‘Systems Thinking about Mega Construction Projects’
Includes learning points captured at INCOSE Bristol 26th September 2007

A personal view by
Patrick Godfrey
Patrick.Godfrey@bristol.ac.uk
patrick@systems-thinking.co.uk
Mobile +44(0)7738448156

Learning points

Process for Tonight

Three mega projects

Maui B
High Speed 1 CTRL
Heathrow Terminal 5

Learning points

Knowledge model (complexity)
Bristol Generic Systems
Practical holism (Last responsible moment)

Three systems thinking models
Systems thinking

• a way of thinking – a **way of tackling problems**.
• three important features, **holons, connectivity** and a new view of **process**
• a hierarchy of interacting processes to build into a process **model**.
• **attributes** attached to process based on questions: why (purpose), how (method), who, what, where, when (the change **parameters**).

*Summarised from Penguin Dictionary of Civil Engineering 2004*

---

Why systems thinking?

- Complexity
- Uncertainty
- Conflict
- Scale
  - Too complex for one person to comprehend
  - Need intellectual teamwork
  - Involves the integration of soft and hard systems
  - On the frontiers of knowledge
Maui B

Why Maui B
• Sustainability
• Required by White Paper

But no additional earnings
• No business case
• Original estimated cost US $1200m

Maui Field

B A

Industry

Tectonic Fault

Section X-X nts

Learning together
Bristol Generic Systems Model

- Extends the USA National Science Foundation systems model by being Stakeholder needs led
- Used to
  - generate understanding,
  - stimulate innovation
  - design programmes

Stakeholder needs

**Government**
- Security of supply
- Privatisation of Petrocorp
- Political risk

**Petrocorp**
- Cash flow
- Privatisation
- Reputation

**Operator**
- Renewal of contract
- Income to head office
- Technical excellence

**NZ Suppliers**
- Business
Systems solution
(enabling technology)

- Security of supply
  (Invest in Maui ‘A’ dependability 1st)
- Can afford high innovation risk
  (understand business case & risks)
- Remove process from platform
  (Wet gas transfer)
- Remove people from platform
  (Unmanned operations)
- Remove pipe laying barge
  (Float pipes out)
- Avoid creating an industry (lean)
  (Very small platform made in Singapore)

Project cost now US$400m
Reduced to 1/3!!!

Learning points from Maui

- Top level strategy well prepared
- Leveraging value from existing infrastructure
- Separate (define) solutions from stakeholder needs
- Needs vision and understanding of stakeholders views ranked by
importance (power and interest)
- Back office solution allowed to be owned by Operator
- Asking good questions allows others to own the answers –
  Socratic process
- Characterisation of cost, time and opportunity/risk from the
  outset
- For strategic planning the process view of risk is better than
  the traditional event view [see: 10 Steps to Managing Strategic
Risk – A holistic approach - Alan Davis and Godfrey - Proc of
Institution of Civil Engineering Vol. 160 August 2007 pages 147 -
143 (copies provided on receipt of e-mail)]
CTRL Routes

- Main Lines to Scotland, the North and the Midlands
- London via Panorama
- London Waterloo
- Gravesend
- Sittingbourne
- Ashford
- Canterbury
- Margate
- Ramsgate
- Dover
- Folkestone

1. Planned capacity < 8 Eurostars + < 8 Domestic Services + 2 other ‘open access’ paths.
2. The maximum speed for services using the track will be 300km/h.
3. Journey time
   - between London and the Channel Tunnel will be 35 min approx
   - Paris will be only 2 hours 15 minutes from St. Pancras,
   - and Brussels only 2 hours from St. Pancras.
4. Able to accommodate freight trains should commercial demand warrant.

CTRL purpose
### Facts and figures

<table>
<thead>
<tr>
<th>Open</th>
<th>Section 1 - opened September 2003</th>
<th>Section 2 - scheduled to open in November 2007</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Route</strong></td>
<td>From the Channel Tunnel to Fawkham Junction, north Kent via Ashford International</td>
<td>Southfleet Junction to St. Pancras via Ebbsfleet and Stratford</td>
</tr>
<tr>
<td><strong>Distance</strong></td>
<td>70km</td>
<td>39km</td>
</tr>
<tr>
<td><strong>Construction period</strong></td>
<td>October 1998 to Summer 2003</td>
<td>July 2001 to 2007</td>
</tr>
<tr>
<td><strong>Construction cost</strong></td>
<td>£1.9bn</td>
<td>£3.9bn excluding Temple Mills Depot</td>
</tr>
<tr>
<td><strong>Reduction of journey time</strong></td>
<td>20 minutes</td>
<td>A further 15 minutes across the whole route.</td>
</tr>
</tbody>
</table>

Temple Mills Depot £350m

---

### Illustrating the complexity

- Context of the project
  - Scale
  - Impacting the lives of millions of people
  - Working with the public in close proximity
  - Respecting the heritage of the railways
  - Condition and nature of existing infrastructure
  - Government is the client
  - Privatisation!
St Pancras Station

St. Pancras Station by William Henry Barlow, Architect, 1864 - 1868

Moving ThameLink under the station

Midland Grand Hotel now

Platforms at the new home of Eurostar

The undercroft will house shops, cafes, and Europe’s longest Champagne bar

Moving ThameLink under the station

NCE 6th September 2007

Learning together
St Pancras Station

Condition of existing infrastructure uncertain

Construction
Logistic complexity

Knowledge model

Source Kurtz and Snowden 2003

Learning together
Domain map

Complex
Open systems
Wicked and messy problems

Knowable
Closed systems
Tame problems

Chaos

Known
Routine procedure

Examples of transfer processes

Complex
Swarming
Terrorism

Knowable
Planning permission
Programme management
Just in time delivery
Creative problem solving
Incremental change

Chaos
Collapse

Known
Dictatorship
Financing problems

• In February 1996, DfT Awarded Contract
• By the end of 1997, actual Eurostar UK revenues indicated that LCR’s forecasts were overly optimistic.
• In June 1998 Government agreed to guarantee most of the private sector funding. Railtrack to manage and purchase the infrastructure.
• 2001 Railtrack Group did not take up the option to build Section 2 of the Link and it then withdrew altogether from the project in 2002 following the entry of its subsidiary, Railtrack plc, into railway administration.
• The likely future call on the taxpayer is uncertain. The most likely revenue scenario suggests a figure of £260 million (1997 prices).

Source NAO report 2005

Economic value

• “The economic justification for the project remains marginal. The project depends heavily on assumptions about regeneration benefits. There are, however, encouraging signs at King’s Cross, Stratford and Ebbsfleet that these are beginning to materialise”.

Source NAO report 2005

• Estimated regeneration in SE
  – £10bn and it has not yet started! (NCE 2007)
Stratford London
– Early 2001

Facts and figures

2.5 Million m³ of box & tunnel excavation

Land raised to approx. 7m above ground level

1660m of reinforced earth walls

100,000 cu. metres of contaminated material treated

Saved £30 million
September 2005

Stratford – 2005
The future view
Learning together

Now Stratford New Town & Olympics 2012

Regeneration

A sports capital for the youth of the world

Learning together

Success – why?

Channel Tunnel Rail Link Act 1996
- Clearly established the requirements
- Strong political sponsorship through to delivery (Heseltine and Prescott)

Phase 1 (ref NAO 2005)
- Appropriate contracts and incentives
- Stability of design and continuity of client people.
- Realistic management of risk

Phase 2 (NCE 060907 interview with Mike Glover and Brian Sedar)
- “The project has been multicultural”
- “Allowing time for planning, avoiding ridiculous deadlines”
- “Allows good communication” “Make time to talk to people”
- “Financial acumen is part of the culture”
- “Clarity of scope, time and the customer what it wanted”
- “Procurement precision” – “People signing have known what the task is”

Learning together
HS1 Success – why?

Channel Tunnel Rail Link Act 1996
- Clearly established the requirements
- Strong political sponsorship through to delivery (Heseltine and Prescott)

Phase 1 (ref NAO 2005)
- Appropriate contracts and incentives
- Stability of design and continuity of management people.
- Realistic management of risk allowances.

Phase 2 (NCE 060907 interview - Mike Glover and Brian Sedar)
- “The project has been Multicultural”
- “Allowing time for planning” - “avoiding ridiculous deadlines”
- “Allows good community relations” “Make time to talk to people”
- “Financial acumen” as part of the culture
- “Clarity of scope” “spend a lot of time with the client”
- “The objective is to give the customer what it wanted”
- “Procurement precision” – “People signing have known what the task is”

Learning points CTRL

- Delivery to time and budget is a state of mind.
- Maintain clear line of sight to purpose and objectives to focus teams
- Make sure with a complex environment you use a wide base of experience to stabilise the project environment
- Use of regulatory and statutory frameworks to to stabilise the boundary into "Knowable"
- Work very closely (presence in the design office) with the client
- Union Rail, and the infrastructure operator (Railtrack/Network rail) to manage expectations and customer interactions.
- Maintain strong political support
- Seek benefit from down stream spin offs (eg regeneration)
Terminal 5 Heathrow

1. M25 London’s orbital motorway widened
2. Terminal 5 between the runways at Heathrow inc 2 satellites beyond the main terminal

Terminal 5 Heathrow

3. Three Underground railway stations
4. Car parks, arrival and departure cars, buses
5. Main terminal building

Learning together
A few facts and figures

Terminal 5 Heathrow
• 35 million passengers per year
• site area 1 million sq.m
• 650 people design team
• 10,000 construction workers
• 100 buildings and structures
• key buildings 400m long
• 3 underground stations
• widening the M25
• moving 2 rivers and removing sewerage works

Source ‘The T5 Handbook 1998’
Twin focused approach

Predict
Provide
Unlocking potential
Innovation
Vision

Purpose
Process
People

Source ‘Doing it differently’
Learning together
Learning together

**WHY**
Why is project needed what are the objectives

**WHAT**
resolution of the why and the how in the evolution of the best solution

**HOW**
the means by which to best engineer & construct it

Delivery approach
- convergent
- integrated
- interactive

business plan
marketing
occupancy

engineer
construct
maintain

- in time
- in practice
- in culture
- ...... in solutions

Source ‘The T5 Handbook 1998’

---

**Problem solving loop**

Define problem
Evaluate feedback
Set up theoretical model
Deduce results
Interpret meaning

Take action
Make a decision

Source ‘Doing it differently’
‘Last responsible moment’

• Planning for change
• Process map back from the future.
• Identify the information needs for each process
• Determine the latest start date that does not jeopardise ultimate completion
• Ensure that decisions are frozen at the ‘last responsible moment’
“Creating systems that work”

6 Principles

1. Debate, define, revise and pursue the purpose
2. Think holistic
3. Follow a systematic procedure (Process)
4. Be creative
5. Take account of the people
6. Manage the project and the relationships.

Royal Academy of Engineering 2007

Source: ‘Creating systems that work’

Learning together

“Doing it Differently”
David Blockley & Patrick Godfrey

“I hope you will find this book an informative and useful text. It is a book that provides numerous tools, techniques and case studies that will help those motivated to change the way things are done within construction to succeed.”

Sir John Egan,

CIOB Authors of the Year & Gold Medal in Construction Management

Learning together
Web links

- EngD Centre in Systems University of Bristol and Bath [www.bristol.ac.uk/engineering/systemsengd](http://www.bristol.ac.uk/engineering/systemsengd)
- System Lecturer at University of Bristol [www.jobs.ac.uk/jobs/RJ453/Lecturer_in_Systems_Engineering](http://www.jobs.ac.uk/jobs/RJ453/Lecturer_in_Systems_Engineering)