Offers participating communities the means for self-sustenance

Sea level rise does not only paralyze purposeful activities on coastal lands but may also impact the activities on adjacent on-land environments. A problem likely to occur is an increase of salinity level in both land and water. This threatens human uses of water and land especially for self sustenance.

The **Hybrid Farming** method will train and assist farmers in desalination for farming purposes using various techniques. Many techniques include adaptations of existing solutions applied to genetically engineered crops and advanced farming facilities. Research into new methods of **Hybrid Farming** continue to ensure food safety, lower costs, and improve efficiency.

Toximeter

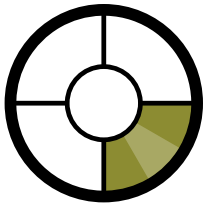


Hydroclenze

Fern Garden

Super System Element

AquaPür



Sub-Elements

- Toximeter
- HydroClenze
- Fern Gardens

"Environmental sanitation and human health are closely linked. Poor management of human wastes can lead to direct or indirect disease transmission. This is why it is important to provide adequate sanitation to combat environmental transmission of pathogens. Sanitation is the primary barrier for preventing the entry of many human pathogens into the environment.
The environmental transmission of pathogens occurs through several different routes including:

- directly, by contact with human excreta;
- directly through contaminated drinking water;
- directly through vegetables, shellfish or other food products exposed to contaminated water or soil;
- by accidental ingestion of contaminated water during swimming or recreational activities;
- by inhalation of aerosols or dust due to irrigation with wastewater, from scums, from showers or by other means;
- vector-borne transmission where the vector or the intermediate host breeds in water;
- by contact with animals and birds, both domestic and wild acting as a host for pathogenic bacteria and parasites;
- by direct contact with the organisms occurring in water bodies (for example Leptospira); and

Properties

- A system of devices and process for detection and removal of toxins from water
- A portable device for conducting environmental damage analysis
- Low-power, color, graphic flat-screen display with touch screen control
- Flashing light for special advisories
- Waterproof casing
- Wireless, GPS networking for rapid data transfer
- A self calibrating temperature controlled compartment
- Micro carbon filter
- A reservoir housing nano Iron and Porous Nanoparticles
- A battery to activate water filtration during periods of stagnation or in still water
- A natural solution for removing toxins from water
- Environmental engineering

AquaPür

Features

- Rapidly detects pollutants in on-site locations using Microtox technology (bacteria Vibrio fischeri NRRL B-11177)
- Transmits data to central hub
- Uses nanotechnology (Nano Iron and Porous Nanoparticles) to trap and expel pollutants from water
- Scalable technology, can be used around the home or in larger bodies of water
- Environmentally sound method of extracting pollutants from environment
- Helps to balance local ecosystems
- Naturally removes toxins from soil and water
- Some components are low cost, easy to maintain, readily accessible to general public
- Prevents toxic soil and water from being removed and sent to a landfill, an expensive process

- by secondary spread through contact with infected individuals.

"The main organisms that pose a threat to health are pathogenic bacteria, viruses, parasitic protozoa and helminths that are excreted in large numbers (up to 1,011/g faeces for some viruses) from infected individuals. Many of these organisms have low infectious doses (e.g., helminths, protozoa and viruses) i.e., only small quantities of infectious agents are needed to infect a new host (the infective dose varies between organisms and with respect to the susceptibility of the exposed individual). In addition, the abundance of opportunistic, normally occurring organisms in water bodies may be affected.

"Interventions are required to lower the impact on human health of environmental contamination of water bodies and receiving areas caused by human activities. Appropriate interventions may vary according to region and the prevailing socioeconomic situation but should be based on a barrier approach to different transmission routes. Many previous and current interventions have failed, at least in developing regions of the world. Interventions at the household level, the industrial level and those related to watershed management must be taken as close to the sources of pollution as possible. Many of the centrally managed facilities have failed partly due to lack of operation and maintenance and partly due to the need for an integrated approach that also focuses on health issues. A household centered approach combined with holistic watershed management may provide a better solution to the problems faced today."[1]

AquaPür is our response to that call for action. **AquaPür** is a water purification system that combines toxin detection and removal on both large and small scales. To detect pathogens, we propose the use of the **Toximeter**, a portable devices that harness the natural function of the bacteria *Vibrio fischeri NRRL B-11177*.

"When properly grown, luminescent bacteria produce light as a by-product of their cellular respiration. Cell respiration is fundamental to cellular metabolism and all associated life processes. Bacterial bioluminescence is tied directly to cell respiration, and any inhibition of cellular activity (toxicity) results in a decreased rate of respiration and a corresponding

[1] "Health Aspects." Sanitation Connection. http://www.sanicon.net/titles/topicintro.php3?topicId=2 (accessed 30 Nov 2006).

decrease in the rate of luminescence. The more toxic the sample, the greater the percent light loss from the test suspension of luminescent bacteria."[2]

The **Toximeter** allows for the collection of this data on site and can communicate this info wirelessly back to a central data hub. Once toxicity has been detected, it must be removed. We propose the use of a scalable technology, called **HydroClenze** that harnesses Nano Iron and Porous Nanoparticles to collect and cluster pollution. Clumped pollutants will later be spun off in a centrifuge or filtered through purifying membranes. Personal **HydroClenze** units can be installed around the home, but more substantial units powered mainly by tidal and wave energy (supplemented by battery power) can be used for larger bodies of water.

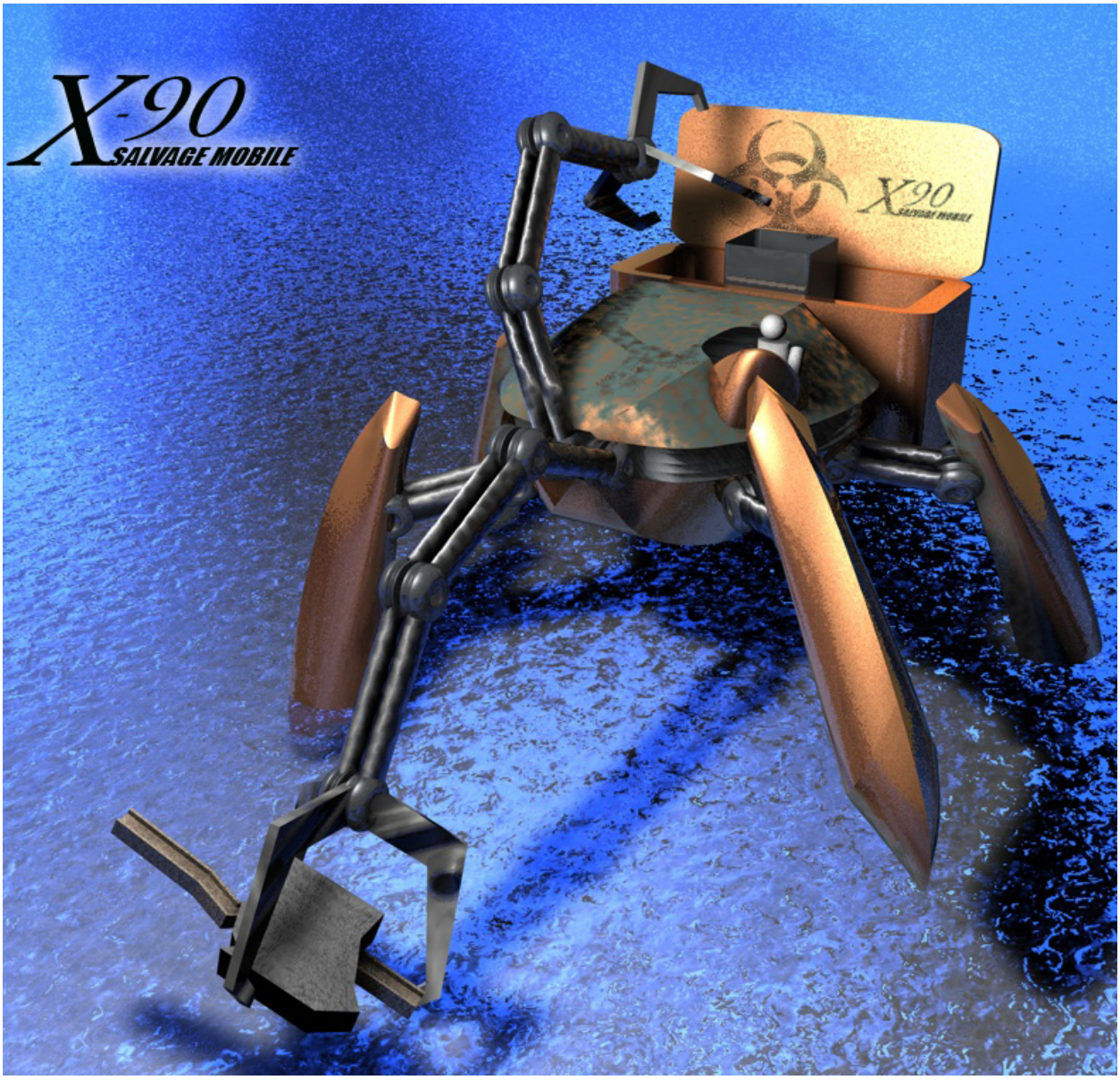
Finally, we propose a natural system for removing toxins from water. It has recently been discovered that ferns are adept at removing toxins from water and storing them in their fronds. An existing solution, we recommend planting **Fern Gardens** at the base of the ground water surrounding local homes. Not only do they help to purify the water, they are a natural and attractive addition to any yard.

"Today, the ferns are being used throughout the United States to remove arsenic from soil and drinking water. Edenspace, which specializes in a variety of plants to cleanup toxic substances, has twelve employees and reported $1.2 million in revenues last year."[3]

[2] "Microtox® Rapid Toxicity Testing System." Azur Environmental. http://www.azurenv.com/mtox.htm (accessed 30 Nov 2006).

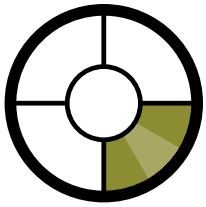
[3] Ruder, Kate. "Ferns Remove Arsenic from Soil and Water." Genome News Network. http://www.genomenewsnetwork.org/articles/2004/08/06/fern.php (accessed 28 Nov 2006).

Salvagemobile X-90 model recovering scrap reinforced concrete



Super System Element

Salvagemobile



Sub-Elements

- Pollution Trap
- Tight Waste Containers

When a disaster strikes, buildings are torn apart, infrastructures are destroyed, all is ravished. Much of this rubble must be discarded, as it is unfit for further use. However, among the trash is material that can be repurposed. It is important to collect this material and reuse it, rather than send it to a landfill, or have it continue to collect in the environment. Since salvageable material (such as timber) has value for only a short time following a disaster, it is important to be able to collect this material as quickly as possible. In addition, a disaster will cause many hazardous substances to be released into the environment. Safe extraction and disposal of these substances will be necessary to ensure public health and safety.

The **Salvagemobile** is an amphibious vehicle that proactively seeks out material that can be reused. Raw materials that can be repurposed are temporarily stored in a large bin for transportation to local recycling/repurposing centers. This vehicle is also equipped with **Tight Waste Containers** which safely storage hazardous wastes for transportation. Attached to the bottom of the vehicle is a **Pollution Trap**, which is powered by the motion of the vehicle and uses a carbon filter, ultra violet light and a medicated wet filtration system to remove bacteria and other toxins from the air in the surrounding environment.

Properties

- Adaptable to maneuvering over land and sea
- Compartments for storing hazardous waste
- Absorbent filter for trapping airborne pollutants
- Receptacle for storing salvageable/ recyclable material

Features

- Mobile, proactive waste collection
- Transportation and distribution of salvageable materials
- Removal of toxins from the surrounding environment
- Toxin extraction powered by motion of vehicle
- Removal of hazardous substances from environment
- Safe disposal of hazardous substances

Jeffrey, a government employee in Baltimore, Maryland, is eager to begin the cleanup effort following the worst hurricane to hit his hometown in recent memory...

The devastation is severe, but the people of Maryland are focused on making the best of the situation and restoring life to normalcy is quickly as possible. Jeffrey is taking part in the effort to reclaim as many raw materials as possible. In addition, he is also tasked with the collection and disposal of hazardous waste in the environment.

To aid him in his work, he will be driving one of the city's Salvagemobiles, an amphibious vehicle equipped to handle all varieties of debris and waste. Jeffrey approaches his first site, dressed in protective gear. He has even done his part to purify the environment on his drive over. His vehicle is equipped with a Pollution Trap. The Trap is attached to the underside of the Salvagemobile and passively extracts pollutants from the air during the drive, as it is powered by the motion of the vehicle.

At the site, Jeffrey begins to place recovered materials into the vehicle. He will drop those off at a local recycling center later. In addition, he carefully deposits hazardous waste into one of the Tight Waste Containers on board the vehicle. This material will be taken to a special facility, but in the meantime Jeffrey feels safe know that this waste is secured within the indestructible receptacles.

Pollution Trap

Properties

- Carbon Filter
- Ultra Violet lamps
- Medicated Wet filtration system
- Durable plastic and metal casing
- Adjustable clasps for connecting to the underside of a vehicle

Features

- Mobile, passive waste collection
- Removal of toxins from the surrounding environment
- Toxin extraction powered by motion of vehicle

"Air Pollution, is the addition of harmful substances to the atmosphere resulting in damage to the environment, human health, and quality of life. One of many forms of pollution, air pollution occurs inside homes, schools, and offices; in cities; across continents; and even globally. Some air pollutants return to Earth in the form of acid rain and snow, which corrode statues and buildings, damage crops and forests, and make lakes and streams unsuitable for fish and other plant and animal life.

"Pollution is changing Earth's atmosphere so that it lets in more harmful radiation from the Sun. At the same time, our polluted atmosphere is becoming a better insulator, preventing heat from escaping back into space and leading to a rise in global average temperatures. Scientists predict that the temperature increase, referred to as global warming, will affect world food supply, alter sea level, make weather more extreme, and increase the spread of tropical diseases."[1]

Droplet transmission

"When you cough or sneeze, you expel droplets into the air around you. Spread of infectious disease in this manner is called droplet spread or droplet transmission. Droplets travel only about three feet because they're usually too large to stay suspended in the air for a long time.

Particle transmission

"Some disease-causing germs travel through the air in particles considerably smaller than droplets. These tiny particles remain suspended in the air for extended periods of time and can travel in air currents."[2]

Existing technology provides us an air filtration system which includes four principle segments. The first segment includes a pre-filter for the removal of dust particles; the second segment is provided with germicidal UV lamps for bacteria removal; the third segment contains a medicated wet filtration system for virus removal, and the fourth segment contains a final carbon filter. We propose to attach this technology to a vehicle, so that the vehicle's motion will enable it to passively combat and contain bacteria and other pollutants in the environment.

[1] "Air Pollution." MSN Encarta. http://encarta.msn.com/encyclopedia_761577413/Air_Pollution.html (accessed 01 Dec 2006).

2 "Infectious diseases: How they spread, how to stop them." Mayo Clinic. http://www.mayoclinic.com/health/infectious-disease/ID00004 (accessed 01 Dec 2006).

Tight Waste Containers

"Hazardous wastes are those wastes which, due to their nature or quantity, are potentially hazardous to human health or the environment and which require special disposal techniques to eliminate or reduce the hazard. They have characteristics such as toxicity, flammability, corrosiveness, and thus can have a wide range of potential impacts due to these hazards, and at times, due to their tendency to persist in the natural environment.

"Some of the more common hazardous wastes are spent acids and caustic, 'still bottoms,' the leftovers from oil refining and the manufacture of chemicals. Hazardous wastes often contain phenols, arsenic, mercury, lead and a large number of other toxic chemicals."[1]

It is important that toxic materials be labeled precisely, for proper and safe disposal. In addition, extreme care must be taken when transporting this material, to prevent further damage to the environment.

To assist in the handling of these toxic chemicals, we propose the implementation of **Tight Waste Containers**. The containers would be composed of high density polyethylene, a ceramic inner coating, and cased with a nickel-based alloy to resist corrosion. They would be outfitted with a drip resistant shield and have clear markings to identify the type of waste contained within. The containers would have a **LockTight** seal, making it impossible for any substance to leak into or out of the container. Carried on board the **Salvagemobile**, trained workers in protective attire will use these modestly sized containers to transport toxic material removed from a disaster site.

Properties

- Specific markings for type of waste
- High density polyethylene
- Ceramic coating
- Drip shield
- Canister comprised of nickel-based alloy
- Drip resistant
- Impact resistant
- Corrosion resistant
- Waterproof

Features

- Safely contains and transports hazardous waste
- Uses universally understood symbols to clearly mark waste containers as hazardous waste

[1] "Transporting Hazardous Waste." Environment Canada. http://www.atl.ec.gc.ca/epb/factsheets/transport.html (accessed 26 Nov 2006).

Super System Element

Marine Systems for Generating Sustainable Energy (MSGSE)

Sub-Elements

- Pelamis Wave Energy Converter
- Solar Array Reef Shade
- Defensive Energy Network of Turbines

Having identified the increasing emission of greenhouse gases as a major cause of climate change, steps are being taken to reduce and eliminate emissions from contributing energy production methods.

While rising sea levels are ultimately going to destroy significant amounts of human infrastructure, the ocean itself provides us with numerous opportunities to capture energy from renewable sources using non-polluting techniques. Of course, we must always be aware of the potential environmental ramifications of coastal power systems. Adopting localized, sustainable energy sources not only mitigates environmental impacts, but reduces dependencies on foreign nations as well.

Some approaches to generating energy using ocean-based renewable supplies provide other benefits as well. Richard LaRosa, for instance, suggests that undersea turbines could be used to harness energy from the Gulf Stream while slowing the flow that transfers warm tropical waters to the Arctic regions. This same principle can be applied to systems of turbines arranged to protect dense population centers from storm surges by slowing advancing waters.

Properties

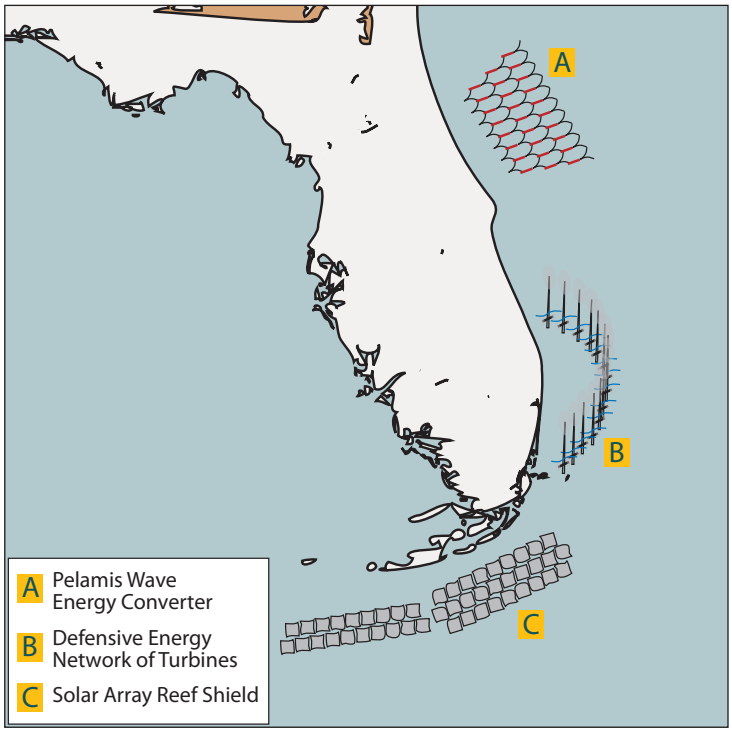
- Systems of power generating plants
- Apparatus for capturing ocean thermal differential energy
- Underwater turbines for capturing current and tidal energy
- Artificial lagoons for capturing tidal energy
- Wave energy converters
- Flexible, floating solar power cells
- Waterproof energy delivery infrastructure

Marine Systems for Generating Sustainable Energy (MSGSE)

Features

- Harnesses thermal and mechanical energy from the ocean
- Delivers sustainable, nonpolluting energy to cities
- Utilizes any of three basic aquatic energy systems: channel systems, float systems, and oscillating water column systems
- Relieves dependency on foreign sources of energy
- Taps tidal energy in rivers and streams to generate power
- Simulates the calming power of reef systems by slowing storm surge waters
- Combines multiple sources of energy to offset forces that only generate power intermittently

MSGSE sub-elements utilized off the Florida coast



The Florida Current and the Gulf Stream are along the fast-moving western boundary of the North Atlantic Subtropical Gyre which moves warm tropical waters north towards the Arctic regions...

Of the estimated 480 gigawatts estimated to be driving the Gyre, marine current turbines strategically placed off the coast of Florida could easily extract a small fraction of that and deliver a significant amount of power to the Eastern Coast. Supplemented by a wind turbine above the surface, each DENT module is currently expected to produce about 4MW of energy. Supposing an array of 100 units, this setup would power 400,000 homes. As technology improves, these ratings can only get higher.

Along the Florida Keys lie the only extensive reef systems near U.S. coasts. While bleaching is not as extensive as that of the Great Barrier Reef, if Australia's use of shading to protect coral from bleaching proves successful, Florida could implement the SARS program to proactively mitigate damage while capturing solar energy at the same time. Finally, installation of a wave farm consisting of 165 Pelamis WECs off the Atlantic coast of Northern Florida would provide another 70,000 households with sustainable energy.

These three approaches are all components of a portfolio of sustainable sources that could supply nearly half of Florida's energy needs.

Pelamis Wave Energy Converter (Pelamis WEC)

Ocean waves, constantly generated by the wind blowing over the surface, efficiently transmit significant energy across long distances. Most of this energy is concentrated in the 50 meters just below the surface of the ocean. Therefore, wave energy is an efficient, if variable, source of renewable energy. According to Ocean Power Deliver Ltd., the seasonal variation of wave energy conveniently mirrors seasonal variation in Western Europe's energy demands.

While farms of these "water snakes" would potentially take up a significant amount of surface area near coastal population centers, they are relatively low profile and represent an enormous opportunity. One square kilometer of ocean dedicated to a wave farm would provide sufficient energy to power 20,000 homes.

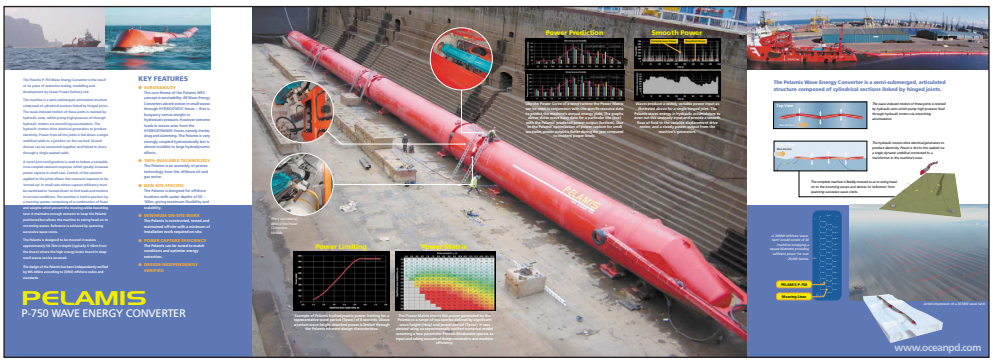
Properties

- Farms of semi-submerged floating wave energy conversion systems
- Floats and weights mooring system which maintains position without becoming taut
- Electricity storage and transmission infrastructure

Features

- Captures energy in hydraulic motors through wave-induced motion
- Emphasizes survivability over operational efficiency
- Reacts against itself, obviating the need for substantial sea bed damage
- Converts variable wave energy into a smooth flow through hydraulic accumulators

The Pelamis P-750 Wave Energy Converter



Solar Array Reef Shade (SARS)

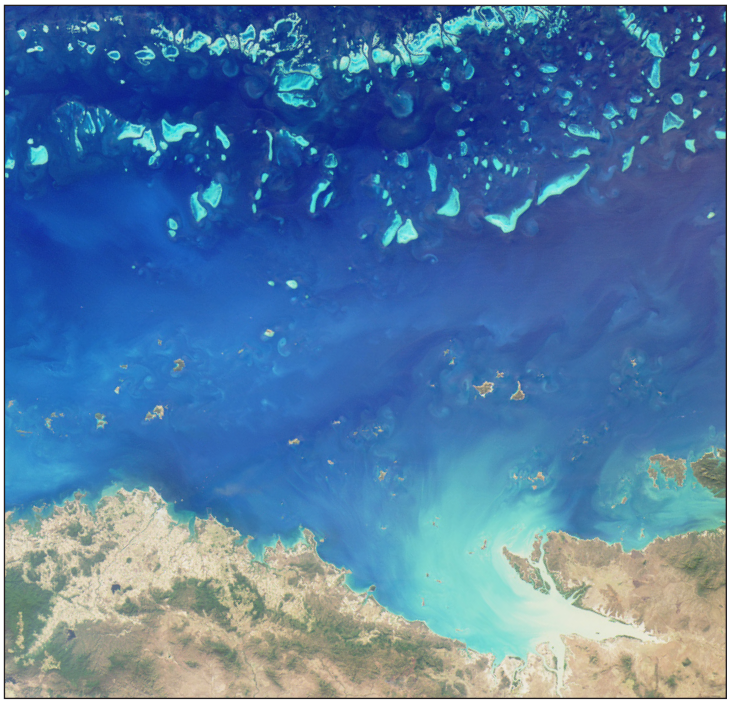
Properties

- Floating arrays of thin, flexible solar cells
- Solar cells composed of an ultrathin film of nano-sized semiconductor crystals
- Electricity storage and transmission infrastructure

Features

- Produces electricity with 11 percent efficiency (compared to typical 4-5 percent efficiency)
- Reduces light intensity and temperatures that contributes directly to coral bleaching

The Great Barrier Reef



Citing damage caused to the Great Barrier Reef by the effects of global warming, Australia is conducting a trial of five-meter square shade cloths to reduce coral bleaching. This strategy was inspired by a scientist's observation that coral formations growing under natural shade were healthier than those found in direct sunlight. New advances in solar cell technology could augment such a strategy if it proves successful. Researchers in Switzerland have recently developed a dye-sensitized solar cell of nano-sized semiconductor crystals that produce energy with twice the efficiency of other cell technologies. Applied to floating shades, this would both provide protection for reefs and generate energy at the same time.

Defensive Energy Network of Turbines (DENT)

Both wind and tidal energy provide reliable and renewable, if intermittent, energy. By their very nature, coastal areas are prone to strong and steady winds, ideal for capture by wind turbines. In a similar fashion, strategically located underwater turbines can harness predictable tidal and ocean current energy. A significant opportunity exists to incorporate both of these technologies into a single modular device to capture both forms of energy. In fact, proposed underwater turbine designs use 15m rotors, the same depth to which most wind turbines are constructed. Each intermittent energy source complements the other, providing more sustained energy than either could produce alone.

Properly reinforced and designed, these devices could be arrayed around dense coastal population centers to slow incoming storm surges, reducing the intensity of waves that make it to shore. This, in turn, would reduce the damage and devastation caused by increasingly violent tropical storms.

As an extension of current wind turbine technology, recent research shows that it might be possible to build giant floating turbines far out in the sea.

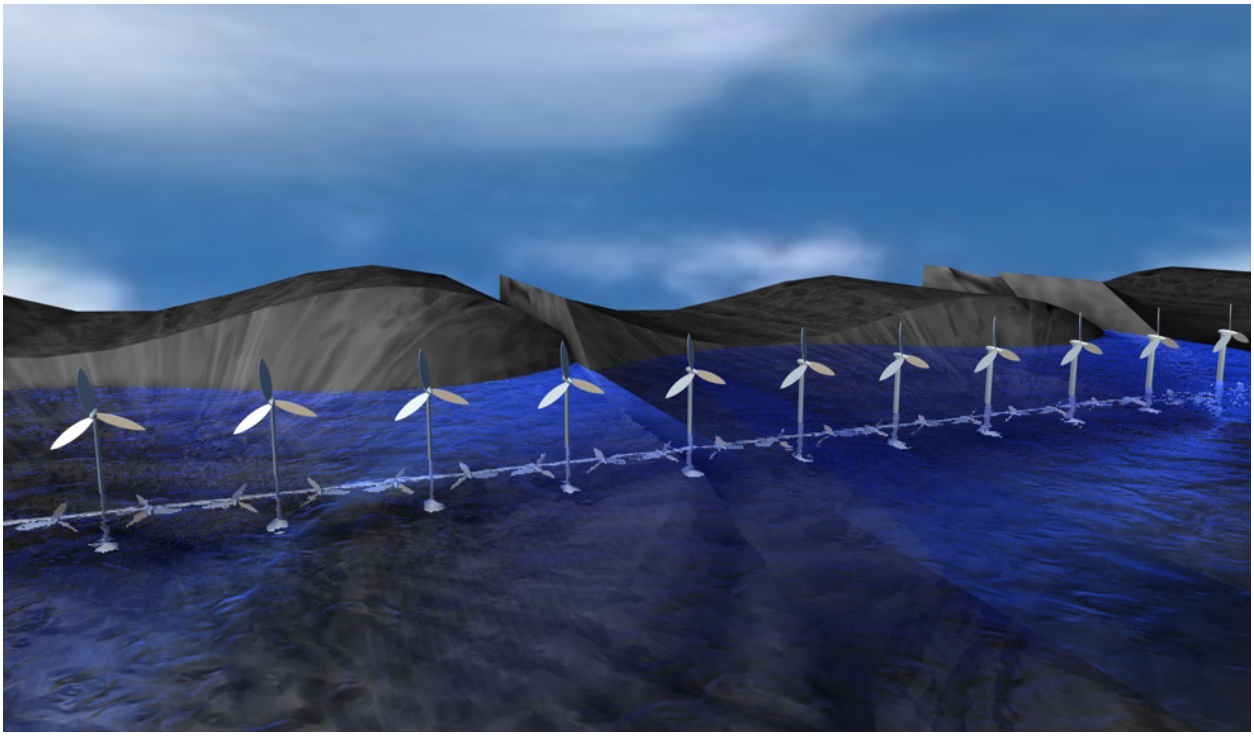
Properties

- Offshore wind turbines
- Marine current turbines
- Electricity storage and transmission infrastructure

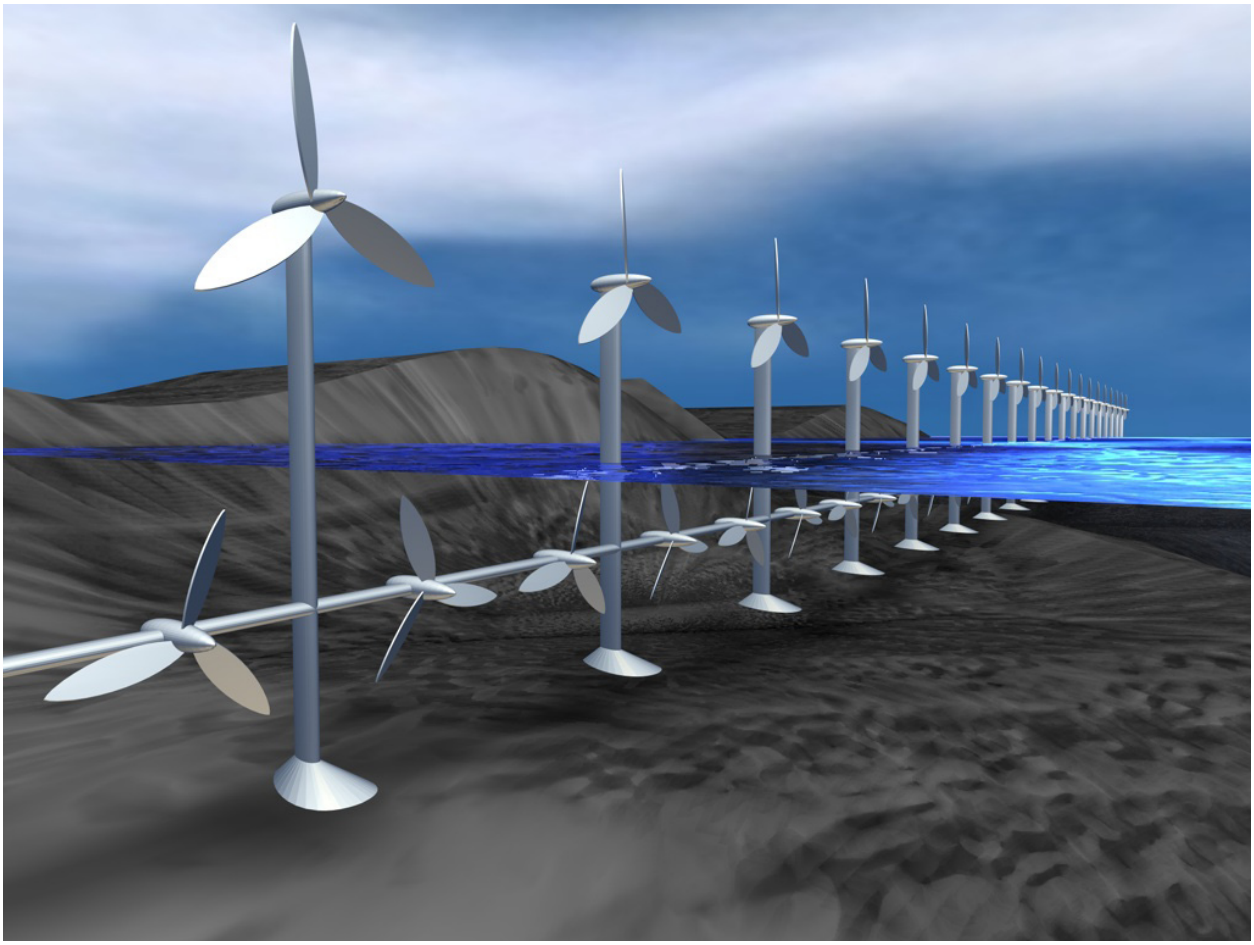
Features

- Captures steady offshore winds
- Captures predictable tidal and ocean current energy
- Combines wind and tidal energy capture in a single device
- Supplements intermittent energy sources with each other
- Slows the speed of incoming storm surge waters

Array of combination wind and tide turbine systems



The Pelamis P-750 Wave Energy Converter



System Elements:

Physical Systems

Super System Element

Shoreline Management System (SMS)

Sub-Elements

- Dredge Repurposing
- Beach Architecture
- Coastal Retention Web

To reverse the effects of shoreline erosion, and prevent further erosion from occurring we propose **Shoreline Management Systems**, a process designed to create environmentally sound natural barriers to retain coastal land, prevent erosion and provide an elemental buffer zone.

The process begins with **Dredge Repurposing**, the act of repurposing the land and sediment that is excavated during the industrial dredging process for use in constructing beach buffer zones. Typically the land that is dredged up is shipped further out to sea for disposal. This land can be put to better use fortifying eroded coastlines, to help dissipate wave energy and provide a buffer zone from storm surges.

Once the necessary earth for creating the buffer zones has been procured, a team of landscape architects can implement their designs for protecting, enriching, and supporting at-risk shores, in a process we are calling **Beach Architecture**. This involves supporting artificially constructed beaches with underwater buffers that absorb incoming wave energy.

Properties

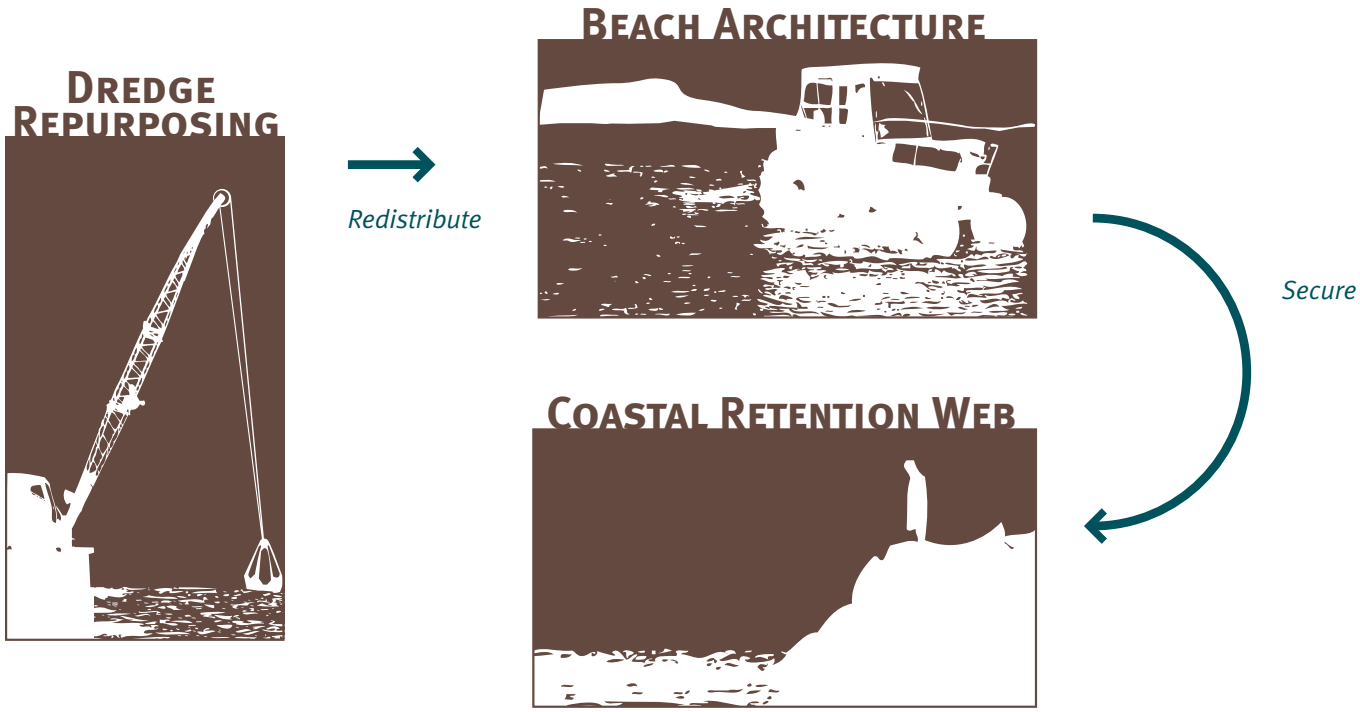
- Tailored, ecologically conscious defense systems
- Biodegradable Keratin composite netting that prevents beach erosion
- Strategic land repurposing that establishes hidden buffer zones
- Program for redistributing excess earth from industrial dredging

Shoreline Management System (SMS)

Features

- Reuses earth from industrial dredging by-products in beach architecture
- Efficiently transfers earth from to areas in need
- Builds and maintains buffer zones
- Protects and improves environments
- Combats existing erosion and prevents further erosion
- Utilizes natural waste to benefit instead of pollute the earth
- Enhances and extends natural buffer zones to dissipate wave energy
- Effectively uses a biodegradable by-product of poultry industry
- Secures existing soil, preventing further erosion
- Traps sediment, reversing erosion

After the precision terra forming has been completed, the new coastline is held in place with a **Coastal Retention Web**. Composed of Keratin, which is biodegradable, the web is held in place with durable stays that are threaded through the earth like the roots of a mangrove. The web is comprised of textured pockets which trap and retain sediment, adding to the carefully crafted shoreline. In time, the web will disintegrate, leaving behind only the buffer zone it helped create. In addition, the web can be used independently of the **Shoreline Management System**, along river beds and other bodies of water at risk from erosion.



The city of Boston is faced with the possibility of decimation at the hands of increasingly intense hurricanes...

To help protect their homes and livelihoods, the mayor of Boston, Francis Sharp, proposes the building of buffer zones along the city's slowly eroding coastline. He learned about this process by reading the GRID website and feels that it will be a sustainable, natural approach to the problem.

In addition, he realizes that with the city's canal expansion program running in tandem with this natural building project, he can use the by-product of the canal dredging to build up the coastline. This will save him from having to pay costly shipping fees and from excavating land from an alternate location.

Mr. Sharp also chooses to solidify his efforts, by draping Coastal Retention Webs over the newly formed barriers. He also uses the webs, to reinforce other areas along the coastline where buffer zones will not be employed, with the expectation that overtime, these webs will aid in the natural creation of beach buffer zones with the sediment they trap and retain.

Dredge Repurposing

Dredge Repurposing involves repurposing the land and sediment that is excavated during the industrial dredging for use in constructing beach buffer zones. Typically excess earth from dredging up is shipped out to sea for disposal. This wasted land can be put to better use fortifying eroded coastlines, helping dissipate wave energy, and providing a buffer zone from storm surges. While this might be effective by simply dumping the excess sand in eroding coastal regions, it is more effective to employ the sand in **Beach Architecture** projects that more thoughtfully apply a supporting structure to reinforce efforts that combat erosion.

Properties

- Vehicles for carrying earth
- Machinery for dredging and spreading earth
- Pipeline and infrastructure for moving earth

Features

- Reuses earth from industrial dredging by-products in beach architecture
- Efficiently transfers earth from to areas in need

Beach Architecture

Properties

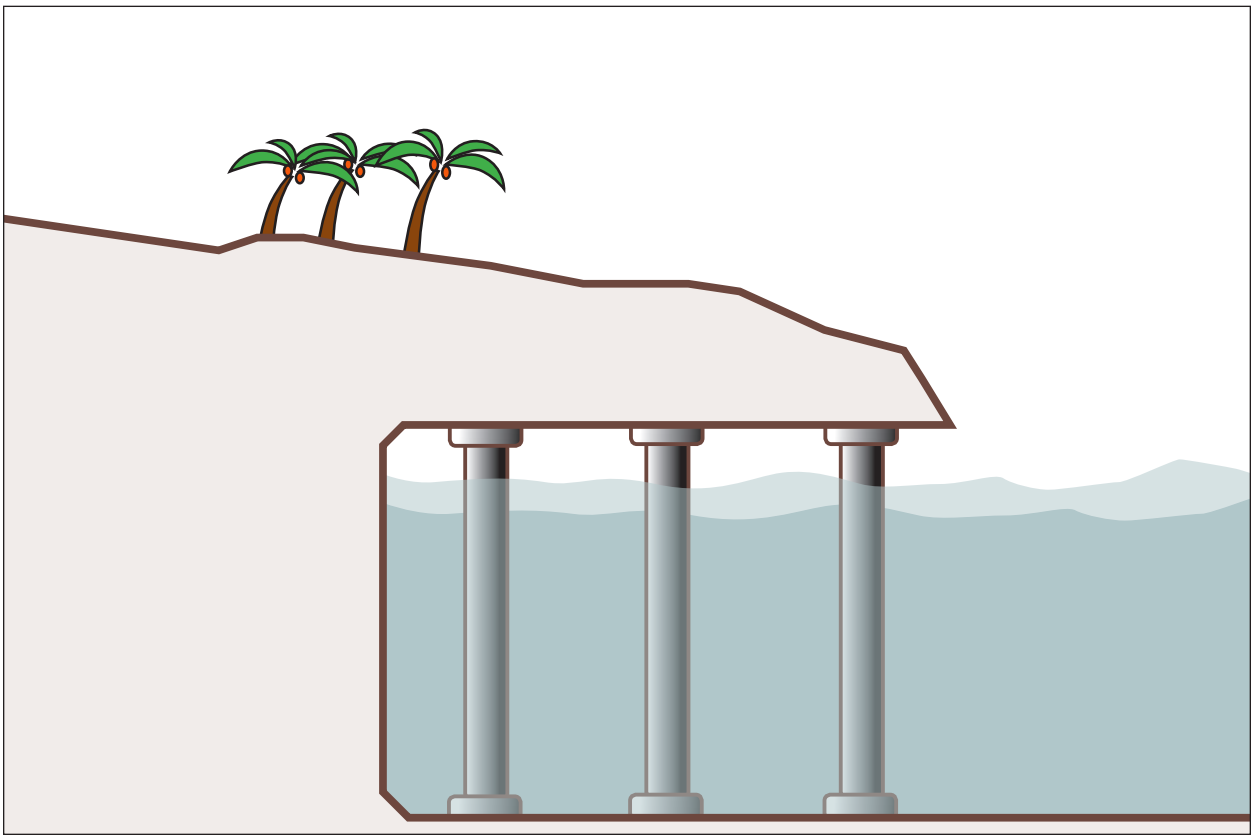
- Precision sculpting process
- Environmental engineering
- Network of landscape architects

Features

- Repurposes earth from industrial dredging
- Builds and maintains beach buffer zones
- Protects and improves environments
- Tailored, specific defense systems

Once the necessary earth for creating buffer zones has been procured, a team of landscape architects can implement their designs for protecting and enriching the shore, a process we are calling **Beach Architecture**.

Beach Architecture proposes to establish a foundation supporting repurposed sands above the sea level. Supported on pylons, a sturdy surface is extended out into the ocean. The surface is designed to be strong enough to support enough sand to extend the beach 50m. Once the structure is established and tested, repurposed land is then layered on top and terra-formed into a new coastline. The space underneath the new artificial beach is intentionally left empty so that ocean waves are less effective at eroding surface sands. This buffer also provides a place for storm wave energy to go, mitigating potential damage to the land above.



Coastal Retention Web

Every year 2 to 3 billion pounds of feather waste is generated by the poultry industry. The feathers, which are comprised of keratin proteins that are rich in the sulphur-containing amino acid cysteine. Sulphur-sulphur cross-links between cysteine molecules are responsible for the good stiffness and strength of keratin.

Recently, a number of studies have shown that the inter-molecular cross-links in keratin can be broken to obtain a soluble fraction, that can be processed into polymeric materials, such as films. Such new biopolymeric materials from feather keratin might find interesting applications; e.g. as packaging material, or as matrix material in fibre reinforced composites. We are proposing to use it as the basis for a web that aids in reversing shoreline erosion.

We contend that one way to combat erosion, is by the implementation of a **Coastal Retention Web**. Composed of Keratin, which is biodegradable, the web is held in place with durable stays that are threaded through the earth like the roots of a mangrove. The web is comprised of textured pockets which trap and retain sediment, adding to the carefully crafted shoreline. In time, the web will disintegrate, leaving behind only the buffer zone it helped create.

Properties

- Textured "pockets" for collecting and trapping sediment
- Strong webbing composed of biodegradable Keratin composite that extends along shoreline or over beach architecture
- Reinforced stays that can be threaded into the ground like roots

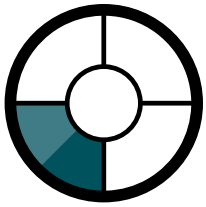
Features

- Disintegrates over time, leaving only the natural barrier it helped create
- Uses chicken feathers, a by-product of poultry industry
- Secures existing soil, preventing further erosion
- Traps sediment and helps to reverse the effects of erosion

Chicken feathers are chopped, washed, and then treated with enzymes to make keratin powder

Super System Element

Submerged Infrastructure Modifications (SIM)



Sub-Elements

- Anchored Floating Seaports
- Modular Adaptive Shield System
- Aqua "El"

The power of nature is immense, and if we can take advantage of these imminent changes, humans will learn to welcome adaptation. In response to invading waters, human nature typically dictates that we should build walls to defend ourselves. For centuries, the Dutch have built dykes to wrest land from the ocean. Contrary to this protective strategy where humans try master nature, **Submerged Infrastructure Modifications** detail a plan to help megacities accommodate rising sea levels while incorporating assimilation strategies to take advantage of new opportunities as well. In this way, we attempt to create a harmonious relationship between humankind and the sea.

Properties

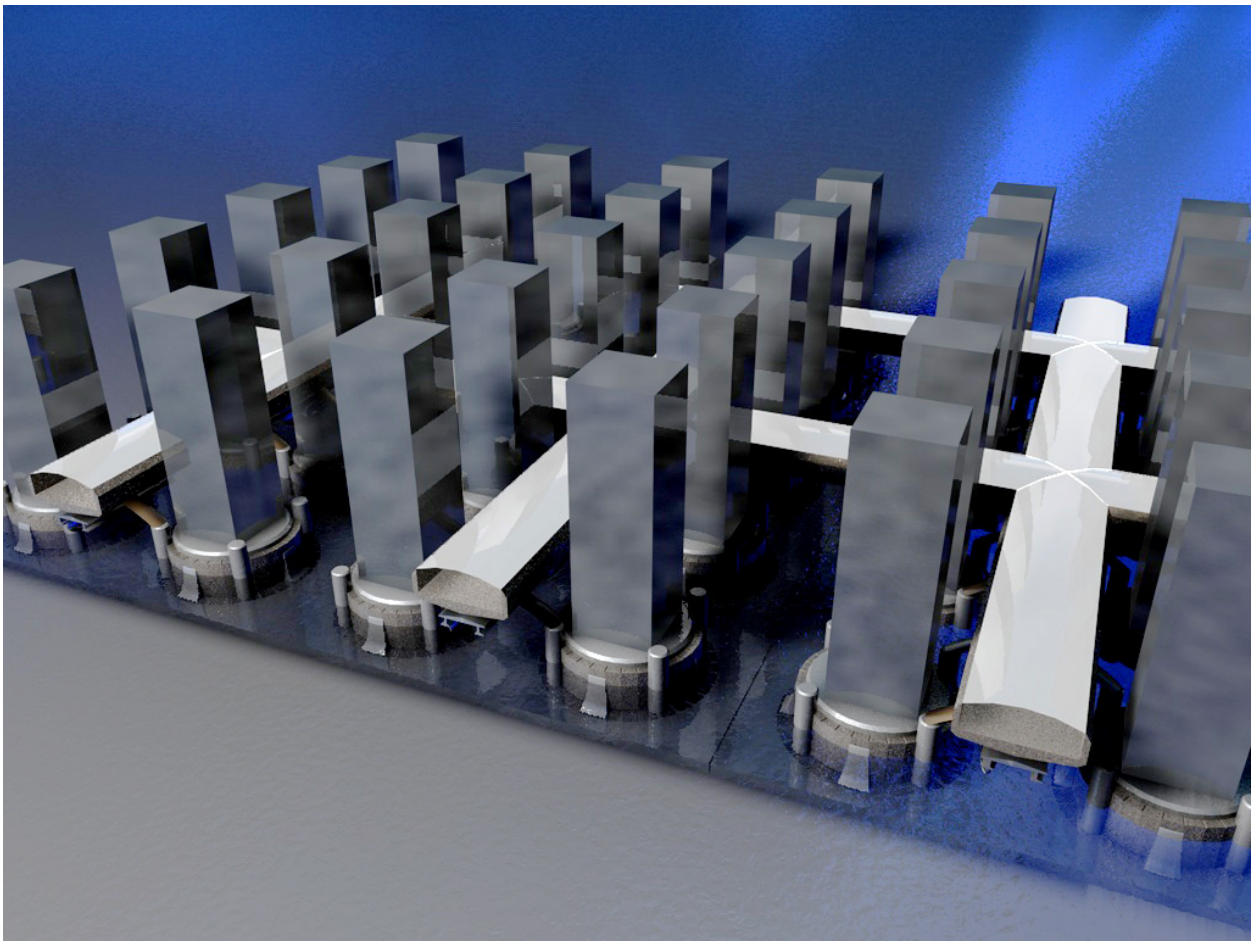
- An infrastructure upgrade program for megacities
- A collection of accommodation and assimilation strategies.
- Modular defenses that adapt quickly to defend against storm surges
- Elevated infrastructure to support transportation and utilities
- Engineered structures to waterproof buildings above and below ground

Submerged Infrastructure Modifications (SIM)

Features

- Upgrades the city in steps through a long time range.
- Reduces costs by following only a single upgrade track
- Implements underground transport of goods to inland receiving centers
- Upgrades incrementally in response to slowly rising water levels
- Incorporates public and private transportation systems into elevated infrastructure

Future submerged city incorporating SIMs



John Keeley, Mayor, New York City, Logbook, July 8, 2048...

The Category 4 hurricane, Medusa, made landfall two days ago and caused some damage in lower Manhattan. Fortunately, there was no serious damage and few injuries. I'm so glad to see that the Modular Adaptive Shield System (MASS) project we struggled for two years to implement has lived up to its promise. Two years ago, I had just won the Mayoral election and started to push funding for the MASS project. In those days, everybody was attacking the MASS project because of the city's financial deficit and transportation inconveniences. But after two years of hard work, our engineering team has accomplished the impossible. The MASS system runs well now, and it only takes a half hour to set up in the face of a hurricane alert. It successfully defends against intruding water, and the city government saves million dollars that used to go to ineffective sand bag barriers. It also reduces building damage, reducing uninsured losses throughout the city.

But after the good news, the GEO Year Book published yesterday confirms predictions that New York will be inundated in 40-60 years.

Two project proposals submitted by a firm in the Netherlands are sitting on my desk: an Anchored Floating Seaport (AFS) project planned at Atlantic City and the Aqua "El" project for elevating the infrastructure in lower Manhattan.

Five years ago, when I was still Director of the New York Hydraulic Engineering Office, these two projects would have seemed like science fiction. But now that New York's major docks are almost submerged and Manhattan is in danger of increasing floods, we are forced to consider other alternatives.

Initial surveys indicate that Atlantic City would be an ideal location to install an Anchored Floating Seaport. Despite daunting initial investment costs, the long tern benefits of the AFS are undeniable. If construction starts now, the selected site will begin servicing New York's maritime industries by 2080.

Despite significant resistance by residents, the reality of the situation requires that we begin the Aqua "El" project to elevate the lower Manhattan's transportation and utilities infrastructure. Eventually, the MTA, roads and all underground infrastructure will need to be incorporated into the Aqua El structure.

Turning in my old office chair to face the Hudson River, I look at the greatest urban skyline on this blue planet. Can this great city accommodate the inevitable future? I truly don't know. I hope I can trust my old friend, Professor Alexander who always said, "The future is wet, the future is great!"

Anchored Floating Seaports (AFS)

Properties

- A new form of seaport that uses rising sea levels to its advantage
- Waterproof underground resource transportation systems
- System of inland receiving centers

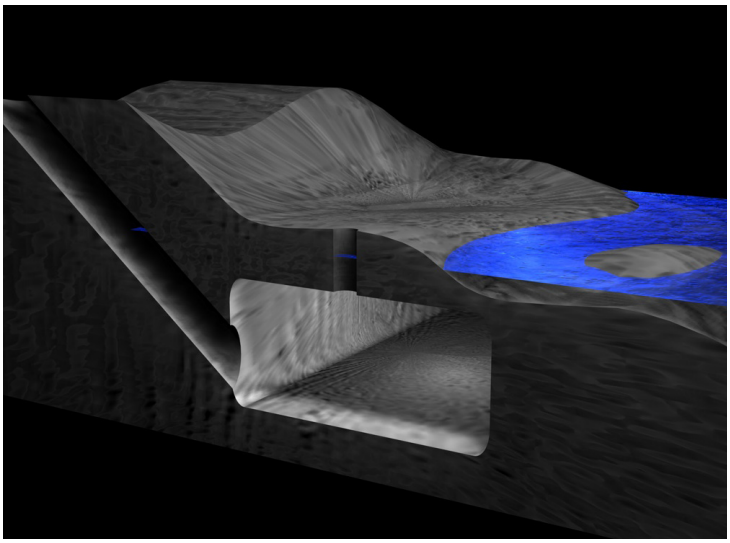
Features

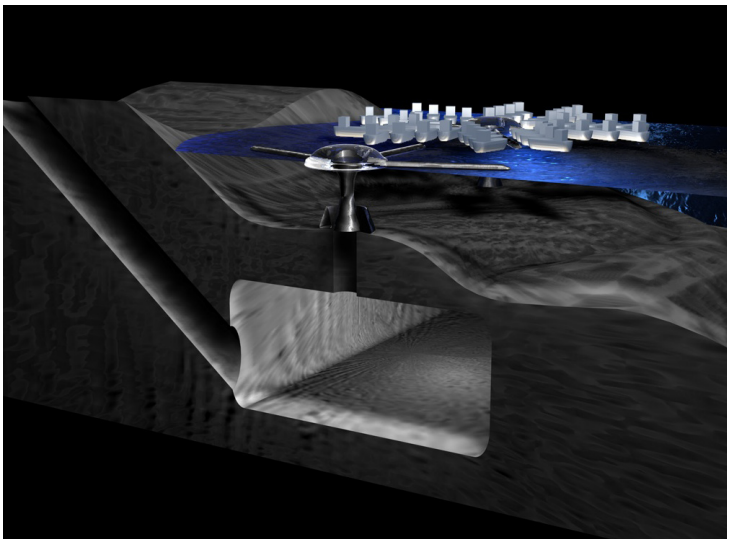
- Reduces costs by requiring only a single move of critical transportation infrastructure
- Adapts dynamically to the ebb and flow of the tides
- Receives goods from cargo ships
- Transports goods underground to inland receiving centers
- Transforms quickly to hide from environmental disasters

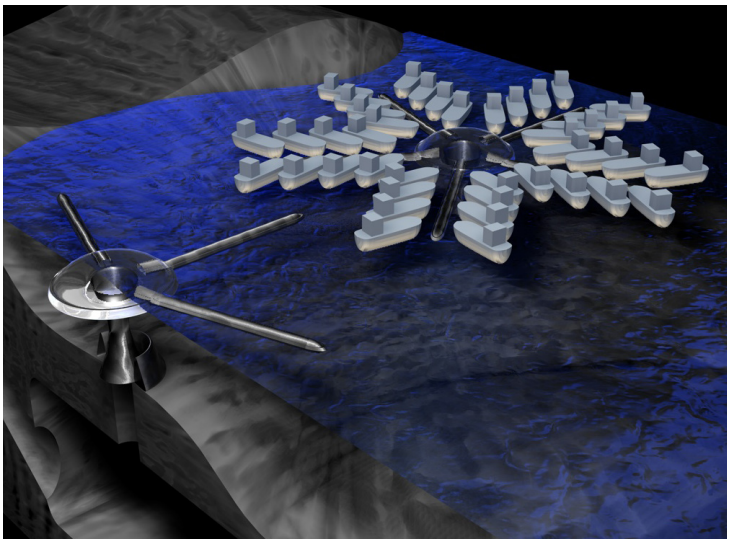
Anchored Floating Seaports are designed to dynamically adapt to future rising seas. As sea levels rise, major seaports will be inundated and forced to move repeatedly to deal with the changing seashore contour. The marine transportation industry faces a huge revolution, and the marine transportation authorities will have an opportunity to embrace the future. This proposed system instead involves a single relocation of seaport infrastructure, assuming that the rise will continue over time and using rising sea levels to its advantage. By establishing a seaport that rises with ocean levels but is anchored to an adaptable core, a permanent infrastructure can be established while the rest of the city relocates slowly over time. Connected through an underground resource transportation and storage network, the **AFS** can efficiently deliver received goods to designated receiving areas throughout the city. These transportation systems will be waterproof, and the receiving centers will be located beyond the projected highest level of sea rise.

Construction starts on dry coastal ground that will ultimately flood and become the new seabed. Identifying an appropriate location is critical. Sealed underground infrastructure is established next. This infrastructure, hiding under the seabed, will eventually facilitate transport of goods between the AFS and landlocked receiving centers further inland. After the seawater intrudes, the **AFS** will slowly rise with sea levels and begin serving as host to cargo freighters. Through the central hub, the **AFS** connects to the underground resource transportation network, enabling efficient transport of goods. Before impending hurricanes strike, the **AFS** is can be quickly disassembled and hidden in the underground system for protection.

Anchored Floating Seaports (AFS)







Stages of development of an Anchored Floating Seaport

Modular Adaptive Shield System (MASS)

Properties

- A supplementary transformative construction module
- A protection system can withstand intruding waters
- Modular construction units
- An upgradable system
- An extendable system

Features

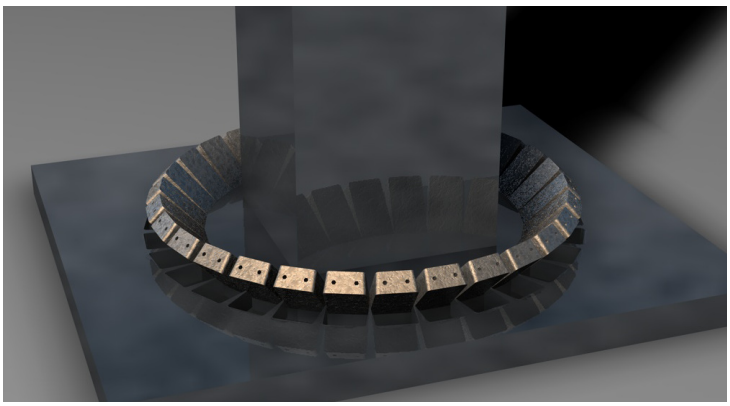
- Separates sea water and uses the water pressure to reinforce its structural strength
- Raises easily and quickly for defense
- Upgrades readily as dangers become increasingly threatening

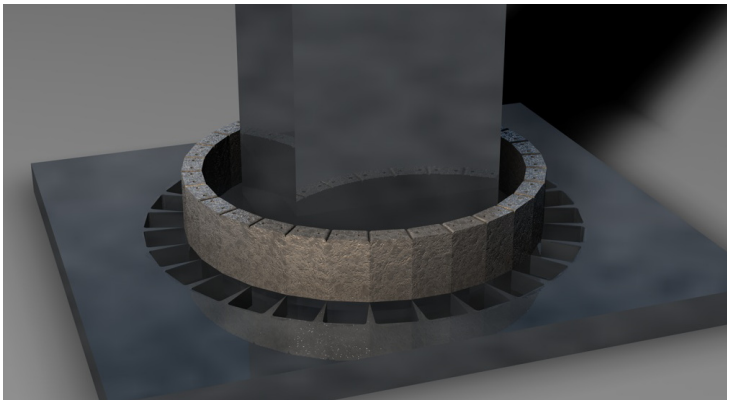
The **Modular Adaptive Shield System (MASS)** is designed to protect a single skyscraper or city block from intruding storm surges during hurricane, tsunami. Ultimately, it will be incorporated into **Upgradable Structural Waterproofing Engineering (USWE)** and protect against long-term sea level rise. The **MASS** is a supplementary construction module that can be installed in the land around the structure and set up rapidly before disaster strikes.

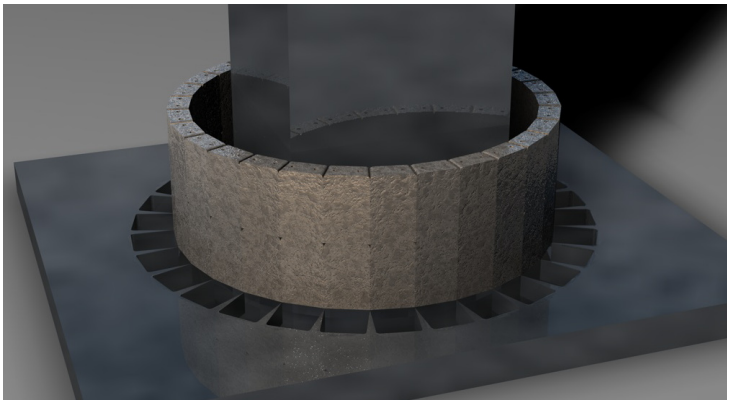
Base on the IPCC report, one of the greatest dangers related to hurricanes is flooding induced by storm surges. In the future, cities will have to deal with increasing hurricane power and unpredictable water levels. Current solutions during hurricane use sand bags as a quick fix to prevent the water from intruding into the lower levels of buildings and public transportation entrances. Using sand bag is not very effective as they break easily under the tremendous pressure of floodwaters. So **MASS** provides an upgradable, rapidly deployable module that can be easily raised in the face of looming disasters. Its circular structure disperses the water pressure equally, and this type of structure will be made even stronger as water pressure pushes its pieces against each other. Its integrated connector allows it to be upgraded from 3m to 10m in height.

MASS units will be stored underground on normal days to provide uninhibited use of the building and an unobstructed view. And when a hurricane is expected to make landfall, **MASS** will rise up to protect property and life.

Modular Adaptive Shield System (MASS)







Aqua "El"

Properties

- A construction upgrade program for submerging cities.
- An iterative plan incorporating multiple construction techniques to address the different stages of rising sea levels.
- Construction materials augmented with nanotechnology to ensure resistance to salt water damage

Features

- **Upgradable Structural Waterproofing Engineering (USWE)** constructs waterproof defenses for tall urban buildings and city blocks
- Upgrades incrementally in response to slowly rising water levels
- **Modular Adaptive Shield System (MASS)** quickly fortifies to resist high-speed winds and surging waters
- **Elevated Infrastructure System (EIS)**
- **Skyway Train (ST)** incorporates public transportation incorporated into the elevated infrastructure
- **Elevated Road System (ERS)** supporting personal transportation above the highest expected sea level

The key issue of submerging megacities is that while sea levels rise very slowly, only one inch per decade, but height of hurricane storm will triple. "Even an increase of as little as 1.5 inches in normal sea level could contribute to flooding many parts of the city if a Category 3 hurricane were to strike", said Gornitz and fellow researcher Rosemary Rosenzweig in their article *Rising Seas and Stronger Storms Threaten New York City*.

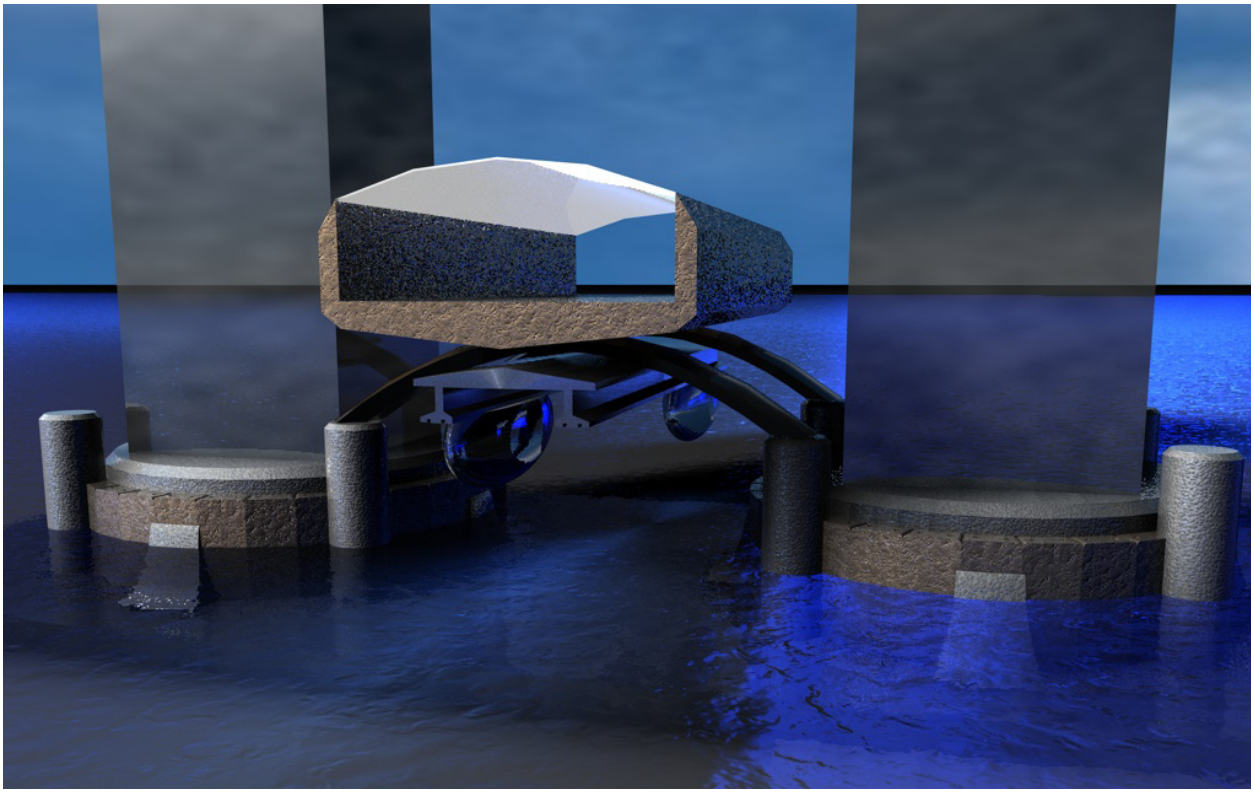
The strategy of accommodation is attractive to some megacities because they have been established as high value transportation centers with significant economic influence. Such megacities also have long historical and cultural roots that will be lost through relocation, and protection is often too costly.

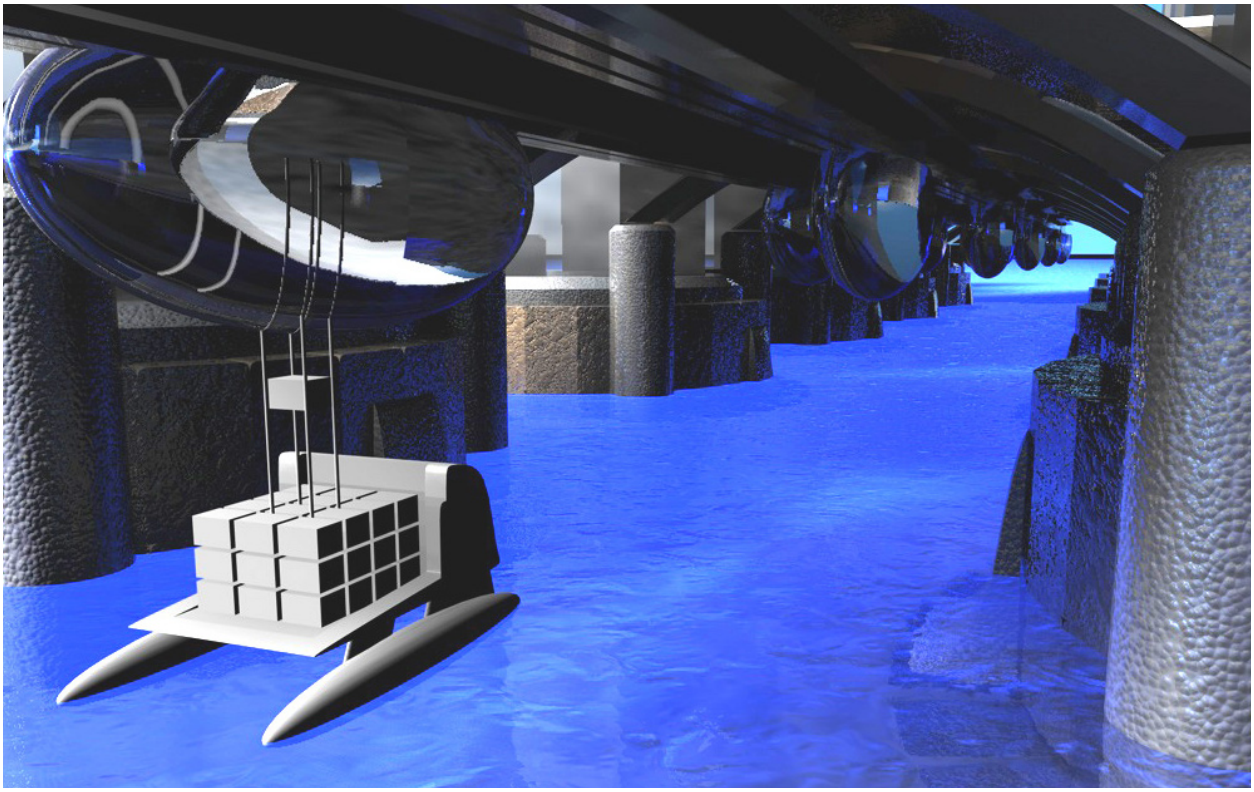
The construction strategy of mega city accommodation has two major strategies: Build Up or Dig Down. The Build Up strategy is based on the current land level and transportation systems are raised above where rising sea level will reach. Dig Down strategy involves constructing a whole new transportation system under ground while defending against inundating waters. In general speaking, the underground section of current mega city is already filled with significant infrastructures such as subway, sewer system, electronic system, etc. It is hard to construct the new transportation system and maintain the basic city function at the same time.

To deal with the progressive effects of rising sea levels, the **Aqua "El"** provides an iterative solution. Initially, **Upgradable Structural Waterproofing Engineering (USWE)** and **Modular Adaptive Shield Systems (MASS)** are designed to protect buildings from rising underground waters and extreme climatic events. Once waters have infiltrated underground infrastructure, the **Elevated Infrastructure System (EIS)** will be constructed, supporting electrical, gas, and sewage infrastructure. Suspended from the **EIS**, **Skyway Trains** will provide public transportation. In anticipation of sea waters ultimately inundating lower levels of the city, **USWE** will be upgraded to protect buildings from long-term damage, and the **Elevated Road System (ERS)** will be laid upon the **EIS** which had already been established. Ultimately, the entire city's transportation and utility infrastructure will be raised to a higher altitude, safe from intruding sea water.

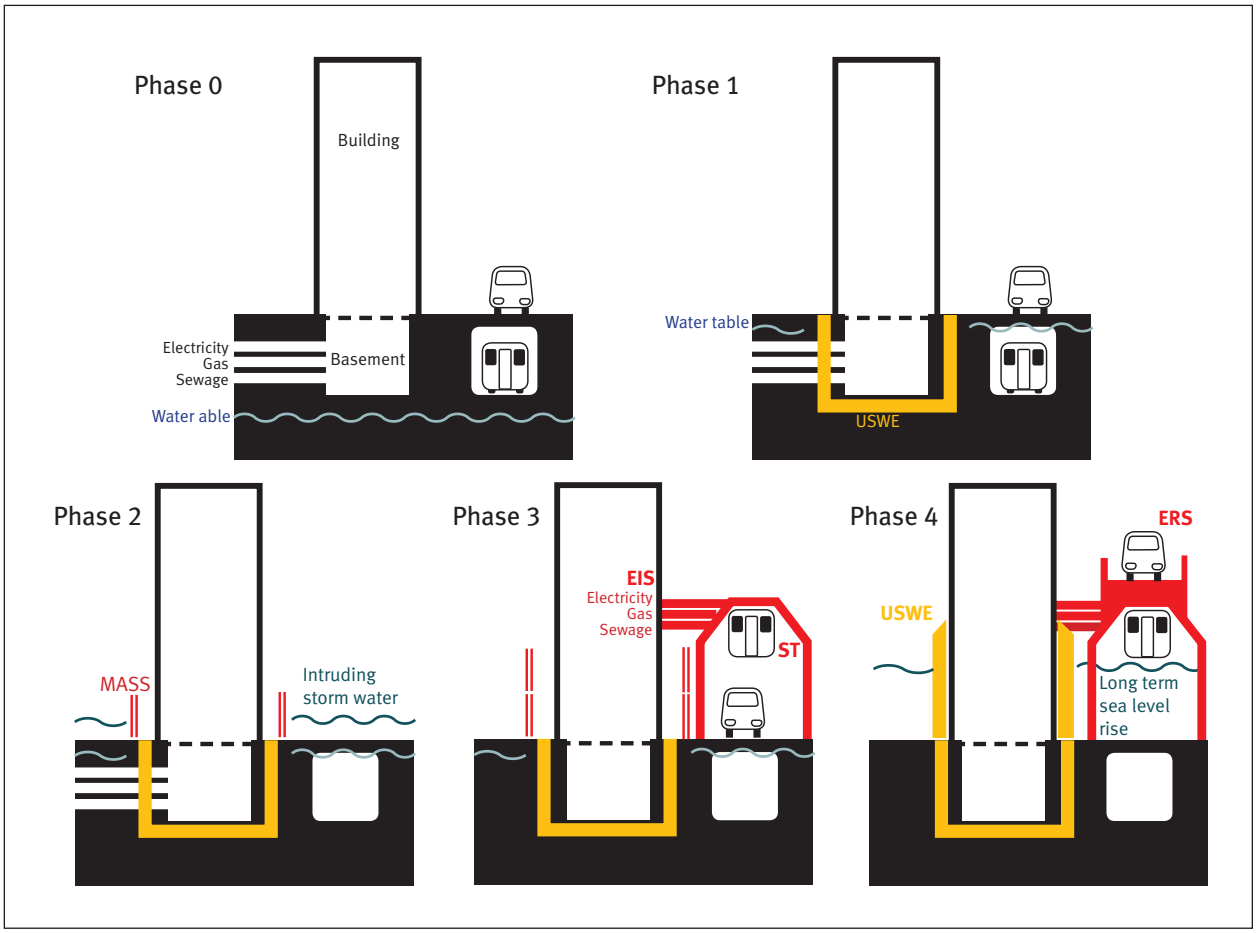
Aqua "El"

Rendered views of a future elevated transportation system for submerged cities





Stages of securing building substructures and elevating transportation infrastructure

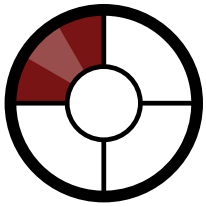


System Elements:

Emergency Management

Super System Element

Disaster Anticipation & Management Program (DAMP)



Sub-Elements

- Agent-Based Modeling & Simulation
- Public Emergency Alert System
- Unified Disaster Index System
- Local Voice
- Phase Forward
- Child Registry

DAMP is a disaster anticipation program that uses agent-based modeling and simulation **(ABMS)** that synthesizes relevant weather and population information to aid in structured responses to looming disaster events. The process quickly incorporates dynamic weather data, predicted population actions, and established response plans to clarify the trade-offs of all options.

A large part of the system deals with preparation before a disaster. The simulation identifies a series of plans based on likely scenarios. Other parts of the system recommend appropriate routes to aid resource stockpile managers and distributors and ensure efficient coordination of evacuation while simultaneously activating the first alert to notify the general public.

The system's **Central Unit** houses the expertise to run the **ABMS**. These experts are responsible for running simulations based on requests from local units and when the monitoring team in the **Central Unit** detects an unusual weather pattern. Results will be proactively presented to the **Local Unit**. The liaison between **Central** and **Local Unit** is headed by **Control Center Agent (Central)** and **DAMP Diplomat Agent (Local)**.

Properties

- A disaster anticipation program running at two levels: **Central** and **Local Units**
- A simulation system proactively used to model disaster scenarios
- Agents to prepare emergency plan from the translated simulation result
- An emergency resource management system
- An emergency alert system
- Archives of cases and data
- A monitoring unit for unusual patterns
- An archive of past cases and simulation results for reference
- Proactive collection of emergency solutions at **Local Unit** level

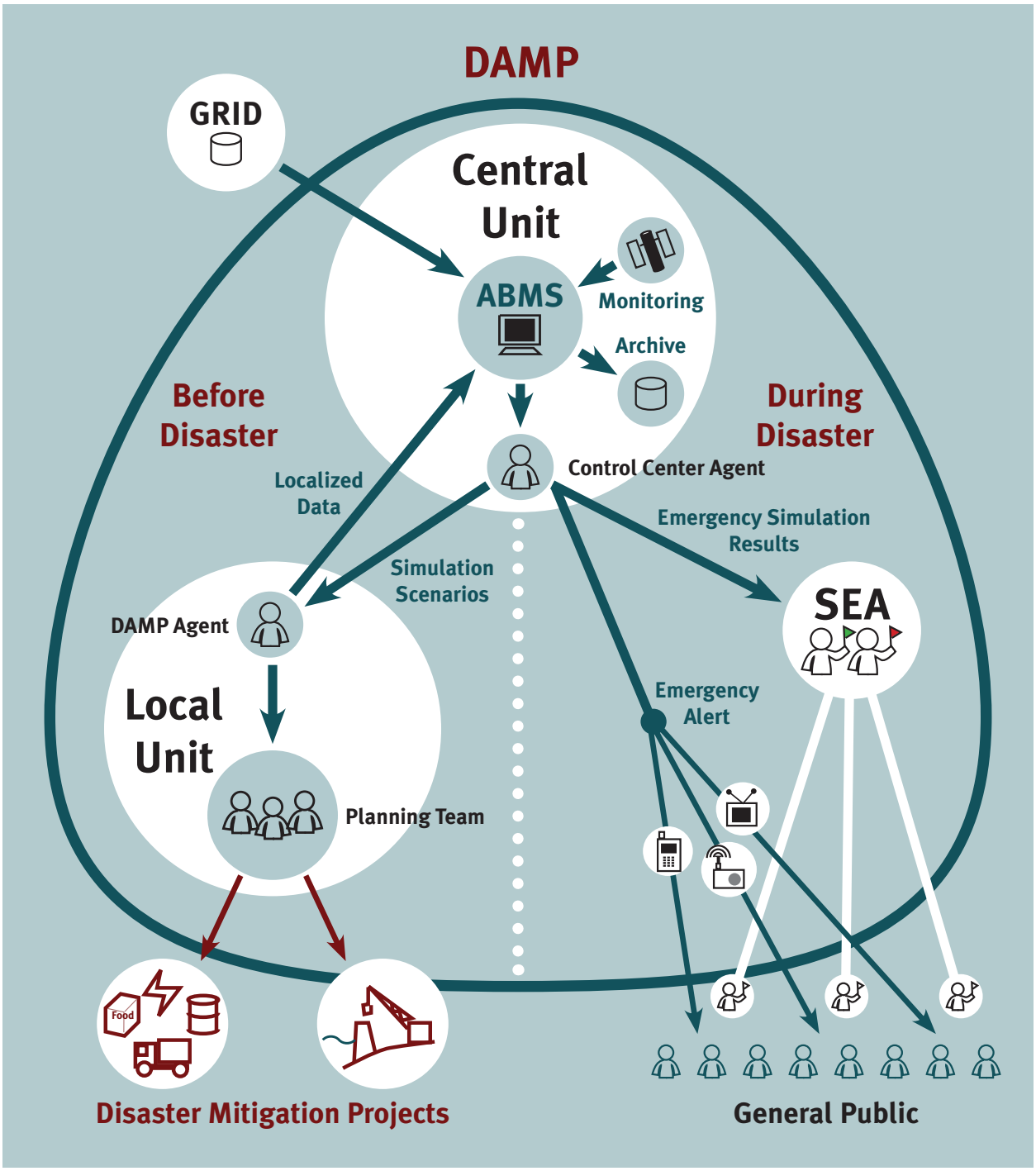
Features

- Provides advanced monitoring technology for participating at-risks communities
- Runs simulations when dangers approach at-risk community
- Clarifies the trade-offs of all options to guide response plan choices
- Collaborate efforts at all level within community to prepare for emergency situation
- Create a comprehensive solution for local context evacuation
- Provide a credible source and means for alert warning which reaches all communities involved
- Provide past and new references for adaptable solutions
- Ease the evacuation process with human level solutions

The result of the simulated run will be forwarded to the **DAMP Diplomat Agent** in a form of early data. This data will be translated and re-interpreted by **Local Unit** planning team who will gather relevant research to fit the result to a local context. Planning team will release proposals plans befitting different anticipated disaster scenarios. The preparation team will then take the responsibility either to collect, allocate and distribute resources of build structures and artifacts in anticipation of disaster.

Being a member of the **Central Unit**, weather conditions of **Local Unit** will be constantly monitored. When an unusual weather pattern is detected, **Central Unit** will run an emergency simulation to predict what outcome the weather will bring. With the result, **Central** will pass the message via the emergency channel and prepare the three pillars of the alert system: combination of technology and human interaction.

Prior to disaster, a big part of planning consist of understanding local context. This channel brings in **Local Voice** to assist in determining the best emergency route, safe zone and resources available. A big part of resources requires human power and a voluntary program at a neighborhood level. These people are responsible to coordinate evacuation plans and manage evacuation centers. Preliminary planning of evacuation centers will divide evacuees into small travel groups. Children will be registered to identify if they are separated from their guardian. The teams of evacuees will be moved according to a pre-determined **Phase Forward** evacuation plan, according to the situation at hand.


DAMP
GRID
Central Unit
ABMS
Monitoring
Archive
Before Disaster
During Disaster
Control Center Agent
Localized Data
Emergency Simulation Results
Simulation Scenarios
SEA
DAMP Agent
Local Unit
Emergency Alert
Planning Team
Food
Disaster Mitigation Projects
General Public

Sandra realizes that the Central Unit has been giving confirmation of an on-alert signal to the Local Unit that she works with...

In the last few hours since the Central Monitoring Team discovered an unusual wind pattern heading towards their coast land, both Local and Central Units are busy running through process checks. Central has run an agent-based simulation based on local wind patterns. The result was both shocking and comforting at the same time. Shocking because, looking out the window, Sandra would never imagine that beyond the clear sky that she is seeing, a Category 4 hurricane is scheduled to hit the coast land in less that 10 hours. On the other hand, she is relieved because the system has allowed her and her team to start evacuation in time. Personally Sandra is worried for her family, despite having her 2 year old daughter registered and prepared to evacuate with her mother and others from their assigned evacuation group. Sandra is not able to evacuate with them but she plans to leave in a few hours once the Local Center evacuation orders given out and all plans are in place. She will be able to reunite with them at her assigned evacuation center.

The confirmation of the hurricane came at the same time the public alert was broadcast over all digital channels including all television and radio network. The public has been on-alert at the same time that the news from the Central reached the Local Unit. Now however, it is up to the local unit to implement the pre-outlined plan based on the level of danger. The report shows that the east side of the land will be most at risk. She assigns immediate evacuation priority to major public and private institutions of the area. The Latent Evacuation Guidance Team (LEG Team) of the area have taken their assigned positions and are communicating with Local Unit to help direct evacuees along the appropriate routes.

Sandra runs through the checklist the second time as the emergency enters phase one. By now, all neighboring areas to the at-risk location are slowly being evacuated. Reports show that situation at the safe zone are under control as people have begun slowly arriving in their pre-assigned teams. Even, the Threat Identification and Positioning Team (TIP Team), which consist of members in the general public, has done its part well, members having secured danger zones with the reflective floating device. An aerial capture from the darkening clouds shows some lowland and industrial sites being marked off as danger zones.

Two hours before the hurricane was scheduled to hit, the Local Unit Team are evacuated in a Mobile Remote Center Van. This allows them to still keep in contact with other evacuation centers. Sandra is not assigned to be at the mobile control center so she was transported to her assigned relief center according to plan. Registering herself at the communication center, she was easily reunited with her group and family.

The whole event during evacuation was unlike what she had experienced as a child. Living in flood prone area, she lost a brother to in that tragic event 20 years ago. This calm and systematic evacuation helped maintain the faith and morale of all evacuees, including herself. Like the others, she is deeply saddened by the lost of her home and the thought of rebuilding her life again, but she has a lot to be thankful for. Seeing all the people working in groups and evacuating in shifts, brings pride to her heart because no lives were lost.

Agent-Based Modeling & Simulation (ABMS)

Agent-based modeling and simulation (ABMS) for disasters is a tool that synthesizes relevant weather and population information to aid in quick decision-making. It dynamically incorporates real-time weather data, predicted population actions, and established response plans to clarify the trade-offs of all options.

This is a way to simulate the behavior of a complex system in which agents interact with each other and with their environment using simple rules. The "agents" represent individual objects independently interacting on "spaces," grids or networks in two or three spatial dimensions, over "time," ticks in a model space managed by a scheduler. Thus **ABMS** combines time, space and identity into a universe being modeled.

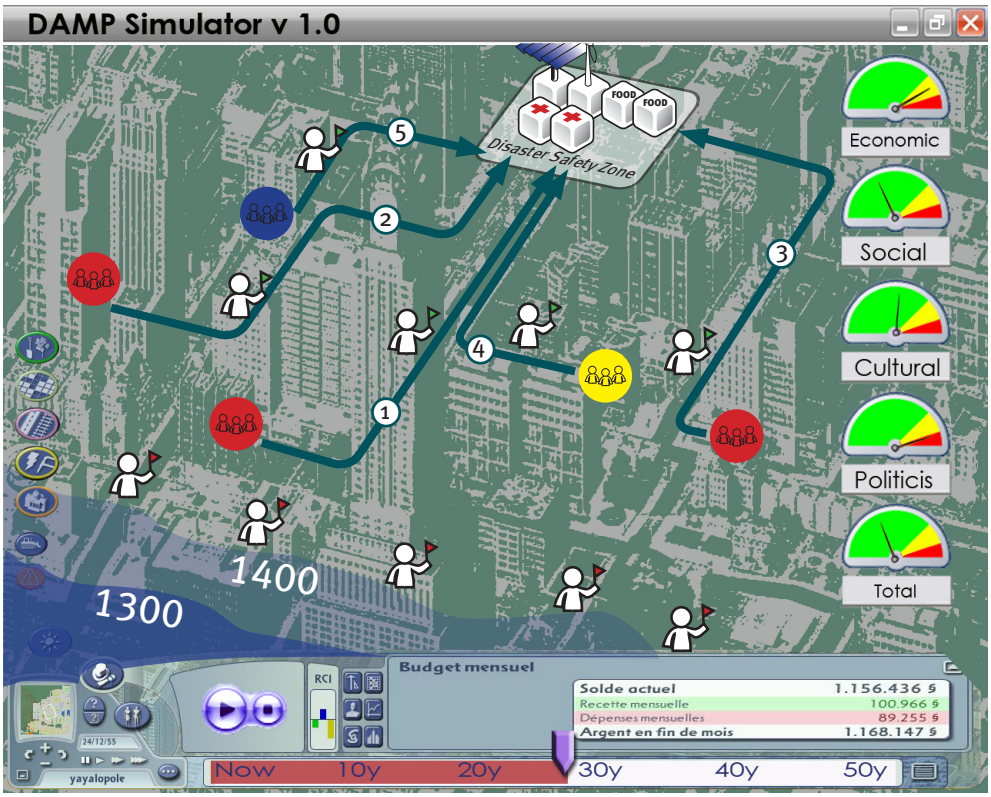
Current success of this approach in predicting traffic flow in metropolitan areas, the spread of infectious diseases, and the behavior of economic systems prove to have a strong basis for it to be run as a simulation of weather impact and human behavior, thus aiding in creation of a comprehensive alert and evacuation plan.

Properties

- A computer program
- A simulation system
- A database on pre-programmed human behavior and space
- A database on variables of events and time

Features

- Runs simulation of expected weather events
- Predict the magnitude of disaster events
- Predict human behavior based on events



Public Emergency Alert System (PEAS)

Properties

- A disaster alert system
- A systematic call for evacuation which runs on stages: On-alert, Evacuation, Phase 1, Phase 2, Impact and Return
- **Digital Emergency Alert System**
- **Latent Evacuation Guidance Team (LEG Team)** made out of members of the general public will assist on evacuation route
- **Threat Identification and Positioning Team (TIP Team)** identifies danger zones with red floating reflectors

Features

- Create a cooperative effort at humane level
- Individual contribution creates a sense of responsibilities to self and surrounding people
- Stages of evacuation keeps public informed and minimize chaos
- Stages of evacuation alerts pessimist who refuse to evacuate

PEAS is a public alert system embedded into community level with information fed by **DAMP** central unit. The system driving force is the people and its main purpose if for the people.

The entire system is built on three pillars which are:

1. **Digital Emergency Alert System (DEAS)**
2. **Latent Evacuation Guidance Team (LEG TEAM)**
3. **Threat Identification and Positioning Team (TIP Team)**

Since **DAMP Central Unit** will run computerized emergency simulation, prediction of the stages for emergency is available upon first level alert. The system runs six levels or alert with a rational that keeping the evacuees aware of situation will make evacuation less chaotic at the same time alert disaster pessimists who refuse to evacuate. The stages are:

1. On-Alert: Pre-Evacuation Briefings
2. Evacuation Warning: People with special needs
3. Phase 1: High Risk Evacuation
4. Phase 2: Full Evacuation and Fortification
5. Impact
6. Return: Passing of danger

From previous accounts, evacuation is never only a technical process. It involves human relation between strangers and spirit of cooperation at a very low level, one-to-one. Understanding this and accepting it to be incorporated as the core fundamental of an evacuation alert system will help make evacuation a smoother process. Based on information fed by **DAMP Central Unit** to **PEAS Local Unit**, evacuation may be performed on a building by building process, from the most at-risks areas.

Aside from standard radio, television and text message announcement. An evacuation announcement will be tapped into the public announcement system in buildings. Announcement will be made as directive for systematic evacuation in buildings based on the pre-established building evacuation plans. To aid a systematic evacuation, Audio system will have a calm manner of presenting evacuation,

Public Emergency Alert System (PEAS)

The three pillars of this system are:

Pillar 1: Digital Emergency Alert System
The **DEAS** will be transmitted by **Central** to the respected **Local Unit**. **Local Unit** will the be able to broadcast bottomless audio message (message with no definite ending) and streaming video. This allows near-instantaneous transmission without delays. Digital alert will be able to transmit text, voice, video and other digital messages to radio, TV, e-mail, text messages, mobile phone and pagers.

Pillar 2: Latent Evacuation Guidance Team (LEG TEAM)
Ground alert team consist of trained lay-people who will be certified to take charge of directing the evacuation process anytime and anywhere they happen to be during an emergency. The election of candidate for the training may be done by private or public companies from amongst its employees. A call for volunteer may also be done through schools, organization or institutions. A main purpose of **LEG Team** is to bring a more humane approach to evacuation and eliminate confusion by providing person to handle public enquiries.

On the day of emergency, **LEG Team** will scan the pre-installed **LEG Team** kit in buildings and public areas. Only a trained crew will be able to activate the kit. This kit contains a distinguishable uniform, loud speaking device, a communication tool with **DAMP** local unit and a directive interface. Following the situation directive will be provided. **LEG Team** is also responsible to disperse floating and reflective green flags along the identified evacuation route.

Pillar 3: Threat Identification and Positioning Team (TIP Team)
Prior to emergencies, a red flag dispensing system will be installed on all public and residential areas. During disasters, people of the general public and especially residential area, will start marking off dangerous zones with red flags. These flags will mark low and steeping ground that may not be distinguished in the event of flood. Residents of area who are familiar with their surrounding will be more aware of instances that may pose danger when disaster happen thus the red flags usage are open to personal instinct of danger which protocols may overlooked.

Unified Disaster Index System (UDIS)

Properties

- A categorizing system
- An analysis tool which adapts categories to the future changes of weather trend

Features

- Categorizes weather events based on its disaster magnitude
- Allows a common language between Central and Local Unit in data transferring

Similar to the existing Saffir-Simpson Hurricane Scale, which is a standard for hurricanes today, **Unified Disaster Index System** is a grouping system that will be a common data-sharing platform amongst different types of disasters monitored by the **DAMP**. Unlike the Saffir-Simpson Hurricane Scale system, this unified categorizing is meant to simplify communication and recording of disaster magnitude. This assists in choosing among predetermined plan of action according to the situation at hand and removes the need to remember different scales for hurricanes, earthquakes, typhoons, blizzards, and all other anthropogenic events. This system also enables the general public to more quickly and accurately discern the magnitude of such events with a unified system.

Local Voice

The participation of local community members is vital in planning an evacuation. The local view of daily routine and interactions captured through this channel will inform the **Local Planning Team** in mapping out evacuation plans and even to the central unit to assist in the agent modeling.

Members of the community are able to reflect their preference in evacuation procedures and offer valuable tips to encourage a smoother transition from alert to evacuation, making it a more voluntary process and not a forced evacuation.

Properties

- An online hub for community members to share views and opinions on local scene
- A hotline for local views on needs and trends or disaster preparation
- A meeting of local representatives to provide insights on community disaster view

Features

- Increases cooperation from the general public during disaster
- Uncovers needs and preference of the community to plan evacuation
- Gathers insights on safest evacuation route based on local knowledge

Phase Forward

Properties

- An evacuation plan
- A comprehensive list of evacuation routes and system
- A name list of registered individual to form groups for evacuation based on location and vicinity to evacuation centre
- A grouping system to keep track of evacuees during evacuation and at evacuation centers.
- A grouping system for resource distribution and task scheduling at safety camp

Features

- Participants motivate and encourage members of the same group to evacuate
- Assist in an easier head count at evacuation safe zone
- Minimizes confusion during an evacuation by allowing smaller groups of people to keep track of one another
- Allows individual to be reported missing or to report themselves separated from other team members
- Encourages vehicle sharing during evacuation
- Provide a sense of order at safety camp

Phase Forward is an evacuation plan built on data of registered community members and their vicinity to one another. Each member of the community will be categorized into clusters of families living close to each other. In the event of a disaster, some members may not be able to evacuate with the assigned group because they may be at work or at school in which case they will later be reported as "Separated" by the assigned camp. "Separated" individuals will need to report themselves to any camp that they are able to reach. Later, they will be reunited with their families.

The communication centers at each evacuation zone will share data on missing people and share reports of "Separated" individuals' whereabouts. This update is crucial in relieving anxiety for evacuees.

At the evacuation camp, the next phase will involve grouping and scheduling evacuees to participate in rebuilding activities. This both provides purpose for idle groups while contributing directly to initial recovery efforts.

An officer of the LEG Team helps direct evacuees

Child Registry

Prior to any event, at-risk communities will continuously maintain a palm-print database of children below the age of 12 living within the community. Registration will be enforced in schools, public places and the official government registrar's office. Visitors entering at-risk areas will also be required to complete the child registration upon entrance and check out upon departure. This is to ensure that in the case of an emergency during their visit, the children will be in the system database.

In the event of emergency, children may be harder to identify when separated from their guardian because they are naturally less independent in nature. The need to keep a database is crucial to ease the emotional burden of worried parents and to make sure all separated children are kept track of.

Upon arriving at evacuation camp, guardian will need to confirm their children's safety by checking their palm prints into the system. All unconfirmed children then will be reported missing and data will be shared with neighboring camp try and locate missing children.

Properties

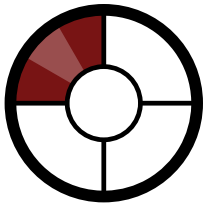
- A palm print recognition system
- Database of children and guardian in at-risk community
- Database of volunteer guardian
- Strict volunteer guardian qualification assessment

Features

- Allows separated children to be identified during emergency situation
- Assign temporary guardian volunteers for separated children
- Allow relocation of children to their guardian or their next-of-kin in the event of guardian's passing

Super System Element

Disaster Survival System (DSS)



Sub-Elements

- Disaster Safety Zone (DSZ)
- Disaster Safe Cube (DSC)

Disaster Survival System is a series of emergency survival tools that help people survive extreme disaster events.

When a disaster strikes suddenly, affected communities usually have only two strategies to choose from: escape or stay in place and wait it out. In most disasters, most victims are the elderly, the ill, children, or physically-disabled people. **Disaster Safety Cubes** are intended to address this problem, creating a structurally-sound chamber to help people survive a disaster.

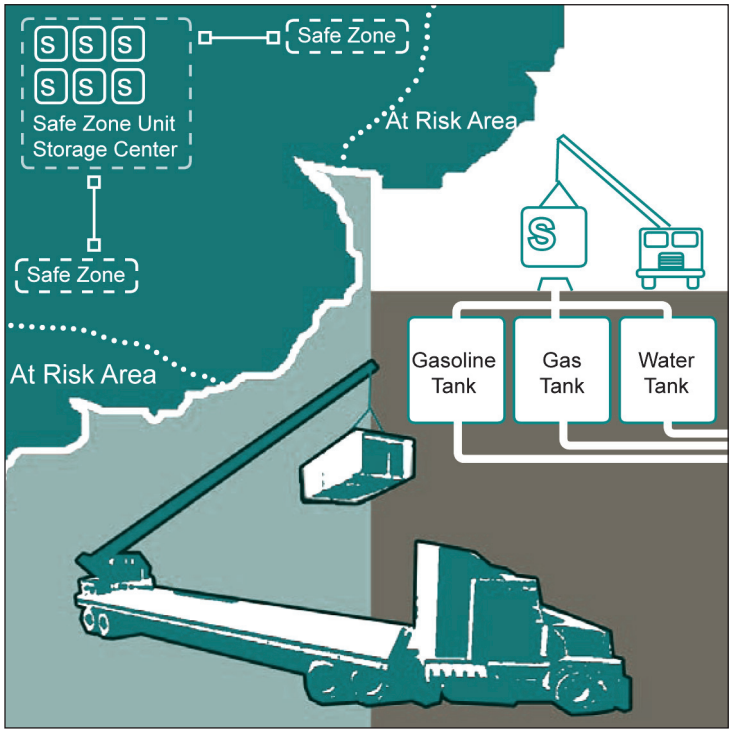
Another issue facing communities in the aftermath of a disaster is how to handle large populations of refugees. Typically, the most critical shortcomings of refugee camps are lack of resources, electricity, fuel, and fresh water. If these basic resources can be stored in anticipation in a **Disaster Safety Zone** as a backup resource for the community, the quality of life for a refugee camp can also be improved.

Properties

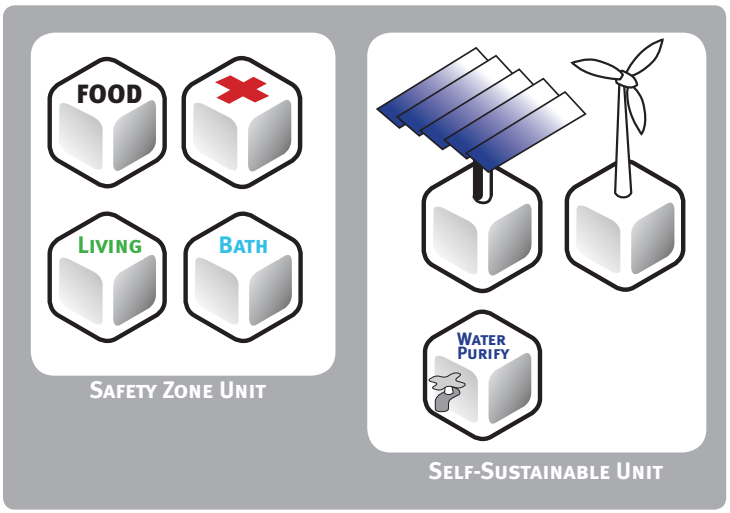
- A fast-setup refugee camp system
- Locations easily accessible from at-risk areas and major transportation systems
- Different types of units supporting basic human needs such as medical, food process, bathroom, living space, etc.
- Self-Sustainable Units that tap resources by capturing solar energy, harnessing wind energy, purifying available water, etc.
- Waterproof equipment for protecting people during disaster events
- Cube-like shelters made of strong, light materials and firmly tethered to the ground

Disaster Survival System (DSS)

The Disaster Survival System at work



Safety Zone Units (SZUs) and Self-Sustaining Units (SSUs)



Features

- Fulfills all basic survival needs during disaster
- Adapts to different environmental conditions by selecting appropriate modular units
- Units easily stored, transported, and set up
- **Safety Zone Unit Storage Center (SZUSC)** which stores **SZUs** when not in use
- Provides easy access from a central location in the **DSZ**
- **Built Underground Resource Storage Tank (BURST)**
- Connects to infrastructure, providing things like sewage, electricity, clean water and fuel
- Contains sufficient resources to support the zone for 2 weeks
- Provides resources by adjusting unit installation based on local resource availability
- Accommodates a maximum 6 adults
- Rests in the backyard on normal days
- Capable of enduring gale force winds and violent waves
- Floats on the intruding waters
- Contains emergency supplies to support 6 people for 5 days
- Communicates directly with other cubes and the central hub
- Purifies and desalinates available water supply

Malacca, the largest coastal city in Malaysia, 2048...

Malacca bore a heavy brunt of the 2004 Indian Ocean Tsunami, and after 40 years of development and disaster preparation, the city's level of tsunami protection is much improved from 40 years prior. All the weaknesses in the city's periphery within 400km have already been surveyed carefully. Based on these data, DAMP generates a tsunami scenario simulation to identify at-risk areas, while the Malacca city government works hard to make tsunami-related construction laws. One example of the latter is a mandate that citizens in areas identified as most at-risk must set up Disaster Safety Cubes (DSCs) in their backyards. Around the city, a few Disaster Safety Zones (DSZs) have been identified, and Built Underground Resource Storage Tanks (BURSTs) have been installed underground in advance. The BURSTs are already connected to Malacca's major resource infrastructure.

September 23, 2048. The Indian Ocean monitor satellite "watcher" has detected an earthquake measuring 8.5 on the Richter scale at the sea bed, 780km from Malacca. The satellite transfers data to DAMP's ABMS center, with the resulting simulation predicting a tsunami will impact Malacca within 20 minutes. The PEAS local emergency team gets a direct order from DAMP Central Unit to send out the emergency alert to the whole city: everyone should seek shelter in their Disaster Safety Cubes and lock the gates carefully. Fifteen minutes later, a tsunami strikes the city's coastline, destroying 40% of coastal buildings. When the tsunami withdraws, those who were not in at-risk areas will be escorted by PEAS team members to temporary relocation at a Disaster Safety Zone. Those people who were in at-risk areas had their lives saved by the Disaster Safety Cubes, and continue to wait inside them for rescue. Because the electrical grid was taken out by the tsunami, the DSZs utilize the resources in the BURSTs for the next 2 weeks. After 2 weeks, the infrastructure still has not been repaired, so Malacca government officials decide to plug in the Self-Sustainable Units (SSUs) for gathering solar energy.

Disaster Safety Zone (DSZ)

Disaster Safety Zone (DSZ) is a fast-setup refugee camp for housing evacuated populations both during and after disaster events. Established near at-risk area, **Built Underground Resource Storage Tanks (BURSTs)** are constructed underground. Once impending disasters have been identified, **Safety Zone Units (SZUs)** will be deployed rapidly from a central storage unit. Once the **SZUs** have been deployed throughout the safety zone, they can be plugged into the **BURST** and begin functioning. While the majority of **SZUs** are designed to support life, others can generate energy, store food, manage sanitation, and purify water so that the **DSZ** can function autonomously. Support units are selected based on different types of environment conditions and available resources. For example, energy production in tropical areas would be handled by **SZUs** designed to capture solar energy.

The process of setting up a **DSZ** is:

1. Identify higher ground near at-risk areas. Area should be accessible by high efficiency transportation systems
2. Build a **BURST** under the center of the **DSZ**
3. Connect **BURST** to established resource infrastructure
4. Prepare and store the **SZUs** in a central location, near the **BURST**
5. When a disaster strikes, **SZUs** can be rapidly transported and assembled at the **DSZ**. Resources from the **BURST** can be directly connected to **SZUs**
6. If the resource infrastructure breaks down due during the disaster, the **BURST** can support the whole **DSZ** for up to 2 weeks

SZUs provide modular survival shelters that can easily be set up and connected directly into the **DSZ** system. The function of each unit is specialized to a specific purpose such as medical care, food processing, comfortable living, or bathroom utilities. Other units are designed to capture solar energy, harness wind energy, purify available water, etc.

The strategy of keeping each unit specialized to a specific function allows each camp to be customized to regional conditions. For example, different areas will have different kinds of natural energy resources, and decision-makers can customize the system to create the most efficient combination of units based on the area's particular characteristics.

Properties

- A fast-setup refugee camp system
- Locations easily accessible from at-risk areas and major transportation systems
- Different types of units supporting basic human needs such as medical, food process, bathroom, living space, etc.
- Self-Sustainable Units that tap resources by capturing solar energy, harnessing wind energy, purifying available water, etc.

Features

- Fulfills all basic survival needs during disaster
- Adapts to different environmental conditions by selecting appropriate modular units
- Units easily stored, transported, and set up
- **Safety Zone Unit Storage Center (SZUSC)** which stores **SZUs** when not in use
- Provides easy access from a central location in the **DSZ**
- **Built Underground Resource Storage Tank (BURST)**
- Connects to infrastructure, providing things like sewage, electricity, clean water and fuel
- Contains sufficient resources to support the zone for 2 weeks
- Provides resources by adjusting unit installation based on local resource availability

Disaster Safety Cube (DSC)

Properties

- Waterproof equipment for protecting people during disaster events
- Cube-like shelters made of strong, light materials and firmly tethered to the ground

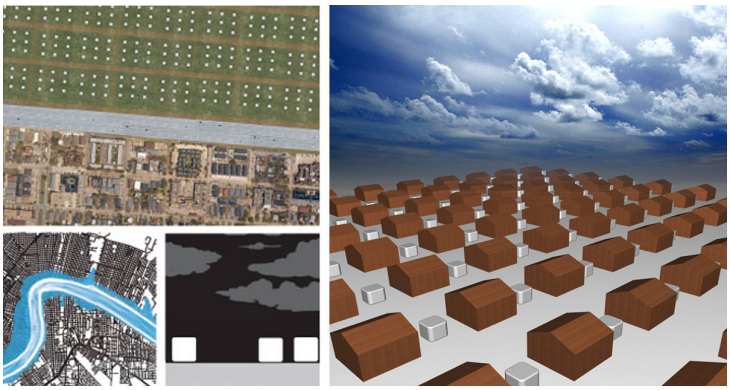
Features

- Accommodates a maximum 6 adults
- Rests in the backyard on normal days
- Capable of enduring gale force winds and violent waves
- Floats on the intruding waters
- Contains emergency supplies to support 6 people for 5 days
- Communicates directly with other cubes and the central hub
- Purifies and desalinates available water supply

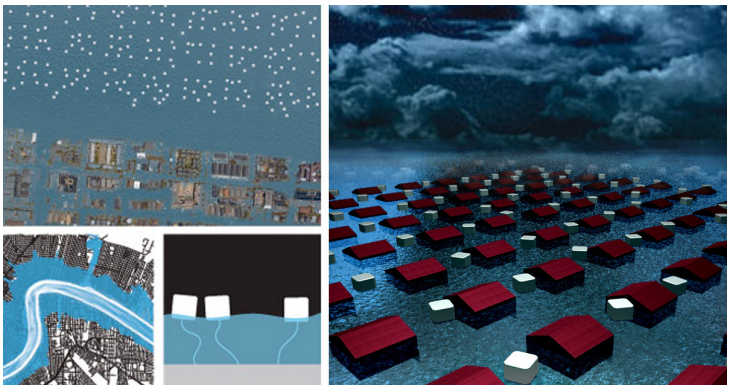
Coping with disasters such as Hurricane Katrina or the tsunami that struck South Asia in 2004, many people didn't have a chance to escape and encountered difficulties while waiting for rescue workers. Disease outbreaks threatened large numbers of victims. After Hurricane Katrina some people stayed on their roofs for days waiting for rescue without food, water or sanitation. Many who couldn't evacuate before Katrina struck include the elderly and disabled. Some of these victims live alone and have difficulty signaling rescue teams.

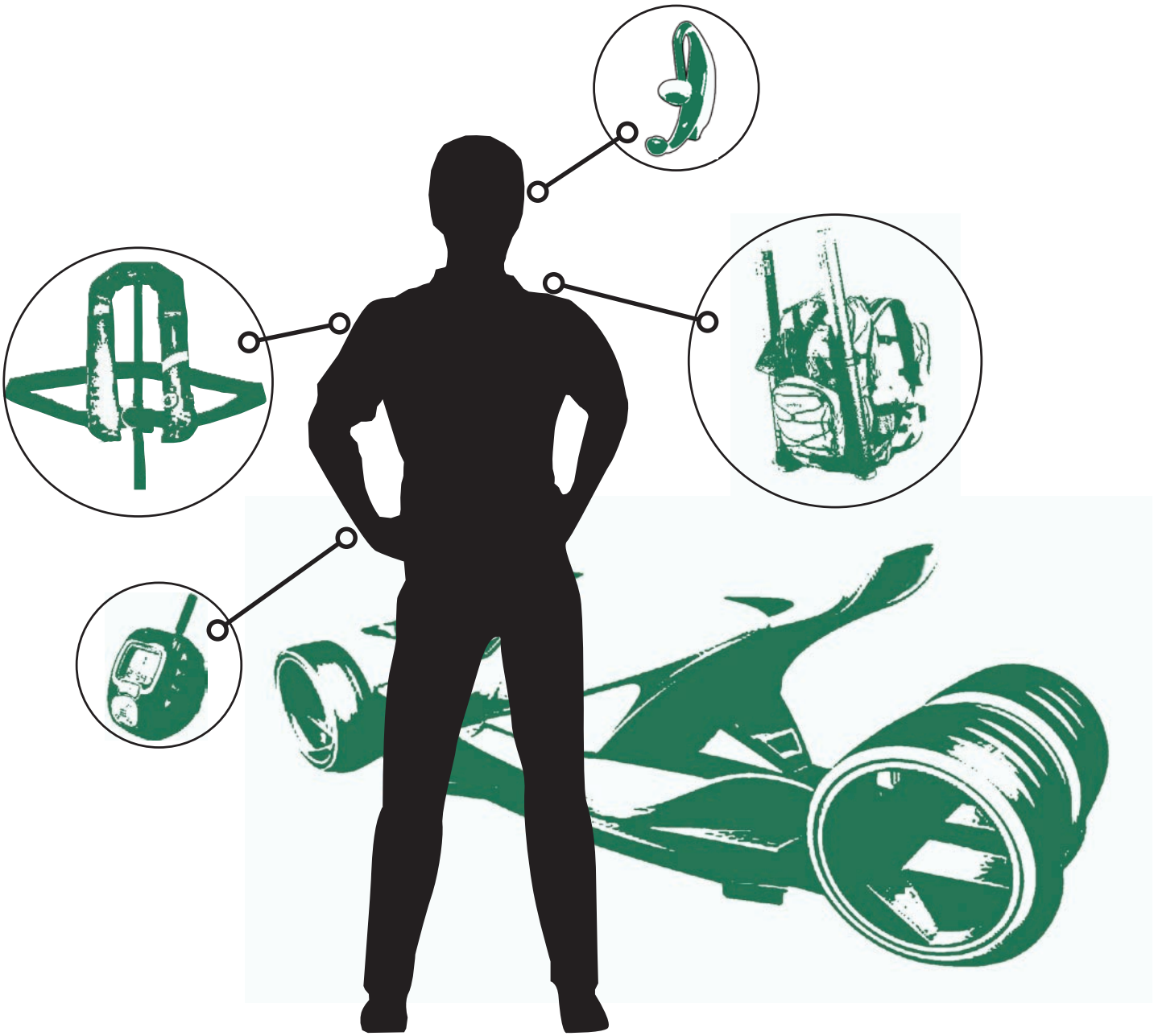
Disaster Safety Cubes are buoyant emergency shelters capable of withstanding gale force winds. During some disasters such as flash floods and tsunamis, many people don't have time to evacuate to higher ground or Disaster **SZUs**. In the case of a tsunami the wave impacts coastal areas minutes after the first tremors. **DSCs** provide a temporary safe shelter that can protect people from immediate danger and shelter them until rescue workers arrive. Light weight and buoyant, **DSCs** are impregnable floating survival shelters. Tethered to the ground, they can float during flooding without moving too far from home.

Homes in at-risk areas with DSCs in backyards



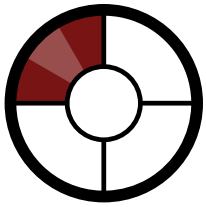
The DSCs are safe, impermeable, and buoyant during a flood





Super System Element

Rescue Mission Management System (ReMMS)



Sub-Elements

- Combined Amphibious Rescue Squad
- Agile Resource Transportation System

ReMMS is a systematic rescue mission which activity begins prior to any event, with anticipation and preparation for it. The two main components of **ReMMS** are **Combined Amphibious Rescue Squad (CARS)** and **Agile Resource Transportation System (ARTS)**. These components are built and strengthened prior to a disaster event with extensive effort scheming towards having everything in place, well-stocked and readily accessible.

CARS are individual personnel trained to conduct rescue mission in the most extreme conditions. Ordinarily, these tasks are performed by the fire fighters special units. The **CARS** provide special rescue squads that are built out of people who has at least basic to advanced rescue training. Today, there are many rescue team organization, profit and non-profit, in existence that is trained to assist in emergency situation. These are great platform for trained volunteers that may be further developed to specifically perform special tasks under **ReMMS**. These chosen people, either volunteered by their respective association, or individual people with prior basic training who volunteers themselves will undergo extensive training to be able to perform rescue both on land and under water. The extensive training will include getting familiar with the **Standard Rescue Gear** that will be issued during real rescue mission. These

Properties

- Systematic rescue mission
- Trained personnel equipped with emergency rescue knowledge
- Amphibious rescue gear provider
- A system of integrated rescue transportation
- Emergency medical assistance that travels on land and water
- Efficient resource gathering, storage and delivery system
- Surveillance system for unfamiliar territory

Rescue Mission Management System (ReMMS)

special positions are certified with proper certification and their names are entered into the database as members of **CARS**. Members of **CARS** will go on with their daily routine until in the event of disaster their services are requested.

Another big part of preparation that is done prior to any disaster is a resource management exercise. This will be a locally-centralized effort to proactively collect and store food in an easily accessible warehouse. Warehouse is centralized between the communities at risk and is always open for donation and occasionally holds donation drive to keep stock count high. Turn-around of stock depends on the frequency of disasters. Despite having food collected by particular communities, exchange of food may also be done amongst neighboring nations when there is a dire need. Later, food is repaid in the form of food stock to replace the ones donated.

People powers are based on volunteer basis with a few permanent staff to handle the stock count and logistics. Another form of garnering volunteers are recruiting individuals sentenced to community service. These individual will be given options to act as volunteer to assist in labor work of moving and caring resource stocks.

Rescue mission are pre-planned to fit the local scene in which various mission route are determined. In the event of the emergency, rescue teams and resource delivery are commissioned according to the situation at hand and simultaneous to evacuation. The rescue mission in this case also assist in evacuation with a main purpose to first ensure safety and then perform emergency protocols when the need arrives.

Resources will be delivered to safe zone via multiple possible channels. The resources is scanned at the point of release by the storage centre and scanned at the point of delivery at the communication centre of the safe zone. The stock count is monitored and request may be made if the stock becomes low in which additional stock will be delivered via multiple transportation system available then.

Features

- Plans rescue mission in anticipation for possible emergencies
- Provides tailored rescue protocols for specific disasters
- Proficiently delegates tasks according to available resources and level of danger
- Proactively gathers resources
- Detects life and cadavers in disaster areas

Rescue Mission Management System (ReMMS)

An important aspect of **ReMMS** is also its medical care. **Amphibious Medical Response Vehicles** will be stationed at all safe zones at which point it will remain on that zones throughout the evacuation period. A smaller version the vehicle will not be stationed but are on stand-by for on call by any members of **CARS**. The exact positioning of the call will be detected via the **Unfamiliar Territory Surveillance System** with GPRS functionality which corresponds to the smaller unit carried by the **CARS** member.

What stated out as an ordinary day for Yu Chen slowly turned into a day in which all his training was finally put into practice...

He was absorbed into Yangtze Combined Amphibious Rescue Squad (CARS) while serving as an intern with the Local Fire Unit. Having earned his certification as a Yangtze CARS member, Yu Chen has had one month of intensive on-land and underwater training. His certification deemed him eligible to be called for special mission dealing with deep water emergency mission.

The local scene has changed tremendously in the past few years alone. Shanghai generally enjoys four distinct seasons, generous sunshine and abundant rainfall. Nearly 60% of the precipitation comes during the May-September flood season, which is divided into three rainy periods which are Spring Rains, the Plum Rains and the autumn Rains. Compared to the annual rainfall of 1,200 millimeters years before, this year definitely counts for higher. The rain the last few days were getting heavier and more violet. It was when the monitoring centre detected a typhoon coming that Yu Chen was called to report himself at the appointed CARS center.

The wind is blowing harder and people are being evacuated faster now. As a member of CARS, Yu Chen was provided with his Standard Issue Rescue Gear. He is unfamiliar with the area that he was assigned to but the Surveillance System helped assist him to find his bearings especially when the water starts to rise.

In his days with the Local Fire Unit, he never felt as nervous as he was feeling then. At that moment, as if nature was playing a joke on him, a sudden wave of strong surge threw him and a group of evacuees off their feet. He was surprise what the training had done for him, at the point of impact, his instinct became sharper. Almost instantly he remained calm and started kicking to reach the surface of the water. As he resurfaced, he started looking around. Some people appear to be drowning while other managed to swim over to higher ground. Protocols taught him to remain calm, swim ahead of the rushing water and secure a safety net to allow drowning citizens to grab on to it. This gave him time to swim after citizens that were not able to hold on to the net.

The aftermath of the strong surges was horrifying. The early evacuation managed to save a lot of lives but some are critically injured. Yu Chen surprised himself for remaining quiet calm throughout the entire ordeal. A fellow CARS member mentioned feeling the same way at the same time saddened by the some unavoidable lost of life. Amidst the debris, Yu Chen worked with fellow CARS members to seek for survivors using the Life Monitor and Life Scanner Tools.

After a half day of searching for survivor, Yu Chen received order to retreat to the nearest safe zone. There injuries were treated by the Amphibious Medical Response Vehicles stationed near to the camp's communication centre, while some of the vehicle are slowly coming in with survivor being treated even as the vehicle are moving slowly from water to land.

Combined Amphibious Rescue Squad (CARS)

This program is an intensive training of selected individuals to step up as special Rescue Squad in times of disaster events. The individual will undergo an extensive one month training to get certification as a member of **Combined Amphibious Rescue Squad**. Their service will be called for during times of disaster in which chosen individual will report at the pre-determined centre. There, they will be issued a standard rescue gear consist of a telecommunication device, **Unfamiliar Territory Surveillance System** and a life monitoring device.

With the gear also the personnel will be provided standard rescuing tools and life saving devices. Their task commissioning will be in tangent with the public evacuation. The main idea of the rescue system is to be on the ground when the event happens so that rescue is not delayed.

Trained personnel are not only ensured to be technically apt at rescuing task but they are trained to remain calm to enable clearer judgments when faced with danger.

Properties

- Special training program for rescue personnel
- Certified training for elite rescue team
- Empowered individuals to act on initiatives and good judgment during rescue mission

Features

- Trains rescue squad candidate extreme event protocols
- Prepares individuals with real life simulations

Agile Resource Transportation System (ARTS)

Properties

- Vast global network of relief aid providers who stockpile and maintain aid resources
- An adaptive system of processes, tools and vehicles
- Decentralized system of rugged cargo transport vehicles stationed globally

Features

- Anticipates need by preparing and mobilizing while the threat of disaster looms rather than waiting for the damage to be assessed
- Delivers aid resources anywhere on earth within 24 hours

In times of disastrous weather events, transportation of response personnel and equipment becomes extremely dangerous. A flexible and resilient delivery system for aid resources is necessary to reliably and efficiently provide relief where it is needed.

In the context of rising sea levels, pertinent disasters will involve massive amount of water inundating the land. Building an system for delivering resources after a disaster is vital to minimizing casualties. Such a system should be able to:

- Cross large bodies of water.
- Rapidly assemble temporary road systems
- Navigate terrain made treacherous by floods and landslides
- Safely transport victims in need of medical aid
- Effectively deliver rescue equipment

While normal transportation systems and infrastructure will be often be destroyed by fast moving water or mudslides, the **Agile Resource Transportation System** is capable of delivery aid resources in places otherwise inaccessible by others.

System Elements:

Communication & Networking

Super System Element

Alliance of Nations & Communities At Risk (ANCAR)

The **Alliance of Nations and Communities At Risk** is a global networking platform focused specifically on addressing the needs of at-risk nations forced to deal with the consequences of climate change.

"There is a high confidence that developing countries will be more vulnerable to climate change than developed countries, and there is medium confidence that climate change would exacerbate income inequalities between and within countries" (IPCC 2001b report p.916).

All at-risk nations, regardless of geographical or national capacity, will need to unite to facilitate negotiations between themselves and other nations that are not directly impacted. **ANCAR** will initiate efforts for cooperation in adapting to living in an environment with rising seas. At-risk nations fall under three categories:

- "Must act now"
- "Could act now"
- "Should act now, but differently"

Properties

- A global network of at-risk nations and communities to support aligned action and knowledge transfer
- Consortium of national leaders
- Consulting board of scientists and subject matter experts

Features

- Provides partnership in knowledge sharing
- Provides smaller at-risk nations/communities the ability to effectively communicate their concerns
- Garners appropriate support from other nations/communities
- Addresses a diverse set of needs
- Negotiates new homes for environmental refugees
- Speaks with a unified voice
- Seeks grounds for balanced international equity
- Fosters synergy in adaptation efforts
- Provides technology transfer to developing states

Adaptation raises serious questions about international equity between countries and even within countries. This is mainly because adaptation is necessary for people or systems that are adversely affected by climate change, but not necessarily for the people or systems that have historically caused the problem.

ANCAR International Equity would facilitate communication and information transfer on a neutral platform, representing poor developing states, which are experiencing first-hand impacts of global climate change. Their grievances will be brought to developed countries whose historical emissions are the main cause of climate change.

Somewhere in the Pacific Ocean...

Currently, some Small Island Developing States (SIDSs) in the Pacific are being forced to move roads and buildings further inland to avoid damaging storm surges, which they attribute to sea-level rise and climate change. They say that responsibility lies with the industrialized world, so developed countries should pay the costs of adaptation. Indeed, the government of Tuvalu in 2001 asked Australia to consider taking environmental refugees from their very low-lying atolls, where people are already threatened by sea-level rise.

So far, Australia has refused to give sanctuary. Instead asking for more proof that climate change is responsible for Tuvalu's predicament. The government of Tuvalu, a founding member of ANCAR, appeals to the alliance for support. The Research & Investigation wing of ANCAR assembles an argument and approaches the Australian government to negotiate with a Unified Voice. Having collected irrefutable evidence of the impacts of climate change from its various nations, ANCAR is able to successfully negotiate sanctuary for Tuvalu's citizens on the island of Tasmania.

Conclusion

Though climate change in general — and rising sea levels in particular — will affect each region differently, it is important to recognize that all members of the global community must work together to mitigate negative human influences and adapt to the challenges that will inevitably follow.

What we have laid out before you is not the answer because there is no singular answer. Instead, these components constitute a variety of concepts and strategies for adapting to rising sea levels, each of which must be evaluated for both its feasibility and appropriateness in any given situation. By first understanding and appreciating the issues that confront us, we will be able to suitably equip ourselves for the future.

Many decisions we make now will affect generations to come, so it is in our children's interest that we approach such decisions with the utmost knowledge and wisdom. Though different regions will face issues specific to their particular locations, each general strategy is vital to our survival and must be addressed. While each civilization will adopt its own measures, adapting our societal mechanisms in a time of massive upheaval, maintaining our supply of resources as climatic systems transform, protecting ourselves from an increasingly hostile environment, and facing disastrous events as a unified people are **all** critical aspects of our continued existence.

The time to act is now, and we hope that the strategies we have presented here will inspire you and provide a point of discussion that leads us all to a brighter future.

Photograph: **A "melt lake" on the Greenland Ice Sheet**
by Greenpeace/Andrew Davies, Project Thin Ice
http://www.flickr.com/photos/adavies/55277965/