Capital Stacks and IRR Analysis: Financing a 10-Person Orbital Habitat

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Thesis Question - How do different financing structures (100% equity, 70/30 debt-equity, and a mezzanine layer) affect project returns (IRR), debt-service coverage (DSCR), and sponsor risk in a 3-year model?

In this analysis, I built a 3-year DCF and cash-waterfall in Python to compare three capital structures for a 10-person orbital habitat: 100 % equity, 70/30 senior debt–equity, and a 70/15/15 senior–mezzanine–equity stack. The base-case unlevered IRR is 3.5 %, while the 70/30 stack yields –27.9 % IRR and the 70/15/15 stack –65.6 % IRR on a 3-year tenor. Extending debt to a 5-year bullet flips the 70/15/15 equity IRR to +44.2 % and improves Year 3 DSCR from 0.08× to 0.94×. A sensitivity sweep shows the project only breaks even at ≥ 70 % utilization and ticket prices ≥ $7 M.

3. <u>Objectives & Scope</u>

- **Objective**
  Evaluate how different capital structures affect project returns and sponsor risk for a 10-person orbital habitat.

- **Scope**
  - **<u>Time horizon:</u>**
    - **Year 0 (construction CapEx) + Years 1–3 operations, with a terminal value at end of Year 3.**
  - **<u>Capital structures analyzed:</u>**
    - **100 % equity**
    - **70 % senior debt / 30 % equity**
    - **70 % senior / 15 % mezzanine / 15 % equity**
    - **Each tested under both a 3-year and a 5-year bullet tenor.**

- **<u>Key metrics:</u>**
  - **Unlevered & levered IRR (to measure returns)**
  - **Debt-Service Coverage Ratio (DSCR) (to gauge covenant risk)**
  - **Sensitivity analysis on microgravity utilization and tourist ticket pricing**

4. <u>Key Assumptions & Inputs</u>

- **Project Timeline**
  - Year 0: Construction CapEx
  - Years 1–3: Operations + terminal value at end of Year 3
- **Capital Expenditures (CapEx)**
  - Year 0: $200 M
  - Year 1: $50 M
- **Operating Expenditures (OpEx)**
  - $10 M per year (Years 1–3)
- **Revenue Drivers**
  - **Microgravity pharma**
    - Fee: $2 M per module-month
    - Utilization: 50 % of 10 seats (base case)
  - **Space tourism**
    - Ticket price: $5 M per tourist
    - Volume: 4 tourists per year
- **Financing Structure**

    - **Senior debt**: 70 % of CapEx @ 8 % annual interest (bullet amort)
    - **Mezzanine debt**: 15 % of CapEx @ 12 % annual interest (bullet amort)
    - **Equity**: 15 % of CapEx at sponsor level
    - **Tenor scenarios**: 3-year bullet (principal due Year 3) and 5-year bullet (principal due Year 5)
- **Financial Assumptions**
    - Discount rate: 10 % (for NPV)
    - Corporate tax rate: 21 %
    - Terminal growth rate: 2 %

Sensitivity Grid

- Utilization: 30 %, 50 %, 70 %
- Ticket price: $3 M, $5 M, $7 M

With these inputs, I built:

1. **Unlevered DCF** (100 % equity)
2. **Debt waterfalls** for senior-only and senior+mezzanine stacks
3. **Levered cash-flows** and equity IRRs
4. **DSCR** year-by-year under each structure
5. **Sensitivity table** across utilization and pricing

5. Model Structure & Methodology

1. **DCF Layout**
   - **Assumptions Tab:** All inputs pulled from a single module (`assumptions.py`): CapEx, OpEx, revenues, financing ratios & rates, discount/tax/terminal-growth.
   - **Projection Function (`project_cash_flows`)**
     - Builds year-by-year revenue (microgravity + tourism), OpEx, EBIT, tax, and NOPAT.
   - **Free Cash Flow (`compute_free_cash_flow`)**
     - FCF = NOPAT + (negative) CapEx, so Year 0 is a negative cash outlay.
   - **Terminal Value (`add_terminal_value`)**
     - Calculates TV at end of Year 3:

       TV = (NOPAT3 * (1+g)) /r-g
2. **Debt Waterfall**
   - **Combined Schedule (`build_combined_debt_schedule`)**
     - Builds parallel bullet schedules for Senior and Mezz tranches.
     - Each tranche pays only interest in Years 1–(tenor–1), with principal + final interest in Year = tenor.
     - **TotalPayment** = Payment_Snr + Payment_Mz.
3. **Levered Cash Flows & Equity IRR**
   - **Levered FCF**
     LeveredFCFt - Total Payment

- **Equity Cash Flows**
  - Year 0: –EquityOutlay
  - Years 1–(N–1): LeveredFCF (negative or positive)
  - Year N: LeveredFCF + TerminalValue

4. **Key Metrics**
   - **Unlevered NPV & IRR:** via `numpy_financial.npv` and `numpy_financial.irr` on the unlevered FCF series.
   - **Debt-Service Coverage Ratio (DSCR):**

     DSCRt = FCFt / Total Payment
   - **Levered Equity IRR:** via `numpy_financial.irr` on the equity cash-flow series.
5. **Sensitivity Analysis**
   - Grid sweep over utilization (30 %, 50 %, 70 %) and ticket price ($3 M, $5 M, $7 M).
   - Reports unlevered NPV for each combination in a pivot table.

6. Key Drivers & Sensitivity Analysis

- **Key Drivers**
  1. **Microgravity Utilization (%)** – the share of module-months sold (base 50 %, tested 30 %–70 %)
  2. **Tourist Ticket Price (M $)** – per-seat price (base $5 M, tested $3 M–$7 M)
  3. **Debt Tenor (years)** – length of the bullet amort (3 yr vs 5 yr)

Sensitivity of Unlevered NPV (in $ M)

Utilization (%) ↓ \ Ticket Price (M $) →	3.0	5.0	7.0
30	–157.8 M	–81.5 M	–5.2 M
50 (base)	–112.0 M	–35.7 M	+40.5 M
70	–66.2 M	+10.0 M	+86.3 M

> **Insight:** The project only breaks even (NPV ≥ 0) at **≥ 70 % utilization** coupled with **≥ $7 M ticket price**.

Debt‑Service Coverage (70/15/15 stack)

Year	FCF (M $)	Total Debt Payment (M $)	DSCR (5-yr tenor)
1	–32.6	18.5	–1.76
2	+17.4	18.5	0.94
3	+17.4	18.5	0.94

> **Insight:** Extending debt to 5 years defers principal, improving Year 3 DSCR from 0.08× to 0.94×—but still below a typical 1.2× covenant threshold.

How to Interpret

- The pairing of **utilization** and **pricing** is critical: modest changes push the NPV from deeply negative to strongly positive.
- **Debt structuring** (tenor) is equally powerful: a 5-year bullet turns a loss-making equity stack (–65.6 % IRR) into a high-return scenario (+44.2 % IRR) by preserving cash-flow during operations.

These sensitivity results underscore both the upside potential (at high utilization/pricing) and the importance of flexible financing to de-risk covenant exposure.

7. Capital‑Stack Comparison

Capital Stack	Debt Tenor	Unlevered IRR	Equity IRR	Year 3 DSCR
100 % Equity	N/A	3.5 %	3.5 %	N/A
70 / 30 Senior / Equity	3-year	3.5 %	–27.9 %	0.08×
70 / 15 / 15 Snr–Mz–Eq	3-year	3.5 %	–65.6 %	0.08×
70 / 15 / 15 Snr–Mz–Eq	5-year	3.5 %	44.2 %	0.94×

Notes:

- Unlevered IRR is identical across stacks (it's the all‑equity baseline).
- Adding senior debt (70/30) crushes equity IRR and nearly destroys DSCR.

- Layering mezzanine (70/15/15) without extending tenor worsens both further.
- Stretching to a 5-year bullet defers principal through your operating window, flipping equity IRR positive and bringing DSCR close to 1×.

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8. Conclusions & Next Steps

- **Conclusions**
  1. **Leverage magnifies sponsor risk.** Both 70/30 and 70/15/15 at a 3-year tenor yield covenant-breach DSCRs (< 1.2×) and deep equity losses.
  2. **Tenor extension is powerful.** A simple move to a 5-year bullet restores Year 3 DSCR to ~0.94× and drives equity IRR to +44 %.
  3. **Operational drivers matter.** Sensitivity shows the project only breaks even at ≥ 70 % utilization & ≥ $7 M ticket price.
- **Next Steps**
  1. **Optimize leverage mix**: Test a 60/20/20 or senior-only 5-year stack to find the lowest-risk, highest-return structure.
  2. **Refine cash-flow drivers**: Model ramping utilization curves and more granular tourism seasonality.
  3. **Stress-test covenants**: Add covenant layers (e.g. minimum DSCR, equity-lock provisions) and run Monte Carlo on revenue/ops volatility.
  4. **Prepare investor deck**: Summarize key metrics and visuals (DSCR curves, IRR waterfalls) for stakeholder presentations.