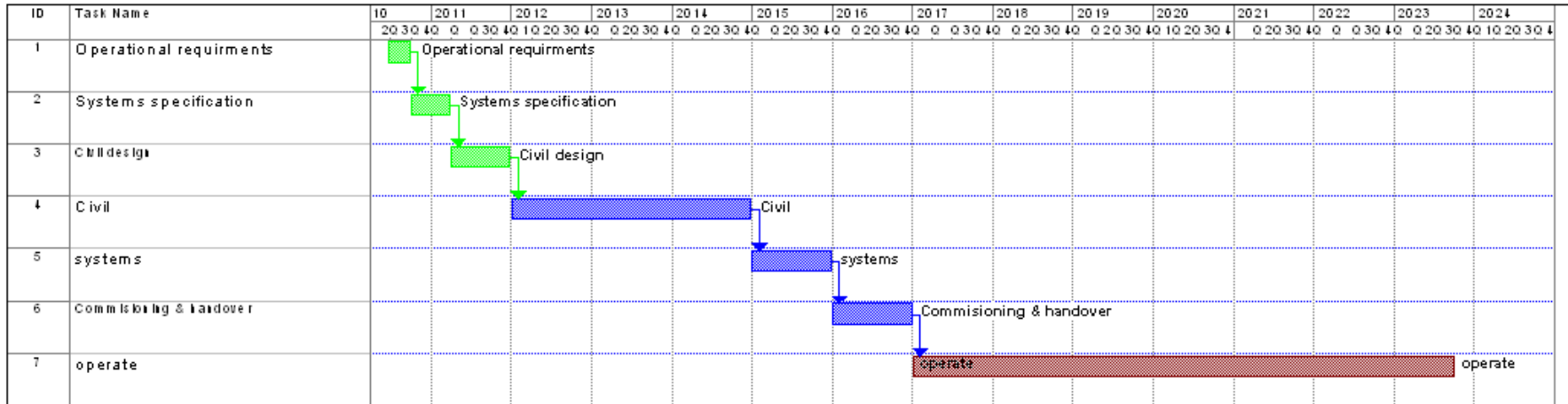


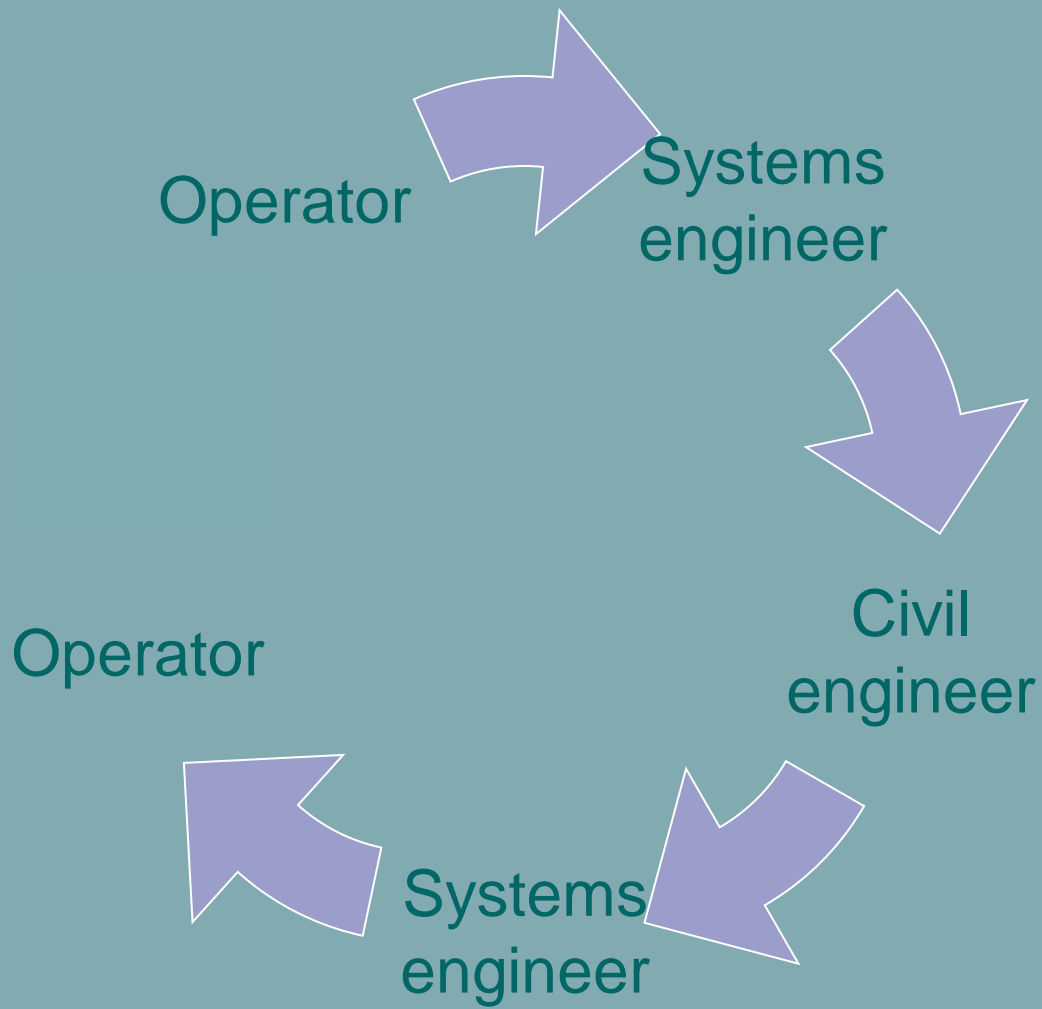
Last is First

Terry Hill

Transport Markets, Arup Group

Last is First







The Royal Academy
of Engineering

Creating systems that work:

Principles of engineering systems for the 21st century

Successful systems demand a different type of engineer with different and broad skills.

Each different discipline must be aware of all others

Six Principles ...

1. Define the purpose

- It is difficult for owners/operators to state what they want
- Performance
- Cost
- Timescale
- ... and risk
- Adaptability/flexibility

*The systems engineer has to see both the world, and
the system, through the eyes of owners, operators,
maintainers and users*

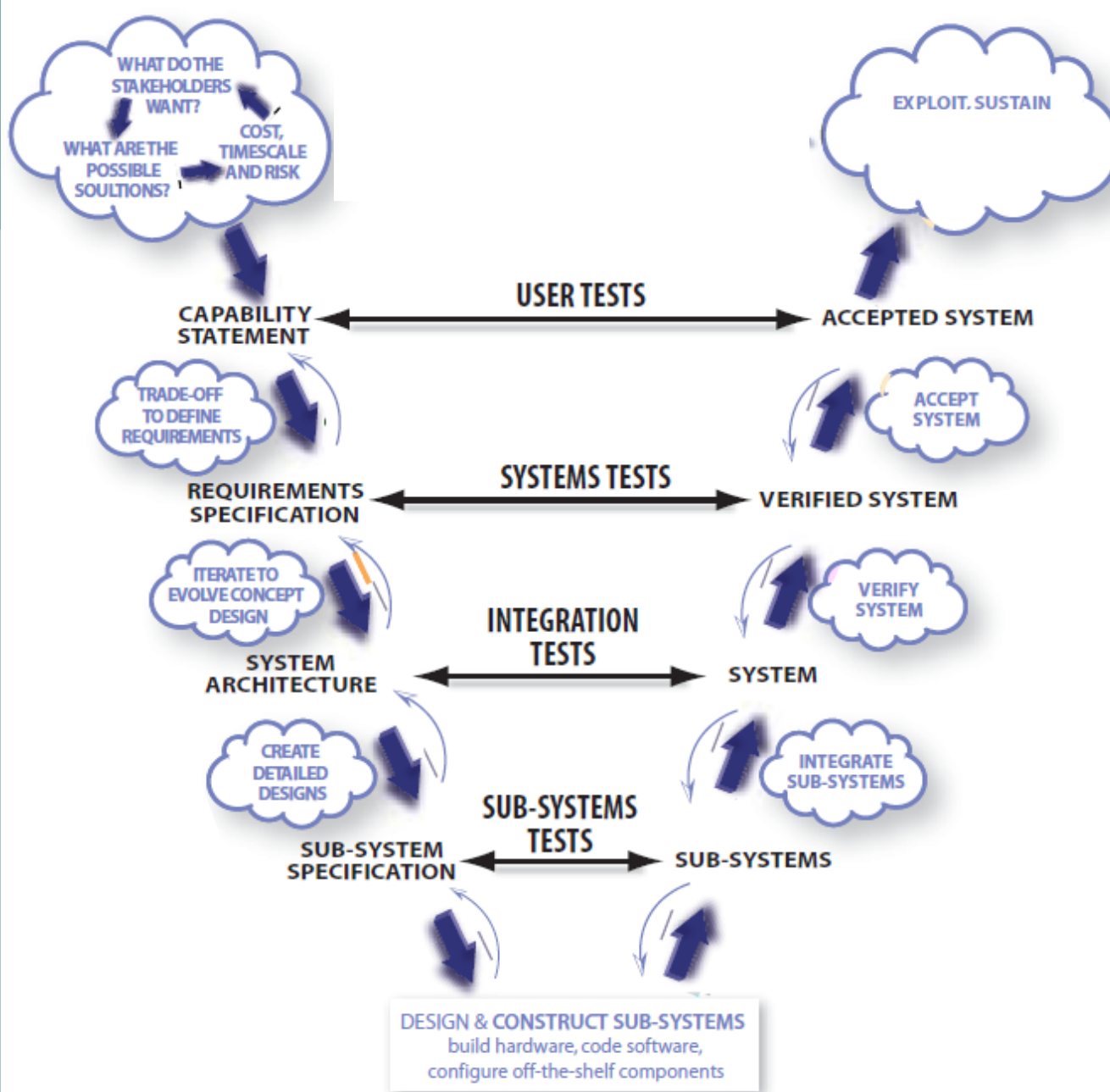
2. Think Holistic

- Optimum system \neq optimum components
- RAMS
- Degrade & recover gracefully
- Capability is an emergent property

3. Follow a disciplined procedure

- **Combine and rule**
- **Divide and conquer**

3. Follow a disciplined procedure



4. Be Creative

- **Work with the customer to tease out the required performance**
- **Performance specifications inspire innovation**
- **Be innovative in designing for performance**
- **Start conservative, find boldness**
- **Innovate to find breakthroughs**
- **Exploit existing knowledge**
- **Test with “what ifs”**

5. People

- People are a part of the system
- At every stage keep sight of those who will own, operate and use the system
- Human error is system error

6. Manage the relationships

- Many people, many organisations
- Where two systems are inextricably bound together, treat them as one
- Integrated systems require a single organisation
- Alliancing procurement
- Allow time to think

“... this was not helped by the strategy of LUL to divide all the works into discrete contract packages leaving many difficult interfaces to be managed by JLEP that would better have been handled by a lead contractor.”

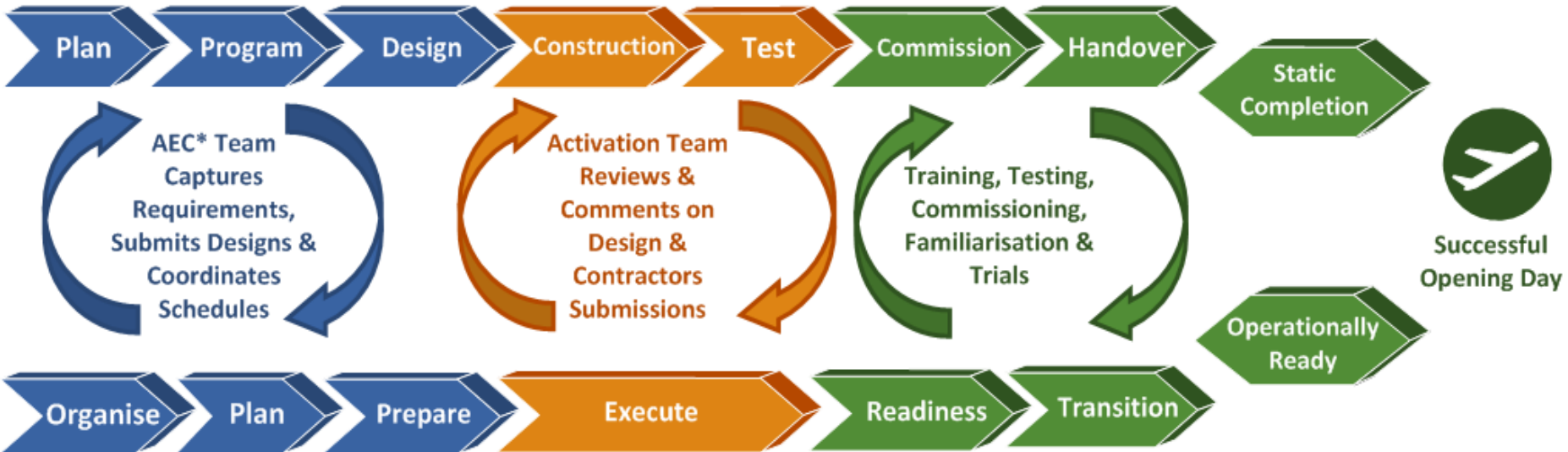
Why airports open late or disappoint on opening

- Inadequate training and familiarization
- Trials not extensive enough
- BHS doesn't work correctly
- Bespoke / Complex Systems
- Testing not finished on time
- Protesters disrupt opening
- Late airline collaboration
- Unclear accountabilities / governance

ARUP

ORAT Timeline

Capital Project Delivery Process



Airport ORAT Process

*AEC – Architect, Engineer, construction)

on
time

on
budget

North Kent
Line connection

North Downs
tunnel

Waterloo
connection



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