MLB + MiLB Trade Value Points (TVP) System Spec — Updated Engine (Detailed)

Goal: Produce one unified numeric trade value for **MLB players + MiLB prospects** that approximates **discounted expected surplus value** and supports apples-to-apples trade comparisons.

Design constraint: Elite prospects (top-10 overall / FV 60–70) should *typically* land around **30–60 TVP** after risk + cost + discounting, while still remaining comparable to MLB assets.

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0) Definitions & Global Anchors

0.1 Unit definition

- **TVP unit:** `1 TVP = $1M of present-value (PV) expected surplus`.
- This preserves interpretability and keeps MLB & MiLB on the same scale.

0.2 Market pricing

- **Market anchor:** `DOLLARS_PER_WAR = $12M` (configurable).
- **In TVP:** `1 WAR ≈ 12 TVP` in the snapshot year.

Optional inflation: - `WAR_PRICE_GROWTH` (e.g., 0–3%/year). If omitted, assume flat $/WAR.

0.3 Time discounting

- **Discount rate:** `DISCOUNT_RATE = 15%` per year.
- Discount function:
- `disc(t) = 1 / (1 + DISCOUNT_RATE)^t`

0.4 Snapshot year & indexing

- `SNAPSHOT_YEAR = 2026` (because prospect file is dated 2026).
- **Year index convention:**
- `t = 0` corresponds to the **2026 season**.
- `t = 1` corresponds to **2027**, etc.

For prospects: - `years_to_MLB = max(0, ETA_year - SNAPSHOT_YEAR)`

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1) Data Requirements

1.1 Prospects (MiLB)

From `all_prospects_*.json` (or equivalent), required: - `fv_value` (40/45/50/55/60/65/70) - `age` - `eta` (year as string or int) - `position` (C, SS, 2B, 3B, CF, 1B, LF/RF/COF, SP, RP, OF/INF) - `system_rank` (org rank) - `top_100_rank` (null if not top-100)

Optional but useful: - handedness, level, injury flag, recent performance signals

1.2 MLB players

Provided by our pipeline (or manual), required: - `player_name`, `mlb_id` - `age` (as-of snapshot) - `projected_fWAR_by_year`: `fWAR_t` for t = 0..N-1 (at least 2 years + a method to extend) - `salary_by_year_$M`: `salary_t` aligned to t = 0..N-1 - contract meta: term/control years, arb/option years if needed

Options (if present): - per option year: `type` ∈ {PO, CO, MO}, `option_salary_$M`, `buyout_$M` (default 0)

Rookie transition (required to value promoted prospects): - `PA_to_date` (hitters) or `IP_to_date` (pitchers) - `fWAR_to_date` (MLB only) - optionally: `service_time_days` (preferred), or `service_years` estimate

Trade mechanics (high impact, recommended): - `cash_sent_$M` / `salary_retained_$M` by year

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2) Prospect Valuation (MiLB → TVP)

Core idea: Prospects are valued as the **PV of expected surplus** across the first 6 MLB seasons **after MLB arrival**, using: - FV → baseline WAR shape - a **single interpretable risk model** (no stacking multiple time haircuts) - a realistic **pre-arb/arb cost curve** - annual discounting

2.1 FV → baseline WAR over first 6 MLB seasons

We map FV to expected **total WAR over first 6 MLB seasons** (`WAR6_base`).

Default table (tunable via calibration):

FV	WAR6_base
70	20.0
65	16.0
60	12.0

FV	WAR6_base
55	8.0
50	5.0
45	2.5
40	1.0

2.2 Convert WAR6_base into a per-season WAR profile

We need `WAR_y_base` for y=1..6 (six MLB seasons after debut).

Default profile weights (sum = 1.00): - `w = [0.10, 0.14, 0.18, 0.20, 0.20, 0.18]`

Then: - `WAR_y_base = WAR6_base * w_y`

Pitcher profile (optional) can be slightly more volatile: - `w_pitch = [0.12, 0.16, 0.18, 0.18, 0.18, 0.18]`

2.3 Top-100 multiplier (small)

Let `r = top_100_rank`.

- if $1 \le r \le 10$: `top100_mult = 1.10`
- if $11 \le r \le 25$: `top100_mult = 1.06`
- if $26 \le r \le 50$: `top100_mult = 1.03`
- if $51 \le r \le 100$: `top100_mult = 1.01`
- if r is null: `top100_mult = 1.00`

Apply as a modest adjustment to WAR (not a separate value add): - `WAR_y_adj = WAR_y_base * top100_mult`

2.4 Risk model (single mechanism, interpretable)

We model uncertainty as an **outcome mixture** producing expected WAR.

2.4.1 Outcomes

Define three outcomes: - **Bust:** `WAR = 0` - **Role:** `WAR = role_mult * WAR_y_adj` (default `role_mult = 0.65`) - **Star:** `WAR = star_mult * WAR_y_adj` (default `star_mult = 1.35`)

2.4.2 Base probabilities by FV

Base probabilities (tunable):

FV	p_bust	p_role	p_star
70	0.15	0.55	0.30
65	0.20	0.58	0.22
60	0.25	0.60	0.15
55	0.35	0.58	0.07
50	0.45	0.52	0.03
45	0.55	0.45	0.00
40	0.65	0.35	0.00

These probabilities are the primary lever that keeps top prospects in the **30–60 TVP** band.

2.4.3 Risk adjustments (do NOT add separate ETA haircuts)

Adjust probabilities multiplicatively / by shifts, then renormalize to sum to 1.

a) Pitcher adjustment (more volatility): - shift `+0.05` from `p_star` to `p_bust` (cap at bounds)

b) Teen adjustment (age ≤ 19): - shift `+0.03` from `p_star` to `p_bust`

c) ETA survival risk (risk, not time discount): Prospects farther away have higher chance of never becoming the baseline.

- `p_survive = 0.92^(years_to_MLB)` (tunable)
- Apply by increasing bust probability:
- `p_bust = 1 - p_survive * (1 - p_bust)`
- keep p_role and p_star proportional to their previous share of (1 - p_bust)

This is allowed because it's a **reach-the-majors** risk component, distinct from time discounting.

2.4.4 Expected WAR by season

For each MLB season y: - `E[WAR_y] = p_role*(role_mult*WAR_y_adj) + p_star*(star_mult*WAR_y_adj)`

2.5 Position multiplier (optional, modest)

Prospect FV partially reflects position, so keep this **light**. Default: - C or SS: `pos_mult = 1.05` - SP: `pos_mult = 1.02` - 2B/3B/CF/INF: `pos_mult = 1.00` - 1B/COF/OF: `pos_mult = 0.92` - RP: `pos_mult = 0.95`

Apply to WAR: - `E[WAR_y] = E[WAR_y] * pos_mult`

2.6 Cost curve during first 6 years of MLB control

Replace the flat cost-base with a realistic schedule.

Config: - `MIN_SALARY_$M = 0.80` (tunable) - `MIN_SALARY_GROWTH = 0.03` (optional)

Arbitration as share of market value (tunable): - `arb_share = [0.00, 0.00, 0.00, 0.30, 0.50, 0.70]`

For each MLB season y=1..6 after debut: 1) Identify calendar index: - `t = years_to_MLB + (y-1)` 2) Compute market value in $M: - `value_$M = E[WAR_y] * $/WAR_t` 3) Compute salary in $M: - `salary_min_$M = MIN_SALARY_$M * (1 + MIN_SALARY_GROWTH)^t` - `salary_$M = max(salary_min_$M, arb_share_y * value_$M)`

Convert salary to TVP: - `salary_TVP = salary_$M` (because 1 TVP = $1M)

2.7 Prospect surplus and discounting

For each post-debut season y: - `value_TVP = E[WAR_y] * ($/WAR_t in TVP per WAR)` - if `$/WAR_t` expressed in $M, then `value_TVP = E[WAR_y] * ($/WAR_t)` - `surplus_TVP = value_TVP - salary_TVP` - `pv_surplus_TVP = surplus_TVP * disc(t)`

Total prospect TVP: - `TVP_prospect_raw = Σ_y pv_surplus_TVP`

2.8 Org-rank bonus (tiny tie-breaker)

Only if NOT top-100 (`top_100_rank is null`): - system_rank 1–5: `org_bonus = +2.0` - 6–10: `+1.0` - 11–20: `+0.5` - else: `+0.0`

If top-100: `org_bonus = 0.0`

2.9 Prospect TVP final + floor

- `TVP_prospect = TVP_prospect_raw + org_bonus`

Optional floor: - `TVP_prospect = max(0, TVP_prospect)`

Calibration note: If elite prospects are too high/low, adjust: - FV probability table (p_bust/p_role/p_star) - role_mult/star_mult - survival curve base (0.92) NOT by stacking additional ETA multipliers.

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3) MLB Player Valuation (MLB → TVP)

3.1 Core MLB TVP formula (no options)

For each contract/control year index `t`: - `value_TVP_t = fWAR_t * $/WAR_t` - `surplus_TVP_t = value_TVP_t - salary_$M_t` (since salary in $M equals TVP) - `pv_surplus_TVP_t = surplus_TVP_t * disc(t)`

Total: - `TVP_MLB_base = Σ_t pv_surplus_TVP_t`

This naturally yields negative TVP for bad contracts.

3.2 Current-season proration (if valuing mid-season)

If valuation happens mid-season (trade deadline), pro-rate remaining season: - `f = remaining_games / 162` (or remaining innings share) - `fWAR_t_remaining = fWAR_t * f` - `salary_t_remaining = salary_t * f` (for salary owed)

Use those for the current year t.

3.3 Reliability / volatility (optional, keep small)

Preferred: encode durability into projections. If you must apply a multiplier, keep it mild: - stable everyday / stable SP: `rel_mult = 1.00` - typical regular: `0.95` - injury-prone / very volatile: `0.85` - reliever: `0.85` (elite closer optional `0.90`)

Then: - `TVP_MLB = TVP_MLB_base * rel_mult`

3.4 Cash, retention, CBT (recommended)

Salary retention / cash directly changes surplus. - If Team A retains `retained_$M_t`, then receiving team salary is reduced: - `salary_received_$M_t = salary_$M_t - retained_$M_t` - If cash is sent as a lump sum, allocate it to the correct year and discount.

(If you later model CBT penalties, treat them as additional salary.)

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4) Contract Options (PO / CO / MO)

We treat options as decision nodes using smoothed exercise probabilities.

Let for option year t: - `V = fWAR_t * $/WAR_t` (team on-field value in TVP) - `S = option_salary_$M` (in TVP) - `B = buyout_$M` (in TVP; default 0)

Smoothing constants: - `K = 6` (≈ $6M width for coin-flip region; tunable) - `sigmoid(x) = 1 / (1 + exp(-x))`

4.1 Team (club) option — CO

Team compares exercise vs decline (buyout).

- Exercise payoff: `V - S`
- Decline payoff: `-B`

Probability of exercise: - `P_ex = sigmoid(((V - S) + B) / K)`

Expected option-year contribution: - `EV_t = P_ex*(V - S) + (1 - P_ex)*(-B)`

4.2 Player option — PO (fix: compare to market, not V)

Player compares option salary to expected free-agent market salary.

Estimate market salary `M` (in $M = TVP) from projected WAR: - `M = max(MIN_FA_$M, FA_SHARE * V)`

Defaults: - `FA_SHARE = 0.90` (player captures most of value) - `MIN_FA_$M = 2.0`

Player opts in if `S` is better than `M`: - `P_in = sigmoid((S - M) / K)`

From the team perspective: - If player opts in, team gets `V - S`. - If player opts out, assume option-year value to team is `0` (they lose the player).

So: - `EV_t = P_in*(V - S) + (1 - P_in)*0`

4.3 Mutual option — MO

Both must agree.

- Team willingness: `P_team = sigmoid(((V - S) + B) / K)`
- Player willingness: `P_player = sigmoid((S - M) / K)`
- Joint: `P_ex = P_team * P_player`
- `EV_t = P_ex*(V - S) + (1 - P_ex)*(-B)`

4.4 Integrating option years into MLB TVP

For option year t, replace the standard surplus `(V - salary)` with `EV_t` and discount: - `pv_EV_t = EV_t * disc(t)`

Then: - `TVP_MLB_base = Σ guaranteed_years(pv_surplus) + Σ option_years(pv_EV)`

5) Prospect → MLB Transition (Promotion / Rookie Phase)

Requirement: value continuity. A debut should not cause irrational jumps unless performance provides strong evidence.

We compute two values after debut: - `TVP_prospect_anchor`: prospect-style value as a pedigree anchor - `TVP_MLB`: MLB-style value using updated projections + control years

Then blend: - `TVP_current = alpha * TVP_prospect_anchor + (1 - alpha) * TVP_MLB`

5.1 Prospect anchor after debut

At debut: - Set `years_to_MLB = 0` and recompute prospect valuation using FV + risk model. - Use only the remaining portion of the 6-year window if you are tracking service time (optional).

5.2 Alpha schedule (by MLB playing time)

Hitters (PA): - 0–200 PA: `alpha_base = 0.85` - 200–600 PA: `0.70` - 600–1200 PA: `0.55` - 1200–2000 PA: `0.40` - 2000+ PA: `0.25`

Pitchers (IP): - 0–70 IP: `0.85` - 70–150 IP: `0.70` - 150–300 IP: `0.55` - 300–500 IP: `0.40` - 500+ IP: `0.25`

5.3 Shock-based alpha reduction (performance matters, but don't overreact)

1) Convert FV to a prior WAR rate. - For hitters: `WAR_rate_prior` in WAR / 600 PA - For pitchers: `WAR_rate_prior` in WAR / 180 IP

Default prior table (tunable): - FV70: 4.0 - FV65: 3.4 - FV60: 3.0 - FV55: 2.3 - FV50: 1.6 - FV45: 1.0 - FV40: 0.5

2) Expected WAR to date from prior: - hitters: `WAR_expected = WAR_rate_prior * (PA/600)` - pitchers: `WAR_expected = WAR_rate_prior * (IP/180)`

3) Shock magnitude: - `Delta = fWAR_to_date - WAR_expected`

4) Evidence score (0..1): - hitters: `e = min(1, abs(Delta)/1.5) * min(1, PA/300)` - pitchers: `e = min(1, abs(Delta)/1.5) * min(1, IP/75)`

5) Alpha adjustment: - `alpha = alpha_base * (1 - 0.35 * e)`

5.4 Updating MLB projections (prior + evidence)

We update the WAR rate used to generate future `fWAR_t` projections.

Base sample weight: - hitters: `w_base = PA / (PA + 600)` - pitchers: `w_base = IP / (IP + 150)`

Shock boost: - `w_shock = 0.25 * e`

Final weight: - `w = clamp(w_base + w_shock, 0, 0.85)`

Observed WAR rate: - hitters: `WAR_rate_obs = fWAR_to_date / (PA/600)` - pitchers: `WAR_rate_obs = fWAR_to_date / (IP/180)`

Updated rate: - `WAR_rate_updated = (1 - w) * WAR_rate_prior + w * WAR_rate_obs`

Use `WAR_rate_updated` to extend future `fWAR_t` (with aging/durability rules) and compute `TVP_MLB`.

5.5 Bust override (prevents permanent prospect halo)

If sufficient MLB evidence shows clear failure: - hitters: if `PA >= 800` and `fWAR_to_date <= -1.0`, force `alpha = min(alpha, 0.10)` - pitchers: if `IP >= 250` and `fWAR_to_date <= -1.0`, force `alpha = min(alpha, 0.10)`

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6) Trade Package Rule (optional, recommended)

Purpose: prevent “prospect spam” from equaling a star and reflect roster consolidation preference.

6.1 Simple step multipliers (compatible with v1)

- Sort assets by `TVP_current` descending.
- Multipliers: `1st ×1.00`, `2nd ×0.95`, `3rd ×0.90`, `4th+ ×0.85`
- `PACKAGE_TVP = Σ (mult_i * TVP_i)`

6.2 Smooth alternative (recommended long-term)

- Concavity power: `p = 0.92` (tunable)
- `PACKAGE_SCORE = Σ (TVP_i^p)`
- Convert back to TVP via calibration if desired.

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7) Output Fields (what the system should produce)

For each asset (prospect or MLB): - identifiers: `mlb_id`, `player_name`, `age` - `status`: `prospect | rookie | mlb` - `tvp_prospect` (null for pure MLB vets if desired) - `tvp_mlb` (null for pure prospects) - `tvp_current` (always present) - `raw_components` (debug friendly): - prospects: FV, ETA, years_to_MLB, top100_mult, p_bust/p_role/p_star, role_mult/star_mult, pos_mult, salary_curve - MLB: yearly fWAR, yearly salary, discount factors, options EV if any - rookie fields: PA/IP, fWAR_to_date, alpha, WAR_rate_prior, WAR_rate_updated - snapshot: `snapshot_year = 2026`, `last_updated_timestamp`

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8) Notes / Implementation Priorities

1) Implement **prospect TVP** first (deterministic from file + config). 2) Implement **MLB TVP** next (needs contract + yearly fWAR projections). 3) Implement **options EV** once option fields exist. 4) Implement **rookie transition** once PA/IP + MLB fWAR to date are available. 5) Add **cash/retention** support (high leverage). 6) Keep all constants in a single config for calibration.

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9) Calibration Harness (Required)

To keep the model tethered to reality:

1) Build a dataset of historical trades (date, assets, retention). 2) Compute TVP for each asset using parameters valid on trade date. 3) Compare package totals vs market consensus. 4) Tune in this order: - FV probability table (primary) - survival curve base (0.92) - arb shares / min salary - FV→WAR6 mapping - discount rate (only if systematically off)

Version your parameter set by season.

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10) Default Config (single place)

```
SNAPSHOT_YEAR: 2026
DOLLARS_PER_WAR: 12.0   # $M per WAR
WAR_PRICE_GROWTH: 0.00
DISCOUNT_RATE: 0.15

MIN_SALARY_$M: 0.80
MIN_SALARY_GROWTH: 0.03
ARB_SHARE: [0.00, 0.00, 0.00, 0.30, 0.50, 0.70]

ROLE_MULT: 0.65
STAR_MULT: 1.35
ETA_SURVIVE_BASE: 0.92

OPTION_SIGMOID_K: 6.0
FA_SHARE: 0.90
MIN_FA_$M: 2.0

PACKAGE_STEP_MULTS: [1.00, 0.95, 0.90, 0.85]
PACKAGE_POWER_P: 0.92
```

Appendix A — Tables (edit during calibration)

A1) FV → WAR6_base

(Defaults in §2.1)

A2) FV → (p_bust, p_role, p_star)

(Defaults in §2.4.2)

A3) FV → WAR_rate_prior (rookie transition)

(Defaults in §5.3)

Appendix B — Sanity checks

1) **Top prospect should land ~30–60 TVP** under default risk & cost assumptions. 2) **Pre-arb superstar (6 years control)** should land roughly ~150–185 TVP. 3) **Awful long contract** can land ~-65 to -115 TVP.

If you miss these ranges, don’t add extra multipliers—adjust the FV outcome probabilities and arb shares first.