DOCUMENT: REs training are the requirements engineers who at the time of the recruitment possess minimal requirements specification writing skills and the domain knowledge and therefore have to be trained. The total number of training requirements engineers on a medium sized process improvement project varies between 4 and 8 people (Royce, 1998).

RE_Hiring = ((Actual_staff__required_for_hire-REs_in_Training)*Exp_REs__Transfering*Cost__effectiveness*Schedule__pressure)/Hiring_delay {person/wk}

UNITS: person/wk

DOCUMENT: RE hiring is the weekly rate at which requirements engineers are recruited on the project. RE hiring is driven by the difference between the actual staff needed to complete the project and the requirements engineers who are undergoing training (Richardson and Pugh, 1981). RE hiring is also determined by increased cost effectiveness, throughput pressure, and the number of requirements engineers who are transferred to work on other projects.

Training_rate = ((REs_in_Training-Trained_REs)*frac_capacity_to_train)/Time_to_train {person/wk}

UNITS: person/wk

DOCUMENT: RE training is the weekly rate at which requirements engineers are trained on the domain knowledge, new technology and skills. In the field it was observed that on average, training takes 2 weeks. Training is aimed at improving productivity and the quality of the requirements. The number of requirements engineers being trained depends on the fraction of the capacity to train.

Schedule_slip(t) = Schedule_slip(t - dt) + (Net_changes__to_schedule) * dtINIT Schedule_slip = 0

UNITS: wk

DOCUMENT: Schedule slip is the additional time needed to complete the project.

Net_changes__to_schedule = (Time_perceived__still_remaining-Schedule_slip)/Schedule__adj_time {Unitless}

UNITS: Unitless

DOCUMENT: Net changes to schedule is the rate of change of the schedule completion date. The rate of change is dependent on the schedule adjustment time (Richardson and Pugh, 1981).

Trained_REs(t) = Trained_REs(t - dt) + (Training_rate - Gaining__experience) * dtINIT Trained_REs = 4 {people}

UNITS: person

DOCUMENT: Trained engineers are the requirements engineers who have completed training in domain knowledge skills.

Training_rate = ((REs_in_Training-Trained_REs)*frac_capacity_to_train)/Time_to_train {person/wk}

UNITS: person/wk

DOCUMENT: RE training is the weekly rate at which requirements engineers are trained on the domain knowledge, new technology and skills. In the field it was observed that on average, training takes 2 weeks. Training is aimed at improving productivity and the quality of the requirements. The number of requirements engineers being trained depends on the fraction of the capacity to train.

Gaining__experience = (Trained_REs-Experienced_REs)/Time_to_gain__experience {person/wk}

UNITS: person/wk

DOCUMENT: Gaining experience is the weekly rate at which the trained requirements engineers acquire technical skills to become experienced requirements engineers.

Actual_completion_time = Schedule_slip+Scheduled_RPI__completion_time

UNITS: wk

Actual_staff__required_for_hire =
(Indicated_Staff_required_to__complete_RPI*Willingness__to_Hire)-
(Total_REs*frac_RPI__completed)

UNITS: person

DOCUMENT: Actual staff required for hire is computed as the weighted average of the indicated staff level required minus the current total number of requirements engineers on the process improvement project (Richardson and Pugh, 1981). Management satisfaction s dependent on how much is perceived completed.

The indicated staff required to complete RPI can be constrained by the willingness to take on new requirements engineers as shown in the first part of the equation. To determine the actual staff required for hire we also substract the total number of requirements engineers currently working on the project given the fraction of RPI completed.

Actual__productivity = SMTH1((Average__productivity*frac_of_RBDC),Productivity__Adj_Time) {Requirements/person/wk}

UNITS: Requirements/person/wk

DOCUMENT: Actual productivity is the average producitivity of the requirements engineers given the fraction of requirements believed to be done correctly.

Average__productivity = MEAN(Productivity_of__exp_REs,Productivity_of__Trained_REs) {Requirements/person/wk}

UNITS: Requirements/person/wk

DOCUMENT: Average productivity represents the average level of productivity that can be attained when the trained requirements engineers and the experienced requirements work on process improvement tasks on the project.

Estimated_effort_remaining = (Initial__requirements__to_review-Approved_spec)/Perceived__productivity {person-wk}

UNITS: person-wk

DOCUMENT: Estimated effort remaining helps us to plan for adjustments in the total number of requirements engineers required to complete the process improvement project given the perceived productivity of the engineers on the project.

fraction__RPI_completed = Approved_spec/Initial__requirements__to_review {Unitless}

UNITS: Unitless

DOCUMENT: Fraction RPI completed is the fraction of the process improvement that has been completed at any given time of the process improvement. It varies from 0 to 1 (Richardson and Pugh, 1981).

frac_capacity_to_train = 0.6 {unitless}

UNITS: Unitless

DOCUMENT: Fraction of capacity to train is the fraction of the hired requirements engineers who can be trained by the process improvement organization can train. Organizational policies always have the capacity to train up to 60% of all untrained staff (Sterman, 2000).

Hiring_delay = 1 {wk}

UNITS: wk

DOCUMENT: Hiring delay is the time it takes to recruit requirements engineers on a project.

Indicated_Staff_required_to__complete_RPI = Estimated_effort_remaining/Time__Remaining {people}

UNITS: person

DOCUMENT: Indicated staff level required to complete RPI are the number of requirements engineers required to complete the project in the scheduled remaining time. It is computed based on the amount of effort remaining to complete the project, measured in person-weeks and the number of weeks remaining before the scheduled completion time (Richardson and Pugh, 1981).

Initial__requirements__to_review = 2500 {Requirements}

UNITS: Requirements

DOCUMENT: Requirements to review are the initial requirements specification. The number of requirements vary depepnding on the type of project being specified and domain complexity. On average, medium sized projects deal with 2,500 requirements (Royce, 1998). In this thesis, 2,500 requirements have been initialed for a small to medium sized commerical software project.

Multiplier_to_productivity__comm_and_loss =
Nominal_frac__personwk*effect_of_comm__overhead_on_pdtivity {Unitless}

UNITS: Unitless

DOCUMENT: Multiplier to productivity due to communication and motivation losses is a representation of the average productive fraction of a Man Day.

Nominal_frac__personwk = 0.5 {Unitless}

UNITS: Unitless

DOCUMENT: Norminal fraction of a person-week on a project is the fraction of time the requirments engineers put their utmost effort on a project

Nominal_prod__of_exp_REs = 15 {Requirements/person/wk}

UNITS: Requirements/person/wk

DOCUMENT: Nominal productivity of experienced requirements engineers is based on Smith and Levery, (1993). It is also close to that observed in field studies at 15 requirements per person per week.

Nominal__prod_of__Trained_REs = 10 {Requirements/person/wk}

UNITS: Requirements/person/wk

DOCUMENT: Nominal productivity of trained requirements engineers is based on Smith and Levery, (1993). It is close to that observed in field studies at 10 requirements per person per week.

Perceived__productivity = SMTH1(Actual__productivity,Time_to_perceive_productivity)

UNITS: Requirements/person/wk

DOCUMENT: Perceived productivity is the perception of how productive the requirements engineers are based on the actual productivity of the requirements engineers.

Productivity_of__exp_REs =
Experienced_REs*Skill_level_of___Exp_REs*Nominal_prod__of_exp_REs {Requirements/person/wk}

UNITS: Requirements/person/wk

DOCUMENT: Productivity of experienced requirements engineers is the actual productivity of the experienced requirements engineers. It is influenced by the number of experienced requirements engineers per the given staff level and the relative productivity of the experienced requirements engineers.

Productivity_of__Trained_REs =
Trained_REs*Skill_level_of__Trained_REs*Nominal__prod_of__Trained_REs
{Requirements/person/wk}

UNITS: Requirements/person/wk

DOCUMENT: Productivity of Trained REs is the level of productivity expected from the trained requirements engineers. It is driven by the nominal productivity of the trained requirements engineers and the skill level of the trained requirements engineers.

Productivity__Adj_Time = 1 {weeks}

UNITS: wk

DOCUMENT: Productivity adjustment time is the time it takes the requirements engineers to have adjustments made in the actual productivity.

Scheduled_RPI__completion_time = 15 {weeks}

UNITS: wk

DOCUMENT: Scheduled completion time is the time that has been planned as the total completion time. The duration of RPI for a medium sized project varies between 1 month and 3 months and between 3 months and 6 months for large projects (Statz, 2005). This research considers 15 simulation weeks which approximated to 3 months.

Schedule__adj_time = 3 {weeks}

UNITS: wk

DOCUMENT: Schedule adjustment time is the time it take to make changes in the RPI schedule completion time.

Schedule__pressure = (Scheduled_RPI__completion_time-Time__Remaining)/Time__Remaining {Unitless}

UNITS: wk

DOCUMENT: Schedule pressure is the variation in the time remaining to the RPI process completion time and the scheduled completion time of the requirements process improvement.

Skill_level_of__Trained_REs = RANDOM(0.3,0.9)

UNITS: Unitless

DOCUMENT: Skill level of trained requirements engineers ranges from a low of 0.35 as a trained requirements engineer, to a high of 0.85 as an experienced requirements engineer (Smith and Levery, 1993). The choice of randomly selecting from a range of 0.3 to 0.9 is to include the range observed from literature.

Skill_level_of___Exp_REs = RANDOM(0.75,1.25)

UNITS: Unitless

DOCUMENT: Skill level of experienced requirements engineers ranges from 0.8 to 1.2 (Smith and Levery, 1993). We randomly select the skill level from a range of 0.75 to 1.25 in include the range observed from literature.

Staffing_progress = Total_REs/Actual_staff__required_for_hire {Unitless}

UNITS: Unitless

DOCUMENT: Staffing progress is the measure of staffing and team dynamics over the process improvement period (Hogbin and Thomas, 1994).

Time_perceived__still_remaining = Estimated_effort_remaining/Actual_staff__required_for_hire {wk}

UNITS: wk

DOCUMENT: Time perceived still remaining is the perceived time required to complete the process improvement. This time is driven by the estimated effort still remaining given the actual staff required for hire (Richardson and Pugh, 1981). Increased effort remaining increases the time perceived still remaining.

Time_to_gain__experience = 2 {wk}

UNITS: wk

DOCUMENT: Time to gain experience is the time it takes in weeks for the trained requirements engineers to attain skills and become experienced requirements engineers.

Time_to_perceive_productivity = 3 {weeks}

UNITS: wk

DOCUMENT: Time to perceive productivity is the time in weeks it takes to make adjustments in the perceived productivity.

Time_to_train = 1.8

UNITS: wk

DOCUMENT: Time to train is the time it takes to train requirements engineers who have been hired on a project. This time is in weeks for this project.

Time__Remaining = Scheduled_RPI__completion_time-TIME {wk}

UNITS: wk

DOCUMENT: Time remaining is the time remaining to complete the project. It is the difference between the scheduled completion time and the current simulation time.

Total_REs = SUM(Experienced_REs+Trained_REs) {people}

UNITS: person

DOCUMENT: Total requirements engineers are the total number of the trained requirements engineers and the experienced requirements engineers that are engaged in a process improvement organisation.

Transfer_time = 3 {wk}

UNITS: wk

DOCUMENT: Transfer time is the time it takes in weeks for the untrained, trained and experienced requirements engineers to be transferred to another project or be fired from the project by the project manager of a process improvement organization.

Work__accomplished = Actual__productivity*Total_REs {Requirements/wk}

UNITS: Requirements/wk

DOCUMENT: Work accomplished is the progress made by the requirements engineers on accomplishing the process improvement tasks per week. It is determined by the total number of requirements engineers and the actual productivity on the project.

effect_of_comm__overhead_on_pdtivity = GRAPH(Tbl_Com__overhead*Actual__productivity {Unitless})

(0.00, 0.035), (0.1, 0.06), (0.2, 0.07), (0.3, 0.085), (0.4, 0.085), (0.5, 0.08), (0.6, 0.095), (0.7, 0.12), (0.8, 0.17), (0.9, 0.195), (1, 0.205)

UNITS: Unitless

DOCUMENT: Communication overhead is the average drop in productivity of a requirements engineer below the nominal productivity due to communication.

Tbl_Com__overhead = GRAPH(TIME)

(0.00, 0.085), (1.36, 0.07), (2.73, 0.035), (4.09, 0.025), (5.45, 0.02), (6.82, 0.035), (8.18, 0.06), (9.55, 0.09), (10.9, 0.11), (12.3, 0.125), (13.6, 0.125), (15.0, 0.125)

UNITS: Unitless

DOCUMENT: Communication overheads are the losses a project incurs due to time spent by the engineers checking their emails and not taking part in the project's activities.

Communication overhead is the ease or difficulty in communicating technical information

Willingness__to_Hire = GRAPH(Time__Remaining)

(0.00, 0.00), (1.20, 0.00), (2.40, 0.00), (3.60, 0.205), (4.80, 0.35), (6.00, 0.485), (7.20, 0.655), (8.40, 0.88), (9.60, 0.985), (10.8, 1.00), (12.0, 1.00)

UNITS: Unitless

DOCUMENT: Willingness to hire is a graphical function that captures the willingness of the process improvement manager to take on more requirements engineers as one of the means to the success of process improvement. The graph assumes that when the time remaining is perceived to be at least 12 weeks, there is total willingness to adjust the total number of requirements engineers to suit the required process improvement. The willigness to hire increases dractically as time remaining to complete the project draws to an end.

Cumulative_Errors__Reworked(t) = Cumulative_Errors__Reworked(t - dt) + (Error_rework - reqts_verification_rate) * dtINIT Cumulative_Errors__Reworked = 0 {Requirements}

UNITS: Requirements

DOCUMENT: Cumulative errors reworked are the total number of errors reworked based on the errors observed by the requirements engineers and the change requests made by the customer. It is assumed to be 0 at the beginning of the process improvement project.

Error_rework = (Errors_observed/((Correction_effort_needed_per_error*frac_effort__for_rework)/Actual__productivity))/Time_for_error_correction

UNITS: Requirements/wk

DOCUMENT: Error rework is the weekly rate at which the number of errors in the requirements are reworked.

reqts_verification_rate = Cumulative_Errors__Reworked/Time_to__detect_defects

UNITS: Requirements/wk

Errors_observed(t) = Errors_observed(t - dt) + (Error_generation + Change_request__submission - Error_rework) * dtINIT Errors_observed = 0 {Requirements}

UNITS: Requirements

DOCUMENT: Errors observed are errors discovered in the requirements document by the requirements engineers. An error is a defect detected in the requirements document from an activity, such as a misspelling in the requirements document or a flaw in the requirements use case model (Williams, 2003).

Error_generation = IF(Nominal_error__fraction>0.2) THEN ((Req_for_Review*Nominal_error__fraction)/((Correction_effort_needed_per_error*frac_effort__for_review)/Actual__productivity))/Time_for_error_correction ELSE Undiscovered_rework

UNITS: Requirements/wk

DOCUMENT: Error generation is the rate at which errors are discovered in a requirements specification.

Change_request__submission (Not in a sector)OUTFLOWS: