Estimating Fiction

SCAF Workshop – Support Solutions
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Gareth Johnson
Parametrics Lead – Future Programmes & Support

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Understanding the **issue**

How do we estimate three decades of Support Costs,

for something that won't be on the line for two decades,

utilising technology that hasn't been invented yet?

Gareth Johnson
Future Programmes & Support

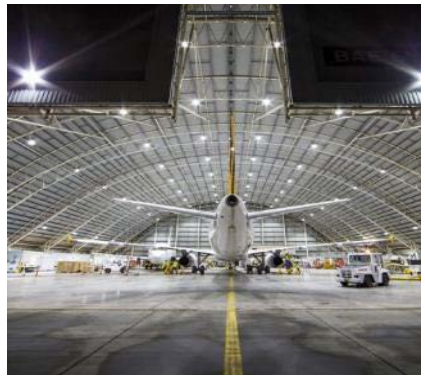
- Lead Parametric Estimator – BAE Systems Future Programmes & Support
  - 22 years in the Aerospace Industry – 20 within the Estimating Function
  - ACostE (5), BA Hons (Business), HND (Electronic Engineering)

- BAE Systems Military Air & Information
  - Future Programmes & Support – Parametric Estimating Lead
  - BAE Systems Saudi Arabia – Estimating Typhoon Aircraft Support Riyadh
  - Aircraft Training Academy – Estimating Group Leader

- MBDA Missile Systems:
  - Technical Apprenticeship
  - Parametric Estimating – Business Cost Forecasting Future Projects
  - Export Weapons Estimating & Pricing Lead.

The reality

- Future Programmes & Support (FP&S) is at the forefront of the next generation Combat Air Vehicle.
- We work very closely with the MoD:
  - Multiple Concept Aircraft Studies.
  - Multiple technology advancement projects.
  - Multiple development aircraft programmes.
  - Creation of new development strategies.
  - Creation of new manufacturing / production methods
  - Creation of new approaches to aircraft support.
  - Technology trades
- Providing early phase costing for all the above activities through a variety of estimating techniques and applications.
- Need to provide confidence and a thorough understanding of the generated outputs.



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The Future of Aviation Technology

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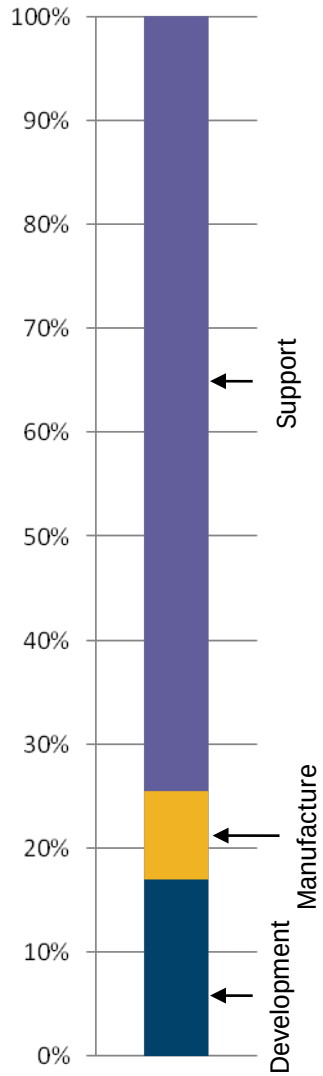
Support – What's all the fuss about?

- **Support is the driver** when assessing the Whole Life Cost (WLC) of aircraft.

- Historically, aircraft are assessed on their development and manufacturing costs, support costs can be a secondary consideration.
  - Focus has been on the short-term, not the long term.
  - How can we influence a shift in thinking?

- Continuing to apply 'as is' thinking creates a static environment. Need to constantly evolve to move forward. Maintain that competitive edge.
  - Is it more cost effective to invest in technology and solutions up front, to offset future cost?
  - Can we design to reduce support?
  - With each generation of aircraft development, more and more emphasis is being placed on the WLC, in particular, support.



Cost Breakdown of a typical Military Aircraft

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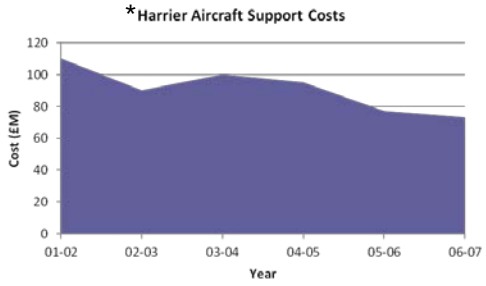
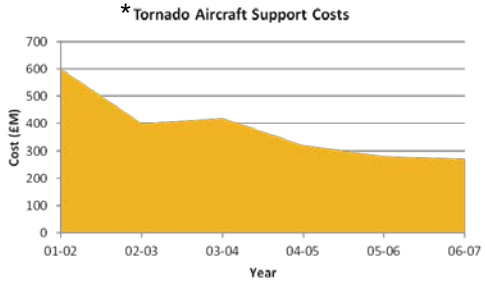
Historical Support Trends

- Can we establish any relationships or trends for aircraft support from actual or historical information?
  - Can we apply these trends to a future programme?
  - **Understand what is driving the historical trend.**
  - Data needs to be 'normalised' in order for it to be used with any confidence.
  - Assessment of multiple data points is required to apply a level of confidence and eliminate the risk of a 'one off'.
- Engage with Subject Matter Experts from across functions, industry, and the Customer base.
  - What direction does the Customer want their future Maintenance / support policies to go?
  - Is Industry able to match this vision? Compromise?
  - Where is the technology going to be? Will this mature in the timeframe being estimated?
  - Significant increase in Software content with each generation.





* National Audit Office Reports

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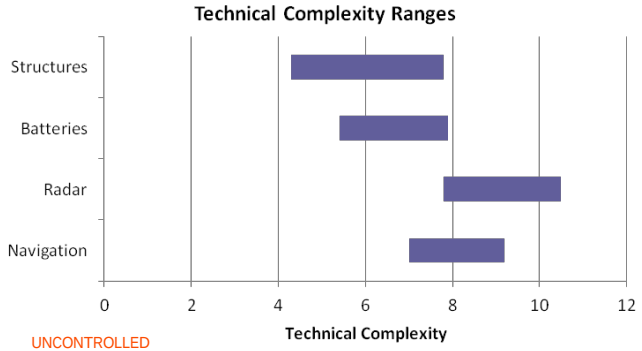
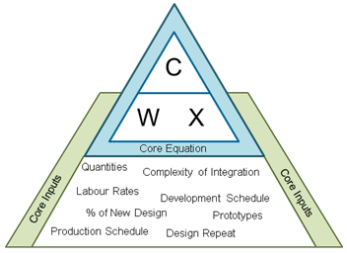
Estimating Future Technology & Support

- Parametric models utilise historical data to generate Cost Estimating Relationships (CER's).
  - Used to predict future technology trends.
  - **Estimate Hardware and Software costs** through development and Production.
  - Hardware costs then used for **Spares & Repairs estimates** through Support.

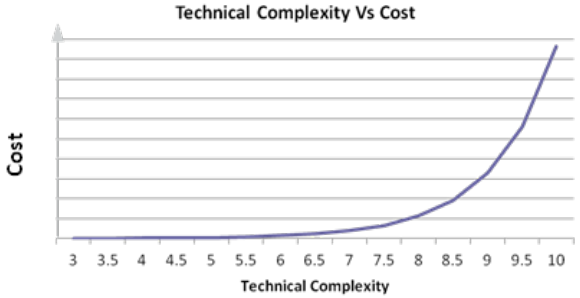
- BAE Systems utilises many Parametric models. The FP&S Team predominantly use PRICE Systems True Planning for Hardware and Software estimation.
  - Model has been used in the Aerospace Industry for over 4 decades. Contains 1000's of comparative data points which can be utilised for parametric cost estimation.
  - This is supported by in house calibrated data to give a 'BAE Systems View' of the industry data.





C = Cost
W = Weight
X = Technical Complexity

TruePlanning® by PRICE® Systems



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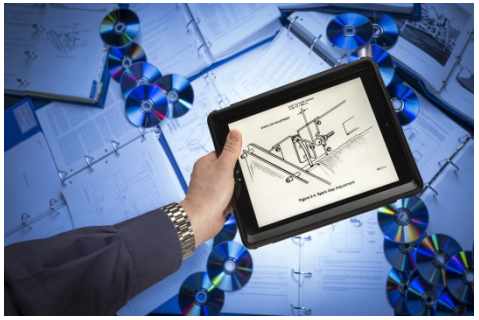
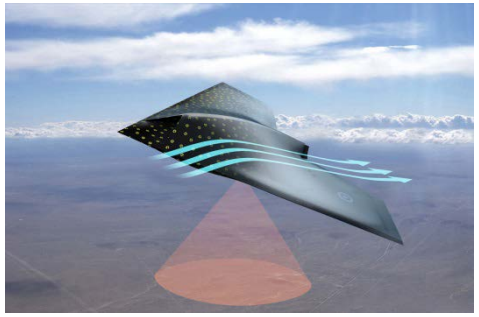
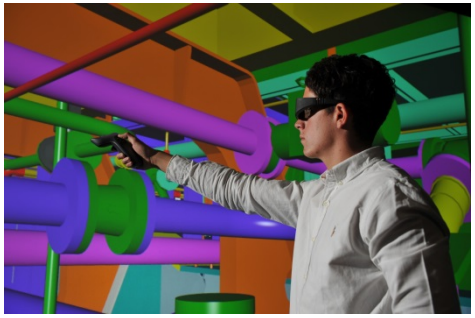
Visualising a Future Support Solution

- Design for Maintenance
  - Can we **influence the air vehicle design** to enable more efficient, effective Maintenance?
    - Enhanced Health Monitoring & Prognosis systems.
    - Equipment accessibility.
  - Longer periods between Scheduled Maintenance.
  - Continuation of digitisation of Tech Pubs & Maintenance process / policies.
  - More efficient Maintainer Training. VR Training environments?
- Future Technical Authority
  - Move from individual platform support to generic.
- Autonomous Air Vehicles
  - Do you train a pilot or a user?
  - Do you physically need to fly the aircraft to maintain user proficiency?







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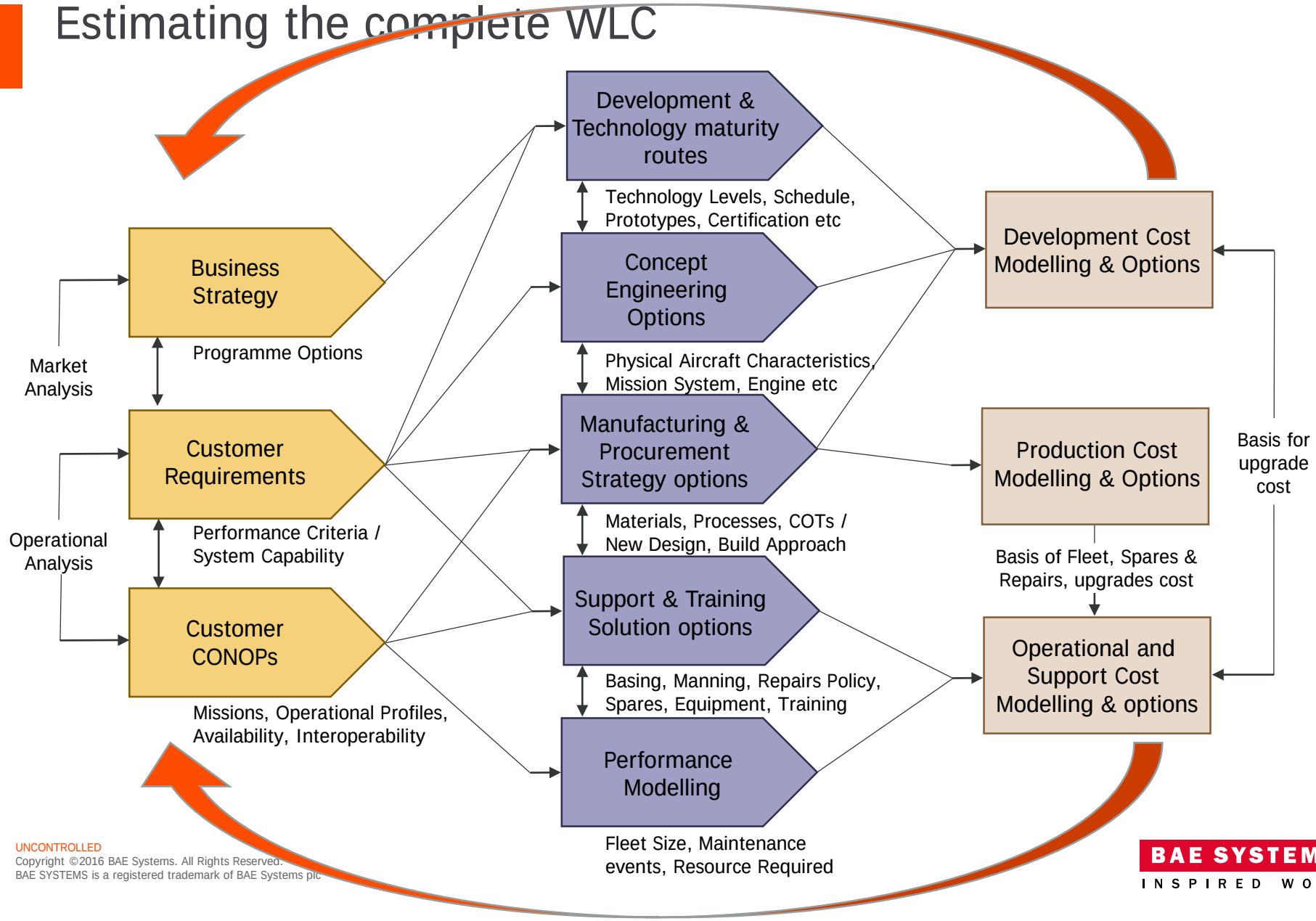
Estimating the complete WLC



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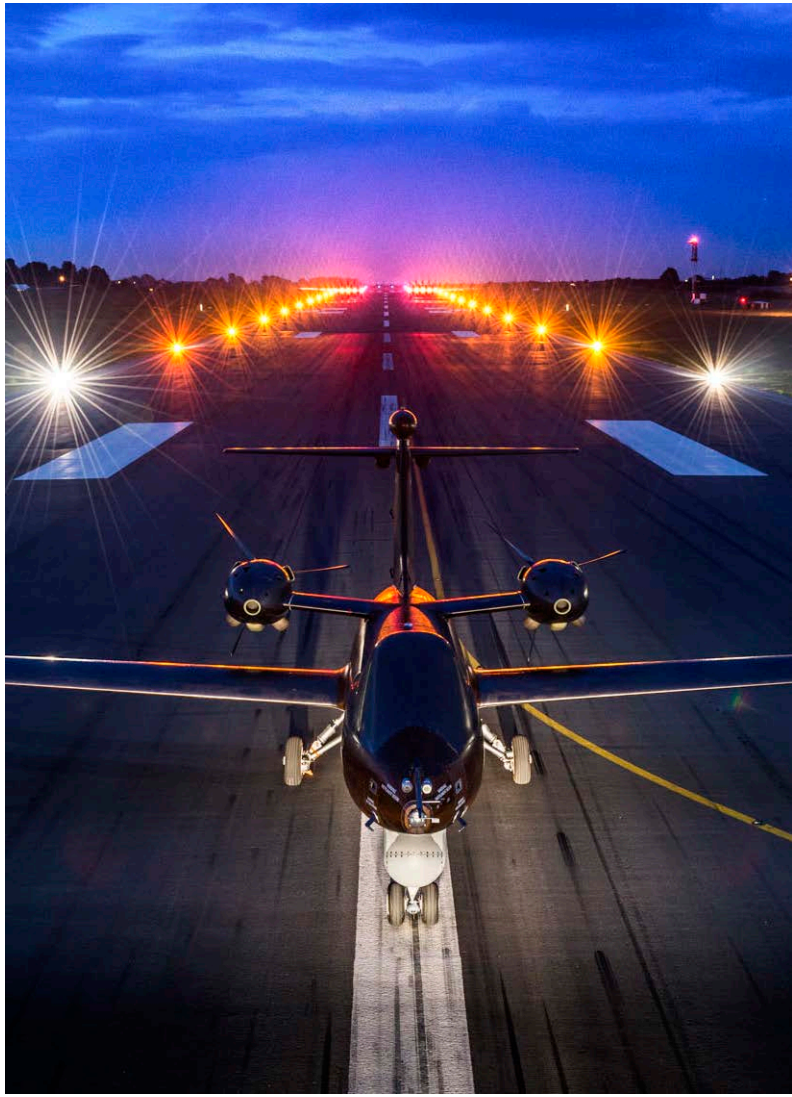
Application of **theory**

Take a new vehicle

utilising new technology

apply the theory

to estimate the future costs



Colonial Fleet have a problem

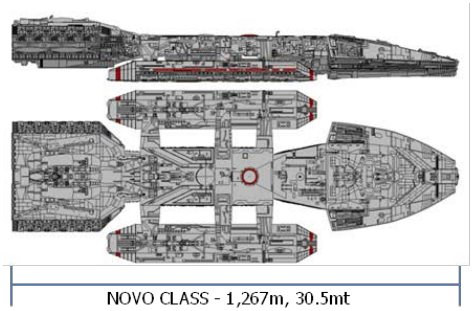
- The Council of Thirteen have requested an independent cost assessment of the Colonial Fleets new 'Mercury Class' Battlestar.

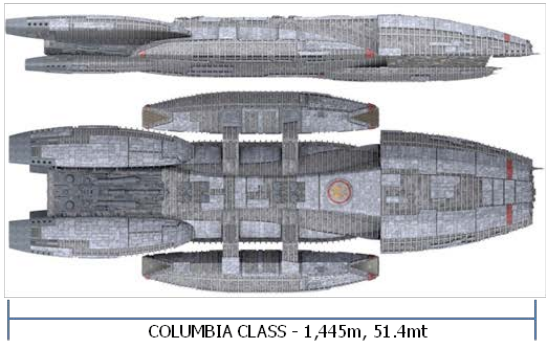
- **Where do you start?**

- Simply put, a Battlestar is an Aircraft Carrier in Space.
  - Carries squadrons of smaller spacecraft.
  - Able to withstand damage from ordnance.
  - Semi-Autonomous production and repair facilities.
  - Similar role.

- Simply put, a Battlestar is a sealed, pressurised environment
  - A submarine. Sealed, pressurised environment.

- Talk to the experts to gain confidence in the assumptions being made.
  - BAE Systems Naval Estimating Teams.
  - How would they rate up their vehicle systems?


NOVO CLASS - 1,267m, 30.5mt


COLUMBIA CLASS - 1,445m, 51.4mt

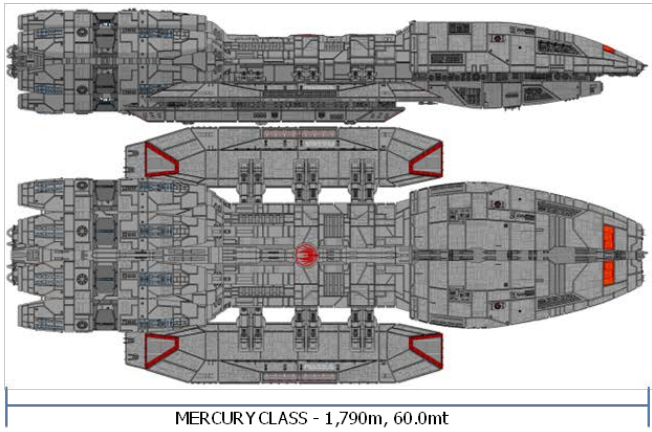

MERCURY CLASS - 1,790m, 60.0mt

Image Reference:
Capital Ship Reference Manual
www.colonialministryofdefense.org

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Establish the **Key Assumptions**

	NOVO Class	COLUMBIA Class	MERCURY Class
Weight **Length** **Crew Compliment**	30.5 mt 1,267m 1,012	51.4 mt 1,445m 4,366	60.0 mt 1,790m 2,571
Scheduled Maintenance: **3-month Overhaul** **Major Service**	 5 yrs 8 yrs	 8 yrs 15 yrs	 8 yrs 16 yrs
Main Engines **Thrusters** **Arestor Mounts**	x2 Ion Drive x24 in 6 Quad Mounts -	x6 Ion Drive x48 in 12 Quad Mounts -	x8 Ion Drive x48 in 12 Quad Mounts x2 Fwd Arestor
DRADIS **(Radar & Sensor)**	Target Track: 3,000	Target Track: 3,750	Target Track: 5,250
Main Armaments	MK21/10B 10 Naval Auto Cannon x32 in 16 Duel Turrets	MK21/10C 10 Naval Auto Cannon x52 in 26 Duel Turrets	MK21/10E 10 Naval Auto Cannon x60 in 30 Duel Turrets
Secondary	Class 2 Point Defense x100 Duel Turrets	Class 2 Point Defense x257 Duel Turrets	Class 2 Point Defense x310 Duel Turrets
Total Air Wing	86	185	230

Parametrically estimate the Hardware

- **Document the Assumptions**. Creates the 'story' of how you arrived at the estimated costs. An iterative process with the Customer and Internal Functional Experts.
  - Read across from similar applications:
    - Assumed 60-70 % of the weight will be the structure.
    - HVAC system increases with the crew compliment.
    - Electrical Wiring increases with size of ship
  - New Technology. What is the most like for like comparison?

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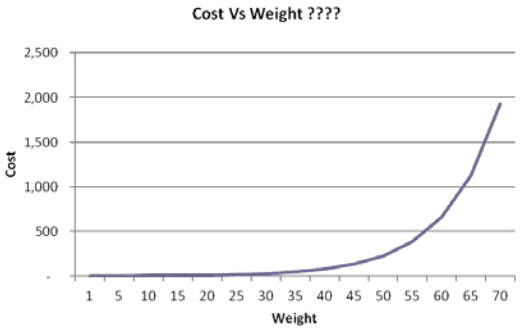
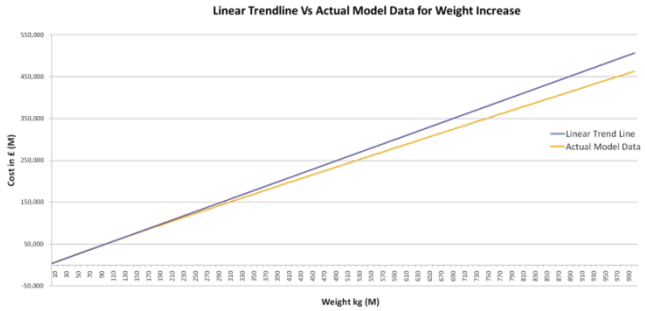


- Normalise the data to allow an equal comparison.
  - Same build rates, schedule alignment

- Understand how the Parametrics work. Test the assumptions.
  - E.g., We assume weight Vs cost is a linear relationship.
  - Aircraft components +100kgs.
  - Are we at the bottom of an exponential curve?
  - Battlestar components + 70,000,000kgs!



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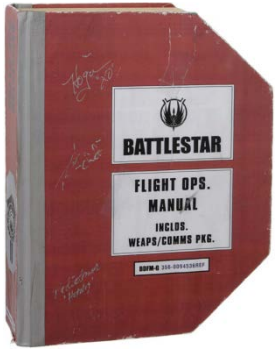
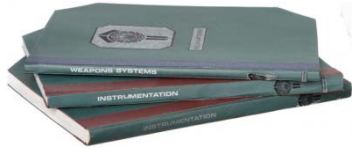
What is the Support Solution?



- Assumed the most comparable solution – Naval Vessel.
  - Each Battlestar generation contains more advanced internal fabrication facilities and autonomous production lines.
  - Engines are lifed for the full in-service period of the vehicle.
  - Increased Operational Life between ‘overhaul’ periods.
  - Consumables are sourced during Operations.
  - Key systems built with multiple redundancy layers. Spares are minimal, repairs carried out during Operations.

- Technical Authority maintains a spiral development of the Battlestar Class.
  - Solutions to Technical Queries are implemented by ship crews and built into the next Production unit. No two Battlestar’s are identical.
  - Structured to provide support and upgrades. Software maintenance is continual, implemented in the next ‘overhaul’ period.



- **Document the Assumptions.**
  - 99.999% of the report to the Customer is documented assumptions.
  - Clear indication of how the estimate is built.

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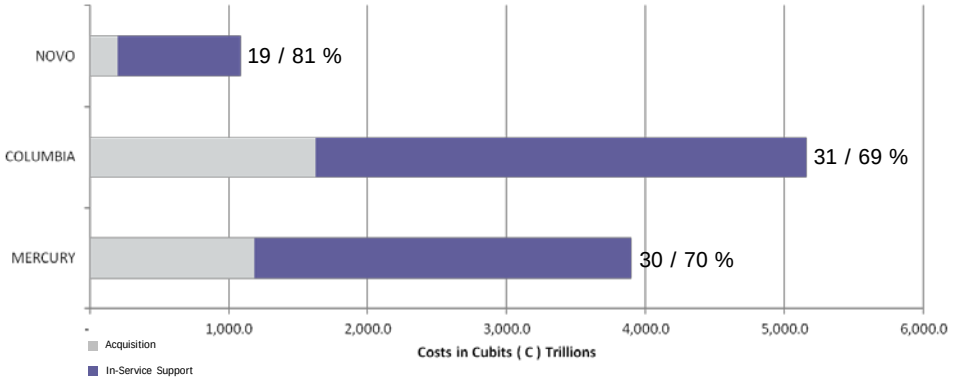
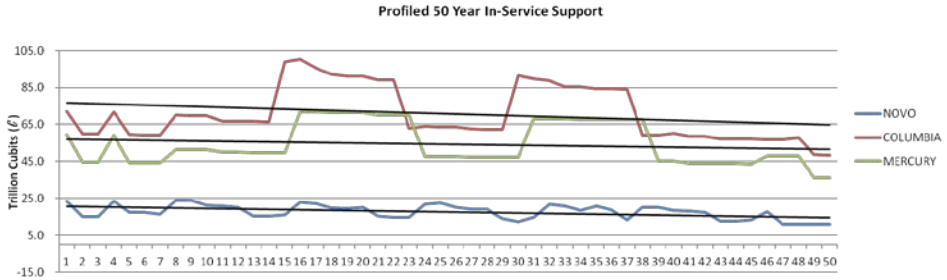
Estimate Summary

- Individually, each Mercury Battlestar:
  - 22% increase in Acquisition Costs.
  - 20% increase in Service Costs.
  - 42% reduction in Manpower Costs.
  - 7% increase between Major servicing periods.
- Increased effectiveness of the Mercury Class leads to a 40% reduction in Fleet Size.
  - 32% reduction in the Acquisition Costs
  - 25% reduction In-Service Costs.
  - 26% reduction overall.
- Average Annual In-Service Costs 54.2 T
  - 49.6 T falling to 36.2 T in the later years. 27% reduction.

		Costs in Cubits (C) Trillions 50 % Confidence Level			
Battlestar Class	Fleet Size	Unit Production Cost	Acquisition Cost	In-Service Fleet Support	Total Fleet Costs
NOVO	12	16.9	203.0	886.0	**1,089.0**
COLUMBIA	67	24.2	1,623.5	3,536.7	**5,160.3**
MERCURY	40	29.6	1,183.1	2,712.2	**3,895.2**





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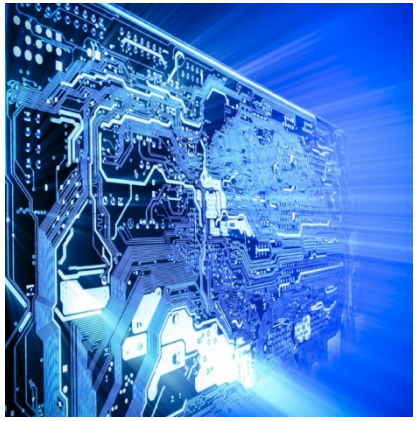
Summary

- At BAE Systems we manufacture and provide support to Aircraft, Surface Ships, Land Vehicles, Submarines, IT Security Systems, and Technology programmes to name just a few.
  - This gives us a unique position in that we are not constrained in looking into one area, we can pool resource and expertise.

- Future Support **estimation is only as good as the assumptions** used to generate the costs.
  - We use a variety of techniques, models and expertise to generate not just the datasets, but also the comparative data used to validate the information.



- This is an iterative process. The results from one estimation exercise will be used to influence the next iteration of the estimate.
  - Difficulty in influencing the long-term with short-term thinking and goals.
  - Value and efficiency must be demonstrated for the Whole Life Cost, not just the acquisition.

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Thank you