Modelling Electromagnetic Performance of Large Structures

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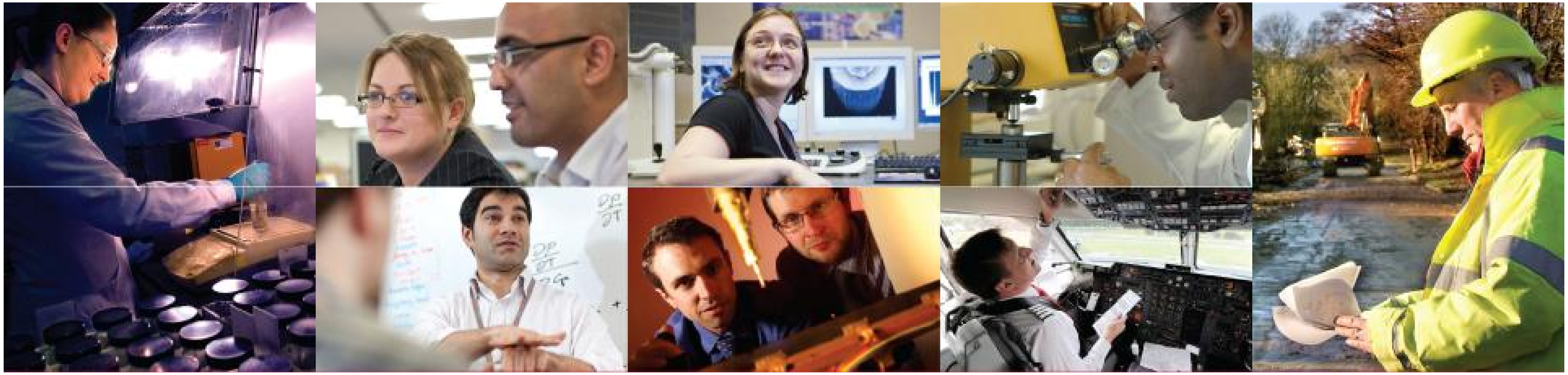
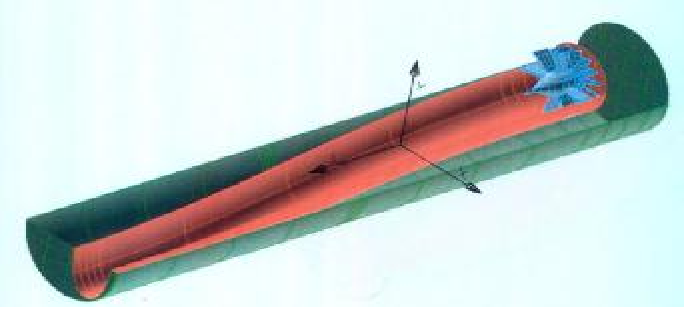


Outline of talk

- Why EM performance is of interest
- How we approach the modelling
- Some thoughts about multi-scale issues
- Possible areas for further research



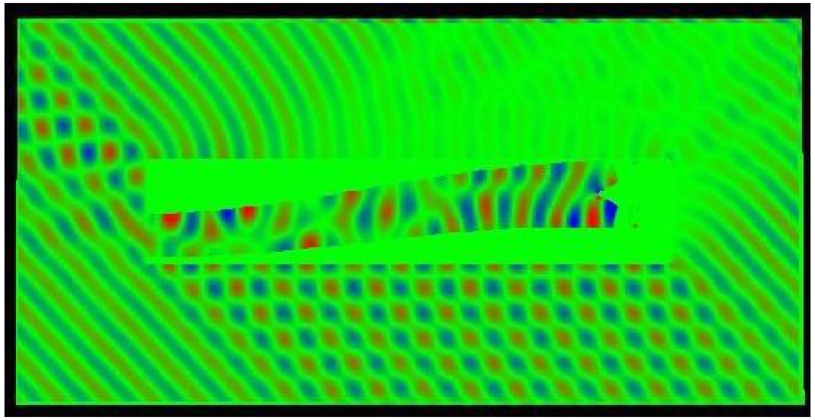
Why EM performance is of interest

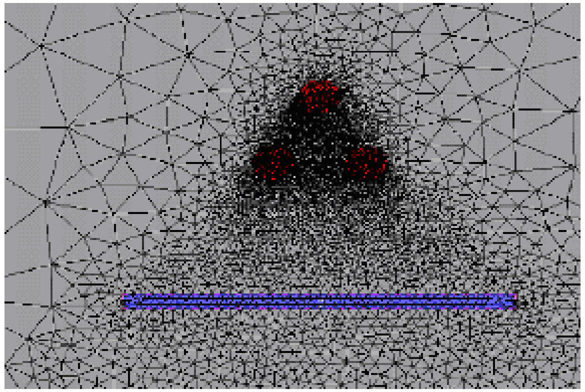
- Large platforms (air, land and sea) in service, or undergoing design, build and test or at concept stage

- Require knowledge of EM performance, such as:
  - Radar cross section (RCS)
  - Installed antenna performance and inter-operability
  - Electromagnetic compatibility (EMC) of complex radiating systems
  - Radiation hazard assessment (eg for personnel)
  - Protection from external hazards

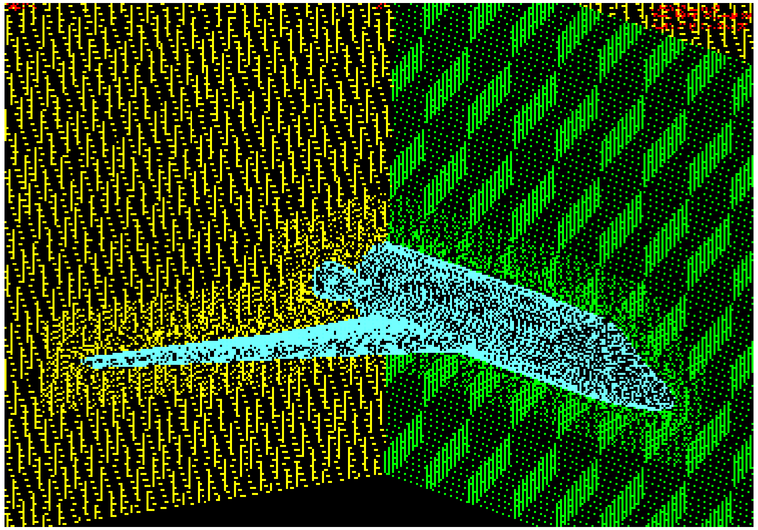
Modelling methods

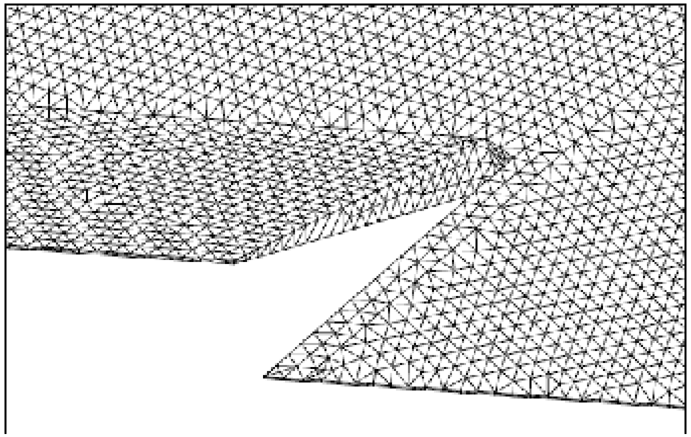
- Full-field methods, such as finite-difference, finite-element, boundary element (accelerated with fast multipole), transmission line matrix …..
- Approximate methods, such as physical optics, physical theory of diffraction, geometrical optics, geometrical theory of diffraction, network-based system model for EMC …
- Hybrid methods (eg finite-difference and finite-element)





Small features on large objects

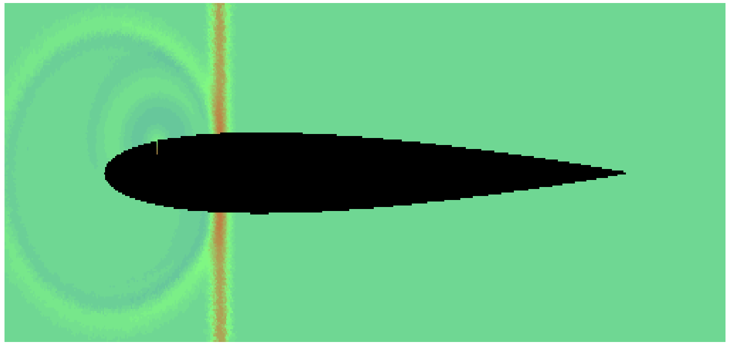


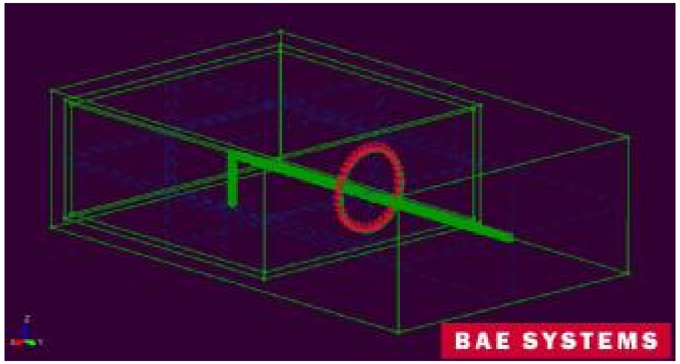


- Large-scale meshing required
- Fine features need resolving
- Levels of accuracy required are often quite stringent
- Wide frequency bands of interest

Some small features of interest

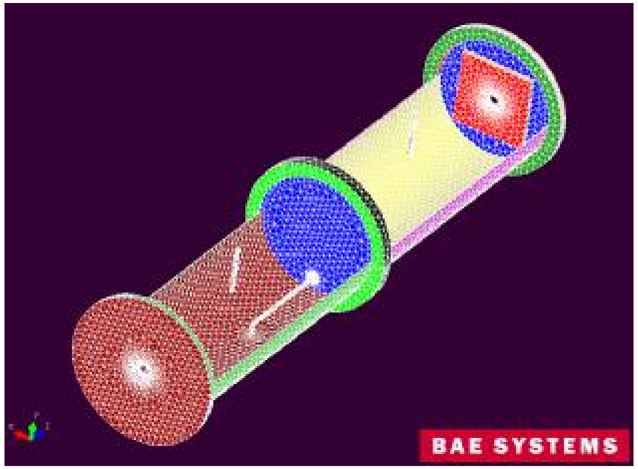
- Radar Cross Section
  - Ø cracks, tips, edges…
- Antenna performance
  - Ø Antenna geometry and materials
- Electromagnetic compatibility
  - Ø Wires and cables in large cavities
  - Ø Slots and gaps
- Lightning protection
  - Ø wires, fasteners, cables, gaps…

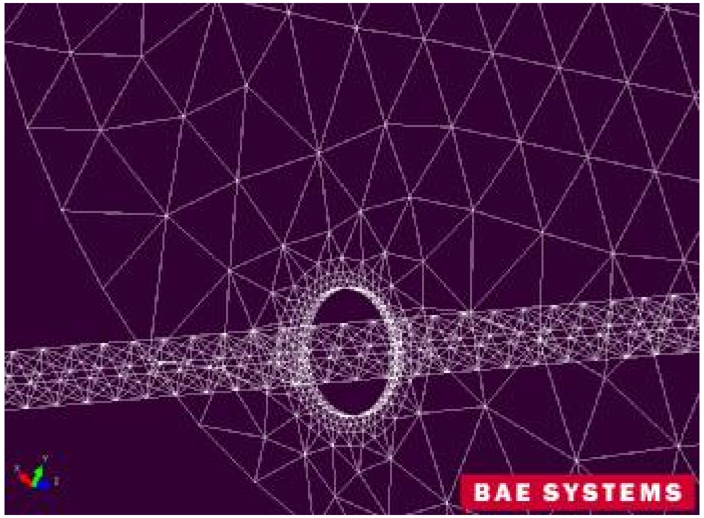


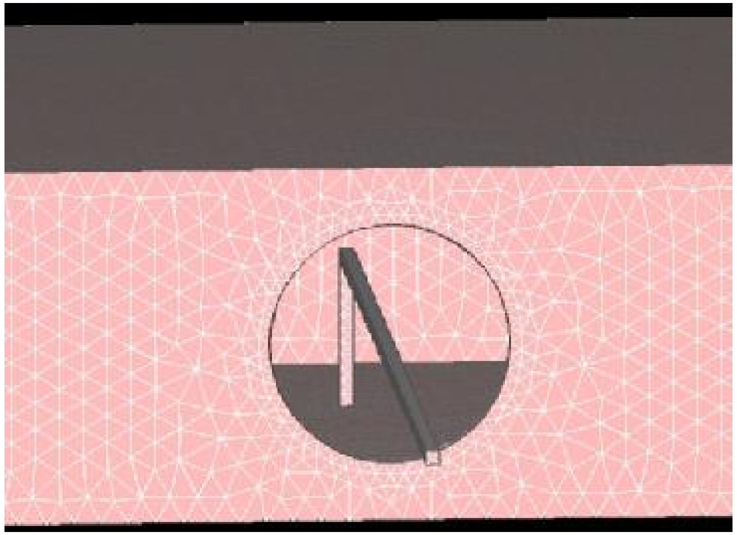


Possible approaches

- Hybrid mesh methods – eg finite difference and finite element with overlapping meshes
  - Ø geometrical versatility and computational efficiency

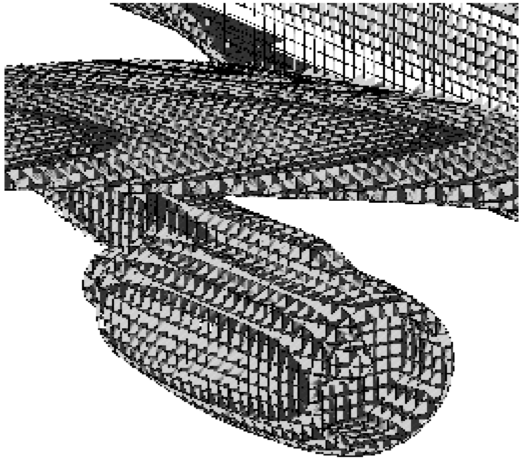


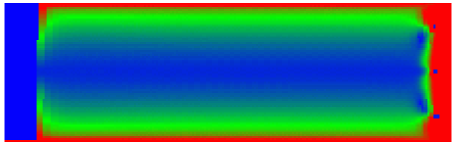


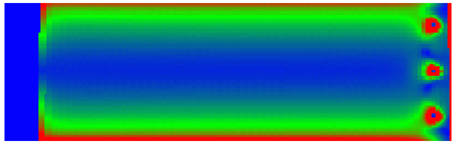


Possible approaches

- Conformal mesh methods – eg finite difference
  - Ø geometrical versatility

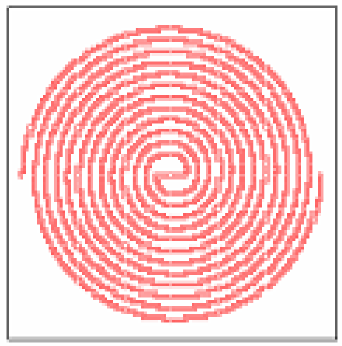


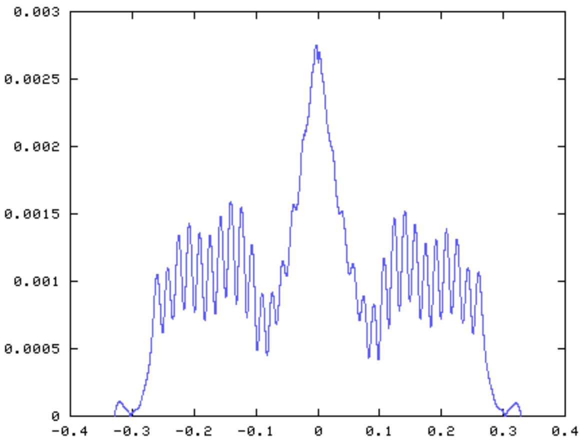


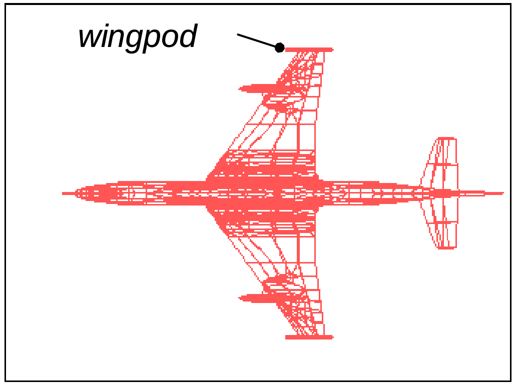


Possible approaches

- Hybrid numerical and asymptotic – eg finite difference method and ray tracing (geometrical optics and geometrical theory of diffraction)
  - Ø Geometrical detail, material properties and whole-body interactions all included

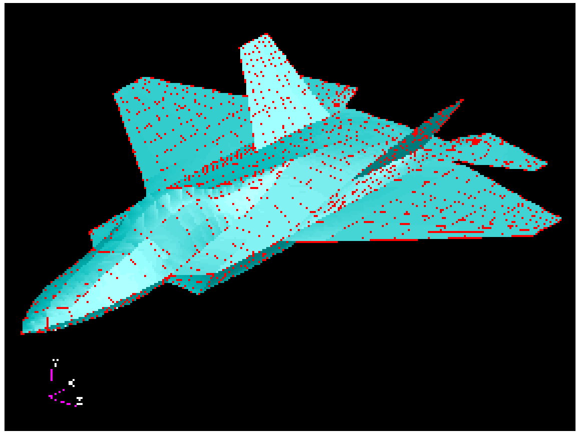


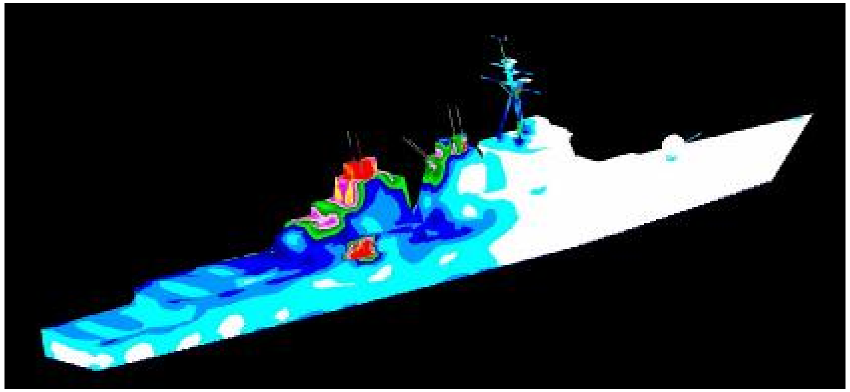




Possible approaches

- Hybrid numerical and asymptotic – eg method of moments and physical optics/physical theory of diffraction (not yet realised)
  - full-scale objects with small, localised sources of radiating energy





Multiscale issues: some thoughts

- Good progress has been made in method development (especially hybrid numerical methods)
- Hybrid numerical/asymptotic methods still ripe for further development
- Fast computing hardware (eg GPUs) has the potential to expand the feasibility of large-scale computations based on repetitive algorithms (eg finite-difference, ray tracing)
- Incorporation of (complex) materials sometimes problematic
- Trend to increasing frequency continues