SCRUM Company Optimization Model (Based on Entities, Relationships, Goals, Conditions, Decision Variables)

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Contents

1 1. Sets (Entities)

We denote each entity as a finite set whose elements are instances of that entity.

- P — **Project**
- T — **Team**
- W — **Worker**
- F — **Feature**
- S — **Skill**
- R — **Role**
- PO — **ProductOwner**
- SM — **ScrumMaster**
- PB — **ProductBacklog**
- SP — **Sprint**
- SPP — **SprintPlanning**
- DS — **DailyScrum**
- SR — **SprintReview**
- SRE — **SprintRetrospective**
- SBL — **SprintBacklog**
- SG — **SprintGoal**
- E — **Epic**
- US — **UserStory**
- TSK — **Task**
- DEV — **DevelopmentSnapshot**
- BL — **Blocker**
- SH — **Stakeholder**
- VEL — **Velocity**
- REP — **ReleasePlan**
- RM — **Roadmap**
- SCB — **ScrumBoard**
- FED — **FeatureDocumentation**

2 2. Indices

We use the following index symbols to refer to set elements:

- $p \in P$ (project), $t \in T$ (team), $w \in W$ (worker)
- $f \in F$ (feature), $s \in S$ (skill), $r \in R$ (role)
- $po \in PO$ (product owner), $sm \in SM$ (scrum master)
- $pb \in PB$ (product backlog), $sp \in SP$ (sprint)
- $spp \in SPP$ (sprint planning), $ds \in DS$ (daily scrum)
- $sr \in SR$ (sprint review), $sre \in SRE$ (retrospective)
- $sbl \in SBL$ (sprint backlog), $sg \in SG$ (sprint goal)
- $e \in E$ (epic), $us \in US$ (user story)
- $tsk \in TSK$ (task), $dev \in DEV$ (dev snapshot)
- $bl \in BL$ (blocker), $sh \in SH$ (stakeholder)
- $vel \in VEL$ (velocity observation), $rep \in REP$ (release plan)
- $rm \in RM$ (roadmap), $scb \in SCB$ (scrum board), $fed \in FED$ (feature doc)

Decision Variables (names from CSV DV0–DV11).

$x^{TP}_{t,p} \in \{0,1\}$	DV0: assign_team_to_project
$x^{WT}_{w,t} \in \{0,1\}$	DV1: assign_worker_to_team
$x^{USSP}_{us,sp} \in \{0,1\}$	DV2: assign_story_to_sprint
$x^{TSKSBL}_{tsk,sbl} \in \{0,1\}$	DV3: plan_task_in_sprint_backlog
$x^{FREP}_{f,rep} \in \{0,1\}$	DV4: select_feature_in_release
$x^{POPB}_{po,pb} \in \{0,1\}$	DV5: choose_product_owner_for_backlog
$x^{SMT}_{sm,t} \in \{0,1\}$	DV6: choose_scrum_master_for_team
$\pi^{US}_{us} \in \{1,\ldots,5\}$	DV7: set_story_priority
$\hat{e}^{TSK}_{tsk} \in \{1,\ldots,40\}$	DV8: set_task_effort (planned)
$cap^{TSP}_{t,sp} \in \{0,\ldots,1000\}$	DV9: set_team_capacity
$b^{P}_{p} \in [0, 10^6]$	DV10: allocate_project_budget
$\tau^{DS}_{t,ds} \in [0,24]$	DV11: schedule_daily_scrum_time

Parameters (from Entities' attributes and Relationships). All parameters are given/estimated from data:

- From **Velocity**: avgSP_{vel}, minVel_{vel}, maxVel_{vel}, trend_{vel}; mapping $M^{VEL\to T}_{vel,t} \in \{0,1\}$ (R19).
- From **Task**: baseline effort e^{TSK}_{tsk}; blockers incidence $B_{tsk,bl} \in \{0,1\}$ (R16).
- From **Blocker**: sev_{bl}; critical indicator $c_{bl} \in \{0,1\}$.
- From **ScrumBoard**: cards_{scb}; tasks-on-board mapping $M^{SCB\to TSK}_{scb,tsk} \in \{0,1\}$ (R14).

- From **UserStory**: story points spoints_{us}, priority $prio^{US}_{us}$, acceptance readiness $accOK_{us} \in \{0,1\}$.
- From **Feature**: priority $prio^{F}_{f}$, estimated effort $estEff^{F}_{f}$.
- From **SprintGoal**: achievement status ach_{sg}; sprint–goal map $M^{SP\leftrightarrow SG}_{sp,sg} \in \{0,1\}$ (R13).
- From **DailyScrum**, **SprintPlanning**, **SprintReview**: durations dur^{DS}_{ds}, dur^{SPP}_{spp}, attendees att^{SR}_{sr}.
- Status/readiness flags: $activeSP_{sp} \in \{0,1\}$, $goalDefined_{sp} \in \{0,1\}$, $readyPB_{pb} \in \{0,1\}$, $readyREP_{rep} \in \{0,1\}$.
- Capacities: team size cap cap^{T}_{t}; worker availability $avail_{w} \in [0,1]$.
- Relationship link parameters used for logical consistency:
  - $M^{SBL\to SP}_{sbl,sp} \in \{0,1\}$ (R12), $M^{US\to SBL}_{us,sbl} \in \{0,1\}$ (R11),
  - $M^{PO\to PB}_{po,pb} \in \{0,1\}$ (R5), $M^{SM\to T}_{sm,t} \in \{0,1\}$ (R6),
  - $M^{F\to REP}_{f,rep} \in \{0,1\}$ (R20), $M^{REP\to RM}_{rep,rm} \in \{0,1\}$ (R21),
  - $M^{T\to P}_{t,p} \in \{0,1\}$ (R1).

3 3. Goals

We aggregate all goal contributions ϕ_g with CSV weights w_g and directions $dir_g \in \{+1 \text{ for “max”}, -1 \text{ for “min”}\}$

$$\max \sum_{g\in\mathcal{G}} dir_g \cdot w_g \cdot \phi_g$$

Each item shows (ID, name), its logic, and its mathematical term ϕ_g.

- **G0: maximize_team_velocity**
  Logic: Prefer teams with higher average story points per sprint.
  Math: $\phi_{G0} = \sum_{vel\in VEL} \text{avgSP}_{vel}$ (used with $dir = +1$, $w = 1.0$)
- **G1: maximize_min_velocity**
  Logic: Improve the worst-case (minimum) observed team velocity.
  Math: Introduce $z^{\min vel} \in \mathbb{R}$ with $z^{\min vel} \le \text{minVel}_{vel}\ \forall vel$; then $\phi_{G1} = z^{\min vel}$ ($dir = +1$, $w = 0.8$)
- **G2: maximize_max_velocity**
  Logic: Favor teams capable of higher peak velocity.
  Math: $\phi_{G2} = \sum_{vel\in VEL} \text{maxVel}_{vel}$ ($dir = +1$, $w = 0.6$)
- **G3: minimize_task_effort**
  Logic: Prefer plans with lower total planned task effort.
  Math: $\phi_{G3} = \sum_{tsk\in TSK} \hat{e}^{TSK}_{tsk}$ ($dir = -1$, $w = 1.0$)
- **G4: minimize_blocker_severity**
  Logic: Penalize scheduling tasks that are blocked, proportional to blocker severity.
  Math: $\phi_{G4} = \sum_{tsk\in TSK} \sum_{sbl\in SBL} \sum_{bl\in BL} \text{sev}_{bl}\, B_{tsk,bl}\, x^{TSKSBL}_{tsk,sbl}$ ($dir = -1$, $w = 1.0$)

- **G5: minimize_number_of_cards**
  Logic: Reduce WIP by limiting cards on Scrum boards.
  Math: $\phi_{G5} = \sum_{scb \in SCB} \text{cards}_{scb} \quad (dir = -1,\ w = 0.7)$

- **G6: maximize_story_points**
  Logic: Deliver more story points by scheduling stories into sprints.
  Math: $\phi_{G6} = \sum_{us \in US} \sum_{sp \in SP} \text{spoints}_{us}\, x^{USSP}_{us,sp} \quad (dir = +1,\ w = 1.0)$

- **G7: maximize_feature_priority**
  Logic: Prefer selecting high-priority features into releases.
  Math: $\phi_{G7} = \sum_{f \in F} \sum_{rep \in REP} prio^{F}_{f}\, x^{FREP}_{f,rep} \quad (dir = +1,\ w = 0.9)$

- **G8: maximize_sprint_goal_achievement**
  Logic: Favor sprints with higher goal achievement.
  Math: $\phi_{G8} = \sum_{sp \in SP} \sum_{sg \in SG} \text{ach}_{sg}\, M^{SP \leftrightarrow SG}_{sp,sg} \quad (dir = +1,\ w = 1.0)$

- **G9: minimize_daily_scrum_duration**
  Logic: Keep daily meetings short (subject to feasibility).
  Math: $\phi_{G9} = \sum_{ds \in DS} \text{dur}^{DS}_{ds} \quad (dir = -1,\ w = 0.3)$

- **G10: minimize_sprint_planning_duration**
  Logic: Reduce planning overhead.
  Math: $\phi_{G10} = \sum_{spp \in SPP} \text{dur}^{SPP}_{spp} \quad (dir = -1,\ w = 0.4)$

- **G11: maximize_review_attendance**
  Logic: Encourage stakeholder participation in reviews.
  Math: $\phi_{G11} = \sum_{sr \in SR} \text{att}^{SR}_{sr} \quad (dir = +1,\ w = 0.5)$

4 4. Conditions

Each condition gives a logical statement ("must/may/cannot match") and a mathematical formulation. "May" conditions are modeled as soft preferences that can be incorporated into the objective as additional terms with their CSV weights; "must" and "cannot" are hard constraints.

- **C0: must_match_active_sprint_status**
  Logic (Must, CriteriaType 2): Only active/planned sprints may receive user stories.
  Math: $x^{USSP}_{us,sp} \le activeSP_{sp} \quad \forall us \in US,\ sp \in SP.$

- **C1: must_match_ordered_backlog_status**
  Logic (Must): Product Backlog must be ready/ordered if a PO manages it.
  Math: $x^{POPB}_{po,pb} \le readyPB_{pb} \quad \forall po \in PO,\ pb \in PB.$

- **C2: must_match_worker_availability**
  Logic (Must): A worker's assignments must respect availability.
  Math: $\sum_{t \in T} x^{WT}_{w,t} \le avail_{w} \quad \forall w \in W.$

- **C3: cannot_match_critical_blocker_severity**
  Logic (Cannot, CriteriaType 0): Tasks with a critical blocker cannot be planned.
  Math: Let $crit_{tsk} = \min\{1, \sum_{bl} c_{bl} B_{tsk,bl}\}$. Then

$$x^{TSKSBL}_{tsk,sbl} \leq 1 - crit_{tsk} \quad \forall tsk \in TSK,\ sbl \in SBL.$$

- **C4: may_match_high_stakeholder_influence**
  Logic (May): Prefer reviews with influential stakeholders.
  Soft Math term: $\Psi_{C4} = \sum_{sr \in SR} \sum_{sh \in SH} influence_{sh} \cdot attend_{sh,sr}$, added with weight 0.6 (maximize).

- **C5: must_match_team_size_capacity**
  Logic (Must): Team headcount cannot exceed capacity.
  Math: $\sum_{w \in W} x^{WT}_{w,t} \leq cap^{T}_{t} \quad \forall t \in T.$

- **C6: may_match_low_feature_effort**
  Logic (May): Prefer lower-effort features in releases.
  Soft Math term (minimize): $\Psi_{C6} = \sum_{f,rep} estEff^{F}_{f}\, x^{FREP}_{f,rep}$ with weight 0.7.

- **C7: must_match_user_story_acceptance_criteria**
  Logic (Must): Only ready stories (acceptance criteria OK) can be scheduled.
  Math: $\sum_{sp \in SP} x^{USSP}_{us,sp} \leq accOK_{us} \quad \forall us \in US.$

- **C8: must_match_release_plan_status**
  Logic (Must): Only ready release plans may include features.
  Math: $x^{FREP}_{f,rep} \leq readyREP_{rep} \quad \forall f \in F,\ rep \in REP.$

- **C9: may_match_high_story_priority**
  Logic (May): Prefer higher-priority stories when scheduling.
  Soft Math term (maximize): $\Psi_{C9} = \sum_{us,sp} prio^{US}_{us}\, x^{USSP}_{us,sp}$ with weight 0.8.

- **C10: must_match_sprint_goal_defined**
  Logic (Must): An active sprint must have a defined goal.
  Math: $activeSP_{sp} \leq goalDefined_{sp} \quad \forall sp \in SP.$

- **C11: may_match_positive_velocity_trend**
  Logic (May): Prefer teams with positive velocity trends.
  Soft Math term (maximize): $\Psi_{C11} = \sum_{vel \in VEL} \text{trend}_{vel}$ with weight 0.5.

Relationship-consistency constraints (from Relationships.csv). These encode the semantics of R1, R5–R7, R11–R14, R19–R22 using the decision variables and link parameters:

$$\text{R1: } x^{TP}_{t,p} \le M^{T\to P}_{t,p} \qquad \forall t,p \qquad (1)$$

$$\text{R5: } x^{POPB}_{po,pb} \le M^{PO\to PB}_{po,pb} \qquad \forall po,pb \qquad (2)$$

$$\text{R6: } x^{SMT}_{sm,t} \le M^{SM\to T}_{sm,t} \qquad \forall sm,t \qquad (3)$$

R7/R8: features/epics belong to PB (selection consistency)

$$\sum_{rep} x^{FREP}_{f,rep} \le \sum_{pb} inPB^{F}_{f,pb} \qquad \forall f \qquad (4)$$

R11/R12: story in SBL of a sprint if scheduled to that sprint:

$$x^{USSP}_{us,sp} \le \sum_{sbl\in SBL} M^{US\to SBL}_{us,sbl}\, M^{SBL\to SP}_{sbl,sp} \qquad \forall us,sp \qquad (5)$$

R14: tasks on the ScrumBoard mirror SBL planning:

$$\sum_{scb} M^{SCB\to TSK}_{scb,tsk} \ge \sum_{sbl} x^{TSKSBL}_{tsk,sbl} \qquad \forall tsk \qquad (6)$$

R19: velocity refers to a team (activate if team exists):

$$\sum_{p} x^{TP}_{t,p} \ge \sum_{vel} M^{VEL\to T}_{vel,t} \cdot y_t, \quad y_t \in \{0,1\} \qquad \forall t \qquad (7)$$

R20/R21: features in releases and releases in roadmap:

$$x^{FREP}_{f,rep} \le \sum_{rm} M^{REP\to RM}_{rep,rm} \qquad \forall f,rep \qquad (8)$$

R22: sprint generates a snapshot (coverage constraint):

$$\sum_{dev} gen^{SP\to DEV}_{sp,dev} \ge activeSP_{sp} \qquad \forall sp \qquad (9)$$

(Parameters $inPB^{F}_{f,pb}$, $gen^{SP\to DEV}_{sp,dev} \in \{0,1\}$ indicate entity link existence.)

Capacity & coupling examples.

$$\sum_{us} \text{spoints}_{us}\, x^{USSP}_{us,sp} \le \sum_{t} cap^{TSP}_{t,sp} \qquad \forall sp \qquad (10)$$

$$\hat{e}^{TSK}_{tsk} \ge e^{TSK}_{tsk} \qquad \forall tsk \qquad (11)$$

5 5. DecisionVariables

The following list mirrors DecisionVariables.csv (ID, name, domain):

- **DV0 assign_team_to_project:** $x^{TP}_{t,p} \in \{0,1\}$
- **DV1 assign_worker_to_team:** $x^{WT}_{w,t} \in \{0,1\}$
- **DV2 assign_story_to_sprint:** $x^{USSP}_{us,sp} \in \{0,1\}$
- **DV3 plan_task_in_sprint_backlog:** $x^{TSKSBL}_{tsk,sbl} \in \{0,1\}$
- **DV4 select_feature_in_release:** $x^{FREP}_{f,rep} \in \{0,1\}$
- **DV5 choose_product_owner_for_backlog:** $x^{POPB}_{po,pb} \in \{0,1\}$
- **DV6 choose_scrum_master_for_team:** $x^{SMT}_{sm,t} \in \{0,1\}$

- **DV7 set_story_priority:** $\pi_{us}^{US} \in \{1, 2, 3, 4, 5\}$
- **DV8 set_task_effort:** $\hat{e}_{tsk}^{TSK} \in \{1, \ldots, 40\}$
- **DV9 set_team_capacity:** $cap_{t,sp}^{TSP} \in \{0, \ldots, 1000\}$
- **DV10 allocate_project_budget:** $b_p^P \in [0, 1{,}000{,}000]$
- **DV11 schedule_daily_scrum_time:** $\tau_{t,ds}^{DS} \in [0, 24]$

Composite objective including "May" conditions (optional). If soft conditions are included, the final objective becomes

$$\max \sum_g dir_g \, w_g \, \phi_g \; + \sum_{C \in \{\text{May}\}} dir_C \, w_C \, \Psi_C,$$

with $dir_C = +1$ for maximize-type, $dir_C = -1$ for minimize-type soft conditions.