FCERM Infrastructure Management and Performance (iMaP)
Research Development Workshop to scope a major new research initiative

Group 1

Flipchart page 1:

- Make better use of observational evidence/"knowledge on the ground" currently disconnected (arguably) to some extent with asset models

- Two way links
  - <----------
  - ---------->

  -Technology – new sensors
  -Wider system (scale issues)

- Reach vs point weaknesses – different in defences
- Approaches used in the UK and Netherlands
- Benefits of installing sensors when building new defences? Cheap sensors
- Linked to 'real time'
- <u>It's all linked</u>

Flipchart page 2:

- Better understanding of physical process of embankment/systems failure under current + future conditions
- Ensembles to replace design events
- "Design event is dead" yes for scientists but no for engineers
- So how to transform practice
- Working locally
- Large scale coastal interventions
- "sand motor or engine!"
- Component based deterioration
  -vs specific drivers T, Level, moisture ….
  -vs specific part of system for future climate change projections
- Not "top down" curve selection

Flipchart page 3

- How to measure resilience?
- Recovery time? Or more complex measures including redundancy + other metrics e.g. Eco-benefits
- Post-event. Replace "like with like" or take the opportunity to adapt in a different way?
- Example of legacy defences
- Flexible designs/ over the long term
- How to develop appropriate climate/socio-economic scenarios?
- Can natural systems "buy time"?
- Ecosystem approaches
- Decision tree type approaches

NOTE: Royal Society report on resilience due December

Flipchart page 4

- How to incorporate 'natural' defence systems 'into design?'
- Improve appraisal processes
- Manage risk/legal issues
- Evidence on performance of ecosystem based solutions?
- Marginal systems
  - Can ecosystem services make them cost/beneficial

    - Can benefit/cost be improved in all schemes by using ecosystem approaches
    - How to build flexibility in practice?/avoid lock in
- Deep uncertainty!!
- Out of time.

Flipchart page 5

- Different scales requiring different criteria
- Optimize across capital and recurrent expenditure at difference time scales?
- Multi-objective opt. across scales & cadvec..(???)
- Eco-system services approach?
- Effect of partnership funding?
- Deep uncertainty and robustness.

Flipchart page 6

- Beyond real time forecasting
- Actions assume that defences perform as designed
- How can we plan for the unexpected
- i.e. defence failure
- Urban flood – sensors in defences model triggers by data
- Time and target sensors for use in events
- Inspection/data gathering on asset can result in pro-longing its life
- Modelling managing complex systems which could include property level protection (difficult to model – human behaviour!)

Flipchart page 7

- Issue of false alerts.
- Better calibration required.
- Real events always the best way to validate a model!!
- Public access to real time data
- -GIS
- -Social media (what data provided)
- Two way – crowd data
- Manage public expectation of accuracy improves
- Research – who needs what info and when?
- From Joe Blogs to COBRA
- Note: this should also consider how info can change behavior

Flipchart page 8

- Gaps – combining forecasting with asset condition and available resources – e.g. men on the ground
- Updating 'for sequencing ' after an event
- Technology around computing
- Better post-event forecasting

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Group 2

Flipchart page 1

- How to assess "better"
- Multiple values
- Can they be monetised?
- Should they be monetised?
- Might change
- Hydro systems services

2 Who, is investing, what?

- Flood credits
- New derivatives

3 Different across scales sometimes

- UK plc vs local levels

4 New "business Models" with a range of funding, act??ts etc

5 Multi-dimensional in time and space and value

- + multi hazardous
- + all infrastructures

6 Search/optimisation algorithms

- Requires some model that address above issues
- Experience from other sectors
- "Gaming"
- Life cycle of infrastructure(s)
- Multi criteria analysis
- Exploratory interface to trade-offs
- Scenario neutral pathways

Flipchart page 2

(1) Design event/events/sequences
    - Difference between design and assessment
    - Designer skill in working with messiness
    - Get adaptation onto the design agenda
(2) Adaptive design – the process of design/management
    -the structure (c.f. F1 cam)
(3) Time evoking methods (network) which take account of past interventions and events
(4) Adaptive materials that respond to changed circumstances
    -Linked to monitoring – feedback action(???)

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Group 2

(5) Resilience
-Be clear about definition
-Designing for failure & recoverability
-Working out how recovery in over-load events but also managing sequences of events
-Seasonal and decadal forecasting + taking this into design

(6) Monitoring natural systems? For resilience
-(mixture of strong and weak elements)

Flipchart page 3

(1) Time dependent reliability
Understanding longer deterioration
Design of sensor networks
Use of sensors
Data mining/statistical models
Use data in – AI
In physical process models
Transfer of theories from other sectors e.g. complex networks
Breaking down barrier between reliability at a point in time + deterioration
Use of Bayesian methods/ calibration

(2) Active time structures – use of social science in terms of probability of gate closures

(3) Link to "consequences" in as much as property level protection (infrastructure)
Here performance – depth damage relationships
How are property level measures implemented? (social dimension)

(4) Impact of maintenance regimes on performance – including social dimension

(5) Monitoring – linking monitoring todays with response of structures

(6) Understanding multi-varied extremes and the "event" – one event or a sequence

Flipchart page 4

Topic v Real time

- Using historic storms ("storm atlas") (impact on)
  ----- include infrastructure & passing receptors
- Data
  -What's appropriate quality
  -??? prevail, topics re monitoring
  -Micro sensors
  -Mobile sensors
  -Crowd source
  -Social media
  -Not just assets, also
  -Hydraulics
  -Receptors

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Group 2

- Managing evacuations (road infra)
  Real time “optimisation” of limited resources
- Identifying the weakest link, real time
- Graphic interface for real time decisions

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Group 3

Flipchart page 1:

- Role of community in measuring and monitoring performance
  {Public perception of performance & viz risk}

- Communication & visualization of performance
  {How to formalize informal observations}
  {Incentives to relocate – compulsory purchase}
  {Using multiple pairs of eyes to get a better view}

- What really happens when 'ownership' is transferred?
  {Differing views about what is performance}
  {Engineering view vs others?}

- Can 'local' ownership improve performance?

- How can we best optimize interacting portfolios – development management/spatial planning emergency planning & assets

- How can we verify performance/reliability based models, physical models. Role of information gathering

Flipchart page 2:

- Why do so few assets fail?
  – over engineering
  - embedded factors of safety?

- Extension of URBANFLOOD
  -Remote 'real time' monitoring
  -Internal vs external
  -Role of UAVs.

- What's the extent of over design now
  -where should we be 2020, 2050, 2100?

- Capture systematically all performance data during 'loading' and 'unloaded' conditions

- Design for failure? Exceedance?

- Response to failure

Flipchart page 3:

Research topics

- More effective monitoring to collect performance data including:
  -Formalization of informal observations
  -Clear links between condition and performance.

Flipchart page 4

- Take a lead from other industries which are experiencing increasing demands
- How can we be sure that adaptations made now will still be relevant in 20 years hence

- Include monitoring with design to enable future adaptation

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Group 3

- Need to explore wider range of scenarios
- Building in flexibility
- Tipping points/decision gateways. Points where options get closed off
- Design has to take place in consultation with communities
- Weigh up community values against design options

Flipchart page 5

- Design for exceedance
- Strong links to planning framework, and emergency planning
- Recover of defenses post event
- Adaptation & resilience should be measured across the system as a whole
    - {Beyond the "infrastructure" system}
- Design for multi-functions
- How to adapt existing defenses with confidence
    - {Retrofit existing asset stock}
- Challenges of retrofitting ---
- Industry standards needed??

Flipchart page 6

- Choices are very spatial-scale dependent
- Society's values change with spatial-scale
- Small (high prob x low impact) flooding could be solved more efficiently at local scale
- Investment models national allocation vs local prioritization – currently a mix of both
- Incentives --- payments for flooding
- Making better multi-use investments
- Temporal dependence what fits now might not fit in the future

Flipchart page 7

- {Propagation of losses through economies:
- Local
- Regional
- National

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Group 3

- How to build effective consortia to deliver FCRM
- Better way of calculating 'true' whole-life costs
- Improved procurement strategies
- Has the CFMP process worked?

Flipchart page 8

- Knowledge of the system behavior in the very short ti??
  {pathways more than the single components}
- Knowledge transfer from system and reliability eng. mg
- (tube, pipeline systems)
- Input in develop system with few operators that have to set ????? and make decisions
- Including ????? and memory(?) in your IT forecast(?)
- Knowledge of transferability of resources and overlapping

Flipchart page 9

- Developing an "app" user friendly tool [conceptual models "network of networks"]
- Real time data acquisition and assimilation (link to Group 1)
- Data to identify "hot spots" – how can they be used to forecast failture
- RQ: how we sift data, use them. What data do we really need?
- Multi-scale in time
  Bronze – immediate, local (operational)
  Silver-regional, village, town (technical??)
  Gold – (strategic), longer term, recovery
- Managing people
  Outlook: what people should report to improve forecast or identify hot spots.

Flipchart page 10
Research topics

- **Modelling**
  - Complexity
  - Pathways
  - Multiscale
- **Data**
  - Acquisition (feeding into pathways)
  - Sifting
  - Assimilation
- **Management**
  - System & reliability
  - Engineering
  - The human factor

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Group 4

Flipchart page 1

Issues Semantics

- resilience – context specific
- ability to recover
- autonomous rebound
- a flood defence that fails slowly
- Multiple expressions of outcomes
- Hard to codify
- What to design for
- Trade offs
- Influenced by partnership funding

Flipchart page 2

Design practice

Changing the time scales

- Longer term and iterative
- Is design practice atomic or should it incorporate a portfolio view?

Knowledge gaps

- Quantifying costs and benefits for multiple benefts(?)
- We have few true multifunction sh????
- Why
- Gap in translation to practice
- Morphological change
- Modes of uncertainty

Flipchart page 2A

How do we transition to living with dynamic in/s (engineered & natural)

- Science not integrated in practice
- Needs integration
- Needs change to policy and legislation
- How?
- Science/research demos to justify the additional costs needed to change practice

Flipchart page 3

I -Risk models (portfolio management in insurance

- How to include time sequences ("memory")
- Networks and supply chains in models? Also sources of flooding, multi-hazards, cascades
- Cost functions - £, time, happiness
- New research
- Use of event sets in maths? To then feedback to practitioners
- Use of seasonal decadal forecasts? – Can this improve decision making?

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Group 4

- Flood risk models
- CAT models – lack some important aspects
- Exposure vulnerability
- Asset deterioration
- Identify flood rich/poor periods
- 'Adaptation models'

II -How to include investment choices in risk models (above)?

- Computational constraints?
- Improved models
- System links
- Effectiveness of interventions

Flipchart page 4

III-Timing of investment

- Delay vs risk
- Ability to est benefits of future adaptation

IV – Spatial scales

- Evaluate local distributed systems vs big infrastructure solution
- Centralised vs decentralised
- Are smaller solutions more resilient?
- Consequences of large system failure are high

Flipchart page 5

I How to make use of good short term forecasting (1-3)

- Add forecast to knowledge of assets
  -Antecedent conditions e.g. beach erosion
  -Condition, failure likelihood
- Integrated forecast, hazard, risk ….. models
  -E.g. "urban flood" project
- Includes sensor in defences etc
- Optimisation of gates, storage etc. ….."flood fighting"

II Medium to seasonal forecast & decision making

- e.g. winter
- 3 months
- 14 days
- Operational decisions
  -logistics e.g. location of mobile defenses
  -beach nourishment
- Anticipatory
- Incident management

Flipchart page 6

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Group 4

III Communication of warning etc. ……..

- Capacity to act on warnings
- The ESRC bit
- What could go wrong? hazards, risk,
- What can be done?
- Who does it?
- How does info trigger action?
  - Immediate 1-3 days
  - 1 month
  - 3 months

Flipchart page 7

Science challenges

- Understanding and modelling sequences (spatial and temporal scales)
- Monitoring, understanding which frequency and high resolution
- Modelling hard and soft defences as a system
- Deterioration models (skochestic??) for a wide range of mechanisms (not only S????, Zonement forecaster)
- Exploitation of new technologies to monitor assets and extract data for models (?????? Sourcing) achieve HR (time and Space)

Flipchart page 8

- Where, why to focus on a system? And what to do?
- Informing science of what is needed for maintenance
- Learning from past experience how to design a cheap and efficient monitoring system (dutch experience)
- Understanding vulnerability and tolerable z????
- How professional understand this? And local authorities 7 stakeholders
- How stakeholders can better assess value of flood defences and help them to do better informed decision?

Flipchart page 9

- Research topics
- Sequences modelling
- Impacting complexity in deterioration models
- Improving monitoring and surveillance
  -Technologies
  -Data sourcing
  -Flooding data into modelling
- Balancing inter?????? Science and sharholders