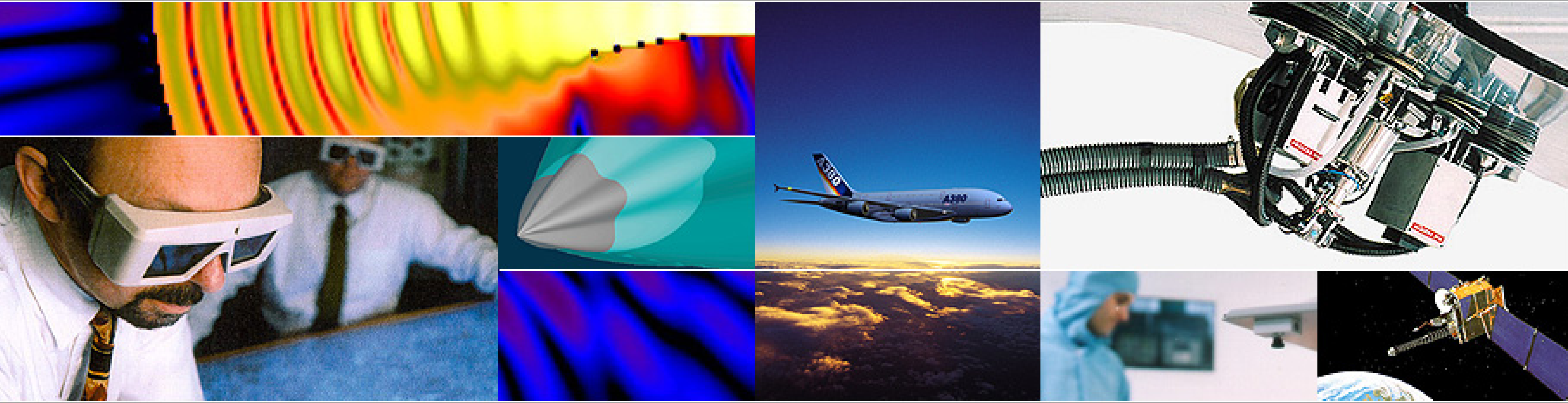
SEFERE (Simulation of Electromagnetic Field Exposure in Resonant Environments)



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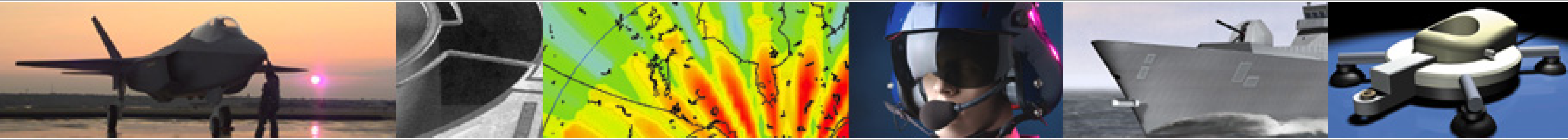
SEFERE (Simulation of Electromagnetic Field Exposure in Resonant Environments)

DTI Project No TP/3/DSM/6/I/15266

Feb 2006 – Jan 2010



OUTLINE OF TALK

- SEFERE project – partners & objectives
- RF Exposure issues – results from the project
- Field computation methods
- MESAF – an intermediate level model
- Synergies with the construction industry

SEFERE (Simulation of Electromagnetic Field Exposure in Resonant Environments)

- Collaborative Project supported by DTI Technology Programme under "Design, Simulation and Modelling" funding competition 2004/5
- Concerned with simulation techniques for predicting the behaviour of radio frequency fields in resonant environments
- Looks at development and application of appropriate methods, and their validation by measurements
- Results applicable to safety assessments
- Project focus on automotive & aerospace industries, but techniques applicable to other sectors
- Project started February 2006, due to finish January 2010

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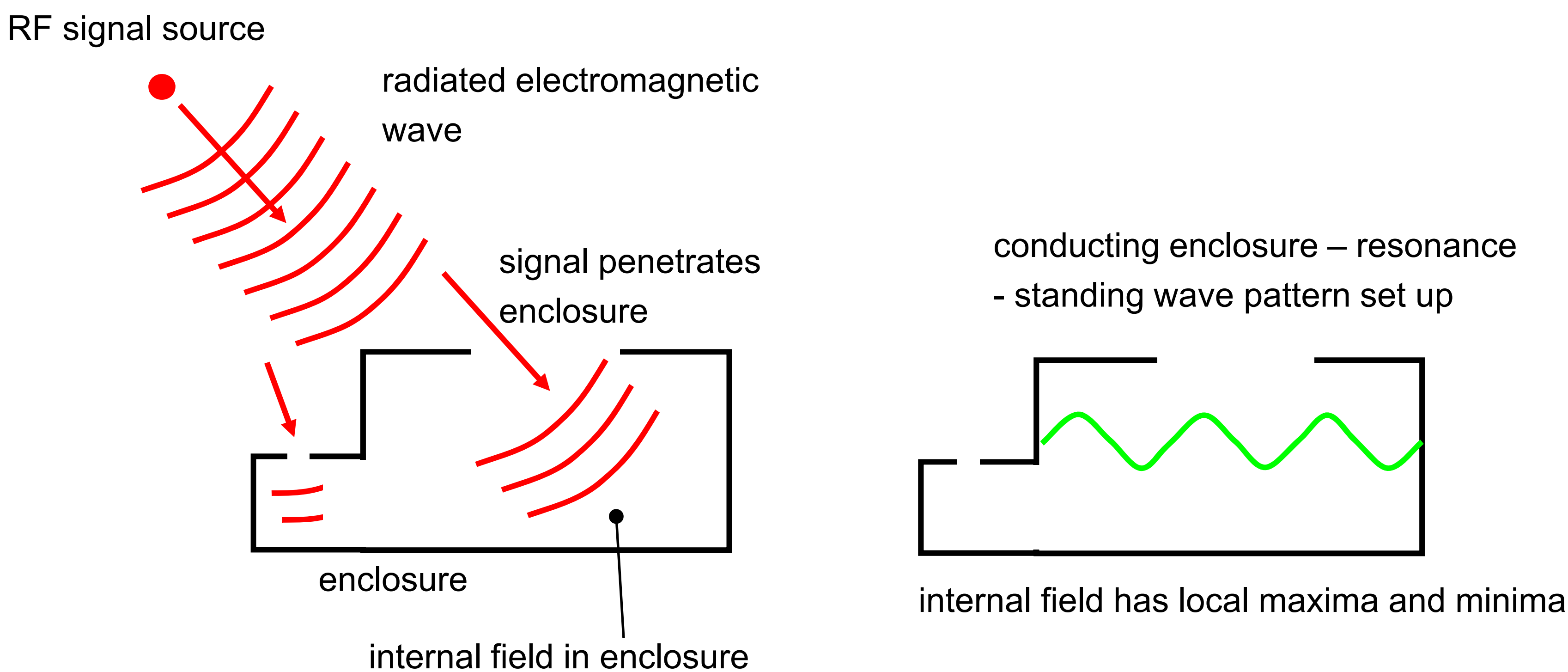
THE BASIC PROBLEM



- Local field distributions in cavities impact on EMC (electromagnetic compatibility) and radio frequency exposure

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SEFERE - Partners

- MIRA Ltd – Project Coordinator – automotive industry
- University of Sheffield – academic partner – EPSRC funded
- Harada Industries Europe - automotive industry
- Police Information Technology Organisation – government
- BAE SYSTEMS – aerospace industry
- ARUP Communications – construction industry
- Jaguar Cars - automotive industry
- Volvo Car Corporation - automotive industry - Sweden

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SEFERE - OBJECTIVES

- Assess & develop methods for simulating electromagnetic fields in partial cavities (MIRA, Sheffield, BAES)
- Characterise the high frequency properties of typical materials used in furnishings (MIRA, Sheffield)
- Validation of results:- (Sheffield, Volvo)
  - (1) Construct a low disruption scanning field measurement system
  - (2) Compare simulation results with reliable measurement data
- Investigate the effect of furnishings & people on the field distribution (MIRA, Sheffield, BAES)
- Understand fields arising from various source types – external, vehicle mounted, personal (MIRA, Harada, Sheffield)
- Investigate possible mitigation measures to limit field exposure (MIRA, Sheffield)

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SEFERE – ANTICIPATED OUTCOMES

- Experience of modelling methods for field predictions in partial cavities – acquire technical know-how, determine which software is best
- Validation of data obtained with such software
- Data on electromagnetic properties of furnishing materials
- Understanding of frequencies, devices/power levels and geometries where radio frequency exposure issues become important
- Investigation of mitigation techniques in cases where it is necessary to limit exposure levels

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RF EXPOSURE ISSUES

- RF exposure can impact negatively on health
- Effects:- (1) stimulation of peripheral nerves
  (2) contact shocks and burns
  (3) elevated tissue temperatures due to absorption of energy
- ICNIRP (International Commission on Non-Ionising Radiation Protection) guidelines set limits for both occupational & general public exposure
- Basic restrictions on current density and SAR (Specific energy Absorption Rate) in body tissue
- Reference levels derived from these – limits on electric and magnetic field intensities, magnetic induction and power density
- EC Directive 2004/40/EC in process of implementation for occupational exposure
- See www.hse.gov.uk/radiation/nonionising/index.htm & www.icnirp.de/

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EXAMPLE OF LIMITS

Basic Restrictions – 10MHz-10GHz

SAR (W/kg) averaged over 6min interval in 10gm tissue

	Occupational	*General Public*
Whole body	0.4	0.08
Localised – head and trunk	10.0	2.0
Localised - limbs	20.0	4.0

Reference Levels – 2-300GHz

	Occupational	General Public
Electric Field (V/m)	137	61
Magnetic Field (A/m)	0.36	0.16
Magnetic Induction (μT)	0.45	0.20
Power Density (W/m^2)	50	10

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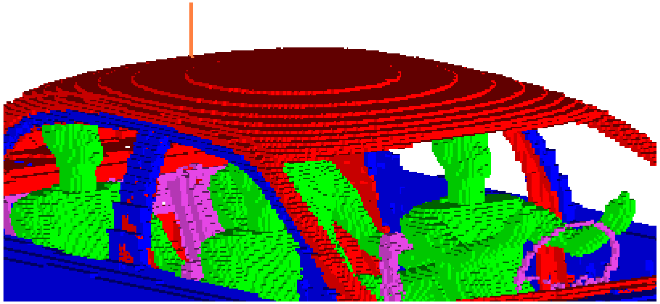
HOW CAN THE PROJECT ASSIST IN ASSESSING RF EXPOSURE?

- Calculation of electric and magnetic field strengths and comparison with reference levels
- Extension in some cases to compute SAR
- Example - some results given by Alastair Ruddle at EMC Europe 2006, Automotive EMC Workshop
- Roof mounted monopole antenna
- Tetra frequencies (390-430MHz)
- 4 homogenised human simulants
- TLM computation of fields
- 1.8m points in passenger compartment
- 53,000 points/person for SAR calculations



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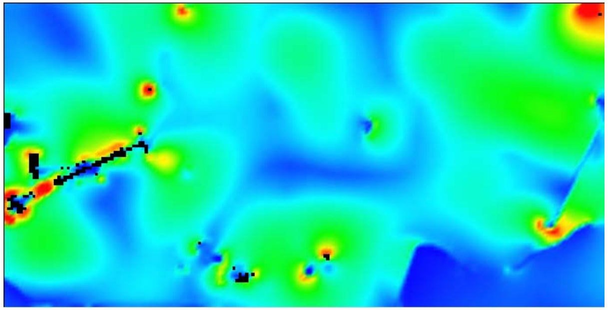
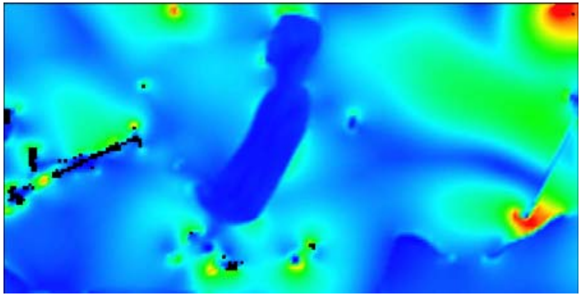
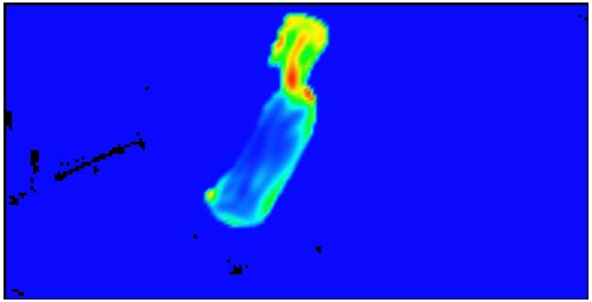
INTERNAL FIELD DISTRIBUTIONS



Empty vehicle



Vehicle + driver



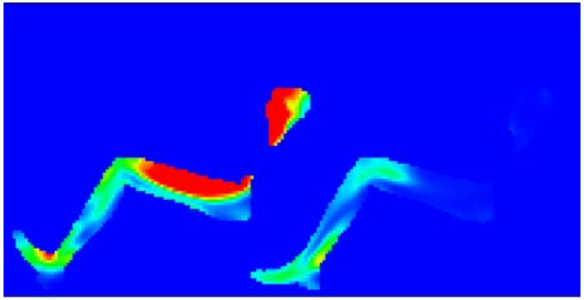
SAR distribution for driver (10g average)

SAR DISTRIBUTIONS

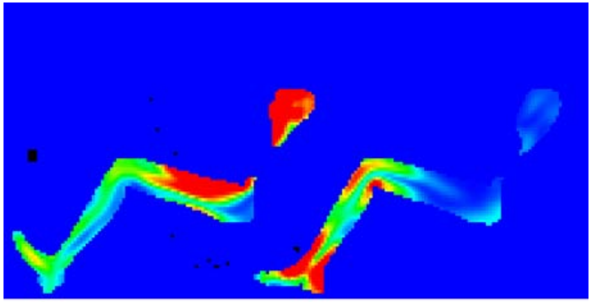
Driver with personal body-worn antenna on chest

Up to 3 passengers modelled

Tetra frequencies



No vehicle



With vehicle

- Driver shows maximum SAR in chest & trunk
- Passenger immediately behind shows maximum SAR in limbs
- For <u>this type of transmitter</u> SAR can reach maximum when mean fields do not exceed reference levels

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CALCULATION METHODS

- Techniques for calculation of electric and magnetic field strengths
- Full wave solvers – apply computational electromagnetics to solve Maxwell's equations (system of four coupled differential equations)
- Finite difference/FIT (Finite Integration Technique) & TLM methods – use a cuboidal mesh
- Finite element method – geometrical flexibility at expense of run time
- Boundary element method – body conforming mesh - FEKO
- Asymptotics (ray based methods) for electrically large structures
- Electrical size of model (d/λ) – mesh at 10 elements/λ minimum
- All methods good, but need – suitable CAD model & meshing tool
  - user with understanding of electromagnetics
  - adequate computer resources
- Intermediate level models - MESAF

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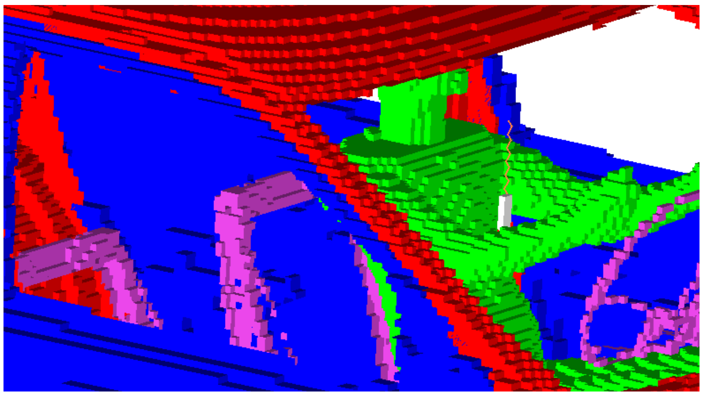
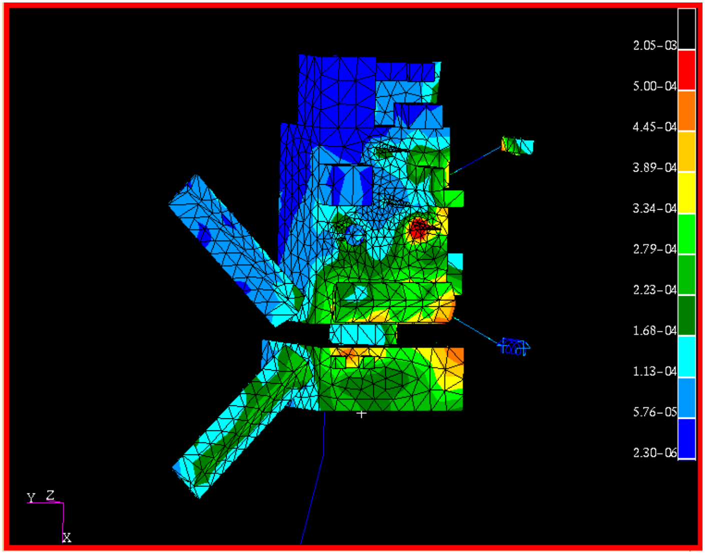
FULL WAVE SOLVERS



TLM Method – cuboidal mesh



Boundary Element Method – body conforming mesh

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MESAF - Multilevel EMC System Analysis Framework

Software specifically designed
for analysing complex products

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MESAF - Multilevel EMC System Analysis Framework

- Intermediate level software for EMC analysis
- Quick and easy to use on PC - EMC engineer focussed
- Designed for radiated emissions and susceptibility
- Indicate areas with compliance problems
- Determine risk of test failure
- Iterative - 'what-if?' analysis possible
- General software - any product, usable throughout design cycle
- Susceptibility, emissions, configuration definition
- Frequency domain (+ facility for FFT of results)
- Based on concept of electromagnetic topology – easy for user to define
- Connection of topological components is quantified by transfer functions
- Code automatically generates ISD - signal flow graph describing interconnection of the system
- Worst case path through ISD computed
- Some MESAF development funded through SEFERE project

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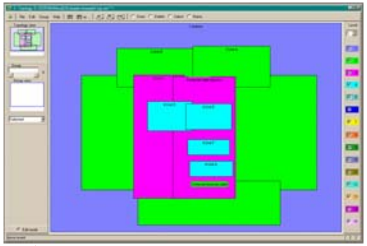
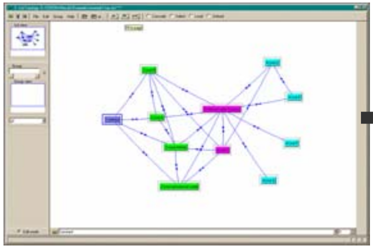
MESAF - Code Structure & Operation



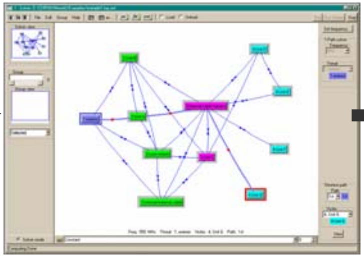
Topology Window

User inputs topology

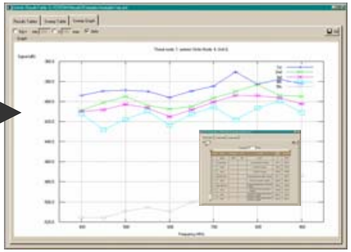
User populates database



ISD Window



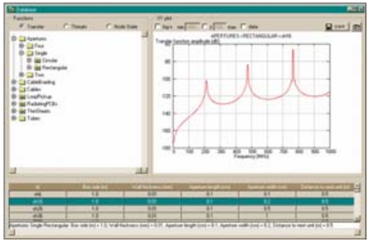
Solver Window



Results Window

User populates ISD with transfer functions

User defines frequencies



Database Window

User inputs (red arrow)

Automatic (black arrow)

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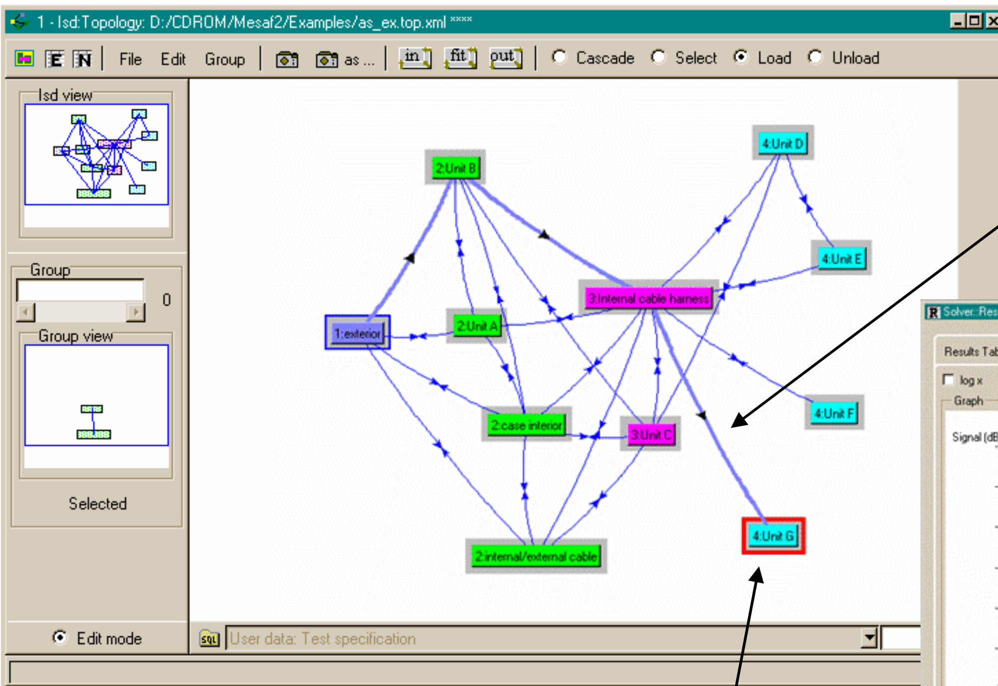
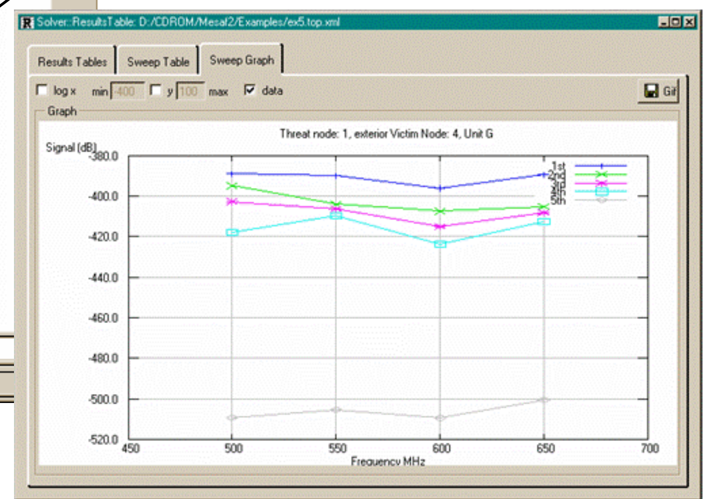
MESAF Solver – Worst Case Path & Results



Worst case path shown in blue



Red margin indicates that signal
at node is above specification level

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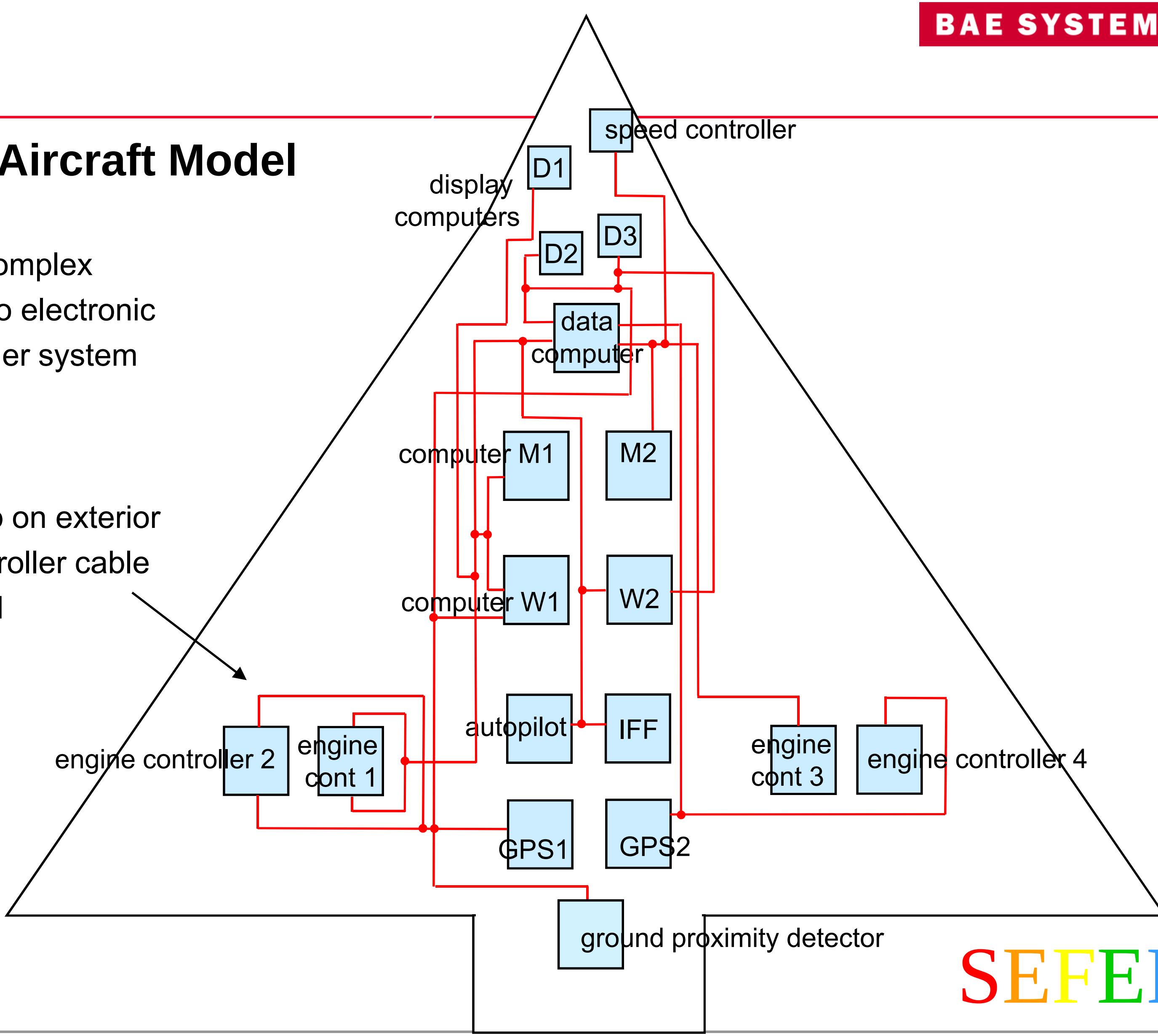
MESAF - Aircraft Model

Modelling of complex cable routing to electronic engine controller system

Current pickup on exterior of engine controller cable loom modelled



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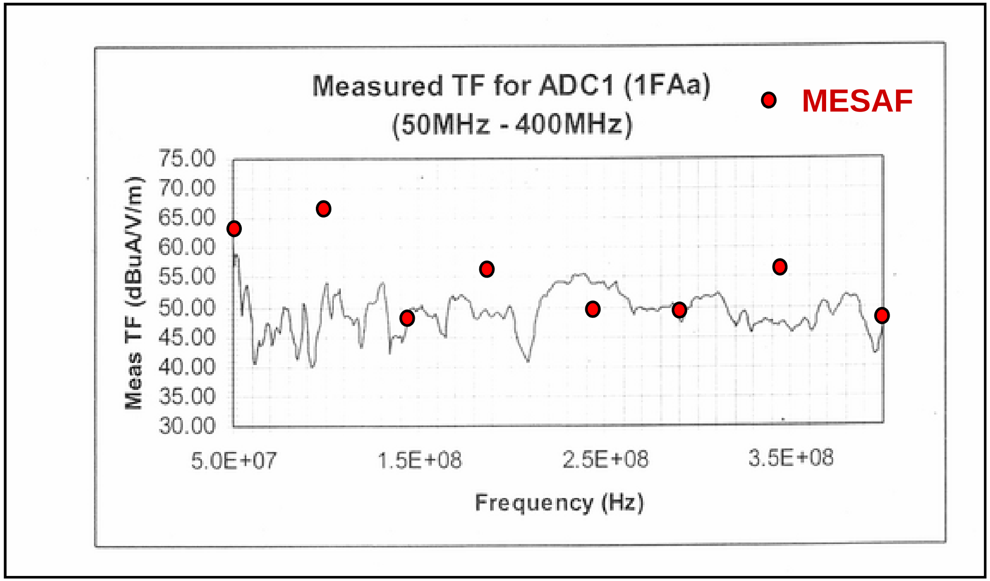
MESAF - Aircraft Model

Comparison MESAF/Measurements



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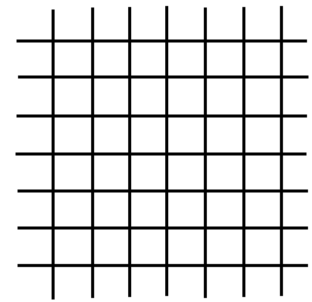
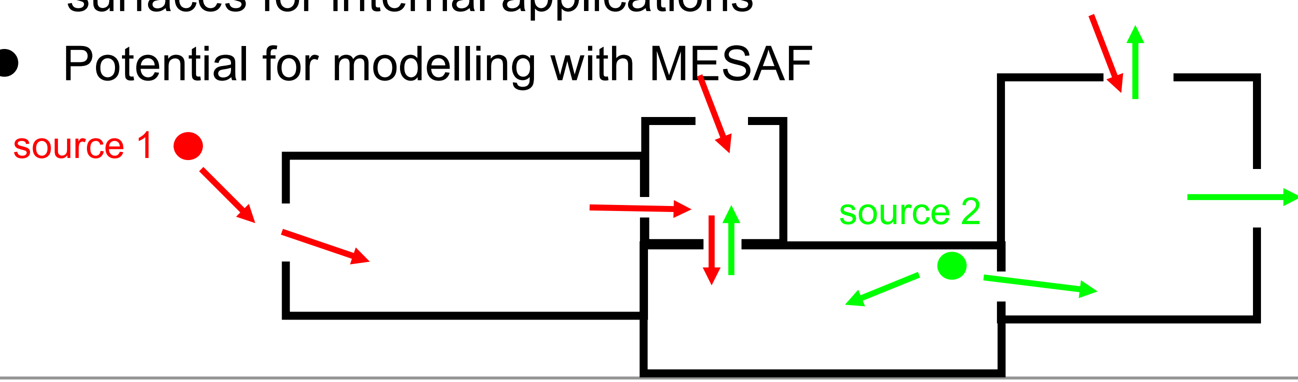
SYNERGIES WITH THE CONSTRUCTION INDUSTRY

- Increased use of mobile communications in the industry
- Buildings with conducting frames or cladding approximate to resonant/ sub-resonant cavities
- Note that conducting structure does not have to be continuous to provide screening – a mesh is adequate
- Intentional transmitters located within buildings, e.g. wireless LANs
- Can offer design and modelling of frequency selective surfaces for internal applications
- Potential for modelling with MESAF





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SEFERE - CONCLUSIONS

- Collaborative project investigating behaviour of fields in resonant/sub-resonant systems
- Modelling of RF exposure in vehicles - results
- Acquisition of expertise in appropriate CEM techniques
- Development of MESAF – software for complex systems
- Outline of potential applications in construction industry

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SEFERE CONTACTS

- Project Website: www.sefere.org
- Project Coordinator – Dr Alastair Ruddle, MIRA Ltd

  Alastair.Ruddle@mira.co.uk
- Prof Richard Langley, Sheffield University

  R.J.Langley@sheffield.ac.uk
- Dr Liz Davenport, BAE SYSTEMS

  Liz.Davenport@baesystems.com

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