Integrated SCRUM Planning Optimization Model

Derived from Entities, Relationships, Goals, Conditions, and Decision Variables

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Contents

1 1. Sets (Entities)

- $\mathcal{P}$ (**Project**, index p): set of projects.
- $\mathcal{T}$ (**Team**, index t): set of teams.
- $\mathcal{W}$ (**Worker**, index w): set of individual workers.
- $\mathcal{F}$ (**Feature**, index f): set of features.
- $\mathcal{S}$ (**Skill**, index s): set of skills.
- $\mathcal{R}$ (**Role**, index r): set of roles.
- $\mathcal{PO}$ (**ProductOwner**, index po): set of Product Owners.
- $\mathcal{SM}$ (**ScrumMaster**, index sm): set of Scrum Masters.
- $\mathcal{PB}$ (**ProductBacklog**, index pb): set of product backlogs.
- $\mathcal{SP}$ (**Sprint**, index sp): set of sprints.
- $\mathcal{SPP}$ (**SprintPlanning**, index spp): set of sprint plannings.
- $\mathcal{DS}$ (**DailyScrum**, index ds): set of daily scrums.
- $\mathcal{SR}$ (**SprintReview**, index sr): set of sprint reviews.
- $\mathcal{SRE}$ (**SprintRetrospective**, index sre): set of sprint retrospectives.
- $\mathcal{SBL}$ (**SprintBacklog**, index sbl): set of sprint backlogs.
- $\mathcal{SG}$ (**SprintGoal**, index sg): set of sprint goals.
- $\mathcal{E}$ (**Epic**, index e): set of epics.
- $\mathcal{US}$ (**UserStory**, index us): set of user stories.
- $\mathcal{TSK}$ (**Task**, index tsk): set of tasks.
- $\mathcal{DEV}$ (**DevelopmentSnapshot**, index dev): set of development snapshots.
- $\mathcal{BL}$ (**Blocker**, index bl): set of blockers.
- $\mathcal{SH}$ (**Stakeholder**, index sh): set of stakeholders.
- $\mathcal{VEL}$ (**Velocity**, index vel): set of team velocity records.
- $\mathcal{REP}$ (**ReleasePlan**, index rep): set of release plans.
- $\mathcal{RM}$ (**Roadmap**, index rm): set of roadmaps.
- $\mathcal{SCB}$ (**ScrumBoard**, index scb): set of scrum boards.
- $\mathcal{FED}$ (**FeatureDocumentation**, index fed): set of feature documentation entries.

Parameters from attributes (illustrative, all derived from `Entities.csv`):

- $budget_p \in \mathbb{R}_{\geq 0}$ (**Project.budget**), $p \in \mathcal{P}$.
- $availability_w \in [0,1]$ (**Worker.availability**), $w \in \mathcal{W}$.
- $priority_f \in \mathbb{Z}_{\geq 0}$, $effort^F_f \in \mathbb{R}_{\geq 0}$ (**Feature.priority**, **Feature.estimated_effort**), $f \in \mathcal{F}$.
- $achieved_{sp} \in \{0,1\}$ (**Sprint.achievement_of_goal**), $sp \in \mathcal{SP}$.
- $velAvg_t \in \mathbb{R}_{\geq 0}$ (**Velocity.avg._story_points**), $t \in \mathcal{T}$ (linked via **R19**).
- $severity_{bl} \in \mathbb{R}_{\geq 0}$ (**Blocker.severity**), $bl \in \mathcal{BL}$.
- $spoints_{us} \in \mathbb{Z}_{\geq 0}$ (**UserStory.story_points**), $us \in \mathcal{US}$.
- $effort^{TSK}_{tsk} \in \mathbb{R}_{\geq 0}$ (**Task.effort**), $tsk \in \mathcal{TSK}$.
- $size_t \in \mathbb{Z}_{\geq 1}$ (**Team.team_size**), $t \in \mathcal{T}$.
- $rel_{sh,f} \in \mathbb{R}_{\geq 0}$ (**Stakeholder.relevance_to_feature**), $(sh, f) \in \mathcal{SH} \times \mathcal{F}$.
- $planDate_{rep} \in \mathbb{R}_{\geq 0}$ (**ReleasePlan.planned_date**), $rep \in \mathcal{REP}$.
- Status/flags (0/1): $activeProject_p$, $readyTeam_t$, $hasAC_{us}$, $activeSprint_{sp}$, $openPB_{pb}$, $docLinked_f$, etc.

Relationship incidence parameters (from `Relationships.csv`):

- $A^{TP}_{t,p} \in \{0,1\}$ (**R1** team t can be assigned to project p).
- $A^{WT}_{w,t} \in \{0,1\}$ (**R2** worker w belongs to team t). (*Note: `Employee` ≡ `Worker`.*)
- $A^{WS}_{w,s} \in \{0,1\}$ (**R3** worker w has skill s).
- $A^{WR}_{w,r} \in \{0,1\}$ (**R4** worker w takes on role r).
- $A^{PO\text{-}PB}_{po,pb} \in \{0,1\}$ (**R5**), $A^{T\text{-}SM}_{t,sm} \in \{0,1\}$ (**R6**).
- $A^{PB\text{-}F}_{pb,f} \in \{0,1\}$ (**R7**), $A^{PB\text{-}E}_{pb,e} \in \{0,1\}$ (**R8**).
- $A^{E\text{-}US}_{e,us} \in \{0,1\}$ (**R9**), $A^{US\text{-}TSK}_{us,tsk} \in \{0,1\}$ (**R10**).
- $A^{US\text{-}SBL}_{us,sbl} \in \{0,1\}$ (**R11**), $A^{SBL\text{-}SP}_{sbl,sp} \in \{0,1\}$ (**R12**).
- $A^{SP\text{-}SG}_{sp,sg} \in \{0,1\}$ (**R13**), $A^{SCB\text{-}TSK}_{scb,tsk} \in \{0,1\}$ (**R14**).
- $A^{FED\text{-}F}_{fed,f} \in \{0,1\}$ (**R15**), $A^{TSK\text{-}BL}_{tsk,bl} \in \{0,1\}$ (**R16**).
- $A^{SH\text{-}SR}_{sh,sr} \in \{0,1\}$ (**R17**), $A^{SM\text{-}SRE}_{sm,sre} \in \{0,1\}$ (**R18**).
- $A^{VEL\text{-}T}_{vel,t} \in \{0,1\}$ (**R19**), $A^{REP\text{-}F}_{rep,f} \in \{0,1\}$ (**R20**).
- $A^{REP\text{-}RM}_{rep,rm} \in \{0,1\}$ (**R21**), $A^{SP\text{-}DEV}_{sp,dev} \in \{0,1\}$ (**R22**).

2 2. Indices

- $p \in \mathcal{P},\ t \in \mathcal{T},\ w \in \mathcal{W},\ f \in \mathcal{F},\ s \in \mathcal{S},\ r \in \mathcal{R},\ po \in \mathcal{PO},\ sm \in \mathcal{SM},$
- $pb \in \mathcal{PB},\ sp \in \mathcal{SP},\ spp \in \mathcal{SPP},\ ds \in \mathcal{DS},\ sr \in \mathcal{SR},\ sre \in \mathcal{SRE},$
- $sbl \in \mathcal{SBL},\ sg \in \mathcal{SG},\ e \in \mathcal{E},\ us \in \mathcal{US},\ tsk \in \mathcal{TSK},\ dev \in \mathcal{DEV},$
- $bl \in \mathcal{BL},\ sh \in \mathcal{SH},\ vel \in \mathcal{VEL},\ rep \in \mathcal{REP},\ rm \in \mathcal{RM},\ scb \in \mathcal{SCB},\ fed \in \mathcal{FED}.$

3 3. Goals

We combine all goal terms via a weighted scalarization. Let $\mathcal{G}$ be the set of goal IDs $G0, \dots, G11$ with weights w_g from `Goals.csv`. The overall single-objective form is:

$$\max\ \Phi\ =\ \sum_{g \in \mathcal{G}} w_g \cdot \Gamma_g,$$

where each Γ_g is defined below; for originally "minimize" goals we use a negative sign so that higher Γ_g is better.

- `G0 minimize_project_budget`
  Logic: Reduce total allocated budget. *Math:* $\Gamma_{G0} = -\sum_{p \in \mathcal{P}} B_p$, where B_p is decision DV4.
- `G1 maximize_worker_availability`
  Logic: Prefer plans leveraging available workers. *Math:* $\Gamma_{G1} = \sum_{w \in \mathcal{W}} availability_w$.
- `G2 maximize_feature_priority`
  Logic: Select high-priority features into active sprints. *Math:* $\Gamma_{G2} = \sum_{f \in \mathcal{F}} \sum_{sp \in \mathcal{SP}} priority_f \cdot y_{f,sp}$, where $y_{f,sp}$ encodes DV1 for feature–sprint selection.
- `G3 minimize_feature_estimated_effort`
  Logic: Prefer features requiring less effort. *Math:* $\Gamma_{G3} = -\sum_{f \in \mathcal{F}} \sum_{sp \in \mathcal{SP}} effort^F_f \cdot y_{f,sp}$.
- `G4 maximize_sprint_goal_achievement`
  Logic: Favor plans with achieved sprint goals. *Math:* $\Gamma_{G4} = \sum_{sp \in \mathcal{SP}} achieved_{sp}$.
- `G5 maximize_velocity_avg_story_points`
  Logic: Prefer teams with higher historical velocity. *Math:* $\Gamma_{G5} = \sum_{t \in \mathcal{T}} velAvg_t$.
- `G6 minimize_blocker_severity`
  Logic: Reduce overall blocker impact. *Math:* $\Gamma_{G6} = -\sum_{bl \in \mathcal{BL}} severity_{bl}$.
- `G7 maximize_user_story_story_points`
  Logic: Deliver more story points. *Math:* $\Gamma_{G7} = \sum_{sp \in \mathcal{SP}} C_{sp}$, where C_{sp} is DV5 (commitment in sprint sp).
- `G8 minimize_task_effort`
  Logic: Reduce effort on tasks in progress. *Math:* $\Gamma_{G8} = -\sum_{tsk \in \mathcal{TSK}} effort^{TSK}_{tsk} \cdot u_{tsk}$, where u_{tsk} is DV3.
- `G9 maximize_team_size_utilization`
  Logic: Utilize larger teams effectively on projects. *Math:* $\Gamma_{G9} = \sum_{t \in \mathcal{T}} \sum_{p \in \mathcal{P}} size_t \cdot x_{t,p}$, where $x_{t,p}$ is DV0.

- G10 `maximize_stakeholder_relevance_to_feature`
  Logic: Emphasize features most relevant to stakeholders. *Math:* $\Gamma_{G10} = \sum_{sh \in \mathcal{SH}} \sum_{f \in \mathcal{F}} \sum_{sp \in \mathcal{SP}} rel_{sh,f} \cdot y_{f,sp}$.

- G11 `minimize_time_to_release`
  Logic: Accelerate release plans. *Math:* $\Gamma_{G11} = -\sum_{rep \in \mathcal{REP}} planDate_{rep}$.

4 4. Conditions

All conditions combine logical gating with linear constraints; `CriteriaType` $\in \{2, 1, 0\}$ maps to Must-/May-/Cannot-Match. The items C0–C11 come directly from `Conditions.csv`. We additionally enforce structural conditions implied by `Relationships.csv` (R1–R22).

C0–C11 from `Conditions.csv`

- C0 `enforce_active_projects` (Must-Match)
  Logic: Assign teams only to active projects.
  Math: $\forall t \in \mathcal{T},\ \forall p \in \mathcal{P}:\ x_{t,p} \le A^{TP}_{t,p} \cdot activeProject_p$.

- C1 `require_team_status_ready` (Must-Match)
  Logic: Only ready teams can be assigned.
  Math: $\forall t, p:\ x_{t,p} \le readyTeam_t$.

- C2 `exclude_unavailable_workers` (Cannot-Match)
  Logic: Workers with zero availability cannot be allocated.
  Math: $\forall w, us:\ z_{w,us} \le \mathbf{1}[\,availability_w > 0\,]$.

- C3 `prefer_certified_skills` (May-Match)
  Logic: Encourage certified skill coverage for stories.
  Math: Let $cert_w = \sum_s A^{WS}_{w,s} \cdot certified_s$. For each sprint sp: $\sum_{us} \sum_w z_{w,us} \cdot cert_w \ \ge\ \kappa_{sp}$ (soft: can be relaxed/penalized).

- C4 `limit_high_severity_blockers` (Must-Match)
  Logic: Cap blocker impact/effort reserved.
  Math: $\sum_{tsk} \sum_{bl} A^{TSK\text{-}BL}_{tsk,bl} \cdot severity_{bl} \cdot u_{tsk} \ \le\ W$ (where W is DV10).

- C5 `require_user_story_acceptance_criteria` (Must-Match)
  Logic: Only stories with acceptance criteria may receive allocation.
  Math: $\forall w, us:\ z_{w,us} \le hasAC_{us}$.

- C6 `prefer_high_team_type_fit` (May-Match)
  Logic: Favor team–project type fit.
  Math: $\sum_{t,p} fit_{t,p} \cdot x_{t,p} \ \ge\ \phi$ (soft threshold; $fit_{t,p} \in [0,1]$).

- C7 `require_sprint_status_active` (Must-Match)
  Logic: Only active sprints may accept features.
  Math: $\forall f, sp:\ y_{f,sp} \le activeSprint_{sp}$.

- C8 `prefer_positive_trend_velocity` (May-Match)
  Logic: Prefer teams with improving trend.
  Math: $\sum_t trend_t \cdot \sum_p x_{t,p} \ \ge\ 0$ (soft; $trend_t \in \mathbb{R}$ from **VEL.trend**).

- C9 `require_backlog_status_open` (Must-Match)
  Logic: Features must come from an open Product Backlog.
  Math: $\forall f, sp:\ y_{f,sp} \le \sum_{pb} A^{PB\text{-}F}_{pb,f} \cdot openPB_{pb}$.

- `C10 limit_scrum_board_wip` (Must-Match)
  Logic: Cap number of cards (WIP) on the board.
  Math: $\sum_{tsk} u_{tsk} \ \le\ K$ (where K is DV11).

- `C11 require_feature_documentation_linked` (Must-Match)
  Logic: Only features with linked documentation can be selected.
  Math: $\forall f, sp:\ y_{f,sp} \le docLinked_f$ (e.g., $docLinked_f = \max_{fed} A^{FED\text{-}F}_{fed,f} \cdot \mathbf{1}[linked\_requirements]$).

Structural constraints from `Relationships.csv` (R1–R22)

- **R1 Team → Project (1:N)**: each team belongs to exactly one project: $\forall t:\ \sum_p x_{t,p} = 1$ and $x_{t,p} \le A^{TP}_{t,p}$.

- **R2 Worker → Team (N:1)**: each worker has exactly one home team: $\forall w:\ \sum_t A^{WT}_{w,t} = 1$.

- **R3 Worker–Skill (N:M)**: skill availability parameterized by $A^{WS}_{w,s}$ (used in C3).

- **R4 Worker–Role (N:M)**: role coverage via $A^{WR}_{w,r}$ as feasibility/input.

- **R5 PO manages PB (1:1)**: unique mapping input $A^{PO\text{-}PB}_{po,pb}$; ensure $\sum_{po} A^{PO\text{-}PB}_{po,pb} = 1 = \sum_{pb} A^{PO\text{-}PB}_{po,pb}$.

- **R6 Team supported by SM (1:1)**: unique mapping input $A^{T\text{-}SM}_{t,sm}$.

- **R7 PB contains Feature (1:N)**: selection only from containing PB (*enforced in C9*).

- **R8 PB contains Epic (1:N)**: feasibility for epic–story relations.

- **R9 Epic contains UserStory (1:N)**: $\forall us:\ \sum_e A^{E\text{-}US}_{e,us} = 1$.

- **R10 UserStory consists of Tasks (1:N)**: task coverage via $A^{US\text{-}TSK}_{us,tsk}$.

- **R11 UserStory in SprintBacklog (N:M)** & **R12 SBL belongs to Sprint (1:1)**: if $y_{f,sp} = 1$ for some us of f, then $\exists sbl$ with $A^{US\text{-}SBL}_{us,sbl} A^{SBL\text{-}SP}_{sbl,sp} = 1$ (modelled via gating).

- **R13 Sprint pursues Goal (1:1)**: for each sp there is a unique sg; consistency used by parameter $achieved_{sp}$.

- **R14 ScrumBoard contains Tasks (1:N)**: $\sum_{tsk} A^{SCB\text{-}TSK}_{scb,tsk} \le K$ for each scb (WIP cap aligns with C10).

- **R15 FED documents Feature (1:1)**: $docLinked_f = \max_{fed} A^{FED\text{-}F}_{fed,f}$ (used in C11).

- **R16 Task blocked by Blocker (N:M)**: accounted in C4 via $A^{TSK\text{-}BL}_{tsk,bl}$.

- **R17 Stakeholder participates in SR (N:M)**: engagement parameter $A^{SH\text{-}SR}_{sh,sr}$; supports goal G10 context.

- **R18 SM moderates Retrospective (1:N)**: feasibility input $A^{SM\text{-}SRE}_{sm,sre}$.

- **R19 Velocity refers to Team (1:1)**: $velAvg_t = \sum_{vel} A^{VEL\text{-}T}_{vel,t} \cdot avgSP_{vel}$.

- **R20 ReleasePlan includes Feature (1:N)**: coupling of rep and f via $A^{REP\text{-}F}_{rep,f}$ (context for G11).

- **R21 ReleasePlan part of Roadmap (N:1)**: feasibility $A^{REP\text{-}RM}_{rep,rm}$.

- **R22 Sprint generates Snapshot (1:1)**: traceability $A^{SP\text{-}DEV}_{sp,dev}$.

Capacity, commitment, and linking constraints (illustrative):

- Worker capacity with buffer: $\forall w, sp : \sum_{us} z_{w,us} \cdot spoints_{us} \ \leq \ availability_w \cdot (1-\beta) \cdot Cap_w$ (DV8 β, given Cap_w).

- Commitment consistency: $\forall sp : \sum_{us} spoints_{us} \cdot q_{us,sp} \ \leq \ C_{sp}$, where $q_{us,sp} \in \{0,1\}$ indicates story scheduled in sprint sp and can be linearized via $z_{w,us}$ (aux. variable; standard big-M linking if introduced).

5 5. DecisionVariables

- DV0 `assign_team_to_project`: $x_{t,p} \in \{0,1\}$ for $(t,p) \in \mathcal{T} \times \mathcal{P}$.

- DV1 `select_feature_for_sprint`: $y_{f,sp} \in \{0,1\}$ for $(f, sp) \in \mathcal{F} \times \mathcal{SP}$.

- DV2 `allocate_worker_to_story`: $z_{w,us} \in \{0,1\}$ for $(w, us) \in \mathcal{W} \times \mathcal{US}$.

- DV3 `set_task_in_progress`: $u_{tsk} \in \{0,1\}$ for $tsk \in \mathcal{TSK}$.

- DV4 `budget_allocation_project`: $B_p \in \mathbb{R}_{\geq 0}$ with $0 \leq B_p \leq \overline{B}_p$ for $p \in \mathcal{P}$.

- DV5 `story_points_commitment`: $C_{sp} \in \mathbb{Z}_{\geq 0}$ with $0 \leq C_{sp} \leq \overline{C}$ for $sp \in \mathcal{SP}$.

- DV6 `max_parallel_tasks_per_worker`: $M \in \mathbb{Z}_{\geq 0}$ with $0 \leq M \leq 20$ (global cap). Constraint: $\forall w : \sum_{tsk} assign_{w,tsk} \leq M$ if a per-task assignment variable $assign_{w,tsk}$ is used.

- DV7 `sprint_length_days`: $L \in \{7, 10, 14, 21, 28\}$.

- DV8 `capacity_buffer_percentage`: $\beta \in [0,1]$.

- DV9 `priority_threshold_feature`: $\theta \in \mathbb{Z}_{\geq 0}$; gating $\forall f, sp : \ y_{f,sp} \leq \mathbf{1}[priority_f \geq \theta]$.

- DV10 `limit_blocker_workaround_effort`: $W \in \mathbb{R}_{\geq 0}$ (used in C4).

- DV11 `max_cards_on_scrum_board`: $K \in \mathbb{Z}_{\geq 0}$ (used in C10).