14th INTERNATIONAL FLEXIBLE PAVEMENTS CONFERENCE

SYDNEY 25- 28 September, 2011

TECHNICAL AND ECONOMIC BASE REQUIREMENTS FOR EFFECTIVE ASSET MANAGEMENT

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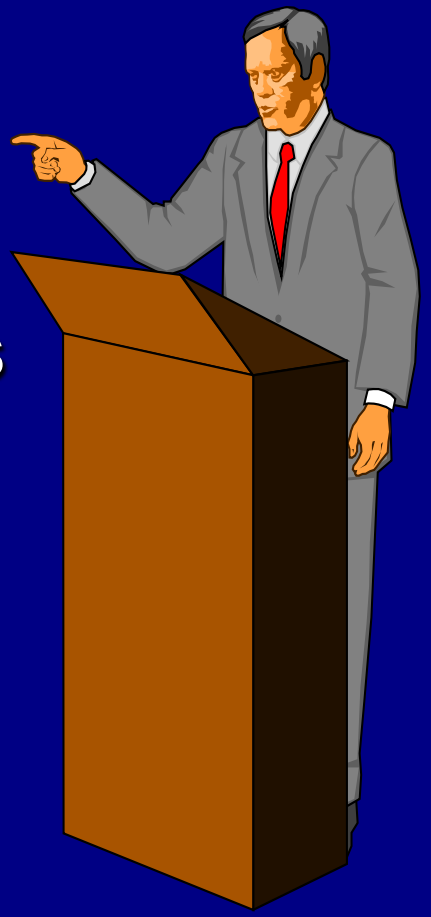
University of Waterloo
Canada

PRESENTATION

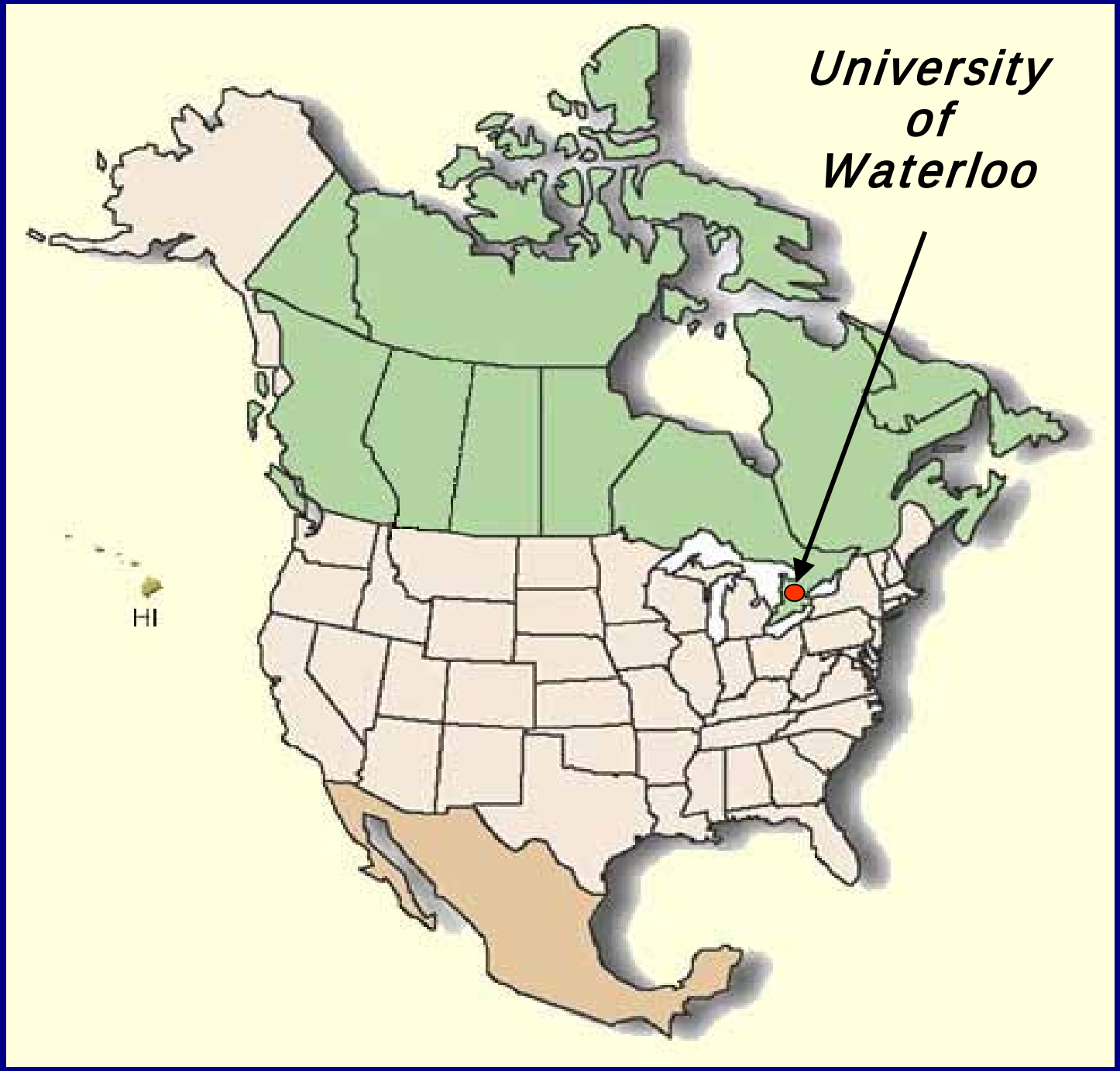
- Introduction
- Life cycle management of road assets
- Essential technical requirements
- Life cycle analysis (levels, methods, applicability example)
- Leading edge technologies
- Forward looking opportunities



INTRODUCTION

- Concept of pavement management 1960's
- Network level PMS (ARRB) 1970
- PMS Books 1970's

- Asset management 1990's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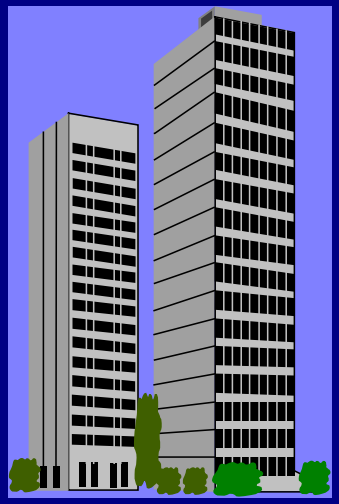
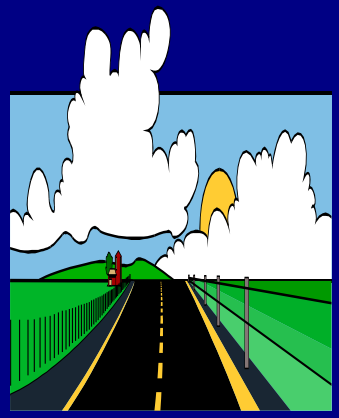
CANADA'S ROADS

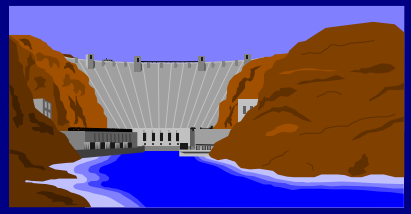
- 900,000+ km ; $150 Billion Investment
- Wide diversity of geography, climate, economic activity, resources and features
- Jurisdiction mainly provincial / territorial and municipal

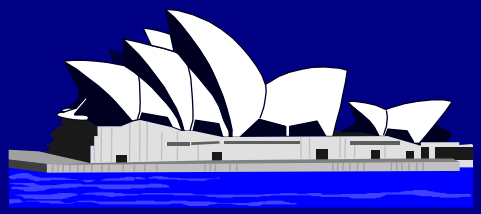


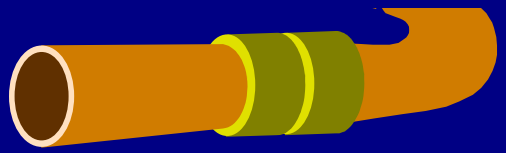
LIFE CYCLE LEVELS OF ASSET MANAGEMENT

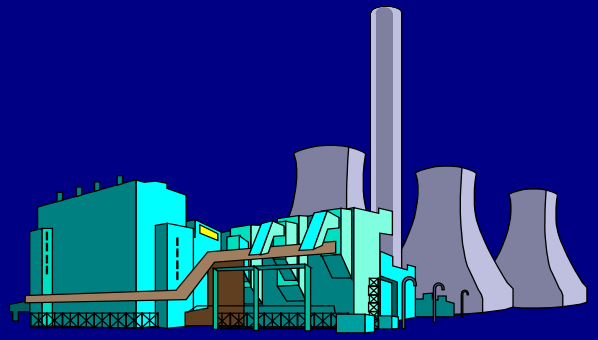


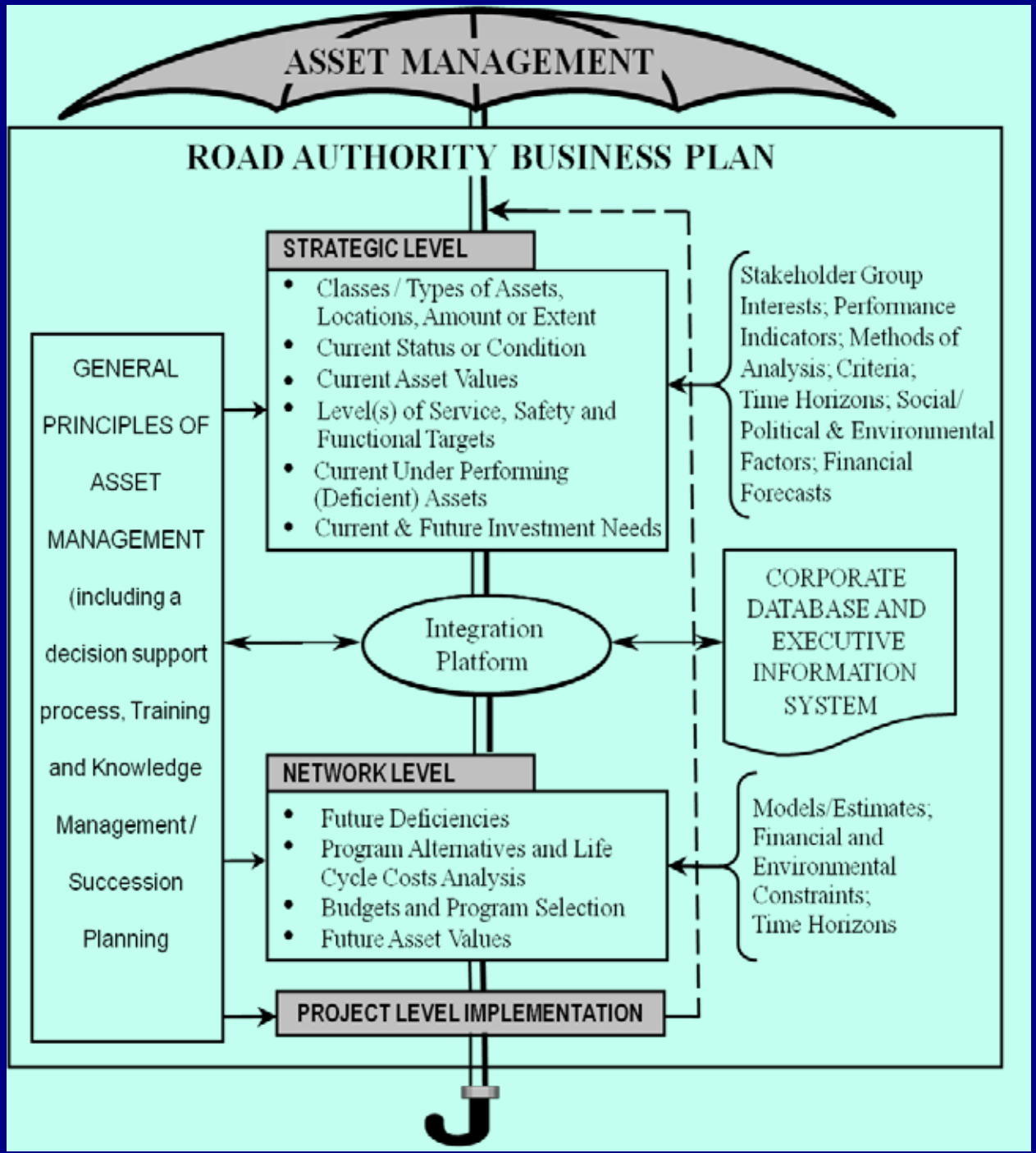
- Strategic level
- Network / system wide level
- Project / site specific level










ASSET MANAGEMENT
ROAD AUTHORITY BUSINESS PLAN
STRATEGIC LEVEL
• Classes / Types of Assets, Locations, Amount or Extent
• Current Status or Condition
• Current Asset Values
• Level(s) of Service, Safety and Functional Targets
• Current Under Performing (Deficient) Assets
• Current & Future Investment Needs
Stakeholder Group Interests; Performance Indicators; Methods of Analysis; Criteria; Time Horizons; Social/ Political & Environmental Factors; Financial Forecasts
GENERAL PRINCIPLES OF ASSET MANAGEMENT (including a decision support process, Training and Knowledge Management / Succession Planning
Integration Platform
CORPORATE DATABASE AND EXECUTIVE INFORMATION SYSTEM
NETWORK LEVEL
• Future Deficiencies
• Program Alternatives and Life Cycle Costs Analysis
• Budgets and Program Selection
• Future Asset Values
Models/Estimates; Financial and Environmental Constraints; Time Horizons
PROJECT LEVEL IMPLEMENTATION

ESSENTIAL TECHNICAL REQUIREMENTS

Include:

Good materials and their characterization, good design, construction and maintenance, and …….

Very Importantly

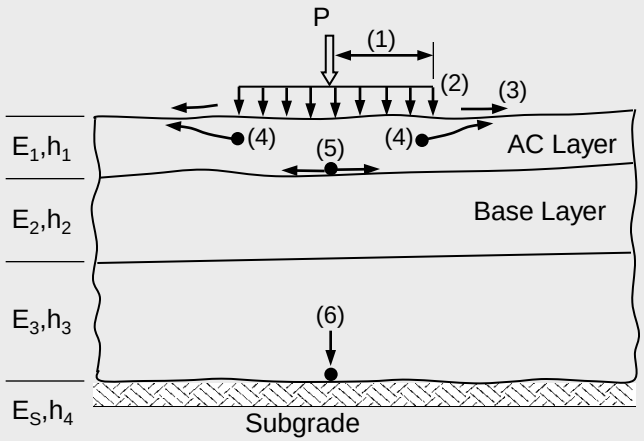
- **Structural analysis methodology**

and

- **Performance prediction methodology**

For M-E Design

FUNDAMENTALS



P, Wheel load

(1) Radius of loaded area

(2) Tire pressure (may not be uniform)

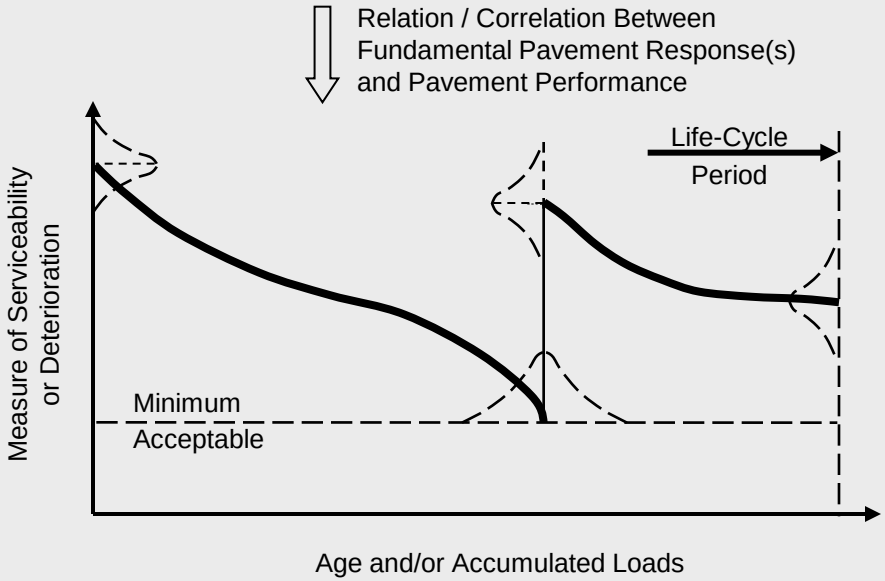
(3) Surface tensile stress or strain

(4) Lateral shear strain or deformation

(5) Tensile strain or stress at bottom of AC layer

(6) Vertical stress, strain or deflection at surface of subgrade

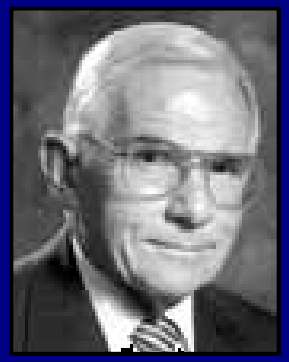
MECHANISTIC PART



EMPIRICAL PART

EVOLUTION OF M-E DESIGN

See Monismith's Distinguished Lecture, ISAP Symposium, Auburn, June 2004



- **1945 Burmister's elastic layer solutions**
- **1962 ICAP1, Ann Arbor, "launchpad" for major fundamental contributions**
- **Test roads (WASHO, AASHO, Brampton) in 1950's and 1960's were instrumental in advancing state of design technology**
- **Now, AASHTO's 2002 MEPDG**

COMPUTERIZED DESIGN PACKAGES

u CHEV5L	Chevron Research	(MLE)	1969
u BISAR	Shell Int.	(MLE)	1970
u ELSYM	FHWA	(MLE)	1972
u JULEA	USACE	(MLE)	1976
u PDMAP	NCHRP 1-10A	(MLE)	1977
u CIRCLY	MINCAD, Austr.	(MLE)	1977

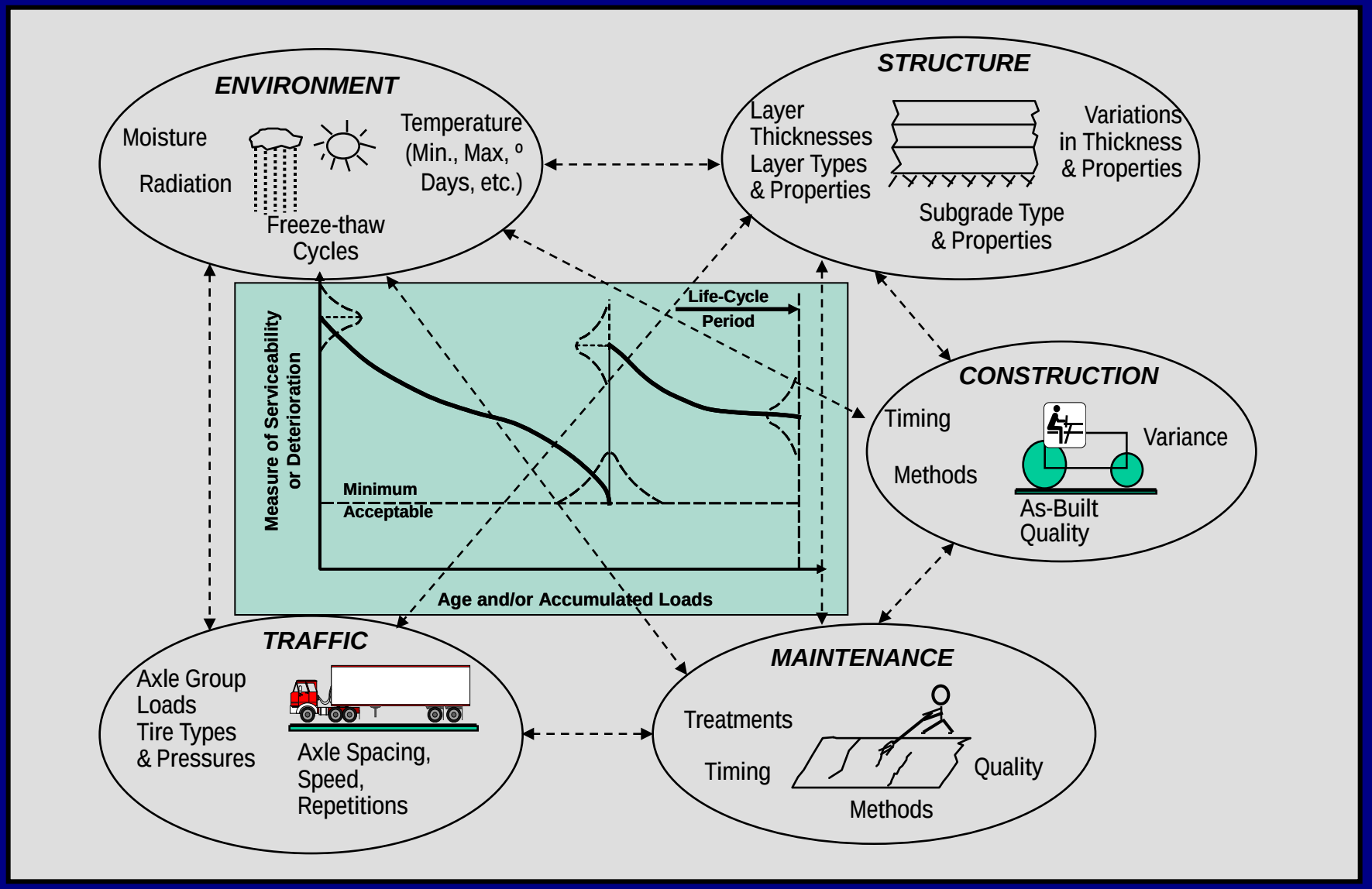
Cont'd

Cont'd

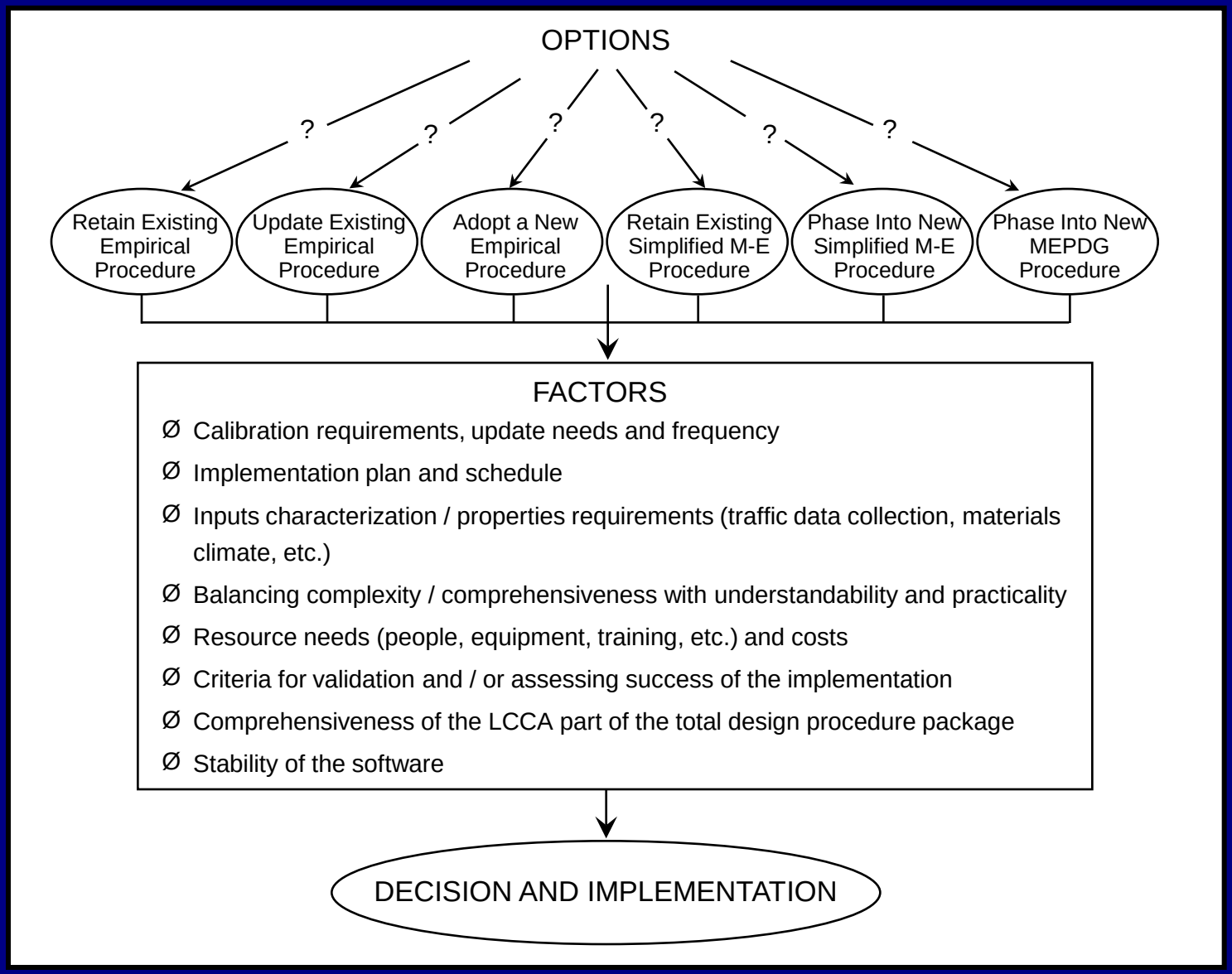
COMPUTERIZED DESIGN PACKAGES

u VESYS	FHWA	(MLVE)	1978
u VEROAD	Delft Univ.	(MLVE)	1996
u ILLIPAVE	U. of Illinois	(FE)	1988
u FENLAP	U. of Nottingham	(FE)	1992
u SAPSI-M	Mich. State U. & U.C. Berkeley	(N. layers on base)	1996

FACTORS AFFECTING PERFORMANCE

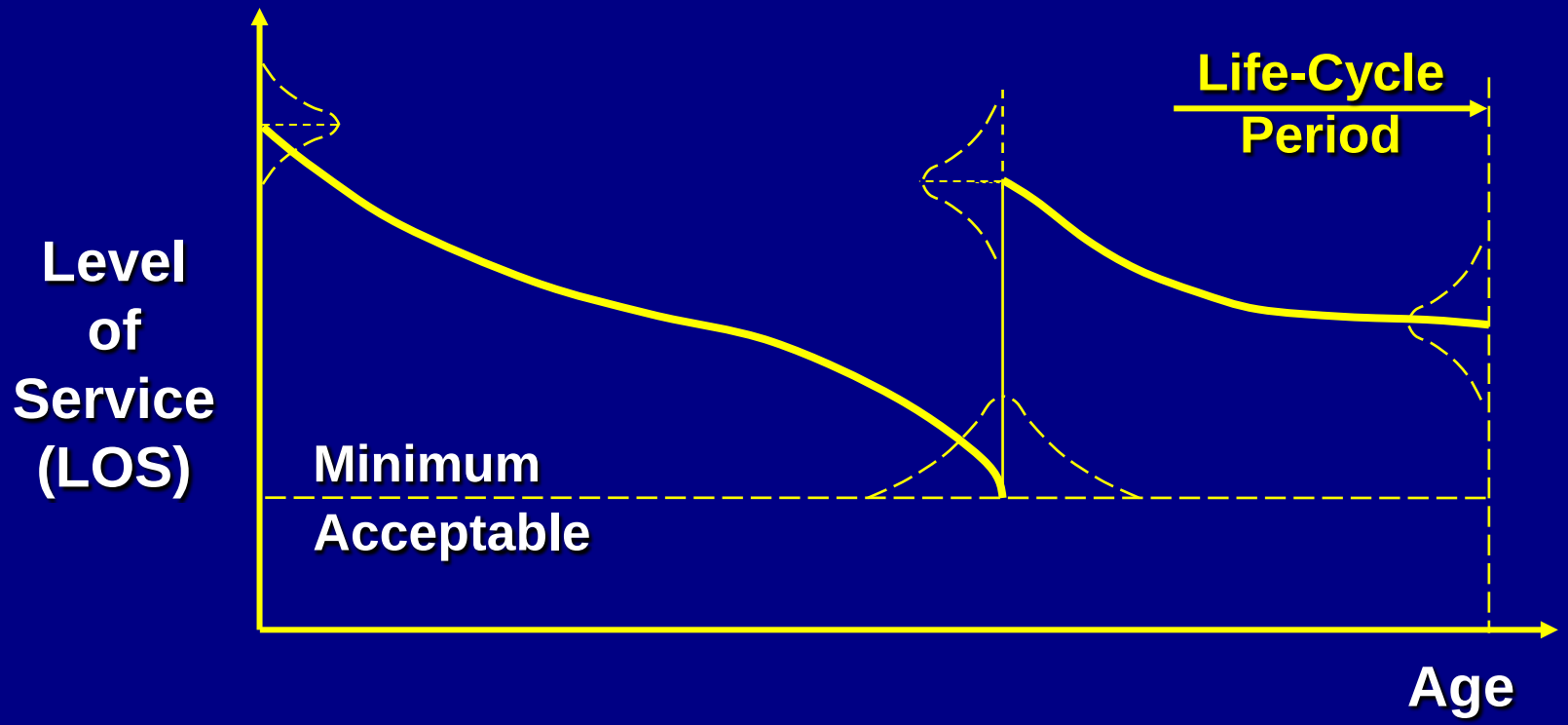


CHOOSING AN APPROPRIATE (M-E ?) PROCEDURE



LIFE CYCLE ANALYSIS

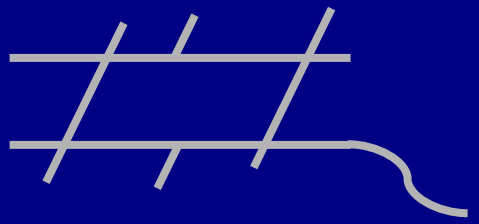
Require: LOS vs Age (Performance) Model
Cost / Cash Flow Calculation (eg. PW)
Asset Value vs Age Calculation
Risk Analysis



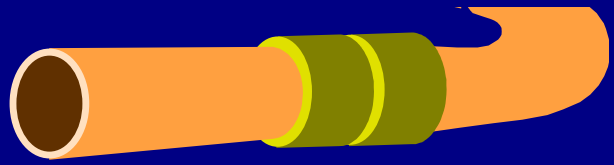
LCCA APPLICATION LEVELS

1. Strategic (Corporate Business Plan)

2. Network / System wide

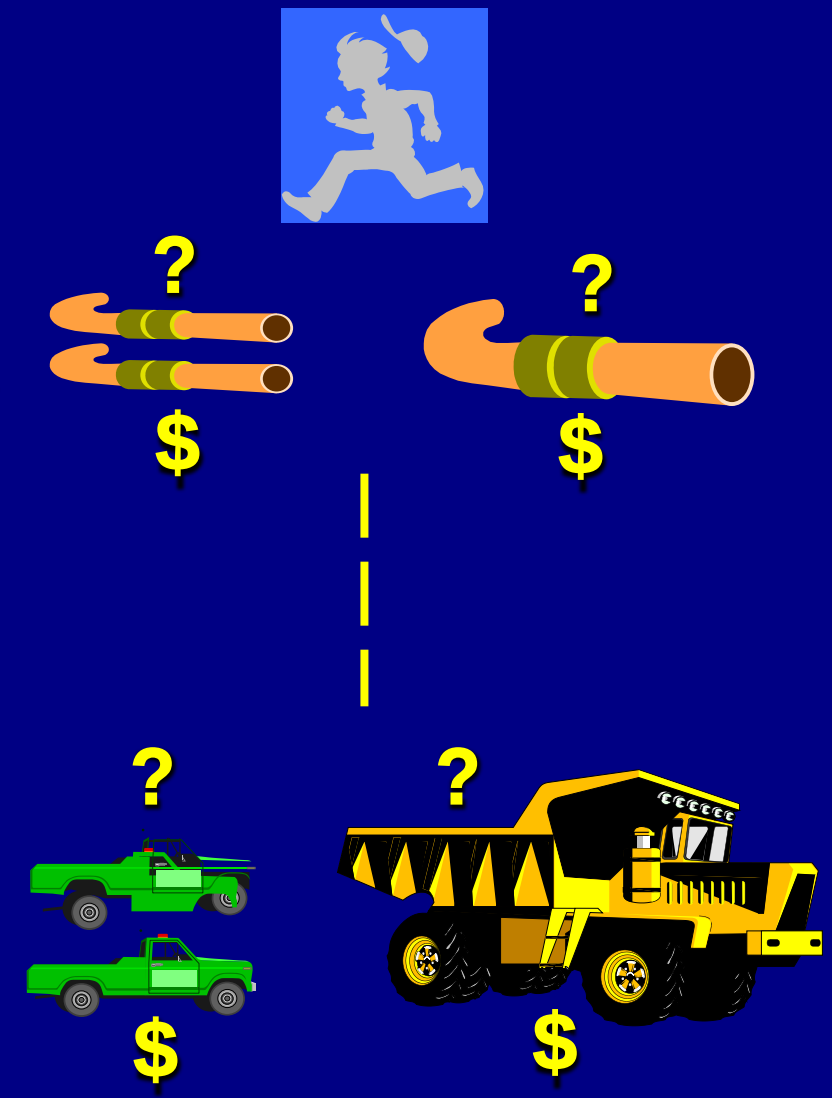


3. Project / Site specific



PURPOSE OF CONVENTIONAL LCCA

- Compare alternative (competing) strategies, over a life cycle period, using economic principles
- Identify what, where and when for best value on expenditures
- Decision support (not the decision itself !)



DIFFERENCE BETWEEN LCCA AND FINANCIAL PLANNING

- LCCA is used to compare alternatives and identify most cost-effective

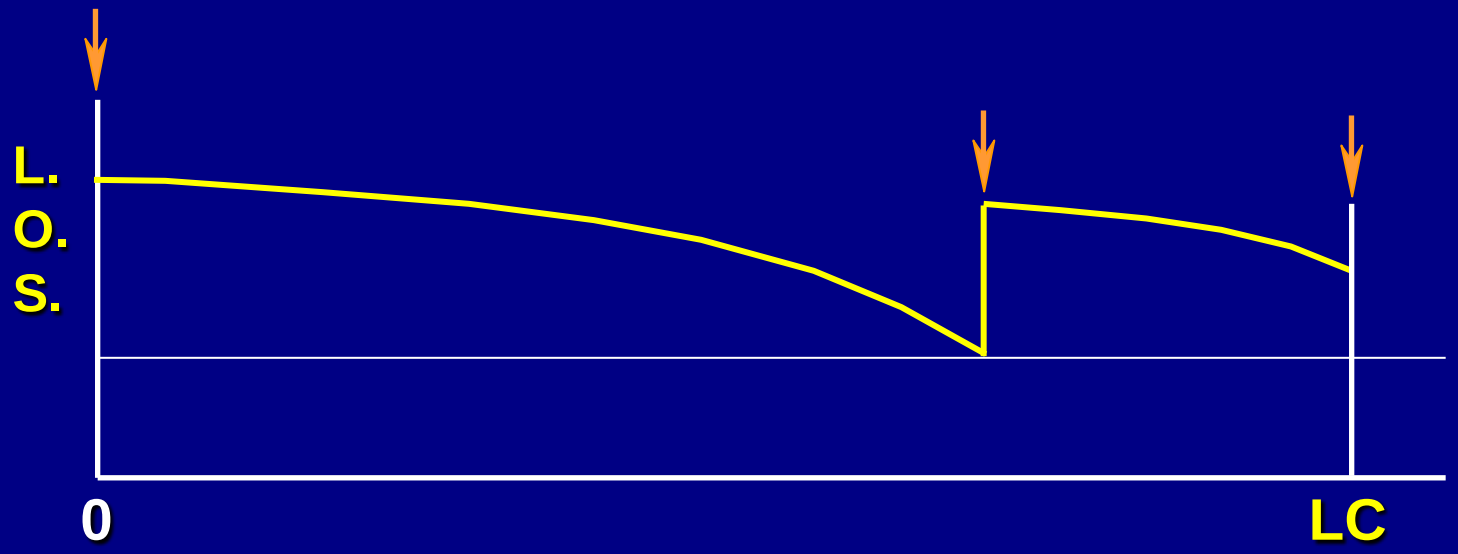
- Financial planning (corporate level activity) is concerned with cash flows (revenues, projected expenditures, budgets and profits)

METHODS OF LCCA

1. Benefits / Cost Ratio
2. Internal Rate of Return
3. Equivalent Uniform Annual Costs
4. Cost-Effectiveness
5. Present Worth

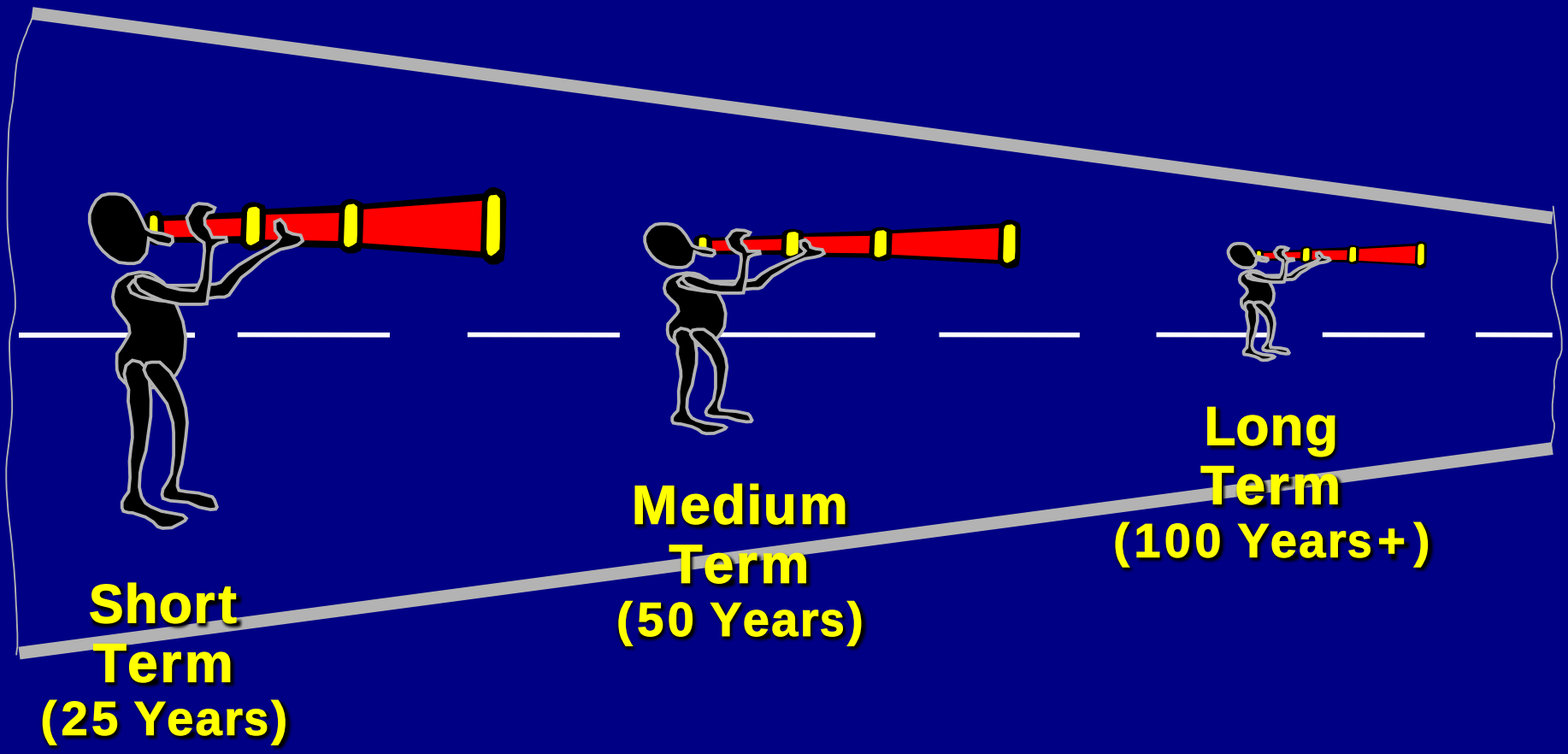
Which Method is Best for Infrastructure ?
(applicability, understanding, consistency)

WHAT LENGTH OF LIFE CYCLE PERIOD ?



- Type of infrastructure involved (fleet vs. roads vs. buildings vs. parks) ?
- Reliability of forecasts (usage, traffic, volumes, etc.) ?
- Agency or department policy ?
- Time after which discounted costs are negligible ?

TIME HORIZON FOR THE FUTURE



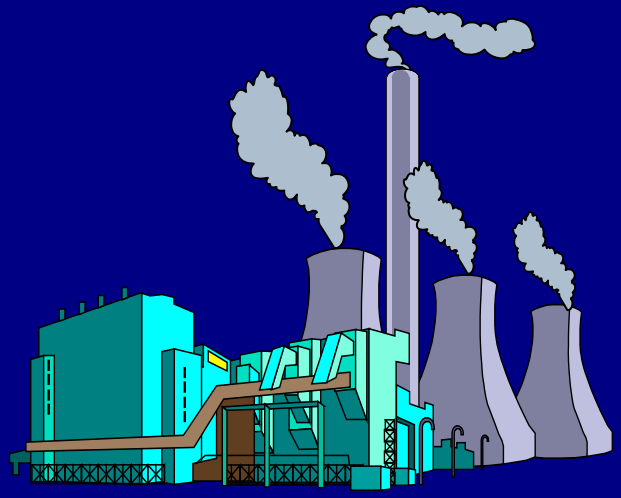
METHODS OF LCCA

1. Benefits / Cost Ratio
2. Internal Rate of Return *
3. Equivalent Uniform Annual Costs
4. Cost-Effectiveness
5. Present Worth

Which Method is Best for Infrastructure ?
(applicability, understanding, consistency)

STAKEHOLDERS FOR LCCA

1. Public at large
2. Elected level
3. Senior administration
4. Technical / operating
5. Interest Groups
6. Industry
7. Others (Associations, Academia, etc.)



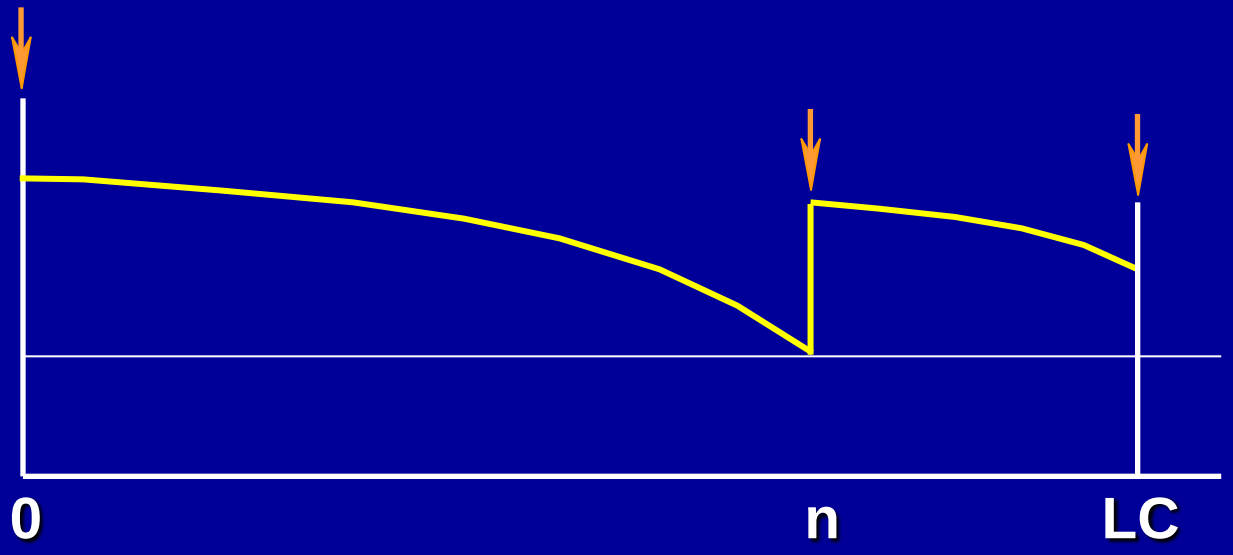
APPLICABILITY OF LCCA METHODS: HIGHWAYS

	Locals		Collectors	
	Public	Private	Public	Private
Short Term	C/E PWC AC	--	C/E PWC AC	--
Medium Term	C/E PWC AC	--	C/E PWC AC	--
Long Term	--	--	--	--

APPLICABILITY OF LCCA METHODS: HIGHWAYS

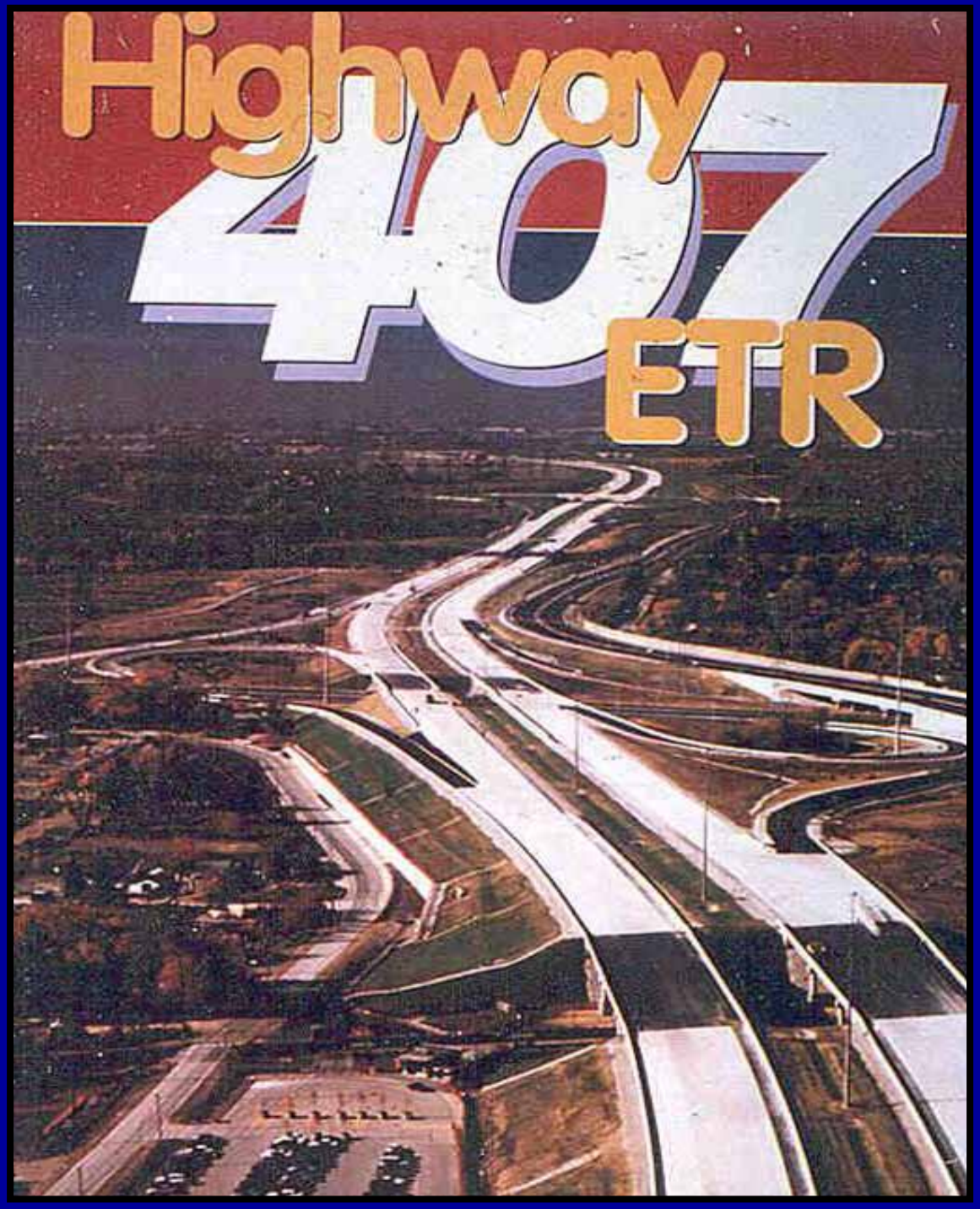
	Arterials		Expressways	
	Public	Private	Public	Private
Short Term	C/E PWC AC IRR	IRR	C/E PWC IRR	IRR
Medium Term	C/E PWC AC IRR	IRR	C/E IRR	IRR
Long Term	--	--	IRR	IRR

INTERNAL RATE OF RETURN METHOD



Discount rate at which costs and benefits of an investment are equal

$$(NPV_{x1} = PWB_{x2,n} - PWC_{x1,n} = 0)$$


Highway
407
ETR

RATE OF RETURN EXAMPLE

- Multi-lane urban bypass
- 50 year life cycle

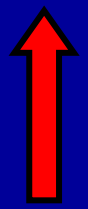
Financial Feasibility of an ETR?

- Long-life pavement design consisting of a heavy duty flexible pavement
- Cost estimates, traffic estimates, toll charge scheme, rehabilitation and maintenance interventions schedule

RATE OF RETURN EXAMPLE

NPV ($ x 10^6) / lane - km for i =

Design	5%	12%	20%
Flexible Pavement	16.555	2.860	- 0.361

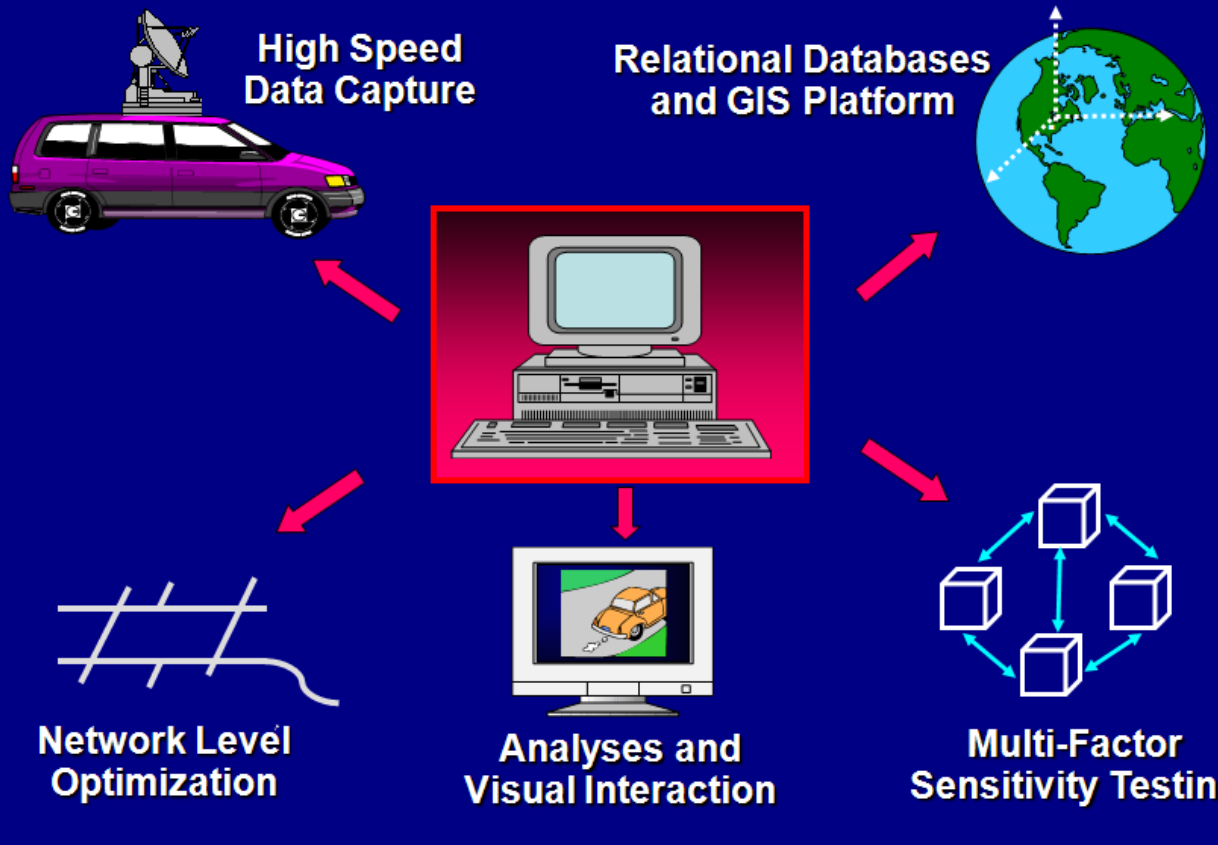


NPV = 0 at IRR≃ 18%

ADDITIONAL CONSIDERATIONS IN VERY LONG TERM LCA

- Resource conservation
- Future recyclability
- Risk exposure
- Long term functionality
- Environmental impacts (noise, solar absorption, energy balance)

Pavement Technologies



FACTORS

- High degree of acceptance by users
- Incorporation of creativity and advanced technologies
- Major impact
- Represents a quantum advance
- New knowledge and skills created
- Basically, better way of doing things

OTHER LEADING EDGE TECHNOLOGIES

- Superpave
- LTPP Database
- MEPDG
- Recycling (RAP and RCP)
- Advancements in Engineered Materials

OTHER LEADING EDGE TECHNOLOGIES

Cont'd.

- Advancements in Construction Processes and Equipment
- MEMS in "Smart Roads"
- RFID Tags for Materials and Construction Tracking
- Emerging Nanotechnology Applications
- Permeable Asphalt and Porous Concrete Pavements

FORWARD LOOKING OPPORTUNITIES

OPPORTUNITY AREA	CHALLENGES	PROSPECTS
A. Pavement Data 1. Needs and Cost-Effectiveness 2. Collection Technologies 3. Quality Assurance 4. Storage and Integration	Numerous Challenges and Prospects for Major Advances Range From Short to Long Term	

FORWARD LOOKING OPPORTUNITIES

OPPORTUNITY AREA	CHALLENGES	PROSPECTS
B. Pavement Management 1. Structural Design and LCCA 2. Performance Modelling 3. Treatment Selection 4. Quantifying Benefits 5. Decision Support	Numerous Challenges and Prospects for Major Advances Range From Short to Long Term	

FORWARD LOOKING OPPORTUNITIES

OPPORTUNITY AREA	CHALLENGES	PROSPECTS
C. Institutional Improvements 1. Organizational Structure 2. Location (PMS and AMS) 3. Technology Updates 4. Skills and Training 5. P 3's		

Numerous Challenges and Prospects for Major Advances Range From Short to Long Term

CONCLUSIONS

- Effective management of road assets requires a sound technical and economic base
- Life cycle analysis is the “umbrella”
- Long-life pavement design requires mechanistic analysis linked to performance prediction
- Continuing advancements and innovations are essential

University of Waterloo

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Dr. Haas is the Norman W. McLeod Engineering Professor and Distinguished Professor Emeritus at the University of Waterloo. He has lectured and consulted worldwide and authored 10 books and 400 technical papers in the areas of infrastructure, pavements and transportation. Dr. Haas is Founding Director of the University's Centre for Pavement and Transportation Technology (CPATT). His contributions have been recognized by various honours and awards including the Order of Canada, Fellow of the Royal Society of Canada, Fellow of the Canadian Academy of Engineering and recipient of the Canadian Society for Civil Engineering's Sandford Fleming Award for "outstanding contributions to research and education in the field of transportation engineering".