Optimization Model for a SCRUM-driven Software Development Company

Generated from Entities/Relationships/Goals/Conditions/DecisionVariables CSVs

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Contents

1 1. Sets (Entities)

- $\mathcal{P}$: Projects (**Project**) — attributes: id, name, project_start, project_end, description, budget, status, target_audience, priority.

- $\mathcal{T}$: Teams (**Team**) — attributes: id, name, team_size, team_start, team_status, location, team_type.

- $\mathcal{W}$: Workers (**Worker**) — attributes: id, name, first_name, email, start_date, status, availability.

- $\mathcal{F}$: Features (**Feature**) — attributes: id, title, description, status, priority, estimated_effort.

- $\mathcal{S}$: Skills (**Skill**) — attributes: id, label, description, level, certified, category.

- $\mathcal{R}$: Roles (**Role**) — attributes: id, role_name, description, area_of_responsibility.

- $\mathcal{PO}$: Product Owners (**ProductOwner**) — attributes: id, name, email, availability.

- $\mathcal{SM}$: Scrum Masters (**ScrumMaster**) — attributes: id, name, email, experience.

- $\mathcal{PB}$: Product Backlogs (**ProductBacklog**) — attributes: id, created_on, last_updated, number_of_entries, status.

- $\mathcal{SP}$: Sprints (**Sprint**) — attributes: id, sprint_number, start_date, end_date, status, achievement_of_goal.

- $\mathcal{SPP}$: Sprint Plannings (**SprintPlanning**) — attributes: id, date, duration (min), moderation, outcome_documentation.

- $\mathcal{DS}$: Daily Scrums (**DailyScrum**) — attributes: id, date, time, duration, moderation.

- $\mathcal{SR}$: Sprint Reviews (**SprintReview**) — attributes: id, date, duration, feedback_documentation, attendees_count.

- $\mathcal{SRE}$: Sprint Retrospectives (**SprintRetrospective**) — attributes: id, date, duration, improvement_actions, team_satisfaction, moderation.

- $\mathcal{SBL}$: Sprint Backlogs (**SprintBacklog**) — attributes: id, number_of_tasks, last_updated, status, total_effort.

- $\mathcal{SG}$: Sprint Goals (**SprintGoal**) — attributes: id, objective_description, achievement_status, benefit.

- $\mathcal{E}$: Epics (**Epic**) — attributes: id, title, description, priority, status, estimated_effort.

- $\mathcal{US}$: User Stories (**UserStory**) — attributes: id, title, description, acceptance_criteria, priority, story_points, status.

- $\mathcal{TSK}$: Tasks (**Task**) — attributes: id, title, description, status, effort, type.

- $\mathcal{DEV}$: Development Snapshots (**DevelopmentSnapshot**) — attributes: id, version_number, creation_date, test_status, deployment_target, documentation.

- $\mathcal{BL}$: Blockers (**Blocker**) — attributes: id, title, description, severity, status, detected_on, resolved_on.

- $\mathcal{SH}$: Stakeholders (**Stakeholder**) — attributes: id, name, organization, role, email, area_of_interest, influence_level, relevance_to_feature.

- $\mathcal{VEL}$: Velocities (**Velocity**) — attributes: id, number_of_sprints_used, avg_story_points, max_velocity, min_velocity, trend.

- $\mathcal{REP}$: Release Plans (**ReleasePlan**) — attributes: id, version, planned_date, included_features, status.

- $\mathcal{RM}$: Roadmaps (**Roadmap**) — attributes: id, start_date, end_date, milestones, objectives, versions.

- $\mathcal{SCB}$: Scrum Boards (**ScrumBoard**) — attributes: id, board_type, columns, number_of_cards, last_updated.

- $\mathcal{FED}$: Feature Docs (**FeatureDocumentation**) — attributes: id, title, description, creation_date, change_log, linked_requirements, author.

2 2. Indices

- $p \in \mathcal{P}$ (projects), $t \in \mathcal{T}$ (teams), $w \in \mathcal{W}$ (workers), $f \in \mathcal{F}$ (features), $s \in \mathcal{S}$ (skills), $r \in \mathcal{R}$ (roles).

- $po \in \mathcal{PO}$, $sm \in \mathcal{SM}$, $pb \in \mathcal{PB}$, $sp \in \mathcal{SP}$, $spp \in \mathcal{SPP}$, $ds \in \mathcal{DS}$, $sr \in \mathcal{SR}$, $sre \in \mathcal{SRE}$.

- $sbl \in \mathcal{SBL}$, $sg \in \mathcal{SG}$, $e \in \mathcal{E}$, $us \in \mathcal{US}$, $tsk \in \mathcal{TSK}$, $dev \in \mathcal{DEV}$, $bl \in \mathcal{BL}$, $sh \in \mathcal{SH}$.

- $v \in \mathcal{VEL}$, $rep \in \mathcal{REP}$, $rm \in \mathcal{RM}$, $scb \in \mathcal{SCB}$, $fed \in \mathcal{FED}$.

- Relationship-induced index maps (from *Relationships.csv*):

    - $\mathcal{T}(p)$ teams assigned to project p (R1).
    - $\mathcal{W}(t)$ workers belonging to team t (R2).
    - $\mathcal{S}(w)$ skills of worker w (R3).
    - $\mathcal{R}(w)$ roles taken by worker w (R4).
    - $pb(po)$ the backlog managed by product owner po (R5).
    - $sm(t)$ the Scrum Master supporting team t (R6).
    - $\mathcal{F}(pb)$ features in product backlog pb (R7).
    - $\mathcal{E}(pb)$ epics in product backlog pb (R8).
    - $\mathcal{US}(e)$ user stories in epic e (R9).
    - $\mathcal{TSK}(us)$ tasks of user story us (R10).
    - $\mathcal{SBL}(sp)$ sprint backlog of sprint sp (R12).
    - $sg(sp)$ sprint goal of sprint sp (R13).
    - $\mathcal{TSK}(scb)$ tasks visualized on scrum board scb (R14).
    - $fdoc(f)$ feature documentation of feature f (R15).
    - $\mathcal{BL}(tsk)$ blockers of task tsk (R16).
    - $\mathcal{SR}\_{\sqrt{}}^{\dashv \nabla \sqcup}(sp)$ stakeholders participating in sprint review of sprint sp (R17).
    - $\mathcal{SRE}\_{\Updownarrow \lceil}(sm)$ retrospectives moderated by Scrum Master sm (R18).
    - $t(v)$ team to which a velocity record v refers (R19).
    - $\mathcal{F}(rep)$ features included in release plan rep (R20).
    - $rm(rep)$ roadmap that contains release plan rep (R21).

– $dev(sp)$ snapshot generated by sprint sp (R22).

Entity attributes as parameters (selected, from *Entities.csv*):

- B_p: project budget; status., priority., dates, etc.

- n_{pb}^{entries}: number_of_entries of product backlog pb.

- $spoints_{us}$: story_points of user story us; $prio_{us}$: priority of us.

- $effort_{tsk}$: effort of task tsk; $status_{tsk}$: status of task tsk.

- sev_{bl}: severity of blocker bl; $status_{bl}$: status of blocker bl.

- $avail_w$: availability of worker w; $status_w$: status of worker w.

- $level_s$: skill level; $cert_s \in \{0,1\}$: certified flag.

- dur_{spp}^{plan}: duration (min) of sprint planning spp; dur_{ds}^{daily}: duration of daily scrum ds.

- att_{sr}: attendees_count of sprint review sr; sat_{sre}: team_satisfaction of retrospective sre.

- v_v^{max}: max_velocity from velocity record v; v_v^{min}: min_velocity; v_v^{avg}: avg_story_points.

- exp_{sm}: experience of Scrum Master sm.

3   3. Goals

We aggregate multiple goals using a weighted-sum scalarization. For each goal g, let weight $\gamma_g > 0$ (from `Weight`) and sign $\sigma_g \in \{+1, -1\}$ where $\sigma_g = +1$ for `GoalType=max` and $\sigma_g = -1$ for `GoalType=min`. The master objective is:

$$\max \sum_{g \in \mathcal{G}} \sigma_g \, \gamma_g \, F_g(\text{variables; data}),$$

where F_g are the goal-specific expressions below. (Goals marked `IsSum=True` sum over their relevant sets.)

- **G0** `maximize_velocity` (*IsSum=True, GoalType=max*, Entity=**Velocity**):

$$F_{G0} = \sum_{v \in \mathcal{VEL}} v_v^{\text{max}} \qquad \text{(maximize recorded max velocity across teams; CriteriaType=1)}$$

- **G1** `minimize_backlog_size` (*IsSum=False, GoalType=min*, Entity=**ProductBacklog**):

$$F_{G1} = \sum_{pb \in \mathcal{PB}^{\text{active}}} n_{pb}^{\text{entries}} \qquad \text{(minimize total entries of active PBs; CriteriaType=2)}$$

- **G2** `minimize_total_task_effort` (*IsSum=True, GoalType=min*, Entity=**Task**):

$$F_{G2} = \sum_{us \in \mathcal{US}} \sum_{tsk \in \mathcal{TSK}(us)} \sum_{w \in \mathcal{W}} a_{w,tsk} \, effort_{tsk} \quad \text{(assignments drive realized effort; CriteriaType=2)}$$

- **G3** `maximize_story_points` (*IsSum=True, GoalType=max*, Entity=**UserStory**):

$$F_{G3} = \sum_{us \in \mathcal{US}} x_{us} \, spoints_{us} \qquad \text{(maximize selected story points; CriteriaType=1)}$$

- **G4** `maximize_team_availability` (*IsSum=True, GoalType=max*, Entity=**Worker**):

$$F_{G4} = \sum_{w \in \mathcal{W}^{\text{active}}} avail_w \qquad \text{(favor higher available capacity; CriteriaType=1)}$$

- **G5** `minimize_blocker_severity` (*IsSum=True, GoalType=min*, Entity=**Blocker**):

$$F_{G5} = \sum_{tsk \in \mathcal{TSK}} \sum_{bl \in \mathcal{BL}(tsk) \cap \mathcal{BL}^{\text{open}}} sev_{bl} \qquad \text{(reduce unresolved blocker risk; CriteriaType=2)}$$

- **G6** `maximize_skill_level_alignment` (*IsSum=True, GoalType=max*, Entity=**Skill**):

$$F_{G6} = \sum_{w \in \mathcal{W}} \sum_{tsk \in \mathcal{TSK}} a_{w,tsk} \left(\sum_{s \in \mathcal{S}(w)} level_s \right) \qquad \text{(prefer higher-skilled assignees; CriteriaType=1)}$$

- **G7** `minimize_planning_time` (*IsSum=True, GoalType=min*, Entity=**SprintPlanning**):

$$F_{G7} = \sum_{spp \in \mathcal{SPP}} \text{dur}_{spp}^{\text{plan}} \qquad \text{(reduce planning overhead; CriteriaType=1)}$$

- **G8** `minimize_meeting_overhead` (*IsSum=True, GoalType=min*, Entity=**DailyScrum**):

$$F_{G8} = \sum_{ds \in \mathcal{DS}} \text{dur}_{ds}^{\text{daily}} \qquad \text{(reduce daily meeting time; CriteriaType=1)}$$

- **G9** `maximize_review_engagement` (*IsSum=True, GoalType=max*, Entity=**SprintReview**):

$$F_{G9} = \sum_{sr \in \mathcal{SR}} att_{sr} \qquad \text{(encourage stakeholder attendance; CriteriaType=1)}$$

- **G10** `maximize_team_satisfaction` (*IsSum=True, GoalType=max*, Entity=**SprintRetrospective**):

$$F_{G10} = \sum_{sre \in \mathcal{SRE}} sat_{sre} \qquad \text{(improve team well-being; CriteriaType=1)}$$

- **G11** `minimize_project_budget_use` (*IsSum=True, GoalType=min*, Entity=**Project**):

$$F_{G11} = \sum_{p \in \mathcal{P}} b_p^{\text{alloc}} \qquad \text{(limit allocated budget; CriteriaType=1)}$$

4 4. Conditions

Logical constraints (hard if `CriteriaType=2`, soft/preferential if `CriteriaType=1`, exclusion if `CriteriaType=0`). Where helpful, we filter entities into condition-satisfying subsets and then constrain variables.

- **C0** `team_size_at_least_min` (*IsSum=False, GoalType=min*, Entity=**Team**, CriteriaType=2):
  Logical: every staffed sprint has a minimum team size.
  Mathematical: for each $sp \in \mathcal{SP}$, let N_{sp} be the staffed team size (decision variable). Then

$$N_{sp} \geq \tau_{\min}.$$

- **C1** `worker_status_active_only` (*IsSum=False*, *GoalType=min*, Entity=**Worker**, CriteriaType=0):
  Logical: inactive workers cannot be assigned. Define $\mathcal{W}^{\text{active}} = \{w \in \mathcal{W} \mid status_w = \text{"active"}\}$.
  Mathematical:
  $$a_{w,tsk} = 0 \quad \forall\, w \in \mathcal{W} \setminus \mathcal{W}^{\text{active}},\ \forall\, tsk \in \mathcal{TSK}.$$

- **C2** `task_status_not_done` (*IsSum=False*, *GoalType=min*, Entity=**Task**, CriteriaType=0):
  Logical: tasks already done are excluded from assignment. Let $\mathcal{TSK}^{\text{open}} = \{tsk \mid status_{tsk} \neq \text{"done"}\}$.
  Mathematical:
  $$\sum_{w \in \mathcal{W}} a_{w,tsk} = 0 \quad \forall\, tsk \in \mathcal{TSK} \setminus \mathcal{TSK}^{\text{open}}.$$

- **C3** `user_story_priority_at_least` (*IsSum=False*, *GoalType=min*, Entity=**UserStory**, CriteriaType=2):
  Logical: only stories with $prio_{us} \geq \pi_{\min}$ can be selected.
  Mathematical:
  $$x_{us} = 0 \quad \forall\, us \in \mathcal{US} \text{ with } prio_{us} < \pi_{\min}.$$

- **C4** `epic_status_in_progress_or_new` (*IsSum=False*, *GoalType=min*, Entity=**Epic**, CriteriaType=2):
  Logical: only epics not closed are considered. Let $\mathcal{E}^{\text{open}} = \{e \in \mathcal{E} \mid status_e \in \{\text{"new"}, \text{"in\_progress"}\}\}$.
  Mathematical: selections or priorities apply only to $\mathcal{E}^{\text{open}}$:
  $$p_e^{\text{bucket}} \in \{1, \ldots, 5\} \text{ only for } e \in \mathcal{E}^{\text{open}}; \quad p_e^{\text{bucket}} = 0 \text{ otherwise.}$$

- **C5** `skill_certified_preferred` (*IsSum=False*, *GoalType=max*, Entity=**Skill**, CriteriaType=1):
  Logical: prefer certified skills on assignments. Let $cert_s \in \{0, 1\}$.
  Soft constraint (implemented via penalty/bonus):
  $$\sum_{w,tsk} a_{w,tsk} \left(\sum_{s \in \mathcal{S}(w)} cert_s \right) \geq \eta \sum_{w,tsk} a_{w,tsk},$$
  for some preference threshold $\eta \in [0, |\mathcal{S}|]$.

- **C6** `sprint_within_date_range` (*IsSum=False*, *GoalType=min*, Entity=**Sprint**, CriteriaType=2):
  Logical: each sprint used for project p must respect project dates.
  Mathematical: if sp is linked to p, then
  $$start\_date_{sp} \geq project\_start_p, \qquad end\_date_{sp} \leq project\_end_p.$$

- **C7** `backlog_status_active_only` (*IsSum=False*, *GoalType=min*, Entity=**ProductBacklog**, CriteriaType=2):
  Logical: only active PBs are considered. Define $\mathcal{PB}^{\text{active}} = \{pb \mid status_{pb} = \text{"active"}\}$.
  Mathematical: all PB-driven terms (e.g., F_{G1}) use $\mathcal{PB}^{\text{active}}$ only.

- **C8** `blocker_status_unresolved_only` (*IsSum=False*, *GoalType=min*, Entity=**Blocker**, CriteriaType=2):
  Logical: only unresolved blockers are counted/activated. Let $\mathcal{BL}^{\text{open}} = \{bl \mid status_{bl} \neq$

"resolved"}.
Mathematical:

$$\sum_w a_{w,tsk} \leq M \cdot \Vdash\big(\mathcal{BL}(tsk) \cap \mathcal{BL}^{\mathrm{open}} = \varnothing\big) \quad \forall\, tsk \in \mathcal{TSK},$$

where M is a sufficiently large constant and $\Vdash(\cdot)$ the indicator.

- **C9** `scrum_master_experience_min` (*IsSum=False*, *GoalType=max*, Entity=**ScrumMaster**, CriteriaType=2):
  Logical: any assigned Scrum Master must meet a minimum experience.
  Mathematical:
  $$z_{sm,t} = 1 \;\Rightarrow\; exp_{sm} \geq \xi_{\min} \quad \forall\, sm \in \mathcal{SM},\ t \in \mathcal{T}.$$

- **C10** `release_plan_status_planned_or_active` (*IsSum=False*, *GoalType=max*, Entity=**ReleasePlan**, CriteriaType=2):
  Logical: only planned/active release plans are considered. Let $\mathcal{REP}^{\mathrm{use}} = \{rep \mid status_{rep} \in \{\text{"planned"}, \text{"active"}\}\}$.
  Mathematical: feature inclusion variables y_f are counted per $rep \in \mathcal{REP}^{\mathrm{use}}$ only.

- **C11** `stakeholder_influence_capped` (*IsSum=True*, *GoalType=min*, Entity=**Stakeholder**, CriteriaType=1):
  Logical: cap aggregate stakeholder influence in reviews.
  Mathematical:
  $$\sum_{sp \in \mathcal{SP}} \sum_{sh \in \mathcal{SR}_{-\sqrt{}\dashv\nabla\sqcup(sp)}} influence_{sh} \leq \kappa.$$

Additional structural constraints from relationships (selections/assignments):

- User story–task consistency: $\sum_{tsk \in \mathcal{TSK}(us)} \sum_w a_{w,tsk} \leq K\, x_{us}$, with K large (link DV0 and DV6).

- Per-worker task cap: $\sum_{tsk \in \mathcal{TSK}} a_{w,tsk} \leq K^{\max}$ for all w (DV6).

- Feature–release selection: $y_f \in \{0,1\}$ and, for any $rep \in \mathcal{REP}^{\mathrm{use}}$, $\sum_{f \in \mathcal{F}(rep)} y_f \leq Y^{\max}$ (DV2).

- Team size control: N_{sp} integer with $N_{sp} \geq \tau_{\min}$ and $N_{sp} \leq \tau_{\max}$ (DV5, C0).

- Budget allocation: $\sum_p b_p^{\mathrm{alloc}} \leq B^{\mathrm{total}}$; $0 \leq b_p^{\mathrm{alloc}} \leq B_p$ (DV4).

5 5. DecisionVariables

Let the following decision variables be defined, reflecting *DecisionVariables.csv*. Domains and bounds follow the CSV fields.

- **DV0** `select_user_story`: $x_{us} \in \{0,1\}$ for each $us \in \mathcal{US}$ (select story into sprint).

- **DV1** `assign_worker_to_task`: $a_{w,tsk} \in \{0,1\}$ for each $(w,tsk) \in \mathcal{W} \times \mathcal{TSK}^{\mathrm{open}}$ (assignment).

- **DV2** `choose_feature_for_release`: $y_f \in \{0,1\}$ for each $f \in \mathcal{F}$ (include in next release).

- **DV3** `set_sprint_length_days`: $L^{\mathrm{days}} \in \mathbb{Z}$, $7 \leq L^{\mathrm{days}} \leq 30$ (chosen sprint length).

- **DV4** `allocate_budget_to_project`: $b_p^{\text{alloc}} \in \mathbb{R}_{\geq 0}$ for $p \in \mathcal{P}$, $0 \leq b_p^{\text{alloc}} \leq 10^6$.

- **DV5** `set_team_size`: $N_{sp} \in \mathbb{Z}$ for $sp \in \mathcal{SP}$, $3 \leq N_{sp} \leq 15$.

- **DV6** `set_max_tasks_per_worker`: $K^{\text{max}} \in \mathbb{Z}$, $1 \leq K^{\text{max}} \leq 10$ (global cap).

- **DV7** `assign_scrum_master_to_team`: $z_{sm,t} \in \{0,1\}$ for $(sm,t) \in \mathcal{SM} \times \mathcal{T}$ with $\sum_{sm} z_{sm,t} = 1$ if team t is staffed.

- **DV8** `allow_overtime`: $o \in \{0,1\}$ (overtime allowance flag; may scale effective availability).

- **DV9** `set_review_attendees_target`: $R^{\text{target}} \in \mathbb{Z}_{\geq 0}$, $0 \leq R^{\text{target}} \leq 100$.

- **DV10** `set_velocity_target`: $V^{\text{target}} \in \mathbb{Z}_{\geq 0}$, $0 \leq V^{\text{target}} \leq 200$.

- **DV11** `prioritize_epic_level`: $p_e^{\text{bucket}} \in \{1,2,3,4,5\}$ for $e \in \mathcal{E}^{\text{open}}$.

Linking and capacity constraints (illustrative):

- Capacity with availability and overtime:

$$\sum_{tsk} a_{w,tsk}\, effort_{tsk} \;\leq\; \left(1 + \alpha o\right) avail_w \quad \forall w \in \mathcal{W}^{\text{active}},$$

with overtime uplift $\alpha \geq 0$.

- Story–task coverage:

$$\sum_{tsk \in \mathcal{TSK}(us)} \sum_{w} a_{w,tsk} \;\geq\; m\, x_{us}, \qquad \sum_{tsk \in \mathcal{TSK}(us)} \sum_{w} a_{w,tsk} \;\leq\; M\, x_{us},$$

for constants $0 < m \leq M$.