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Integrated Modelling for Strategic Planning of Waste Disposal

A case study based on sewage sludge disposal

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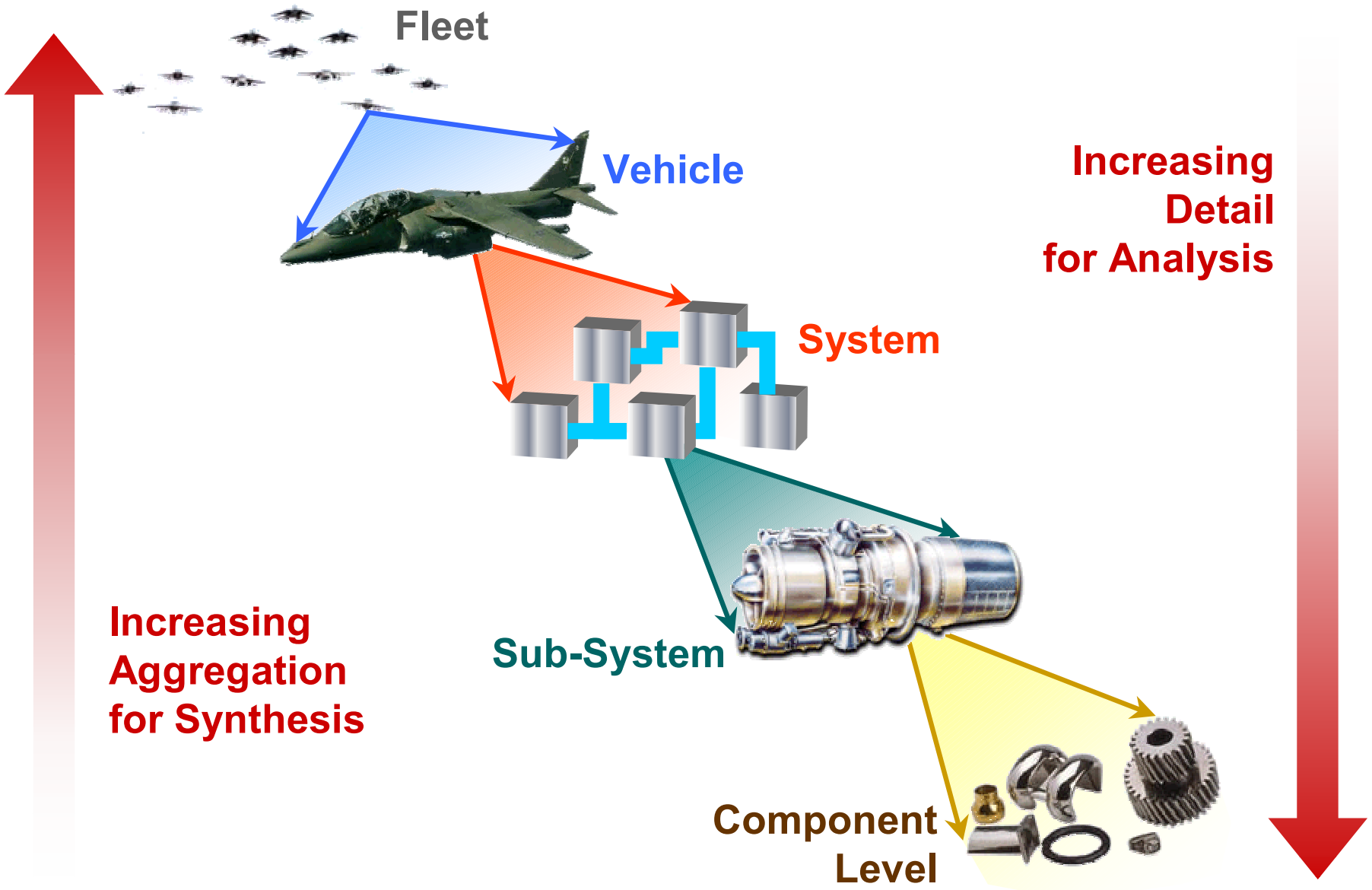
Integrated Modelling Environment (IME) for systems modelling

- Originally developed for the aerospace industry for air systems design support
- Later considered for use for aircraft fleet planning – deployment, operation & maintenance to fulfil strategic objectives


Fleet
Vehicle
System
Sub-System
Component
Level
Increasing
Detail
for Analysis
Increasing
Aggregation
for Synthesis

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Integrated Modelling Environment (IME) for systems modelling

- Generic systems modelling environment – not restricted just to aerospace

- Can be applied in other industries

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Integrated Modelling Environment (IME) for systems modelling

- Generic systems modelling environment – not restricted just to aerospace
- Process plant planning – deployment, operation & maintenance to fulfil strategic objectives
- In the case of the process plant, the strategic objectives might include sustainability
- Waste disposal is a process, requiring plant and subject to strategic objectives

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Integrated Modelling Environment (IME) for systems modelling

Example scenario:

- Disposal of 200,000 tpa of sewage sludge
- Plan and optimise a disposal strategy
- Routes
    1. Gasification or incineration
    2. Drying & pelletising
    3. Agricultural use
    4. Forestry
    5. Landfill

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Integrated Modelling Environment (IME) for systems modelling

Other considerations:

- Sludge rate increasing – 350,000 tpa?
- Will a new disposal strategy be needed?
- If so, do we:
    1. Increase existing plant size?
    2. Build new facilities?

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Integrated Modelling Environment (IME) for systems modelling

Five planning models considered:

1. Strategy for 200,000 tpa
2. Same strategy, but increased disposal to 350,000 tpa
3. Change the strategy
4. Increase plant size
5. Build new facilities

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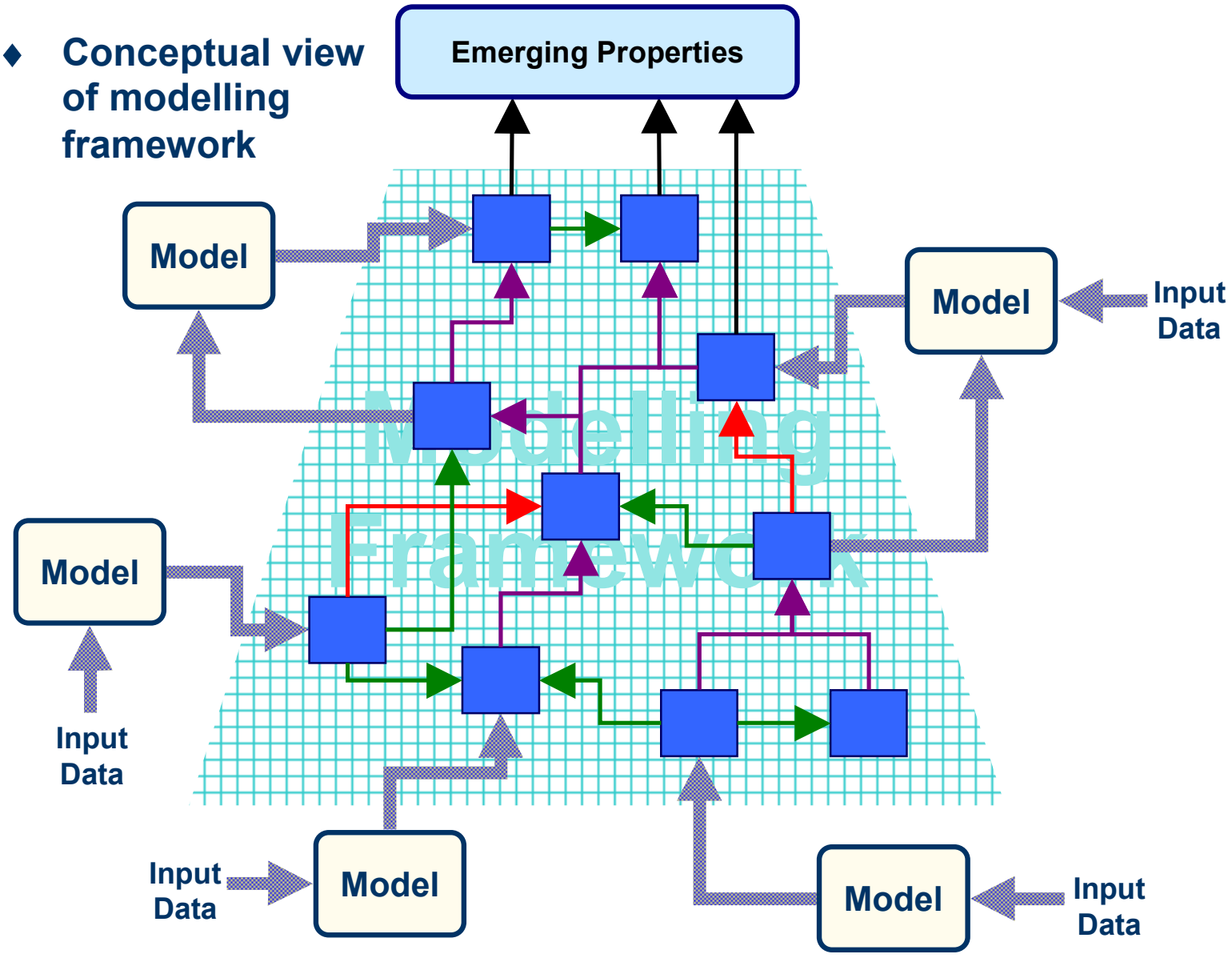
Integrated Modelling Environment (IME) for systems modelling

Planning models are systems created from component submodels

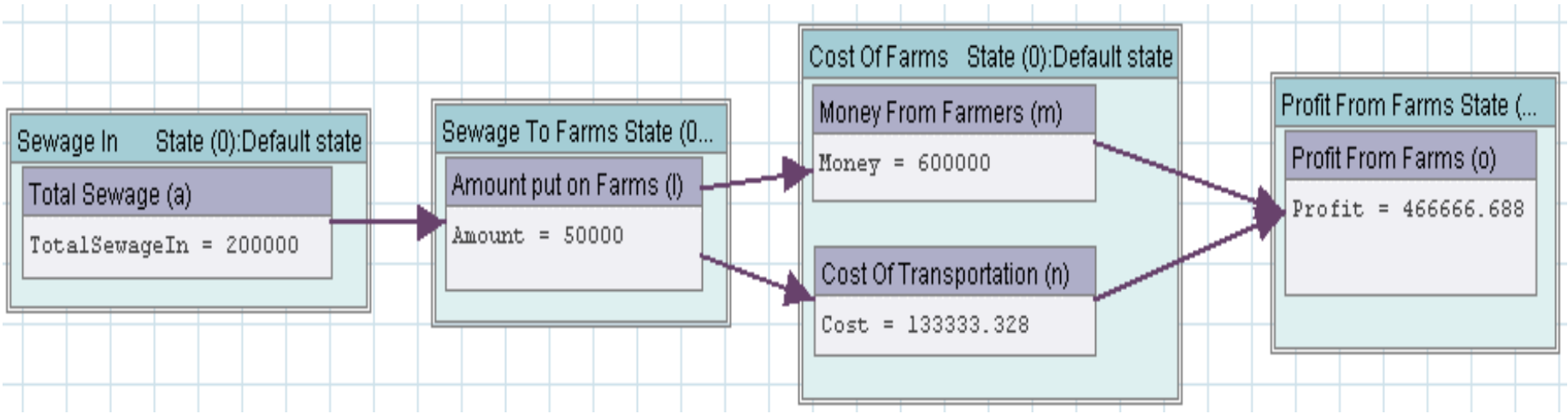
IME provides the framework to integrate submodels into the higher level system

No restriction on form, format or complexity of submodels that are integrated in an IME framework model

- Conceptual view of modelling framework



The system model is built from the component models using the IME modelling environment's plug-and-play graphical interface



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Integrated Modelling Environment (IME) for systems modelling

Component models:

- Simple or intricate – from tables, via Excel, to mega-models
- Data – experimental, real time, etc
- The IME meta-model is the integration medium
- The main practical issue is data compatibility
- For expediency in this case study, we have used tabular data models

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Integrated Modelling Environment (IME) for systems modelling

Component models used in the example:

- Gasification plant operational and sustainability models
- Pelletiser sustainability and operational models
- Other models such as transport costs, etc., entered directly into IME framework via graphical user interface

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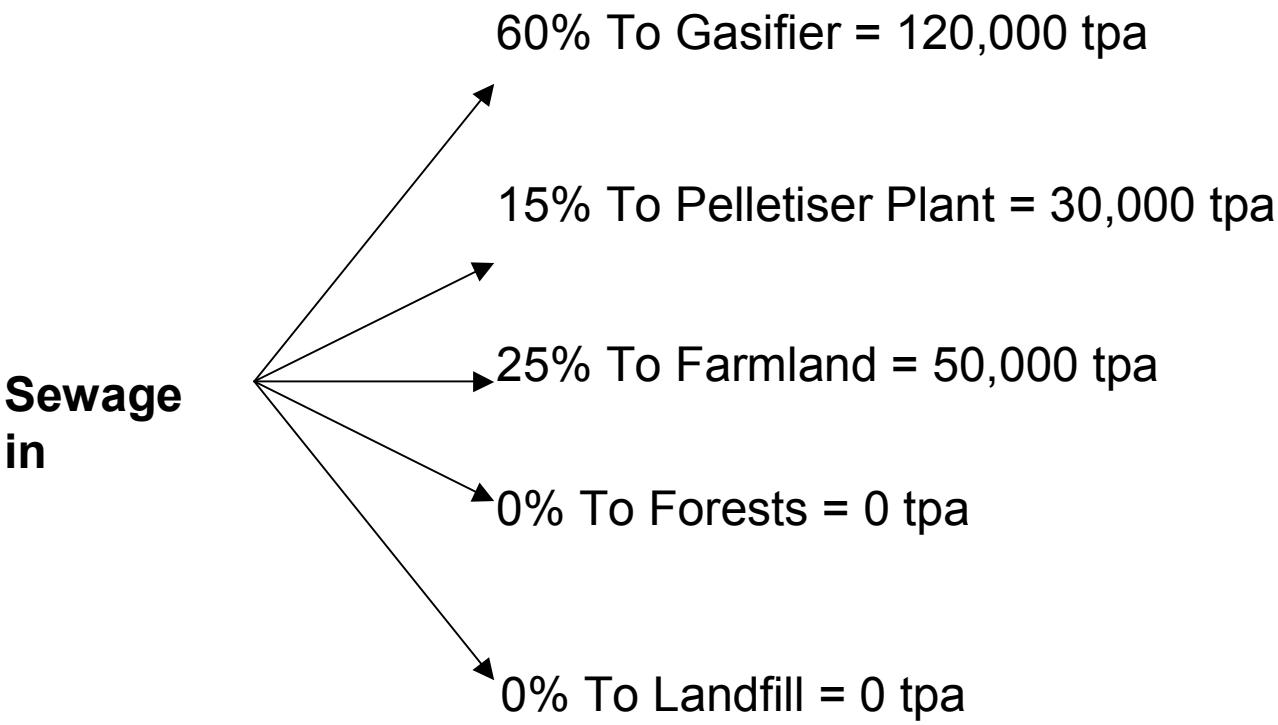
Example of Gasifier Sustainability model:

Amount of sludge (tpa)	← Sustainability scores →			
	ECO	ENV	SOC	Total
0	0.000	5.000	5.000	10.000
10000	0.000	4.750	4.680	9.430
30000	1.000	4.500	4.360	9.860
50000	2.000	4.250	4.040	10.290
70000	3.000	4.000	3.720	10.720
90000	4.000	3.750	3.400	11.150
110000	5.000	3.500	3.000	11.500
130000	5.000	3.250	2.700	10.950
150000	0.000	3.000	2.400	5.400
170000	0.000	2.200	2.000	4.200
190000	0.000	1.500	1.000	2.500
210000	0.000	0.000	0.000	0.000

Example strategy for disposal of 200,000 tpa sludge



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Example strategy for disposal of 200,000 tpa sludge
Outcome predicted by IME model

Top level results:

Profit: £1.59M pa

Sustainability number: 53.5 out of 75

If the required disposal rises to **350,000 tpa**, the disposal option (based on existing strategy) shows:

Loss: £3.6M pa

Sustainability number: 28.5 out of 75

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Example strategy for disposal of 350,000 tpa sludge

The strategy is now changed, with differing proportions to the various disposal routes:

Loss: £3.0M pa
Sustainability number: 34.2 out of 75

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Example strategy for disposal of 350,000 tpa sludge

The gasifier capacity is increased by modifying the existing facility:

Profit: £1.1M pa
Sustainability number: 35.9 out of 75

Finally, a new gasification facility is built:

Profit: £2.9M pa
Sustainability number: 49.3 out of 75

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CONCLUSIONS

The IME has amply demonstrated its capability for modelling strategic planning scenarios beyond its original remit in aerospace

The IME is extremely flexible and can accommodate a range of models.

In this case, a simple sustainability model has been built in, which gives an overall indication of system sustainability.

New features are being introduced that will improve the utility of the IME, including:

An optimisation facility
An audit trail for design decisions
Capability for design re-use.