UNIVERSITY OF CAMBRIDGE

# Sustainable development in urban environments: Research into Practice

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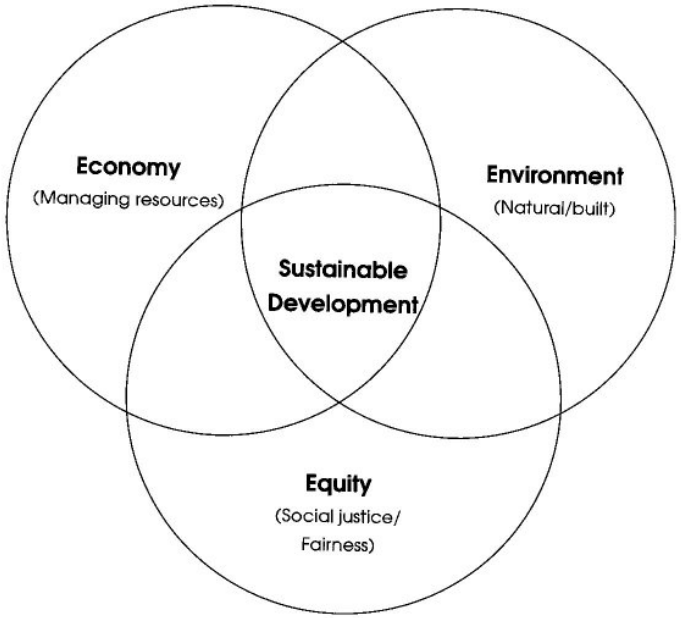
# Sustainable Development: a value laden term

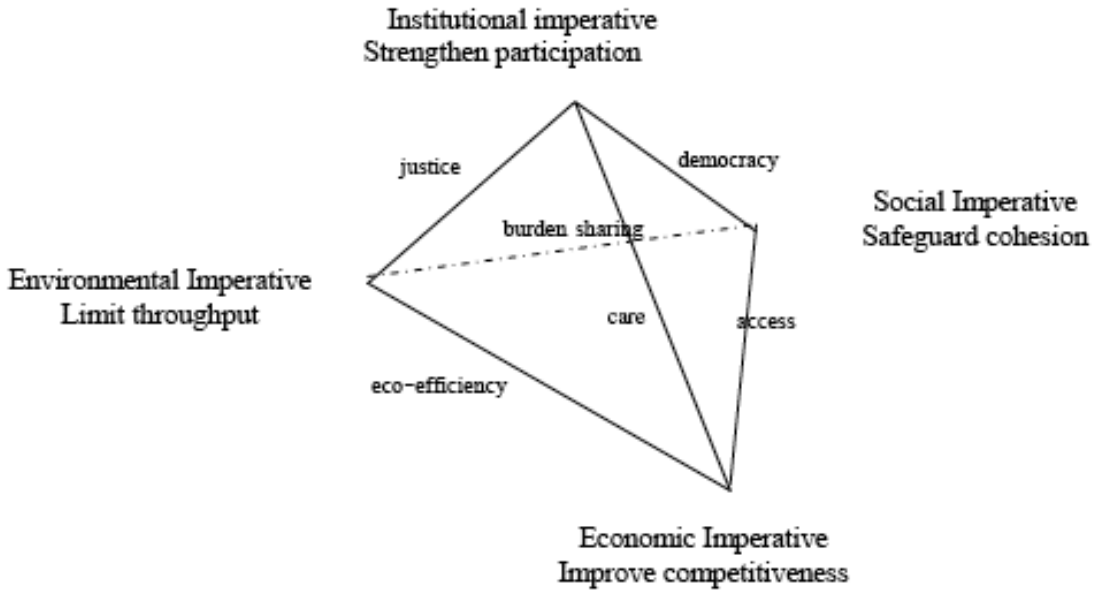
- **Brundtland definition**

**[Sustainable development is] … development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs**

# Sustainable Development: a value laden term

- Brundtland definition
- **Triple bottom line (or 4 legged table)**



# Sustainable Development: a value laden term

- Brundtland definition
- Triple bottom line (or 4 legged table)
- **Weak versus strong sustainability**

**5 capitals:**

**Natural Capital**

Human Capital

Social capital

Manufactured capital

Financial capital

# Sustainable Development: a value laden term

- Brundtland definition
- Triple bottom line  (or 4 legged table)
- Strong versus weak sustainability
- **Non-technical challenges and multi perspective viewpoints**

# Sustainable Development: a value laden term

- Brundtland definition
- Triple bottom line  (or 4 legged table)
- Strong versus weak sustainability
- Non-technical challenges and multi perspective viewpoints
- **Holistic vs reductionist approach**

qualitative

versus

$$\vec{A}_1 = A_1 \cos(\omega t + \alpha_1)$$

$$\vec{A}_2 = A_2 \cos(\omega t + \alpha_2)$$

$$A^2 = A_1^2 + A_2^2 + 2A_1A_2\cos(\alpha_2 - \alpha_1)$$

$$I = I_2 + I_5 + 2\sqrt{I_2}\sqrt{I_5}\cos(\alpha_2 - \alpha_1)$$

$$\text{Phase shift} = \alpha_2 - \alpha_1 = (\frac{2\pi}{\lambda})(2t \cdot n) - \pi$$

$$I = I_2 + I_5 + 2\sqrt{I_2}\sqrt{I_5}\cos(4\pi nt/\lambda - \pi)$$

quantitative

# Systems compared

**Simple systems**: can be described using a single model or viewpoint

**Complicated systems**: rich in detail, lots of component parts, (assemblages)

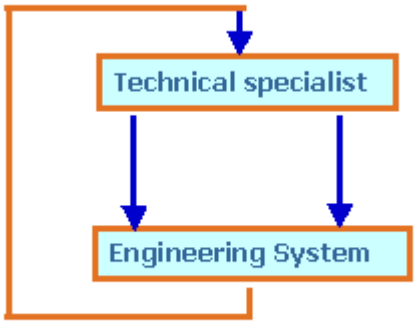
**Complex systems**: need two or more irreducible perspectives to characterise

(e.g. social, technical, economic, even psychological)

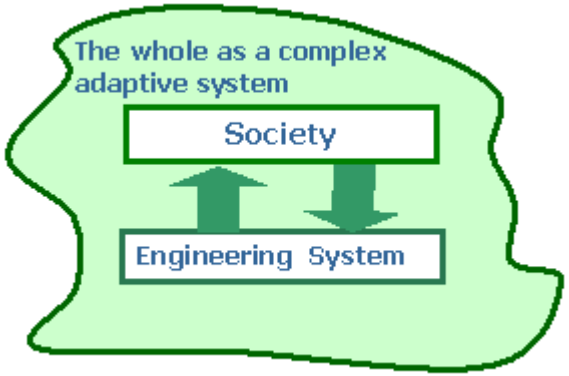
emergent properties arise from the component inter-relationships

**Engineering has focused almost exclusively on the <u>technical</u> aspects of a complex <u>socio-technical</u> system**

**Model A**




**Model B**



# Widening horizons: enlarge the system boundary

**3 stages of a civil engineering project:**

**i) Defining the problem**

- most engineering services needed by society are framed by socio- economic-environmental considerations

- complex adaptive system; hard to measure; needs to be embraced holistically

**ii) Choosing a solution**

- requires the transition between these two different domains

- to achieve this: more options need to be considered and evaluated
more choice criteria need to be developed (not easily measurable)

**iii) Design, construction and operation**

- use traditional mechanics and familiar analytical techniques

- very successful over last 300 years providing safe , working solutions

- rely completely on measurement

# Purpose

**Three aims:**

**i) Define a framework which widens the arena in which engineers both operate and influence**

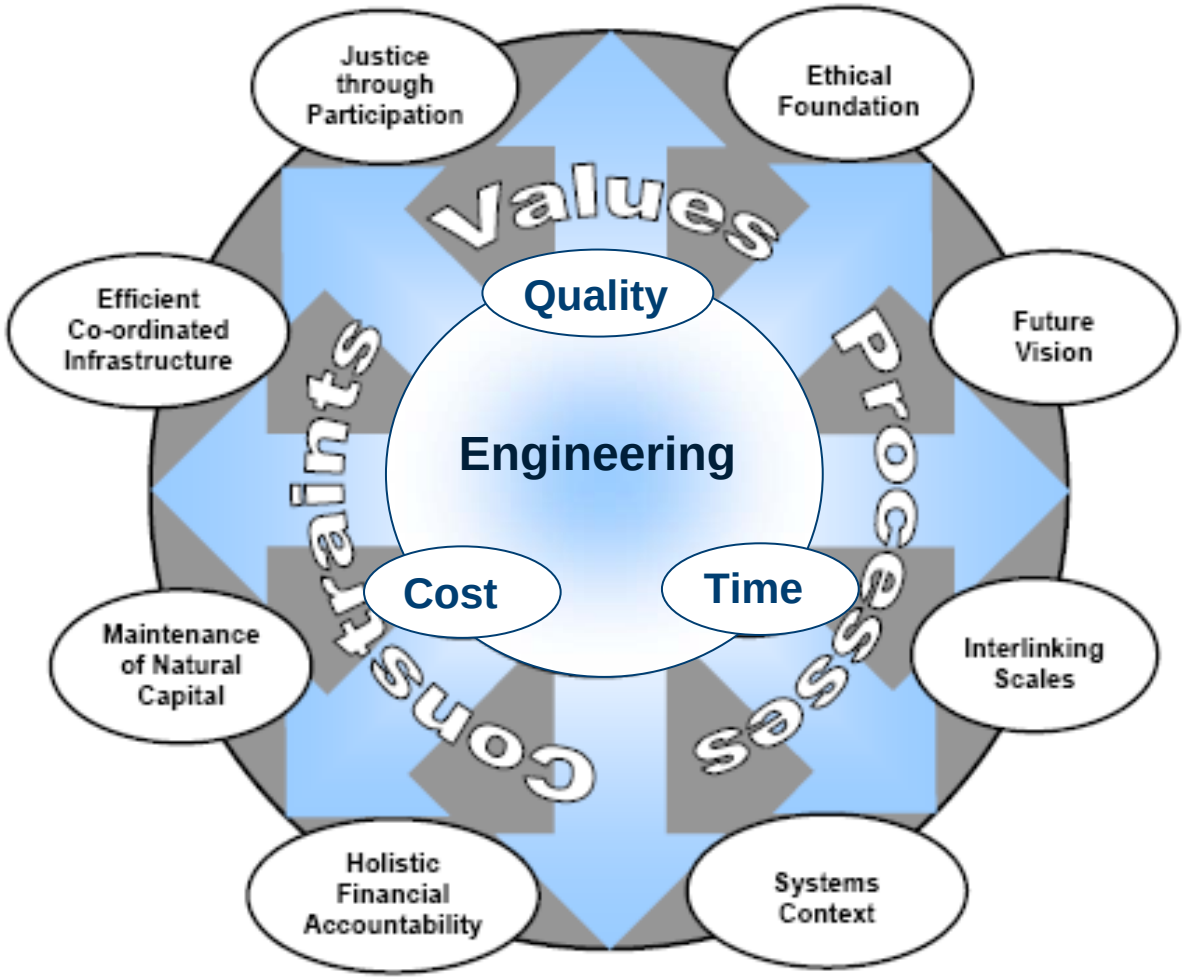
- to demonstrate to non-engineering professionals that we have thought holistically about wider problems

**ii) Use these to prompt reflective questions, intended to test:**
**" how sustainable am I being ?"**

- use such scrutiny to feed directly into the engineering process

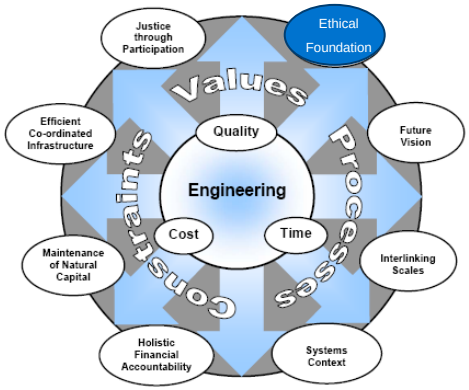
**iii) Test the practicality of the approach against a case history of an engineering project**

# Starting the dialogue: capturing complexity



# Values

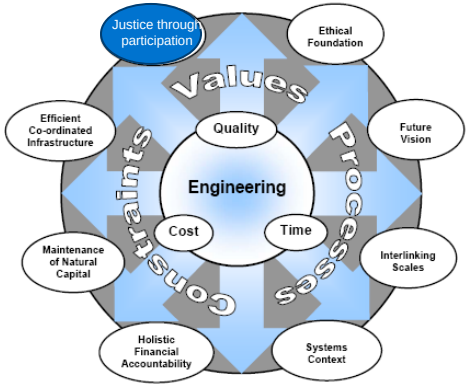
**Ethical Foundation**




- ✓ How does the project meet clearly defined need?
- ✓ When was justification for the project explored
- ✓ Where do the benefits lie and who wins and who loses?
- ✓ What responsibilities to the Client and to the environment/society have been identified?
- ✓ In the absence of certainty are value judgments based on the precautionary principle?
- ✓ Is the option to say no retained so as not to proceed with unethical work?
- ✓ How has technical advocacy for pre-determined solutions been avoided?
- ✓ Have alternative solutions been approached with an open mind ?
- ✓ Has the ***engineering process*** shown respect for people and the environment?

# Values

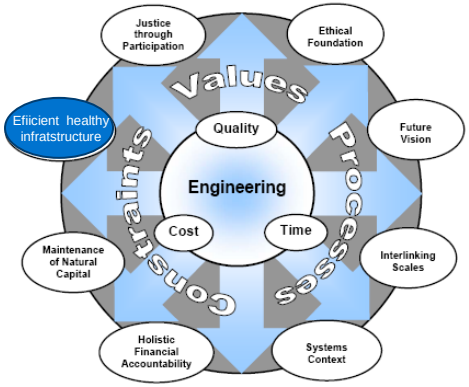
**Justice through participation**




- ✓ Has a base of agreed positions been established, and by whom?
- ✓ Who explains what cannot be altered, and why ?
- ✓ What communication channels have been established with the public?
- ✓ Which cultural, religious, ethnic, or gender issues may be relevant?
- ✓ Are genuine concerns embraced with an openness to modify designs?
- ✓ Is the basis for decision making known to all stakeholders at the outset ?
- ✓ How has the scheme been developed in partnership will all stakeholders?
- ✓ What are the steps in the process for managing disagreement
- ✓ How are the interests of those not well represented in the process recognised?

# Constraints

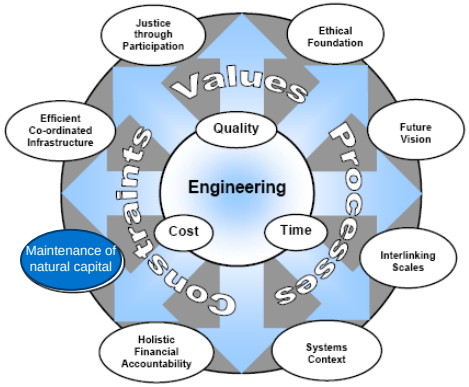
**Efficient healthy infrastructure**




- ✓ What opportunities for environmental enhancement have been sought ( as well as mitigation) ?
- ✓ When are balances between form and function of engineered systems explored?
- ✓ What flexible / adaptable designs have been used to allow for extended useful life?
- ✓ To what extent do designs contribute to social cohesion and inclusion and welfare
- ✓ How have wasteful resource use and pollution been minimised ?
- ✓ Does the ***engineering product*** provide value and satisfaction to all end users?
- ✓ Has an extended range of options been examined ?
- ✓ How do the choice criteria required to evaluate decisions reflect sustainability issues?

# Constraints

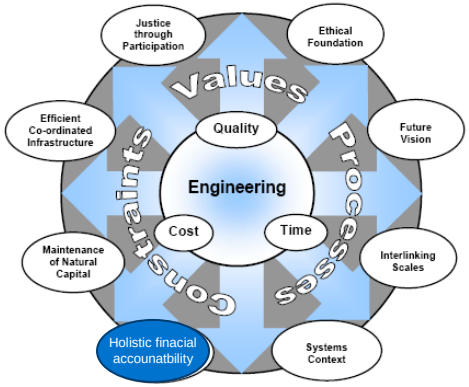
**Maintenance of natural capital**




- ✓ How has pollution and negative visual impact been minimsed?
- ✓ What opportunities for re-use have been considered?
- ✓ How is over-specification avoided and informed material selection ensured?
- ✓ How is resource and energy efficiency optimised over whole life of the project?
- ✓ Is a formal Environmental Management System adopted?
- ✓ To what extent is natural capital lost sought to be replaced and replenished?
- ✓ Are distinctions made between actions which lead to irreversible impacts and smaller reversible ones ?

# Constraints

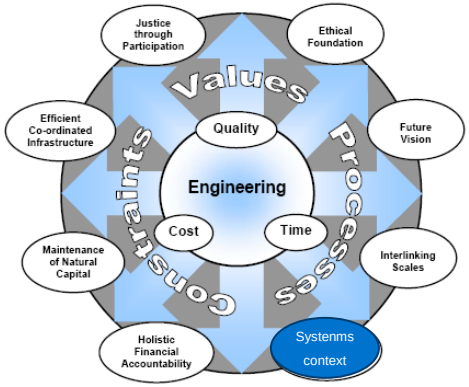
**Holistic financial accountability**




- ✓ Are whole life costs included in options appraisal?
- ✓ Are there long  term relationships with clients and suppliers?
- ✓ How is it recognised that best value is not always lowest cost ?
- ✓ What methods are used to assign other than monetary value to natural asset and social gain?
- ✓ To what extent are  transparent business practices audited externally?
- ✓ How is risk managed ?
- ✓ How do costs reflect environmental and social externalities and at what intervals  are these embraced and reported?

# Processes

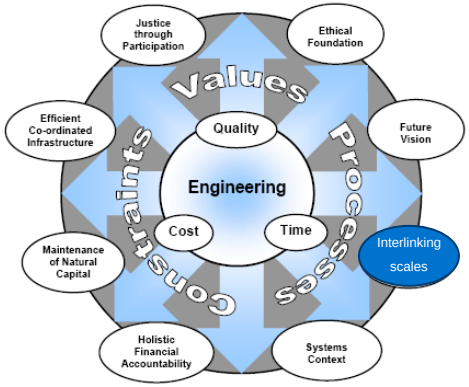
**Systems context**




- ✓ Who has responsibility for seeking integrative solutions?
- ✓ What agencies are involved for adopting a co-ordinated approach to infrastructure provision and land use planning?
- ✓ How are other professionals and special interest groups managed ?
- ✓ How is cradle to grave life cycle thinking adopted and a systems approach to engineering followed?
- ✓ How is complexity recognised and uncertainty managed (and the relationships between system components understood) ?
- ✓ How are impacts that go beyond the site boundary identified and what measurements are made?

# Processes

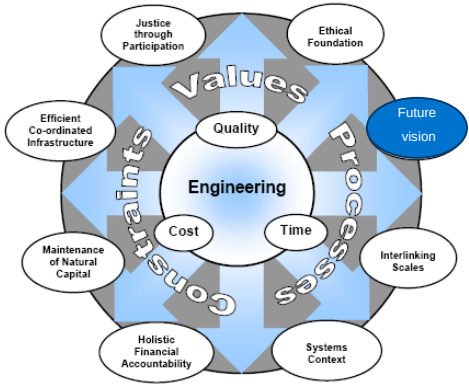
**Interlinking scales**




- ✓ Are global challenges appreciated and how do these influence local solutions? (do you act as if local actions WILL have a wider influence)?
- ✓ Over what operational timescales are schemes considered and how is their influence on future generations considered?
- ✓ How is the exploitation of distant resources and people minimised?
- ✓ At what stage are secondary (remote) impacts recognised in both space and time?
- ✓ What protocols exist for actively managing the supply chain?

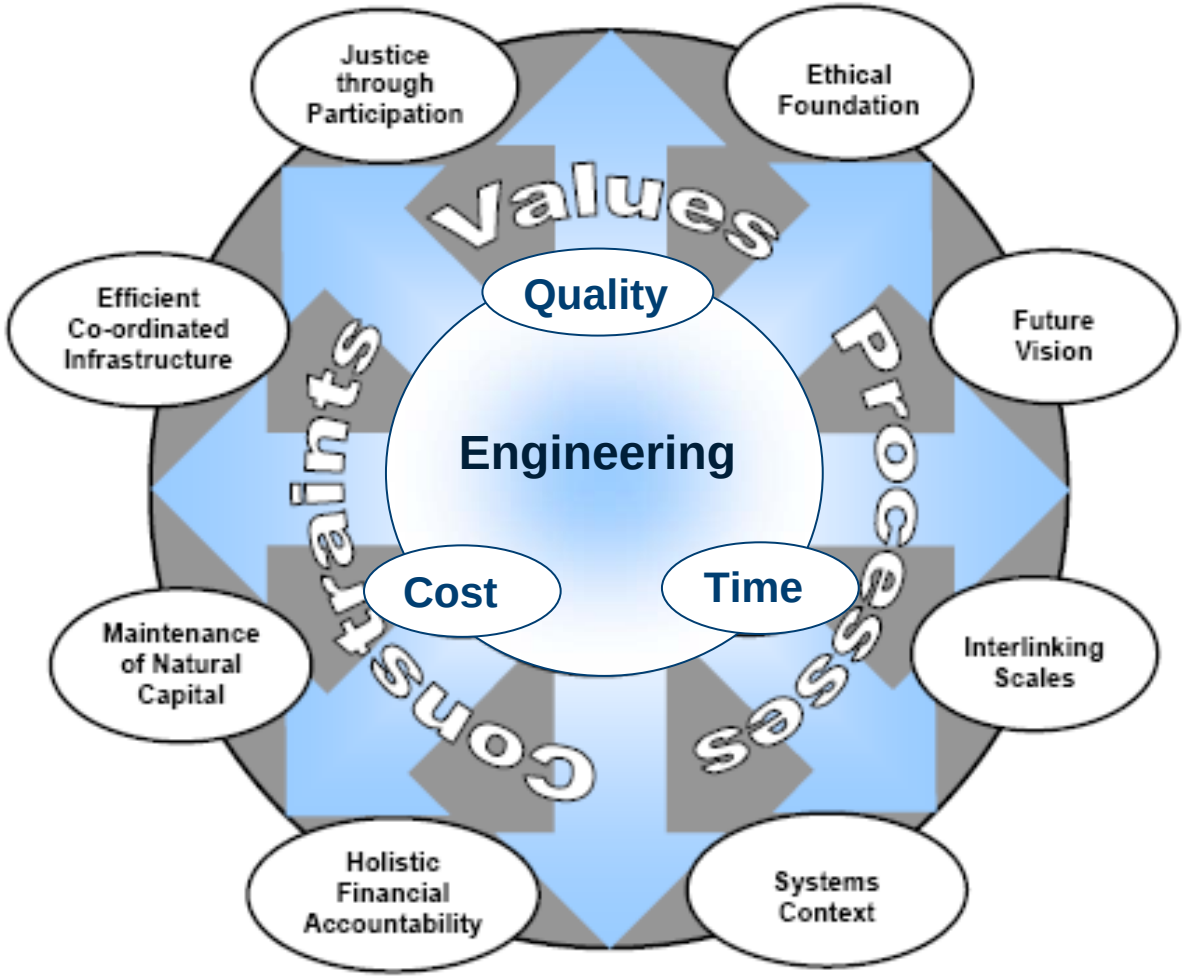
# Processes

**Future vision**




- ✓ How commonplace is it to act BEFORE legislation and regulation require change?
- ✓ Are increased costs of energy, and declining availability assumed?
- ✓ Are methods such as scenario planning and backcasting used to explore a range of futures?
- ✓ How is it ensured that real needs are met through a proper problem definition?
- ✓ What assumptions are made regarding increasing levels of regulatory control over emissions,waste, natural resources?
- ✓ What ambitious goals and targets are set to stimulate creativity?
- ✓ Which long term aims are considered important drivers compared to short term needs?
- ✓ How is performance benchmarked as a precursor to seeking continual improvement?
- ✓ What formal requirements are there to analyse and learn from past performance?

# A sustainable framework for civil engineers



# Engineers' critiques of this framework…

We don't *need* to start in the messy language of sustainability activists..

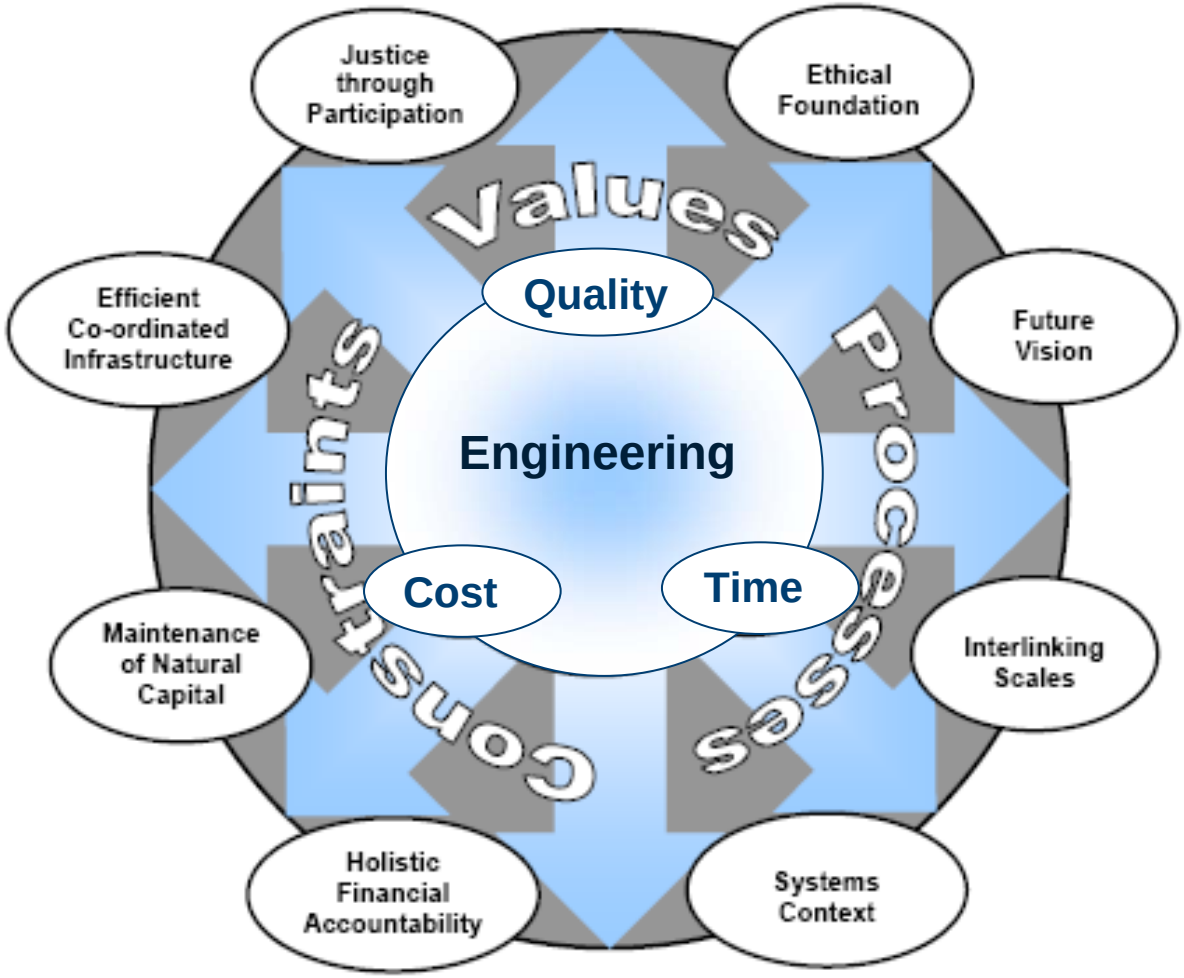
The framework is too much an *open ended set of questions*, rather than a 'manual'..

The 58 questions, under 8 headings, are *too complicated* to be easily and cost-effectively applied to most projects

Another framework is *un-necessary* – from two directions:

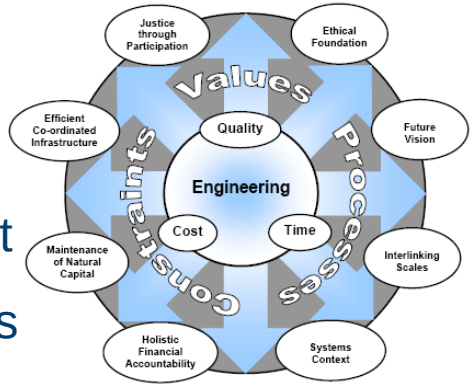
- For project evaluation, already covered by *more detailed* sustainability methodologies, such as BREEAM, Spear, Aspire, CIRIA and other company specific tools..
- For individual professional behaviour, already dealt with by *simpler* frameworks, such as the RAEng twelve guiding principles (most engineering institutions have a sustainability code).

# A sustainable framework for civil engineers



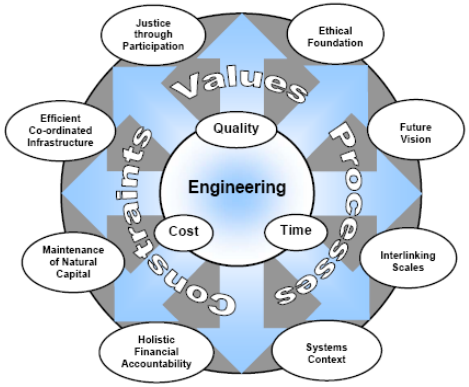
# Conclusions

**Considering the 8 point framework could help**:




- scoping the both the project and the engineer's role with the Client
- discussing the validity of (and even challenging) the project drivers
- agreeing the extent of social and environmental engagement
- defining the values the Client will use in decision making
- transparently establishing the extent and rules of stakeholder consultation
- deliberately extending the range of options to be examined
- asking more searching questions at both the problem formulation and solution stages
- stretching the constraints and choice / evaluation criteria

# Conclusions



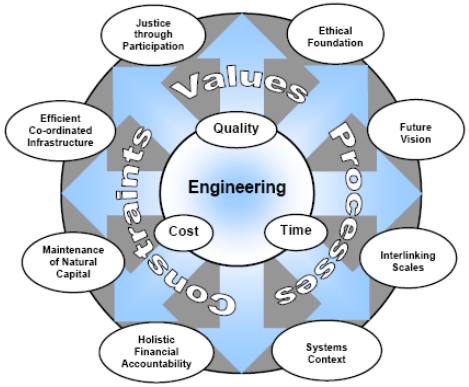

The questions need to be discussed early and built into standard processes for project delivery (not added as “extras” later on)

Where Carbon is a critical feature this would be included in the framework

The issues covered reflect objectives that leading Clients are already adopting

Answers to many of the questions may be buried within Government and clients policies, regulations and standard practice and not easily accessible by engineers actually delivering the project

# Final thoughts




Answers to the questions raised here could be standardised as a “sustainability annex” attached to each project’s information record

Reference to this at each stage  would allow an engineer to answer the question “how have we addressed sustainability on this project”

# Towards a Sustainable Urban Environment (SUE)

- EPSRC funded projects, **£38m** since 2003

- 4 clusters: Urban and Built Environment

  Waste, Water and Land Management

  Metrics, Knowledge Management and Decision-making

  Transport

# Towards a Sustainable Urban Environment (SUE)

## SUE1

- 12 consortia
- £22m funding
- over 30 UK universities
- 120 project partners
- Now closed or concluding

## SUE2

- 6 consortia
- £16m funding
- over 30 UK universities
- 93 project partners
- Now starting work

# The ISSUES Project

•The ISSUES project (2007-2010) has four main areas of activity:

- **Showcasing** SUE research findings for policy makers and practitioners
- **Identifying and communicating** the research needs of policy makers and practitioners to researchers and funders
- **Enhancing knowledge transfer** and knowledge exchange activities
- **Establishing an ongoing knowledge exchange** between end-users, researchers and research funders

# The Role of ISSUES

**•Within SUE**

Work with the SUE consortia to share good practice

Develop a critical appraisal of knowledge exchange methods

**•Within industry**

Through interviews and surveys, develop an understanding of how industry could better access and use research findings to inform working practices

# The Role of ISSUES

- **Policy and Government**

Investigate the ‘funding – research – policy – application’ cycle to identify how to make more effective links between each group

Advocacy and broad dissemination of completed outputs from SUE research

# Methodology

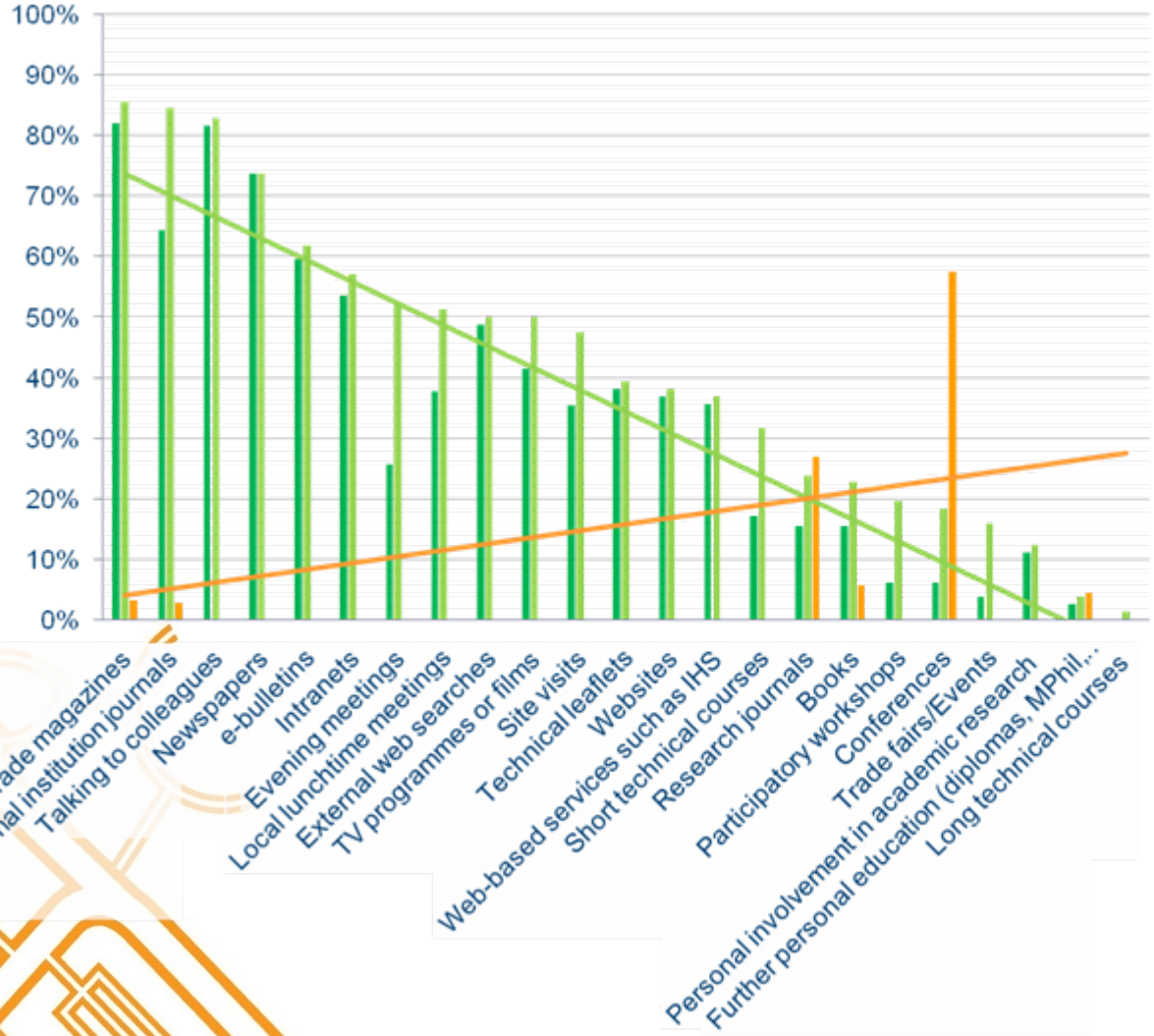
- Marshal and understand the **knowledge held by the SUE** groups
- Identify and understand the **knowledge needs of potential end-users**
- Learn from and **build on existing knowledge transfer activities** in the UK
- **Create channels** to make the knowledge accessible to those at each end of the process

# Knowledge Applications

- **Useful** is the knowledge and outputs generated by academics addressing a problem that is useful to end users?
- **Useable** is the work in a format that is accessible to end users and is the dissemination timely?
- **Used** have the results been used by end users and have these results contributed to changes in practice or policy?

The ISSUES Project

# Industry preferred methods for acquiring new information, against SUE cluster dissemination methods




- Industry preferred methods of acquiring new information (at least monthly)
- Industry preferred methods...(at least quarterly)
- Chosen method of dissemination by SUE consortia (average frequency)
- Linear (Industry preferred methods of acquiring new information (at least monthly))
- Linear (Chosen method of dissemination by SUE consortia (average frequency))

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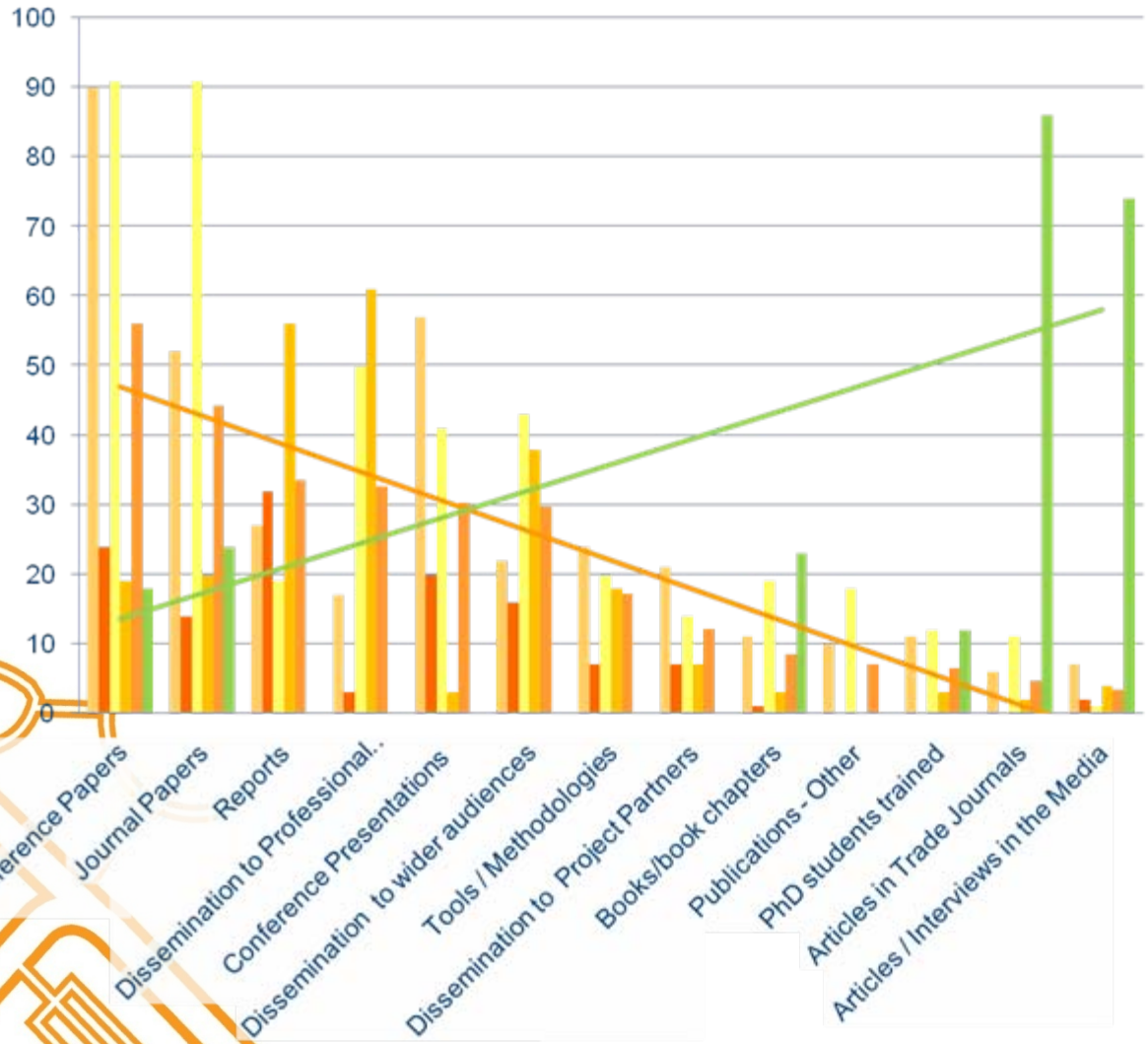
The
**ISSUES**
Project

SUE cluster dissemination methods, against
industry preferred methods for acquiring new information




Urban and Built Environment

Metrics, Knowledge Management and Decision Making

Waste, Water and Land Management

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The
**ISSUES**
Project

- 82% thought “More accessible research information in **publications which they already read**” would be very or quite useful
- 78% thought “More **time/funding provided for training** by employers” would be very or quite useful
- 72% would like more access to **tailored workshops**
- ... to enable them to acquire more effectively new knowledge in sustainability

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The
**ISSUES**
Project

Personal interest is a key driver; however, this is limited both by lack of accessible research outputs and by lack of time and funding provided by employer

Publish articles in trade magazines and national press, and advertise links to coherent web pages

Aim technical journal papers at Professional Institution publications rather than pure research journals

Involve established networks of practitioner and training bodies, such as CIRIA, to provide tailored workshops

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# Bringing researchers and end-users together

- **Ebbsfleet Valley Challenge Event** to exchange knowledge and to bring out some of the issues surrounding KT/KE
- ISSUES-run event where SUE researchers were given the **opportunity to present the results of their work** and ways in which it would be used in the context of the Land Securities Thames Gateway Development
- Highlighted several **disconnections** between researchers and practitioners
- However, delegates found the event to be **useful** and **stimulating**, **positive** and **constructive**

# Ebbsfleet Valley Challenge Event

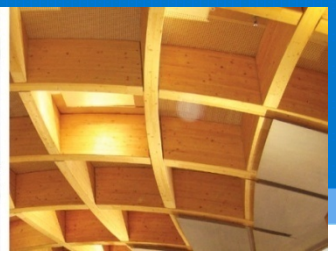
"It is important for the Academic world to pick up on knowledge being developed in the Industry world"
Practitioner

"The constructor community is a key component of the development and of its sustainability"
Practitioner

"..to do justice to the research, yes?, you need a 50 minute lecture…"
Researcher

"…it takes twenty years before research is used..."
Researcher

# Underpinning concerns of Knowledge Practices



•Complexity of knowledge work and communication across knowledge divides

•A need to understand (and address) the situated nature of knowledge practices

•Tacit or explicit (propositional) knowledge; actionable knowledge

•Informing the practice perspective; communities of practice, legitimate peripheral participation

•Making tacit knowledge explicit through participation in different social worlds

# Some Engagement Processes used in SUE

- A creative approach to collaborative knowledge transfer
- Academic credibility not automatic
- Require careful attention to relationships
- ‘Active’ engagement of industrial partners may be based on their ‘trusted sources’
- Provide opportunities for action research and action learning and bridging the ‘theory-practice gap’
- Create opportunities for interns within the practice based organisation

# Summary of key messages

- The design of the SUE programme was novel, forcing partnerships between academia and industry

- The research arising from SUE, where Industry was actively involved, is important, high quality and exemplary.

- There remains a concern as to whether the outputs from the research will have a significant impact on widespread practice, at least in a reasonable time frame

# Summary of key messages

•**SUE** has displayed some examples of **best practice engagement** between research and end users, which should be published to reach funders, researchers and practitioners

•**Researchers need to understand** parallel knowledge development in industry

•**Blue skies research is still needed**, but needs to be interpreted to industry much more quickly than is currently happening

•**Practitioners need research to be published** in appropriate media, These changes can be effected through **changes in research funding**

•**Lack of client awareness and prioritisation of sustainability** are also key barriers in practice

- “Don’t let these **impressive** results fester in academic journals”

# What can be done?

- Change the basis of research funding
- Change the relationship between industry and Academia
- Change the valuation and reward of academic activity

# Change the basis of research funding

- Include a 5% retention for exchange of knowledge after research contract completion
- Value and reward knowledge exchange in research activity funding
- Encourage innovation in dissemination and exchange of knowledge

# Change the relationship between industry and Academia

- Develop career paths for individuals to share their careers between academia and industry
- Develop closer links between industry based research and academia
- Encourage more funding of research in academia from industry through more accessible deliverables

# Change the valuation and reward of academic activity

- Public funding of research to include more valuation of engagement with industry and practice
- Recognise and encourage career development across the academia/industry boundary

# Why does this matter?

- The traditional delay of up to twenty years between knowledge being gained and its exploitation is too long in the face of urgent action needed for
  - Mitigation of climate change
  - Adaptation to climate change
  - Sustainable development

# Why does this matter?

- We do not have the luxury of time