INFRASTRUCTURE

MINING & METALS

NUCLEAR, SECURITY & ENVIRONMENTAL

OIL, GAS & CHEMICALS

Sustainability and Climate Change Adaptation for Infrastructure

Meeting of the Roundtable on Science and Technology for Sustainability
June 5, 2015
Catherine McKalip-Thompson

Discussion questions

- What are the implications of climate change on the transformation of infrastructure?
- What are some barriers to addressing infrastructure needs in light of climate change and what are some solutions to those barriers?
- What are the knowledge gaps in better understanding how to address infrastructure needs?

In context

- Climate change impacts and potential adaptations are should be approached as part of RESILIENCE strategies
- Holistic look is needed in a dynamic world – many concurrent factors
  - Demographics and population
  - Increasing urbanization
  - Ecosystem services
  - Increased expectations for rising standard of living
  - Natural disasters, cyberattacks, etc.
  - Sustainability

Resiliency

1.0

- Hardening of structures
- Redundancy of components (back-ups for everything)
- Spare pumps, back-up generators
- Can't afford to build for worst case scenario and use 1 for 1 replacements

2.0

- "Software" + select hardware approaches
- Systems perspective
- Reliability centered maintenance
- Preserve connections and alternatives so that systems still function
- Flexibility/adaptability

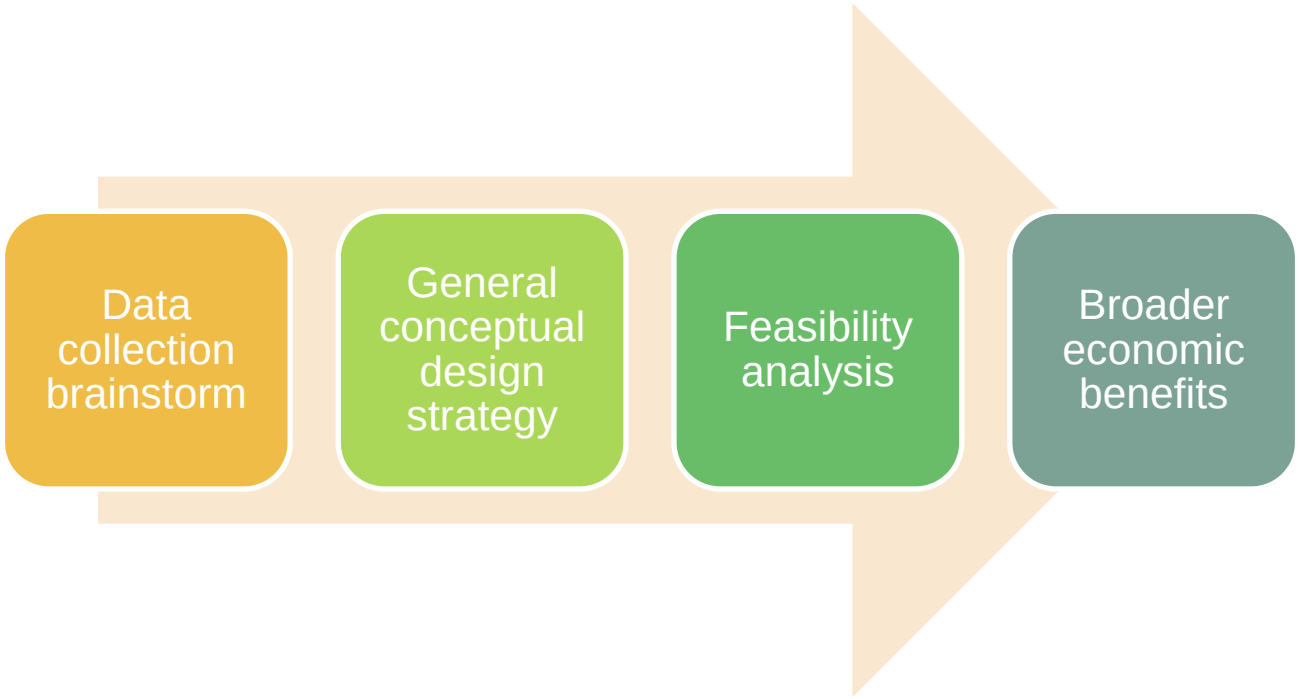
RE:Invest

- Systems approach (not projects) think costs, losses and finance from the beginning
- mix of hard and soft solutions (multiple objectives)
- Re-think approaches, involve many actors and perspectives

Green, resilient, and sustainable infrastructure systems are not made up of a few large projects, but many small pieces and parts.

Resiliency planning

- Delivery mechanism design and system return on investment + technical analysis
  - Combined expertise of engineering, legal and finance



Prototype concepts

Re:park

- Integrate public green and open spaces with stormwater management, underground parking
  - Separate revenue streams
  - Efficient use of land

Re:cycle

- Switch to recycled water for many municipal uses
- Onsite recycled water treatment integrated with renewable energy technologies
  - Financeable via RE mandates, utility fees, ESCO models

Prototype concepts

Re:pave

- Coordinate and sequence road repaving or widening with expanding green infrastructure, porous pavement areas, tree trenches, etc.
  - Surface parking to retain stormwater

Re:inforce

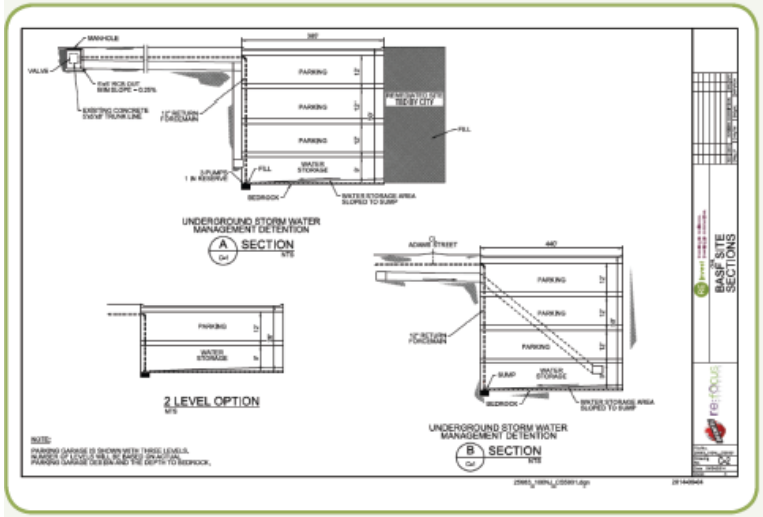
- Coastal protection is stronger when done at once and with certainty
  - Paid for collectively through risk reduction / insurance savings

Distributed generation & microgrids

- Co-op City (330 acres): a 40-megawatt combined heat and power (CHP) plant providing electricity, steam, heating and cooling to 60,000 people all in one package... it worked flawlessly during Sandy.
- All 24 CHP systems in New York that were designed to operate independently from the grid during a power outage performed – whereas in 2003 half of emergency generators failed. (ICF International Report)
- PLUS efficiency, smart grid technologies, demand response, EV infrastructure 2-way flows…

Re:invest example: Hoboken

- Financial flood damage
- integrated underground parking structure plus stormwater detention chamber solving two problems and topped with green space



BASF Site Sections Highlighting Various Scenarios

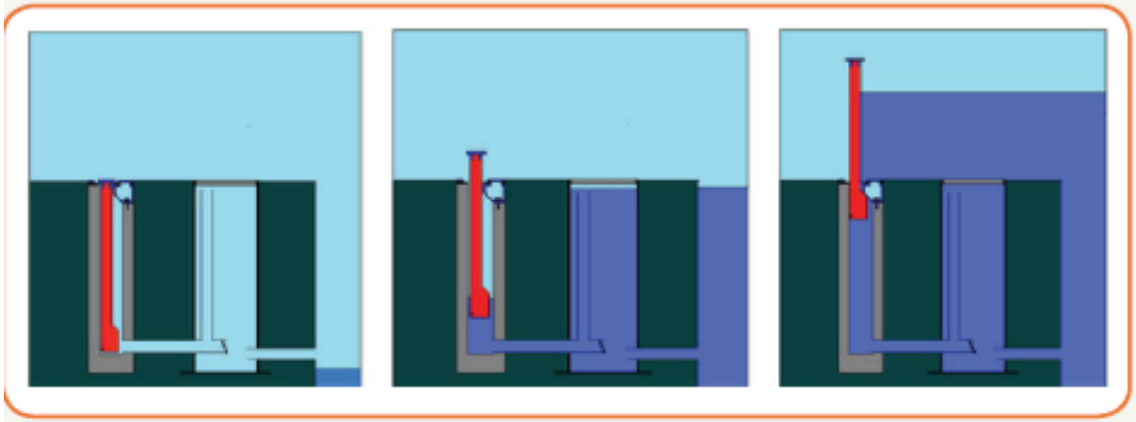
Storm Depth (inches)	Storm Categorization	Storm Volume (MG)	Adjusted Volume (MG)*
2.41	1-Year	3.2	4.0
2.92	2-Year	3.9	4.9
3.69	5-Year	4.9	6.2
4.33	10-Year	5.8	7.2

Table 1 - Summary of Contributory Stormwater Runoff Volume

Source: Re:invest Report 2015

Re:invest example: Norfolk

- Needs increased capacity for stormwater; converting hardscape to ‘green infrastructure’
  - Green alleys, planters, permeable pavements, surface depression storage throughout arts district
- Self-deploying floodwall systems
- Tax-increment finance (real estate value increases)



Self Closing Flood Barrier Working Principle
(Source: Aggeres Flood Solutions)

Bechtel

- Over 700 technical specialists; Distinguished engineers and scientists and Fellows – participate in industry consortia, code committees
  - Technical papers
    - *Proposed strategies and regulatory framework in mitigating coastal flooding hazards from a beyond-design-basis external event*
    - *Risk and Uncertainty Analysis in Extreme Hydrologic Events*
    - *Water Use Management Challenges in Power Generation*

- Planners: scenarios, hard and soft solutions, holistic approaches integrating multiple influences, trends and scenarios
  - system functioning is what we want to preserve

- Risk assessment and adaptation in Design
  - Design basis report (assumptions, recommendations) to be agreed with customer, regulators
  - Variables: Commercial /government clients, location
  - Sources: ASCE, NAE, NAS, NIST, NOAA, USACE…

Bechtel Case Study: Libreville, Gabon

Problems:

- Recent growth - to almost 1 million people - has outpaced the city's ability to accommodate change
- Libreville suffers from unplanned land uses and incompatible development

Solutions:

- Introduced the Smart Code into Gabon and adopted as the primary basis for urban land development in Libreville
- Framework for flexibility, making it possible to incorporate new ideas in land planning as well as smart technologies

Port Mole waterfront development expands land use opportunities and incorporated analysis of tides, storm surges, potential sea level rise in determining the elevation, sea walls and left existing river outlets open and expandable.

Bechtel Case Study: Libreville, Gabon

Problem:

- Lack of data
- Coastal erosion, inadequate stormwater management, future risks/vulnerabilities

Solutions:

- Hydrologic modeling and flood maps as base for stormwater/waste water master plans with ‘safety margins’, vulnerability analysis, integrated with land use & other sectors
- •Climate change assumptions embedded in the model: sea level fluctuation (+2.5m) and extreme weather event (100+years scenario)

Storm water model Bechtel – ANGT - Merlin

Example: Impact on the "Sainte Marie" watershed

Without improvements

With improvements

Key output

- Design specification for existing river crossing: reinforcement of 65 existing structures
- New road construction impact on neighbourhoods and area flooding – definition of more than 15 buffer zones to store excess water during extreme events
- Drainage infrastructure construction program – more than 50 km of drainage channel reinforcements

Increased temperatures: what are we designing to?

21 km of new tunnels under London

Tunnel Boring Machines

Crossrail, UK

- 10 new stations connecting to 30 existing stations
- Design standards specified following climate risk assessment against UK climate change projections
- Should higher temperature of 35 degrees C be adopted due to projected warming?
- 30 degrees confirmed given 30-35 year design life of mechanical cooling and ventilation equipment for trains, platforms and tunnels.
- Passive space provision for future upgrade/ replacement provided if higher cooling demand required.

Smart City Considerations for PABMEC

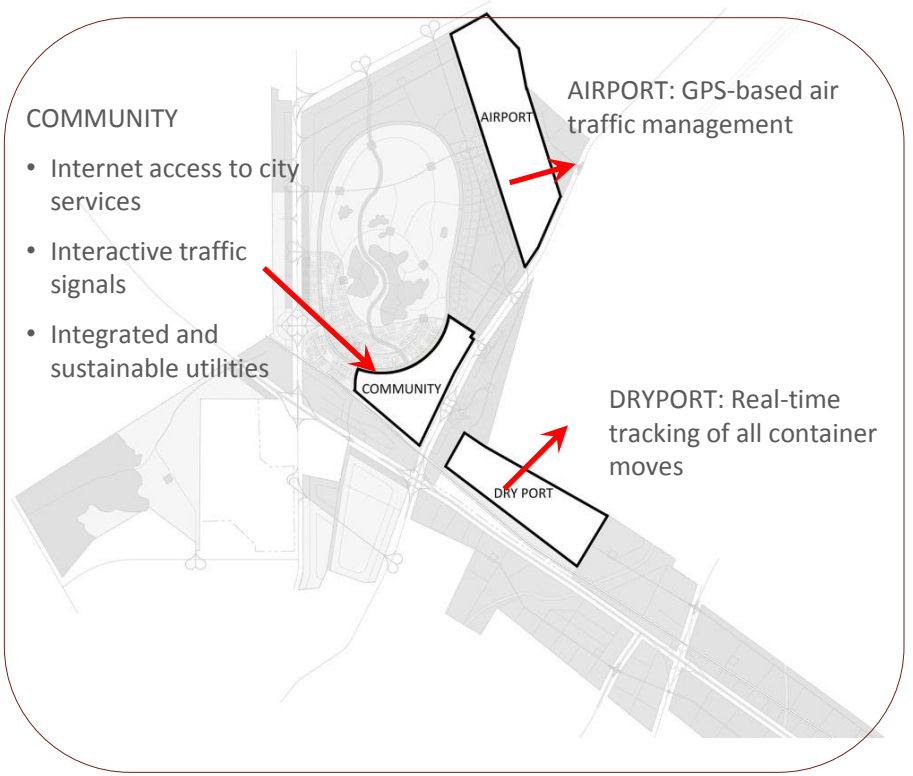
Transportation: Automated traffic signals. Bus transit system within the community linking to a world class airport and passenger rail.

Public Safety: Control center with integrated police, fire and emergency services providing real-time monitoring and response

Energy & Utilities: Extensive use of solar energy. Low water fixtures and smart meters on houses and businesses. Gray water recycling system.

Telecommunications: Fiber optic network with high capacity bandwidth, expansion capability and connectivity to the national grid

City Services: Access to information via smart phones, iPads provides direct links to the municipal agencies and databases



Priority Smart City Systems for the 3 PABMEC sub-areas

Resources

Executive Order Preparing the United States for the Impacts of Climate Change

- Provide Information, Data, and Tools for Climate Change Preparedness and Resilience
- Adaptation Plans

Infrastructure rating systems

Envision™

- Climate and Risk as a separate category
- Threat assessment and climate adaptation plan
- Avoid traps and vulnerabilities
- Prepare for long-term adaptability

LAWA Sustainable Airport Guideline

Climate change adaptation planning:

Increased temperatures,
severe weather,
sea level rise and storm surge,
ecosystem changes

TABLE OF POINT VALUES

				Improved	Enhanced	Superior	Conserving	Restorative
1	QUALITY OF LIFE	PURPOSE	QL1.1 Improve community quality of life	2	5	10	20	25
2			QL1.2 Stimulate sustainable growth and development	1	2	5	13	16
3			QL1.3 Develop local skills and capabilities	1	2	5	12	15
4		COMMUNITY	QL2.1 Enhance public health and safety	2			16	
5			QL2.2 Minimize noise and vibration	1			8	11
6			QL2.3 Minimize light pollution	1	2	4	8	11
7			QL2.4 Improve community mobility and access	1	4	7	14	
8			QL2.5 Encourage alternative modes of transportation	1	3	6	12	15
9			QL2.6 Improve site accessibility, safety and wayfinding		3	6	12	15
10		WELLBEING	QL3.1 Preserve historic and cultural resources	1		7	13	16
11			QL3.2 Preserve views and local character	1	3	6	11	14
12			QL3.3 Enhance public space	1	3	6	11	13
				13	**27**	**62**	**150**	**151**
13	LEADERSHIP	COLLABORATION	LD1.1 Provide effective leadership and commitment	2	4	9	17	
14			LD1.2 Establish a sustainability management system	1	4	7	14	
15			LD1.3 Foster collaboration and teamwork	1	4	8	15	
16			LD1.4 Provide for stakeholder involvement	1	5	9	14	
17		MNGMT.	LD2.1 Pursue by-product synergy opportunities	1	3	6	12	15
18			LD2.2 Improve infrastructure integration	1	3	7	13	16
19		PLANNING	LD3.1 Plan for long-term monitoring and maintenance	1	3		10	
20			LD3.2 Address conflicting regulations and policies	1	2	4	8	
21			LD3.3 Extend useful life	1	3	6	12	
				10	**31**	**56**	**115**	**31**
22	RESOURCE ALLOCATION	MATERIALS	RA1.1 Reduce net embodied energy	2	6	12	18	
23			RA1.2 Support sustainable procurement practices	2	3	6	9	
24			RA1.3 Use recycled materials	2	5	11	14	
25			RA1.4 Use regional materials	3	6	9	10	
26			RA1.5 Divert waste from landfills	3	6	8	11	
27			RA1.6 Reduce excavated materials taken off site	2	4	5	6	
28			RA1.7 Provide for deconstruction and recycling	1	4	8	12	
29		ENERGY	RA2.1 Reduce energy consumption	3	7	12	18	
30			RA2.2 Use renewable energy	4	6	13	16	20
31			RA2.3 Commission and monitor energy systems		3		11	
32		WATER	RA3.1 Protect fresh water availability	2	4	9	17	21
33			RA3.2 Reduce potable water consumption	4	9	13	17	21
34			RA3.3 Monitor water systems	1	3	6	11	
				29	**66**	**112**	**170**	**62**
35	NATURAL WORLD	SITING	NW1.1 Preserve prime habitat			9	14	18
36			NW1.2 Protect wetlands and surface water	1	4	9	14	18
37			NW1.3 Preserve prime farmland			6	12	15
38			NW1.4 Avoid adverse geology	1	2	3	5	
39			NW1.5 Preserve floodplain functions	2	5	8	14	
40			NW1.6 Avoid unsuitable development on steep slopes	1		4	6	
41			NW1.7 Preserve greenfields	3	6	10	15	23
42		L&W	NW2.1 Manage stormwater		4	9	17	21
43			NW2.2 Reduce pesticide and fertilizer impacts	1	2	5	9	
44			NW2.3 Prevent surface and groundwater contamination	1	4	9	14	18
45		BIODIVERSITY	NW3.1 Preserve species biodiversity	2			13	16
46			NW3.2 Control invasive species			5	9	11
47			NW3.3 Restore disturbed soils				8	10
48			NW3.4 Maintain wetland and surface water functions	3	6	9	15	19
				15	**33**	**86**	**165**	**169**
49	CLIMATE	Emission	CR1.1 Reduce greenhouse gas emissions	4	7	13	18	25
50			CR1.2 Reduce air pollutant emissions	2	6		12	15
51		Resilience	CR2.1 Assess climate threat				15	
52			CR2.2 Avoid traps and vulnerabilities	2	6	12	16	20
53			CR2.3 Prepare for long-term adaptability				16	20
54			CR2.4 Prepare for short-term hazards	3		10	17	21
55			CR2.5 Manage heat islands effects	1	2	4	6	
				12	**21**	**39**	**100**	**101**