



DESIGN AND EXERCISE OF FLEXIBILITY IN THE BOEING 787 DREAMLINER

Lean Aerospace Initiative
LAI Plenary Conference
Enterprise Architectures: Emerging Ideas
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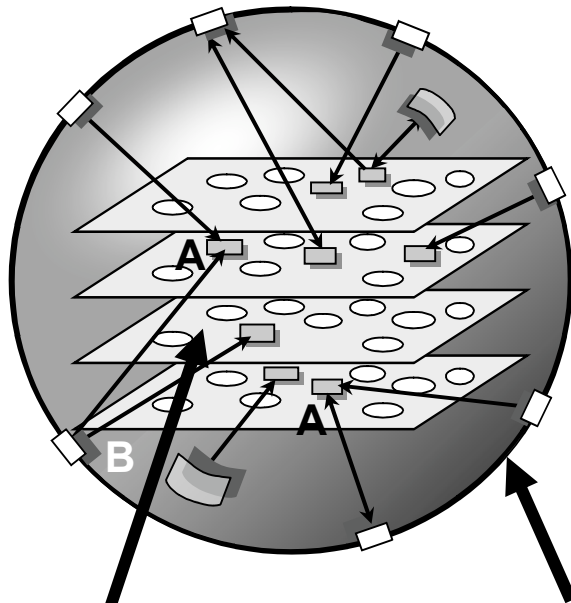
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Large Commercial Aircraft Enterprises as a Complex System

Nested Complexity



Physical Domain

- Aircraft
- Manufacturing
- Airports
- etc.

Institutional Sphere

- Manufacturers
- Suppliers
- Airlines
- Governments
- etc.

- Large system, large stakes
- Time scales
- Non-linear effects
- Evaluative complexity
- **Difficult to predict future behavior**



LAI Case Study:

Market demand for aircraft derivatives, focus on Boeing 787 Dreamliner



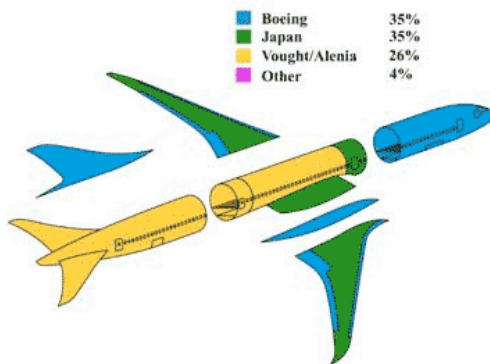
Understand:

- **Use technology and architecture to create flexible 787 design**
- **Can existing Boeing enterprise architecture utilize flexible 787?**

Flexibility in the 787 Technical Architecture and a Supporting Enterprise Architecture

Flexibility allows system configuration to adapt to future circumstances, at a reduced cost

7E7 Structures Work Share

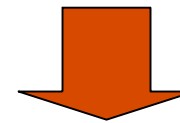


Modular fuselage and wing design creates flexibility to more quickly and inexpensively create 787 derivatives



Increased flexibility in meeting changing market demand

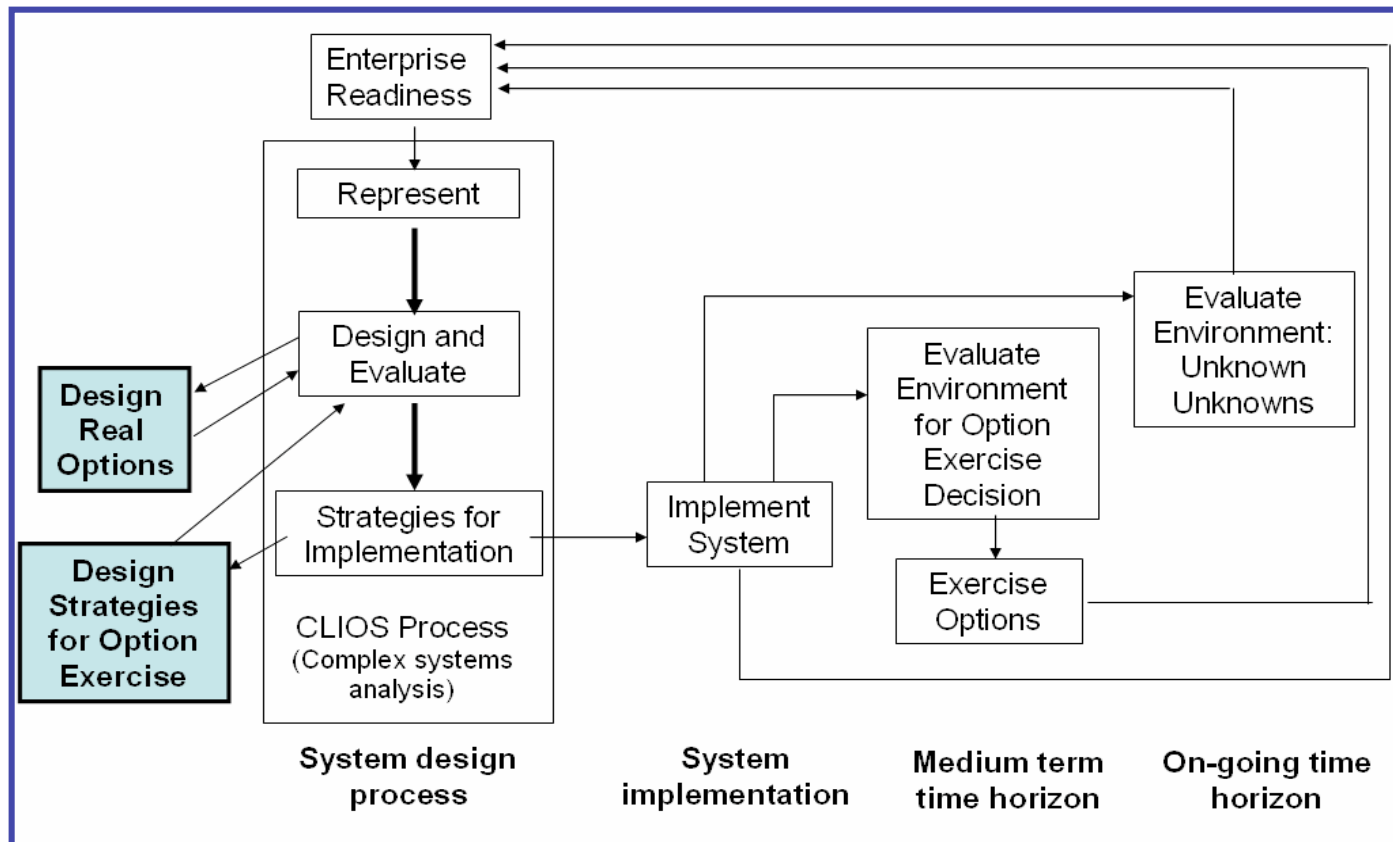
Boeing **enterprise architecture** able to take advantage of flexible 787 architecture?



To utilize flexible architecture, need for:

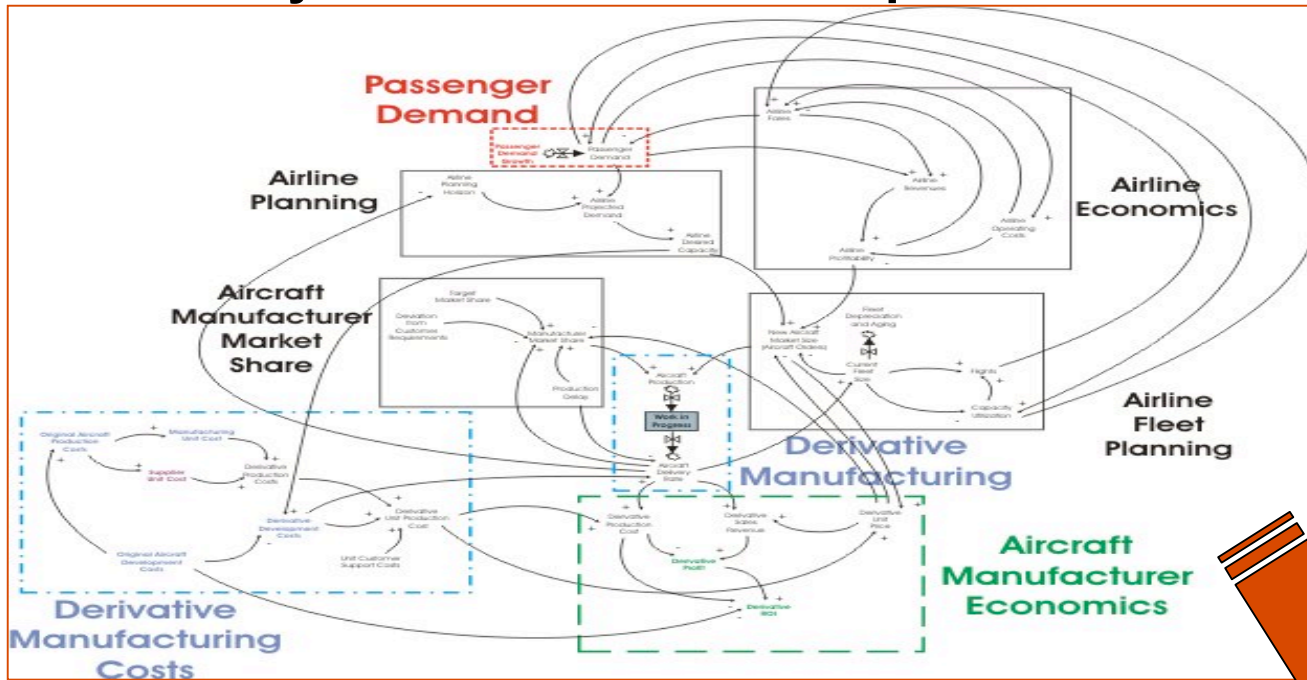
- timely analysis of market conditions and customer needs
- supply chain capable of changing assemblies quickly

Research to Date (I): Life-Cycle Flexibility Framework



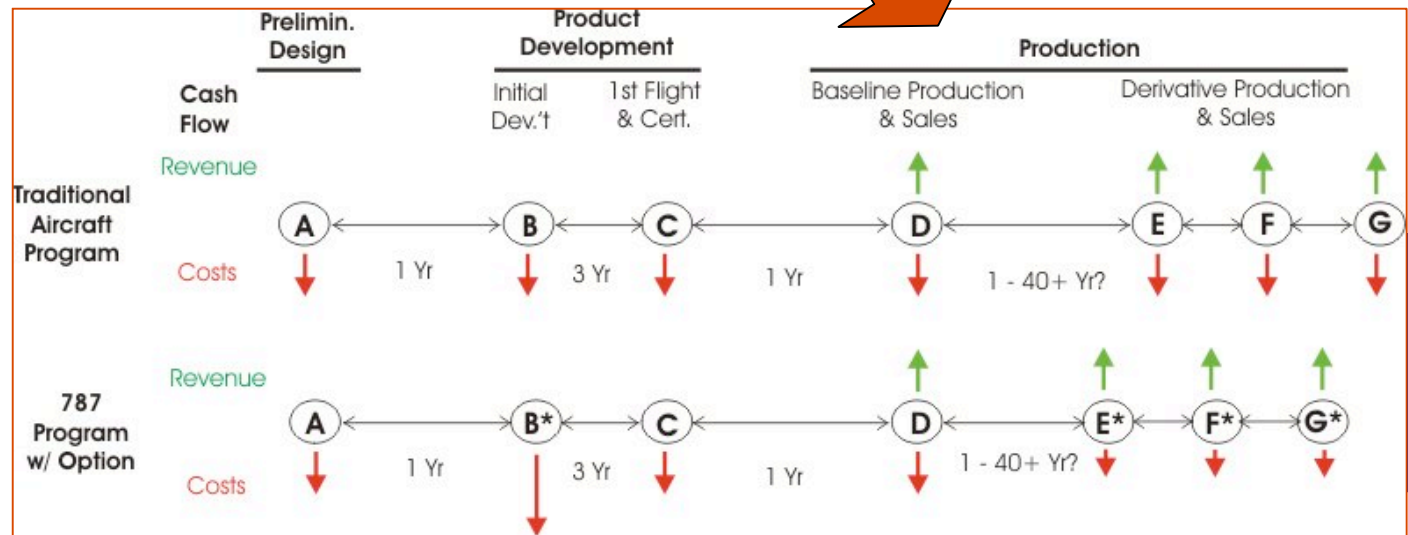
- **Overview:** framework for activities needed to enable, design and support flexible systems: both technically and within enterprise

Research to Date (II): Analysis of 787 Derivative Option



System Dynamics Model Overview: evaluate benefits and costs of modular airframe and faster 787 derivative development and manufacturing times

Real Options Analysis Overview: evaluate value of option created by 787 modular airframe architecture



Research to Date (III): Analysis of Boeing Enterprise Architecture (EA)

Product Architecture



787
Derivative

Product
Development

Product
Manufacturing

Enterprise Architecture



Customer
Responsiveness /
ID Changing
Environment

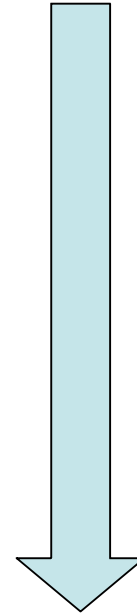
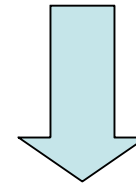
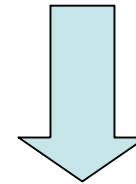
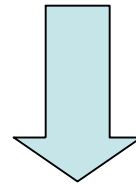
Life-cycle
planning



Global Supply Chain

Design
coordination

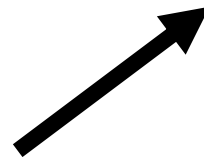
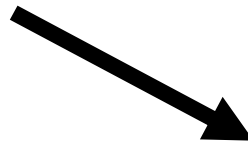
Flexible
manufacturing



Applicability of Research to LAI Members

Areas of Interest to LAI

- Use real options to cope with uncertainty
- Create and evaluate (benefits and costs) flexibility in technical architectures
- Enterprise architectures for harnessing benefits of flexibility



Research Focus

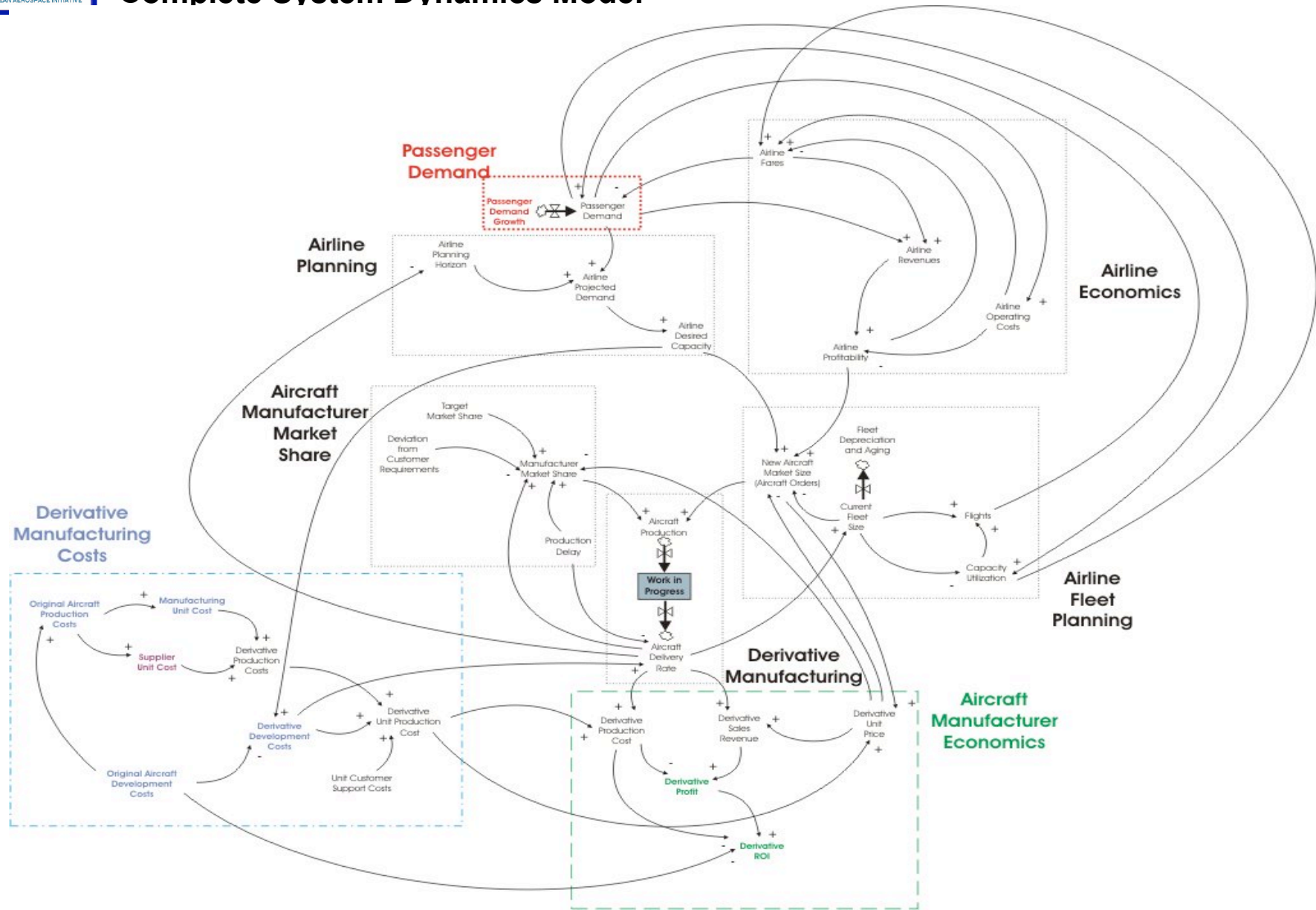
- Life-cycle flexibility framework addresses issues with flexibility throughout life-cycle, at technical system and enterprise levels
- Boeing 787 case study provides real world application at both the technical system and enterprise levels



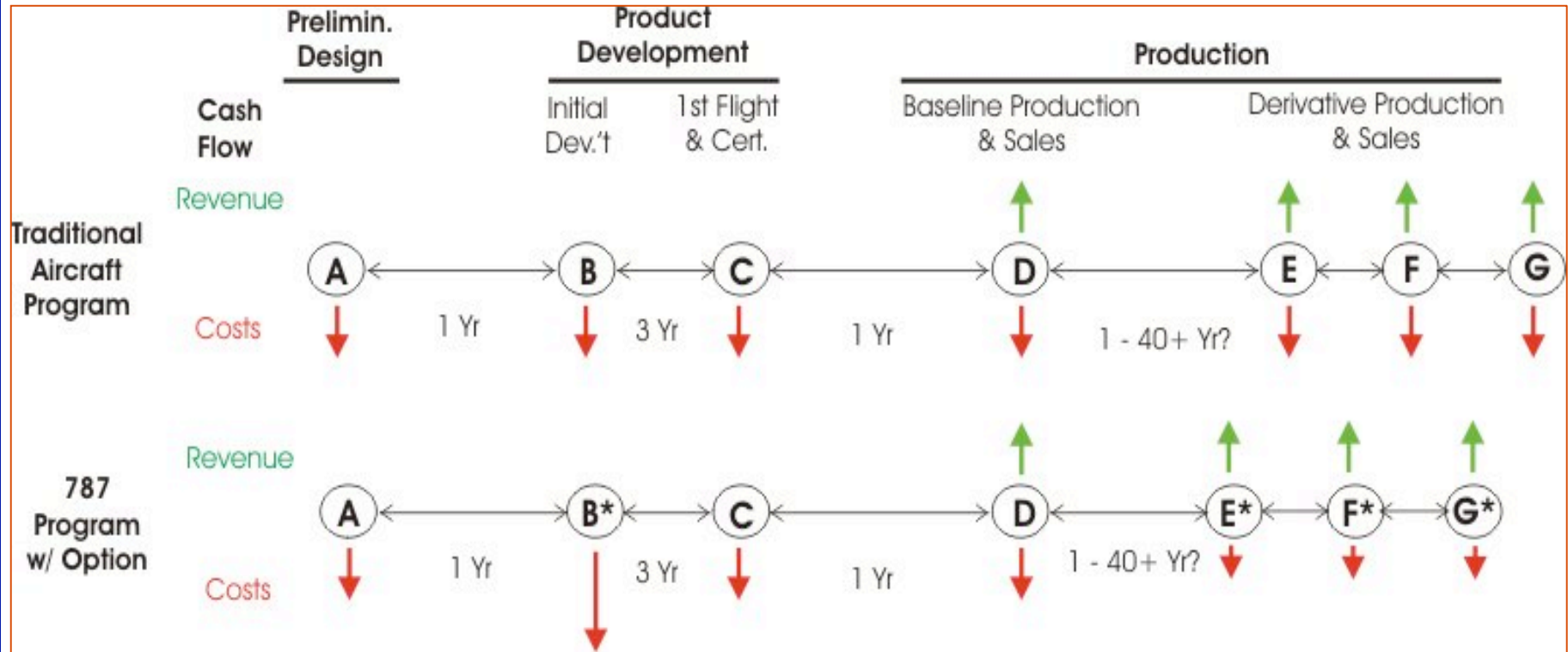
Backup Slides



Analysis of 787 Derivative Option Complete System Dynamics Model



Analysis of 787 Derivative Option



Option benefit – reduced time and cost related to designing and manufacturing 787 derivative

Option cost – development of the composite and manufacturing technology

Uncertainty – future demand for 787 derivatives

Exercise cost – the actual cost of designing and manufacturing variant

Expiration time – technological and/or economic life of the aircraft family