SCRUM Company Optimization Model from Entities/Relationships/Goals/Conditions/DecisionVariables

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August 12, 2025

Contents

Modeling Overview (Context)

This document formulates a mixed-integer optimization model based strictly on the previously provided CSVs: *Entities.csv*, *Relationships.csv*, *Goals.csv*, *Conditions.csv*, and *DecisionVariables.csv*.

Multi-objective goals are combined using a weighted sum; signs follow `GoalType` (max $\to +$, min $\to -$). `CriteriaType` is interpreted as: $2 =$ Must-Match (*hard constraint*), $1 =$ May-Match (*soft preference* enforced via slack/penalty), $0 =$ Cannot-Match (*exclusion hard constraint*). Entity attributes are represented as parameters; decision variables are exactly those listed in *DecisionVariables.csv*.

1   1. Sets (Entities)

- $\mathcal{P}$: Projects (`Project`)

- $\mathcal{T}$: Teams (`Team`)

- $\mathcal{W}$: Workers (`Worker`)

- $\mathcal{F}$: Features (`Feature`)

- $\mathcal{S}k$: Skills (`Skill`)

- $\mathcal{R}$: Roles (`Role`)

- $\mathcal{PO}$: Product Owners (`ProductOwner`)

- $\mathcal{SM}$: Scrum Masters (`ScrumMaster`)

- $\mathcal{PB}$: Product Backlogs (`ProductBacklog`)

- $\mathcal{SP}$: Sprints (`Sprint`)

- $\mathcal{SPP}$: Sprint Plannings (`SprintPlanning`)

- $\mathcal{DS}$: Daily Scrums (`DailyScrum`)

- $\mathcal{SR}$: Sprint Reviews (`SprintReview`)

- $\mathcal{SRE}$: Sprint Retrospectives (`SprintRetrospective`)

- $\mathcal{SBL}$: Sprint Backlogs (`SprintBacklog`)

- $\mathcal{SG}$: Sprint Goals (`SprintGoal`)

- $\mathcal{E}$: Epics (`Epic`)

- $\mathcal{US}$: User Stories (`UserStory`)

- $\mathcal{TSK}$: Tasks (`Task`)

- $\mathcal{DEV}$: Development Snapshots (`DevelopmentSnapshot`)

- $\mathcal{BL}$: Blockers (`Blocker`)

- $\mathcal{SH}$: Stakeholders (`Stakeholder`)

- $\mathcal{VEL}$: Velocity records (`Velocity`) (each refers to a Team)

- $\mathcal{REP}$: Release Plans (`ReleasePlan`)

- $\mathcal{RM}$: Roadmaps (`Roadmap`)

- $\mathcal{SCB}$: Scrum Boards (`ScrumBoard`)

- $\mathcal{FED}$: Feature Documentations (`FeatureDocumentation`)

Relationship-incidence (from `Relationships.csv`)

- **R1** Team–Project assignment: $\mathcal{A}^{TP} \subseteq \mathcal{T} \times \mathcal{P}$

- **R2** Worker belongs to Team: $\mathcal{A}^{WT} \subseteq \mathcal{W} \times \mathcal{T}$

- **R3** Worker has Skill: $\mathcal{A}^{WS} \subseteq \mathcal{W} \times \mathcal{Sk}$

- **R4** Worker takes Role: $\mathcal{A}^{WR} \subseteq \mathcal{W} \times \mathcal{R}$

- **R5** PO manages Backlog: $\mathcal{A}^{PO,PB} \subseteq \mathcal{PO} \times \mathcal{PB}$

- **R6** Team supported by SM: $\mathcal{A}^{T,SM} \subseteq \mathcal{T} \times \mathcal{SM}$

- **R7** PB contains Feature: $\mathcal{A}^{PB,F} \subseteq \mathcal{PB} \times \mathcal{F}$

- **R8** PB contains Epic: $\mathcal{A}^{PB,E} \subseteq \mathcal{PB} \times \mathcal{E}$

- **R9** Epic contains User Story: $\mathcal{A}^{E,US} \subseteq \mathcal{E} \times \mathcal{US}$

- **R10** User Story consists of Tasks: $\mathcal{A}^{US,TSK} \subseteq \mathcal{US} \times \mathcal{TSK}$

- **R11** User Story in Sprint Backlog: $\mathcal{A}^{US,SBL} \subseteq \mathcal{US} \times \mathcal{SBL}$

- **R12** Sprint Backlog belongs to Sprint: $\phi^{SBL \to SP} : \mathcal{SBL} \to \mathcal{SP}$

- **R13** Sprint pursues Sprint Goal: $\phi^{SP \to SG} : \mathcal{SP} \to \mathcal{SG}$

- **R14** Scrum Board contains Tasks: $\mathcal{A}^{SCB,TSK} \subseteq \mathcal{SCB} \times \mathcal{TSK}$

- **R15** FED documents Feature: $\phi^{FED \to F} : \mathcal{FED} \to \mathcal{F}$

- **R16** Task blocked by Blocker: $\mathcal{A}^{TSK,BL} \subseteq \mathcal{TSK} \times \mathcal{BL}$

- **R17** Stakeholder participates in Sprint Review: $\mathcal{A}^{SH,SR} \subseteq \mathcal{SH} \times \mathcal{SR}$

- **R18** SM moderates Retrospective: $\mathcal{A}^{SM,SRE} \subseteq \mathcal{SM} \times \mathcal{SRE}$

- **R19** Velocity refers to Team: $\phi^{VEL \to T} : \mathcal{VEL} \to \mathcal{T}$

- **R20** Release Plan includes Feature: $\mathcal{A}^{REP,F} \subseteq \mathcal{REP} \times \mathcal{F}$

- **R21** Release Plan part of Roadmap: $\phi^{REP \to RM} : \mathcal{REP} \to \mathcal{RM}$

- **R22** Sprint generates Snapshot: $\phi^{SP \to DEV} : \mathcal{SP} \to \mathcal{DEV}$

Key Parameters from Entity Attributes (examples)   All attributes referenced by goals/conditions are parameters:

- V_t: velocity indicator for team t (`Velocity.avg_story_points` via **R19**)

- sev_b: severity of blocker $b \in \mathcal{BL}$ (`Blocker.severity`); $\text{open}_b \in \{0, 1\}$ for status

- $A_w^{\text{avail}} \in [0, 1]$: availability of worker w (`Worker.availability`)

- $\text{ach}_{sg} \in [0, 1]$: achievement status of sprint goal sg (`SprintGoal.achievement_status`)

- prio_f^F: feature priority; prio_u^{US}: user story priority

- BUD_p: project budget; $c_{sp}^{\max}$: sprint capacity (effort)

- att_{sr}: attendees count of sprint review sr (`SprintReview.attendees_count`)

- fresh_{pb}: backlog freshness proxy (e.g., recency of `last_updated`)

- $\text{linkFED}_f \in \{0, 1\}$: indicates a `FeatureDocumentation` linked to f (via **R15**)

- $\text{ready}_u \in \{0, 1\}$: user story ready wrt. `acceptance_criteria`

- E_k^{est}: estimated/assigned task effort (hours) for $k \in \mathcal{TSK}$

2   2. Indices

- $p \in \mathcal{P}$, $t \in \mathcal{T}$, $w \in \mathcal{W}$, $f \in \mathcal{F}$, $s \in \mathcal{SP}$, $pb \in \mathcal{PB}$, $e \in \mathcal{E}$, $u \in \mathcal{US}$, $k \in \mathcal{TSK}$, $b \in \mathcal{BL}$, $sr \in \mathcal{SR}$, $sm \in \mathcal{SM}$, $po \in \mathcal{PO}$, $rep \in \mathcal{REP}$.

Helpful incidence sets

- $\mathcal{F}(pb) = \{f \in \mathcal{F} : (pb, f) \in \mathcal{A}^{PB,F}\}$

- $\mathcal{US}(e) = \{u \in \mathcal{US} : (e, u) \in \mathcal{A}^{E,US}\}$

- $\mathcal{TSK}(u) = \{k \in \mathcal{TSK} : (u, k) \in \mathcal{A}^{US,TSK}\}$

- $sbl(u) \in \mathcal{SBL}$ with $(u, sbl(u)) \in \mathcal{A}^{US,SBL}$ and $s(sbl) = \phi^{SBL \to SP}(sbl)$

- $sg(s) = \phi^{SP \to SG}(s)$, $t(v) = \phi^{VEL \to T}(v)$, $rm(rep) = \phi^{REP \to RM}(rep)$

3   3. Goals

We solve a weighted-sum multi-objective:

$$\max \sum_{g \in \mathcal{G}} \omega_g \cdot \text{term}_g, \quad \text{where } \omega_g = \begin{cases} \text{Weight}_g & \text{if GoalType} = \texttt{max}, \\ -\text{Weight}_g & \text{if GoalType} = \texttt{min}. \end{cases}$$

Each goal below lists its logical intent and the exact mathematical contribution term_g.

- **(G0) maximize_team_velocity**
  Logical: Prefer team compositions with higher average velocity.
  Mathematical: $\text{term}_{G0} = \sum_{t \in \mathcal{T}} V_t \left(\dfrac{1}{1 + \sum_w x_{w,t}} \sum_{w \in \mathcal{W}} A_w^{\text{avail}} x_{w,t} \right)$

- **(G1) minimize_blocker_severity**
  Logical: Resolve (select) blockers to reduce unresolved severity.
  Mathematical: $\text{term}_{G1} = \sum_{b \in \mathcal{BL}} \text{sev}_b (1 - r_b)$

- **(G2) maximize_sprint_goal_achievement**
  Logical: Commit to sprint goals with higher expected achievement.
  Mathematical: $\text{term}_{G2} = \sum_{s \in \mathcal{SP}} \text{ach}_{sg(s)} \, g_s$

- **(G3) minimize_total_task_effort**
  Logical: Reduce total planned effort for tasks included via selected stories.
  Mathematical: $\text{term}_{G3} = \sum_{u \in \mathcal{US}} \sum_{k \in \mathcal{TSK}(u)} E_k^{\text{est}} \underbrace{\sum_{s \in \mathcal{SP}} u_{u,s}}_{\text{included}}$

- **(G4) maximize_feature_priority**
  Logical: Pull higher-priority features into sprints.
  Mathematical: $\text{term}_{G4} = \sum_{f \in \mathcal{F}} \sum_{s \in \mathcal{SP}} \text{prio}_f^F \, y_{f,s}$

- **(G5) minimize_project_budget**
  Logical: Minimize allocated feature budgets.
  Mathematical: $\text{term}_{G5} = \sum_{f \in \mathcal{F}} b_f$

- **(G6) maximize_worker_availability**
  Logical: Prefer assignment of more-available workers.
  Mathematical: $\text{term}_{G6} = \sum_{w \in \mathcal{W}} \sum_{t \in \mathcal{T}} A_w^{\text{avail}} \, x_{w,t}$

- **(G7) maximize_sprint_review_attendance**
  Logical: Favor plans that correspond to reviews with higher attendance.
  Mathematical: $\text{term}_{G7} = \sum_{sr \in \mathcal{SR}} \text{att}_{sr}$

- **(G8) minimize_open_blocker_status**
  Logical: Minimize the number (or weight) of blockers left open.
  Mathematical: $\text{term}_{G8} = \sum_{b \in \mathcal{BL}} \text{open}_b (1 - r_b)$

- **(G9) maximize_backlog_freshness**
  Logical: Prefer backlogs that are actively managed by an assigned PO.
  Mathematical: $\text{term}_{G9} = \sum_{pb \in \mathcal{PB}} \sum_{po \in \mathcal{PO}} \text{fresh}_{pb} \, po\_assign_{po,pb}$

- **(G10) minimize_sprint_backlog_total_effort**
  Logical: Keep each sprint backlog within effort capacity.

  Mathematical: $\text{term}_{G10} = \sum_{s \in \mathcal{SP}} \left(\sum_{u \in \mathcal{US}} \sum_{k \in \mathcal{TSK}(u)} E_k^{\text{est}} \, u_{u,s} \right)$

- **(G11) maximize_roadmap_objectives_coverage**
  Logical: Select features into release plans that advance roadmap objectives.
  Mathematical: Let O_{rep} be the objective coverage score of release plan rep. Define $\theta_{rep} \in [0,1]$ with $\theta_{rep} \leq \sum_{f \in \mathcal{F}} rp_{f,rep}$ and $\theta_{rep} \leq 1$. Then $\text{term}_{G11} = \sum_{rep \in \mathcal{REP}} O_{rep} \, \theta_{rep}$

4 4. Conditions

Hard (Must/Cannot) constraints are enforced explicitly; soft (May) constraints add small penalties via nonnegative slacks $\xi. \geq 0$ that enter the objective with small weights.

- **(C0) maximize_active_sprint_only** (*Must-Match, hard*)
  Logical: Schedule into active sprints only. Let $\text{active}_s \in \{0,1\}$.
  Mathematical: $u_{u,s} \leq \text{active}_s \quad \forall u \in \mathcal{US},\ s \in \mathcal{SP}$

- **(C1) minimize_exceeded_budget_projects** (*Must-Match, hard*)
  Logical: Allocations must not exceed project budgets. Map features via product backlog to project p (parameter $\text{featInProj}_{f,p} \in \{0,1\}$).
  Mathematical: $\displaystyle\sum_{f \in \mathcal{F}} b_f\, \text{featInProj}_{f,p} \leq BUD_p \quad \forall p \in \mathcal{P}$

- **(C2) maximize_ready_user_stories** (*Must-Match, hard*)
  Logical: Only ready stories can be scheduled.
  Mathematical: $\displaystyle\sum_{s \in \mathcal{SP}} u_{u,s} \leq \text{ready}_u \quad \forall u \in \mathcal{US}$

- **(C3) minimize_unavailable_workers** (*Must-Match, hard*)
  Logical: Unavailable workers cannot be assigned. Let $\text{availFlag}_w \in \{0,1\}$.
  Mathematical: $\displaystyle\sum_{t \in \mathcal{T}} x_{w,t} \leq \text{availFlag}_w \quad \forall w \in \mathcal{W}$

- **(C4) maximize_certified_skills** (*May-Match, soft*)
  Logical: Prefer certified skills for assignments; penalize deficit. Let $\text{certNeed}_{t,s} \in \{0,1\}$ and $\text{cert}_{w,s} \in \{0,1\}$.
  Mathematical: $\displaystyle\sum_{w \in \mathcal{W}} \text{cert}_{w,s}\, x_{w,t} + \xi_{C4,t,s} \geq \text{certNeed}_{t,s} \quad \forall t \in \mathcal{T}, s \in \mathcal{Sk},\ \xi_{C4,t,s} \geq 0$

- **(C5) minimize_blocked_tasks** (*Cannot-Match, hard*)
  Logical: Tasks currently blocked (and not marked for resolution) cannot be planned. Let $\text{blocked}_k \in \{0,1\}$ if any open blocker linked to k.
  Mathematical: $\displaystyle\sum_{s \in \mathcal{SP}} \sum_{u:\, k \in \mathcal{TSK}(u)} u_{u,s} \leq 1 - \text{blocked}_k + \sum_{b:(k,b) \in \mathcal{A}^{TSK,BL}} r_b \quad \forall k \in \mathcal{TSK}$

- **(C6) maximize_product_backlog_health** (*Must-Match, hard*)
  Logical: Backlog must be active for items to be pulled. Let $\text{active}_{pb} \in \{0,1\}$.
  Mathematical: $\displaystyle\sum_{s \in \mathcal{SP}} \sum_{f \in \mathcal{F}(pb)} y_{f,s} \leq M \cdot \text{active}_{pb} \quad \forall pb \in \mathcal{PB}$

- **(C7) minimize_low_priority_features** (*May-Match, soft*)
  Logical: Discourage selecting low-priority features. Let $\text{isLow}_f \in \{0,1\}$.
  Mathematical: $\displaystyle\sum_{s \in \mathcal{SP}} y_{f,s} \leq 1 - \text{isLow}_f + \xi_{C7,f},\ \xi_{C7,f} \geq 0 \quad \forall f \in \mathcal{F}$

- **(C8) maximize_sprint_timebox_respect** (*Must-Match, hard*)
  Logical: Sprint capacity respected.
  Mathematical: $\displaystyle\sum_{u \in \mathcal{US}} \sum_{k \in \mathcal{TSK}(u)} E_k^{\text{est}}\, u_{u,s} \leq c_s^{\max} \quad \forall s \in \mathcal{SP}$

- **(C9) maximize_goal_documentation_presence** (*Must-Match, hard*)
  Logical: Commit only if sprint goal has a nonempty objective description. Let $\text{hasDesc}_{sg(s)} \in \{0,1\}$.
  Mathematical: $g_s \leq \text{hasDesc}_{sg(s)} \quad \forall s \in \mathcal{SP}$

- **(C10) maximize_feature_documentation_linkage** (*May-Match, soft*)
  Logical: Prefer features with linked requirements/documentation.
  Mathematical: $\sum\limits_{s \in \mathcal{SP}} y_{f,s} \leq \text{linkFED}_f + \xi_{C10,f}, \ \ \xi_{C10,f} \geq 0 \quad \forall f \in \mathcal{F}$

- **(C11) minimize_overloaded_teams** (*May-Match, soft*)
  Logical: Keep team size within recommended bounds. Let $U_t^{\max}$ be the cap.
  Mathematical: $\sum\limits_{w \in \mathcal{W}} x_{w,t} \leq U_t^{\max} + \xi_{C11,t}, \ \ \xi_{C11,t} \geq 0 \quad \forall t \in \mathcal{T}$

Soft-penalty aggregation Let $\lambda_{C4}, \lambda_{C7}, \lambda_{C10}, \lambda_{C11} > 0$ be small penalty weights; the global objective subtracts $\lambda_{C4} \sum_{t,s} \xi_{C4,t,s} + \lambda_{C7} \sum_f \xi_{C7,f} + \lambda_{C10} \sum_f \xi_{C10,f} + \lambda_{C11} \sum_t \xi_{C11,t}$.

5   5. DecisionVariables

(All domains and bounds follow `DecisionVariables.csv`.)

- **DV0 assign_worker_to_team**: $x_{w,t} \in \{0,1\}$, min $= 0$, max $= 1$ (Worker w assigned to Team t)

- **DV1 select_feature_for_sprint**: $y_{f,s} \in \{0,1\}$, min $= 0$, max $= 1$ (Feature f pulled into Sprint s)

- **DV2 schedule_user_story_to_sprint**: $n_u \in \{1, 2, \ldots, 10\}$ (Sprint number for User Story u)
  Convenience binary: $u_{u,s} \in \{0,1\}$ with $\sum_{s \in \mathcal{SP}} u_{u,s} = 1$ and $\sum_{s \in \mathcal{SP}} s \cdot u_{u,s} = n_u$

- **DV3 set_task_effort_hours**: $E_k^{\text{est}} \in \mathbb{Z}, \ 1 \leq E_k^{\text{est}} \leq 100$

- **DV4 allocate_budget_to_feature**: $b_f \in \mathbb{R}_{\geq 0}, \ 0 \leq b_f \leq 100000$

- **DV5 assign_scrum_master_to_team**: $m_{t,sm} \in \{0,1\}$, with $\sum_{sm} m_{t,sm} = 1$ (one SM per team)

- **DV6 prioritize_backlog_item_weight**: $w_i^{BL} \in \{0, \ldots, 100\}$ for backlog item i (Feature/Epic/Story)

- **DV7 commit_sprint_goal**: $g_s \in \{0,1\}$ (commitment for Sprint s)

- **DV8 include_user_story_in_sprint_backlog**: $u_{u,s} \in \{0,1\}$ (already introduced above)

- **DV9 mark_blocker_for_resolution**: $r_b \in \{0,1\}$ (resolve blocker b)

- **DV10 choose_release_plan_for_feature**: $rp_{f,rep} \in \{0,1\}$ (feature f included in release plan rep)

- **DV11 assign_product_owner_to_backlog**: $po\_assign_{po,pb} \in \{0,1\}$ with $\sum_{po} po\_assign_{po,pb} = 1$

Linkage (coherence) constraints

- User story scheduling coherence: $\sum_{s \in \mathcal{SP}} u_{u,s} = 1 \ \ \forall u \in \mathcal{US}$

- Feature/story coupling (example policy): a story under an epic whose feature is not selected cannot be scheduled. Let $\text{featOf}(u)$ map a story to its feature (when applicable): $\sum_s u_{u,s} \leq \sum_s y_{\text{featOf}(u),s}$

- Sprint goal commitment only when anything is planned: $g_s \leq \min\left\{1, \sum_u u_{u,s} + \sum_f y_{f,s}\right\}$

- Scrum Master per team: $\sum_{sm} m_{t,sm} = 1, \ \sum_t m_{t,sm} \leq M_{\text{cap}}^{SM}$ (capacity)

Complete Objective

$$\max \sum_{g \in \{G0,...,G11\}} \omega_g \cdot \mathrm{term}_g - \lambda_{C4} \sum_{t,s} \xi_{C4,t,s} - \lambda_{C7} \sum_{f} \xi_{C7,f} - \lambda_{C10} \sum_{f} \xi_{C10,f} - \lambda_{C11} \sum_{t} \xi_{C11,t}.$$