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Development of performance measures for integrated management of Canada's core public infrastructure

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Publisher's version / Version de l'éditeur:

Workshop of Canadian Network of Asset Managers-CNAM [Proceedings], pp. 1-26, 2009-05-11

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Development of Performance Measures for Integrated Management of Canada's Core Public Infrastructure

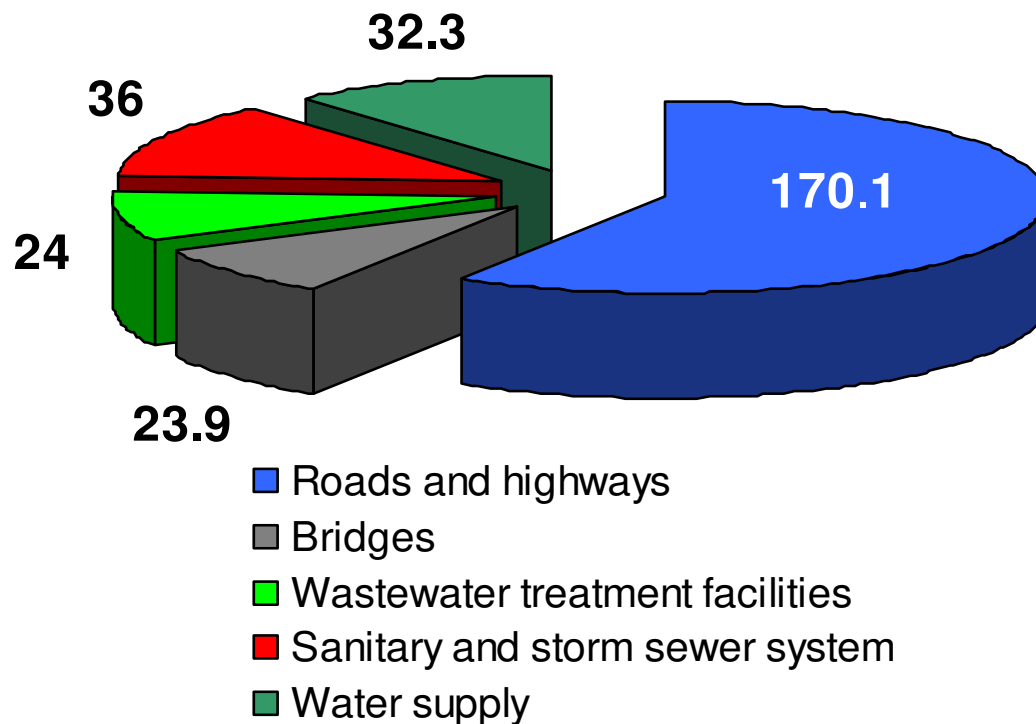
Zoubir Lounis, Group Leader
Urban Infrastructure Research Program

Background

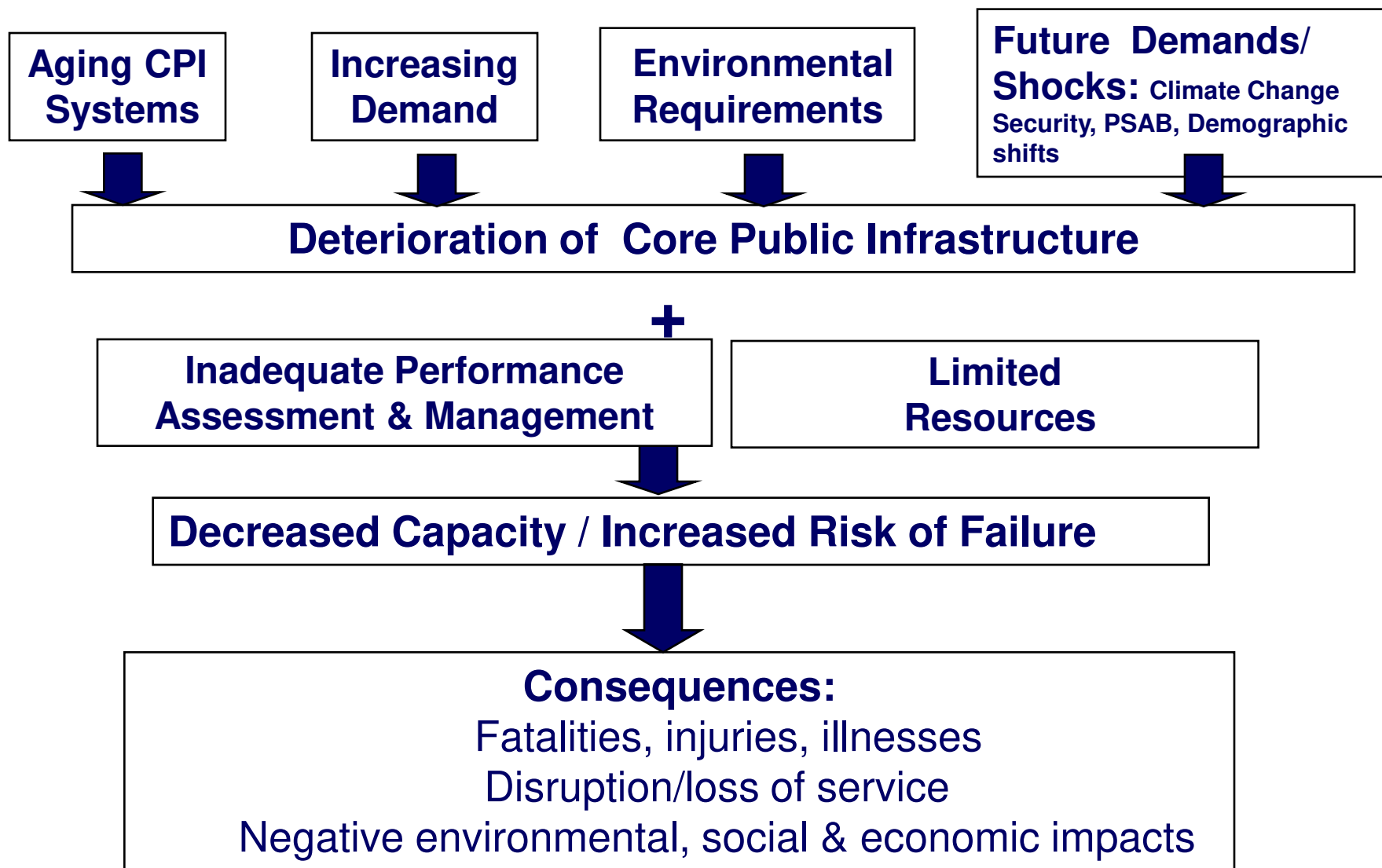
- Core Public Infrastructure (CPI):
 - Transportation infrastructure: roads, bridges, transit
 - Water and wastewater infrastructure

- Canada's CPI enable:
 - personal mobility
 - transport of people and goods
 - provide safe drinking water
 - remove wastes
 - critical to Canada's economy and quality of life

Value of Core Public Infrastructure (in \$ billions)



Challenges



Challenges

- Need performance measures to address **knowledge gaps** in:
 - current state of Canada's CPI
 - future demands on CPI (e.g. due to climate change)
 - life cycle performance of CPI

- Need **decision-support tools** for:
 - ensuring public safety, health, and security
 - integrating management of different CPI assets
 - minimizing life cycle costs
 - optimizing allocation of limited funds
 - improving CPI performance
 - supporting broad vision of sustainable communities

Objectives

- Identify current gap/ “deficit” in knowledge of performance assessment and management of CPI
- Develop model framework for performance assessment and management of Canada's CPI
- Propose 5-year plan to address knowledge gap and help decision-makers assess condition and optimize management of CPI

Project Overview

- Collaborative Research Project:
 - NRC-IRC
 - Engineers Canada
 - NRTSI (National Round Table on Sustainable Infrastructure)
 - Infrastructure Canada (INFC)
 - Canadian Urban Transit Association
 - Universities of British Columbia, McGill, Ryerson, Waterloo
 - Duration: 15 months: Jan. 2008 – March 2009

Workshop on Life Cycle Performance & Management of CPI

- Presentations on national & international practices: USA, UK, France, Switzerland-
- Identified shortcomings of current practices:
 - Large numbers of indicators and measures
 - Limited considerations for performance assessment of assets and services and their inter-dependencies
 - Focus on one objective at a time
 - Focus on one type of CPI system only
 - Inappropriate allocation of limited funds
 - Increased risk of failure of some critical systems

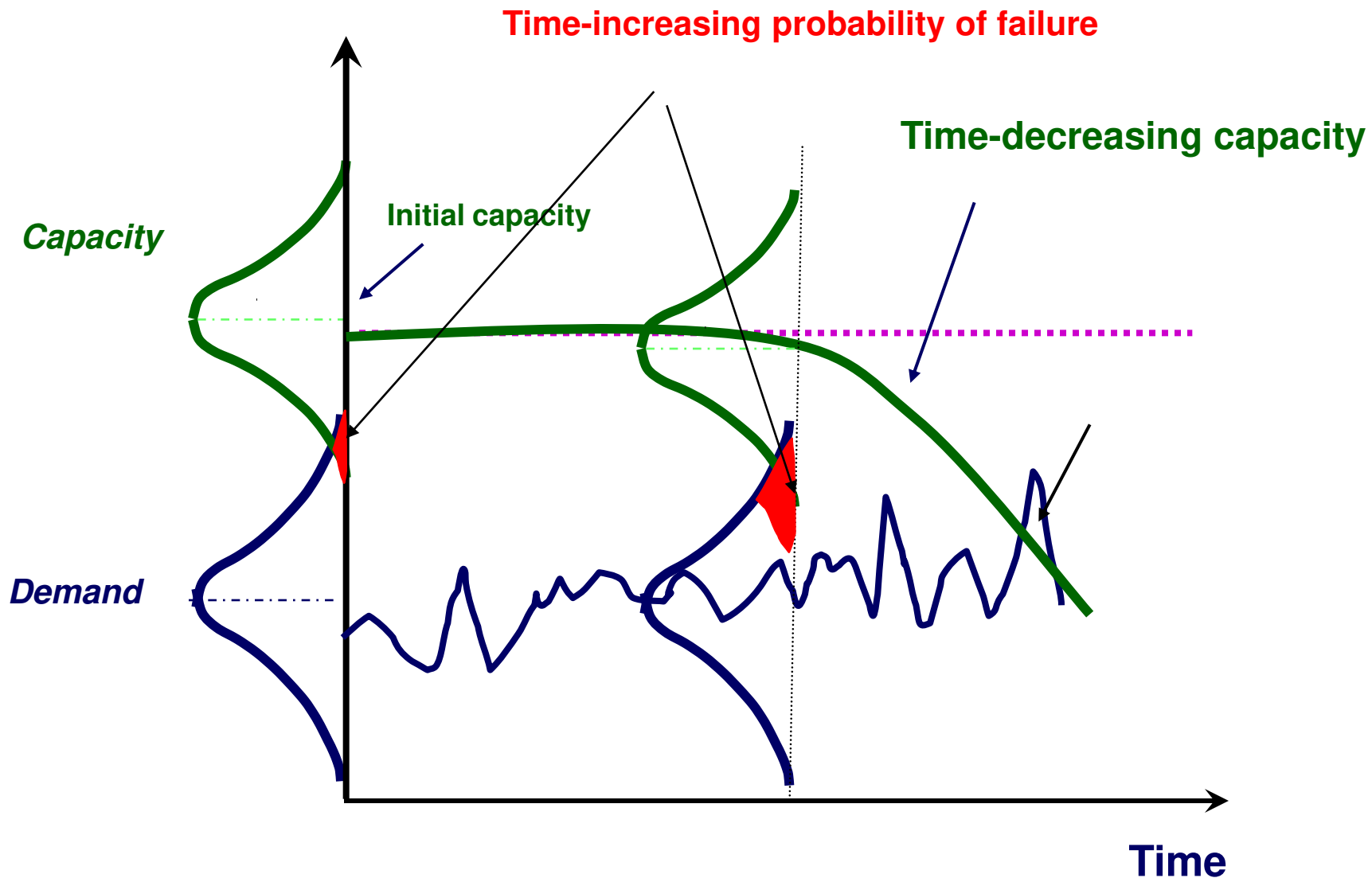
Reviews of State of Art & Practice

- Large numbers of measures – hardly comparable
- No clear definitions of objectives of performance assessment and management
- Subjective qualitative performance indicators for safety and health-critical systems
- Inconsistent weighting of measures for tactical and strategic levels of decision-making
- No integration of performance assessment & management of different CPI systems

Reviews of State of Art & Practice

- Limited reliability of qualitative condition ratings
 - 2, 3 or more ratings variability by different inspectors
 - No quantitative information on safety, service life of asset
- Predictions of remaining life highly uncertain
- No standard definitions of minimum acceptable condition or “end of life “- hard to compare data
- Deterioration prediction based on unrealistic & qualitative Markovian models

Performance of CPI Assets



Need for CPI Model Framework

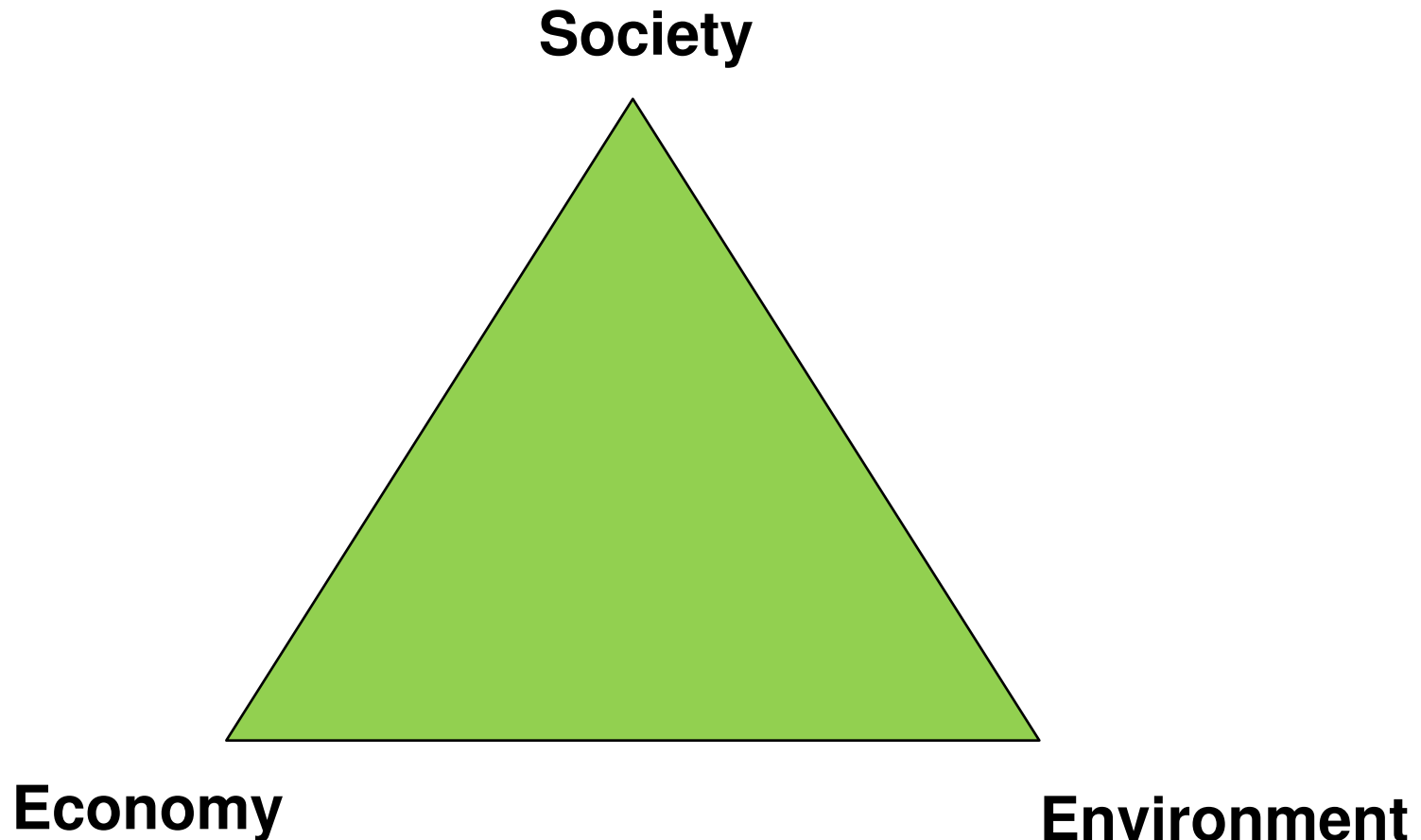
- Need a conceptual structure within which:
 - Public expectations and corresponding demands or loads on CPI systems are established
 - Knowledge, technologies, and funding are leveraged
 - Actions/decisions to improve CPI performance and meet public expectations are identified

CPI Model Framework

- Support broad vision of sustainable communities
- Focus on core services:
 - personal mobility
 - transport of people and goods
 - provide safe drinking water
 - remove wastes
- Identify interdependencies among all CPI systems
- Support comprehensive and integrated solutions
- Objective performance measures to support effective decision-making

CPI Model Framework

Triple Bottom Line
Sustainable Infrastructure / Sustainable Communities



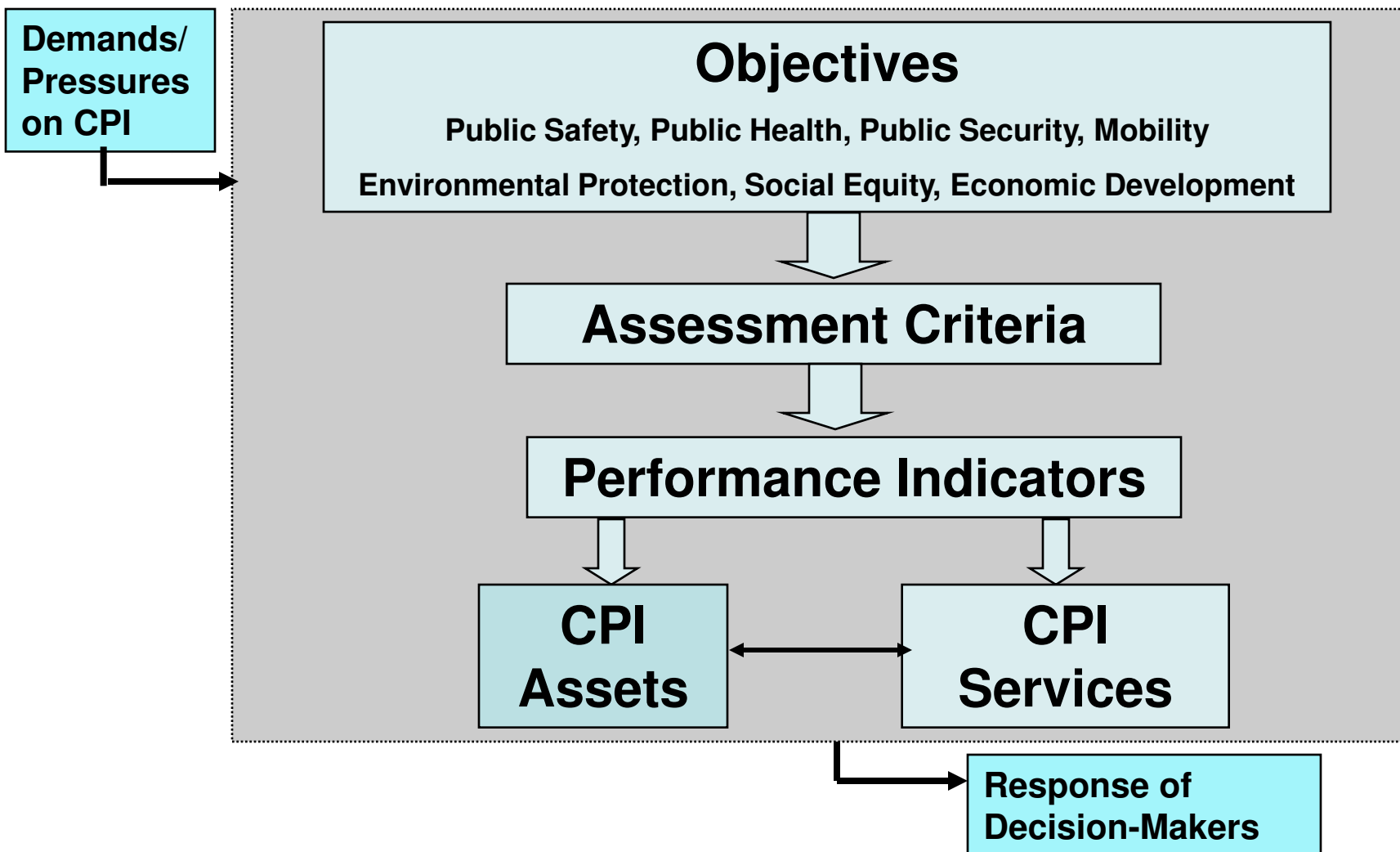
Development of CPI Model Framework

- Address the knowledge gaps and needs identified from:
 - Reviews of state-of-art and state-of-practice
 - NRTSI Meeting, March 2008
 - International Workshop on Life Cycle Performance of CPI, July 2008
 - NRC-led Interim Report
- Creation of Committees to ensure participation, input, feedback and engagement of stakeholders
 - CPI Assets Committee
 - CPI Services Committee

Development of CPI Model Framework

- CPI Model Framework developed through consensus within and between the 2 Committees
- NRTSI endorsed proposed CPI Model Framework, Sept., 2008
- NRC & NRTSI developed 5-year plan to address knowledge gaps and needs of decision-makers

CPI Model Framework



CPI Model Framework

- Objectives: Support broad vision of sustainable infrastructure & sustainable communities
 1. Public safety
 2. Public health
 3. Public security
 4. Mobility of people and goods
 5. Social equity
 6. Environmental quality
 7. Economy

CPI Model Framework

- Assessment Criteria: Statements or requirements used to measure the satisfaction of objectives
 1. Safety impacts
 2. Health impacts
 3. Security impacts
 4. Asset preservation
 5. Economic impacts
 6. Environmental impacts
 7. Quality of service
 8. Access to service
 9. Adaptability
 10. Reliability
 11. Capacity to meet demand

CPI Model Framework

■ Key Performance Indicators

- Asset Condition rating
- Ratio of rated capacity to maximum load
- Remaining service life
- Number of deaths, injuries and illnesses
- Actual level of service vs. agency target level of service
- Access to services in normal and emergency conditions
- Percentage of user days/year without service interruptions
- Number of planned interruptions as percentage of total service interruptions
- Cost of service per capita
- Monthly average cost of service as percentage of median income
- Ratio of direct agency revenues to total agency costs
- Benefit/cost ratio
- Asset value
- Reserve funds as percentage of total present replacement value of infrastructure
- Reduction in total/net energy use, GHG, NO_x, SO_x, VOC emissions/capita
- Deliberate and vandalism acts and costs of security measures

Example- Integrated Management of Different CPI Systems

- 5 different CPI assets
 - Road segment, bridge, water main, wastewater collector, bus
 - Assume all have “**Poor**” condition ratings
 - Budgetary constraint- cannot fix all assets
 - How to prioritize assets for maintenance?
- Very hard to make decisions on the basis of condition only

Example- Integrated Management of Different CPI Systems

- CPI Model Framework as decision support
 - Objectives: Public safety, health, mobility, social, environmental and economic impacts
 - Minimize risk of fatalities, injuries, illnesses
 - Minimize traffic disruptions
 - Maximize transit ridership
 - Minimize socio-economic & environmental impacts
- Measure performance with regard to above 6 objectives
 - Consequences of failure
 - Bridge & water main transmission main: **High**
 - Wastewater: **Medium**
 - Road & transit : **Low**

“Fix High Risk First

Proposed 5-Year Plan

- Develop condition assessment and deterioration prediction models and guidelines
- Conduct broad national assessment using Model CPI Framework
- Integration of risk management into decision-making
Focus on safety-critical and health-critical CPI systems
- Adaptation and mitigation of impacts of climate change on CPI
- Assess links between CPI performance and community and environment

Expected Benefits

- Advance state of knowledge in performance assessment and management of CPI
- Foster cooperation and synergy between NRC-IRC, NRTSI, federal/provincial/municipal governments, academia
- Provide objective “Model” & harmonized Performance Measures to improve assessment of CPI condition
- Provide decision support to improve CPI performance
- Support broad vision of sustainable Canadian communities

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