SETE 2003
practical approaches for COMPLEX SYSTEMS

Raytheon Australia

Requirements and Techniques for Early Representation of Complex Systems

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The pitfalls …

- Chance of a Fortune 500 company SW Project coming in on time and budget - ***23.6%.*** Cancelled before completion - ***40%*** (source: Standish Group)
- US Federal Aviation Authority commenced system revamp in 1982:
  - 4 year design study, 2000 engineers involved
  - These subsystems undergo individual iteration in design
  - “Requirements analysis” performed, ATC personnel not consulted
  - No prototyping before or during design phase
  - ***Result: US $ 8 Billion cost overrun***

Coverage

- Issues with Complex Systems
- Early Understanding and Representation
- Facilitating Early Representation - The two layer model

Issues with Complex Systems

- Recent advances in science & technology have led to increased complexity in engineered systems
- Not only do we have complex boxes, these boxes now *talk to each-other!* - Internet, GPS, sensor networks, network-centric warfare….
- Complex Systems are composed of heterogeneous sub-systems with individual behaviours
- These subsystems undergo individual iteration in design

Throughout the Development Lifecycle Q's need to be addressed

- How will it look & feel?
- Will it scale?
- Will it work with legacy systems?
- Can we use it to support training ?
- Time to market ?
- Can we boost the throughput ?
- Will it support system loads?
- Is it easy to maintain?
- Can we re-use components?
- What is the impact on other components if we make modifications?

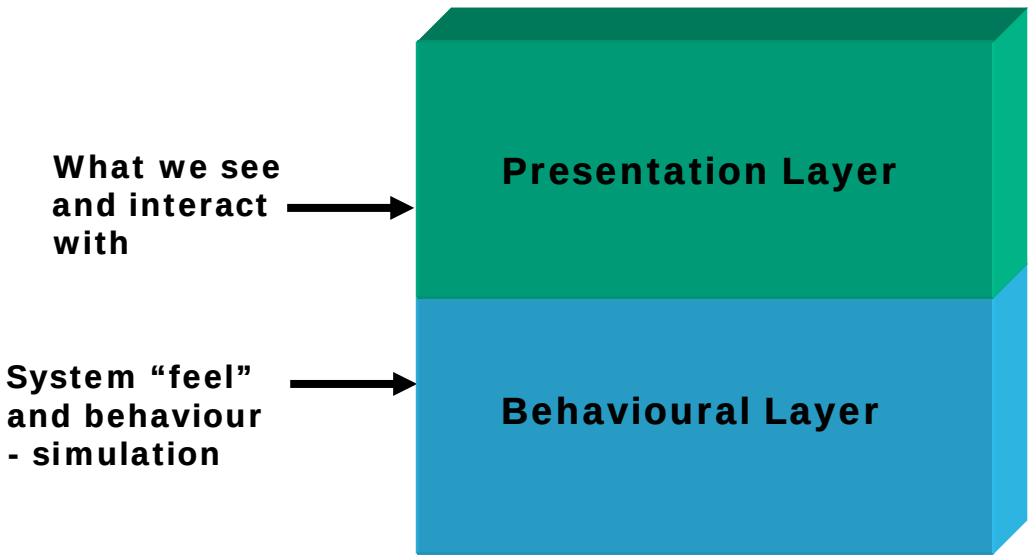
Early Understanding and Representation of what we need?

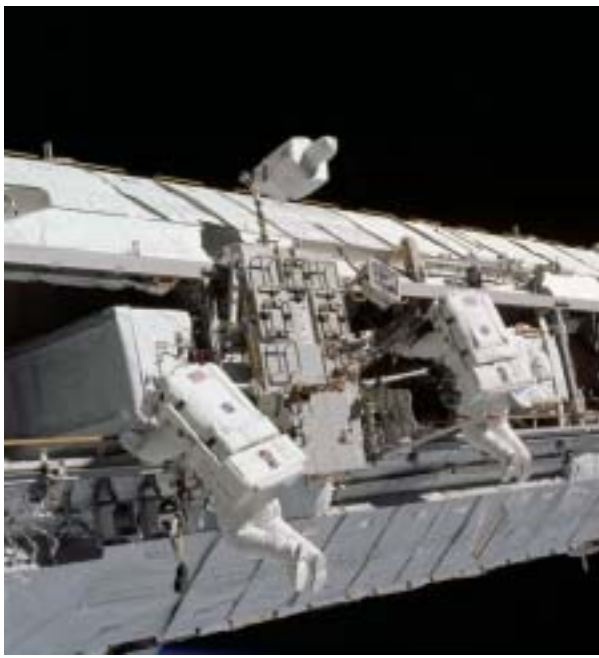
- Achieved through Simulations that are:
  - Capable of being rapidly developed
  - Flexible
  - Scalable
  - Portable
  - Support Risk Mitigation strategies
  - Ultimately provide significant ROI

- Can be applied as early as possible and are applicable throughout the development lifecycle.

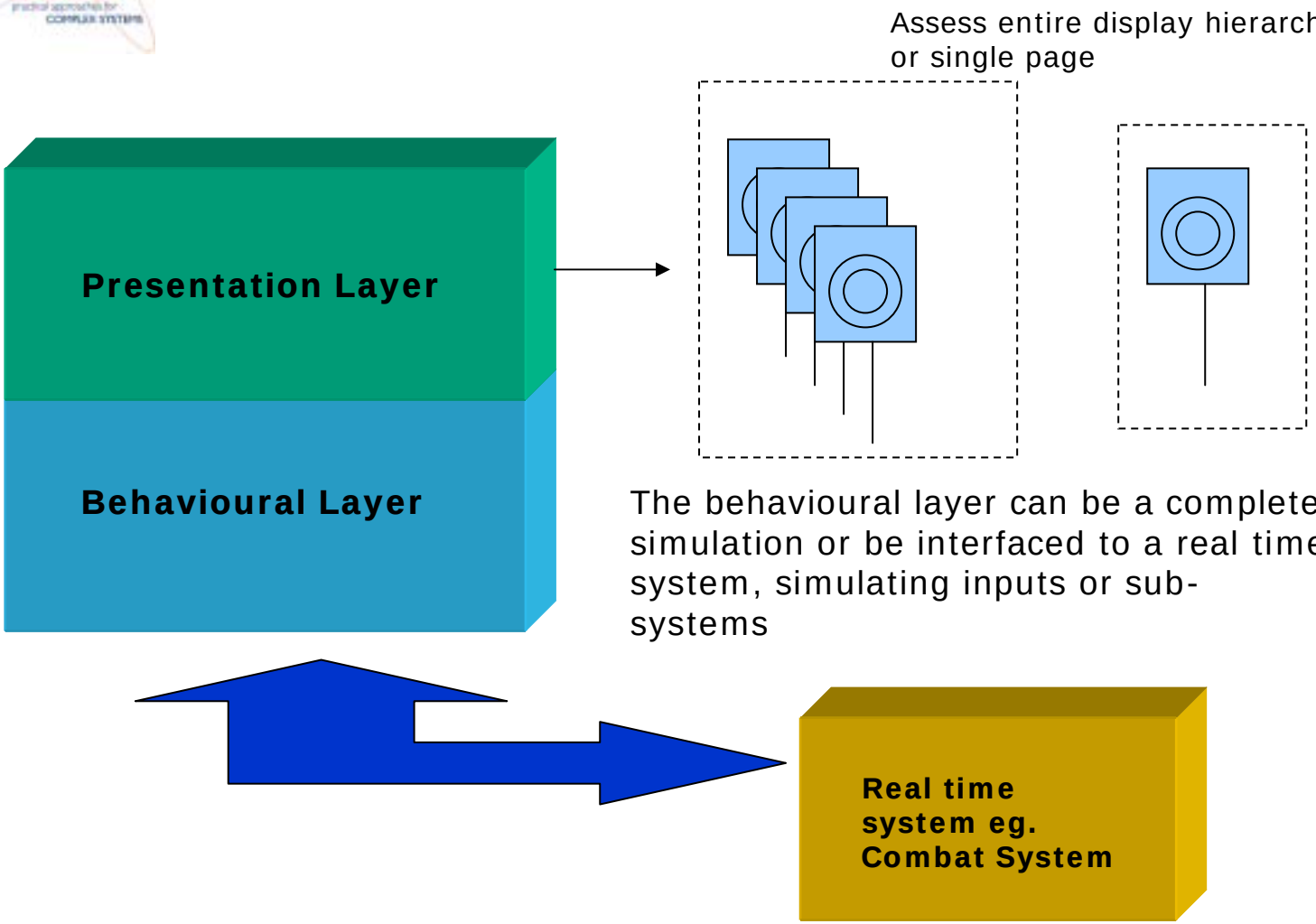
Facilitating Early Representation - Two Layer Approach

- "Representation" of any system involves considering how the real system "looks" and "feels" (or behaves).
- We can consider the representation of a system through a two tier approach:





How the two layer approach works



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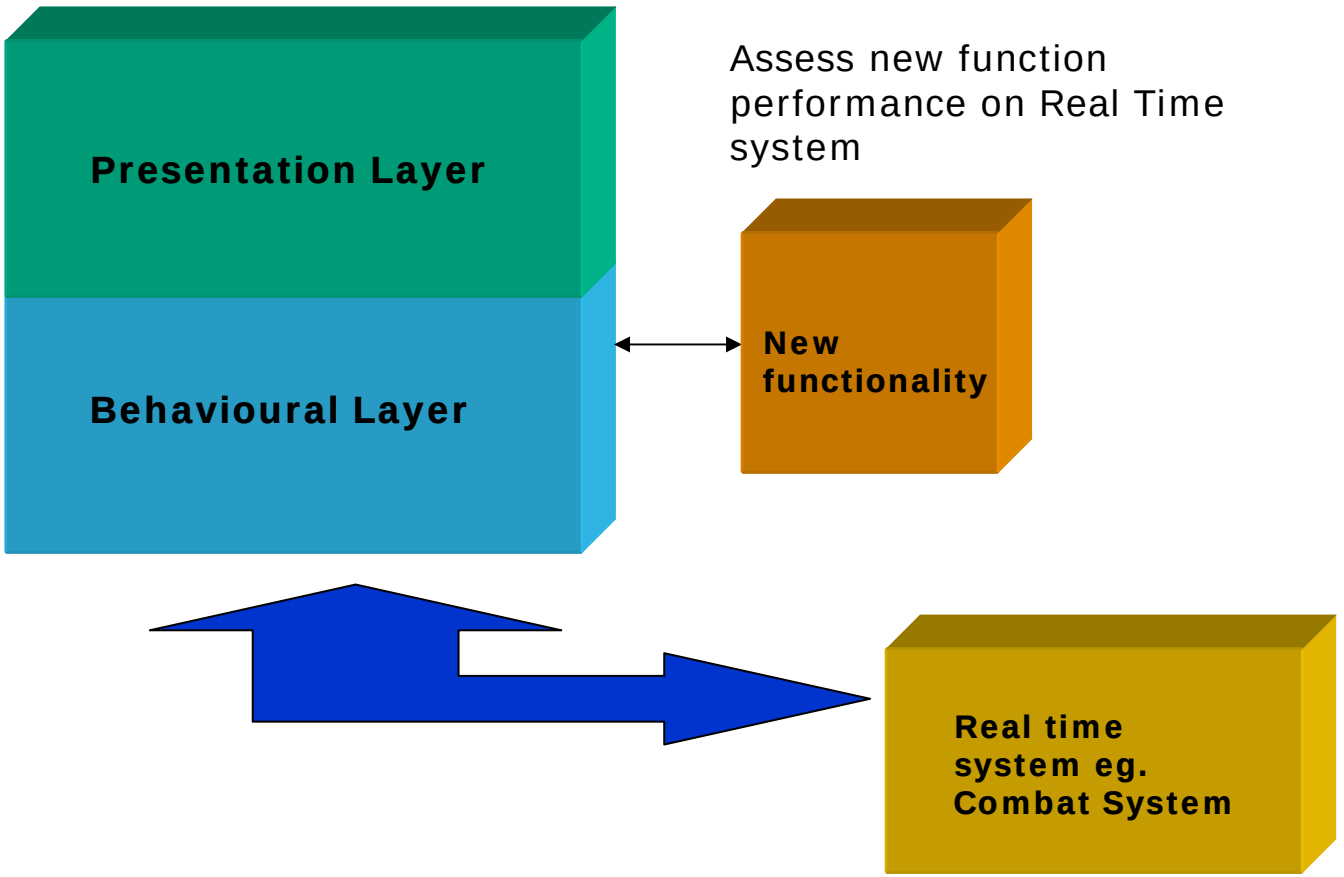
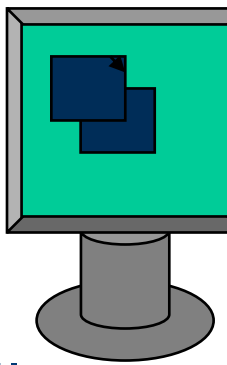


Facilitating Early Representation - Presentation Layer

- The User Interface (UI) is the first aspect of any system that is encountered by humans
- The UI provides system monitoring and control - it is a view into the system & is a good place to start in its conception
- The UI is subjective, risky and should be addressed early. This requires a rapid development capability for UI representation……...

Rapid UI Development

- Provides ability to rapidly prototype display systems with end-user buy-in (via workshop-style approaches and Human-Computer Interaction (HCI) analysis)
- Require infrastructure to capture, track and incorporate user feedback into prototypes in a controlled fashion
- A variety of GUI Tool-kits and development environments available to facilitate layout of the UI
- Need a simulation back-end to stimulate the UI



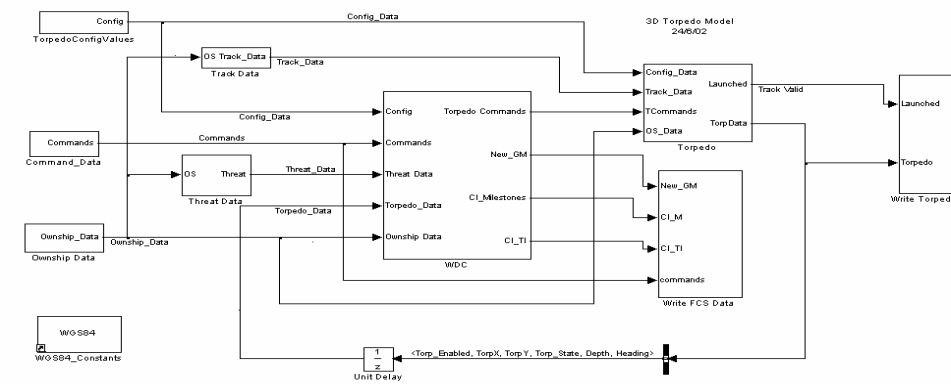
Facilitating Early Representation - Behavioural Layer

Behavioural layer

- Simulations consists of models executing over time. So we need
  - Models
  - Communications infrastructure
- As related earlier, we want simulations early to help in the lifecycle activities - this requires a rapid development capability

Modelling

- Describing behaviour through models
  - Model: physical, mathematical or logical representation of a system entity, phenomenon or process.
  - Input->Reaction->Output
  - Reaction: Simple to complex formulation (resolution/fidelity)

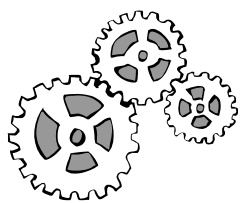


Modelling - Requirements

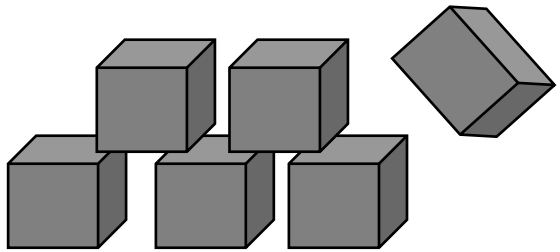
- Rapid Modelling
  - Coding models is usually a complex task
  - Can accelerate using graphical-based tools such as Simulink
  - Component-based models - reusability - cost savings
- Modelling Tools
  - promote model visibility/clarity
  - easily tuned/modified/verified

Communications Infrastructure - Requirements

- To enable contribution to the different phases of the system development life cycle, the simulation communications infrastructure needs to be:
  - Flexible (want to be able to introduce new elements as required)
  - Scalable (want to be able to increase/decrease scope)
  - Portable (want to be able to run on heterogeneous platforms)
- This is currently well catered for by the use of a middle-ware technology



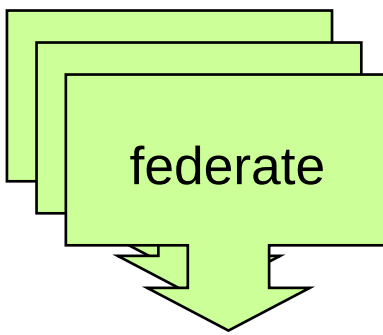
Component Architectures



- *Component Architecture*
  - Architectures composed of modular, self-contained and re-usable components.
- *Model Repository*
  - Build models as re-usable components
  - can be re-used in other simulations
- *Composable Architectures*
  - simulations for different applications can be built from common components

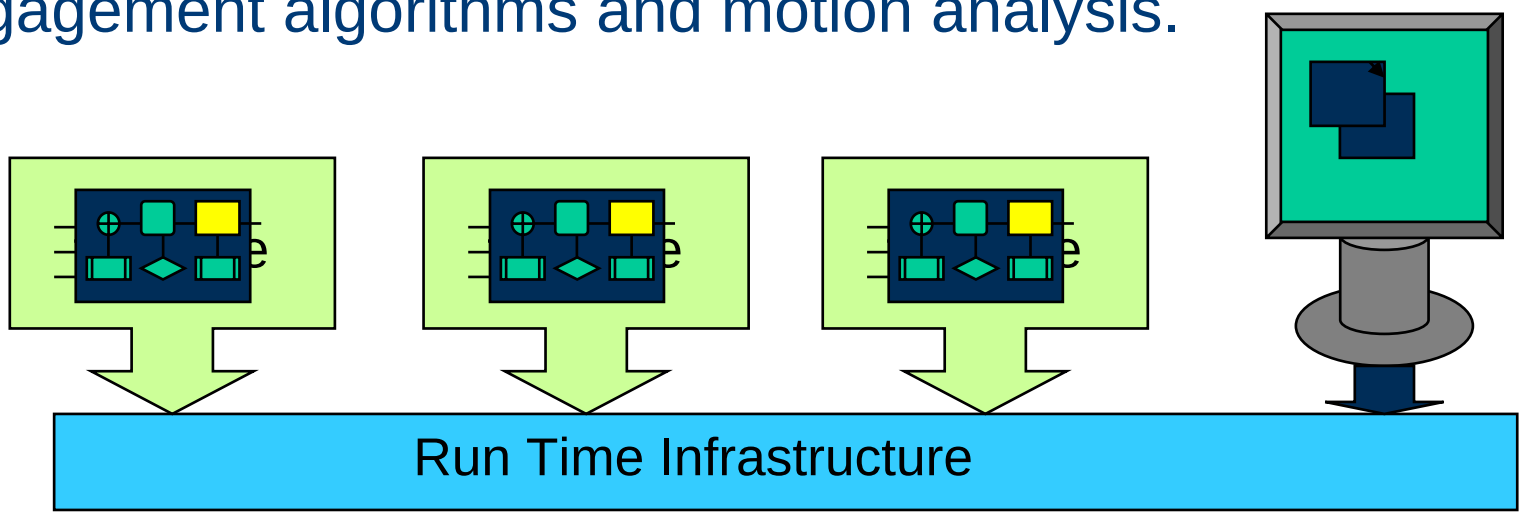
Models as Components - HLA Federates

- High Level Architecture (HLA): An architectural paradigm specifying an approach for the aggregation of discrete simulations.
- This aggregation is known as a ‘federation’ comprising of ‘federates’ linked via the ‘RTI’
- This is an approach Raytheon has adopted to allow us to componentise models and achieve a common communications infrastructure.



Rapid Component Integration - HLA Federations

- Federates can be considered to be components within a federation. Interfaces are well-defined and federates are re-usable.
- Raytheon has used this approach for the modelling of submarine combat system aspects such as torpedo engagement algorithms and motion analysis.



Conclusions

- Early Representation of Complex Systems is a useful approach that minimises the risk of failure at each stage of development from requirements definition to build/integration. Rapid techniques are required to facilitate this.
- The approach prescribes a two tier model consisting of a presentation and behaviour layer.
- The layers maximise the use of graphical tools, component-oriented architectures and middleware to enable rapid production and configuration.
- The approach aims to reduce both cost and risk throughout the engineering life-cycle.

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Some of the graphics used in this presentation have been sourced from the National Aeronautics and Space Administration site: http://spaceflight.nasa.gov/gallery/index.html