Lean Aerospace Initiative

Creating Value Through Integration

Valuation Techniques for Complex Space Systems

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➢ **Adding value to the valuation and design process**

  ➢ **Motivation of this research**

➢ **Traditional valuation methods**

  ➢ **Several insulated groups involved**

    ➢ **Engineering, cost estimating, marketing, etc.**

  ➢ **Analyses are uncoupled, serial**

  ➢ **Result: sub-optimization**

➢ **Proposed improvement**

  ➢ **A common representation of the system**

  ➢ **Bringing together the stakeholders**

  ➢ **Analyses are coupled, simultaneous**

➢ **Why are new valuation techniques necessary?**

➢ **Objective**

➢ **Framework**

➢ **Case study: Aquarius**

➢ **Satellite servicing analysis**

➢ **Applying concepts to military space applications**

➢ **Conclusion/Future Work**

➢ **Failure of current valuation techniques**

    ➢ **Interface between technology and economics**

        ➢ **Engineers: design something cool, lack understanding of economics/markets**

        ➢ **Finance: lack of understanding about how technology can be developed/adapted to capitalize on a particular market's needs**

        ➢ **Fundamental disconnect between two groups**

    ➢ **Neglect value of flexibility**

        ➢ **Accounted for by manager's "feel"**

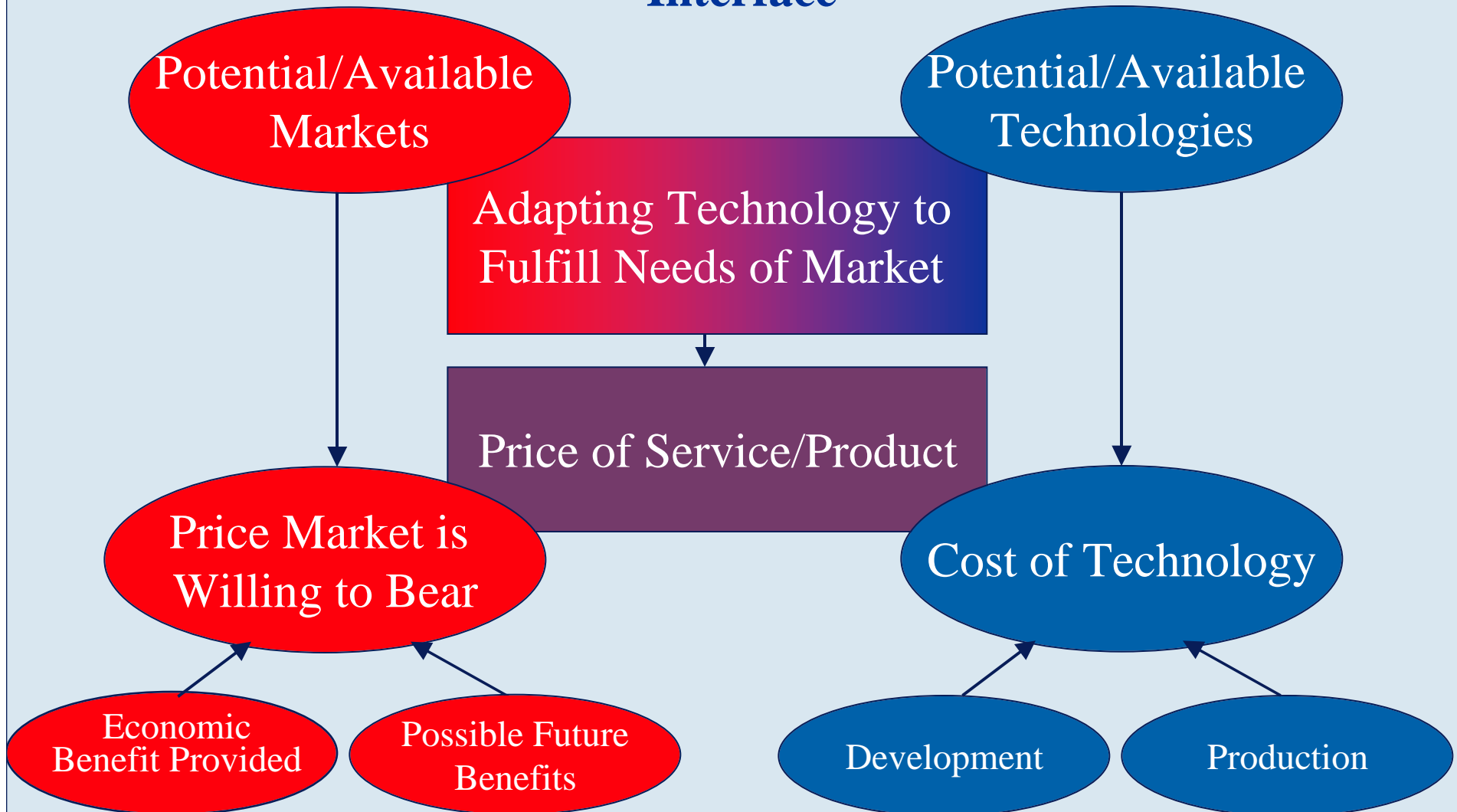   ➢ **Need more quantitative approach**

➤ **Create valuation approach to**

- ➤ **Account for both technology and economics of project**

- ➤ **Encourage interaction between finance and engineers**

- ➤ **Utilize trade-studies to determine optimal product and architecture design**

➤ **Use valuation approach to**

- ➤ **Determine viability of servicing market**

- ➤ **Investigate product and architecture design trades on market viability**

Economics

Technology

Interface

Potential/Available Markets

Potential/Available Technologies

Adapting Technology to Fulfill Needs of Market

Price of Service/Product

Price Market is Willing to Bear

Cost of Technology

Economic Benefit Provided

Possible Future Benefits

Development

Production

➢ **What is Aquarius?**

- ➢ **Low-reliability launch vehicle**

- ➢ **Significantly reduced costs**

- ➢ **Used for low-cost deliverables (water, duct tape, fuel, etc.)**

- ➢ **Possible enabler for new markets (i.e. satellite servicing market)**

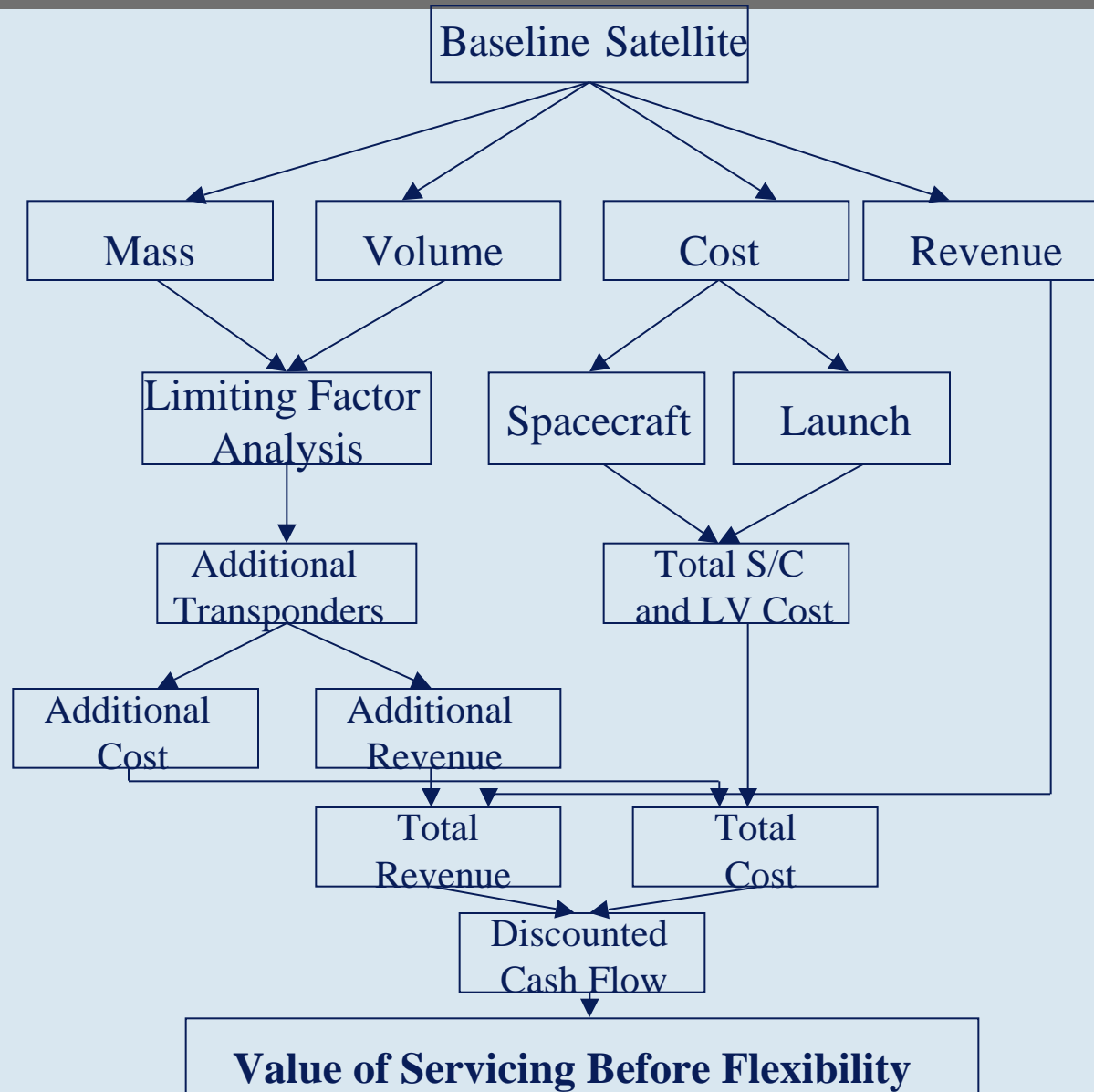 - ➢ **Determination of servicing market viability and value**

Satellite Servicing Analysis

➢ **Definition: Servicing only as it applies to refueling or using tug vehicle for orbital maneuvers**

➢ **Determine most "valuable" approach to servicing**

➢ **Compare to competition cases**

➢ **Focus on revenue and cost of s/c, not servicing**

  ➢ **% of increased revenue pays for servicing**

➢ **Cost of servicing architecture and fuel delivery**

| Revenue | — | Expenses | = | Profit |
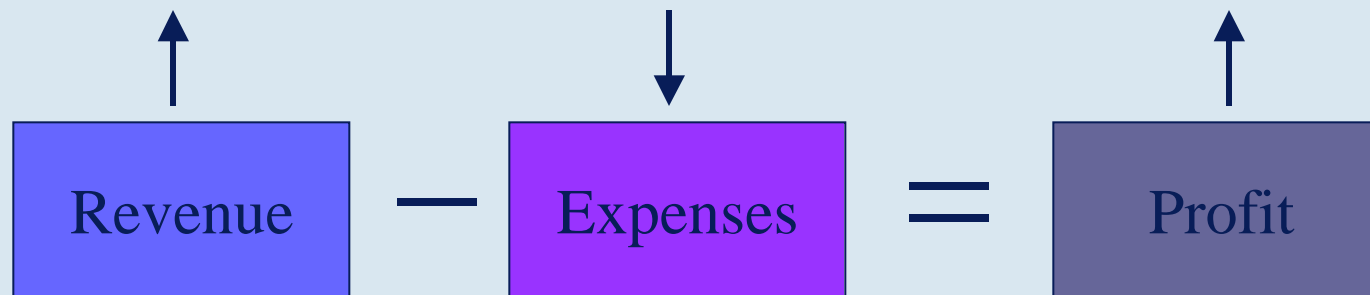
Case	Initial Orbit	Final Orbit	Fuel Tanks	Aquarius Task	Comments
Baseline	GTO	GEO	OR and SK: Biprop	None	Current s/c design
AQR 1	Staging	GEO	OR and SK: Biprop (launched empty)	Fuel 1-Time at Staging Orbit for OR and SK	Cheaper Launch
AQR 2	Staging	GEO	EWSK and contingency: Biprop	Tug for OR and NSSK	Cheaper Launch or Additional Transponders
AQR 3	GEO	GEO	EWSK and contingency: Biprop	Tug for NSSK	Additional Transponders
AQR 4	GEO	GEO	Small Biprop	Refuel before each NSSK maneuver	Additional Transponders
AQR 5	GEO	GEO	Biprop	"Optimal Just in Time" Refueling	Additional Transponders
AQR 6	Staging	GEO	OR: Biprop SK: EP	Fuel 1-Time at Staging Orbit for OR	Cheaper Launch Or Add. Trans.
Comp 1	GEO	GEO	SK: EP	None	Additional Transponders
Comp 2	GTO	GEO	OR and SK: EP	None	Additional Transponders

Servicing Analysis Approach

Baseline Satellite

Mass   Volume   Cost   Revenue

Limiting Factor Analysis

Spacecraft   Launch

Additional Transponders

Total S/C and LV Cost

Additional Cost   Additional Revenue

Total Revenue   Total Cost

Discounted Cash Flow

Value of Servicing Before Flexibility

Valuing Flexibility

➤ **Option for life extension**

  ➤ **Continue providing service after design lifetime of satellite**

➤ **Option for relocation**

  ➤ **Capitalize on valuable market opportunities**

Options have value especially in highly volatile markets!

- **Examined customer-side:**

  - **NPVs before options indicate significant customer value (9% increase in after-tax returns)**

  - **Option for life extension: PV of up to $140 M**

  - **Competition cases: within 3% rate of return**

    - **Uses EP: time to orbit and radiation exposure issues**

- **Examining provider-side:**

  - **Cost estimates for different architectures and fuel delivery**

- **Use above info to estimate market size**

➢ **Similar analysis with new metrics**

  ➢ **% increase in available payload mass and volume**

➢ **Options very valuable**

  ➢ **Relocation: Important for surveillance**

  ➢ **Life extension**

- ➢ **New valuation techniques necessary**

  - ➢ **Account for technology and economics**

  - ➢ **Examine customer and provider benefits**

  - ➢ **Don't forget the competition!**

- ➢ **Satellite servicing market**

  - ➢ **Promising from customer-side**

  - ➢ **Evaluate provider-side**