

Vehicle System Design Process

M. Squair

Principal Engineer – Systems Assurance

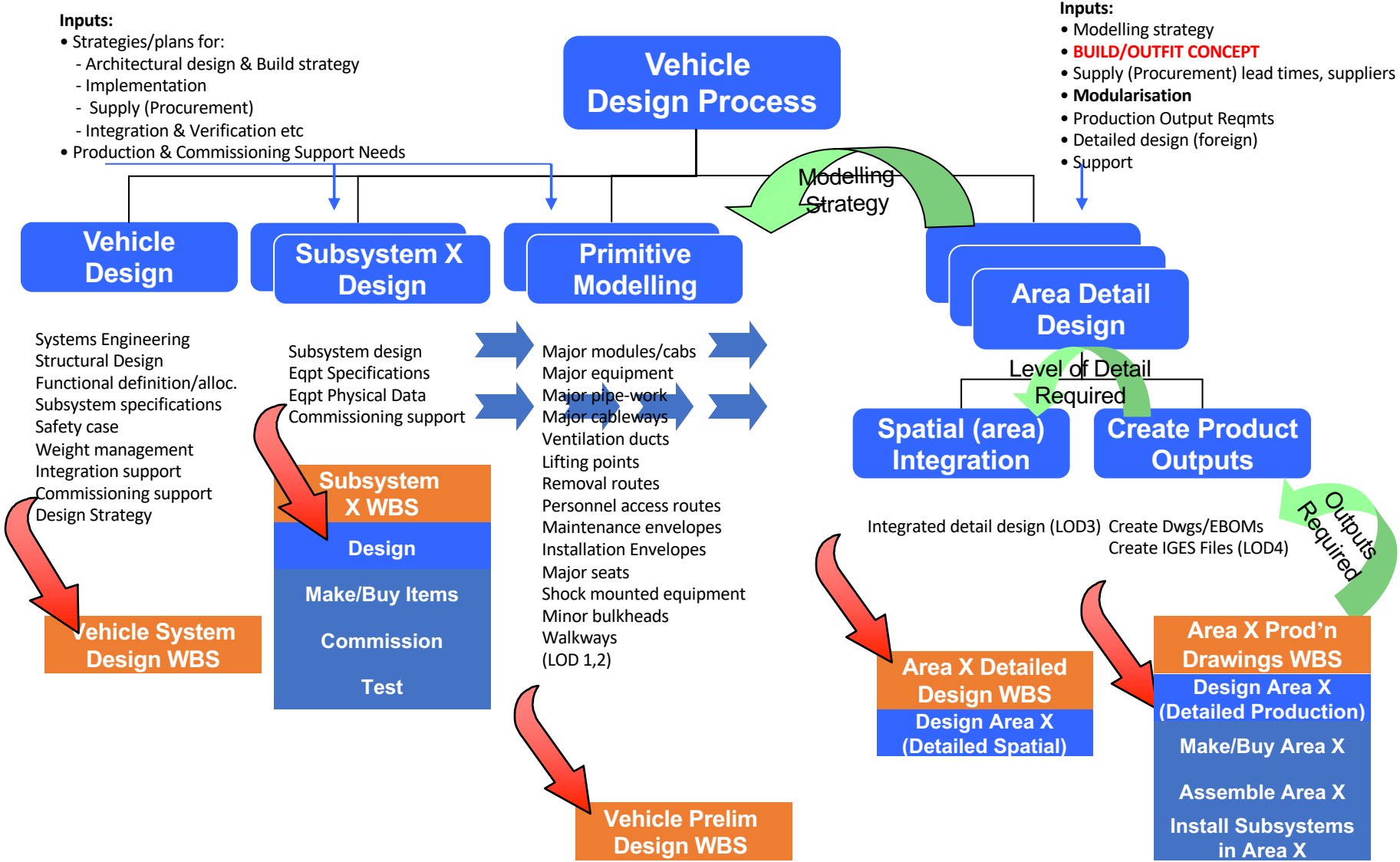
Architectural Design

- Currently we have little that defines a process for architectural design
 - Start out with a set of 'system' requirements & end up with production drawings
- And in the middle?
- Reality is that design proceeds *concurrently* at
 - System level
 - Subsystem (functional design)
 - Detailed physical design of the vehicle
- Traditional response to concurrency is to adopt a first pass (primitive modelling) then second pass (detailed) modelling
- Nor forgetting the need to make advance parts buys to make schedule (lock in solution at piece part before system/subsystem design)

Design WBS Ambiguity

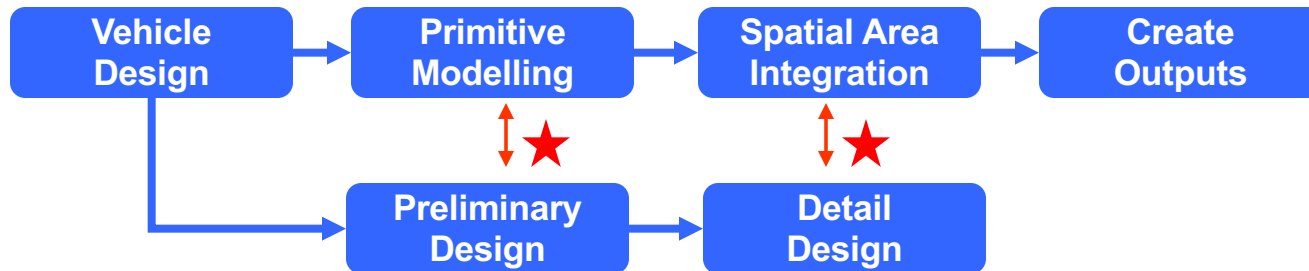
- A problem with the current engineering WBS is the concept of 'areas' in design
 - Used to represent the design principal of an integrated 3D model
 - Designers work in areas to develop a model then from the model 2D drawings are generated for manufacture/procurement
 - Input design of procured components & adjust vehicle design e.g. bracket design, move components around, reroute cables & ducts
 - Represents a integrating (vehicle system) level design element
- **Problem:** A Model is not a deliverable of itself, so a 'physical area' as a WBS element makes no sense unless it is tied to specific deliverables.
 - **End result.** Modelling becomes an end in itself → OSCAR Design Blow-out

Proposed Total *Vehicle* Design Process



Subsystem Design

- What About Subsystem Design?
- How does a phased design approach integrate efforts
 - Remember the V Model
 - Are system (Vehicle) & subsystem design in parallel?
 - If so does subsystem prelim design leads/lag \leftrightarrow Vehicle prelim design?

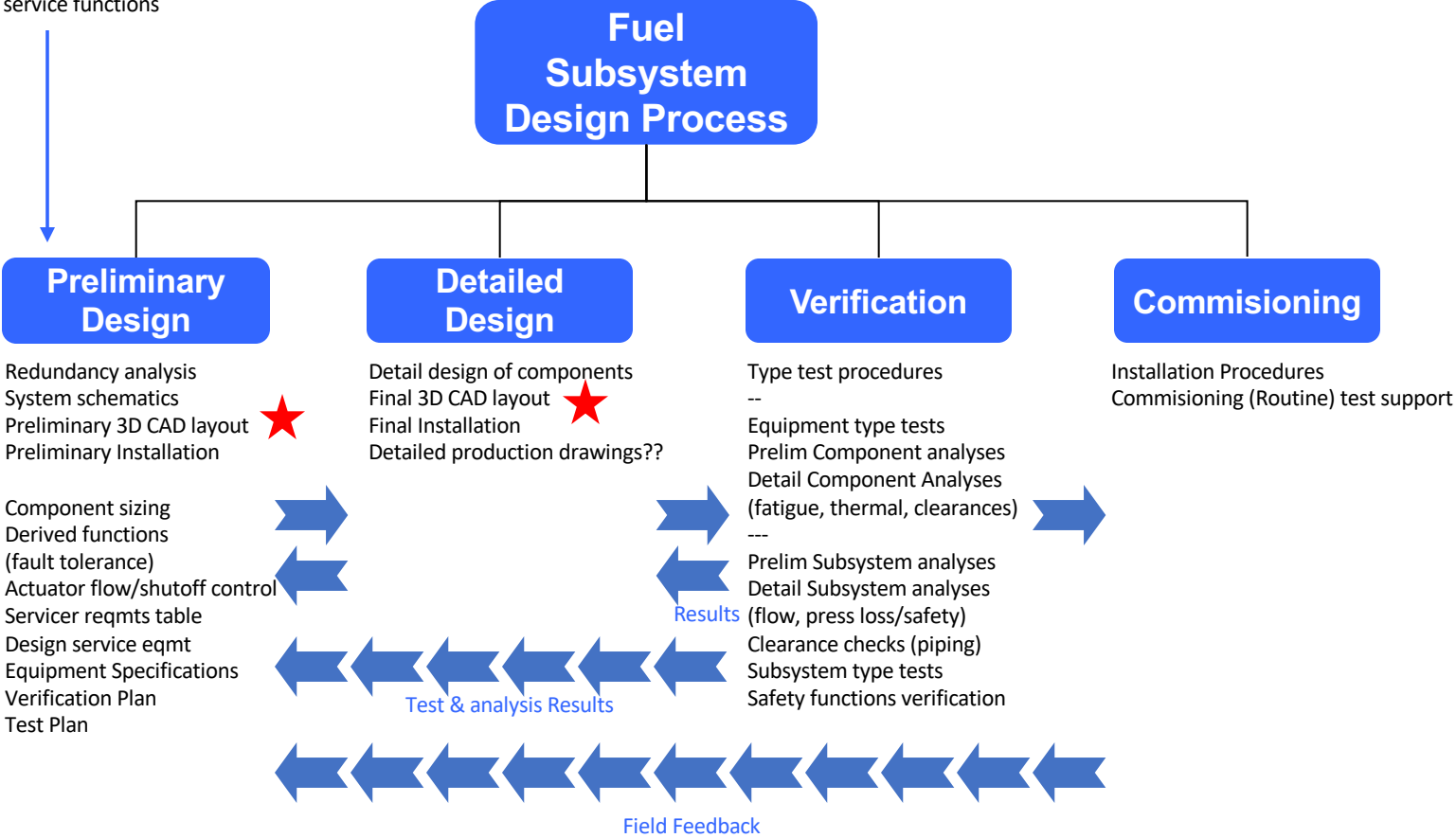


★ Interface to vehicle design? Completion of subsystem design phase = Entry Criteria for Vehicle Phase End Control Gate?

Example: Fuel *Subsystem* Design

Inputs:

- Required Fuel service functions



★ Interface to vehicle design? Completion of subsystem design phase = Entry Criteria for Vehicle Phase End Control Gate?

Design Process & WBS

- The original design WBS reflected an attempt to address the subsystem design versus area integration problem
- Model 'areas' are not an end in themselves, need to identify the deliverables
 - Some elements of the modelling task = vehicle design
 - Intermediate product (Primitive to detail modelling)
 - Some elements of the modelling task = detailed design
- To successfully integrate engineering effort to manufacturing effort a common framework for manufacture, assemble & commissioning of the product needs to be established
- Bottom line – Physical area WBS (in Design WBS) needs to be merged with actual manufacturing WBS Areas
 - Shipbuilding has been doing this for years

Design Management

- Level of work at each preceding step defined by required outputs to next
 - Production drawing needs (end user) defines detailed area modelling
 - Detailed modelling strategy defines level of primitive modelling required
- Question, where are these requirements defined currently?
- Subsystem design (equipment) is an intermediate design input
 - Require delivery iteratively e.g.
 - envelope & mounts to primitive modelling
 - then detailed interface to detailed spatial modelling

Distributed Subsystems

- Design distributed subsystems (lighting, power, pneumatic etc) functionally
- **But, we build by module/zone/area**
- Result is production 'cherry picks' information from various source documents, time consuming and error prone – especially for spaghetti (wiring & piping)
- **Cure:** Integrate area /modular outfit into distributed subsystems
 - Wiring, piping, paint schemes, ducting design by area
 - Easy to mate interfaces between areas
 - Integrated drawings package for areas
 - Carry back partitioning into system schematics
- Ideally integrate (wiring tests & checks) by area, then integrate areas as part of commissioning of subsystem – **Mileage may vary**
- **Allows for off vehicle test & checkout then plug in and play**

Product Line Management

- By definition
 - New product variant should *not* change the fundamental product line design
 - Review for impact
 - But where is this captured, how can it be reviewed?
 - Changes to some system, subsystem design (for example ECP)
 - More change at model level (assuming a detailed model has been created)
 - New elements step through LOD refinement 1→3,4
 - **Do/Don't revisit primitive modelling?** – How do we capture installation & access routes in detailed models?

Other Benefits: Outsourcing Design

- Modularisation allows us to efficiently outsource design
 - Defined and lock down interface
 - Subsystem design needs to be managed 'through' the module design
- A vehicle design process gives us the methodology 'who', 'what' & 'when'
 - Outsource primitive modelling (we fill in the detail), OR
 - Outsource the detail (they fill in the detail), OR
 - Completely outsource design (to an agreed interface)*

Reference

- People who use this process, or a variant thereof:
 - Electric Boat (Submarines)
 - BAE Systems & Alenia Marconi (Shipbuilding)
 - General Dynamics & Lockheed Martin (Shipbuilding)

Recommendations

- Accept that we have a 'chicken & egg' concurrent design process
- Define lead/lag relationship between subsystem and vehicle design
- Merge physical manufacturing areas with design areas using WBS
- Establish how we manage zone/area design interfaces
- Define subsystem design inputs and sequence to modelling
- Integrate area/modularisation into distributed subsystem design process
- Define scope of engineering WBS in the WBS dictionary

- Revise the Design Process Procedure