



Corporate Motivations for Vertical Integration

A Parametric Assessment of Make vs. Buy Acquisition Approaches for Small Satellite Constellations

Aug 2018

Caleb Williams

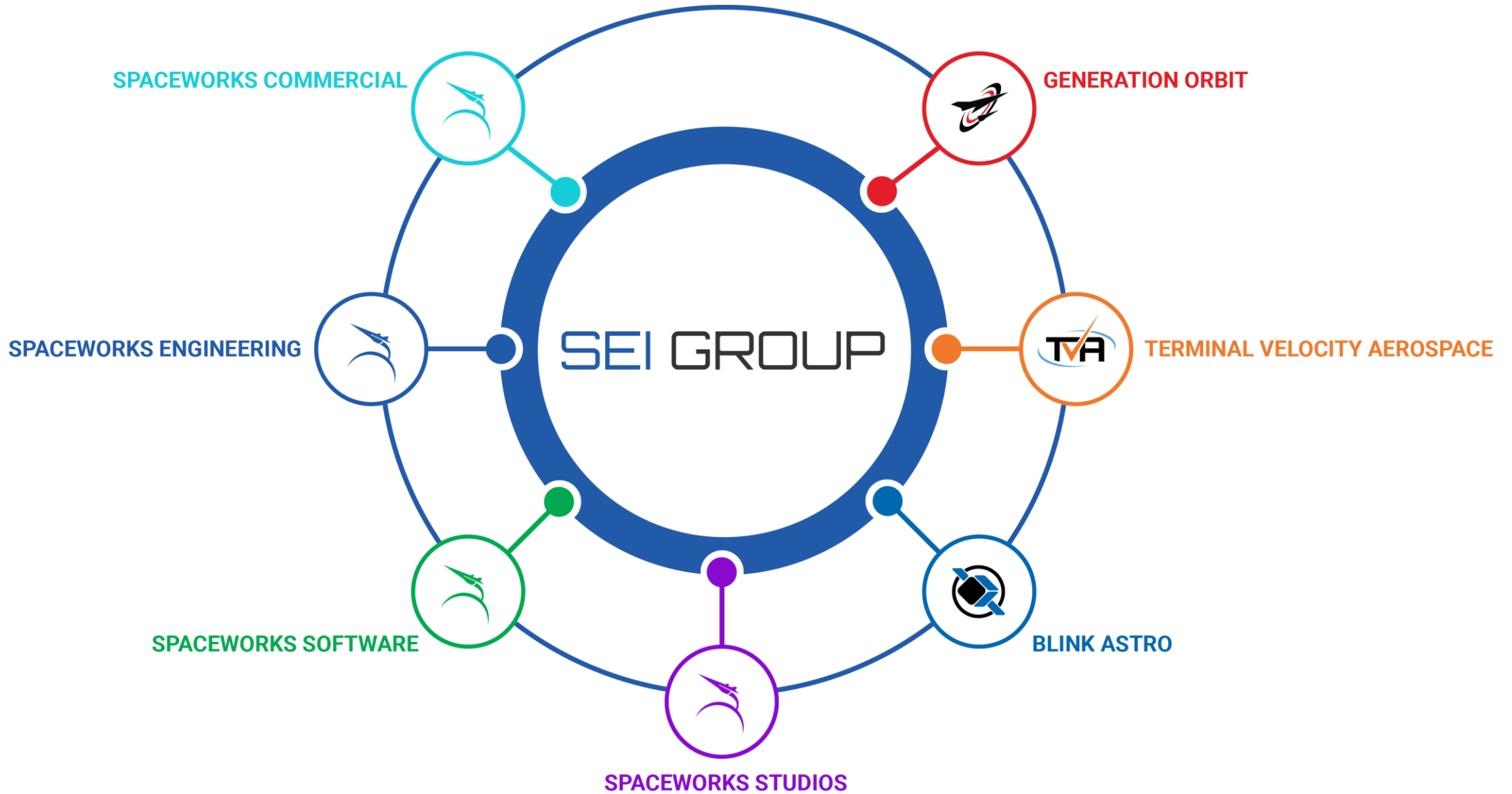
Space Systems Analyst

caleb.williams@spaceworks.aero | 770.379.8017

Co-authors: Jon Wallace, Bill Doncaster, & Jordan Shulman

Introduction to SpaceWorks

Introduction to SpaceWorks | SEI Group



**QUANTITATIVE MODELING
+ MARKET EXPERTISE**



STRATEGIC INSIGHTS



**COST ESTIMATION &
ECONOMIC ANALYSIS**

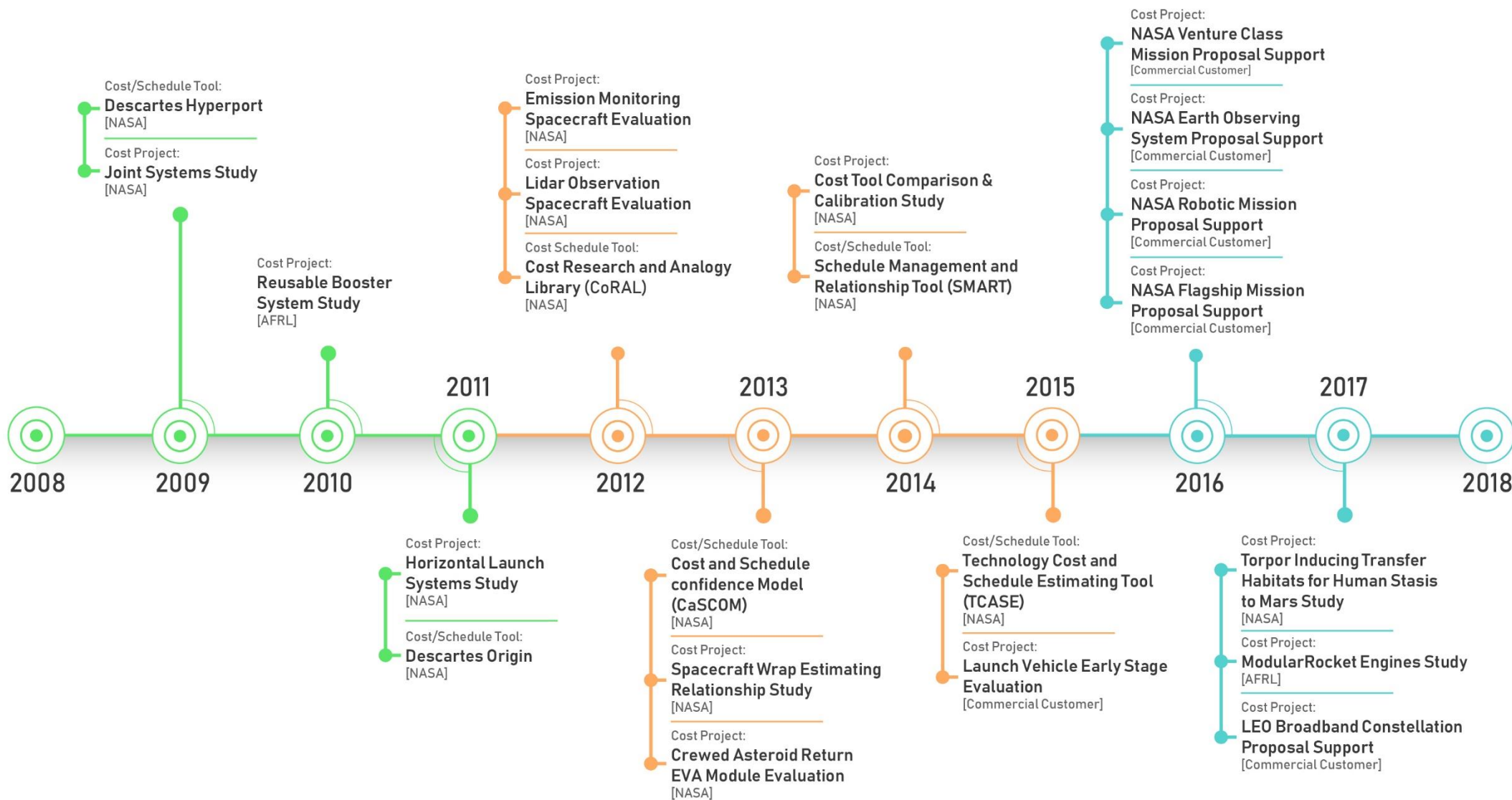


**MARKET FORECASTING &
COMPETITIVE INTELLIGENCE**



**STRATEGIC ADVISORY &
CONSULTING SERVICES**

Introduction to SpaceWorks | History in NASA Cost/Schedule Community



Study Overview

Study Overview | Corporate Motivations for Vertical Integration

- Over the last 10 years, there has been a substantial shift in space industry **attitudes towards vertical integration**, particularly in the small satellite sector
- Unlike traditional GEO stationary satellite companies, small satellite companies are increasingly choosing to manufacture, integrate, operate, and manage end user sales **entirely in-house**
 - Examples include Planet, Satellogic, and Capella Space
- Recently, another shift has been observed: small satellite companies are further integrating upstream into the development and manufacture of their own **satellite components**
- SpaceWorks developed this study as an internal research effort aimed at better **understanding corporate motivations** for the observed increase in **vertical integration activity** in the small satellite sector

Study Overview | Vertical Integration in the Satellite Sector



COMPONENT MANUFACTURER



SYSTEM INTEGRATOR



OPERATOR



Traditionally, satellite firms have solely operated spacecraft, but recently they are additionally taking on manufacturer and integrator roles

Study Overview | Investigative Approach

- Three **relevant motivations for vertical integration** in the small satellite sector were identified
- For each motivation the market scenario was **quantitatively modeled** using Galorath's SEER-H parametric costing tool to calculate the Average Per Unit Cost (APUC) and Theoretical First Unit (TFU) cost for two different procurement approaches:
 - A **“traditional” procurement approach** in which the majority of the system is purchased from component vendors (with the exception of the communications payload and system integration/test)
 - A **“vertically integrated” procurement approach** in which the manufacturer handles the entirety of the development and manufacture of the satellite and components in-house
- Two different satellite concepts were considered: a **3U communications CubeSat**, and a **300 kg communications Small Satellite** (nominally for IOT and broadband applications)

Average Per Unit Cost (APUC) equals the sum of Research, Development, Testing, & Evaluation and Production cost divided by total operational units

Motivations for Vertical Integration in the Small Satellite Sector

Baseline Case

The baseline case considers the impact of overall constellation size on corporate decisions to vertically integrate. It uses nominal market assumptions to evaluate whether constellation size alone is enough to motivate a satellite company to vertically integrate. It also serves as the basis for additional case studies.

Case #1: Market Power

Case study #1 examines how market power may influence the decision for satellite companies to vertically integrate. Specifically, it takes into account supplier/buyer dynamics in each market segment to evaluate whether smart vendor relations and negotiations could change the decision to vertically integrate.

Case #2: Quality Control

Case study #2 looks into how a desire for increased quality control could lead a firm to vertically integrate. Unreliable components are a common occurrence in the small satellite industry, and this case specifically examines how different reliability rates can motivate satellite companies to vertically integrate.

Case #3: Vendor Disruptions

Case study #3 evaluates how vendor disruptions can increase transaction costs and considers whether vertical integration is a viable alternative for protecting a company's supply chain. It specifically examines a scenario where a vendor disruption for CD&H and Power subsystems occurs and whether this could motivate a firm to vertically integrate.

Market-Realistic Case

The final case considers each of the individual cases in conjunction, applying the lens of SpaceWorks' market expertise to model the most realistic market scenario. It specifically considers the market differences between the Cube Satellite and Small Satellite segments and applies them to examine why firms in each segment are vertically integrating.

Study Overview | Methodology

REFERENCES

- MASTER EQUIPMENT LIST (SPACEWORKS ENTERPRISES)
- UNIT LEARNING CURVE FRAMEWORK (PRICE SYSTEMS)
- "WHEN AND WHEN NOT TO VERTICALLY INTEGRATE" (MCKINSEY & COMPANY)
- SEER-H SPACE GUIDANCE V3.0 (GALORATH/NASA)

FRAMEWORK

- LEARNING CURVE ANALYSIS
- COMPONENT-LEVEL ASSUMPTIONS
- LEARNING CURVES ASSIGNED
- CASE-SPECIFIC MODELING

ESTIMATION

- PARAMETRIC HARDWARE COST (SEER)
- PARAMETRIC SENSITIVITIES

RESULTS

- TRADITIONAL MANUFACTURING APUC
- INTEGRATED MANUFACTURING APUC
- CONSTELLATION BREAK-EVEN POINT

ASSUMPTIONS

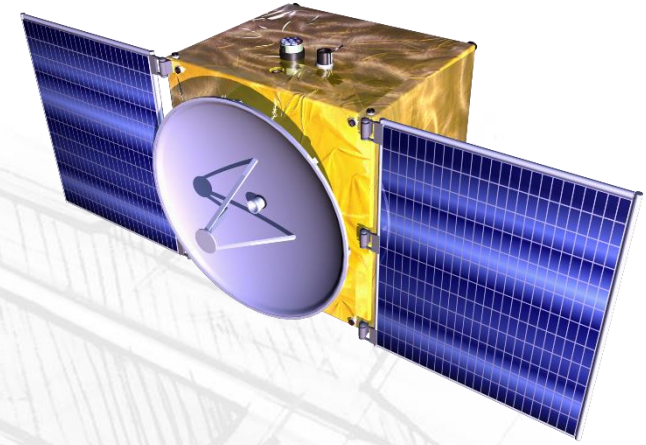
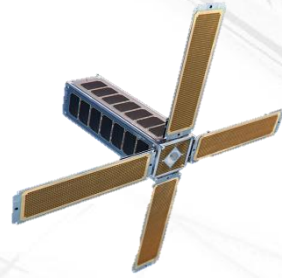
PRODUCTION EXPERIENCE

PROJECT COMPLEXITY

PRODUCTION ENVIRONMENT

HARDWARE HERITAGE

Study Overview | Baseline Assumptions



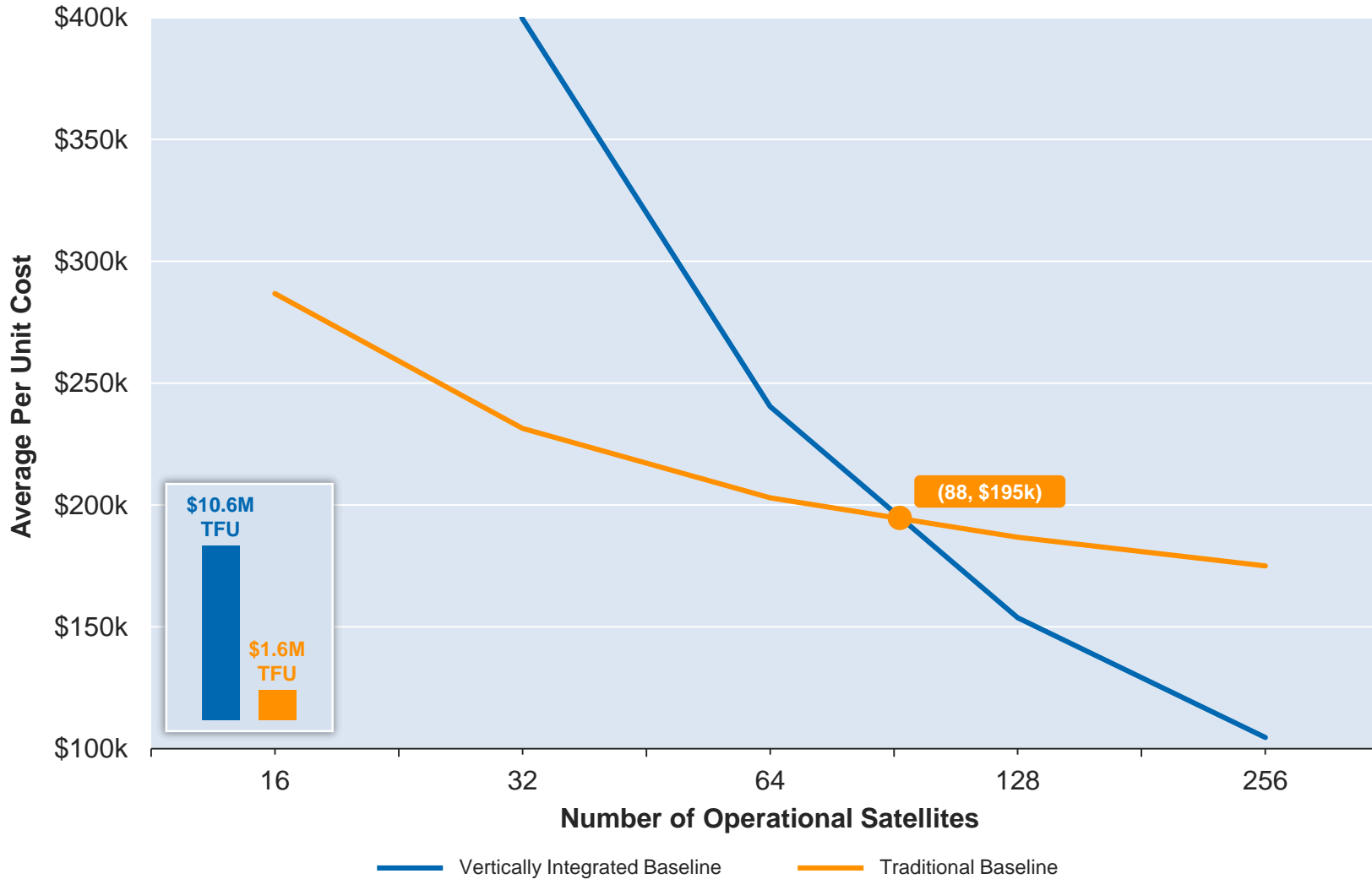
All Cases Assumption	3U Cube Satellite	300 kg Satellite
Prototype Effort	Low	High
Learning Curve	85%	Various (83% - 93%) ¹
Project Complexity	Low	Medium
Development Standard	Commercial	Commercial
Production Experience	Medium	High
Production Environment	Medium	Medium
Hardware Heritage	Varying (COTS ² – Make)	Varying (COTS ² – Make)
Prior Production Units	Various (1 – 1000)	Various (1 – 1000)
Market Power	50/50	50/50
Reliability	90%	97%
Vendor Disruptions	None	None

¹ Learning Curve rates determined using Price Unit Learning Curve Framework

² COTS = Commercial off the Shelf

Baseline Results

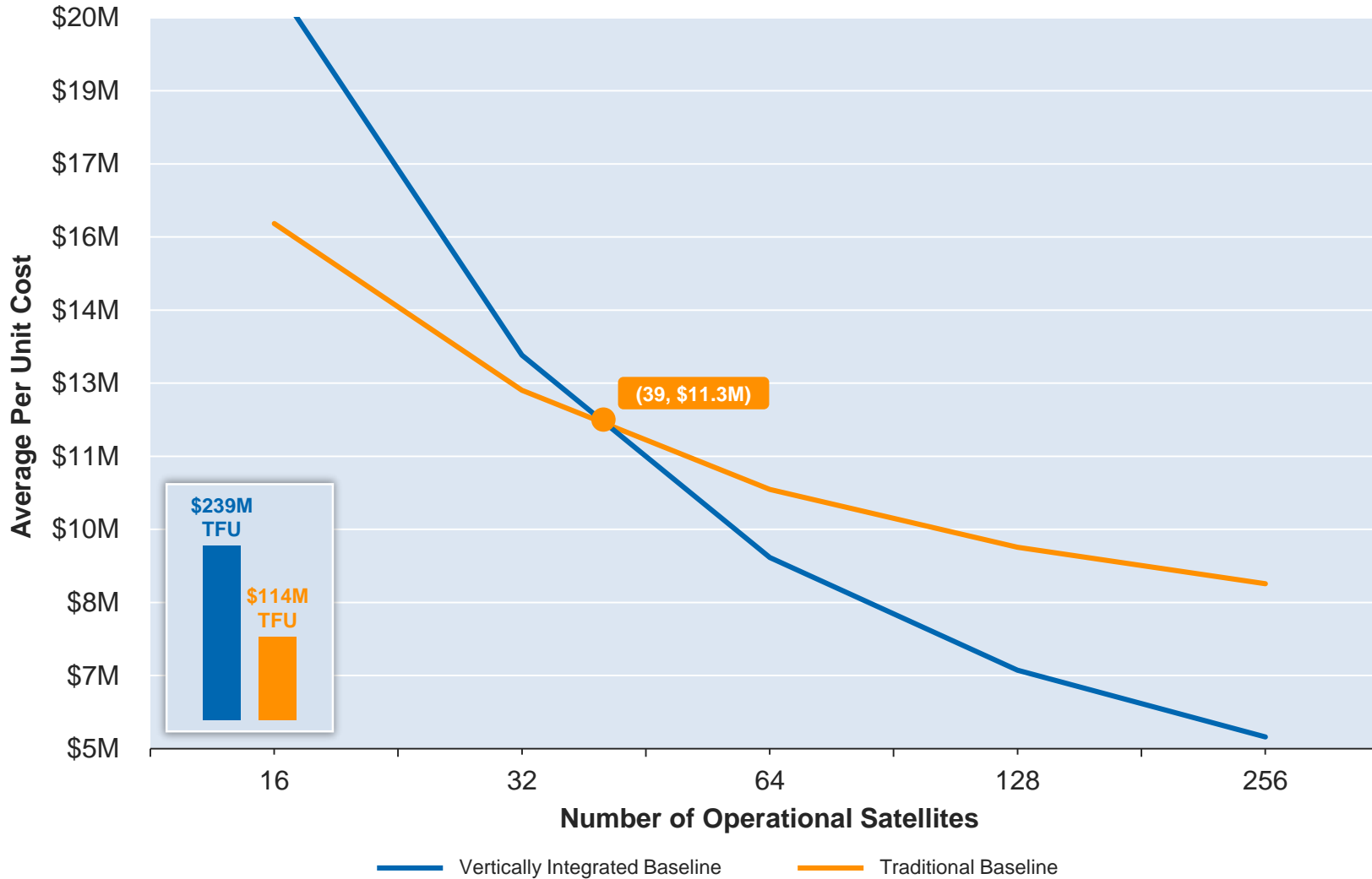
Baseline Results | 3U Cube Satellite



At more than **87 operational units**, vertical integration is more attractive in this segment, but at the **cost of more upfront capital**.

Constellation size alone may **explain motivations for vertical integration** in this segment, as many operators are targeting fleets of 100+ satellites.

Baseline Results | 300 kg Small Satellite



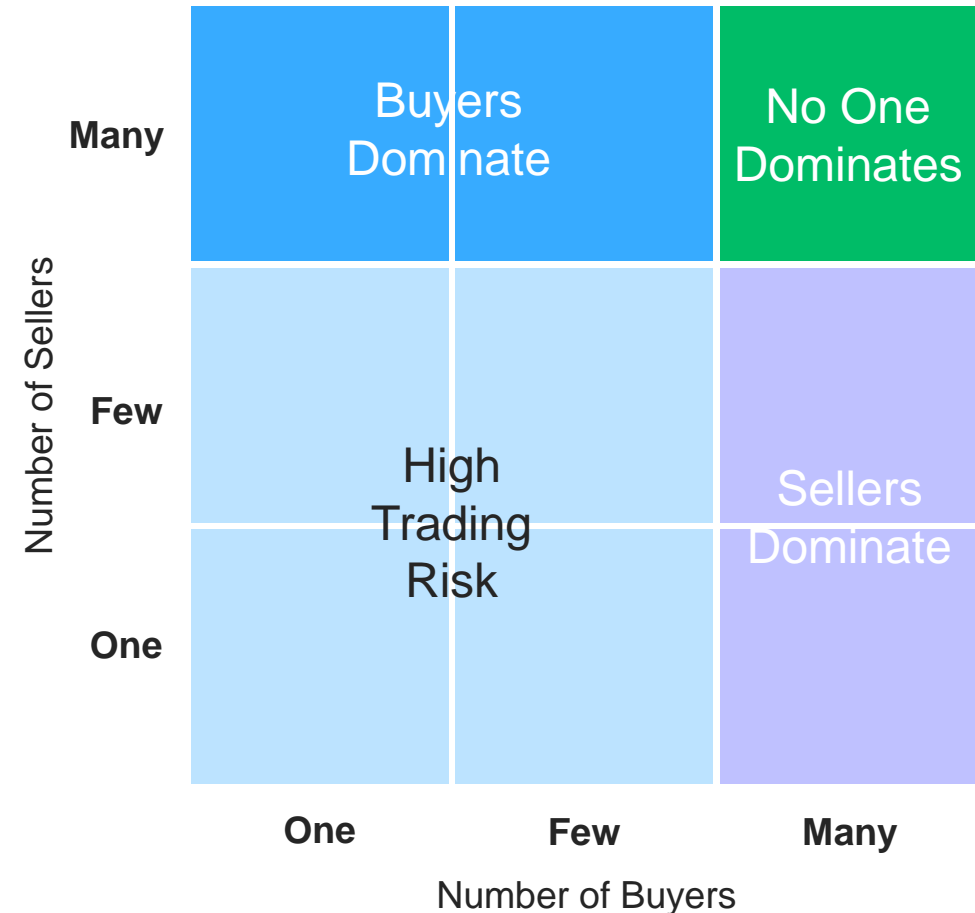
TFU cost of the vertically integrated approach in this segment is **2x traditional TFU (vs. 10x for the 3U satellite)**, leading to a lower breakeven point.

The vertically integrated APUC curve is **more gradual in this segment** due to lower learning improvements vs. the CubeSat segment.

Case #1: Market Power

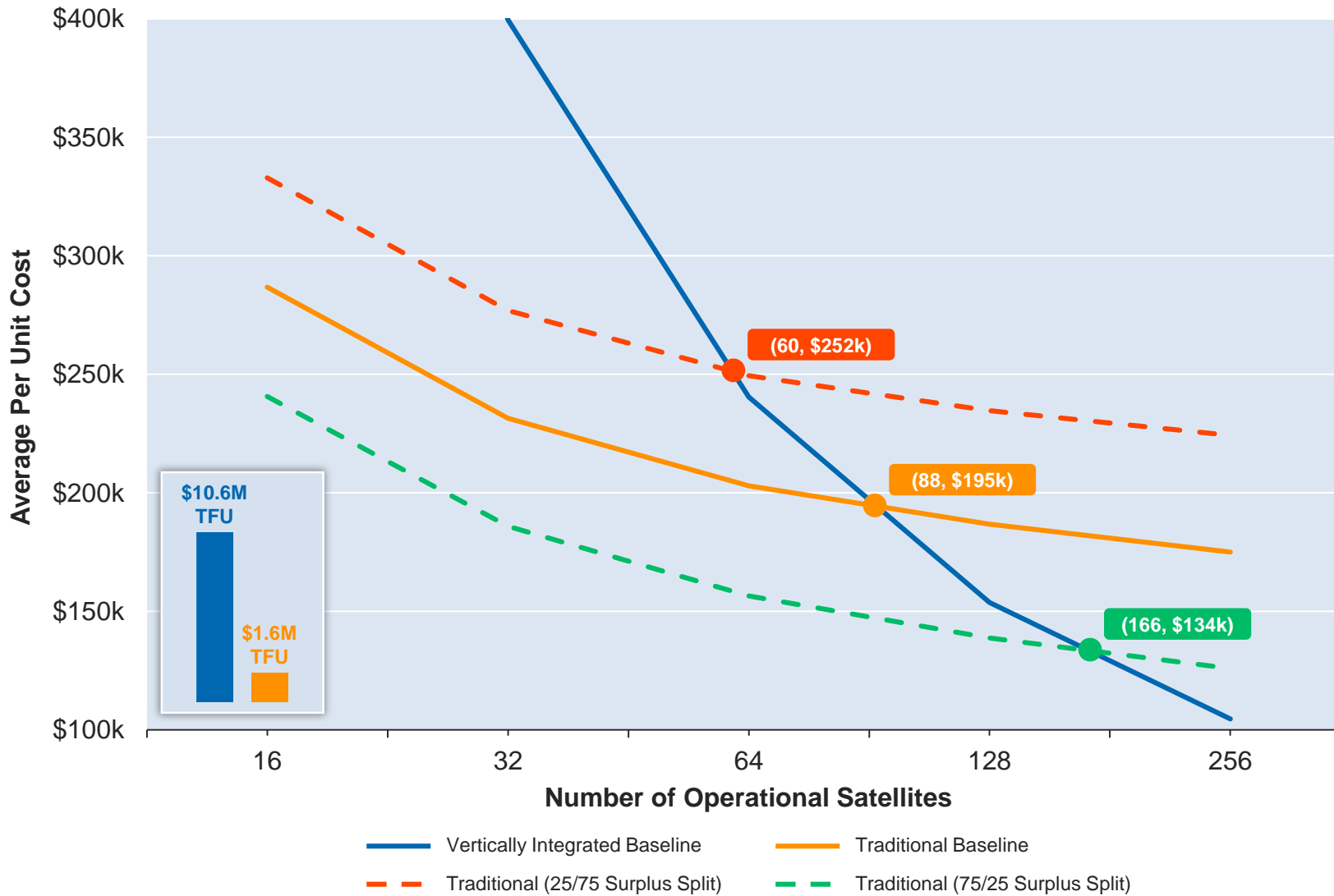
Case #1: Market Power | Framework & Methodology

- A major motivation for vertical integration across all sectors is to **increase market power**
- SpaceWorks calculated the savings due to learning effects and **varied the supplier/buyer share of the surplus** to simulate the impact of market power
 - Surplus equals the value of the learning effect savings
 - Surplus is split evenly, in favor of the buyer, or in favor of the or seller
- Within the CubeSat segment, a large number of both buyers and sellers has led to the ideal **no one dominates** scenario (50/50 surplus split)
- Within the 300 kg segment, relatively few buyers combined with an influx of traditional GEO satellite component suppliers have led to **buyers dominating** (75/25 surplus split)



Source: McKinsey & Company

Case #1: Market Power | 3U Cube Satellite

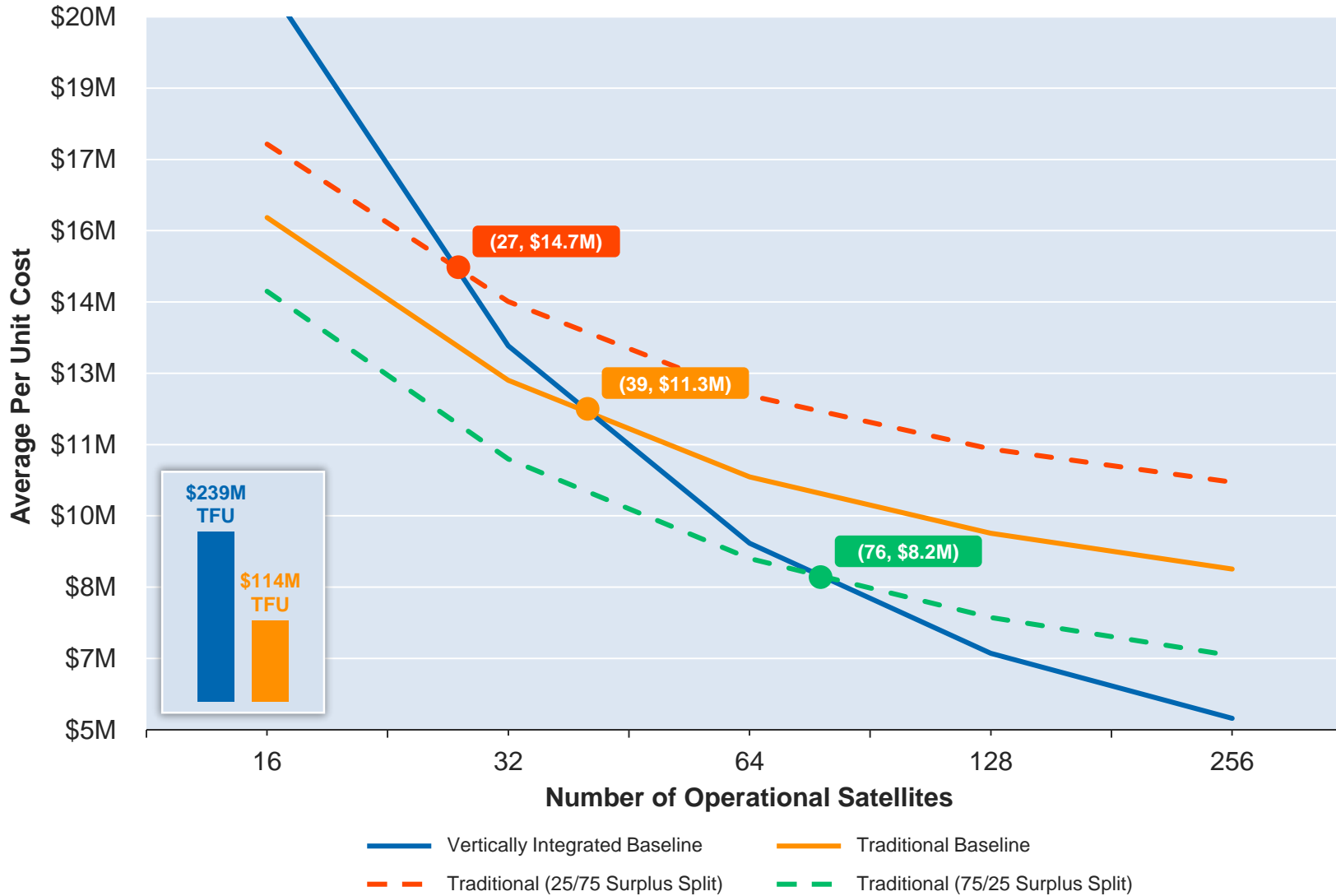


Market power has a **substantial impact on constellation breakeven** and could be a compelling reason to pursue vertical integration.

Within the CubeSat market, we currently have a **relatively balanced distribution of buyers and sellers**, leading to neither side dominating.

If there is a **shift in either the number of buyers or sellers** (and thus market power) in the future, this could impact decisions to vertically integrate.

Case #1: Market Power | 300 kg Small Satellite



In current market conditions, companies will find it **easy to squeeze suppliers** in this segment, making vertical integration less compelling.

Given the favorable market conditions for buyers, **constellations up to 76 satellites** are likely better off using traditional procurement approaches.

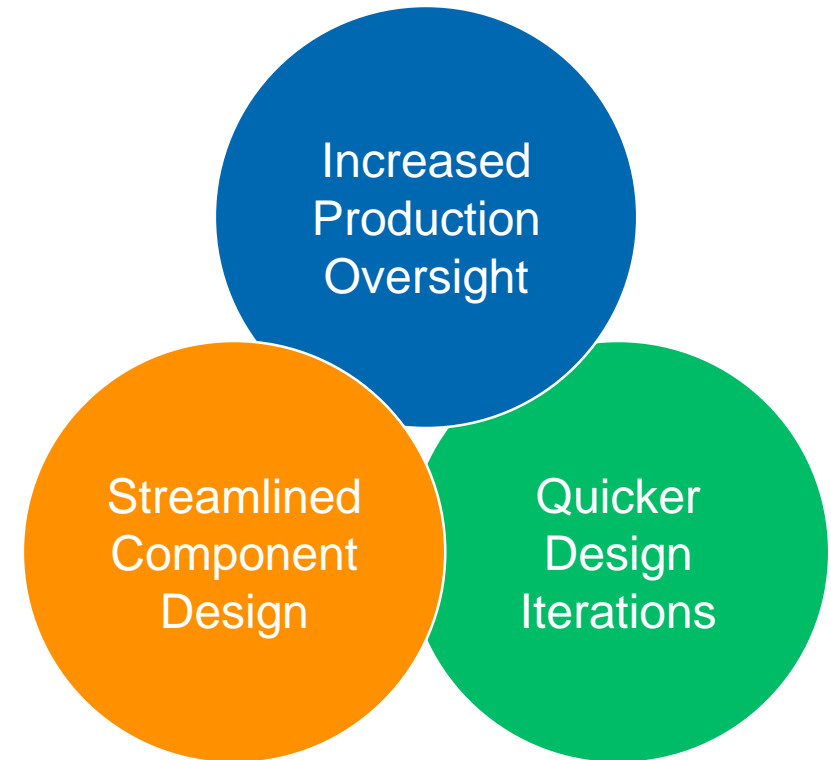
Companies must consider **expected market power in the future**, as well as current trends to avoid a mistaken decision to vertically integrate.

Case #2: Quality Control

Case #2: Quality Control | Framework & Methodology

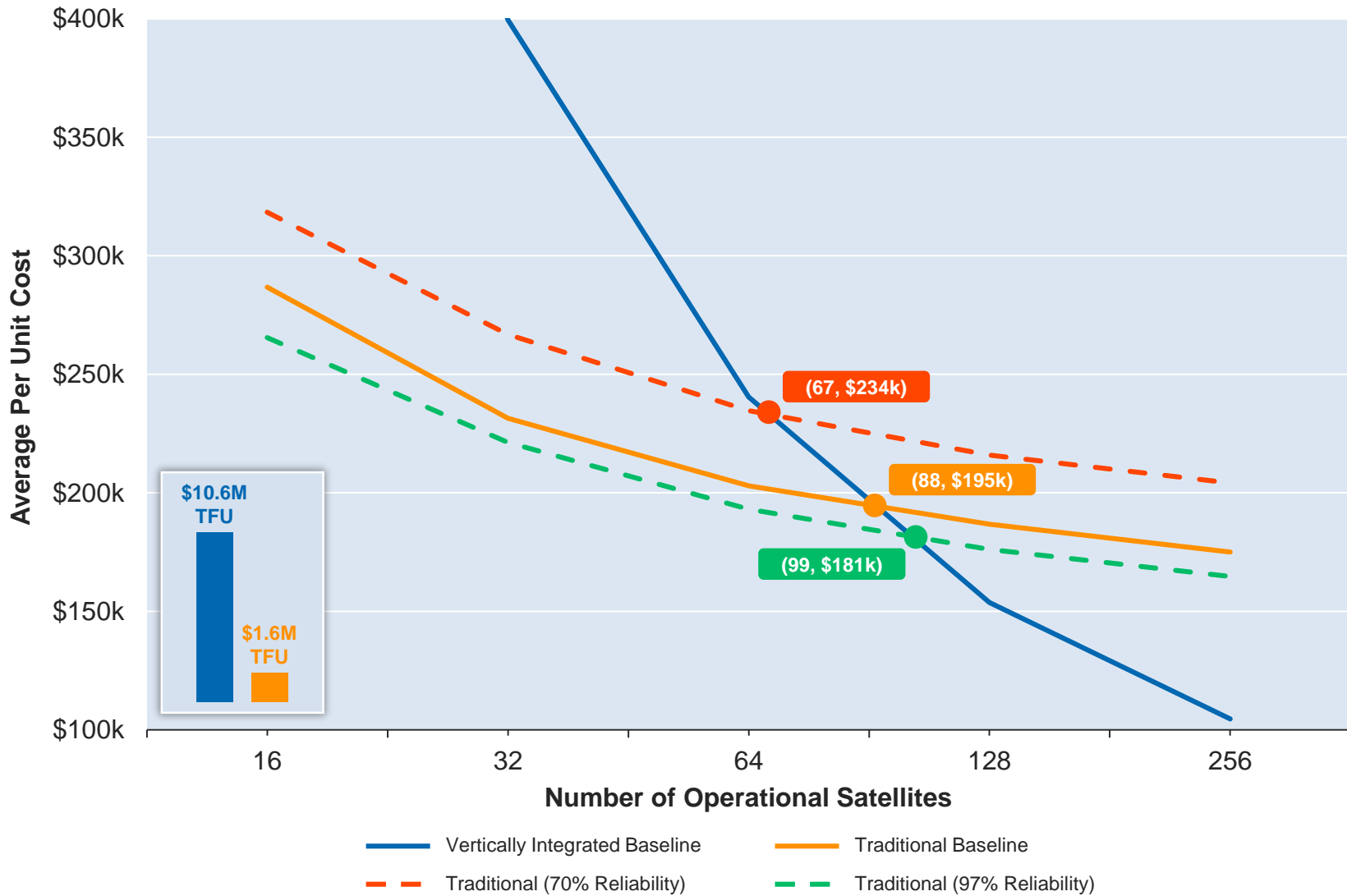
- **Improved quality control** can also be a powerful motivation for vertical integration, particularly in the CubeSat segment, where **many components are still in their infancy**
- SpaceWorks calculated the **total number of satellites** necessary for production to **achieve a certain number of operational satellites** to simulate the cost impact of different reliability rates
 - I.e., given a 90% reliability, to have 100 operational satellites, 110 satellites would need to be produced vs. given a 97% reliability, 103 satellites would need to be produced
- Within the CubeSat segment, the baseline **nominaly assumed a 90% reliability rate**, but empirical evidence suggests this **may be closer to 70%**
- Within the 300 kg segment, **more reliable components** and **additional prototyping** lead to increased reliability – **nominaly 97% for the baseline**

Vertically Integrated Quality Control Benefits



Source: SpaceWorks Commercial

Case #2: Quality Control | 3U Cube Satellite

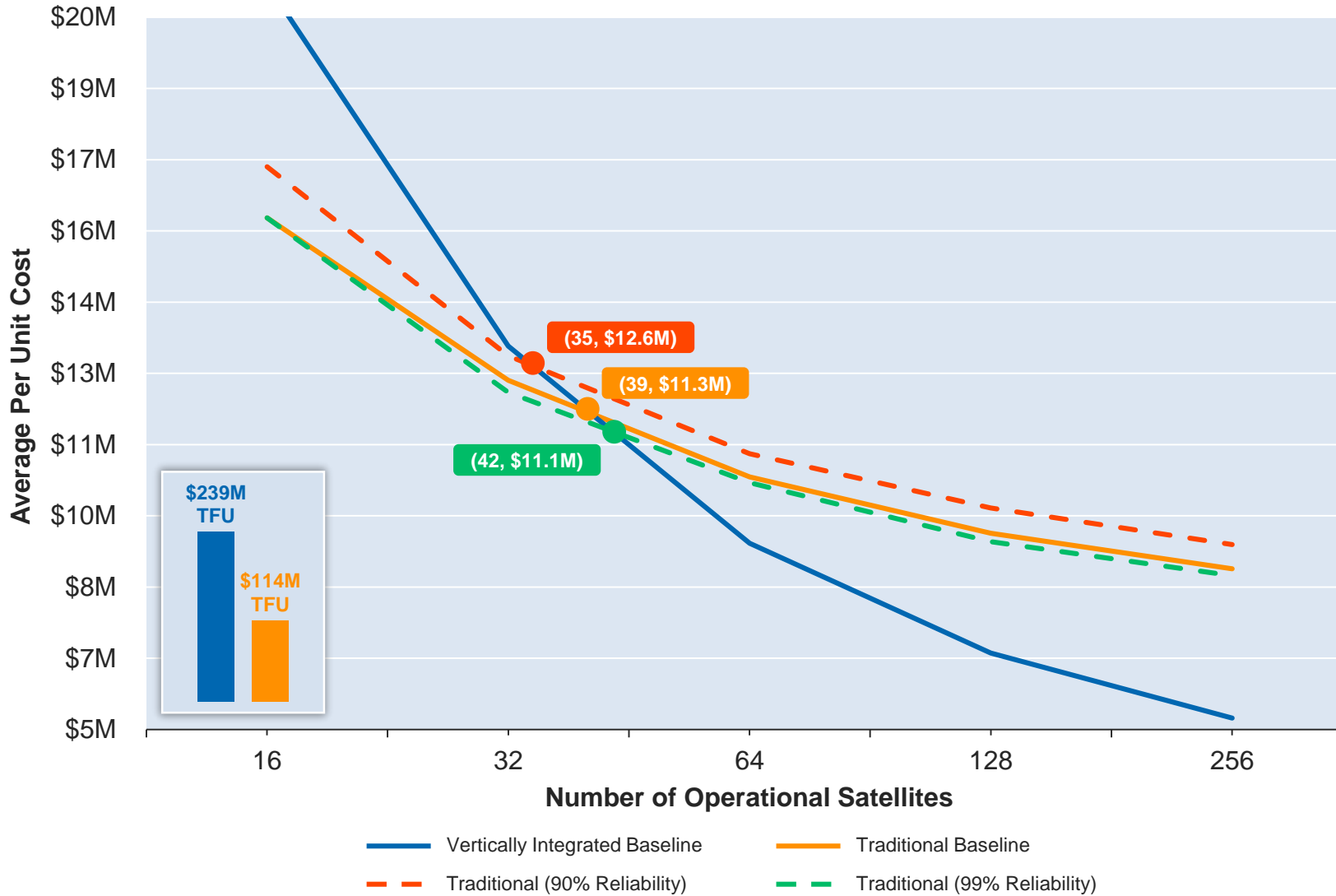


Moving from a low reliability rate can be a **compelling reason to integrate**, but firms must be able improve that reliability in-house.

If satellites already have a high reliability rate, integrating to **improve incrementally is not nearly as advantageous**.

This particular analysis **does not consider the potentially lost revenue** due to quality issue, which could be substantial.

Case #2: Quality Control | 300 kg Small Satellite



Quality control in this segment is not as compelling of a motivation for integration, as the **status-quo reliability is already quite high.**

Marginal improvements in reliability **yield minimal change** in the constellation size breakeven point.

Using new suppliers and/or components may result in **lower TFU costs**, but can also result in **lower reliability** and a different breakeven point.

Case #3: Vendor Disruptions

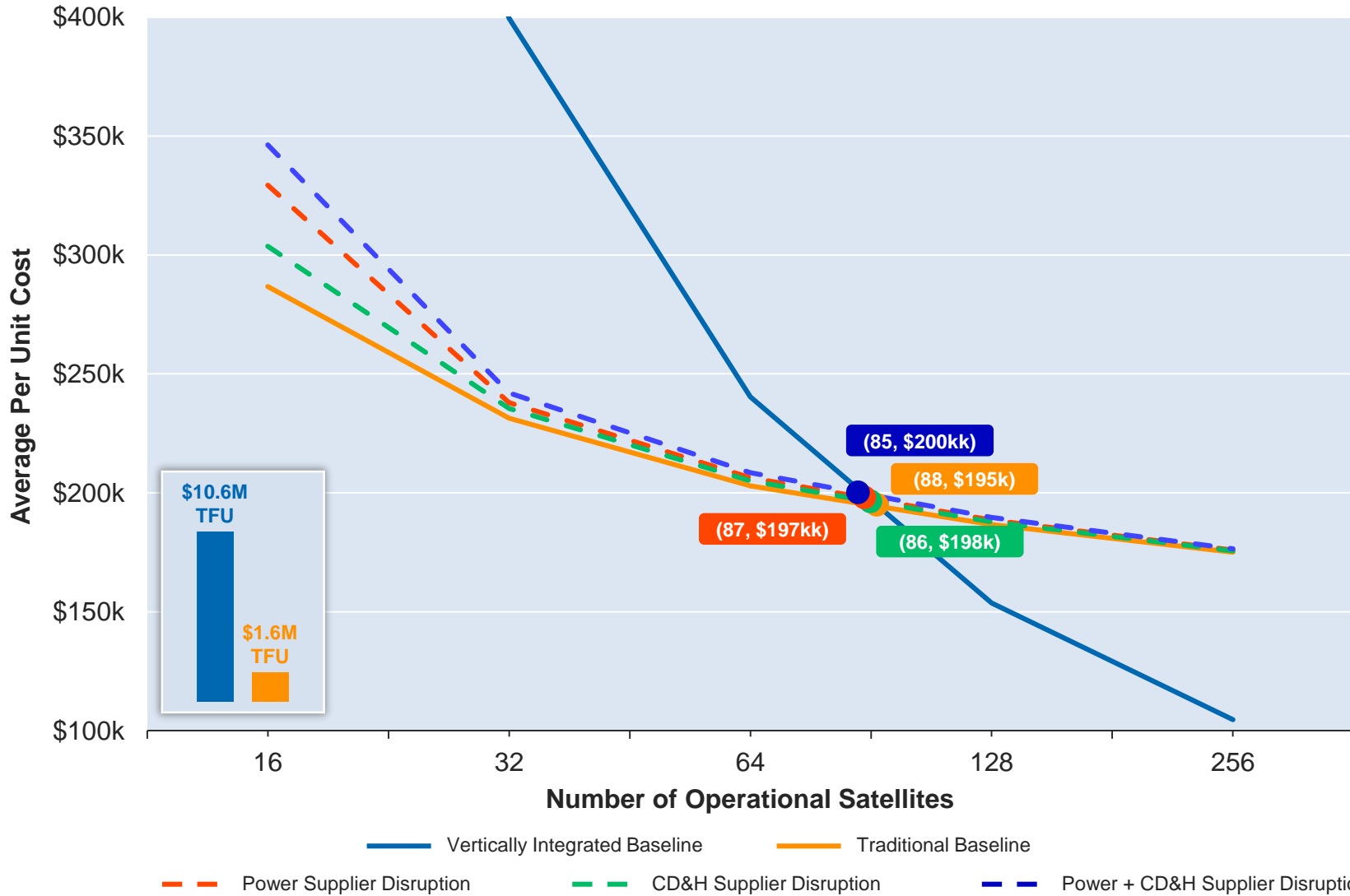
Case #3: Vendor Disruptions | Framework & Methodology

- **High transaction costs** can result in a powerful motivator for vertical integration
- Typically satellite companies make a small number of transactions for a large number of highly specialized assets (resulting in **low transaction costs**)
 - The baseline case reflects this with zero vendor disruptions
- Increased transaction costs would occur if, for example, a **supplier stopped selling a component**, and an additional vendor needed to be secured
- SpaceWorks considered **a supplier disruption** for high value subsystems (CD&H and Power) **after the 16th unit**, forcing the manufacturer to find a new vendor
 - New subsystem development cost as well as a fractional system development cost were factored in to account for the higher transaction cost

Transaction Frequency	Often	Standardized transactions (e.g., groceries)	Vertical integration (e.g., bauxite, specialized auto components)
	Seldom	Detailed standardized contracts (e.g., office lease, credit sales arrangements)	Detailed, probably unique contract (e.g., major public construction projects)
		Low	High
Asset Specificity, Durability, and Intensity			

Source: McKinsey & Company

Case #3: Vendor Disruptions | 3U Cube Satellite

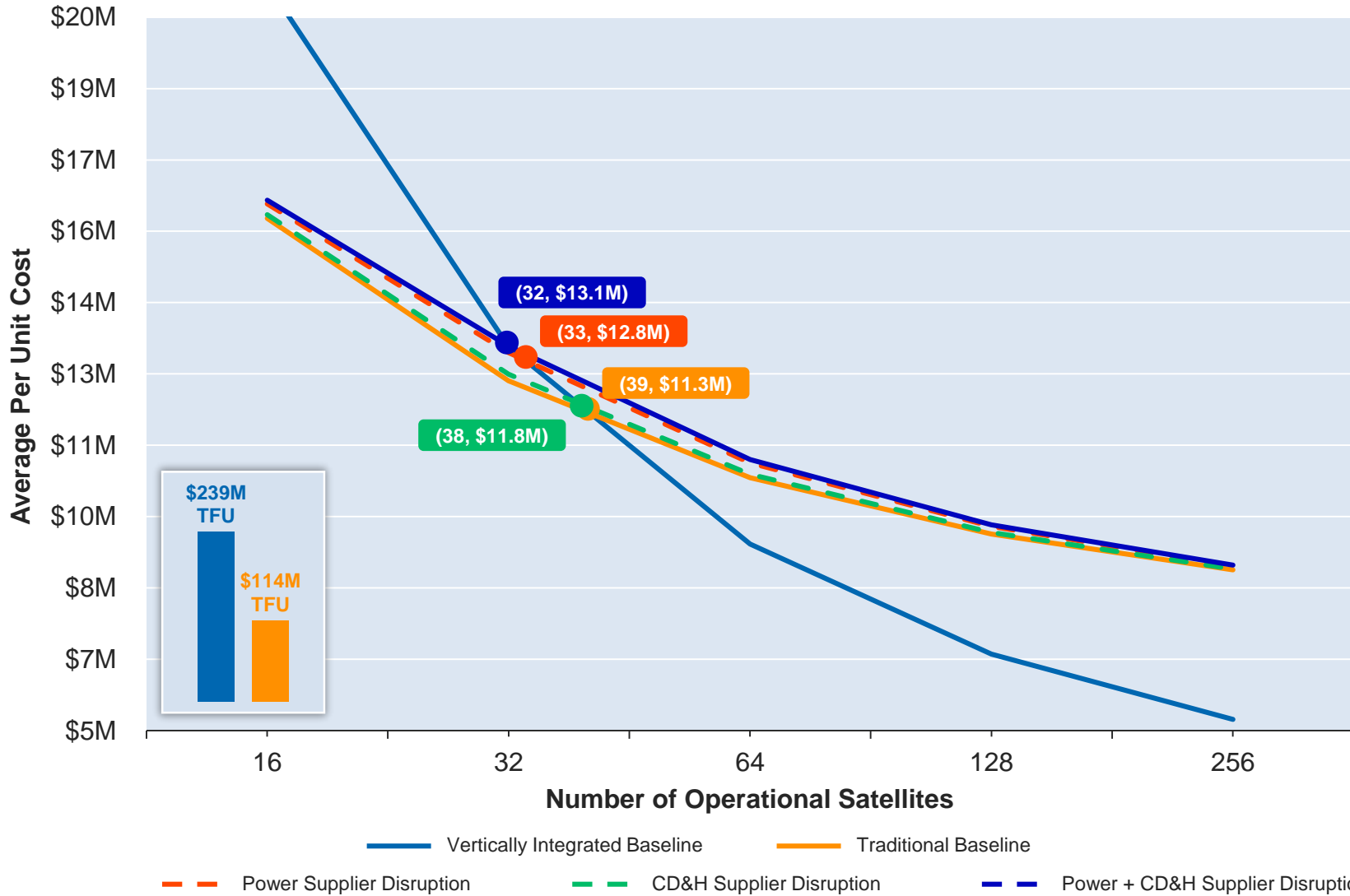


Vendor disruptions have minimal impact on constellation breakeven points, as their **cost is amortized across satellites very quickly.**

Concerns regarding vendor disruptions may be overstated, leading to a **mistaken motivation for vertical integration.**

This analysis does not consider if the manufacturer brings the component development in-house, which **could be more costly.**

Case #3: Vendor Disruptions | 300 kg Small Satellite



The impact of vendor disruptions in this segment is more substantial due to more expensive components, but it is **still overcome quickly**.

The additional complexity of components in this segment may require **greater satellite redesign**, but this was not considered.

If **additional subsystem vendor disruptions** were to occur, there would be more substantial motivation for vertical integration in this segment.

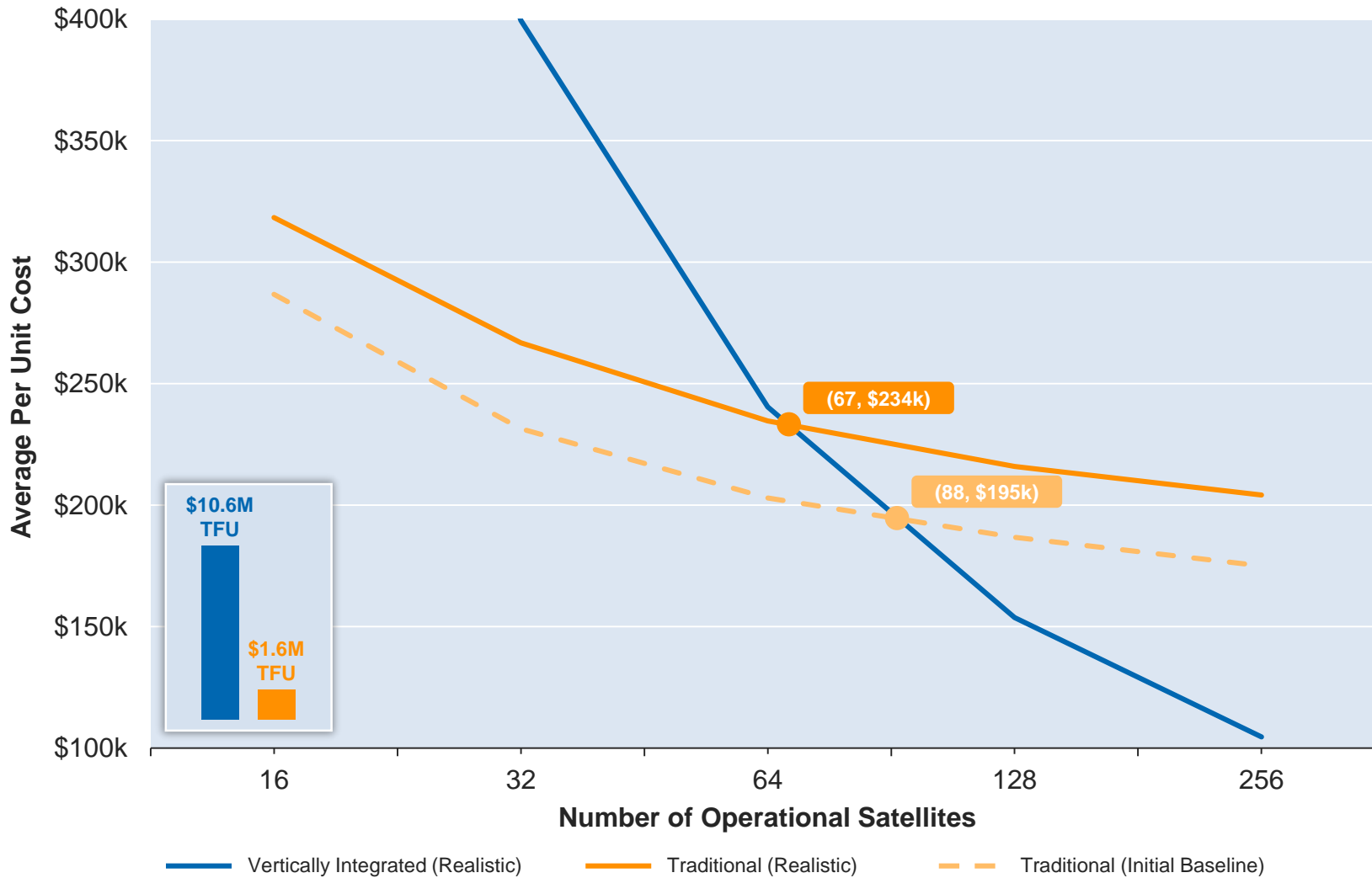
Integrating Market Expertise

Final Results | Integrating Market Expertise

- SpaceWorks has built significant **insight into current market conditions** and trends through various forecasting and strategic analysis engagements with government and commercial clients
- While each previous case considers various sensitivities to market conditions, they are evaluated **independent of one another**
- Integrating and evaluating the different sensitivities together based on current market trends gives a glimpse into a **“market-realistic” model for evaluating vertical integration** decisions for small satellite constellations

The final case considers only those conditions that are currently observed in the market place for each segment

Final Results | 3U Cube Satellite

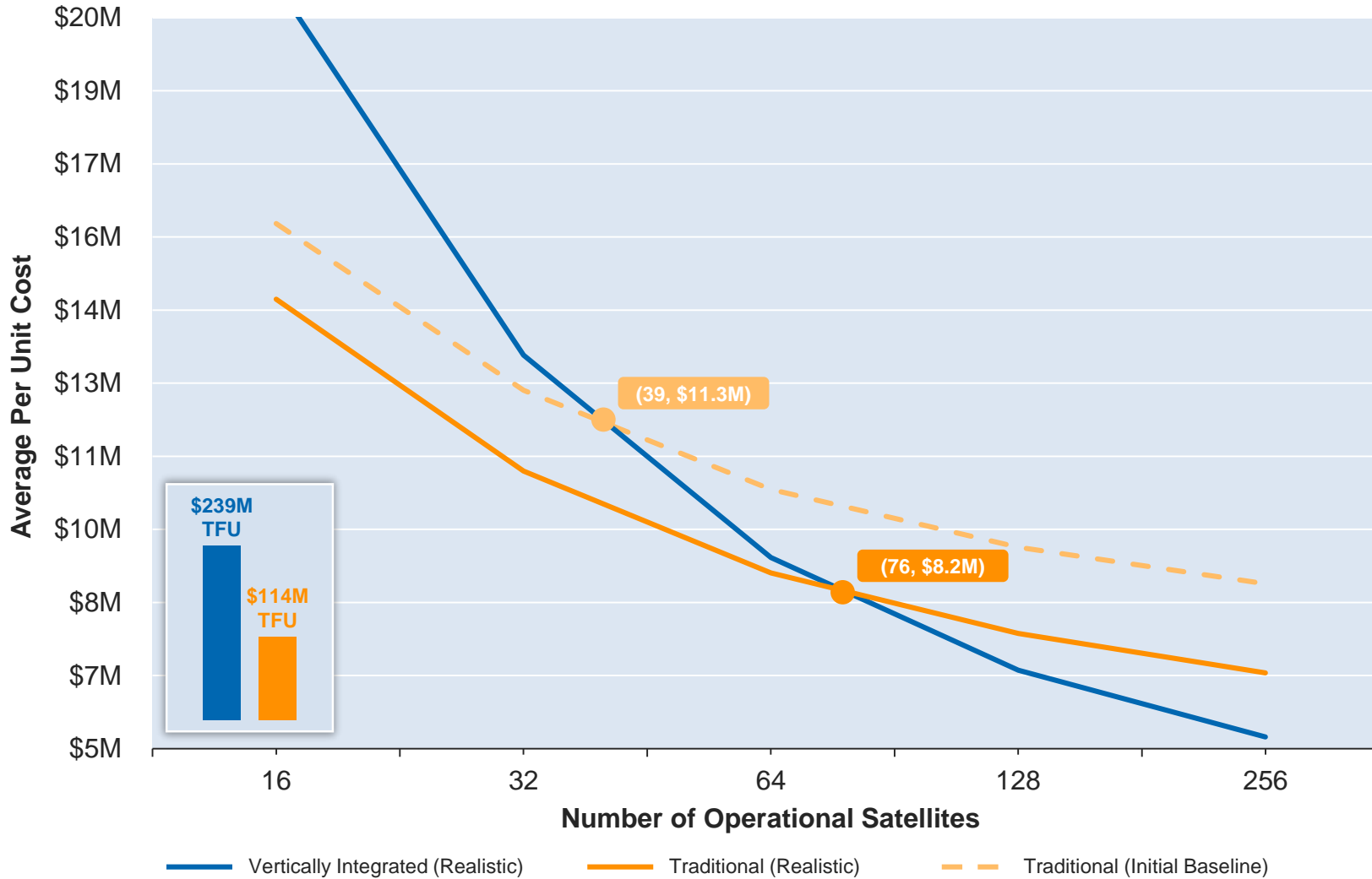


At **67 satellites** a vertically integrated approach is more cost-effective than traditional manufacturing for Cube Satellites.

In contrast to the baseline, the market-realistic 3U model uses a **70% reliability rate**, significantly lowering the breakeven point.

The **high TFU costs associated** with the vertically integrated approach provide insight into why firms are not adopting this approach.

Final Results | 300 kg Small Satellite



At **76 satellites**, a vertically integrated approach becomes more attractive than traditional manufacturing approaches in the 300 kg segment.

The constellation size breakeven shifts outward when considering the current **market environment favoring buyers** in this segment.

Even in much larger constellation sizes, the benefits of vertical integration are **not as drastic in this segment** as in the 3U segment.

Insights & Takeaways

Insights & Takeaways | Conclusions

- This analysis provides insight into **real-world motivations** for when and when not to vertically integrate
- Applying market expertise has a dramatic impact on constellation-size breakeven points and helps to illustrate why a venture such as **IridiumNEXT** (75 satellites) chose a **traditional procurement approach**, while a venture like **Spire** (150+ satellites) is leveraging a **vertically integrated approach**
- Of the cases considered, market power is the **most compelling motivation** for vertical integration
 - Within the Cube Satellite segment, market power is currently well balanced, thanks to a relatively large number of both buyers and sellers, providing little insight into why manufacturers are integrating
 - Within the Small Satellite segment, market power is in currently heavily favor of the buyers, which demonstrate why companies in this segment have been slower to adopt vertical integration strategies
- Improved quality control, while often cited as a motivation for vertical integration, is compelling only when **large advancements in reliability can be achieved** with a vertically integrated approach
- Vendor disruptions are **not a compelling reason** for vertical integration as their cost is absorbed easily by large-batch production runs

- **Constellation size** itself is likely the **strongest motivator for vertical integration**
 - Results indicate that manufacturers considering constellations greater than around 70 satellites in either segment should be considering a vertically integrated approach
- Despite the results presented here that indicate many of constellations currently in development would benefit from vertical integration, such a **strategy should be approached with caution**
- Vertical integration is a **costly and near irreversible strategy** with significant associated risks
 - The upfront investment costs (shown here as TFU costs) required for a vertically integrated approach offer insight into why companies may not be pursuing this approach even given its advantages
- The decision to vertically integrate should be made holistically, considering **market expectations in the future** (not just current trends), and a variety of **financial and organizational factors**

- Specific areas of future research identified by SpaceWorks include:
 - Consideration of additional satellite mass-classes and satellite application types
 - Consideration of additional types of vendor disruptions
 - Integration of more precise learning curve analysis for Cube Satellite components
 - Integration of revenue estimates and financial modeling (Net Present Value, Internal Rate of Return)
 - Evaluation of vertical integration decisions at the component-level
 - Evaluation of operator to manufacturer vertical integration
 - Evaluation of quasi-integration strategies (Joint Partnerships, Partial Vertical Integration)
 - ... and many others

The current effort establishes a valuable baseline for understanding motivations for vertical integration and opens many other lines of inquiry

**QUANTITATIVE MODELING
+ MARKET EXPERTISE**



STRATEGIC INSIGHTS



**COST ESTIMATION &
ECONOMIC ANALYSIS**



**MARKET FORECASTING &
COMPETITIVE INTELLIGENCE**



**STRATEGIC ADVISORY &
CONSULTING SERVICES**