THE RESOURCE ALLOCATION CAPABILITIES OF COMMERCIAL CONSTRUCTION PROJECT MANAGEMENT SOFTWARE FOR THE RESOURCE LEVELING PROBLEM

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ABSTRACT

THE RESOURCE ALLOCATION CAPABILITIES OF COMMERCIAL CONSTRUCTION PROJECT MANAGEMENT SOFTWARE FOR THE RESOURCE LEVELING PROBLEM

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Critical path method (CPM) has been commonly used for scheduling of construction projects. However, CPM only considers the relations between the activities, but does not optimize the resource allocation. Resource leveling problem (RLP) concentrates on optimizing resource utilization histograms obtained by Critical Path Method (CPM) without changing the project duration. Resource leveling is crucial for effective use of construction resources particularly, manpower and machinery resources to minimize the project costs. The main objective of this thesis is to evaluate the resource leveling capabilities of commercial project management software packages including Microsoft Project Professional 2013, Primavera P6 Professional R.8.3 and ASTA Powerproject V.12.5 which are being commonly used for scheduling of construction projects. For this purpose an extensive problem set consisting of 640 instances including up to 500 activities and 15 resources were

generated. Three different heuristics with thirteen leveling priorities of project management software packages were included in the performance evaluation. The results of the heuristics of software packages were compared with the results of a shifting leveling heuristic which is commonly cited in the literature. Comparison revealed the limitations of recent project management software packages for the RLP. The results also provide guidance on selection of the adequate leveling heuristic for different type of construction projects.

Keywords: Resource Leveling Problem, Critical Path Method, Project Management Software, Heuristics

ÖZ

PROJE YÖNETİMİ YAZILIMLARININ KAYNAK DENGELEME PROBLEMİ İÇİN ETKENLİĞİNİN İNCELENMESİ

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İnşaat yapım projelerinin programlamasında kritik yol yöntemi (KYY) yaygın olarak kullanılmaktadır. KYY sadece faaliyetler arasındaki ilişkiler dikkate alındığından bu yöntem sonucunda elde edilen çözüm, projede kullanılacak kaynaklar açısından en optimal çözüm değildir. Kaynak dengeleme problemi (KDP) Kritik Yol Yöntemi (KYY) ile elde edilen kaynak kullanımı çizelgesini proje süresini değiştirmeden optimize etmeyi hedeflemektedir. Kaynak dengelenmesi, inşaat yapım projelerinde kullanılan özelikle işgücü ve makine kaynaklarının verimli bir şekilde kullanılıp, projelerinin düşük maliyetle tamamlanması açısından çok önemlidir. Bu tezin temel amacı inşaat projelerinin programlamasında yaygın olarak kullanılan Microsoft Project Professional 2013, Primavera P6 Professional R.8.3 ve ASTA Powerproject V.12.5 proje yönetimi paket programlarının KDP'in çözümündeki performansının belirlenmesidir. Bu doğrultuda 500 faaliyet ve 15 kaynağa kadar problemlerden oluşan toplam 640 problem içeren bir set oluşturulmuştur. Performans

değerlendirmelerinde paket programlara ait 13 adet sezgisel dahil edilmiştir. Paket programların sezgisellerin sonuçları literatürde yaygın olarak yer alan bir sezgiselinin performansı ile kıyaslanmıştır. Kıyaslamalar paket programların kaynak dengeleme probleminin çözümündeki yetersizliğini ortaya çıkartmıştır. Sonuçlar aynı zamanda değişik projeler için uygun sezgiselin seçiminde yol gösterici niteliktedir.

Anahtar Kelimeler: Kaynak Dengeleme Problemi, Kritik Yol Yöntemi, Proje Yönetimi Yazılımları, Sezgiseller

To My Family

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LIST OF ABBREVIATIONS

ABSDEV	Absolute Deviation Metric
Asc.	Ascending
B&B	Branch and Bound
B&K	Burgess and Killebrew Algorithm
CI	Complexity Index
CPM	Critical Path Method
CPU	Central Processing Unit
Desc.	Descending
DOS	Disk Operating System
DSS	Decision Support System
DUR	Duration
ES	Early Start Time
ES-A	Early Start Ascending
ES-D	Early Start Descending
FS	Finish to Start
GA	Genetic Algorithm
GB	Gigabyte
GHz	Gigahertz
ID	Identity

ID-A	Activity ID Ascending
ID-D	Activity ID Descending
LF	Late Finish Time
LF-A	Late Finish Ascending
LF-D	Late Finish Descending
MRD	Maximum Daily Resource Demand
MSP	Microsoft Project
NP-HARD	Non-deterministic Polynomial Time Hard
OS	Order Strength
OVERLOAD	Overload Resource Metric
PACK	Packing Method
PMBOK	Project Management Body of Knowledge
PMI	Project Management Institute
PSA	Particle Swarm Algorithm
PSPLIB	Project Scheduling Problem Library
R8.3	Release 8.3
RAM	Random Access Memory
RCPSP	Resource Constrained Project Scheduling Problem
RC	Resource Constrainedness
Res	Resource
RF	Resource Factor
RID	Resource Idle Days

RLP	Resource Leveling Problem
RS	Resource Strength
SA	Simulated Annealing
Sec.	Second
SD	Start Date
SSQR	Sum of Squares Metric
TCTP	Time-Cost Trade-off Problem
TF	Total Float
TF-A	Total Float Ascending
TF-D	Total Float Descending

CHAPTER 1

INTRODUCTION

Project Management Institute (PMI) defines project as a “temporary endeavor undertaken to create a unique product or service” in Project Management Body of Knowledge (PMBOK, 2004). Hence, there are some capital parameters which separate a project from other activities. First, temporary means projects are not permanent and a deadline fixed for them. Second, unique means all projects have different specifications and there are no two similar projects with same conditions. Specifications could be place of project, weather conditions, project owner, equipment, manpower resources used, etc. If there is not a well-defined plan or schedule to start and continue the project, it will encounter with some major complications such as delays, exceeding budget or even a disaster may happen. Therefore, project management and planning is going to be a vital process during project lifetime. The main aim of project management is finishing project within planned time, expected budget and also intended quality. Construction projects have same significance from the perspective of project management because most construction projects’ working status can change easily by unforeseen conditions and need a more universal and comprehensive plan for their lifetime.

Critical Path Method (CPM) is one of the most commonly used methods for project scheduling entire planning phase. CPM tries to schedule activities as earliest as possible time to satisfy precedence relationship among activities. Furthermore, difference between earliest and latest start time indicates number of float day(s) for each activity. Activities with zero float days are critical activities which define the total project duration. Scheduling activities at their earliest start times can cause

undesired fluctuations in resource(s) daily usage histogram(s). These fluctuations could affect project's total budget. Therefore, some modifications should be implemented for entire scheduling in order to have a much smoother resource profile.

One of the most important actions through project scheduling is optimization. Construction projects commonly are massive jobs from the aspect of activity number, resource usage volume and financial turnover. Resources (especially manpower and machinery) that are being used entire a project may not be available at needed amount or in a specific period of time. Therefore, instead of using resources for short periods with higher fee amount it can be more reasonable to occupy them in lower quantities but more stable, smooth and longer time period. This action can be achieved by using an effective optimization progress during construction planning phase.

Three types of optimization problems concern to construction management projects are: Time-Cost Trade-off Problem (TCTP), Resource-constrained project scheduling problem (RCPSP) and Resource Leveling Problem (RLP).

Time-Cost Trade-off Problem (TCTP):

TCTP deals with compression (crashing) activities duration to expedite project finish time by using alternative methods such as: increasing crew size above planned level, working overtime or using various construction methods. It should be considered that crashing alternatives come at an additional cost. Trade-off between time and cost is called Time-Cost Trade-off Problem (TCTP). TCTP deals with optimization of project schedule and budget by considering alternative time/cost options for the activities.

Resource-constrained project scheduling problem (RCPSP):

The objective of general resource-constrained project scheduling problem (RCPSP) is to schedule projects with limited resources by determining a start date for each activity in such a way that both precedence and resource constraints are satisfied, and the project duration (makespan) is minimized. RCPSP is crucial for planning

and management of construction projects, when there are constraints or limitations on resources.

Resource Leveling Problem (RLP):

RLP tries to minimize fluctuations in resource utilization curves to make an effective work schedule and reduce probability of facing with undesirable problems which will be discussed later. RLP carries out this optimization process only by changing the start date of non-critical activities considering the constraints. Precedence relationship constraint and project fixed deadline are the limitations in RLP. Beside of fluctuation minimization, resource demand peak minimization is another significant objective. Peak minimization has a vital role in project's total budget. For example, manpower resource peak demand determines the size of facility camp which should be constructed for this purpose. When peak is reduced, a smaller camp size can be achieved.

During planning step by using critical path method, project schedule is prepared based on activities' earliest start or finish time and it may cause fluctuations in daily resource usage histograms which can influence project outgoings. Resource leveling method will provide more efficient and smoother schedule according to the resource usage (especially labor and machinery) without changing the project deadline and precedence relationship among activities. The resource fluctuations can lead to four major problems: (1) number of workforce hire and release will be increased (2) significant decrease in quality of the workforce (due to the nature of there is no guaranty for continuous employment), (3) the disruption of the learning curve, and (4) since some personnel do not work properly there will be a significant productivity loss (El-Rayes and Jun 2009). By minimizing resource fluctuations, resource leveling aims to prevent occurrence of these problems.

The RLP studies included in the literature can be categorized into two groups. The first group includes the exact methods. Exact methods' purpose is to find optimal solution for problems. Linear integer programming, dynamic programming and branch and bound (B&B) techniques are among the methods proposed to achieve the optimal solution for the RLP. There are limited numbers of researches focusing

on exact methods and majority of these researches are limited with small problems. The second group of leveling studies includes heuristics and meta-heuristics. The purpose of heuristics and meta-heuristics is finding a near optimal result in a short period of time. There are many heuristics and meta-heuristics proposed in the literature for the RLP. However few studies have focused on evaluating the capabilities of commercial project management software packages for RLP.

In this thesis study, the resource allocation capabilities of commercial construction project management software for the resource leveling will be investigated. The capabilities of 3 heuristics with 13 leveling priorities of Microsoft Project professional 2013, Primavera P6 professional R8.3 and ASTA Powerproject V.12.5 will be compared and evaluated. The results of the heuristics of software packages were compared with the results of a shifting leveling heuristic which is commonly cited in the literature.

The remainder of this thesis is organized as follows. In Chapter 2, the literature review is provided. In Chapter 3, the objective functions used for RLP and problem set generation are stated. In Chapter 4 performance of commercial construction project management software for RLP were evaluated and finally in Chapter 5, the conclusions and the outlook for further research are outlined.

CHAPTER 2

LITERATURE REVIEW

Through the optimization process in construction project management, when planners try to implement CPM to schedule a project (as early as possible by the logic) there will be fluctuations in daily resource utilization histograms. If there is no effort to minimize these variations, it can lead following problems during construction progress:

1) Short term of employment periods for the staff.

2) Reduction in ability of hiring effective workforce for projects since permanent employment cannot be guaranteed.

3) Loss of productivity due to short term employment.

(El-Rayes and Jun 2009).

Therefore, resource leveling is vital during planning phase in order to reduce the effect of unleveled schedules on total project budget. Hence, RLP is an important problem in construction management. RLP studies in literature review can be classified in two categories:

- ✓ Exact Methods
- ✓ Heuristic and meta-heuristic methods

2.1 Exact Methods

Exact methods try to achieve the optimal result for the RLP. Integer programming, dynamic programming and branch and bound (B&B) techniques are some of commonly used approaches for exact methods.

Easa (1989) developed a linear-integer programming model for optimal resource leveling. Absolute deviation objective function (ABSDEV) was used for optimization of the resource profile in this study. Karshenas and Haber (1990) also suggested a linear-integer programming method for RLP. Bandelloni et al. (1994) have suggested a non-serial dynamic programming method by using absolute deviation (ABSDEV) objective function. Younis and Saad (1996) presented a mathematical algorithm for the RLP. This algorithm has an ability to level both single and multi-resource problems. Moreover, it tends to establish a uniform resource curve for each resource type by using ABSDEV objective function. A 5-activity instance with 3 resource types is used for optimal leveling in this study. Mattila and Abraham (1998) used linear integer programming technique for resource leveling problem. Mattila and Abraham (1998) have mentioned that defining large size instances to the model regarding to high amount of variables and constraints is a complex issue. Neumann and Zimmermann (2000) presented branch and bound (B&B) and truncated branch and bound algorithms for RLP. Son and Mattila (2004) implemented two commercial software packages for RLP by assuming that activities can be split. Mutlu (2010) developed an algorithm based on branch and bound method for RLP. A problem set with instances up to 20 activities and 4 resources have been employed. In the study four objective functions including absolute deviation, sum of squares, resource idle days and maximum daily resource demand have been used. These objectives functions will be explained in detail in the next chapter.

2.2 Heuristic and Meta-heuristic Methods

Heuristic and meta-heuristic methods try to find optimal or near optimal results in a reasonable computation time

In one of the earliest leveling studies Burgess and Killebrew (1962) developed a heuristic method for RLP. This algorithm aimed to minimize objective function by shifting the start day of non-critical activities based on a pre-defined priority. In the study, sum of squares (SSQR) objective function was used. Harris (1990) has established a new algorithm to minimize the moment of resource histograms for RLP. This new algorithm was called Packing Method (PACK). In PACK method, resource utilization curves generated by considering minimum resource demands of critical activities. Then resource demands of non-critical activities are added like small packages into base histogram in such a way that the final resource histogram shape is similar to a rectangular. The name of this method has been taken from packing containers. Martinez and Ioannou (1993) also used PACK system like Harris (1990) to minimizing resource usages curves fluctuations. This approach focused on priority based shifting techniques like Burgess and Killebrew (1962).

In recent years, many researchers have adopted meta-heuristic algorithms for RLP. Genetic algorithms (GA) (Chan et al. 1996, Hegazy 1999, Leu et al. 2000, El-Rayes and Jun 2009, Iranagh and Sonmez 2012, Ponz-Tienda et al. 2013) are among the top meta-heuristics proposed to solve the RLP.

Chan et al. (1996) presented a genetic algorithm (GA) both for resource leveling (RLP) and resource constrained scheduling problems (RCPSP). Two standard test problems were used in this study (Shanmuganayam 1989, Morder et al. 1983). Both had 11 activities with one and two resource types. The aim of the algorithm was to minimize fluctuations between resource availability and utilization without an exponential increase in computational time even for instances with larger network size.

Hegazy (1999) has developed a genetic algorithm (GA) to find near-optimal solutions by minimizing resource utilization fluctuations both for resource constrained project scheduling (RCPSP) and resource leveling problem (RLP). Instances used in this study have up to 20 activities and 6 resource types. Random activity priority has been employed for GA. Leu et al. (2000) have defined a decision support system (DSS) to improve capabilities of genetic algorithms for the RLP. Decision support system (DSS) presents the availability to customize weights,

schedules and other parameters to access more reliable and practical plans. In this research, instances up to 9 activities and 3 resources have been employed.

El-Rayes and Jun (2009) have suggested two new resource optimization metrics using a genetic algorithm (GA). Resource idle days (RID) and maximum daily resource demand (MRD) objective functions are proposed in this study for the first time. El-Rayes and Jun used a 20-activity instance with one resource type to assess their algorithm. RID represents the total number of idle and nonproductive resource days, and MRD denotes the maximum resource demand during the entire project duration. This metric considers minimizing the resource fluctuations and peak resource simultaneously. The utilization curves obtained using only RID might tend to imply high peak resource demands since it does not consider the resource demand peak. Hence MRD is jointly used with RID to overcome this shortcoming of RID.

Iranagh and Sonmez (2012) have made a performance comparison of Microsoft Project 2010 with a sole GA for RLP. In this research, 16 instances up to 21 activities and single resource type were selected from the literature. Ponz-Tienda et al. (2013) have developed a genetic algorithm based model for solving RLP. A 1440-instance problem set was taken from Project Scheduling Problem Library (PSPLIB) with up to 120 activities.

Recently, researchers tend to integrate different heuristic and meta-heuristic methods in order to improve capabilities of algorithms for different optimization problems. The aim of this tendency is to employ the capabilities of each method and overcome limitations of sole heuristic or meta-heuristic methods. Son and Skibniewski (1999) have proposed a local optimizer and a hybrid model for minimizing undesired resource utilization. Multi-heuristic and simulated annealing (SA) methods have implemented to generate proposed model for RLP. Doulabi et al. (2011) have proposed a modern hybrid genetic algorithm (GA) for RLP which is equipped by local search heuristic and also repair mechanism. By this mechanism GA capabilities were improved.

Alsayegh and Hariga (2012) proposed a hybrid meta-heuristic algorithm with combination of two different meta-heuristic methods for multi-resource leveling

problem. Particle swarm optimization (PSO) and simulated annealing (SA) methods were applied in this study to minimize effect of resource fluctuations on total project budget by considering splitting of non-critical activities.

2.3 Resource Allocation Capabilities of Commercial Construction Project Management Software Packages

Majority of previous researches have focused on evaluating capabilities of commercial project scheduling and management software (such as Microsoft Project, Primavera, and ASTA Powerproject etc.) for the resource constrained project scheduling problems (RCPSP).

Johnson (1992) evaluated seven different commercial software including, SuperProject Expert 1.0, SuperProject 2.0, Primavera 4.0, 4.1 and 5.0 for DOS, Timeline 2.0 and 4.0, Harvard Total Project Manager II and Harvard Project Manager 3.0, Pertmaster advanced, Hornet, and Microsoft Project 1.0 and 3.0 for Microsoft Windows. In this study a 110-instance problem set was used. Timeline 2.0 obtained the best performances and Microsoft Project 1.0 achieved the worst performance.

Maroto and Tormos (1994) made an assessment among Micro Planner for Windows 6.24A, Micro Planner Professional 7.3B, CA SuperProject 2.0A, Instaplan 3.0B, Microsoft Project for Windows 1.0 and 3.0, and Project Scheduler 1.0 for RCPSP. The only problem was used in this assessment consist of 51 activities and three resources. The best result was obtained by CA SuperProject and Microsoft Project 3.0 simultaneously with Microsoft Project 1.0 had the worst results.

Kolisch et al. (1999) examined the quality of seven commercial project management software packages for RCPSP. Kolisch et al. used a 160-instance problem set for this evaluation with up to 30 activities and 3 resources. CA SuperProject V.3.0 C, Microsoft Project V.4.0, Artemis Schedule Publisher V.4.1, Project Manager Workbench V.1.1.02w, Primavera Project Planner V.1.0, Project Scheduler 6.0 V.1.0.2 and Timeline V.6.0.0 commercial software packages were used during the assessment. Timeline V.6.0.0 achieved the best results while Artemis Schedule Publisher V.4.1 had the worst result.

Mellentien and Trautmann (2001) tested performance capabilities of five different commercial software packages for RCPSP. Scitor Project Scheduler 8.0.1, CA SuperProject 5.0a, CS Project Professional 3.0, MS Project 2000 and Acos Plus.1 8.2 were tested. A 1560-instance problem set was used with 30, 60 and 120 activities and 4 resource types. In this research, Acos Plus.1 8.2 and Scitor Project Scheduler 8.0.1 achieved the best results.

Hekimoglu (2007) investigated the performance of Primavera V.4.1 and Microsoft Project 2003 for RCPSP. Deviation from upper bound of the minimum makespan was computed to evaluate RCPSP capabilities. All of the 2040 PSPLIB instances were used in this study in comparisons.

Kastor and Sirakoulis (2008) assessed the of performance of commercial project management software packages including Primavera P6.0, Microsoft Project 2007 and Open Workbench 1.1.6 for RCPSP. Two real construction projects were used in the study. The first instance has 98 activities and one resource. The second project included 668 activities and seven resource types. The results indicated that Primavera P6.0 gave the best results followed by MS Project. Cekmece (2009) evaluated the resource constrained scheduling capabilities of Primavera Enterprise V.6.0 and Microsoft Project 2007.

Very few studies have focused on evaluating resource leveling capabilities of commercial software. Son and Mattila (2004) used two problems consisting of ten and eleven activities with one resource to reveal limitations of SureTrak Project Manager Version 3.0 and Primavera Project Planner (P3) version 3.0 for the RLP. Iranagh and Sonmez (2012) compared performance of a sole genetic algorithm (GA) with the performance of Microsoft Project 2010 for RLP. In this study, a 16-instance problem set was selected from the literature up to 21 activities and a single resource. This study indicates that suggested GA outperforms Microsoft Project 2010's resource leveling heuristic significantly. The summary of literature focusing on capabilities of commercial project management software is presented in Table 2.1.

Majority of previous research have evaluated capabilities of commercial project management software for the RSCPSP. Despite the importance of resource leveling

in practice, very few studies in the literature evaluated the performance of project management software for the RLP using small instances up to twenty activities. Hence the major objective of this thesis is to fill this gap in the literature and provide a comprehensive evaluation of commercial project management software for RLP.

Table 2.1 Literature review of evaluating resource allocation performance capabilities of commercial software packages (1/3)

Study	Problem Type	Commercial Software Packages Evaluated	Problem Set
Johnson (1992)	**RCPSP**	Super project 1.0 & 2.0 Timeline 2.0 & 4.0 Primavera 4.00, 4.1 & 5.0 Harvard Total Project Manager II Harvard Project Manager 3.0 Hornet Pertmaster Microsoft Project 1.0 & 3.0	No. of instances = 110 No. of activities = 7 - 51 No. of resources = 1-3
Kolisch (1999)	**RCPSP**	Artemis Schedule Publisher V.4.1 CA Super Project V.3.0 C Microsoft Project V.4.0 Primavera Project Planner V.1.0 Project Manager Workbench V.1.1.02w Project Scheduler 6.0 V.1.02 Time Line V.6.0.0	No. of instances = 160 No. of activities = 10, 20 and 30 No. of resources = 1-3

Table 2.1 Literature review of evaluating resource allocation performance capabilities of commercial software packages (2/3)

Study	Problem Type	Commercial Software Packages Evaluated	Problem Set
Mallentien and Trautmann (2001)	**RCPSP**	Acos Plus.1 8.2 CA SuperProject 5.0a CS Project Professional 3.0 MS Project 2000 Scitor Project Scheduler 8.0.1	No. of instances = 1560 No. of activities = 30, 60 and 120 No. of resources = 4
Hekimoglu (2007)	**RCPSP**	Primavera Enterprise V 4.1-Project Management Microsoft Project 2003	No. of instances = 2040 No. of activities = 30, 60, 90 and 120 No. of resources = 4
Kastor and Sirakoulis (2008)	**RCPSP**	Primavera p6.0 Microsoft Project 2007 Open Workbench 1.1.6	No. of instances = 2 No. of activities = 98 and 668 No. of resources = 1 and 7

Table 2.1 Literature review of evaluating resource allocation performance capabilities of commercial software packages (3/3)

Study	Problem Type	Commercial Software Packages Evaluated	Problem Set
Cekmece (2009)	**RCPSP**	Primavera Enterprise V.6.0-Project Management (P6) Microsoft Project 2007	No. of instances = 45 No. of activities = 30, 60 and 120 No. of resources = 4
Son and Mattila (2004)	**RLP**	SureTrak Project Manager V. 3.0 Primavera Project Planner (P3) V.3.0	No. of instances = 2 No. of activities = 10 & 11 No. of resource(s) = 1
Iranagh and Sonmez (2012)	**RLP**	Microsoft Project 2010	No. of instances = 16 No. of activities = 5 - 20 No. of resource(s) = 1

CHAPTER 3

OBJECTIVE FUNCTIONS AND PROBLEM SET GENERATION

The objective of RLP in project management resource optimization is to minimize undesired fluctuations in resource utilization histograms through changing start date of non-critical activities without changing the completion date of the project while satisfying the precedence relationship among activities.

3.1 Objective Functions

Various metrics are proposed to minimize the fluctuations in the resource profile. Absolute Deviation Metric (ABSDEV), Sum of Squares Metric (SSQR), Resource Idle Days and Maximum Daily Resource Demand Metric (RID-MRD), and Overload Metric (OVERLOAD) are commonly used as leveling metrics in the literature. In this section these metrics will be explained.

3.1.1 Absolute Deviation (ABSDEV)

This metric measures absolute fluctuations of daily resource usages from targeted resource daily usage amount. This amount is usually calculated as daily resource utilization average which is a fixed amount for each resource. Standard rounding is commonly applied for average resource demand calculation. The formulation of ABSDEV has been shown as below in equation (3.1).

$$f_{ABSDEV} = \sum_{k=1}^{K} w_k \sum_{t=1}^{T} |r_{kt} - y_k| \qquad (3.1)$$

$$y_k = \left\lfloor \left(\frac{1}{T} \sum_{t=1}^{T} r_{kt} \right) \right\rfloor \quad (3.2)$$

where; f_{ABSDEV} is the objective function to be minimized, K is total number of resource types, k is the resource type, w_k is the weight of resource type k, T is the total project duration, t is a day in the project span, r_{kt} is the resource usage of resource type k at the day of t, and y_k is the average resource utilization level as calculated in equation (3.2).

3.1.2 Sum of Squares (SSQR)

This metric determines sum of squares of daily resource requirements and has a better effectiveness to decrease the pick resource demand in comparison with the absolute deviations method. The equation for SSQR has been given in equation (3.3).

$$f_{SSQR} = \sum_{k=1}^{K} w_k \sum_{t=1}^{T} r_{kt}^2 \quad (3.3)$$

Here; f_{SSQR} is the objective function to be minimized, K is the total number of resource types, k is the resource type, w_k is the weight of resource k, T is the total project duration, t is a day in the project span, r_{kt} is the resource usage of resource type k at the day of t.

3.1.3 Resource Idle Days and Maximum Daily Resource Demand Method (RID-MRD)

This metric is a combination of two different metrics of RID and MRD. RID aims to eliminate the idle days for resources. However this metric does not have any capability to reduce the peak demand for resources. So, MRD metric is used along with RID to minimize peak demand for all resources. Other mean utilization histogram(s) created by RID objective function do not deal with reduction of resource demands peak amount. A combined metric RID-MRD has been introduced

by El-Rayes and Jun (2009) to minimize the idle days of resources and the maximum resource demands of resources simultaneously. The formulation of RID-MRD objective function is shown in equations (3.4), (3.5) and (3.6).

$$f_{RID-MRD} = f_{RID} w_{RID} + f_{MRD} w_{MRD} \tag{3.4}$$

Where;

$$f_{RID} = \sum_{k=1}^{K} w_k \sum_{t=1}^{T} \left(min\left(max(r_{k1}, r_{k2}, \dots, r_{kt}), max(r_{kt}, r_{kt+1}, \dots, r_{kT}) \right) - r_{kt} \right) \tag{3.5}$$

$$f_{MRD} = \sum_{k=1}^{K} w_k * max(r_{k1}, r_{k2}, \dots, r_{kt}, \dots, r_{T-1}, r_{kT}) \tag{3.6}$$

Where, $f_{RID\text{-}MRD}$ is the objective function to be minimized, K is the total number of resource types, k is the resource type, w_k is the weight of resource type k, T is the total project duration, t is a day in the project span, r_{kt} is the resource usage of resource type k at the day of t, w_{RID} is the weight of RID metric, w_{MRD} is the weight of MRD metric.

3.1.4 Overload (OVERLOAD)

This objective function is similar to the ABSDEV. The only distinction is OVERLOAD only measures the positive deviations whereas ABSDEV calculates both positive and negative deviations from targeted resource utilization. Hence, histograms for these two objective functions are same and just amount of objective functions will be varied. This objective function has been applied for this thesis study. The formulation of this metric has been given in equation (3.7).

$$f_{OVERLOAD} = \sum_{k=1}^{K} w_k \sum_{t=1}^{T} (overload_k) \tag{3.7}$$

$$where;\ \ if\ (r_{kt} - y_k) > 0 \rightarrow overload_k = (r_{kt} - y_k)$$

$$else\ \rightarrow overload_k = 0$$

$f_{OVERLOAD}$ is the objective function to be minimized, K is the total number of resource types, k is the resource type, w_k is the weight of resource type k, T is the total project duration, t is a day in the project span, r_{kt} is the resource usage of resource type k at the day of t and y_k is the average resource utilization level as calculated in equation (3.2).

Since resource allocation process in commercial software for both RCPSP and RLP are the same, an availability constraint has to be inputted for each resource in RLP like RCPSP. As for both ABSDEV and OVERLOAD objective function metrics a resource target value has to be defined, therefore it can be seemed that the heuristics used in commercial software packages developed for objective functions like ABSDEV and OVERLOAD. When the resource availability is inputted as the average resource demand, the OVERLOAD and ABSDEV metrics measure the deviations from the average resource demand. OVERLOAD objective function was used to measure these deviations in this thesis since it can be easily implemented compared to ABSDEV.

3.2 Problem Set Generation

In order to test resource allocation capabilities of commercial construction project management software for the resource leveling problem (RLP), a new problem set is generated to have more comprehensive evaluation. Most problem-sets which were used in previous RLP studies suffer from shortage of at least one item: low activity or resource number. These two items impose a significant effect on evaluation of

software capabilities. Small activity or resource numbers are impractical and cannot illustrate actual performance of software in real cases.

In order to generate an extensive problem set RanGen random instance generator (Demeulemeester et al., 2003) has been used. RanGen has some advantages versus other instance generators like ProGen and ProGen/Max. Neither of networks generated by ProGen and ProGen/Max can be defined as strongly random networks. RanGen gives the ability to choose a wide variety of parameters to generate a comprehensive problem set (Demeulemeester et al., 2003). Activity number, network complexity or topology indicator (Order Strength (OS)), resource factor (RF), resource constrainedness (RC) and resource strength (RS) are the parameters considered during the generation process.

3.2.1 Activity Number

Activity number defines the number of activities generated for problem set instances. 50, 100, 200 and 500 activity numbers were used in this study to generate the problems.

3.2.2 Network Complexity/Topology Indicator

Order Strength (OS) was defined as index for network complexity. OS indicates number of precedence relations divided by the theoretical maximum number of precedence relations in the network. A 20-activity visual sample which shows different network shapes and complexity when the OS changes are shown in Figures 3.1, 3.2, 3.3 and 3.4 to display a 20-activity sample instance with order strength value of 0.7, 0.5, 0.3 and 0.1 respectively. These values are selected in this thesis to generate four different types of network topology in each problem set. When the value of OS is decreased, network complexity decreases.

3.2.3 Resource Factor (RF)

Resource factor reflects average fraction of resource types requested per activity. Resource factor is an index which indicates the ratio of resources used.

3.2.4 Resource Constrainedness (RC)

Resource constrainedness parameter determines magnitude of each resource demand. By increasing the amount of RC from 0 to 1, the value for each resource demand increases from 0 to maximum availability of that resource. In order to have relatively more complex instances for leveling RC = 0.9 is selected for all resource types.

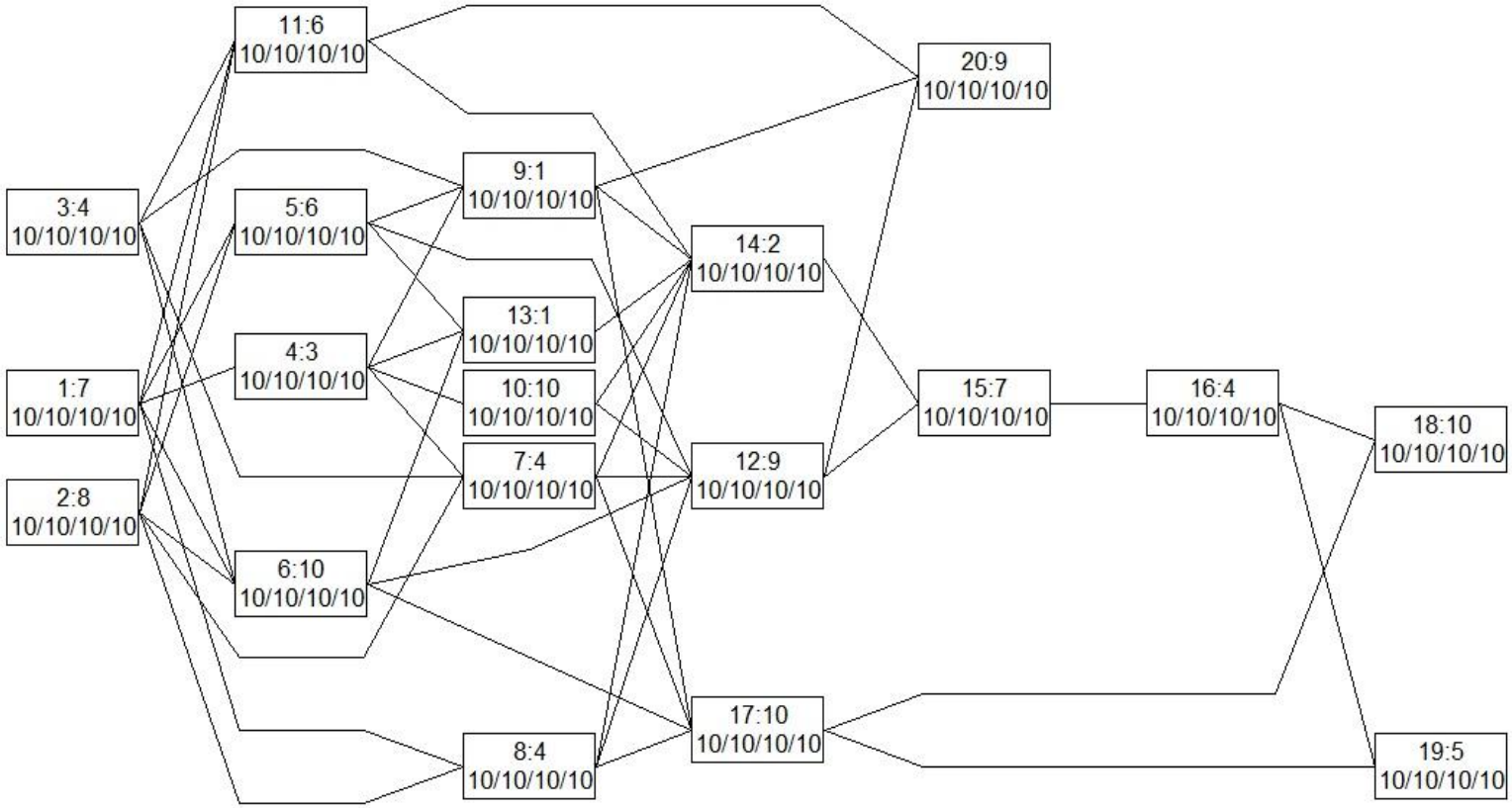

Figure 3.1 20-activity sample instance with OS = 0.7

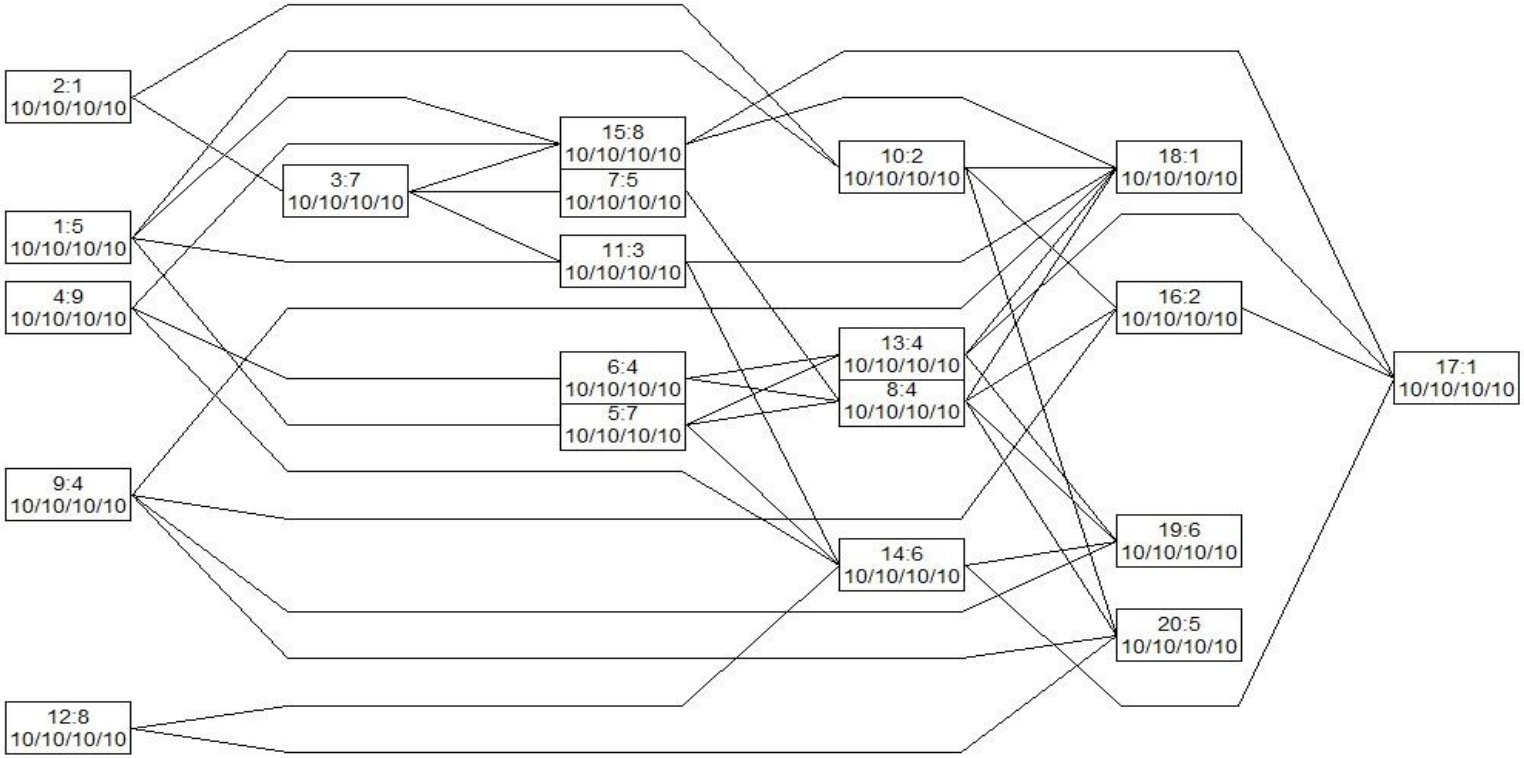

Figure 3.2 20-activity sample instance with OS = 0.5

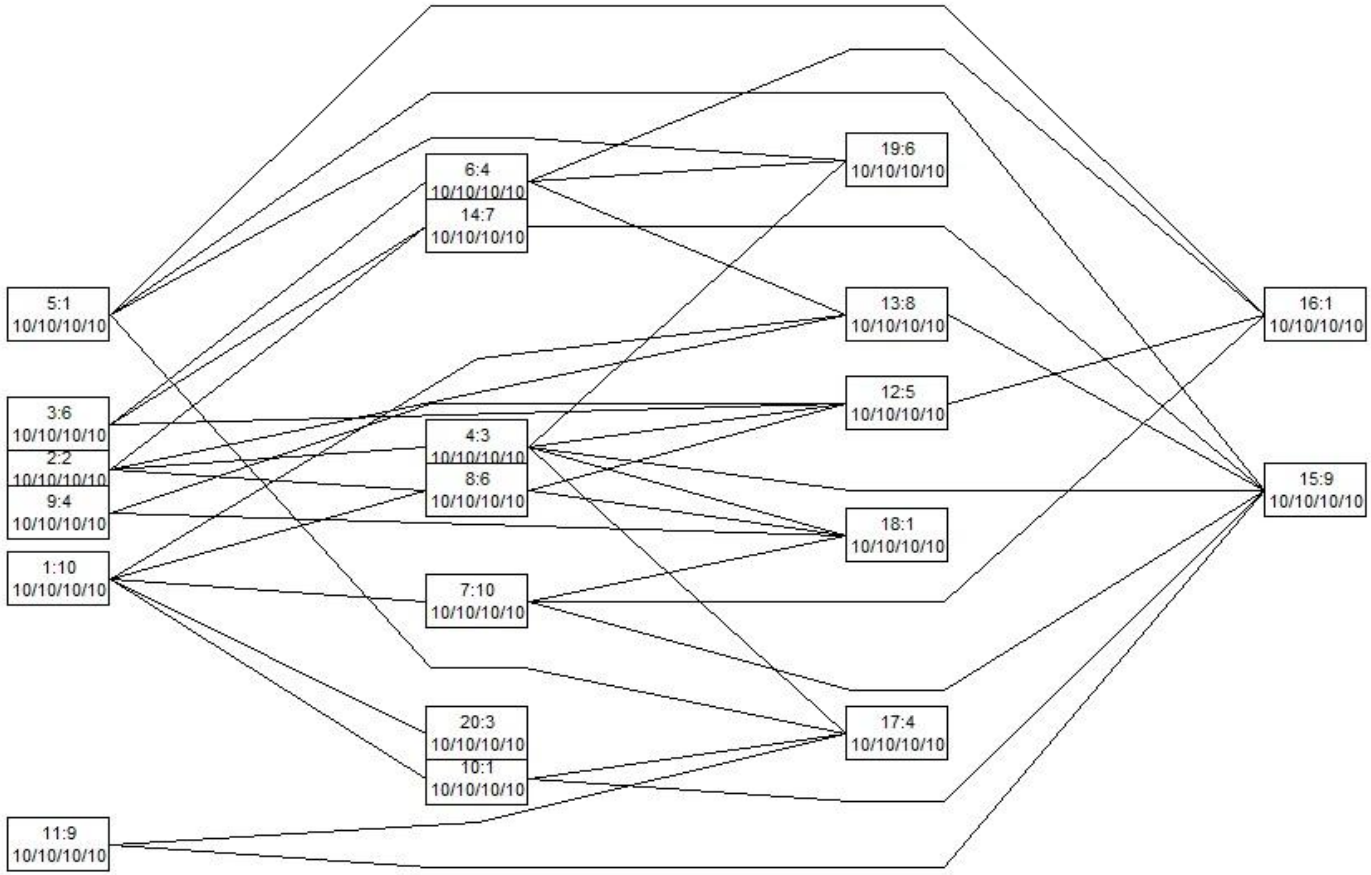

Figure 3.3 20-activity sample instance with OS = 0.3

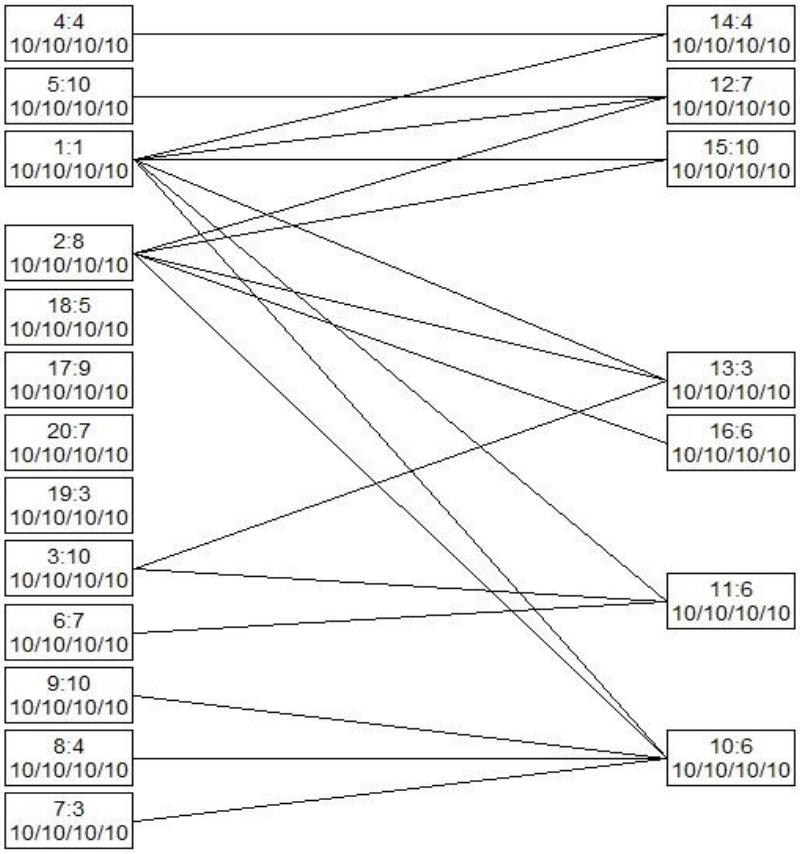

Figure 3.4 20-activity sample instance with OS = 0.1

3.2.5 Resource Strength (RS)

Resource Strength is a parameter which can increase or decrease amount of resource availability. When RS ratio (from 0 to 1) decreases resource availability decreases. Actually this parameter is not used in RLP because the target resource demand is entered by user.

3.2.6 Instance Generation

All generation and testing procedure has been performed by a computer with Intel® Core™ i7-2630QM CPU at 2.00 GHz, an operating system of 64 bit and 8 GB RAM capacity. Tables 3.1, 3.2, 3.3 and 3.4 present all instances' specifications and generation duration respectively:

Table 3.1 50-activity problem set specifications

Activity number	**number of resources**	**Number of instances generated considering order strength (OS)**		**Generation duration (sec.)**
50	1	OS = 0.1	10	2
		OS = 0.3	10	2
		OS = 0.5	10	2
		OS = 0.7	10	2
50	5	OS = 0.1	10	2
		OS = 0.3	10	2
		OS = 0.5	10	2
		OS = 0.7	10	2
50	10	OS = 0.1	10	2
		OS = 0.3	10	2
		OS = 0.5	10	2
		OS = 0.7	10	2
50	15	OS = 0.1	10	2
		OS = 0.3	10	2
		OS = 0.5	10	2
		OS = 0.7	10	2

Table 3.2 100-activity problem set specifications

Activity number	**Number of resources**	**Number of instances generated considering order strength (OS)**		**Generation duration (sec.)**
100	1	OS = 0.1	10	11
		OS = 0.3	10	3
		OS = 0.5	10	2
		OS = 0.7	10	1
100	5	OS = 0.1	10	11
		OS = 0.3	10	3
		OS = 0.5	10	2
		OS = 0.7	10	1
100	10	OS = 0.1	10	11
		OS = 0.3	10	3
		OS = 0.5	10	2
		OS = 0.7	10	1
100	15	OS = 0.1	10	11
		OS = 0.3	10	3
		OS = 0.5	10	2
		OS = 0.7	10	1

Table 3.3 200-activity problem set specifications

Activity number	**Number of resources**	**Number of instances generated considering order strength (OS)**		**Generation duration (sec.)**
200	1	OS = 0.1	10	57
		OS = 0.3	10	12
		OS = 0.5	10	5
		OS = 0.7	10	2
200	5	OS = 0.1	10	57
		OS = 0.3	10	12
		OS = 0.5	10	5
		OS = 0.7	10	2
200	10	OS = 0.1	10	57
		OS = 0.3	10	12
		OS = 0.5	10	5
		OS = 0.7	10	2
200	15	OS = 0.1	10	57
		OS = 0.3	10	12
		OS = 0.5	10	5
		OS = 0.7	10	2

Table 3.4 500-activity problem set specifications

Activity number	Number of resources	Number of instances generated considering order strength (OS)		Generation duration (sec.)
500	1	OS = 0.1	10	587
		OS = 0.3	10	125
		OS = 0.5	10	80
		OS = 0.7	10	28
500	5	OS = 0.1	10	587
		OS = 0.3	10	125
		OS = 0.5	10	80
		OS = 0.7	10	28
500	10	OS = 0.1	10	587
		OS = 0.3	10	125
		OS = 0.5	10	80
		OS = 0.7	10	28
500	15	OS = 0.1	10	587
		OS = 0.3	10	125
		OS = 0.5	10	80
		OS = 0.7	10	28

All instances generated by RanGen are in text format which cannot be inputted into any of mentioned commercial software directly. Hence, first the file format has to be re-arranged. Figure 3.5 shows part of a 50-activity sample with 5 resource type. First row shows activity and resource number respectively. In this sample there are 50 activities plus one start and one finish milestone activities. Second row indicates resource availability. This data can be used for RCPSP purposes and are not used in this study. Next rows display problem information. First column is activity duration. There are five resources, so next five columns indicate each resource's daily usage. Next column explains number of successors for that activity and the other columns show activities' successors. All of the precedence relationships among activities are Finish to Start (FS). FS logic means each activity can start after all its predecessors are finished. Figure 3.6 is modified version of Figure 3.5 to show RanGen's output data which will be inputted to the commercial project management software.

52 5
78 79 63 86 49

0	0	0	0	0	0	10	2	3	4	5	7	12	13	20	26	30
2	9	0	9	3	4	8	22	18	16	11	10	9	8	6		
6	5	3	4	2	4	9	51	37	36	33	27	24	23	15	14	
4	9	8	3	9	8	4	47	31	28	27						
4	0	1	3	6	3	8	51	46	39	33	29	28	23	19		
9	4	3	1	10	2	8	51	50	49	34	24	21	19	14		
9	0	3	3	6	1	9	49	48	47	35	34	33	31	21	16	
4	10	8	7	8	8	10	50	48	47	36	35	33	31	29	24	21
6	1	10	9	1	6	7	49	48	36	32	31	17	14			
6	8	10	5	8	3	7	51	50	42	36	33	29	24			
2	7	0	8	3	1	7	50	49	42	35	33	32	29			
9	2	5	8	10	0	7	47	44	40	38	37	35	25			
3	6	5	9	0	10	7	49	48	47	43	42	40	24			
5	10	4	1	6	3	6	47	46	45	42	40	29				
8	7	7	3	7	5	6	48	47	44	43	41	31				
2	1	7	8	4	1	4	45	43	42	36						
8	6	8	0	4	1	4	47	46	40	35						
8	6	7	5	9	4	4	48	47	45	35						
10	2	6	4	6	9	6	48	47	44	42	40	37				
9	0	5	4	10	5	4	49	42	35	32						
3	2	4	5	9	1	6	46	45	43	42	41	40				
8	5	3	2	5	1	4	48	46	42	40						
6	7	8	7	9	4	4	50	48	44	31						
4	10	5	8	5	1	4	46	45	44	41						
2	2	0	1	8	5	4	45	43	42	41						
8	4	10	2	6	0	4	49	47	42	41						
2	4	6	2	3	3	3	49	44	35							
2	4	1	3	7	2	2	45	32								
1	2	0	1	4	4	3	44	43	41							
10	8	6	1	5	1	3	49	43	42							
2	10	9	8	0	0	2	42	40								
3	9	8	10	0	1	2	44	40								

Figure 3.5 Part of 50-activity instance with five resource types

Activity numbers																
52	Resource types															
	5															
Each resource avaiability measure (RCPSP)																
78	79	63	86	49												
Activity duration																
0	Each resource types' daily utilization value															
2	0	0	0	0	0	Number of successors										
6	9	0	9	3	4	10	Successors									
4	5	3	4	2	4	8	2	3	4	5	7	12	13	20	26	30
4	9	8	3	9	8	9	22	18	16	11	10	9	8	6		
9	0	1	3	6	3	4	51	37	36	33	27	24	23	15	14	
9	4	3	1	10	2	8	47	31	28	27						
4	0	3	3	6	1	8	51	46	39	33	29	28	23	19		
6	10	8	7	8	8	9	51	50	49	34	24	21	19	14		
6	1	10	9	1	6	10	49	48	47	35	34	33	31	21	16	
2	8	10	5	8	3	7	50	48	47	36	35	33	31	29	24	21
9	7	0	8	3	1	7	49	48	36	32	31	17	14			
3	2	5	8	10	0	7	51	50	42	36	33	29	24			
5	6	5	9	0	10	7	50	49	42	35	33	32	29			
8	10	4	1	6	3	7	47	44	40	38	37	35	25			
2	7	7	3	7	5	6	49	48	47	43	42	40	24			
8	1	7	8	4	1	6	47	46	45	42	40	29				
8	6	8	0	4	1	4	48	47	44	43	41	31				
10	6	7	5	9	4	4	45	43	42	36						
9	2	6	4	6	9	4	47	46	40	35						
3	0	5	4	10	5	6	48	47	45	35						
8	2	4	5	9	1	4	48	47	44	42	40	37				
6	5	3	2	5	1	6	49	42	35	32						
4	7	8	7	9	4	4	46	45	43	42	41	40				
2	10	5	8	5	1	4	48	46	42	40						
8	2	0	1	8	5	4	50	48	44	31						

Figure 3.6 Part of 50-activity instance with five resource types and descriptions

Text formatted data is imported to Microsoft Excel and after implementing modifications such as adding commas, prefixes and suffixes, extracted data can be imported to Microsoft Project 2013. In MSP 2013 each resource type in all instances has the same name (such as; Res-1 for first resource, Res-2 for second resource … etc.).

After leveling process is finished by MSP 2013 they should be unleveled and turn back into the original CPM schedule. In this situation data should be saved as .xml format and therefore will be usable by Primavera P6 and ASTA Powerproject. Importing data from MSP 2013 to P6 and ASTA Powerproject is not a very easy process and may require significant effort especially for large projects since .xml format does not always work perfectly to transfer data.

CHAPTER 4

PERFORMANCE OF COMMERCIAL CONSTRUCTION PROJECT MANAGEMENT SOFTWARE FOR THE RESOURCE LEVELING

In this chapter resource allocation capabilities of Primavera P6 Professional R8.3, Microsoft Project Professional 2013 and ASTA Powerproject V.12.5 are evaluated for RLP. As an alternative approach, results are also compared with a very basic and commonly used shifting heuristic developed by Burgess and Killebrew (1962). A comprehensive problem set which consist of 640 instances was generated for this purpose. 640 problem instances were generated with up to 500 activities and up to 15 resource types. The durations of instances were between 16 days and 2146 days. Since 14 priorities were used in analysis, the leveling was performed 14 * 640 = 8960 times.

4.1 Leveling Priorities

13 different types of priorities are selected for the commercial project management software. The priorities include the common priorities that are being used in practice and in literature. Table 4.1 shows the resource leveling priorities used in this study. The multi priority used in ASTA Powerproject is a combination of three single priorities namely, Task Start Date, Activity ID and Total Float.

Leveling priority determines the order of leveling. When Activity ID ascending (ID-A) priority is selected it means software will select activities with lower ID number first. In total float ascending (TF-A) priority software will take the activity with lowest amount of total float regardless of its start time, ID number or other parameters. Vice versa in total float descending (TF-D) the activity with highest

amount of total float will be chosen at first for leveling process. Early start and late finish priorities have the same logic by regarding early start and late finish measures of each activity respectively. Figures 4.1, 4.2 and 4.3 show a snapshot of resource leveling menus of three commercial software packages Microsoft Project Professional 2013, Primavera P6 Professional R.8.3 and ASTA Powerproject V.12.5 respectively.

Table 4.1 Priorities selected for each leveling process

Software	**Priority Selected**	**Sorting Type**
MSP 2013	Standard	
Primavera P6	Activity ID	Ascending
	Activity ID	Descending
	Total Float	Ascending
	Total Float	Descending
	Early Start	Ascending
	Early Start	Descending
	Late Finish	Ascending
	Late Finish	Descending
ASTA Powerproject	Total Float	
	Activity ID	
	Task Start Date	
	Multi Priority	
Burgess and Killebrew	Activity ID	

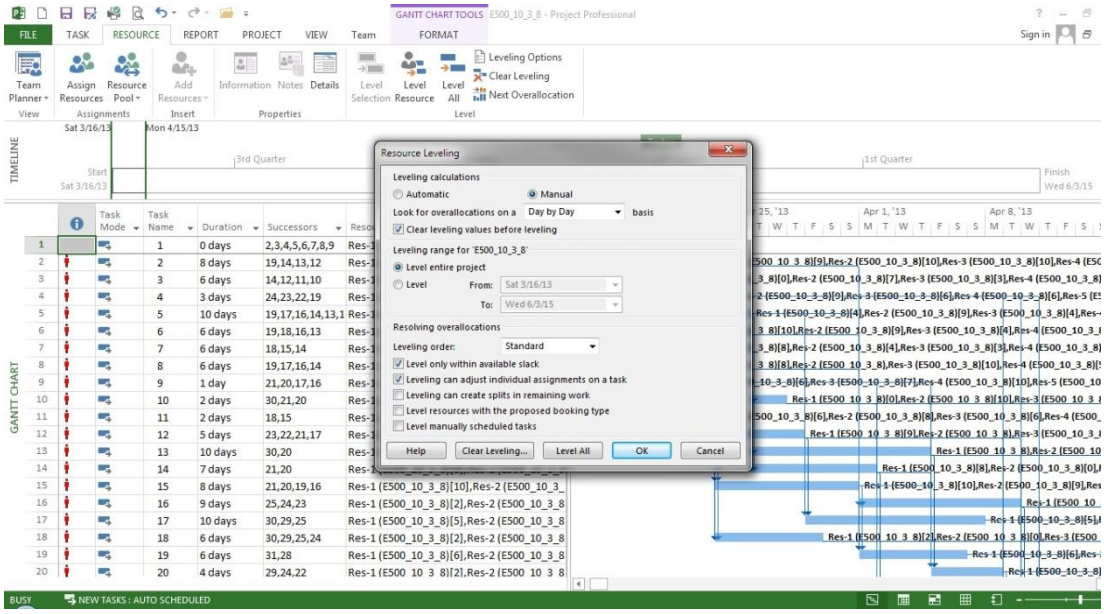

Figure 4.1 Microsoft Project 2013 resource leveling menu

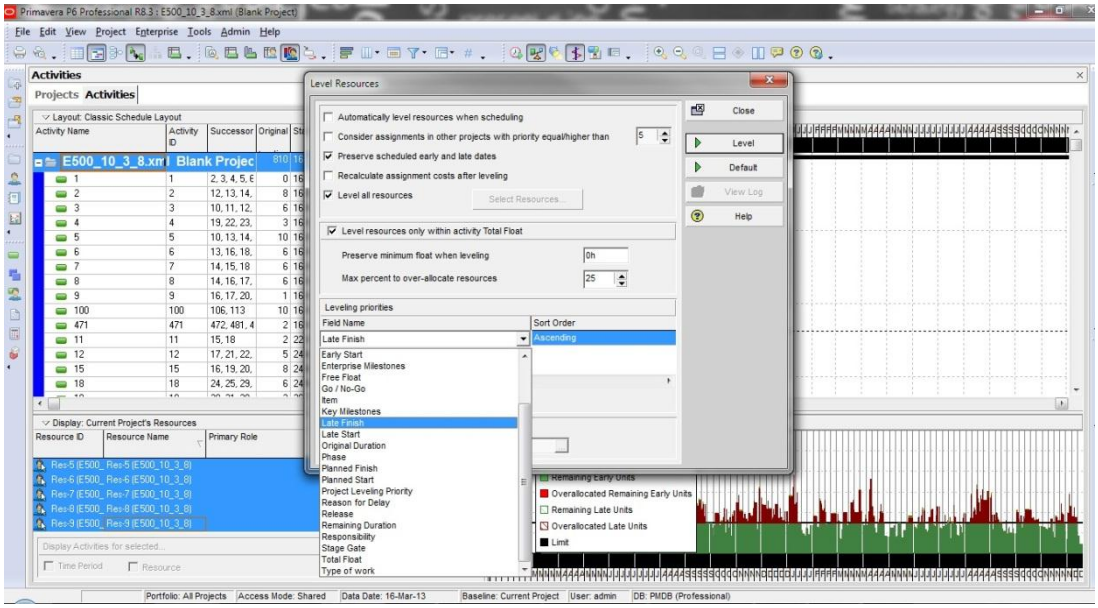

Figure 4.2 Primavera P6 resource leveling menu

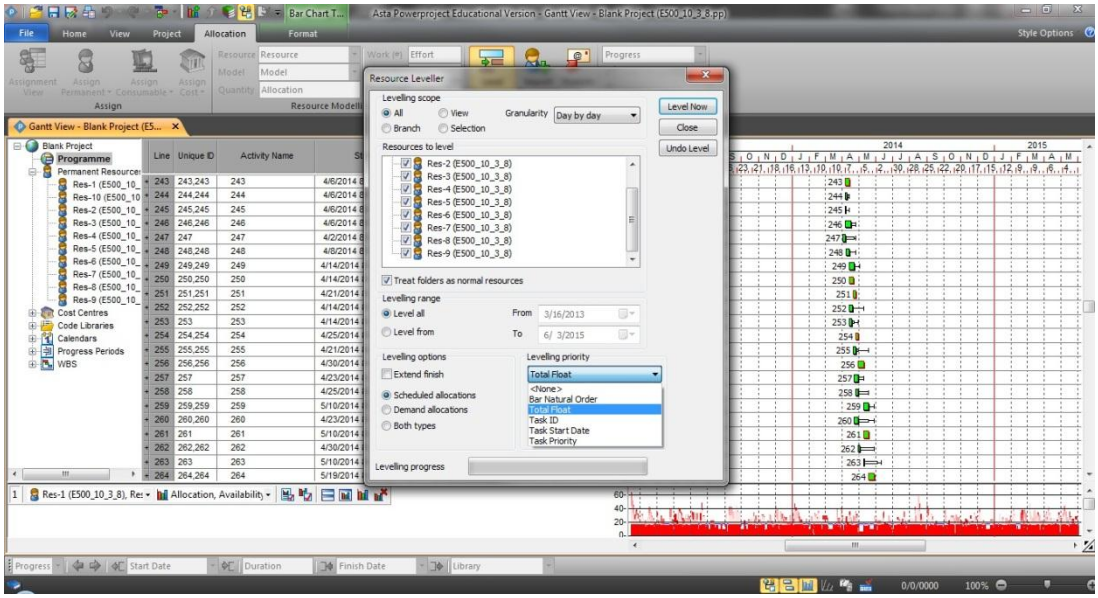

Figure 4.3 ASTA Powerproject resource leveling menu

4.2 Burgess and Killebrew Algorithm (1962)

The RLP results of 13 priorities of the commercial project management are compared with the result of Burgess and Killebrew (1962) heuristic. The overload objective function (OVERLOAD) is used for the Burgess and Killebrew heuristic for minimizing resource fluctuations. B&K algorithm used in this study was developed in C# programming language and implemented by using activity ID priority for RLP. B&K algorithm consists of the following steps:

Step 1) The algorithm will first schedule all non-critical activities at their early start times and will sort all non-critical activities according to a priority list (activity ID, early start, late finish, etc.).

Step 2) The algorithm will select the first non-critical activity from the list. Algorithm aims to minimize the objective function by shifting the start day of selected activity. If more than one option gives same minimum objective function, then the algorithm will schedule the activity as late as possible.

Step 3) Algorithm will select next non-critical activity from the list and repeat step 2.

Step 4) Steps 2 and 3 will be repeated until all non-critical activities are considered to complete first cycle.

Step 5) The algorithm will carry out additional re-scheduling cycles by repeating steps 2 through 4 until no further reduction in the total objective function is possible. In this step only movement of an activity to the right (schedule later) is permissible.

4.3 Objective Function Calculations

Commercial software packages releases resource utilization data based on man-hour per day metric. Calculations are done in Microsoft Excel to determine the objective function of the leveled schedule. Figure 4.4 shows an objective function calculation in Microsoft Excel for a case problem. This problem has 26 days duration with five resource types and total objective function calculated is 468. This value indicates how much man-day metric resource utilization is above the average daily resource usage for all resource types entire project's lifetime.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	
1	392	392	360	392	392	360	376	352	280	392	384	384	344	384	384	392	368	360	384	520	496	504	544	440	344	184	**68**
2	400	400	416	416	408	400	408	400	416	384	416	392	384	432	456	360	336	560	512	512	592	584	472	384	320	24	**99**
3	352	368	392	392	392	368	384	344	384	416	384	376	368	344	376	368	376	576	480	432	432	512	544	416	272	56	**84**
4	312	376	376	376	368	368	336	352	368	336	432	472	464	408	408	360	288	448	480	424	480	432	392	384	296	0	**89**
5	384	368	344	400	400	368	368	360	392	384	440	400	360	464	440	416	432	648	568	600	600	408	408	248	168	0	**128**
																											468

	Res.1																										
Day	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*	*26*	
Work (hours)	*392*	*392*	*360*	*392*	*392*	*360*	*376*	*352*	*280*	*392*	*384*	*384*	*344*	*384*	*384*	*392*	*368*	*360*	*384*	*520*	*496*	*504*	*544*	*440*	*344*	*184*	
Work (Days)	49	49	45	49	49	45	47	44	35	49	48	48	43	48	48	49	46	45	48	65	62	63	68	55	43	23	1263
Average Daily Usage	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	48.576923
Over Load	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	13	14	19	6	0	0	**68**

	Res.2																										
Day	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*	*26*	
Work (hours)	*400*	*400*	*416*	*416*	*408*	*400*	*408*	*400*	*416*	*384*	*416*	*392*	*384*	*432*	*456*	*360*	*336*	*560*	*512*	*512*	*592*	*584*	*472*	*384*	*320*	*24*	
Work (Days)	50	50	52	52	51	50	51	50	52	48	52	49	48	54	57	45	42	70	64	64	74	73	59	48	40	3	1348
Average Daily Usage	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	51.846154
Over Load	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	0	0	18	12	12	22	21	7	0	0	0	**99**

	Res.3																										
Day	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*	*26*	
Work (hours)	*352*	*368*	*392*	*392*	*392*	*368*	*384*	*344*	*384*	*416*	*384*	*376*	*368*	*344*	*376*	*368*	*376*	*576*	*480*	*432*	*432*	*512*	*544*	*416*	*272*	*56*	
Work (Days)	44	46	49	49	49	46	48	43	48	52	48	47	46	43	47	46	47	72	60	54	54	64	68	52	34	7	1263
Average Daily Usage	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	48.576923
Over Load	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	23	11	5	5	15	19	3	0	0	**84**

	Res.4																										
Day	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*	*26*	
Work (hours)	*312*	*376*	*376*	*376*	*368*	*368*	*336*	*352*	*368*	*336*	*432*	*472*	*464*	*408*	*408*	*360*	*288*	*448*	*480*	*424*	*480*	*432*	*392*	*384*	*296*	*0*	
Work (Days)	39	47	47	47	46	46	42	44	46	42	54	59	58	51	51	45	36	56	60	53	60	54	49	48	37	0	1217
Average Daily Usage	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	46.807692
Over Load	0	0	0	0	0	0	0	0	0	0	7	12	11	4	4	0	0	9	13	6	13	7	2	1	0	0	**89**

	Res.5																										
Day	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*	*26*	
Work (hours)	*384*	*368*	*344*	*400*	*400*	*368*	*368*	*360*	*392*	*384*	*440*	*400*	*360*	*464*	*440*	*416*	*432*	*648*	*568*	*600*	*600*	*408*	*408*	*248*	*168*	*0*	
Work (Days)	48	46	43	50	50	46	46	45	49	48	55	50	45	58	55	52	54	81	71	75	75	51	51	31	21	0	1296
Average Daily Usage	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	49.846154
Over Load	0	0	0	0	0	0	0	0	0	0	5	0	0	8	5	2	4	31	21	25	25	1	1	0	0	0	**128**

Figure 4.4 Objective function calculation example

4.4 Leveling Process Duration

The duration of leveling is recorded for each problem and each priority separately. Table 4.2 shows average duration for the heuristics for each problem set. Fastest heuristic was Burgess and Killebrew's algorithm with an average of 1 second which is followed by Primavera P6 with an average of 2 seconds. Microsoft Project and ASTA Powerproject solution times are significantly longer than B&K algorithm and Primavera P6. Tables B.1 to B.16 of appendix B provide leveling duration of each instance.

The results indicate that for small size instances (50 activities) all heuristics of software packages and B&K algorithm have almost same leveling duration which is

around 1 second. For medium size samples (100 and 200 activities), B&K, Microsoft Project, and Primavera P6 heuristics all have reasonable processing duration. However, for large size instances (500 activities) only Primavera P6 and B&K have reasonable processing duration. The results indicate that MSP and ASTA Powerproject are very slow especially for large size instances. Since most of construction projects contain high numbers of activities, the leveling process time is very important for practical purposes.

4.5 Performance Results

4.5.1 Performance Results Based on Number of Activities

Since, this comprehensive problem set is exclusively generated for this study; the optimal solutions for the problems are not available. Hence, percent deviation from the upper bound (best solution) is used to evaluate commercial software packages and B&K algorithm's performance. Each instance is leveled 14 times and deviation of each result calculated by the best result. Tables A.1 to A.32 located in appendix A show performance of each commercial software packages and B&K algorithm for each instances. Table 4.3 summarizes the average deviation from upper bound for instances with different number of activities.

Table 4.2 Average duration of leveling process for each problem set in second metric

No.	Activity Number	Resource Number	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				B&K
			standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start	Multi	
1	50 Activity	1	1	1	1	1	1	1	1	1	1	1	1	1	3	1
2	50 Activity	5	1	1	1	1	1	1	1	1	1	1	1	1	3	1
3	50 Activity	10	1	1	1	1	1	1	1	1	1	1	1	1	3	1
4	50 Activity	15	1	1	1	1	1	1	1	1	1	1	1	1	3	1
5	100 Activity	1	1	1	1	1	1	1	1	1	1	1	1	1	3	1
6	100 Activity	5	3	1	1	1	1	1	1	1	1	5	5	5	14	1
7	100 Activity	10	5	1	1	1	1	1	1	1	1	13	14	13	40	1
8	100 Activity	15	8	1	1	1	1	1	1	1	1	20	21	22	63	1
9	200 Activity	1	2	1	1	1	1	1	1	1	1	7	7	7	21	1
10	200 Activity	5	12	1	1	1	1	1	1	1	1	18	20	19	57	1
11	200 Activity	10	21	2	2	2	2	2	2	2	2	49	52	50	151	1
12	200 Activity	15	31	2	2	2	2	2	2	2	2	87	91	89	267	1
13	500 Activity	1	17	1	1	1	1	1	1	1	1	32	36	34	101	1
14	500 Activity	5	127	3	3	3	3	3	3	3	3	126	138	132	396	1
15	500 Activity	10	208	5	5	5	5	5	5	6	5	257	273	262	792	3
16	500 Activity	15	311	7	6	7	7	7	7	7	7	461	488	478	1427	5
17	Total Average		47	2	2	2	2	2	2	2	2	67	72	70	209	1

Table 4.3 Average deviation from upper bound for each problem set

Activity No.	Resource No.	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				B&K
		standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
50	1	57.1%	205.9%	221.9%	105.1%	274.4%	149.8%	186.9%	155.4%	267.7%	604.0%	517.3%	481.9%	428.2%	10.7%
50	5	25.3%	58.8%	73.2%	35.7%	77.8%	60.3%	68.7%	51.7%	77.4%	220.1%	216.9%	189.6%	160.2%	2.2%
50	10	63.8%	55.6%	52.3%	29.8%	58.3%	61.7%	58.3%	48.0%	55.3%	207.5%	189.1%	155.7%	122.1%	1.8%
50	15	76.7%	47.8%	53.6%	41.8%	42.7%	60.5%	54.2%	48.4%	40.6%	172.6%	149.1%	124.9%	89.9%	1.7%
Average		**55.7%**	**92.0%**	**100.2%**	**53.1%**	**113.3%**	**83.1%**	**92.0%**	**75.9%**	**110.3%**	**301.0%**	**268.1%**	**238.0%**	**200.1%**	**4.1%**
100	1	39.9%	44.7%	70.8%	37.7%	83.3%	43.2%	55.5%	28.7%	83.9%	128.7%	112.1%	124.0%	110.9%	5.4%
100	5	10.9%	28.0%	23.0%	26.4%	23.3%	21.5%	26.0%	32.9%	23.1%	53.3%	53.0%	50.3%	47.7%	1.8%
100	10	9.8%	24.5%	17.0%	23.6%	15.9%	18.3%	21.7%	32.1%	16.2%	39.6%	38.6%	38.1%	35.2%	1.8%
100	15	8.2%	26.8%	15.9%	27.2%	13.7%	18.5%	23.5%	33.6%	14.6%	38.0%	37.0%	37.7%	36.9%	2.7%
Average		**17.2%**	**31.0%**	**31.7%**	**28.7%**	**34.1%**	**25.4%**	**31.7%**	**31.8%**	**34.5%**	**64.9%**	**60.2%**	**62.5%**	**57.7%**	**2.9%**
200	1	25.0%	24.5%	44.3%	19.9%	47.6%	27.9%	38.1%	14.0%	43.9%	77.5%	77.5%	80.0%	71.3%	0.1%
200	5	10.4%	20.3%	20.7%	20.0%	20.6%	19.2%	22.3%	21.7%	20.4%	40.0%	41.0%	39.4%	39.6%	0.2%
200	10	9.0%	19.8%	16.5%	20.1%	15.5%	15.9%	18.9%	22.5%	16.2%	30.6%	32.5%	31.4%	29.1%	0.5%
200	15	10.1%	19.5%	15.4%	18.9%	14.4%	15.6%	18.1%	22.1%	14.9%	32.4%	32.0%	31.8%	29.0%	0.1%
Average		**13.6%**	**21.0%**	**24.2%**	**19.7%**	**24.5%**	**19.6%**	**24.4%**	**20.1%**	**23.9%**	**45.1%**	**45.8%**	**45.7%**	**42.3%**	**0.2%**
500	1	16.6%	18.1%	30.0%	12.2%	36.0%	20.3%	23.4%	10.7%	34.1%	51.6%	50.9%	48.4%	44.5%	0.3%
500	5	11.1%	17.9%	16.7%	17.0%	16.6%	16.1%	17.3%	18.8%	15.9%	34.5%	34.8%	33.3%	33.5%	0.0%
500	10	9.4%	16.1%	13.9%	15.8%	12.4%	14.0%	14.8%	16.8%	12.3%	25.9%	25.4%	25.4%	23.9%	0.0%
500	15	9.4%	15.7%	12.9%	16.0%	12.1%	13.5%	14.6%	17.0%	12.3%	25.9%	26.0%	25.7%	23.4%	0.0%
Average		**11.6%**	**16.9%**	**18.4%**	**15.3%**	**19.3%**	**16.0%**	**17.5%**	**15.8%**	**18.6%**	**34.5%**	**34.3%**	**33.2%**	**31.3%**	**0.1%**
Total Average		**24.5%**	**40.2%**	**43.6%**	**29.2%**	**47.8%**	**36.0%**	**41.4%**	**35.9%**	**46.8%**	**111.4%**	**102.1%**	**94.9%**	**82.8%**	**1.8%**

Table 4.3 shows average deviation for each problem set considering activity number. In each category the best results belongs to B&K algorithm. B&K algorithm has a 1.8% deviation from best solution. Microsoft Project professional 2013 was placed first among commercial software packages. However, 24.5% deviation for MSP 2013 in comparison with 1.8% deviation for B&K algorithm indicates the limitations of commercial management software for RLP. Primavera P6 which has 29.2% deviation for total float ascending (TF-A) is close to MSP 2013 results and can be used as an alternative method since it is very fast. ASTA Powerproject's best result belongs to multi priority heuristics. Multi priority has an 82.8% deviation and it shows a big gap between ASTA Powerproject performance and best solution results. Combination of three single priorities in multi priority, leveling process takes too long and makes it impractical to use. Each problem set's best average solutions are shown as below.

- ✓ 50-activity problem set, Primavera P6 total float ascending (TF-A) with average of 53.1% deviation.
- ✓ 100,200 and 500-activity problem set, MSP 2013 with average of 17.2%, 13.6% and 11.6% deviation respectively.

4.5.2 Performance Results Based on Number of Resources

Number of resources has a significant effect on leveling process results. According to Table 4.3 best performance of each activity problem set can differ according to the number of resources. For example, in 50-activity problem set MSP 2013 has the best performance in single and 5 resource problems, whereas Primavera P6 total float ascending (TF-A) and late finish descending (LF-D) priority got the best outcomes for 10 and 15 resource instances respectively.

Table 4.4 illustrates resource leveling performance for commercial software packages and B&K algorithm sorted by resource type numbers. According to table 4.4 each problem set's best average solutions are listed as below:

- ✓ Single and 5-resource problem sets, MSP 2013 with average of 34.7% and 14.4% deviations respectively.

- ✓ 10-resource problem set, Primavera P6 total float ascending (TF-A) priority with average of 22.3% deviation.
- ✓ 15-resource problem set, Primavera P6 late finish descending (LF-D) priority with average deviation of 20.6%.

4.5.3 Performance Results Based on Network Complexity (OS)

Another factor which could enforce the performance results are network complexity measurement (OS). Table 4.5 shows resource leveling performance for commercial software packages and B&K algorithm sorted by order strength (OS) metric. Considering outcomes in Table 4.5 each problem set's best average solutions are listed as below:

- ✓ OS = 0.1, 0.3 and 0.5 problem sets, MSP 2013 with average of 18.4%, 20.3% and 24.4% deviations respectively
- ✓ OS = 0.7 problem set, Primavera P6 total float ascending (TF-A) priority with average deviation of 25.6%.

Since all three resource parameters used for problem set generation (RF, RC and RS) are assigned with a constant value (0.9), the sensitivity for these three parameters cannot be analyzed entire this study.

Table 4.4 Objective function average deviation for each problem set considering resource number metric

Activity No.	Resource No.	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				B & K
		standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
50	1	57.1%	205.9%	221.9%	105.1%	274.4%	149.8%	186.9%	155.4%	267.7%	604.0%	517.3%	481.9%	428.2%	10.7%
100	1	39.9%	44.7%	70.8%	37.7%	83.3%	43.2%	55.5%	28.7%	83.9%	128.7%	112.1%	124.0%	110.9%	5.4%
200	1	25.0%	24.5%	44.3%	19.9%	47.6%	27.9%	38.1%	14.0%	43.9%	77.5%	77.5%	80.0%	71.3%	0.1%
500	1	16.6%	18.1%	30.0%	12.2%	36.0%	20.3%	23.4%	10.7%	34.1%	51.6%	50.9%	48.4%	44.5%	0.3%
Average		**34.7%**	**73.3%**	**91.7%**	**43.7%**	**110.4%**	**60.3%**	**76.0%**	**52.2%**	**107.4%**	**215.4%**	**189.5%**	**183.6%**	**163.7%**	**4.1%**
50	5	25.3%	58.8%	73.2%	35.7%	77.8%	60.3%	68.7%	51.7%	77.4%	220.1%	216.9%	189.6%	160.2%	2.2%
100	5	10.9%	28.0%	23.0%	26.4%	23.3%	21.5%	26.0%	32.9%	23.1%	53.3%	53.0%	50.3%	47.7%	1.8%
200	5	10.4%	20.3%	20.7%	20.0%	20.6%	19.2%	22.3%	21.7%	20.4%	40.0%	41.0%	39.4%	39.6%	0.2%
500	5	11.1%	17.9%	16.7%	17.0%	16.6%	16.1%	17.3%	18.8%	15.9%	34.5%	34.8%	33.3%	33.5%	0.0%
Average		**14.4%**	**31.2%**	**33.4%**	**24.8%**	**34.6%**	**29.3%**	**33.6%**	**31.3%**	**34.2%**	**87.0%**	**86.4%**	**78.2%**	**70.2%**	**1.0%**
50	10	63.8%	55.6%	52.3%	29.8%	58.3%	61.7%	58.3%	48.0%	55.3%	207.5%	189.1%	155.7%	122.1%	1.8%
100	10	9.8%	24.5%	17.0%	23.6%	15.9%	18.3%	21.7%	32.1%	16.2%	39.6%	38.6%	38.1%	35.2%	1.8%
200	10	9.0%	19.8%	16.5%	20.1%	15.5%	15.9%	18.9%	22.5%	16.2%	30.6%	32.5%	31.4%	29.1%	0.5%
500	10	9.4%	16.1%	13.9%	15.8%	12.4%	14.0%	14.8%	16.8%	12.3%	25.9%	25.4%	25.4%	23.9%	0.0%
Average		**23.0%**	**29.0%**	**24.9%**	**22.3%**	**25.5%**	**27.5%**	**28.4%**	**29.9%**	**25.0%**	**75.9%**	**71.4%**	**62.7%**	**52.6%**	**1.0%**
50	15	76.7%	47.8%	53.6%	41.8%	42.7%	60.5%	54.2%	48.4%	40.6%	172.6%	149.1%	124.9%	89.9%	1.7%
100	15	8.2%	26.8%	15.9%	27.2%	13.7%	18.5%	23.5%	33.6%	14.6%	38.0%	37.0%	37.7%	36.9%	2.7%
200	15	10.1%	19.5%	15.4%	18.9%	14.4%	15.6%	18.1%	22.1%	14.9%	32.4%	32.0%	31.8%	29.0%	0.1%
500	15	9.4%	15.7%	12.9%	16.0%	12.1%	13.5%	14.6%	17.0%	12.3%	25.9%	26.0%	25.7%	23.4%	0.0%
Average		**26.1%**	**27.4%**	**24.4%**	**26.0%**	**20.7%**	**27.0%**	**27.6%**	**30.2%**	**20.6%**	**67.2%**	**61.0%**	**55.0%**	**44.8%**	**1.1%**
Total Average		**24.5%**	**40.2%**	**43.6%**	**29.2%**	**47.8%**	**36.0%**	**41.4%**	**35.9%**	**46.8%**	**111.4%**	**102.1%**	**94.9%**	**82.8%**	**1.8%**

Table 4.5 Objective function average deviation for each problem set considering complexity of network metric

Activity No.	OS	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				B & K
		standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
50	0.1	37.9%	63.2%	66.7%	39.9%	84.0%	46.7%	61.4%	50.8%	76.4%	143.4%	146.4%	135.1%	114.3%	7.7%
100	0.1	7.9%	46.4%	58.7%	41.8%	69.8%	41.4%	52.3%	45.9%	72.2%	145.5%	131.9%	140.2%	126.8%	10.8%
200	0.1	15.9%	39.4%	55.5%	36.8%	55.2%	39.3%	54.0%	35.2%	52.9%	116.6%	118.8%	119.0%	111.6%	0.8%
500	0.1	11.7%	25.1%	31.7%	21.7%	34.6%	22.9%	30.2%	24.0%	31.8%	72.8%	72.8%	69.2%	67.2%	0.3%
Average		**18.4%**	**43.5%**	**53.1%**	**35.0%**	**60.9%**	**37.6%**	**49.5%**	**39.0%**	**58.3%**	**119.6%**	**117.4%**	**115.9%**	**105.0%**	**4.9%**
50	0.3	25.7%	62.4%	72.8%	45.6%	84.5%	57.6%	71.0%	60.6%	85.2%	182.5%	166.2%	161.2%	143.2%	5.8%
100	0.3	27.2%	29.4%	27.2%	26.1%	26.8%	23.7%	27.7%	31.1%	26.1%	54.0%	51.6%	52.6%	49.6%	0.8%
200	0.3	11.4%	14.0%	15.0%	12.8%	16.3%	13.1%	13.0%	12.8%	15.7%	26.9%	26.9%	26.7%	22.7%	0.0%
500	0.3	17.0%	20.7%	20.5%	18.7%	20.6%	19.1%	19.9%	18.8%	20.7%	38.8%	38.2%	37.6%	34.2%	0.0%
Average		**20.3%**	**31.6%**	**33.9%**	**25.8%**	**37.0%**	**28.4%**	**32.9%**	**30.8%**	**36.9%**	**75.5%**	**70.7%**	**69.5%**	**62.4%**	**1.7%**
50	0.5	51.3%	96.6%	121.8%	64.3%	127.1%	93.8%	102.7%	79.0%	127.4%	290.7%	270.8%	237.1%	198.2%	2.8%
100	0.5	19.3%	26.7%	17.8%	27.0%	16.6%	14.5%	27.1%	29.7%	16.4%	35.6%	33.2%	33.4%	30.5%	0.1%
200	0.5	15.8%	18.5%	14.2%	17.4%	14.9%	13.8%	17.7%	20.1%	15.0%	23.7%	23.8%	24.0%	21.3%	0.0%
500	0.5	11.1%	12.8%	12.2%	12.7%	12.4%	13.1%	12.0%	12.2%	12.7%	16.7%	16.6%	16.3%	14.7%	0.0%
Average		**24.4%**	**38.6%**	**41.5%**	**30.4%**	**42.7%**	**33.8%**	**39.9%**	**35.3%**	**42.9%**	**91.6%**	**86.1%**	**77.7%**	**66.2%**	**0.7%**
50	0.7	108.1%	145.9%	139.7%	62.5%	157.7%	134.3%	133.0%	113.0%	152.0%	587.7%	489.1%	418.6%	344.7%	0.1%
100	0.7	14.3%	21.4%	22.9%	19.9%	23.1%	22.0%	19.6%	20.5%	23.2%	24.6%	23.9%	23.9%	23.7%	0.0%
200	0.7	11.4%	12.2%	12.2%	11.9%	11.8%	12.4%	12.7%	12.2%	11.9%	13.3%	13.6%	13.0%	13.4%	0.0%
500	0.7	6.6%	9.1%	9.0%	8.0%	9.4%	8.7%	8.1%	8.2%	9.3%	9.6%	9.6%	9.7%	9.1%	0.0%
Average		**35.1%**	**47.2%**	**45.9%**	**25.6%**	**50.5%**	**44.4%**	**43.4%**	**38.5%**	**49.1%**	**158.8%**	**134.0%**	**116.3%**	**97.7%**	**0.0%**
Total Average		**24.5%**	**40.2%**	**43.6%**	**29.2%**	**47.8%**	**36.0%**	**41.4%**	**35.9%**	**46.8%**	**111.4%**	**102.1%**	**94.9%**	**82.8%**	**1.8%**

4.5.4 Performance comparison graph

In this section guidance is provided for the practitioners for selections of the adequate leveling heuristic among 13 heuristics of commercial project management software. Table 4.3 shows average deviation for each problem set sorted by activity number. Each value represented 40 instances average outcome deviations. These 40 instances consist of four different network complexity topology values (order strength (OS) = 0.1, 0.3, 0.5 and 0.7). Considering results shown on Tables 4.2 and 4.3 following conclusions are made:

50 activities with single and 5 resource types:

For small sized instances with up to 50 activities and 5 resources, best results are related to MSP 2013 by far with the other software programs.

50 activity numbers with 10 resource types:

Primavera P6 total float ascending (TF-A) priority outperforms other priorities and heuristics for small problems with 50 activities and 10 resource types. For this type of problems MSP 2013 and ASTA Powerproject have inadequate performances in comparison with all Primavera P6 priorities.

50 activity numbers and 15 resource types:

Both Primavera P6 late finish descending (LF-D) and total float ascending (TF-A) priorities takes first place from aspect of leveling and speed performance (1% difference between LF-D and TF-A approximately).

100, 200 and 500 activity numbers with single resource types:

Primavera P6 late finish ascending (LF-A) priority has the best results from aspect of resource leveling and speed performance.

100, 200 and 500 activity numbers with 5, 10 and 15 resource types:

This section of problem set consists of 360 instances and the best performance belongs to MSP 2013 from the aspect of leveling metric. However, Primavera P6 processing time performance is much better in comparison with MSP 2013

especially in 500-activity with 15-resource type instances (311 seconds for MSP 2013 and 7 seconds all Primavera P6 priorities in average). Figure 4.5 illustrates summary of results and presents recommendations for the practitioners in terms of selection of leveling heuristics for different number of activities and resources.

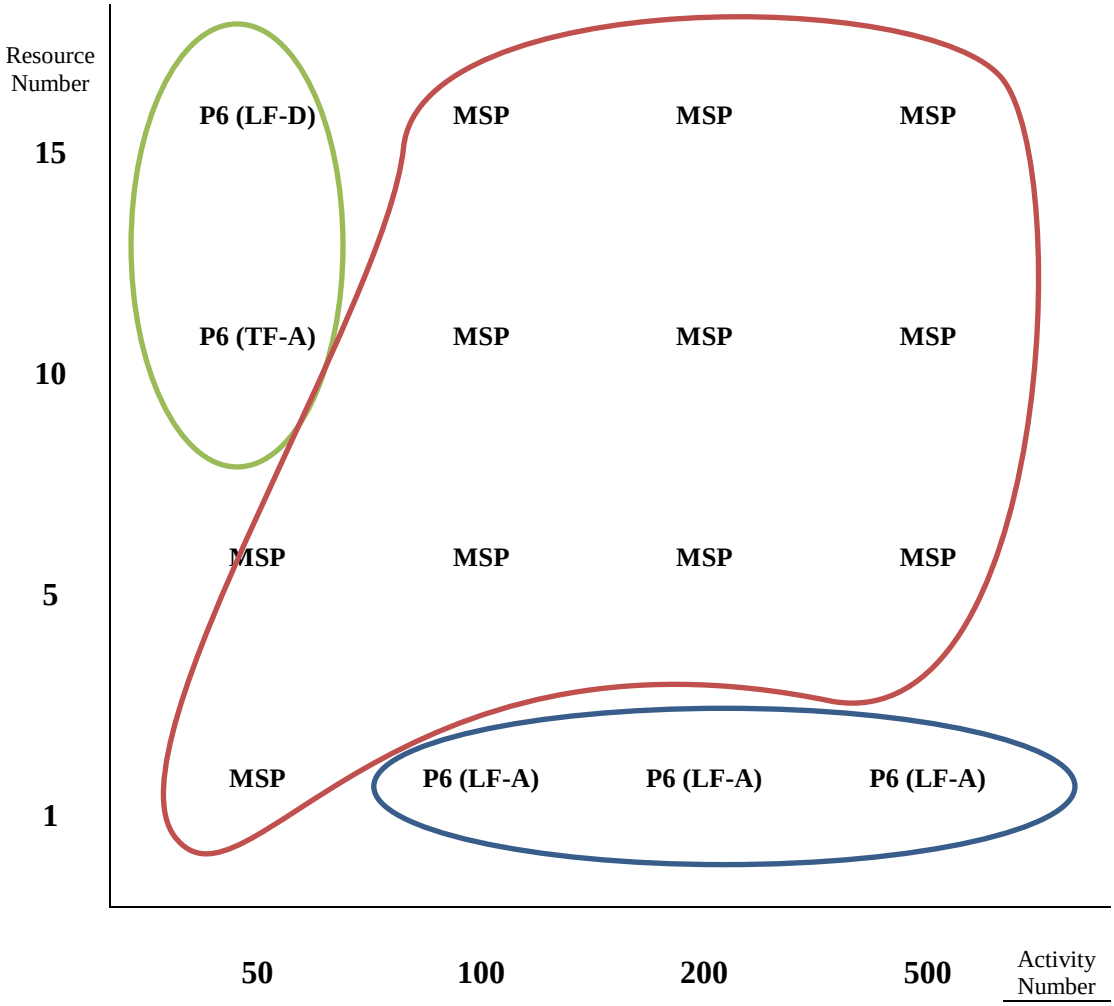

Figure 4.5 Performance comparison chart according to deviation from the upper bound

In order to have a better visual performance comparison, some of resource usage profiles for the case problem E500_15_4_10 are shown in figures 4.6, 4.7, 4.8, 4.9 and 4.10. This case problem consists of 500 activities with 15 resource types. In these figures, X-axis indicates project work days and Y-axis shows man-hour value for resource consumption per day. Figure 4.6 shows the resource number 5 profiles for early start schedule. As it can be seen there are plenty of fluctuations with peak amount of over 900 man-hour per day.

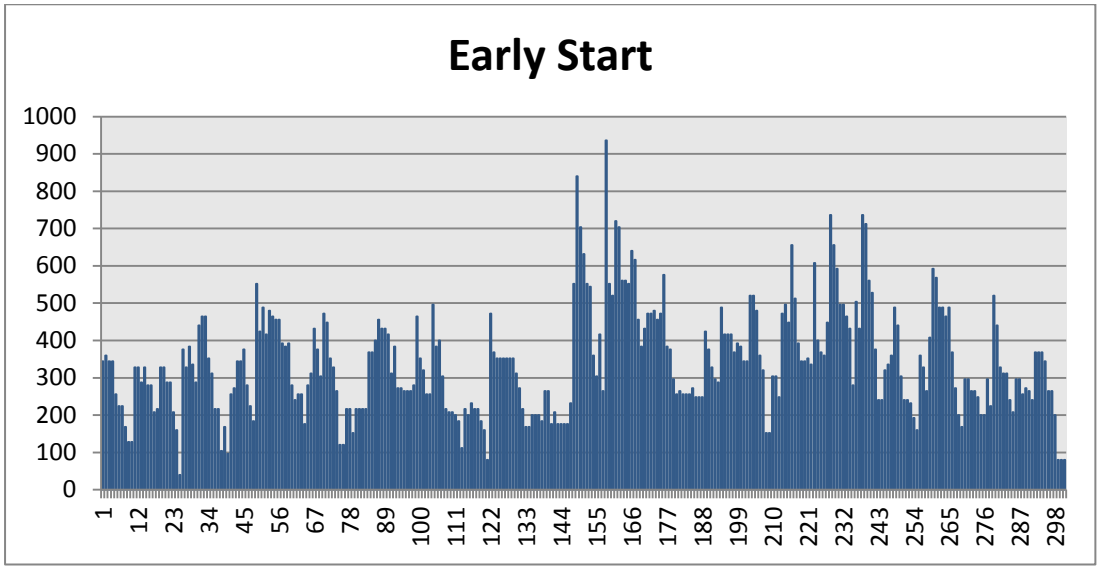

Figure 4.6 Resource number 5 usage profile for early start schedule of instance E500_15_4_10

Figures 4.7, 4.8 and 4.9 show profiles for the same resource leveled by MSP 2013, Primavera P6 (TF-D) and Primavera P6 (LF-D) priorities respectively. According to these figures fluctuations are decreased slightly by both software packages. Moreover, the peak value is decreased to around 650 man-hour per day by Primavera P6 (TF-D) priority. Figure 4.10 belongs to resource profile of the same resource, leveled by B&K algorithm. Here, fluctuations decreased more significantly in comparison with other software packages. Furthermore, daily resource usage peak amount is fallen down around 550 man-hour per day.

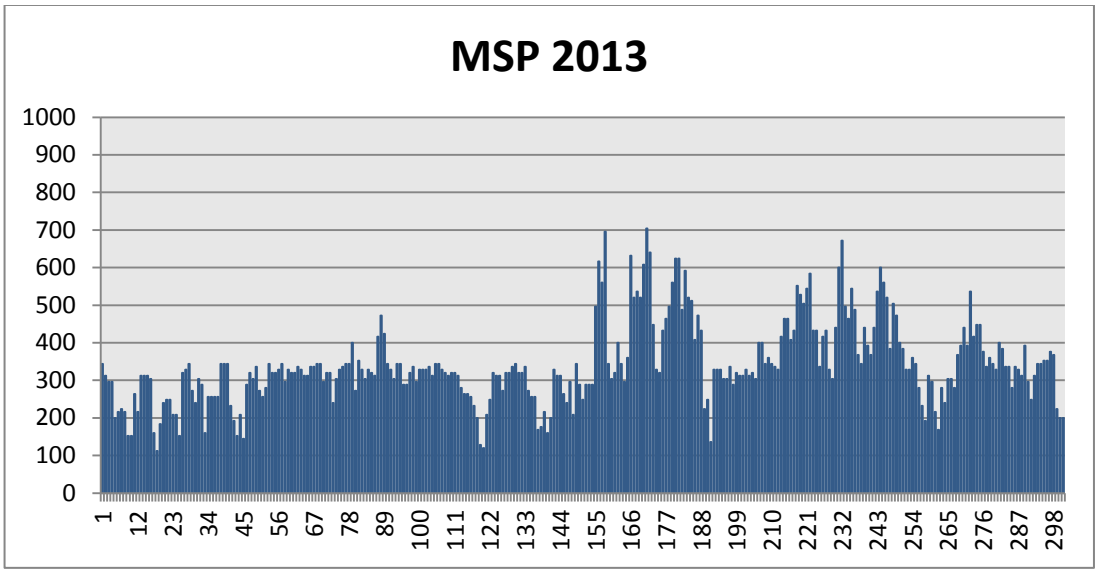

Figure 4.7 Resource number 5 usage profile leveled by MSP 2013 for instance E500_15_4_10

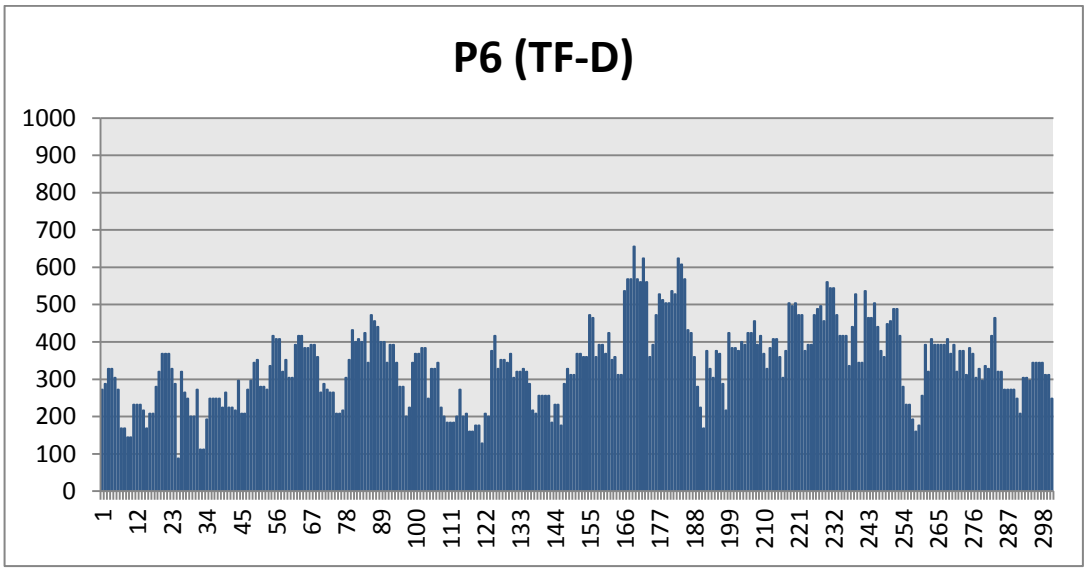

Figure 4.8 Resource number 5 usage profile leveled by Primavera P6 (TF-D) priority for instance E500_15_4_10

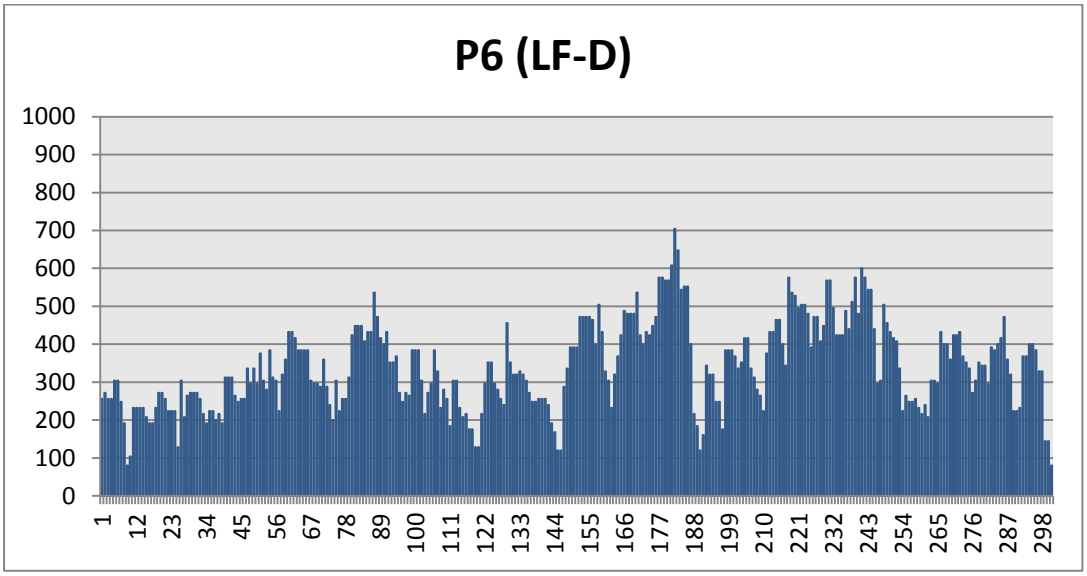

Figure 4.9 Resource number 5 usage profile leveled by Primavera P6 (LF-D) priority for instance E500_15_4_10

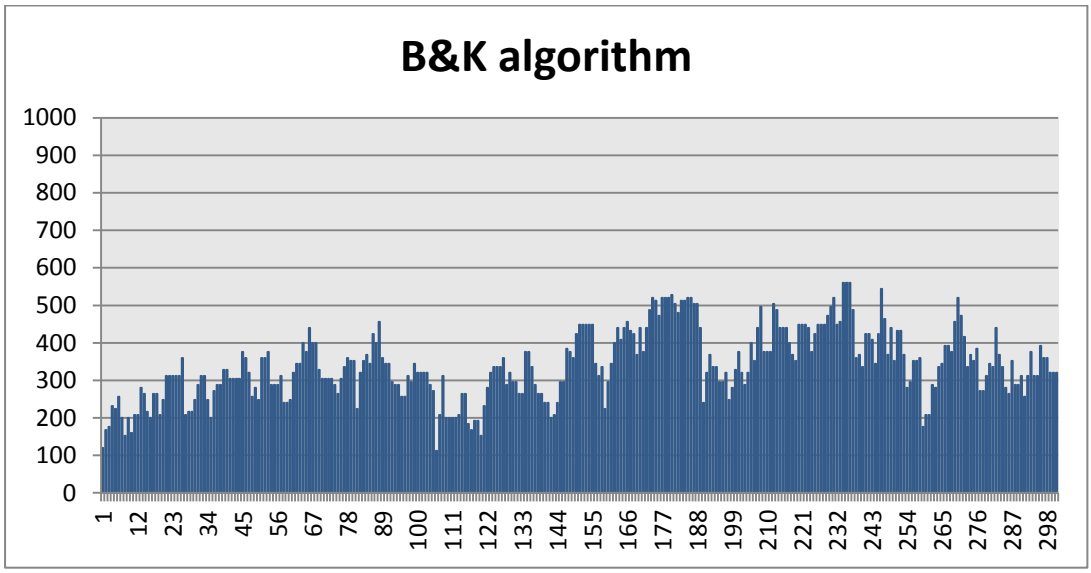

Figure 4.10 Resource number 5 usage profile leveled by B&K algorithm for instance E500_15_4_10

CHAPTER 5

CONCLUSION

Despite the importance of RLP in construction project management, there are limited studies focusing on evaluation of the resource leveling capabilities of commercial project management software packages. This research has taken an important step to fill this gap by providing extensive comparisons of leveling heuristics of commercial management software and revealed their limitations for the RLP.

The performance of commercial software packages including Microsoft Project Professional 2013 with standard priority, Primavera P6 Professional R8.3 with 8 different priorities and ASTA Powerproject V.12.5 with 4 different priorities were tested in this study for RLP. Moreover, the heuristic algorithm presented by Burgess and Killebrew (1962) (B&K) was included as an alternative method. A comprehensive problem set including 640 instances with up to 500 activities and 15 resource types which generated by RanGen random instance generator software (Demeulemeester et al., 2003) was used in performance tests.

Based on results shown in chapter 4, commercial software packages have inadequate performance for RLP in comparison with the B&K algorithm. Regardless of B&K method results, Microsoft Project Professional 2013 has the best results in most problems with various combinations for number of activities and resource types. However, for especially large problems including large number of resources, Microsoft Project Professional 2013 was very slow compared to the Primavera P6

Professional R8.3 (Table 4.2). According to Figure 4.5, Primavera P6 Professional R8.3 with late finish ascending (LF-A), total float ascending (TF-A) and late finish descending (LF-D) priorities have better results in comparison to the remaining heuristics.

Considering the results following recommendations can be given:

Small projects with low number of resource(s) (50 activities with up to 5 resources), should be leveled by MSP 2013. Medium and large size projects (100 to 500 activities), with small number of resource(s) are recommended to be optimized by Primavera P6, late finish ascending (LF-A) priority. Medium and large size projects (100 to 500 activities), with resources number (5 to 15) are suggested to level by MSP 2013. In case of leveling process duration which is a significant parameter, there is a big difference between MSP 2013 and Primavera P6 for instances with high number of activities and resource types. Hence, if the process time for leveling is considered as a critical parameter in planning phase, planners should apply total float descending (TF-D) and late finish descending (LF-D) priorities in Primavera P6 instead of MSP 2013.

Results have indicated that, the commercial construction project management software packages have limited capabilities in solving RLPs. Therefore development of new algorithms is essential in this area. Integration of more effective heuristic algorithms into software packages can help to improve RLP capabilities of software packages.

Data transferring between the software programs was one of the most time consuming activities during performance analysis of problem set instances. An urgent improvement is needed for having smoother, simpler and much accurate methods to data transfer among different project management software.

As a further study, RLP capabilities of commercial software can be tested by problem sets with higher number of activities and resource types. Indeed, almost all construction projects in practice have large number of activities and different resource types. Therefore, the leveling process time is become a very critical parameter. For example when a 500-activity project's leveling process lasts

approximately more than ten minutes in MSP 2013, it could be an impractical solution method.

Total float measurement can be added into future studies as an evaluation parameter in case of sensitivity analysis. Total float seems to have a significant role in leveling performance of algorithms. By increasing average number of total float per each activity, number of leveling options increases exponentially and takes more effort and time for leveling. Therefore, calculating average total float for each non-critical activity can be used as a parameter in further researches.

Moreover, evaluating commercial software packages capabilities for RLP with different objective function types such as overall or weighted daily total peak can be implemented in future studies.

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APPENDIX A

OBJECTIVE FUNCTION VALUES AND DEVIATIONS FOR EACH INSTANCE

Table A.1 Overload objective function values for 50-activity instances (1/4)

No.	Project name & performance	Early Start Objective Function	Upper Bound	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
				Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start	Multi	
1	*E50_1_1_1*	*709*	*45*	50	179	161	45	207	108	101	135	126	581	468	391	408	47
2	*E50_1_1_2*	*498*	*70*	76	247	258	109	225	186	195	100	279	385	476	411	401	70
3	*E50_1_1_3*	*830*	*31*	80	156	120	47	163	176	158	158	179	727	523	524	428	31
4	*E50_1_1_4*	*441*	*36*	41	221	204	81	219	193	193	193	200	300	227	314	314	36
5	*E50_1_1_5*	*262*	*42*	83	157	105	86	145	66	110	94	138	262	254	208	208	42
6	*E50_1_1_6*	*498*	*58*	74	254	214	190	343	228	256	179	291	466	439	244	219	58
7	*E50_1_1_7*	*491*	*43*	79	179	146	81	178	108	104	104	157	446	388	394	364	43
8	*E50_1_1_8*	*617*	*37*	63	146	115	42	121	118	146	133	119	494	411	367	272	37
9	*E50_1_1_9*	*529*	*30*	58	176	180	168	223	157	142	142	235	525	375	418	377	30
10	*E50_1_1_10*	*562*	*40*	67	110	204	68	199	205	182	144	191	560	513	314	320	40
11	*E50_1_2_1*	*491*	*56*	88	218	263	108	183	112	133	139	176	378	395	379	357	56
12	*E50_1_2_2*	*649*	*71*	99	210	252	122	251	179	242	191	290	600	450	439	411	71
13	*E50_1_2_3*	*392*	*49*	81	124	176	92	175	109	123	97	206	356	332	253	233	49
14	*E50_1_2_4*	*382*	*50*	135	120	167	163	229	159	213	145	204	290	326	311	324	50
15	*E50_1_2_5*	*258*	*56*	56	110	189	109	180	89	179	123	168	193	140	226	226	101
16	*E50_1_2_6*	*258*	*39*	62	119	142	105	174	80	130	79	175	166	112	84	85	39
17	*E50_1_2_7*	*496*	*45*	101	123	280	160	220	168	156	145	205	396	392	422	361	45
18	*E50_1_2_8*	*574*	*58*	73	256	164	132	191	161	164	96	178	547	425	482	381	58
19	*E50_1_2_9*	*395*	*23*	23	171	165	67	224	155	62	104	246	330	304	180	152	30
20	*E50_1_2_10*	*324*	*57*	118	143	106	85	155	73	188	128	196	294	353	263	263	57
21	*E50_1_3_1*	*275*	*51*	112	73	142	107	139	95	130	97	143	262	150	216	191	51
22	*E50_1_3_2*	*244*	*71*	81	176	106	138	189	80	158	134	177	203	202	236	165	71
23	*E50_1_3_3*	*602*	*59*	69	155	191	93	220	112	166	117	168	453	363	487	353	59
24	*E50_1_3_4*	*271*	*55*	55	100	137	68	123	97	123	70	146	262	224	216	226	106
25	*E50_1_3_5*	*244*	*89*	138	149	188	166	209	93	184	226	199	296	258	185	185	89
26	*E50_1_3_6*	*400*	*39*	47	98	126	52	47	65	86	86	157	287	159	136	168	39
27	*E50_1_3_7*	*373*	*80*	137	218	135	169	174	142	122	138	254	319	342	348	314	80
28	*E50_1_3_8*	*460*	*50*	50	167	145	145	165	122	207	156	201	440	400	321	321	69
29	*E50_1_3_9*	*298*	*35*	47	128	139	136	237	85	120	185	159	247	289	252	227	35
30	*E50_1_3_10*	*251*	*64*	165	125	165	131	155	134	129	133	161	226	244	227	236	64
31	*E50_1_4_1*	*250*	*41*	47	111	101	57	181	84	91	91	163	160	120	132	99	41
32	*E50_1_4_2*	*229*	*40*	104	95	110	78	164	65	90	100	103	239	243	265	250	40
33	*E50_1_4_3*	*299*	*47*	77	165	209	48	241	172	146	92	216	207	217	206	139	47
34	*E50_1_4_4*	*230*	*84*	119	116	128	84	188	101	142	161	155	218	155	234	164	124
35	*E50_1_4_5*	*218*	*67*	122	100	92	96	112	67	140	100	114	220	187	241	176	71
36	*E50_1_4_6*	*348*	*100*	125	193	227	159	262	151	168	100	249	258	315	275	275	103
37	*E50_1_4_7*	*306*	*72*	81	150	155	126	236	133	175	115	221	270	248	273	251	72
38	*E50_1_4_8*	*264*	*98*	135	158	161	140	147	116	144	175	149	254	232	273	231	98
39	*E50_1_4_9*	*211*	*72*	101	150	104	166	153	72	126	130	132	181	222	177	208	114
40	*E50_1_4_10*	*307*	*131*	179	204	175	201	199	131	176	185	195	277	304	349	350	219

Table A.2 Overload objective function deviations for 50-activity instances (1/4)

No.	Project name & performance	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
		Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
1	*E50_1_1_1*	11.1%	297.8%	257.8%	0.0%	360.0%	140.0%	124.4%	200.0%	180.0%	1191.1%	940.0%	768.9%	806.7%	4.4%
2	*E50_1_1_2*	8.6%	252.9%	268.6%	55.7%	221.4%	165.7%	178.6%	42.9%	298.6%	450.0%	580.0%	487.1%	472.9%	0.0%
3	*E50_1_1_3*	158.1%	403.2%	287.1%	51.6%	425.8%	467.7%	409.7%	409.7%	477.4%	2245.2%	1587.1%	1590.3%	1280.6%	0.0%
4	*E50_1_1_4*	13.9%	513.9%	466.7%	125.0%	508.3%	436.1%	436.1%	436.1%	455.6%	733.3%	530.6%	772.2%	772.2%	0.0%
5	*E50_1_1_5*	97.6%	273.8%	150.0%	104.8%	245.2%	57.1%	161.9%	123.8%	228.6%	523.8%	504.8%	395.2%	395.2%	0.0%
6	*E50_1_1_6*	27.6%	337.9%	269.0%	227.6%	491.4%	293.1%	341.4%	208.6%	401.7%	703.4%	656.9%	320.7%	277.6%	0.0%
7	*E50_1_1_7*	83.7%	316.3%	239.5%	88.4%	314.0%	151.2%	141.9%	141.9%	265.1%	937.2%	802.3%	816.3%	746.5%	0.0%
8	*E50_1_1_8*	70.3%	294.6%	210.8%	13.5%	227.0%	218.9%	294.6%	259.5%	221.6%	1235.1%	1010.8%	891.9%	635.1%	0.0%
9	*E50_1_1_9*	93.3%	486.7%	500.0%	460.0%	643.3%	423.3%	373.3%	373.3%	683.3%	1650.0%	1150.0%	1293.3%	1156.7%	0.0%
10	*E50_1_1_10*	67.5%	175.0%	410.0%	70.0%	397.5%	412.5%	355.0%	260.0%	377.5%	1300.0%	1182.5%	685.0%	700.0%	0.0%
11	*E50_1_2_1*	57.1%	289.3%	369.6%	92.9%	226.8%	100.0%	137.5%	148.2%	214.3%	575.0%	605.4%	576.8%	537.5%	0.0%
12	*E50_1_2_2*	39.4%	195.8%	254.9%	71.8%	253.5%	152.1%	240.8%	169.0%	308.5%	745.1%	533.8%	518.3%	478.9%	0.0%
13	*E50_1_2_3*	65.3%	153.1%	259.2%	87.8%	257.1%	122.4%	151.0%	98.0%	320.4%	626.5%	577.6%	416.3%	375.5%	0.0%
14	*E50_1_2_4*	170.0%	140.0%	234.0%	226.0%	358.0%	218.0%	326.0%	190.0%	308.0%	480.0%	552.0%	522.0%	548.0%	0.0%
15	*E50_1_2_5*	0.0%	96.4%	237.5%	94.6%	221.4%	58.9%	219.6%	119.6%	200.0%	244.6%	150.0%	303.6%	303.6%	80.4%
16	*E50_1_2_6*	59.0%	205.1%	264.1%	169.2%	346.2%	105.1%	233.3%	102.6%	348.7%	325.6%	187.2%	115.4%	117.9%	0.0%
17	*E50_1_2_7*	124.4%	173.3%	522.2%	255.6%	388.9%	273.3%	246.7%	222.2%	355.6%	780.0%	771.1%	837.8%	702.2%	0.0%
18	*E50_1_2_8*	25.9%	341.4%	182.8%	127.6%	229.3%	177.6%	182.8%	65.5%	206.9%	843.1%	632.8%	731.0%	556.9%	0.0%
19	*E50_1_2_9*	0.0%	643.5%	617.4%	191.3%	873.9%	573.9%	169.6%	352.2%	969.6%	1334.8%	1221.7%	682.6%	560.9%	30.4%
20	*E50_1_2_10*	107.0%	150.9%	86.0%	49.1%	171.9%	28.1%	229.8%	124.6%	243.9%	415.8%	519.3%	361.4%	361.4%	0.0%
21	*E50_1_3_1*	119.6%	43.1%	178.4%	109.8%	172.5%	86.3%	154.9%	90.2%	180.4%	413.7%	194.1%	323.5%	274.5%	0.0%
22	*E50_1_3_2*	14.1%	147.9%	49.3%	94.4%	166.2%	12.7%	122.5%	88.7%	149.3%	185.9%	184.5%	232.4%	132.4%	0.0%
23	*E50_1_3_3*	16.9%	162.7%	223.7%	57.6%	272.9%	89.8%	181.4%	98.3%	184.7%	667.8%	515.3%	725.4%	498.3%	0.0%
24	*E50_1_3_4*	0.0%	81.8%	149.1%	23.6%	123.6%	76.4%	123.6%	27.3%	165.5%	376.4%	307.3%	292.7%	310.9%	92.7%
25	*E50_1_3_5*	55.1%	67.4%	111.2%	86.5%	134.8%	4.5%	106.7%	153.9%	123.6%	232.6%	189.9%	107.9%	107.9%	0.0%
26	*E50_1_3_6*	20.5%	151.3%	223.1%	33.3%	20.5%	66.7%	120.5%	120.5%	302.6%	635.9%	307.7%	248.7%	330.8%	0.0%
27	*E50_1_3_7*	71.3%	172.5%	68.8%	111.3%	117.5%	77.5%	52.5%	72.5%	217.5%	298.8%	327.5%	335.0%	292.5%	0.0%
28	*E50_1_3_8*	0.0%	234.0%	190.0%	190.0%	230.0%	144.0%	314.0%	212.0%	302.0%	780.0%	700.0%	542.0%	542.0%	38.0%
29	*E50_1_3_9*	34.3%	265.7%	297.1%	288.6%	577.1%	142.9%	242.9%	428.6%	354.3%	605.7%	725.7%	620.0%	548.6%	0.0%
30	*E50_1_3_10*	157.8%	95.3%	157.8%	104.7%	142.2%	109.4%	101.6%	107.8%	151.6%	253.1%	281.3%	254.7%	268.8%	0.0%
31	*E50_1_4_1*	14.6%	170.7%	146.3%	39.0%	341.5%	104.9%	122.0%	122.0%	297.6%	290.2%	192.7%	222.0%	141.5%	0.0%
32	*E50_1_4_2*	160.0%	137.5%	175.0%	95.0%	310.0%	62.5%	125.0%	150.0%	157.5%	497.5%	507.5%	562.5%	525.0%	0.0%
33	*E50_1_4_3*	63.8%	251.1%	344.7%	2.1%	412.8%	266.0%	210.6%	95.7%	359.6%	340.4%	361.7%	338.3%	195.7%	0.0%
34	*E50_1_4_4*	41.7%	38.1%	52.4%	0.0%	123.8%	20.2%	69.0%	91.7%	84.5%	159.5%	84.5%	178.6%	95.2%	47.6%
35	*E50_1_4_5*	82.1%	49.3%	37.3%	43.3%	67.2%	0.0%	109.0%	49.3%	70.1%	228.4%	179.1%	259.7%	162.7%	6.0%
36	*E50_1_4_6*	25.0%	93.0%	127.0%	59.0%	162.0%	51.0%	68.0%	0.0%	149.0%	158.0%	215.0%	175.0%	175.0%	3.0%
37	*E50_1_4_7*	12.5%	108.3%	115.3%	75.0%	227.8%	84.7%	143.1%	59.7%	206.9%	275.0%	244.4%	279.2%	248.6%	0.0%
38	*E50_1_4_8*	37.8%	61.2%	64.3%	42.9%	50.0%	18.4%	46.9%	78.6%	52.0%	159.2%	136.7%	178.6%	135.7%	0.0%
39	*E50_1_4_9*	40.3%	108.3%	44.4%	130.6%	112.5%	0.0%	75.0%	80.6%	83.3%	151.4%	208.3%	145.8%	188.9%	58.3%
40	*E50_1_4_10*	36.6%	55.7%	33.6%	53.4%	51.9%	0.0%	34.4%	41.2%	48.9%	111.5%	132.1%	166.4%	167.2%	67.2%
	Average Deviatian	57.1%	205.9%	221.9%	105.1%	274.4%	149.8%	186.9%	155.4%	267.7%	604.0%	517.3%	481.9%	428.2%	10.7%

Table A.3 Overload objective function values for 50-activity instances (2/4)

No.	Project name & performance	Early Start Objective Function	Upper Bound	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
				Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start	Multi	
1	*E50_5_1_1*	*2141*	*352*	575	821	812	628	810	600	1044	716	599	1738	1779	1321	1477	352
2	*E50_5_1_2*	*1195*	*340*	441	595	690	701	576	509	561	637	776	800	1047	760	643	340
3	*E50_5_1_3*	*1859*	*301*	413	579	690	468	771	775	450	546	673	1565	1456	1377	1274	301
4	*E50_5_1_4*	*2057*	*326*	523	896	615	462	670	756	769	512	939	1742	1700	979	1060	326
5	*E50_5_1_5*	*2132*	*399*	469	654	716	438	653	536	670	584	585	1769	1543	1681	1301	399
6	*E50_5_1_6*	*1606*	*398*	467	502	654	452	569	799	536	451	686	1470	1229	1124	913	398
7	*E50_5_1_7*	*2180*	*420*	523	643	747	691	805	785	721	516	685	1791	1604	990	1081	420
8	*E50_5_1_8*	*2671*	*356*	499	664	968	534	689	948	1026	765	871	1922	1833	1541	1520	356
9	*E50_5_1_9*	*2415*	*284*	481	614	577	502	580	572	710	444	578	1760	1971	1439	1308	284
10	*E50_5_1_10*	*2435*	*280*	401	832	722	434	872	436	508	517	743	2196	1859	1822	1530	280
11	*E50_5_2_1*	*1856*	*406*	468	557	628	926	734	713	1100	488	785	1359	1020	1319	838	406
12	*E50_5_2_2*	*2157*	*414*	564	610	735	543	683	573	581	602	645	1476	1424	1352	1256	414
13	*E50_5_2_3*	*2424*	*338*	522	686	1041	530	903	610	759	753	706	1427	1968	1670	1392	338
14	*E50_5_2_4*	*1604*	*454*	654	764	691	578	733	876	883	801	610	1217	974	1160	1006	454
15	*E50_5_2_5*	*2756*	*441*	583	729	661	560	575	549	599	774	665	2169	1930	1825	1595	441
16	*E50_5_2_6*	*1902*	*350*	480	583	982	422	702	587	726	492	800	1183	1709	1433	973	350
17	*E50_5_2_7*	*1537*	*383*	678	597	736	413	754	658	654	830	705	1098	1252	1130	997	383
18	*E50_5_2_8*	*2690*	*509*	525	646	763	615	699	660	717	571	716	1963	1821	1382	1295	509
19	*E50_5_2_9*	*1454*	*544*	679	813	803	840	850	903	791	762	743	1117	898	1042	696	544
20	*E50_5_2_10*	*2009*	*463*	475	637	692	486	613	767	650	831	816	1858	1729	1542	1513	463
21	*E50_5_3_1*	*1422*	*514*	550	514	669	708	690	1024	828	889	771	1008	905	1016	1117	623
22	*E50_5_3_2*	*1451*	*495*	560	692	691	630	1071	899	985	585	913	1316	1312	1209	1141	495
23	*E50_5_3_3*	*1333*	*389*	575	543	722	559	887	645	684	729	870	875	959	949	895	389
24	*E50_5_3_4*	*1629*	*596*	596	693	727	612	797	636	799	745	729	1326	1528	1258	1279	645
25	*E50_5_3_5*	*1383*	*453*	453	533	728	566	713	822	581	704	605	1059	1244	1144	1240	485
26	*E50_5_3_6*	*1967*	*467*	514	618	647	516	1009	658	782	563	985	1400	1303	1506	1473	467
27	*E50_5_3_7*	*1302*	*429*	513	887	758	630	851	540	836	555	740	988	1004	1000	865	429
28	*E50_5_3_8*	*1476*	*613*	613	707	849	704	835	725	636	698	796	1219	1079	1283	1239	633
29	*E50_5_3_9*	*1806*	*599*	704	871	1130	773	1025	721	1141	817	1089	1317	1254	1126	1041	599
30	*E50_5_3_10*	*1925*	*605*	726	826	692	639	962	828	695	610	1015	1076	920	1315	853	605
31	*E50_5_4_1*	*1713*	*549*	622	796	1047	914	1143	768	872	651	1116	954	1338	1208	858	549
32	*E50_5_4_2*	*1480*	*490*	669	677	866	521	880	748	565	674	957	1286	1209	1189	1159	490
33	*E50_5_4_3*	*1258*	*565*	574	739	600	565	762	764	600	674	780	1111	865	1026	916	589
34	*E50_5_4_4*	*1756*	*659*	659	797	873	749	787	899	839	991	768	1240	1413	1250	1015	758
35	*E50_5_4_5*	*2196*	*549*	708	814	722	651	688	706	785	673	635	1449	1517	1131	1085	549
36	*E50_5_4_6*	*1532*	*566*	634	724	724	713	929	764	773	733	911	1007	937	1012	934	566
37	*E50_5_4_7*	*1450*	*640*	640	674	683	643	698	757	756	745	760	1204	1216	1270	1195	742
38	*E50_5_4_8*	*1098*	*452*	452	634	680	633	801	557	807	652	724	1026	984	981	1082	516
39	*E50_5_4_9*	*983*	*393*	532	901	907	633	735	569	704	955	874	904	920	986	765	393
40	*E50_5_4_10*	*1036*	*498*	604	692	553	609	803	756	523	644	872	848	765	887	787	498

Table A.4 Overload objective function deviations for 50-activity instances (2/4)

No.	Project name & performance	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
		Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
1	*E50_5_1_1*	63.4%	133.2%	130.7%	78.4%	130.1%	70.5%	196.6%	103.4%	70.2%	393.8%	405.4%	275.3%	319.6%	0.0%
2	*E50_5_1_2*	29.7%	75.0%	102.9%	106.2%	69.4%	49.7%	65.0%	87.4%	128.2%	135.3%	207.9%	123.5%	89.1%	0.0%
3	*E50_5_1_3*	37.2%	92.4%	129.2%	55.5%	156.1%	157.5%	49.5%	81.4%	123.6%	419.9%	383.7%	357.5%	323.3%	0.0%
4	*E50_5_1_4*	60.4%	174.8%	88.7%	41.7%	105.5%	131.9%	135.9%	57.1%	188.0%	434.4%	421.5%	200.3%	225.2%	0.0%
5	*E50_5_1_5*	17.5%	63.9%	79.4%	9.8%	63.7%	34.3%	67.9%	46.4%	46.6%	343.4%	286.7%	321.3%	226.1%	0.0%
6	*E50_5_1_6*	17.3%	26.1%	64.3%	13.6%	43.0%	100.8%	34.7%	13.3%	72.4%	269.3%	208.8%	182.4%	129.4%	0.0%
7	*E50_5_1_7*	24.5%	53.1%	77.9%	64.5%	91.7%	86.9%	71.7%	22.9%	63.1%	326.4%	281.9%	135.7%	157.4%	0.0%
8	*E50_5_1_8*	40.2%	86.5%	171.9%	50.0%	93.5%	166.3%	188.2%	114.9%	144.7%	439.9%	414.9%	332.9%	327.0%	0.0%
9	*E50_5_1_9*	69.4%	116.2%	103.2%	76.8%	104.2%	101.4%	150.0%	56.3%	103.5%	519.7%	594.0%	406.7%	360.6%	0.0%
10	*E50_5_1_10*	43.2%	197.1%	157.9%	55.0%	211.4%	55.7%	81.4%	84.6%	165.4%	684.3%	563.9%	550.7%	446.4%	0.0%
11	*E50_5_2_1*	15.3%	37.2%	54.7%	128.1%	80.8%	75.6%	170.9%	20.2%	93.3%	234.7%	151.2%	224.9%	106.4%	0.0%
12	*E50_5_2_2*	36.2%	47.3%	77.5%	31.2%	65.0%	38.4%	40.3%	45.4%	55.8%	256.5%	244.0%	226.6%	203.4%	0.0%
13	*E50_5_2_3*	54.4%	103.0%	208.0%	56.8%	167.2%	80.5%	124.6%	122.8%	108.9%	322.2%	482.2%	394.1%	311.8%	0.0%
14	*E50_5_2_4*	44.1%	68.3%	52.2%	27.3%	61.5%	93.0%	94.5%	76.4%	34.4%	168.1%	114.5%	155.5%	121.6%	0.0%
15	*E50_5_2_5*	32.2%	65.3%	49.9%	27.0%	30.4%	24.5%	35.8%	75.5%	50.8%	391.8%	337.6%	313.8%	261.7%	0.0%
16	*E50_5_2_6*	37.1%	66.6%	180.6%	20.6%	100.6%	67.7%	107.4%	40.6%	128.6%	238.0%	388.3%	309.4%	178.0%	0.0%
17	*E50_5_2_7*	77.0%	55.9%	92.2%	7.8%	96.9%	71.8%	70.8%	116.7%	84.1%	186.7%	226.9%	195.0%	160.3%	0.0%
18	*E50_5_2_8*	3.1%	26.9%	49.9%	20.8%	37.3%	29.7%	40.9%	12.2%	40.7%	285.7%	257.8%	171.5%	154.4%	0.0%
19	*E50_5_2_9*	24.8%	49.4%	47.6%	54.4%	56.3%	66.0%	45.4%	40.1%	36.6%	105.3%	65.1%	91.5%	27.9%	0.0%
20	*E50_5_2_10*	2.6%	37.6%	49.5%	5.0%	32.4%	65.7%	40.4%	79.5%	76.2%	301.3%	273.4%	233.0%	226.8%	0.0%
21	*E50_5_3_1*	7.0%	0.0%	30.2%	37.7%	34.2%	99.2%	61.1%	73.0%	50.0%	96.1%	76.1%	97.7%	117.3%	21.2%
22	*E50_5_3_2*	13.1%	39.8%	39.6%	27.3%	116.4%	81.6%	99.0%	18.2%	84.4%	165.9%	165.1%	144.2%	130.5%	0.0%
23	*E50_5_3_3*	47.8%	39.6%	85.6%	43.7%	128.0%	65.8%	75.8%	87.4%	123.7%	124.9%	146.5%	144.0%	130.1%	0.0%
24	*E50_5_3_4*	0.0%	16.3%	22.0%	2.7%	33.7%	6.7%	34.1%	25.0%	22.3%	122.5%	156.4%	111.1%	114.6%	8.2%
25	*E50_5_3_5*	0.0%	17.7%	60.7%	24.9%	57.4%	81.5%	28.3%	55.4%	33.6%	133.8%	174.6%	152.5%	173.7%	7.1%
26	*E50_5_3_6*	10.1%	32.3%	38.5%	10.5%	116.1%	40.9%	67.5%	20.6%	110.9%	199.8%	179.0%	222.5%	215.4%	0.0%
27	*E50_5_3_7*	19.6%	106.8%	76.7%	46.9%	98.4%	25.9%	94.9%	29.4%	72.5%	130.3%	134.0%	133.1%	101.6%	0.0%
28	*E50_5_3_8*	0.0%	15.3%	38.5%	14.8%	36.2%	18.3%	3.8%	13.9%	29.9%	98.9%	76.0%	109.3%	102.1%	3.3%
29	*E50_5_3_9*	17.5%	45.4%	88.6%	29.0%	71.1%	20.4%	90.5%	36.4%	81.8%	119.9%	109.3%	88.0%	73.8%	0.0%
30	*E50_5_3_10*	20.0%	36.5%	14.4%	5.6%	59.0%	36.9%	14.9%	0.8%	67.8%	77.9%	52.1%	117.4%	41.0%	0.0%
31	*E50_5_4_1*	13.3%	45.0%	90.7%	66.5%	108.2%	39.9%	58.8%	18.6%	103.3%	73.8%	143.7%	120.0%	56.3%	0.0%
32	*E50_5_4_2*	36.5%	38.2%	76.7%	6.3%	79.6%	52.7%	15.3%	37.6%	95.3%	162.4%	146.7%	142.7%	136.5%	0.0%
33	*E50_5_4_3*	1.6%	30.8%	6.2%	0.0%	34.9%	35.2%	6.2%	19.3%	38.1%	96.6%	53.1%	81.6%	62.1%	4.2%
34	*E50_5_4_4*	0.0%	20.9%	32.5%	13.7%	19.4%	36.4%	27.3%	50.4%	16.5%	88.2%	114.4%	89.7%	54.0%	15.0%
35	*E50_5_4_5*	29.0%	48.3%	31.5%	18.6%	25.3%	28.6%	43.0%	22.6%	15.7%	163.9%	176.3%	106.0%	97.6%	0.0%
36	*E50_5_4_6*	12.0%	27.9%	27.9%	26.0%	64.1%	35.0%	36.6%	29.5%	61.0%	77.9%	65.5%	78.8%	65.0%	0.0%
37	*E50_5_4_7*	0.0%	5.3%	6.7%	0.5%	9.1%	18.3%	18.1%	16.4%	18.8%	88.1%	90.0%	98.4%	86.7%	15.9%
38	*E50_5_4_8*	0.0%	40.3%	50.4%	40.0%	77.2%	23.2%	78.5%	44.2%	60.2%	127.0%	117.7%	117.0%	139.4%	14.2%
39	*E50_5_4_9*	35.4%	129.3%	130.8%	61.1%	87.0%	44.8%	79.1%	143.0%	122.4%	130.0%	134.1%	150.9%	94.7%	0.0%
40	*E50_5_4_10*	21.3%	39.0%	11.0%	22.3%	61.2%	51.8%	5.0%	29.3%	75.1%	70.3%	53.6%	78.1%	58.0%	0.0%
	Average Deviatian	25.3%	58.8%	73.2%	35.7%	77.8%	60.3%	68.7%	51.7%	77.4%	220.1%	216.9%	189.6%	160.2%	2.2%

Table A.5 Overload objective function values for 50-activity instances (3/4)

No.	Project name & performance	Early Start Objective Function	Upper Bound	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
				Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start	Multi	
1	*E50_10_1_1*	*7334*	*780*	3008	1831	1458	1089	2071	1617	1463	1475	2341	6101	5848	4790	4408	780
2	*E50_10_1_2*	*7305*	*783*	2135	1494	1823	1180	1593	1195	1511	1684	1421	6054	4126	3963	2674	783
3	*E50_10_1_3*	*6358*	*812*	2316	1286	1402	1099	1246	1266	1091	1221	1064	4878	3962	4956	3052	812
4	*E50_10_1_4*	*5568*	*792*	2084	1195	1312	906	1829	1495	1140	1240	1729	5400	5036	3367	2937	792
5	*E50_10_1_5*	*7468*	*1003*	1741	1673	1319	1283	1439	1043	1603	1754	1238	7106	4580	4580	2451	1003
6	*E50_10_1_6*	*5746*	*717*	2905	1339	1241	949	1343	1547	1426	1271	1686	4103	4442	4455	3360	717
7	*E50_10_1_7*	*3868*	*666*	1676	1575	1279	915	1239	1445	1372	1158	1423	3089	2871	2871	2871	666
8	*E50_10_1_8*	*4698*	*750*	1668	1284	1385	911	1405	1554	1409	1420	1320	3833	3394	1929	1549	750
9	*E50_10_1_9*	*5861*	*799*	1457	1315	1252	843	1315	1348	1664	1330	1229	4836	4826	2763	2277	799
10	*E50_10_1_10*	*5745*	*686*	1868	2000	1089	1100	1148	1922	1464	1117	1397	5163	4070	3405	2731	686
11	*E50_10_2_1*	*4040*	*1103*	1224	1372	1594	1363	1558	2207	1658	1421	1812	2592	1958	2549	2446	1103
12	*E50_10_2_2*	*4423*	*925*	1745	1143	1307	1727	1272	1399	1599	1450	1265	3264	2791	2304	2151	925
13	*E50_10_2_3*	*2590*	*798*	1092	1194	1241	1225	1044	1004	1453	1168	1178	1789	1891	1960	1732	798
14	*E50_10_2_4*	*3230*	*932*	1252	1392	1489	962	1585	1535	1216	1232	1760	2219	1976	1956	1727	932
15	*E50_10_2_5*	*3267*	*770*	1141	1273	959	770	1198	1219	1220	1242	1000	2243	1454	1845	1445	786
16	*E50_10_2_6*	*4338*	*1015*	1372	1508	2051	1156	1689	1395	1353	1042	1483	3161	3113	2615	2623	1015
17	*E50_10_2_7*	*2625*	*793*	1409	1414	1162	1103	1367	1291	1599	1320	1424	1464	1574	1488	1343	793
18	*E50_10_2_8*	*3131*	*890*	1101	1330	1396	1201	1381	1399	1631	1224	1028	1953	1573	1828	1530	890
19	*E50_10_2_9*	*4813*	*1276*	1867	1565	1897	1618	1549	2068	2074	1963	1820	2591	2988	1607	1709	1276
20	*E50_10_2_10*	*3941*	*860*	1612	1127	1294	1296	1517	1893	1950	1286	1540	1986	2843	2104	1779	860
21	*E50_10_3_1*	*3416*	*1357*	1548	1462	1497	1397	1902	1737	1402	1650	1452	1660	1770	1657	1696	1357
22	*E50_10_3_2*	*3180*	*1194*	1393	1842	1971	1356	1849	1952	1457	1382	1718	2527	2295	1800	1620	1194
23	*E50_10_3_3*	*4040*	*1190*	1570	1545	1488	2084	1568	1931	2151	1772	1682	1884	2769	1760	1943	1190
24	*E50_10_3_4*	*3635*	*1197*	1244	1727	1285	1197	1669	1732	1585	1729	1379	2117	2183	2212	2105	1227
25	*E50_10_3_5*	*3477*	*1089*	1274	1467	1672	1520	1402	2142	1388	1433	1513	1962	2149	2035	2041	1089
26	*E50_10_3_6*	*2234*	*942*	1293	1663	1499	1202	1297	1423	1495	1183	1439	1692	1618	1903	1629	942
27	*E50_10_3_7*	*3348*	*1115*	1132	1363	1570	1331	1653	1791	1512	1307	1377	2047	1969	1788	1757	1115
28	*E50_10_3_8*	*2615*	*1115*	1157	1416	1533	1369	1700	1637	1371	1521	1115	1801	2020	2238	1812	1355
29	*E50_10_3_9*	*3056*	*1154*	1519	1768	1154	1724	1470	2249	2077	1807	1551	1781	2238	1711	1581	1182
30	*E50_10_3_10*	*4615*	*979*	1380	1593	1991	1282	2137	1246	1703	1409	1687	3163	3016	2807	2525	979
31	*E50_10_4_1*	*3349*	*1253*	1399	1783	2016	1599	2107	1846	1553	1704	2185	2290	1880	2330	1990	1253
32	*E50_10_4_2*	*3171*	*1172*	1583	1732	1611	1432	2140	1614	1700	1659	1893	1846	2109	1800	1682	1172
33	*E50_10_4_3*	*3045*	*1084*	1084	1510	1548	1253	1568	1347	1436	1592	1539	1840	1794	1477	1458	1159
34	*E50_10_4_4*	*2715*	*1254*	1500	1594	1501	1633	1607	1530	1801	1578	1753	1505	1479	1486	1513	1254
35	*E50_10_4_5*	*2911*	*1354*	1546	1448	1837	1399	1581	1742	1685	1481	1490	1820	2488	1890	1916	1354
36	*E50_10_4_6*	*2543*	*1059*	1545	1614	1487	1460	1465	1372	1563	1742	1413	1732	1564	1299	1359	1059
37	*E50_10_4_7*	*2924*	*1142*	1167	1877	1560	1303	1928	1519	1711	1612	1613	1463	2092	1743	1757	1142
38	*E50_10_4_8*	*2566*	*1006*	1218	1453	1538	1380	1497	1567	1523	1414	1876	1461	1856	2048	2048	1006
39	*E50_10_4_9*	*3355*	*1420*	1420	1985	1902	2032	1617	1760	1579	1979	1527	1808	2192	1946	2631	1791
40	*E50_10_4_10*	*3038*	*1169*	1169	1791	1681	1409	1491	1803	1514	1636	1388	1904	2353	1809	1938	1302

Table A.6 Overload objective function deviations for 50-activity instances (3/4)

No.	Project name & performance	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
		Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
1	*E50_10_1_1*	285.6%	134.7%	86.9%	39.6%	165.5%	107.3%	87.6%	89.1%	200.1%	682.2%	649.7%	514.1%	465.1%	0.0%
2	*E50_10_1_2*	172.7%	90.8%	132.8%	50.7%	103.4%	52.6%	93.0%	115.1%	81.5%	673.2%	426.9%	406.1%	241.5%	0.0%
3	*E50_10_1_3*	185.2%	58.4%	72.7%	35.3%	53.4%	55.9%	34.4%	50.4%	31.0%	500.7%	387.9%	510.3%	275.9%	0.0%
4	*E50_10_1_4*	163.1%	50.9%	65.7%	14.4%	130.9%	88.8%	43.9%	56.6%	118.3%	581.8%	535.9%	325.1%	270.8%	0.0%
5	*E50_10_1_5*	73.6%	66.8%	31.5%	27.9%	43.5%	4.0%	59.8%	74.9%	23.4%	608.5%	356.6%	356.6%	144.4%	0.0%
6	*E50_10_1_6*	305.2%	86.8%	73.1%	32.4%	87.3%	115.8%	98.9%	77.3%	135.1%	472.2%	519.5%	521.3%	368.6%	0.0%
7	*E50_10_1_7*	151.7%	136.5%	92.0%	37.4%	86.0%	117.0%	106.0%	73.9%	113.7%	363.8%	331.1%	331.1%	331.1%	0.0%
8	*E50_10_1_8*	122.4%	71.2%	84.7%	21.5%	87.3%	107.2%	87.9%	89.3%	76.0%	411.1%	352.5%	157.2%	106.5%	0.0%
9	*E50_10_1_9*	82.4%	64.6%	56.7%	5.5%	64.6%	68.7%	108.3%	66.5%	53.8%	505.3%	504.0%	245.8%	185.0%	0.0%
10	*E50_10_1_10*	172.3%	191.5%	58.7%	60.3%	67.3%	180.2%	113.4%	62.8%	103.6%	652.6%	493.3%	396.4%	298.1%	0.0%
11	*E50_10_2_1*	11.0%	24.4%	44.5%	23.6%	41.3%	100.1%	50.3%	28.8%	64.3%	135.0%	77.5%	131.1%	121.8%	0.0%
12	*E50_10_2_2*	88.6%	23.6%	41.3%	86.7%	37.5%	51.2%	72.9%	56.8%	36.8%	252.9%	201.7%	149.1%	132.5%	0.0%
13	*E50_10_2_3*	36.8%	49.6%	55.5%	53.5%	30.8%	25.8%	82.1%	46.4%	47.6%	137.0%	145.6%	117.0%	117.0%	0.0%
14	*E50_10_2_4*	34.3%	49.4%	59.8%	3.2%	70.1%	64.7%	30.5%	32.2%	88.8%	138.1%	112.0%	109.9%	85.3%	0.0%
15	*E50_10_2_5*	48.2%	65.3%	24.5%	0.0%	55.6%	58.3%	58.4%	61.3%	29.9%	191.3%	88.8%	139.6%	87.7%	2.1%
16	*E50_10_2_6*	35.2%	48.6%	102.1%	13.9%	66.4%	37.4%	33.3%	2.7%	46.1%	211.4%	206.7%	157.6%	158.4%	0.0%
17	*E50_10_2_7*	77.7%	78.3%	46.5%	39.1%	72.4%	62.8%	101.6%	66.5%	79.6%	84.6%	98.5%	87.6%	69.4%	0.0%
18	*E50_10_2_8*	23.7%	49.4%	56.9%	34.9%	55.2%	57.2%	83.3%	37.5%	15.5%	119.4%	76.7%	105.4%	71.9%	0.0%
19	*E50_10_2_9*	46.3%	22.6%	48.7%	26.8%	21.4%	62.1%	62.5%	53.8%	42.6%	103.1%	134.2%	25.9%	33.9%	0.0%
20	*E50_10_2_10*	87.4%	31.0%	50.5%	50.7%	76.4%	120.1%	126.7%	49.5%	79.1%	130.9%	230.6%	144.7%	106.9%	0.0%
21	*E50_10_3_1*	14.1%	7.7%	10.3%	2.9%	40.2%	28.0%	3.3%	21.6%	7.0%	22.3%	30.4%	22.1%	25.0%	0.0%
22	*E50_10_3_2*	16.7%	54.3%	65.1%	13.6%	54.9%	63.5%	22.0%	15.7%	43.9%	111.6%	92.2%	50.8%	35.7%	0.0%
23	*E50_10_3_3*	31.9%	29.8%	25.0%	75.1%	31.8%	62.3%	80.8%	48.9%	41.3%	58.3%	132.7%	47.9%	63.3%	0.0%
24	*E50_10_3_4*	3.9%	44.3%	7.4%	0.0%	39.4%	44.7%	32.4%	44.4%	15.2%	76.9%	82.4%	84.8%	75.9%	2.5%
25	*E50_10_3_5*	17.0%	34.7%	53.5%	39.6%	28.7%	96.7%	27.5%	31.6%	38.9%	80.2%	97.3%	86.9%	87.4%	0.0%
26	*E50_10_3_6*	37.3%	76.5%	59.1%	27.6%	37.7%	51.1%	58.7%	25.6%	52.8%	79.6%	71.8%	102.0%	72.9%	0.0%
27	*E50_10_3_7*	1.5%	22.2%	40.8%	19.4%	48.3%	60.6%	35.6%	17.2%	23.5%	83.6%	76.6%	60.4%	57.6%	0.0%
28	*E50_10_3_8*	3.8%	27.0%	37.5%	22.8%	52.5%	46.8%	23.0%	36.4%	0.0%	61.5%	81.2%	100.7%	62.5%	21.5%
29	*E50_10_3_9*	31.6%	53.2%	0.0%	49.4%	27.4%	94.9%	80.0%	56.6%	34.4%	54.3%	93.9%	48.3%	37.0%	2.4%
30	*E50_10_3_10*	41.0%	62.7%	103.4%	30.9%	118.3%	27.3%	74.0%	43.9%	72.3%	223.1%	208.1%	186.7%	157.9%	0.0%
31	*E50_10_4_1*	11.7%	42.3%	60.9%	27.6%	68.2%	47.3%	23.9%	36.0%	74.4%	82.8%	50.0%	86.0%	58.8%	0.0%
32	*E50_10_4_2*	35.1%	47.8%	37.5%	22.2%	82.6%	37.7%	45.1%	41.6%	61.5%	57.5%	79.9%	53.6%	43.5%	0.0%
33	*E50_10_4_3*	0.0%	39.3%	42.8%	15.6%	44.6%	24.3%	32.5%	46.9%	42.0%	69.7%	65.5%	36.3%	34.5%	6.9%
34	*E50_10_4_4*	19.6%	27.1%	19.7%	30.2%	28.1%	22.0%	43.6%	25.8%	39.8%	20.0%	17.9%	18.5%	20.7%	0.0%
35	*E50_10_4_5*	14.2%	6.9%	35.7%	3.3%	16.8%	28.7%	24.4%	9.4%	10.0%	34.4%	83.8%	39.6%	41.5%	0.0%
36	*E50_10_4_6*	45.9%	52.4%	40.4%	37.9%	38.3%	29.6%	47.6%	64.5%	33.4%	63.6%	47.7%	22.7%	28.3%	0.0%
37	*E50_10_4_7*	2.2%	64.4%	36.6%	14.1%	68.8%	33.0%	49.8%	41.2%	41.2%	28.1%	83.2%	52.6%	53.9%	0.0%
38	*E50_10_4_8*	21.1%	44.4%	52.9%	37.2%	48.8%	55.8%	51.4%	40.6%	86.5%	45.2%	84.5%	103.6%	103.6%	0.0%
39	*E50_10_4_9*	0.0%	39.8%	33.9%	43.1%	13.9%	23.9%	11.2%	39.4%	7.5%	27.3%	54.4%	37.0%	85.3%	26.1%
40	*E50_10_4_10*	0.0%	53.2%	43.8%	20.5%	27.5%	54.2%	29.5%	39.9%	18.7%	62.9%	101.3%	54.7%	65.8%	11.4%
	Average Deviatian	63.8%	55.6%	52.3%	29.8%	58.3%	61.7%	58.3%	48.0%	55.3%	207.5%	189.1%	155.7%	122.1%	1.8%

Table A.7 Overload objective function values for 50-activity instances (4/4)

No.	Project name & performance	Early Start Objective Function	Upper Bound	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
				Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start	Multi	
1	*E50_15_1_1*	*6352*	*1512*	2137	2215	1938	2127	2368	2702	2135	2003	1811	2244	2363	2764	2604	1512
2	*E50_15_1_2*	*4725*	*1135*	2543	2208	2065	1966	2125	2533	1595	1547	1906	3548	2364	2755	2399	1135
3	*E50_15_1_3*	*4321*	*1202*	2426	2060	2597	1614	2029	2317	2057	1591	1818	2814	2318	2288	1862	1202
4	*E50_15_1_4*	*8344*	*1393*	4597	1999	1913	1817	1922	2010	2529	2403	1704	7019	7199	4618	4182	1393
5	*E50_15_1_5*	*11435*	*1442*	5562	1984	2169	1765	2531	2203	2083	2727	1760	8472	7759	6663	3546	1442
6	*E50_15_1_6*	*9004*	*1535*	2941	2357	1837	3046	2087	3022	2888	2894	2102	7732	5225	6547	5055	1535
7	*E50_15_1_7*	*8583*	*1556*	4013	1984	3134	1852	1935	2581	2545	2706	2120	6525	6008	4553	3253	1556
8	*E50_15_1_8*	*10400*	*1472*	6198	2462	2188	1554	2191	2832	2280	2280	2690	8641	4613	6941	4025	1472
9	*E50_15_1_9*	*10229*	*1634*	3753	2104	2429	2129	2556	2373	3057	3485	2156	8618	6323	4289	3003	1634
10	*E50_15_1_10*	*4601*	*1070*	2041	1535	2498	1848	1342	1750	1685	1588	1910	3162	2698	2252	1837	1070
11	*E50_15_2_1*	*4911*	*1601*	2333	2046	2582	1867	2306	2396	2323	1921	2164	2657	2788	2255	2093	1601
12	*E50_15_2_2*	*4202*	*1559*	1964	2306	2058	1906	2411	2065	2074	1879	1996	3176	2166	3115	2485	1559
13	*E50_15_2_3*	*3860*	*1411*	2410	2624	1556	1781	2395	2318	2114	1767	1989	1995	3068	2206	1925	1411
14	*E50_15_2_4*	*7345*	*1677*	2600	2245	2575	3215	3038	2887	2659	2709	2842	4743	3932	3101	2432	1677
15	*E50_15_2_5*	*4910*	*1231*	2124	1666	2516	2069	1942	2260	2003	1788	1855	3058	2846	2732	2459	1231
16	*E50_15_2_6*	*6275*	*1361*	2710	1729	1598	1667	1679	1895	1656	1809	1665	4581	4754	2808	2588	1361
17	*E50_15_2_7*	*5780*	*1534*	2424	2357	2174	2526	2278	3675	2754	2217	2046	2709	2728	2840	2547	1534
18	*E50_15_2_8*	*5581*	*1843*	2435	2463	2367	2539	2318	3379	2541	3016	2317	3205	2847	2647	2664	1843
19	*E50_15_2_9*	*6202*	*1215*	2041	1885	2007	1817	1899	1801	1879	2604	1715	3471	3739	4410	3070	1215
20	*E50_15_2_10*	*4669*	*1547*	2453	2721	2155	3053	2164	2715	2421	2705	2050	3812	2818	2053	1907	1547
21	*E50_15_3_1*	*3605*	*1493*	1493	2061	2225	2279	1885	2478	2157	2260	2010	2530	2239	2719	2459	1674
22	*E50_15_3_2*	*4038*	*1700*	2116	1700	2472	2190	2229	2115	2258	2433	2237	2642	2084	2376	2192	1779
23	*E50_15_3_3*	*4468*	*1884*	1884	2914	2510	2146	2416	2469	2250	2572	2526	3700	3741	3465	3054	1997
24	*E50_15_3_4*	*5968*	*1558*	2538	2675	2168	2106	2184	3238	2029	2087	2231	2878	3025	2526	2556	1558
25	*E50_15_3_5*	*4420*	*1714*	2468	2333	2283	2338	1717	2196	2039	2690	1925	2250	2629	2560	2496	1714
26	*E50_15_3_6*	*3409*	*1379*	1613	2019	1757	1379	1942	1734	1993	1627	1566	2386	2380	1912	1912	1441
27	*E50_15_3_7*	*3847*	*1617*	1792	1769	1944	1690	1878	2176	1957	1645	2217	2123	2670	2577	2190	1617
28	*E50_15_3_8*	*7165*	*1885*	1909	1920	2366	2043	1978	2440	2493	2413	2008	3668	3502	4497	3372	1885
29	*E50_15_3_9*	*3143*	*1515*	2103	1604	2402	1788	1581	2112	2309	2002	2185	3163	2057	2456	2471	1515
30	*E50_15_3_10*	*6537*	*2312*	2477	3386	3085	2395	2312	3557	2689	2779	2657	4224	4613	3251	3793	2493
31	*E50_15_4_1*	*7763*	*1098*	3803	2200	2480	1390	1850	2315	2303	2304	2224	6549	7031	3814	3419	1098
32	*E50_15_4_2*	*4892*	*1696*	1696	2169	1947	2512	2700	2253	3135	2049	2399	3081	2714	3134	3043	1742
33	*E50_15_4_3*	*6756*	*1750*	2340	3109	3277	3463	2512	2340	2889	2198	2602	3662	4164	4166	3646	1750
34	*E50_15_4_4*	*3413*	*1627*	1627	2303	2428	2118	2255	2860	2185	2317	2237	2543	2648	2400	2214	1768
35	*E50_15_4_5*	*4110*	*1561*	2120	2423	2222	2279	1987	2159	2055	1989	2073	2629	2716	2640	2945	1561
36	*E50_15_4_6*	*9189*	*1324*	4678	1504	1932	1631	1444	1836	2412	1843	1701	6335	7928	4532	3729	1324
37	*E50_15_4_7*	*5277*	*1664*	2692	2409	2760	2411	2650	2376	2297	2239	2458	3327	2342	2825	2530	1664
38	*E50_15_4_8*	*4754*	*1713*	1713	2259	2434	2714	2003	3118	2453	2415	2053	4019	3198	3261	2965	2092
39	*E50_15_4_9*	*4941*	*1416*	2252	2896	3084	3128	2993	2106	3802	2427	2606	4533	4348	4266	4266	1416
40	*E50_15_4_10*	*3269*	*1399*	1585	2996	2336	2135	2306	1875	2357	2173	2540	3472	3081	3373	3081	1399

Table A.8 Overload objective function deviations for 50-activity instances (4/4)

No.	Project name & performance	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
		Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
1	*E50_15_1_1*	41.3%	46.5%	28.2%	40.7%	56.6%	78.7%	41.2%	32.5%	19.8%	48.4%	56.3%	82.8%	72.2%	0.0%
2	*E50_15_1_2*	124.1%	94.5%	81.9%	73.2%	87.2%	123.2%	40.5%	36.3%	67.9%	212.6%	108.3%	142.7%	111.4%	0.0%
3	*E50_15_1_3*	101.8%	71.4%	116.1%	34.3%	68.8%	92.8%	71.1%	32.4%	51.2%	134.1%	92.8%	90.3%	54.9%	0.0%
4	*E50_15_1_4*	230.0%	43.5%	37.3%	30.4%	38.0%	44.3%	81.6%	72.5%	22.3%	403.9%	416.8%	231.5%	200.2%	0.0%
5	*E50_15_1_5*	285.7%	37.6%	50.4%	22.4%	75.5%	52.8%	44.5%	89.1%	22.1%	487.5%	438.1%	362.1%	145.9%	0.0%
6	*E50_15_1_6*	91.6%	53.6%	19.7%	98.4%	36.0%	96.9%	88.1%	88.5%	36.9%	403.7%	240.4%	326.5%	229.3%	0.0%
7	*E50_15_1_7*	157.9%	27.5%	101.4%	19.0%	24.4%	65.9%	63.6%	73.9%	36.2%	319.3%	286.1%	192.6%	109.1%	0.0%
8	*E50_15_1_8*	321.1%	67.3%	48.6%	5.6%	48.8%	92.4%	54.9%	54.9%	82.7%	487.0%	213.4%	371.5%	173.4%	0.0%
9	*E50_15_1_9*	129.7%	28.8%	48.7%	30.3%	56.4%	45.2%	87.1%	113.3%	31.9%	427.4%	287.0%	162.5%	83.8%	0.0%
10	*E50_15_1_10*	90.7%	43.5%	133.5%	72.7%	25.4%	63.6%	57.5%	48.4%	78.5%	195.5%	152.1%	110.5%	71.7%	0.0%
11	*E50_15_2_1*	45.7%	27.8%	61.3%	16.6%	44.0%	49.7%	45.1%	20.0%	35.2%	66.0%	74.1%	40.8%	30.7%	0.0%
12	*E50_15_2_2*	26.0%	47.9%	32.0%	22.3%	54.7%	32.5%	33.0%	20.5%	28.0%	103.7%	38.9%	99.8%	59.4%	0.0%
13	*E50_15_2_3*	70.8%	86.0%	10.3%	26.2%	69.7%	64.3%	49.8%	25.2%	41.0%	41.4%	117.4%	56.3%	36.4%	0.0%
14	*E50_15_2_4*	55.0%	33.9%	53.5%	91.7%	81.2%	72.2%	58.6%	61.5%	69.5%	182.8%	134.5%	84.9%	45.0%	0.0%
15	*E50_15_2_5*	72.5%	35.3%	104.4%	68.1%	57.8%	83.6%	62.7%	45.2%	50.7%	148.4%	131.2%	121.9%	99.8%	0.0%
16	*E50_15_2_6*	99.1%	27.0%	17.4%	22.5%	23.4%	39.2%	21.7%	32.9%	22.3%	236.6%	249.3%	106.3%	90.2%	0.0%
17	*E50_15_2_7*	58.0%	53.7%	41.7%	64.7%	48.5%	139.6%	79.5%	44.5%	33.4%	76.6%	77.8%	85.1%	66.0%	0.0%
18	*E50_15_2_8*	32.1%	33.6%	28.4%	37.8%	25.8%	83.3%	37.9%	63.6%	25.7%	73.9%	54.5%	43.6%	44.5%	0.0%
19	*E50_15_2_9*	68.0%	55.1%	65.2%	49.5%	56.3%	48.2%	54.7%	114.3%	41.2%	185.7%	207.7%	263.0%	152.7%	0.0%
20	*E50_15_2_10*	58.6%	75.9%	39.3%	97.3%	39.9%	75.5%	56.5%	74.9%	32.5%	146.4%	82.2%	32.7%	23.3%	0.0%
21	*E50_15_3_1*	0.0%	38.0%	49.0%	52.6%	26.3%	66.0%	44.5%	51.4%	34.6%	69.5%	50.0%	82.1%	64.7%	12.1%
22	*E50_15_3_2*	24.5%	0.0%	45.4%	28.8%	31.1%	24.4%	32.8%	43.1%	31.6%	55.4%	22.6%	39.8%	28.9%	4.6%
23	*E50_15_3_3*	0.0%	54.7%	33.2%	13.9%	28.2%	31.1%	19.4%	36.5%	34.1%	96.4%	98.6%	83.9%	62.1%	6.0%
24	*E50_15_3_4*	62.9%	71.7%	39.2%	35.2%	40.2%	107.8%	30.2%	34.0%	43.2%	84.7%	94.2%	62.1%	64.1%	0.0%
25	*E50_15_3_5*	44.0%	36.1%	33.2%	36.4%	0.2%	28.1%	19.0%	56.9%	12.3%	31.3%	53.4%	49.4%	45.6%	0.0%
26	*E50_15_3_6*	17.0%	46.4%	27.4%	0.0%	40.8%	25.7%	44.5%	18.0%	13.6%	73.0%	72.6%	38.7%	38.7%	4.5%
27	*E50_15_3_7*	10.8%	9.4%	20.2%	4.5%	16.1%	34.6%	21.0%	1.7%	37.1%	31.3%	65.1%	59.4%	35.4%	0.0%
28	*E50_15_3_8*	1.3%	1.9%	25.5%	8.4%	4.9%	29.4%	32.3%	28.0%	6.5%	94.6%	85.8%	138.6%	78.9%	0.0%
29	*E50_15_3_9*	38.8%	5.9%	58.5%	18.0%	4.4%	39.4%	52.4%	32.1%	44.2%	108.8%	35.8%	62.1%	63.1%	0.0%
30	*E50_15_3_10*	7.1%	46.5%	33.4%	3.6%	0.0%	53.8%	16.3%	20.2%	14.9%	82.7%	99.5%	40.6%	64.1%	7.8%
31	*E50_15_4_1*	246.4%	100.4%	125.9%	26.6%	68.5%	110.8%	109.7%	109.8%	102.6%	496.4%	540.3%	247.4%	211.4%	0.0%
32	*E50_15_4_2*	0.0%	27.9%	14.8%	48.1%	59.2%	32.8%	84.8%	20.8%	41.5%	81.7%	60.0%	84.8%	79.4%	2.7%
33	*E50_15_4_3*	33.7%	77.7%	87.3%	97.9%	43.5%	33.7%	65.1%	25.6%	48.7%	109.3%	137.9%	138.1%	108.3%	0.0%
34	*E50_15_4_4*	0.0%	41.5%	49.2%	30.2%	38.6%	75.8%	34.3%	42.4%	37.5%	56.3%	62.8%	47.5%	36.1%	8.7%
35	*E50_15_4_5*	35.8%	55.2%	42.3%	46.0%	27.3%	38.3%	31.6%	27.4%	32.8%	68.4%	74.0%	69.1%	88.7%	0.0%
36	*E50_15_4_6*	253.3%	13.6%	45.9%	23.2%	9.1%	38.7%	82.2%	39.2%	28.5%	378.5%	498.8%	242.3%	181.6%	0.0%
37	*E50_15_4_7*	61.8%	44.8%	65.9%	44.9%	59.3%	42.8%	38.0%	34.6%	47.7%	99.9%	40.7%	69.8%	52.0%	0.0%
38	*E50_15_4_8*	0.0%	31.9%	42.1%	58.4%	16.9%	82.0%	43.2%	41.0%	19.8%	134.6%	86.7%	90.4%	73.1%	22.1%
39	*E50_15_4_9*	59.0%	104.5%	117.8%	120.9%	111.4%	48.7%	168.5%	71.4%	84.0%	220.1%	207.1%	201.3%	201.3%	0.0%
40	*E50_15_4_10*	13.3%	114.2%	67.0%	52.6%	64.8%	34.0%	68.5%	55.3%	81.6%	148.2%	120.2%	141.1%	120.2%	0.0%
	Average Deviatian	76.7%	47.8%	53.6%	41.8%	42.7%	60.5%	54.2%	48.4%	40.6%	172.6%	149.1%	124.9%	89.9%	1.7%

Table A.9 Overload objective function values for 100-activity instances (1/4)

No.	Project name & performance	Early Start Objective Function	Upper Bound	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
				Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start	Multi	
1	*E100_1_1_1*	*806*	*382*	530	491	631	466	663	659	543	436	663	606	630	619	619	382
2	*E100_1_1_2*	*831*	*601*	748	734	798	754	807	758	769	750	812	766	766	766	766	601
3	*E100_1_1_3*	*691*	*449*	546	600	590	524	600	576	571	534	600	587	611	616	621	449
4	*E100_1_1_4*	*934*	*495*	656	589	722	546	772	689	528	545	779	775	789	689	707	495
5	*E100_1_1_5*	*790*	*484*	720	650	772	677	774	750	720	650	774	768	772	735	735	484
6	*E100_1_1_6*	*797*	*479*	682	626	689	693	659	685	680	648	659	778	784	763	761	479
7	*E100_1_1_7*	*676*	*435*	572	565	623	543	652	630	525	473	652	591	574	589	604	435
8	*E100_1_1_8*	*895*	*563*	741	795	833	812	861	818	801	750	861	863	793	804	804	563
9	*E100_1_1_9*	*815*	*636*	718	691	794	716	808	765	716	698	809	757	758	762	763	636
10	*E100_1_1_10*	*723*	*402*	613	535	633	502	634	623	578	497	634	601	615	576	576	402
11	*E100_1_2_1*	*703*	*357*	519	514	521	456	576	437	488	445	570	484	541	548	557	357
12	*E100_1_2_2*	*759*	*486*	529	558	628	560	657	550	583	551	651	572	584	614	573	486
13	*E100_1_2_3*	*976*	*524*	677	717	759	680	800	744	715	680	813	825	823	825	776	524
14	*E100_1_2_4*	*806*	*393*	672	544	525	511	581	558	570	506	581	638	607	549	579	393
15	*E100_1_2_5*	*797*	*535*	689	679	712	540	745	708	693	597	735	553	551	717	686	535
16	*E100_1_2_6*	*814*	*420*	605	501	573	462	572	559	517	493	571	586	575	599	545	420
17	*E100_1_2_7*	*787*	*345*	566	410	427	364	469	429	425	399	455	522	516	483	459	345
18	*E100_1_2_8*	*669*	*436*	529	561	564	527	627	541	550	518	630	559	560	516	522	436
19	*E100_1_2_9*	*694*	*376*	567	447	545	477	512	465	545	428	517	532	571	526	508	376
20	*E100_1_2_10*	*588*	*370*	452	434	527	393	526	451	452	405	526	476	448	497	477	370
21	*E100_1_3_1*	*419*	*201*	389	294	331	301	286	252	284	284	312	403	400	368	449	201
22	*E100_1_3_2*	*607*	*208*	374	318	383	332	424	310	318	311	404	463	457	551	541	208
23	*E100_1_3_3*	*542*	*240*	357	307	312	251	389	284	333	262	333	430	403	487	406	240
24	*E100_1_3_4*	*549*	*282*	390	381	419	306	451	384	375	359	448	447	420	415	417	282
25	*E100_1_3_5*	*401*	*148*	354	275	263	212	255	246	243	207	257	417	338	356	349	148
26	*E100_1_3_6*	*647*	*339*	539	456	518	411	480	452	462	458	478	603	542	552	540	339
27	*E100_1_3_7*	*777*	*365*	501	448	635	430	602	454	564	468	591	577	658	657	608	365
28	*E100_1_3_8*	*674*	*370*	497	383	415	414	469	425	458	413	469	530	462	458	472	370
29	*E100_1_3_9*	*667*	*324*	524	457	417	414	467	417	517	418	453	614	578	593	578	324
30	*E100_1_3_10*	*731*	*276*	371	338	394	340	470	329	318	276	376	464	505	482	403	364
31	*E100_1_4_1*	*625*	*92*	92	218	300	176	352	259	213	161	379	631	468	483	414	135
32	*E100_1_4_2*	*606*	*141*	141	229	316	247	354	211	223	167	377	665	425	367	355	154
33	*E100_1_4_3*	*484*	*230*	269	236	340	230	332	276	270	258	270	504	490	517	491	267
34	*E100_1_4_4*	*408*	*101*	156	157	246	138	222	149	257	122	227	380	409	371	368	101
35	*E100_1_4_5*	*577*	*79*	93	189	278	213	355	223	283	174	332	452	428	529	412	79
36	*E100_1_4_6*	*528*	*90*	165	208	401	212	430	203	258	173	443	453	395	462	352	90
37	*E100_1_4_7*	*438*	*128*	128	247	214	155	245	178	210	158	234	542	442	504	525	221
38	*E100_1_4_8*	*516*	*107*	155	213	219	242	238	136	235	230	322	481	456	677	539	107
39	*E100_1_4_9*	*499*	*101*	129	218	229	177	296	122	202	101	287	406	398	518	525	142
40	*E100_1_4_10*	*401*	*126*	128	170	206	214	253	141	237	129	275	436	320	245	283	126

Table A.10 Overload objective function deviations for 100-activity instances (1/4)

No.	Project name & performance	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
		Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
1	*E100_1_1_1*	38.7%	28.5%	65.2%	22.0%	73.6%	72.5%	42.1%	14.1%	73.6%	58.6%	64.9%	62.0%	62.0%	0.0%
2	*E100_1_1_2*	24.5%	22.1%	32.8%	25.5%	34.3%	26.1%	28.0%	24.8%	35.1%	27.5%	27.5%	27.5%	27.5%	0.0%
3	*E100_1_1_3*	21.6%	33.6%	31.4%	16.7%	33.6%	28.3%	27.2%	18.9%	33.6%	30.7%	36.1%	37.2%	38.3%	0.0%
4	*E100_1_1_4*	32.5%	19.0%	45.9%	10.3%	56.0%	39.2%	6.7%	10.1%	57.4%	56.6%	59.4%	39.2%	42.8%	0.0%
5	*E100_1_1_5*	48.8%	34.3%	59.5%	39.9%	59.9%	55.0%	48.8%	34.3%	59.9%	58.7%	59.5%	51.9%	51.9%	0.0%
6	*E100_1_1_6*	42.4%	30.7%	43.8%	44.7%	37.6%	43.0%	42.0%	35.3%	37.6%	62.4%	63.7%	59.3%	58.9%	0.0%
7	*E100_1_1_7*	31.5%	29.9%	43.2%	24.8%	49.9%	44.8%	20.7%	8.7%	49.9%	35.9%	32.0%	35.4%	38.9%	0.0%
8	*E100_1_1_8*	31.6%	41.2%	48.0%	44.2%	52.9%	45.3%	42.3%	33.2%	52.9%	53.3%	40.9%	42.8%	42.8%	0.0%
9	*E100_1_1_9*	12.9%	8.6%	24.8%	12.6%	27.0%	20.3%	12.6%	9.7%	27.2%	19.0%	19.2%	19.8%	20.0%	0.0%
10	*E100_1_1_10*	52.5%	33.1%	57.5%	24.9%	57.7%	55.0%	43.8%	23.6%	57.7%	49.5%	53.0%	43.3%	43.3%	0.0%
11	*E100_1_2_1*	45.4%	44.0%	45.9%	27.7%	61.3%	22.4%	36.7%	24.6%	59.7%	35.6%	51.5%	53.5%	56.0%	0.0%
12	*E100_1_2_2*	8.8%	14.8%	29.2%	15.2%	35.2%	13.2%	20.0%	13.4%	34.0%	17.7%	20.2%	26.3%	17.9%	0.0%
13	*E100_1_2_3*	29.2%	36.8%	44.8%	29.8%	52.7%	42.0%	36.5%	29.8%	55.2%	57.4%	57.1%	57.4%	48.1%	0.0%
14	*E100_1_2_4*	71.0%	38.4%	33.6%	30.0%	47.8%	42.0%	45.0%	28.8%	47.8%	62.3%	54.5%	39.7%	47.3%	0.0%
15	*E100_1_2_5*	28.8%	26.9%	33.1%	0.9%	39.3%	32.3%	29.5%	11.6%	37.4%	3.4%	3.0%	34.0%	28.2%	0.0%
16	*E100_1_2_6*	44.0%	19.3%	36.4%	10.0%	36.2%	33.1%	23.1%	17.4%	36.0%	39.5%	36.9%	42.6%	29.8%	0.0%
17	*E100_1_2_7*	64.1%	18.8%	23.8%	5.5%	35.9%	24.3%	23.2%	15.7%	31.9%	51.3%	49.6%	40.0%	33.0%	0.0%
18	*E100_1_2_8*	21.3%	28.7%	29.4%	20.9%	43.8%	24.1%	26.1%	18.8%	44.5%	28.2%	28.4%	18.3%	19.7%	0.0%
19	*E100_1_2_9*	50.8%	18.9%	44.9%	26.9%	36.2%	23.7%	44.9%	13.8%	37.5%	41.5%	51.9%	39.9%	35.1%	0.0%
20	*E100_1_2_10*	22.2%	17.3%	42.4%	6.2%	42.2%	21.9%	22.2%	9.5%	42.2%	28.6%	21.1%	34.3%	28.9%	0.0%
21	*E100_1_3_1*	93.5%	46.3%	64.7%	49.8%	42.3%	25.4%	41.3%	41.3%	55.2%	100.5%	99.0%	83.1%	123.4%	0.0%
22	*E100_1_3_2*	79.8%	52.9%	84.1%	59.6%	103.8%	49.0%	52.9%	49.5%	94.2%	122.6%	119.7%	164.9%	160.1%	0.0%
23	*E100_1_3_3*	48.8%	27.9%	30.0%	4.6%	62.1%	18.3%	38.8%	9.2%	38.8%	79.2%	102.9%	102.9%	69.2%	0.0%
24	*E100_1_3_4*	38.3%	35.1%	48.6%	8.5%	59.9%	36.2%	33.0%	27.3%	58.9%	58.5%	48.9%	47.2%	47.9%	0.0%
25	*E100_1_3_5*	139.2%	85.8%	77.7%	43.2%	72.3%	66.2%	64.2%	39.9%	73.6%	181.8%	128.4%	140.5%	135.8%	0.0%
26	*E100_1_3_6*	59.0%	34.5%	52.8%	21.2%	41.6%	33.3%	36.3%	35.1%	41.0%	77.9%	59.9%	62.8%	59.3%	0.0%
27	*E100_1_3_7*	37.3%	22.7%	74.0%	17.8%	64.9%	24.4%	54.5%	28.2%	61.9%	58.1%	80.3%	80.0%	66.6%	0.0%
28	*E100_1_3_8*	34.3%	3.5%	12.2%	11.9%	26.8%	14.9%	23.8%	11.6%	26.8%	43.2%	24.9%	23.8%	27.6%	0.0%
29	*E100_1_3_9*	61.7%	41.0%	28.7%	27.8%	44.1%	28.7%	59.6%	29.0%	39.8%	89.5%	78.4%	83.0%	78.4%	0.0%
30	*E100_1_3_10*	34.4%	22.5%	42.8%	23.2%	70.3%	19.2%	15.2%	0.0%	36.2%	68.1%	83.0%	74.6%	46.0%	31.9%
31	*E100_1_4_1*	0.0%	137.0%	226.1%	91.3%	282.6%	181.5%	131.5%	75.0%	312.0%	585.9%	408.7%	425.0%	350.0%	46.7%
32	*E100_1_4_2*	0.0%	62.4%	124.1%	75.2%	151.1%	49.6%	58.2%	18.4%	167.4%	371.6%	201.4%	160.3%	151.8%	9.2%
33	*E100_1_4_3*	17.0%	2.6%	47.8%	0.0%	44.3%	20.0%	17.4%	12.2%	17.4%	119.1%	113.0%	124.8%	113.5%	16.1%
34	*E100_1_4_4*	54.5%	55.4%	143.6%	36.6%	119.8%	47.5%	154.5%	20.8%	124.8%	276.2%	305.0%	267.3%	264.4%	0.0%
35	*E100_1_4_5*	17.7%	139.2%	251.9%	169.6%	349.4%	182.3%	258.2%	120.3%	320.3%	472.2%	441.8%	569.6%	421.5%	0.0%
36	*E100_1_4_6*	83.3%	131.1%	345.6%	135.6%	377.8%	125.6%	186.7%	92.2%	392.2%	403.3%	338.9%	413.3%	291.1%	0.0%
37	*E100_1_4_7*	0.0%	93.0%	67.2%	21.1%	91.4%	39.1%	64.1%	23.4%	82.8%	323.4%	245.3%	293.8%	310.2%	72.7%
38	*E100_1_4_8*	44.9%	99.1%	104.7%	126.2%	122.4%	27.1%	119.6%	115.0%	200.9%	349.5%	326.2%	532.7%	403.7%	0.0%
39	*E100_1_4_9*	27.7%	115.8%	126.7%	75.2%	193.1%	20.8%	100.0%	0.0%	184.2%	302.0%	294.1%	412.9%	419.8%	40.6%
40	*E100_1_4_10*	1.6%	34.9%	63.5%	69.8%	100.8%	11.9%	88.1%	2.4%	118.3%	246.0%	154.0%	94.4%	124.6%	0.0%
	Average Deviatian	39.9%	44.7%	70.8%	37.7%	83.3%	43.2%	55.5%	28.7%	83.9%	128.7%	112.1%	124.0%	110.9%	5.4%

Table A.11 Overload objective function values for 100-activity instances (2/4)

No.	Project name & performance	Early Start Objective Function	Upper Bound	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
				Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start	Multi	
1	*E100_5_1_1*	*3863*	*2618*	3032	3547	3303	3566	3229	3319	3191	3676	3229	3734	3626	3561	3550	2618
2	*E100_5_1_2*	*3896*	*3744*	3835	3866	3873	3896	3873	3830	3896	3866	3853	3886	3853	3827	3814	3744
3	*E100_5_1_3*	*3230*	*2681*	3001	3272	3107	3017	3137	3243	3139	3183	3137	3167	3259	3171	3171	2681
4	*E100_5_1_4*	*4336*	*2962*	3441	3847	3926	3838	3803	3754	4022	3870	3793	3863	3842	3848	3842	2962
5	*E100_5_1_5*	*3791*	*2806*	3104	3430	3493	3488	3424	3651	3267	3488	3418	3481	3422	3446	3420	2806
6	*E100_5_1_6*	*3886*	*3188*	3491	3819	3669	3623	3716	3775	3633	3766	3709	3770	3841	3736	3730	3188
7	*E100_5_1_7*	*3836*	*2959*	3344	3572	3742	3638	3716	3779	3792	3550	3716	3689	3791	3762	3762	2959
8	*E100_5_1_8*	*4028*	*2879*	3366	3782	3656	3531	3607	3553	3443	3799	3622	3782	3674	3682	3644	2879
9	*E100_5_1_9*	*3700*	*3095*	3320	3587	3439	3519	3517	3455	3572	3582	3517	3498	3584	3588	3524	3095
10	*E100_5_1_10*	*3803*	*3510*	3607	3752	3762	3807	3753	3726	3775	3703	3762	3723	3685	3740	3707	3510
11	*E100_5_2_1*	*3546*	*2391*	2857	2985	2882	3079	2704	2560	3025	3493	2529	3134	3252	3177	3254	2391
12	*E100_5_2_2*	*3251*	*2376*	2610	3082	2643	2908	2572	2720	2931	3024	2614	3448	3286	3371	3177	2376
13	*E100_5_2_3*	*3458*	*2541*	3032	3212	2648	3488	2552	2657	3207	3209	2598	3464	3336	3272	3183	2541
14	*E100_5_2_4*	*4061*	*2704*	3308	3771	3010	3605	2906	2901	3141	3803	2922	3813	3813	3826	3810	2704
15	*E100_5_2_5*	*3483*	*2598*	3120	3267	3211	3217	3009	3088	3270	3447	3009	3931	3607	3817	3668	2598
16	*E100_5_2_6*	*4169*	*2995*	3319	3643	3481	3734	3338	3242	3736	3666	3338	3995	3729	4045	3909	2995
17	*E100_5_2_7*	*3702*	*2541*	2912	3372	2964	3395	2794	2935	3385	3478	2838	3400	3366	3163	3279	2541
18	*E100_5_2_8*	*3439*	*2488*	2909	3220	2872	3138	2802	3063	2946	3368	2803	3500	3108	3507	3223	2488
19	*E100_5_2_9*	*3815*	*2873*	3242	3525	3118	3594	3302	3425	3371	3666	3247	3754	3634	3341	3471	2873
20	*E100_5_2_10*	*3476*	*2371*	2525	2836	2575	2680	2371	2459	2866	2976	2387	3214	2939	3082	3020	2386
21	*E100_5_3_1*	*2442*	*1666*	1945	2368	2064	2133	1961	2234	2175	2155	1967	2570	2498	2452	2457	1666
22	*E100_5_3_2*	*2687*	*1290*	1537	1864	1815	2007	1877	1821	1988	1975	1998	2414	2273	2339	2409	1290
23	*E100_5_3_3*	*3048*	*2052*	2420	2620	2566	2431	2695	2478	2331	2757	2583	2748	2535	2649	2650	2052
24	*E100_5_3_4*	*2812*	*1904*	2216	2292	2284	2324	2309	2195	2231	2343	2278	2488	2418	2352	2354	1904
25	*E100_5_3_5*	*3052*	*1700*	1995	2248	1990	2219	1902	2034	2249	2372	1856	2666	2804	2590	2420	1700
26	*E100_5_3_6*	*2496*	*1717*	1975	2229	1912	2095	1865	2071	2203	2223	1969	2469	2493	2473	2482	1717
27	*E100_5_3_7*	*3032*	*2067*	2377	2571	2274	2435	2329	2446	2194	2655	2303	2670	2973	2747	2689	2067
28	*E100_5_3_8*	*2746*	*1944*	2138	2281	2183	2372	2196	2289	2321	2269	2285	2585	2441	2462	2590	1944
29	*E100_5_3_9*	*3346*	*2292*	2690	2820	2662	2806	2721	2950	2884	2996	2820	3140	2859	3025	3009	2292
30	*E100_5_3_10*	*2685*	*1900*	2240	2446	2370	2252	2265	2373	2315	2419	2264	2612	2781	2789	2843	1900
31	*E100_5_4_1*	*3058*	*977*	977	1301	1370	1329	1525	1258	1202	1466	1448	2394	2283	2133	1976	992
32	*E100_5_4_2*	*2325*	*764*	764	1124	1155	998	1323	1170	1261	1377	1328	1892	2370	2047	1900	987
33	*E100_5_4_3*	*2909*	*985*	985	1495	1520	1392	1458	1311	1496	1460	1355	2003	2264	2397	2345	1143
34	*E100_5_4_4*	*1994*	*917*	917	1206	1199	1145	1472	1251	1414	1170	1518	1787	1839	1658	1586	920
35	*E100_5_4_5*	*2441*	*1195*	1195	1485	1485	1856	1488	1574	1211	2124	1632	2261	2287	2471	2240	1340
36	*E100_5_4_6*	*2635*	*1016*	1094	1257	1168	1322	1189	1072	1407	1509	1160	1763	1858	1626	1414	1016
37	*E100_5_4_7*	*2591*	*1239*	1239	1791	1820	1485	1529	1467	1753	1680	1430	2235	2277	2391	2240	1275
38	*E100_5_4_8*	*2144*	*1249*	1249	1544	1674	1588	1686	1450	1461	1805	1472	2254	1777	2110	2054	1282
39	*E100_5_4_9*	*2313*	*926*	926	1258	1399	1496	1431	1348	1249	1317	1334	2187	2111	1597	1800	984
40	*E100_5_4_10*	*2619*	*975*	1054	1310	1427	1120	1605	1312	1455	1172	1811	2418	2553	2364	2436	975

Table A.12 Overload objective function deviations for 100-activity instances (2/4)

No.	Project name & performance	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
		Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
1	*E100_5_1_1*	15.8%	35.5%	26.2%	36.2%	23.3%	26.8%	21.9%	40.4%	23.3%	42.6%	38.5%	36.0%	35.6%	0.0%
2	*E100_5_1_2*	2.4%	3.3%	3.4%	4.1%	3.4%	2.3%	4.1%	3.3%	2.9%	3.8%	2.9%	2.2%	1.9%	0.0%
3	*E100_5_1_3*	11.9%	22.0%	15.9%	12.5%	17.0%	21.0%	17.1%	18.7%	17.0%	18.1%	21.6%	18.3%	18.3%	0.0%
4	*E100_5_1_4*	16.2%	29.9%	32.5%	29.6%	28.4%	26.7%	35.8%	30.7%	28.1%	30.4%	29.7%	29.9%	29.7%	0.0%
5	*E100_5_1_5*	10.6%	22.2%	24.5%	24.3%	22.0%	30.1%	16.4%	24.3%	21.8%	24.1%	22.0%	22.8%	21.9%	0.0%
6	*E100_5_1_6*	9.5%	19.8%	15.1%	13.6%	16.6%	18.4%	14.0%	18.1%	16.3%	18.3%	20.5%	17.2%	17.0%	0.0%
7	*E100_5_1_7*	13.0%	20.7%	26.5%	22.9%	25.6%	27.7%	28.2%	20.0%	25.6%	24.7%	28.1%	27.1%	27.1%	0.0%
8	*E100_5_1_8*	16.9%	31.4%	27.0%	22.6%	25.3%	23.4%	19.6%	32.0%	25.8%	31.4%	27.6%	27.9%	26.6%	0.0%
9	*E100_5_1_9*	7.3%	15.9%	11.1%	13.7%	13.6%	11.6%	15.4%	15.7%	13.6%	13.0%	15.8%	15.9%	13.9%	0.0%
10	*E100_5_1_10*	2.8%	6.9%	7.2%	8.5%	6.9%	6.2%	7.5%	5.5%	7.2%	6.1%	5.0%	6.6%	5.6%	0.0%
11	*E100_5_2_1*	19.5%	24.8%	20.5%	28.8%	13.1%	7.1%	26.5%	46.1%	5.8%	31.1%	36.0%	32.9%	36.1%	0.0%
12	*E100_5_2_2*	9.8%	29.7%	11.2%	22.4%	8.2%	14.5%	23.4%	27.3%	10.0%	45.1%	38.3%	41.9%	33.7%	0.0%
13	*E100_5_2_3*	19.3%	26.4%	4.2%	37.3%	0.4%	4.6%	26.2%	26.3%	2.2%	36.3%	31.3%	28.8%	25.3%	0.0%
14	*E100_5_2_4*	22.3%	39.5%	11.3%	33.3%	7.5%	7.3%	16.2%	40.6%	8.1%	41.0%	41.0%	41.5%	40.9%	0.0%
15	*E100_5_2_5*	20.1%	25.8%	23.6%	23.8%	15.8%	18.9%	25.9%	32.7%	15.8%	51.3%	38.8%	46.9%	41.2%	0.0%
16	*E100_5_2_6*	10.8%	21.6%	16.2%	24.7%	11.5%	8.2%	24.7%	22.4%	11.5%	33.4%	24.5%	35.1%	30.5%	0.0%
17	*E100_5_2_7*	14.6%	32.7%	16.6%	33.6%	10.0%	15.5%	33.2%	36.9%	11.7%	33.8%	32.5%	24.5%	29.0%	0.0%
18	*E100_5_2_8*	16.9%	29.4%	15.4%	26.1%	12.6%	23.1%	18.4%	35.4%	12.7%	40.7%	24.9%	41.0%	29.5%	0.0%
19	*E100_5_2_9*	12.8%	22.7%	8.5%	25.1%	14.9%	19.2%	17.3%	27.6%	13.0%	30.7%	26.5%	16.3%	20.8%	0.0%
20	*E100_5_2_10*	6.5%	19.6%	8.6%	13.0%	0.0%	3.7%	20.9%	25.5%	0.7%	35.6%	24.0%	30.0%	27.4%	0.6%
21	*E100_5_3_1*	16.7%	42.1%	23.9%	28.0%	17.7%	34.1%	30.6%	29.4%	18.1%	54.3%	49.9%	47.2%	47.5%	0.0%
22	*E100_5_3_2*	19.1%	44.5%	40.7%	55.6%	45.5%	41.2%	54.1%	53.1%	54.9%	87.1%	76.2%	81.3%	86.7%	0.0%
23	*E100_5_3_3*	17.9%	27.7%	25.0%	18.5%	31.3%	20.8%	13.6%	34.4%	25.9%	33.9%	23.5%	29.1%	29.1%	0.0%
24	*E100_5_3_4*	16.4%	20.4%	20.0%	22.1%	21.3%	15.3%	17.2%	23.1%	19.6%	30.7%	27.0%	23.5%	23.6%	0.0%
25	*E100_5_3_5*	17.4%	32.2%	17.1%	30.5%	11.9%	19.6%	32.3%	39.5%	9.2%	56.8%	64.9%	52.4%	42.4%	0.0%
26	*E100_5_3_6*	15.0%	29.8%	11.4%	22.0%	8.6%	20.6%	28.3%	29.5%	14.7%	43.8%	45.2%	44.0%	44.6%	0.0%
27	*E100_5_3_7*	15.0%	24.4%	10.0%	17.8%	12.7%	18.3%	6.1%	28.4%	11.4%	29.2%	43.8%	32.9%	30.1%	0.0%
28	*E100_5_3_8*	10.0%	17.3%	12.3%	22.0%	13.0%	17.7%	19.4%	16.7%	17.5%	33.0%	25.6%	26.6%	33.2%	0.0%
29	*E100_5_3_9*	17.4%	23.0%	16.1%	22.4%	18.7%	28.7%	25.8%	30.7%	23.0%	37.0%	24.7%	32.0%	31.3%	0.0%
30	*E100_5_3_10*	17.9%	28.7%	24.7%	18.5%	19.2%	24.9%	21.8%	27.3%	19.2%	37.5%	46.4%	46.8%	49.6%	0.0%
31	*E100_5_4_1*	0.0%	33.2%	40.2%	36.0%	56.1%	28.8%	23.0%	50.1%	48.2%	145.0%	133.7%	118.3%	102.3%	1.5%
32	*E100_5_4_2*	0.0%	47.1%	51.2%	30.6%	73.2%	53.1%	65.1%	80.2%	73.8%	147.6%	210.2%	167.9%	148.7%	29.2%
33	*E100_5_4_3*	0.0%	51.8%	54.3%	41.3%	48.0%	33.1%	51.9%	48.2%	37.6%	103.4%	129.8%	143.4%	138.1%	16.0%
34	*E100_5_4_4*	0.0%	31.5%	30.8%	24.9%	60.5%	36.4%	54.2%	27.6%	65.5%	94.9%	100.5%	80.8%	73.0%	0.3%
35	*E100_5_4_5*	0.0%	24.3%	24.3%	55.3%	24.5%	31.7%	1.3%	77.7%	36.6%	89.2%	91.4%	106.8%	87.4%	12.1%
36	*E100_5_4_6*	7.7%	23.7%	15.0%	30.1%	17.0%	5.5%	38.5%	48.5%	14.2%	73.5%	82.9%	60.0%	39.2%	0.0%
37	*E100_5_4_7*	0.0%	44.6%	46.9%	19.9%	23.4%	18.4%	41.5%	35.6%	15.4%	80.4%	83.8%	93.0%	80.8%	2.9%
38	*E100_5_4_8*	0.0%	23.6%	34.0%	27.1%	35.0%	16.1%	17.0%	44.5%	17.9%	80.5%	42.3%	68.9%	64.5%	2.6%
39	*E100_5_4_9*	0.0%	35.9%	51.1%	61.6%	54.5%	45.6%	34.9%	42.2%	44.1%	136.2%	128.0%	72.5%	94.4%	6.3%
40	*E100_5_4_10*	8.1%	34.4%	46.4%	14.9%	64.6%	34.6%	49.2%	20.2%	85.7%	148.0%	161.8%	142.5%	149.8%	0.0%
	Average Deviatian	10.9%	28.0%	23.0%	26.4%	23.3%	21.5%	26.0%	32.9%	23.1%	53.3%	53.0%	50.3%	47.7%	1.8%

Table A.13 Overload objective function values for 100-activity instances (3/4)

No.	Project name & performance	Early Start Objective Function	Upper Bound	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
				Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start	Multi	
1	*E100_10_1_1*	*7989*	*6328*	6565	7718	6893	7833	6944	7188	7006	7955	6944	7645	7408	7548	7545	6328
2	*E100_10_1_2*	*7903*	*6305*	6833	7744	7575	7474	7257	7351	7280	7659	7267	7616	7354	7545	7524	6305
3	*E100_10_1_3*	*8143*	*6861*	7427	7427	7556	7662	7489	7319	7892	8127	7489	7650	7313	7792	7781	6861
4	*E100_10_1_4*	*7849*	*6314*	7107	7587	7214	7586	7096	6876	7520	7737	7096	7514	7477	7557	7373	6314
5	*E100_10_1_5*	*7597*	*6052*	6287	7449	7033	7107	7044	7145	7038	7481	7044	7156	7029	7228	7259	6052
6	*E100_10_1_6*	*7775*	*5924*	6250	7525	6652	6970	6612	6876	6415	7672	6612	7202	6386	7170	7170	5924
7	*E100_10_1_7*	*8181*	*6313*	6799	7814	7222	7410	7251	7180	7232	7887	7215	7386	7280	7390	7390	6313
8	*E100_10_1_8*	*7422*	*6708*	7110	7227	7133	7332	7120	7266	7259	7266	7051	7156	7125	6997	6919	6708
9	*E100_10_1_9*	*7028*	*5821*	6065	6583	6565	6301	6562	6563	6411	6790	6562	6693	6662	6512	6429	5821
10	*E100_10_1_10*	*8204*	*6094*	7089	7517	7605	7601	7476	7515	7355	7840	7476	7581	7251	7734	7730	6094
11	*E100_10_2_1*	*6915*	*5196*	5861	6731	5888	6773	5635	5504	6598	7219	5621	6886	6473	6752	6609	5196
12	*E100_10_2_2*	*7911*	*5933*	6358	6987	6297	7345	6188	6195	7479	7341	6213	7082	7267	7153	7121	5933
13	*E100_10_2_3*	*7994*	*5902*	6184	7458	6456	7407	6253	6301	7085	7197	6249	7861	7333	7530	7720	5902
14	*E100_10_2_4*	*7588*	*4879*	5702	6112	5451	6630	5253	5722	6335	6573	5242	7090	7209	7449	7003	4879
15	*E100_10_2_5*	*7042*	*5111*	5556	6228	5895	6328	5712	5728	6403	6511	5631	6538	6049	6307	6059	5111
16	*E100_10_2_6*	*7781*	*6150*	6764	7562	6793	7696	6654	6985	7268	7394	6638	7451	7288	7483	7138	6150
17	*E100_10_2_7*	*7201*	*5172*	5759	6712	5794	7135	5664	5682	7147	7026	5671	7175	7027	6721	6782	5172
18	*E100_10_2_8*	*7944*	*5223*	6209	7203	6259	7115	5755	5680	7053	7733	5734	7587	7332	7244	7230	5223
19	*E100_10_2_9*	*7342*	*5349*	6589	6695	6201	7197	5942	5818	6806	6797	5955	6870	7386	6978	6905	5349
20	*E100_10_2_10*	*6697*	*4825*	5198	6228	5066	6600	5226	5330	5944	6805	5245	7082	7076	6753	6698	4825
21	*E100_10_3_1*	*4657*	*3301*	3831	4516	3920	4410	4089	4183	4264	4927	3806	4945	4544	4847	4569	3301
22	*E100_10_3_2*	*5866*	*3958*	4767	5251	4911	4712	4735	4430	4982	5010	4939	5993	5761	5890	5646	3958
23	*E100_10_3_3*	*5545*	*3820*	4503	4716	4207	4450	4294	4516	4330	4797	4207	5155	4910	5218	4965	3820
24	*E100_10_3_4*	*5854*	*3118*	3703	3683	4042	4379	3587	3577	4627	4089	3544	4925	4880	4637	4700	3118
25	*E100_10_3_5*	*6195*	*3340*	4215	4494	4454	4724	4345	4441	4174	5343	4155	5911	5635	5444	5117	3340
26	*E100_10_3_6*	*5917*	*4301*	4852	5048	5102	5265	5074	5337	5243	5209	5017	5833	6270	5598	5528	4301
27	*E100_10_3_7*	*5025*	*3551*	3999	4787	4282	4200	4190	4184	3983	5033	4218	4678	5010	5141	5243	3551
28	*E100_10_3_8*	*5890*	*4438*	5078	5451	5102	5233	5033	5118	5146	5822	4831	5451	5525	5654	5707	4438
29	*E100_10_3_9*	*5450*	*4035*	4278	4932	4678	4437	4086	4578	4479	5043	4524	5451	5355	5710	5492	4035
30	*E100_10_3_10*	*4972*	*3509*	4161	4573	4401	4120	4196	4460	4218	4707	4336	5140	4794	5106	4573	3509
31	*E100_10_4_1*	*5955*	*2332*	2690	2720	2593	2522	3108	2613	2894	3290	2836	3481	3330	3685	3359	2332
32	*E100_10_4_2*	*4538*	*2357*	2357	3066	3436	3670	3298	3638	3136	3729	3281	4206	4423	3679	3677	2417
33	*E100_10_4_3*	*4527*	*2352*	2352	2680	2719	3140	2471	2826	2719	3117	2574	3084	3735	3534	3354	2355
34	*E100_10_4_4*	*5535*	*2241*	2241	2481	2745	2704	2939	2870	2725	2773	2865	4175	3815	3643	3602	2490
35	*E100_10_4_5*	*3607*	*2167*	2167	2279	2471	2514	2504	2636	2776	2925	2662	3717	3145	3351	3061	2459
36	*E100_10_4_6*	*4762*	*2038*	2038	3056	2855	2488	2384	2821	2550	3079	2375	3752	3820	3747	3801	2312
37	*E100_10_4_7*	*3643*	*2321*	2399	2783	2412	2407	2737	2776	2839	3249	2649	3451	3686	3441	3156	2321
38	*E100_10_4_8*	*3517*	*2289*	2370	2814	2335	2626	2626	3195	2749	3257	3381	3648	3469	3719	3901	2289
39	*E100_10_4_9*	*3339*	*1709*	1823	2196	1983	2028	2262	2016	1854	2012	2205	2954	2747	2428	2507	1709
40	*E100_10_4_10*	*5736*	*2278*	2278	3422	3161	3073	3254	3283	3045	3756	3035	3458	4642	4248	4003	3027

Table A.14 Overload objective function deviations for 100-activity instances (3/4)

No.	Project name & performance	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
		Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
1	*E100_10_1_1*	3.7%	22.0%	8.9%	23.8%	9.7%	13.6%	10.7%	25.7%	9.7%	20.8%	17.1%	19.3%	19.2%	0.0%
2	*E100_10_1_2*	8.4%	22.8%	20.1%	18.5%	15.1%	15.5%	21.5%	15.3%	20.8%	16.6%	19.7%	19.3%	19.3%	0.0%
3	*E100_10_1_3*	8.2%	8.2%	10.1%	11.7%	9.2%	6.7%	15.0%	18.5%	9.2%	11.5%	6.6%	13.6%	13.4%	0.0%
4	*E100_10_1_4*	12.6%	20.2%	14.3%	20.1%	12.4%	8.9%	19.1%	22.5%	12.4%	19.0%	18.4%	19.7%	16.8%	0.0%
5	*E100_10_1_5*	3.9%	23.1%	16.2%	17.4%	16.4%	18.1%	16.3%	23.6%	16.4%	18.2%	16.1%	19.4%	19.9%	0.0%
6	*E100_10_1_6*	5.5%	27.0%	12.3%	17.7%	11.6%	16.1%	8.3%	29.5%	11.6%	21.6%	7.8%	21.0%	21.0%	0.0%
7	*E100_10_1_7*	7.7%	23.8%	14.4%	17.4%	14.9%	13.7%	14.6%	24.9%	14.3%	17.0%	15.3%	17.1%	17.1%	0.0%
8	*E100_10_1_8*	6.0%	7.7%	6.3%	9.3%	6.1%	8.3%	8.2%	8.3%	5.1%	6.7%	6.2%	4.3%	3.1%	0.0%
9	*E100_10_1_9*	4.2%	13.1%	12.8%	8.2%	12.7%	12.7%	10.1%	16.6%	12.7%	15.0%	14.4%	11.9%	10.4%	0.0%
10	*E100_10_1_10*	16.3%	23.4%	24.8%	24.7%	22.7%	23.3%	20.7%	28.7%	22.7%	24.4%	19.0%	26.9%	26.8%	0.0%
11	*E100_10_2_1*	12.8%	29.5%	13.3%	30.4%	8.4%	5.9%	27.0%	38.9%	8.2%	32.5%	24.6%	29.9%	27.2%	0.0%
12	*E100_10_2_2*	7.2%	17.8%	6.1%	23.8%	4.3%	4.4%	26.1%	23.7%	4.7%	19.4%	22.5%	20.6%	20.0%	0.0%
13	*E100_10_2_3*	4.8%	26.4%	9.4%	25.5%	5.9%	6.8%	20.0%	21.9%	5.9%	33.2%	24.2%	27.6%	30.8%	0.0%
14	*E100_10_2_4*	16.9%	25.3%	11.7%	35.9%	7.7%	17.3%	29.8%	34.7%	7.4%	45.3%	47.8%	52.7%	43.5%	0.0%
15	*E100_10_2_5*	8.7%	21.9%	15.3%	23.8%	11.8%	12.1%	25.3%	27.4%	10.2%	27.9%	18.4%	23.4%	18.5%	0.0%
16	*E100_10_2_6*	10.0%	23.0%	10.5%	25.1%	8.2%	13.6%	18.2%	20.2%	7.9%	21.2%	18.5%	21.7%	16.1%	0.0%
17	*E100_10_2_7*	11.3%	29.8%	12.0%	38.0%	9.5%	9.9%	38.2%	35.8%	9.6%	38.7%	35.9%	29.9%	31.1%	0.0%
18	*E100_10_2_8*	18.9%	37.9%	19.8%	36.2%	10.2%	8.7%	35.0%	48.1%	9.8%	45.3%	40.4%	38.7%	38.4%	0.0%
19	*E100_10_2_9*	23.2%	25.2%	15.9%	34.5%	11.1%	8.8%	27.2%	27.1%	11.3%	28.4%	38.1%	30.5%	29.1%	0.0%
20	*E100_10_2_10*	7.7%	29.1%	5.0%	36.8%	8.3%	10.5%	23.2%	41.0%	8.7%	46.8%	46.7%	40.0%	38.8%	0.0%
21	*E100_10_3_1*	16.1%	36.8%	18.8%	33.6%	23.9%	26.7%	29.2%	49.3%	15.3%	49.8%	37.7%	46.8%	38.4%	0.0%
22	*E100_10_3_2*	20.4%	32.7%	24.1%	19.1%	19.6%	11.9%	25.9%	26.6%	24.8%	51.4%	45.6%	48.8%	42.6%	0.0%
23	*E100_10_3_3*	17.9%	23.5%	10.1%	16.5%	12.4%	18.2%	13.4%	25.6%	10.1%	34.9%	28.5%	36.6%	30.0%	0.0%
24	*E100_10_3_4*	18.8%	18.1%	29.6%	40.4%	15.0%	14.7%	48.4%	31.1%	13.7%	58.0%	56.5%	48.7%	50.7%	0.0%
25	*E100_10_3_5*	26.2%	34.6%	33.4%	41.4%	30.1%	33.0%	25.0%	60.0%	24.4%	77.0%	68.7%	63.0%	53.2%	0.0%
26	*E100_10_3_6*	12.8%	17.4%	18.6%	22.4%	18.0%	24.1%	21.9%	21.1%	16.6%	35.6%	45.8%	30.2%	28.5%	0.0%
27	*E100_10_3_7*	12.6%	34.8%	20.6%	18.3%	18.0%	17.8%	12.2%	41.7%	18.8%	31.7%	41.1%	44.8%	47.6%	0.0%
28	*E100_10_3_8*	14.4%	22.8%	15.0%	17.9%	13.4%	15.3%	16.0%	31.2%	8.9%	22.8%	24.5%	27.4%	28.6%	0.0%
29	*E100_10_3_9*	6.0%	22.2%	15.9%	10.0%	1.3%	13.5%	11.0%	25.0%	12.1%	35.1%	32.7%	41.5%	36.1%	0.0%
30	*E100_10_3_10*	18.6%	30.3%	25.4%	17.4%	19.6%	27.1%	20.2%	34.1%	23.6%	46.5%	36.6%	45.5%	30.3%	0.0%
31	*E100_10_4_1*	15.4%	16.6%	11.2%	8.1%	33.3%	12.0%	24.1%	41.1%	21.6%	49.3%	42.8%	58.0%	44.0%	0.0%
32	*E100_10_4_2*	0.0%	30.1%	45.8%	55.7%	39.9%	54.3%	33.1%	58.2%	39.2%	78.4%	87.7%	56.1%	56.0%	2.5%
33	*E100_10_4_3*	0.0%	13.9%	15.6%	33.5%	5.1%	20.2%	15.6%	32.5%	9.4%	31.1%	58.8%	50.3%	42.6%	0.1%
34	*E100_10_4_4*	0.0%	10.7%	22.5%	20.7%	31.1%	28.1%	21.6%	23.7%	27.8%	86.3%	70.2%	62.6%	60.7%	11.1%
35	*E100_10_4_5*	0.0%	5.2%	14.0%	16.0%	15.6%	21.6%	28.1%	35.0%	22.8%	71.5%	45.1%	54.6%	41.3%	13.5%
36	*E100_10_4_6*	0.0%	50.0%	40.1%	22.1%	17.0%	38.4%	25.1%	51.1%	16.5%	84.1%	87.4%	83.9%	86.5%	13.4%
37	*E100_10_4_7*	3.4%	19.9%	3.9%	3.7%	17.9%	19.6%	22.3%	40.0%	14.1%	48.7%	58.8%	48.3%	36.0%	0.0%
38	*E100_10_4_8*	3.5%	22.9%	2.0%	14.7%	14.7%	39.6%	20.1%	42.3%	47.7%	59.4%	51.6%	62.5%	70.4%	0.0%
39	*E100_10_4_9*	6.7%	28.5%	16.0%	18.7%	32.4%	18.0%	8.5%	17.7%	29.0%	72.8%	60.7%	42.1%	46.7%	0.0%
40	*E100_10_4_10*	0.0%	50.2%	38.8%	34.9%	42.8%	44.1%	33.7%	64.9%	33.2%	51.8%	103.8%	86.5%	75.7%	32.9%
	Average Deviatian	9.8%	24.5%	17.0%	23.6%	15.9%	18.3%	21.7%	32.1%	16.2%	39.6%	38.6%	38.1%	35.2%	1.8%

Table A.15 Overload objective function values for 100-activity instances (4/4)

No.	Project name & performance	Early Start Objective Function	Upper Bound	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
				Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start	Multi	
1	*E100_15_1_1*	*11643*	*8753*	9539	11020	10286	11621	10392	10580	10353	11170	10392	10086	10236	10947	10754	8753
2	*E100_15_1_2*	*10944*	*8845*	9546	10723	10509	10684	10021	10149	10365	10710	10117	9853	10303	10649	10486	8845
3	*E100_15_1_3*	*11850*	*10375*	10941	11685	11497	11858	11223	10910	11557	11702	11264	11349	11324	11540	11552	10375
4	*E100_15_1_4*	*12364*	*9798*	9892	11787	11520	11676	11332	10928	11786	11530	11245	11488	11900	11735	11815	9798
5	*E100_15_1_5*	*10938*	*9113*	9546	10732	10517	10498	10561	10696	10198	10569	10561	10941	10881	10759	10790	9113
6	*E100_15_1_6*	*11948*	*9876*	9876	11497	11157	11083	11025	10814	11243	11429	11025	11257	11142	11278	11278	9977
7	*E100_15_1_7*	*10562*	*8743*	8962	9837	9878	10289	9863	9882	10135	10448	9863	9933	9941	9906	9906	8743
8	*E100_15_1_8*	*12336*	*10304*	10907	11917	11207	12014	11309	11092	11584	11902	11259	11789	11744	11542	11493	10304
9	*E100_15_1_9*	*12497*	*9578*	10289	11957	10952	11339	11022	10753	11362	12370	10933	11717	11176	11465	11387	9578
10	*E100_15_1_10*	*12083*	*10964*	11830	12146	11549	11838	11648	11630	11722	12255	11625	12022	11917	11882	11917	10964
11	*E100_15_2_1*	*10083*	*7526*	8546	9609	8312	9869	8119	7526	9510	10540	8119	9319	9682	9360	9070	7619
12	*E100_15_2_2*	*12270*	*8867*	9919	11668	9735	11798	9108	9825	11569	12365	9108	13129	12176	11705	11589	8867
13	*E100_15_2_3*	*10656*	*9180*	9932	10744	9684	10657	9450	9985	10439	10839	9450	10454	10247	10518	10212	9180
14	*E100_15_2_4*	*10995*	*7372*	8932	10829	8793	11824	8579	8599	10301	11163	8579	11567	10538	10717	10505	7372
15	*E100_15_2_5*	*10575*	*8100*	8921	10013	8568	10069	8753	8752	9638	10925	8753	10616	10424	9998	9639	8100
16	*E100_15_2_6*	*10170*	*7559*	8477	9657	7819	10069	7559	8317	10068	10824	7574	10556	11158	10308	10538	7706
17	*E100_15_2_7*	*11960*	*8752*	9550	10896	9157	12016	8753	9687	11867	11344	8753	11385	10895	10817	10246	8752
18	*E100_15_2_8*	*11803*	*9629*	10584	11933	10761	11583	10391	10245	11602	12052	10391	12799	12353	12678	11678	9629
19	*E100_15_2_9*	*11810*	*8087*	9259	9811	9422	11303	8728	9008	11259	11837	8728	11492	11610	11600	11610	8087
20	*E100_15_2_10*	*12107*	*8881*	9155	10665	9574	11943	8977	8881	10366	12066	8977	10710	11278	10807	10899	8937
21	*E100_15_3_1*	*7431*	*5594*	6237	7772	7098	7363	6833	6768	7057	8076	6920	8364	8308	8139	8044	5594
22	*E100_15_3_2*	*10841*	*6543*	8325	8960	7925	8871	7257	7885	8952	9736	8110	9738	9397	9364	9134	6543
23	*E100_15_3_3*	*10249*	*7485*	8087	8898	8971	9546	8118	8325	9120	8915	7781	10137	9633	10034	9479	7485
24	*E100_15_3_4*	*7996*	*5660*	6823	6889	6359	7621	6664	7154	7051	7262	6052	7963	8058	7767	7545	5660
25	*E100_15_3_5*	*9024*	*5817*	5960	6470	6398	6694	6540	6333	6652	6935	5910	7893	7098	8649	8209	5817
26	*E100_15_3_6*	*8632*	*5646*	6139	6602	6101	7298	6147	6693	6615	7701	6685	7186	8576	7924	8162	5646
27	*E100_15_3_7*	*9707*	*7310*	8339	9584	8536	8856	8104	8649	8696	9432	8414	9806	9790	9865	9479	7310
28	*E100_15_3_8*	*7648*	*5838*	6827	7096	6734	8301	6374	7515	6891	7944	6683	7685	8163	7773	7749	5838
29	*E100_15_3_9*	*8501*	*5169*	5531	5762	6083	5930	5384	5640	6355	6568	6141	8042	7411	7636	7555	5169
30	*E100_15_3_10*	*7653*	*5913*	6969	7878	6618	7756	6333	7400	6775	7604	6520	8075	8276	7560	7672	5913
31	*E100_15_4_1*	*9706*	*3681*	4153	4326	4475	3841	4468	4469	4614	5207	4297	5910	4886	6971	6107	3681
32	*E100_15_4_2*	*8429*	*4201*	4201	5338	5325	5359	5103	4886	4967	5499	4835	5436	6331	6361	6088	4486
33	*E100_15_4_3*	*8230*	*3444*	3444	5491	4425	4965	4521	5242	4623	5826	4784	5974	6691	6213	5934	4411
34	*E100_15_4_4*	*6484*	*2951*	2951	4243	3538	4451	4482	4317	4050	4713	4221	5045	4375	5256	5081	3554
35	*E100_15_4_5*	*9176*	*3636*	3636	5368	4696	4183	4398	4541	4455	5365	4589	5968	6657	5607	6062	3833
36	*E100_15_4_6*	*6213*	*4100*	4617	5162	5279	5471	4793	5571	5077	5787	4771	6876	6595	7912	8272	4100
37	*E100_15_4_7*	*6435*	*3470*	3470	4742	4289	4435	4305	4520	3877	4872	3699	5663	5286	4554	6164	3533
38	*E100_15_4_8*	*8658*	*4140*	4140	5941	5341	5023	4328	5510	6196	5791	5021	6698	6831	6482	6692	4702
39	*E100_15_4_9*	*10408*	*3537*	3537	5040	4425	5536	5111	5410	5332	6031	5118	6404	6188	5940	6067	4474
40	*E100_15_4_10*	*5568*	*3409*	3448	4843	3836	4080	3976	4733	4421	4592	4707	5624	5247	5215	5040	3409

Table A.16 Overload objective function deviations for 100-activity instances (4/4)

No.	Project name & performance	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
		Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
1	*E100_15_1_1*	9.0%	25.9%	17.5%	32.8%	18.7%	20.9%	18.3%	27.6%	18.7%	15.2%	16.9%	25.1%	22.9%	0.0%
2	*E100_15_1_2*	7.9%	21.2%	18.8%	20.8%	13.3%	14.7%	17.2%	21.1%	14.4%	11.4%	16.5%	20.4%	18.6%	0.0%
3	*E100_15_1_3*	5.5%	12.6%	10.8%	14.3%	8.2%	5.2%	11.4%	12.8%	8.6%	9.4%	9.1%	11.2%	11.3%	0.0%
4	*E100_15_1_4*	1.0%	20.3%	17.6%	19.2%	15.7%	11.5%	20.3%	17.7%	14.8%	17.2%	21.5%	19.8%	20.6%	0.0%
5	*E100_15_1_5*	4.8%	17.8%	15.4%	15.2%	15.9%	17.4%	11.9%	16.0%	15.9%	20.1%	19.4%	18.1%	18.4%	0.0%
6	*E100_15_1_6*	0.0%	16.4%	13.0%	12.2%	11.6%	9.5%	13.8%	15.7%	11.6%	14.0%	12.8%	14.2%	14.2%	1.0%
7	*E100_15_1_7*	2.5%	12.5%	13.0%	17.7%	12.8%	13.0%	15.9%	19.5%	12.8%	13.6%	13.7%	13.3%	13.3%	0.0%
8	*E100_15_1_8*	5.9%	15.7%	8.8%	16.6%	9.8%	7.6%	12.4%	15.5%	9.3%	14.4%	14.0%	12.0%	11.5%	0.0%
9	*E100_15_1_9*	7.4%	24.8%	14.3%	18.4%	15.1%	12.3%	18.6%	29.2%	14.1%	22.3%	16.7%	19.7%	18.9%	0.0%
10	*E100_15_1_10*	7.9%	10.8%	5.3%	8.0%	6.2%	6.1%	6.9%	11.8%	6.0%	9.6%	8.7%	8.4%	8.7%	0.0%
11	*E100_15_2_1*	13.6%	27.7%	10.4%	31.1%	7.9%	0.0%	26.4%	40.0%	7.9%	23.8%	28.6%	24.4%	20.5%	1.2%
12	*E100_15_2_2*	11.9%	31.6%	9.8%	33.1%	2.7%	10.8%	30.5%	39.4%	2.7%	48.1%	37.3%	32.0%	30.7%	0.0%
13	*E100_15_2_3*	8.2%	17.0%	5.5%	16.1%	2.9%	8.8%	13.7%	18.1%	2.9%	13.9%	11.6%	14.6%	11.2%	0.0%
14	*E100_15_2_4*	21.2%	46.9%	19.3%	60.4%	16.4%	16.6%	39.7%	51.4%	16.4%	56.9%	42.9%	45.4%	42.5%	0.0%
15	*E100_15_2_5*	10.1%	23.6%	5.8%	24.3%	8.1%	8.0%	19.0%	34.9%	8.1%	31.1%	28.7%	23.4%	19.0%	0.0%
16	*E100_15_2_6*	12.1%	27.8%	3.4%	33.2%	0.0%	10.0%	33.2%	43.2%	0.2%	39.6%	47.6%	36.4%	39.4%	1.9%
17	*E100_15_2_7*	9.1%	24.5%	4.6%	37.3%	0.0%	10.7%	35.6%	29.6%	0.0%	30.1%	24.5%	23.6%	17.1%	0.0%
18	*E100_15_2_8*	9.9%	23.9%	11.8%	20.3%	7.9%	6.4%	20.5%	25.2%	7.9%	32.9%	28.3%	31.7%	21.3%	0.0%
19	*E100_15_2_9*	14.5%	21.3%	16.5%	39.8%	7.9%	11.4%	39.2%	46.4%	7.9%	42.1%	43.6%	43.4%	43.6%	0.0%
20	*E100_15_2_10*	3.1%	20.1%	7.8%	34.5%	1.1%	0.0%	16.7%	35.9%	1.1%	20.6%	27.0%	21.7%	22.7%	0.6%
21	*E100_15_3_1*	11.5%	38.9%	26.9%	31.6%	22.1%	21.0%	26.2%	44.4%	23.7%	49.5%	48.5%	45.5%	43.8%	0.0%
22	*E100_15_3_2*	27.2%	36.9%	21.1%	35.6%	10.9%	20.5%	36.8%	48.8%	23.9%	48.8%	43.6%	43.1%	39.6%	0.0%
23	*E100_15_3_3*	8.0%	18.9%	19.9%	27.5%	8.5%	11.2%	21.8%	19.1%	4.0%	35.4%	28.7%	34.1%	26.6%	0.0%
24	*E100_15_3_4*	20.5%	21.7%	12.3%	34.6%	17.7%	26.4%	24.6%	28.3%	6.9%	40.7%	42.4%	37.2%	33.3%	0.0%
25	*E100_15_3_5*	2.5%	11.2%	10.0%	15.1%	12.4%	8.9%	14.4%	19.2%	1.6%	35.7%	22.0%	48.7%	41.1%	0.0%
26	*E100_15_3_6*	8.7%	16.9%	8.1%	29.3%	8.9%	18.5%	17.2%	36.4%	18.4%	27.3%	51.9%	40.3%	44.6%	0.0%
27	*E100_15_3_7*	14.1%	31.1%	16.8%	21.1%	10.9%	18.3%	19.0%	29.0%	15.1%	34.1%	33.9%	35.0%	29.7%	0.0%
28	*E100_15_3_8*	16.9%	21.5%	15.3%	42.2%	9.2%	28.7%	18.0%	36.1%	14.5%	31.6%	39.8%	33.1%	32.7%	0.0%
29	*E100_15_3_9*	7.0%	11.5%	17.7%	14.7%	4.2%	9.1%	22.9%	27.1%	18.8%	55.6%	43.4%	47.7%	46.2%	0.0%
30	*E100_15_3_10*	17.9%	33.2%	11.9%	31.2%	7.1%	25.1%	14.6%	28.6%	10.3%	36.6%	40.0%	27.9%	29.7%	0.0%
31	*E100_15_4_1*	12.8%	17.5%	21.6%	4.3%	21.4%	21.4%	25.3%	41.5%	16.7%	60.6%	32.7%	89.4%	65.9%	0.0%
32	*E100_15_4_2*	0.0%	27.1%	26.8%	27.6%	21.5%	16.3%	18.2%	30.9%	15.1%	29.4%	50.7%	51.4%	44.9%	6.8%
33	*E100_15_4_3*	0.0%	59.4%	28.5%	44.2%	31.3%	52.2%	34.2%	69.2%	38.9%	73.5%	94.3%	80.4%	72.3%	28.1%
34	*E100_15_4_4*	0.0%	43.8%	19.9%	50.8%	51.9%	46.3%	37.2%	59.7%	43.0%	71.0%	48.3%	78.1%	72.2%	20.4%
35	*E100_15_4_5*	0.0%	47.6%	29.2%	15.0%	21.0%	24.9%	22.5%	47.6%	26.2%	64.1%	83.1%	54.2%	66.7%	5.4%
36	*E100_15_4_6*	12.6%	25.9%	28.8%	33.4%	16.9%	35.9%	23.8%	41.1%	16.4%	67.7%	60.9%	93.0%	101.8%	0.0%
37	*E100_15_4_7*	0.0%	36.7%	23.6%	27.8%	24.1%	30.3%	11.7%	40.4%	6.6%	63.2%	52.3%	31.2%	77.6%	1.8%
38	*E100_15_4_8*	0.0%	43.5%	29.0%	21.3%	4.5%	33.1%	49.7%	39.9%	21.3%	61.8%	65.0%	56.6%	61.6%	13.6%
39	*E100_15_4_9*	0.0%	42.5%	25.1%	56.5%	44.5%	53.0%	50.7%	70.5%	44.7%	81.1%	75.0%	67.9%	71.5%	26.5%
40	*E100_15_4_10*	1.1%	42.1%	12.5%	19.7%	16.6%	38.8%	29.7%	34.7%	38.1%	65.0%	53.9%	53.0%	47.8%	0.0%
	Average Deviatian	8.2%	26.8%	15.9%	27.2%	13.7%	18.5%	23.5%	33.6%	14.6%	38.0%	37.0%	37.7%	36.9%	2.7%

Table A.17 Overload objective function values for 200-activity instances (1/4)

No.	Project name & performance	Early Start Objective Function	Upper Bound	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
				Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start	Multi	
1	*E200_1_1_1*	*2079*	*1728*	2011	1980	1999	1999	2022	2062	1960	1932	2022	1994	2102	1993	2021	1728
2	*E200_1_1_2*	*1945*	*1501*	1983	1821	1836	1790	1812	1750	1864	1753	1818	1878	1867	1858	1858	1501
3	*E200_1_1_3*	*1789*	*1384*	1871	1687	1598	1621	1621	1692	1711	1604	1621	1755	1718	1707	1749	1384
4	*E200_1_1_4*	*1765*	*1456*	1788	1666	1704	1682	1704	1684	1683	1688	1692	1793	1787	1794	1842	1456
5	*E200_1_1_5*	*1715*	*1442*	1959	1618	1686	1644	1659	1769	1595	1592	1659	1773	1747	1752	1771	1442
6	*E200_1_1_6*	*1739*	*1540*	1721	1695	1711	1707	1692	1705	1753	1709	1705	1749	1777	1712	1766	1540
7	*E200_1_1_7*	*1829*	*1486*	1983	1774	1756	1666	1750	1813	1757	1817	1752	1816	1852	1780	1815	1486
8	*E200_1_1_8*	*1689*	*1395*	1976	1667	1664	1536	1613	1698	1604	1615	1613	1642	1691	1638	1698	1395
9	*E200_1_1_9*	*1929*	*1546*	1867	1822	1809	1939	1805	1814	1929	1778	1820	1888	1920	1908	1952	1546
10	*E200_1_1_10*	*1624*	*1355*	1712	1626	1559	1596	1554	1666	1613	1669	1554	1580	1622	1585	1590	1355
11	*E200_1_2_1*	*1654*	*1046*	1303	1189	1358	1127	1381	1220	1171	1186	1372	1415	1406	1415	1315	1046
12	*E200_1_2_2*	*1493*	*1279*	1369	1379	1391	1311	1431	1356	1346	1340	1409	1389	1425	1414	1416	1279
13	*E200_1_2_3*	*1695*	*908*	1312	1119	1334	1138	1383	1150	1226	1119	1382	1239	1321	1448	1321	908
14	*E200_1_2_4*	*1519*	*1096*	1370	1259	1335	1222	1339	1252	1316	1230	1332	1388	1386	1399	1343	1096
15	*E200_1_2_5*	*1736*	*1220*	1458	1474	1436	1393	1425	1405	1493	1487	1421	1505	1479	1496	1495	1220
16	*E200_1_2_6*	*1670*	*894*	1362	1130	1277	1056	1293	1194	1122	1040	1279	1333	1453	1527	1414	894
17	*E200_1_2_7*	*1497*	*1168*	1374	1342	1341	1191	1364	1315	1271	1369	1366	1359	1292	1419	1371	1168
18	*E200_1_2_8*	*1961*	*1648*	1948	1921	1863	1785	1861	1858	1752	1839	1865	1877	1863	1893	1843	1648
19	*E200_1_2_9*	*1718*	*1258*	1510	1421	1493	1394	1537	1496	1583	1362	1520	1611	1559	1547	1565	1258
20	*E200_1_2_10*	*1951*	*1531*	1658	1597	1748	1614	1782	1726	1814	1578	1750	1644	1663	1748	1731	1531
21	*E200_1_3_1*	*1820*	*1364*	1484	1451	1528	1479	1611	1551	1498	1460	1608	1630	1549	1579	1576	1364
22	*E200_1_3_2*	*1626*	*1107*	1355	1206	1357	1185	1342	1200	1252	1177	1353	1263	1384	1415	1271	1107
23	*E200_1_3_3*	*1764*	*1216*	1291	1292	1502	1278	1535	1405	1360	1216	1489	1553	1547	1614	1452	1218
24	*E200_1_3_4*	*1593*	*969*	1087	1138	1206	1037	1347	1222	1154	970	1315	1289	1234	1378	1182	969
25	*E200_1_3_5*	*1664*	*1083*	1205	1142	1295	1154	1356	1233	1227	1083	1338	1524	1428	1455	1376	1102
26	*E200_1_3_6*	*1661*	*1145*	1229	1309	1396	1227	1494	1321	1341	1183	1524	1292	1268	1336	1199	1145
27	*E200_1_3_7*	*1533*	*854*	875	1033	1190	894	1239	1075	1129	943	1253	1264	1352	1359	1233	854
28	*E200_1_3_8*	*1805*	*1442*	1571	1534	1733	1559	1671	1644	1570	1544	1685	1678	1628	1677	1624	1442
29	*E200_1_3_9*	*1634*	*1076*	1154	1208	1303	1192	1376	1195	1218	1076	1388	1470	1418	1416	1428	1076
30	*E200_1_3_10*	*1724*	*1204*	1245	1253	1336	1264	1419	1317	1246	1215	1415	1438	1393	1405	1367	1204
31	*E200_1_4_1*	*1207*	*578*	643	734	805	578	899	755	881	578	796	1033	1048	1003	964	599
32	*E200_1_4_2*	*800*	*168*	349	323	559	293	556	342	533	269	502	851	801	860	838	168
33	*E200_1_4_3*	*873*	*300*	336	462	585	407	542	388	501	328	552	777	785	746	739	300
34	*E200_1_4_4*	*944*	*315*	368	443	550	435	677	503	551	340	618	781	756	951	642	315
35	*E200_1_4_5*	*971*	*393*	479	510	612	417	629	446	500	481	538	1044	890	776	1017	393
36	*E200_1_4_6*	*761*	*225*	232	367	503	343	536	289	483	289	391	942	896	775	817	225
37	*E200_1_4_7*	*1089*	*305*	421	488	618	471	727	598	654	363	675	937	995	943	806	305
38	*E200_1_4_8*	*1154*	*306*	479	400	690	473	608	473	642	393	665	1076	904	955	1002	306
39	*E200_1_4_9*	*1027*	*259*	361	387	635	424	624	453	551	300	614	834	1123	1147	827	259
40	*E200_1_4_10*	*1202*	*205*	391	417	541	375	551	436	479	290	584	1072	1085	1163	1078	205

Table A.18 Overload objective function deviations for 200-activity instances (1/4)

No.	Project name & performance	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
		Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
1	*E200_1_1_1*	16.4%	14.6%	15.7%	15.7%	17.0%	19.3%	13.4%	11.8%	17.0%	15.4%	21.6%	15.3%	17.0%	0.0%
2	*E200_1_1_2*	32.1%	21.3%	22.3%	19.3%	20.7%	16.6%	24.2%	16.8%	21.1%	25.1%	24.4%	23.8%	23.8%	0.0%
3	*E200_1_1_3*	35.2%	21.9%	15.5%	17.1%	17.1%	22.3%	23.6%	15.9%	17.1%	26.8%	24.1%	23.3%	26.4%	0.0%
4	*E200_1_1_4*	22.8%	14.4%	17.0%	15.5%	17.0%	15.7%	15.6%	15.9%	16.2%	23.1%	22.7%	23.2%	26.5%	0.0%
5	*E200_1_1_5*	35.9%	12.2%	16.9%	14.0%	15.0%	22.7%	10.6%	10.4%	15.0%	23.0%	21.2%	21.5%	22.8%	0.0%
6	*E200_1_1_6*	11.8%	10.1%	11.1%	10.8%	9.9%	10.7%	13.8%	11.0%	10.7%	13.6%	15.4%	11.2%	14.7%	0.0%
7	*E200_1_1_7*	33.4%	19.4%	18.2%	12.1%	17.8%	22.0%	18.2%	22.3%	17.9%	22.2%	24.6%	19.8%	22.1%	0.0%
8	*E200_1_1_8*	41.6%	19.5%	19.3%	10.1%	15.6%	21.7%	15.0%	15.8%	15.6%	17.7%	21.2%	17.4%	21.7%	0.0%
9	*E200_1_1_9*	20.8%	17.9%	17.0%	25.4%	16.8%	17.3%	24.8%	15.0%	17.7%	22.1%	24.2%	23.4%	26.3%	0.0%
10	*E200_1_1_10*	26.3%	20.0%	15.1%	17.8%	14.7%	23.0%	19.0%	23.2%	14.7%	16.6%	19.7%	17.0%	17.3%	0.0%
11	*E200_1_2_1*	24.6%	13.7%	29.8%	7.7%	32.0%	16.6%	12.0%	13.4%	31.2%	35.3%	34.4%	35.3%	25.7%	0.0%
12	*E200_1_2_2*	7.0%	7.8%	8.8%	2.5%	11.9%	6.0%	5.2%	4.8%	10.2%	8.6%	11.4%	10.6%	10.7%	0.0%
13	*E200_1_2_3*	44.5%	23.2%	46.9%	25.3%	52.3%	26.7%	35.0%	23.2%	52.2%	36.5%	45.5%	59.5%	45.5%	0.0%
14	*E200_1_2_4*	25.0%	14.9%	21.8%	11.5%	22.2%	14.2%	20.1%	12.2%	21.5%	26.6%	26.5%	27.6%	22.5%	0.0%
15	*E200_1_2_5*	19.5%	20.8%	17.7%	14.2%	16.8%	15.2%	22.4%	21.9%	16.5%	23.4%	21.2%	22.6%	22.5%	0.0%
16	*E200_1_2_6*	52.3%	26.4%	42.8%	18.1%	44.6%	33.6%	25.5%	16.3%	43.1%	49.1%	62.5%	70.8%	58.2%	0.0%
17	*E200_1_2_7*	17.6%	14.9%	14.8%	2.0%	16.8%	12.6%	8.8%	17.2%	17.0%	16.4%	10.6%	21.5%	17.4%	0.0%
18	*E200_1_2_8*	18.2%	16.6%	13.0%	8.3%	12.9%	12.7%	6.3%	11.6%	13.2%	13.9%	13.0%	14.9%	11.8%	0.0%
19	*E200_1_2_9*	20.0%	13.0%	18.7%	10.8%	22.2%	18.9%	25.8%	8.3%	20.8%	28.1%	23.9%	23.0%	24.4%	0.0%
20	*E200_1_2_10*	8.3%	4.3%	14.2%	5.4%	16.4%	12.7%	18.5%	3.1%	14.3%	7.4%	8.6%	14.2%	13.1%	0.0%
21	*E200_1_3_1*	8.8%	6.4%	12.0%	8.4%	18.1%	13.7%	9.8%	7.0%	17.9%	19.5%	13.6%	15.8%	15.5%	0.0%
22	*E200_1_3_2*	22.4%	8.9%	22.6%	7.0%	21.2%	8.4%	13.1%	6.3%	22.2%	14.1%	25.0%	27.8%	14.8%	0.0%
23	*E200_1_3_3*	6.2%	6.3%	23.5%	5.1%	26.2%	15.5%	11.8%	0.0%	22.5%	27.7%	27.2%	32.7%	19.4%	0.2%
24	*E200_1_3_4*	12.2%	17.4%	24.5%	7.0%	39.0%	26.1%	19.1%	0.1%	35.7%	33.0%	27.3%	42.2%	22.0%	0.0%
25	*E200_1_3_5*	11.3%	5.4%	19.6%	6.6%	25.2%	13.9%	13.3%	0.0%	23.5%	40.7%	31.9%	34.3%	27.1%	1.8%
26	*E200_1_3_6*	7.3%	14.3%	21.9%	7.2%	30.5%	15.4%	17.1%	3.3%	33.1%	12.8%	10.7%	16.7%	4.7%	0.0%
27	*E200_1_3_7*	2.5%	21.0%	39.3%	4.7%	45.1%	25.9%	32.2%	10.4%	46.7%	48.0%	58.3%	59.1%	44.4%	0.0%
28	*E200_1_3_8*	8.9%	6.4%	20.2%	8.1%	15.9%	14.0%	8.9%	7.1%	16.9%	16.4%	12.9%	16.3%	12.6%	0.0%
29	*E200_1_3_9*	7.2%	12.3%	21.1%	10.8%	27.9%	11.1%	13.2%	0.0%	29.0%	36.6%	31.8%	31.6%	32.7%	0.0%
30	*E200_1_3_10*	3.4%	4.1%	11.0%	5.0%	17.9%	9.4%	3.5%	0.9%	17.5%	19.4%	15.7%	16.7%	13.5%	0.0%
31	*E200_1_4_1*	11.2%	27.0%	39.3%	0.0%	55.5%	30.6%	52.4%	0.0%	37.7%	78.7%	81.3%	73.5%	66.8%	3.6%
32	*E200_1_4_2*	107.7%	92.3%	232.7%	74.4%	231.0%	103.6%	217.3%	60.1%	198.8%	406.5%	376.8%	411.9%	398.8%	0.0%
33	*E200_1_4_3*	12.0%	54.0%	95.0%	35.7%	80.7%	29.3%	67.0%	9.3%	84.0%	159.0%	161.7%	148.7%	146.3%	0.0%
34	*E200_1_4_4*	16.8%	40.6%	74.6%	38.1%	114.9%	59.7%	74.9%	7.9%	96.2%	147.9%	140.0%	201.9%	103.8%	0.0%
35	*E200_1_4_5*	21.9%	29.8%	55.7%	6.1%	60.1%	13.5%	27.2%	22.4%	36.9%	165.6%	126.5%	97.5%	158.8%	0.0%
36	*E200_1_4_6*	3.1%	63.1%	123.6%	52.4%	138.2%	28.4%	114.7%	28.4%	73.8%	318.7%	298.2%	244.4%	263.1%	0.0%
37	*E200_1_4_7*	38.0%	60.0%	102.6%	54.4%	138.4%	96.1%	114.4%	19.0%	121.3%	207.2%	226.2%	209.2%	164.3%	0.0%
38	*E200_1_4_8*	56.5%	30.7%	125.5%	54.6%	98.7%	54.6%	109.8%	28.4%	117.3%	251.6%	195.4%	212.1%	227.5%	0.0%
39	*E200_1_4_9*	39.4%	49.4%	145.2%	63.7%	140.9%	74.9%	112.7%	15.8%	137.1%	222.0%	333.6%	342.9%	219.3%	0.0%
40	*E200_1_4_10*	90.7%	103.4%	163.9%	82.9%	168.8%	112.7%	133.7%	41.5%	184.9%	422.9%	429.3%	467.3%	425.9%	0.0%
	Average Deviatian	25.0%	24.5%	44.3%	19.9%	47.6%	27.9%	38.1%	14.0%	43.9%	77.5%	77.5%	80.0%	71.3%	0.1%

Table A.19 Overload objective function values for 200-activity instances (2/4)

No.	Project name & performance	Early Start Objective Function	Upper Bound	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
				Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start	Multi	
1	*E200_5_1_1*	*7542*	*6491*	6931	7408	7535	7528	7492	7351	7625	7409	7496	7514	7346	7408	7383	6491
2	*E200_5_1_2*	*7368*	*6138*	6892	7328	7203	6902	7298	7336	7117	7094	7298	7182	7252	7273	7158	6138
3	*E200_5_1_3*	*7019*	*5856*	6103	6736	6831	6802	6889	6832	7079	6932	6889	6809	6825	6796	6839	5856
4	*E200_5_1_4*	*7554*	*6494*	7281	7440	7497	7606	7477	7542	7386	7423	7447	7662	7685	7627	7663	6494
5	*E200_5_1_5*	*6332*	*5503*	5891	6244	6271	6217	6249	6337	6327	6283	6242	6371	6328	6406	6380	5503
6	*E200_5_1_6*	*7137*	*6252*	6842	6975	7085	6887	7102	6958	7047	7020	7103	6881	7039	6897	6731	6252
7	*E200_5_1_7*	*7066*	*5997*	6729	6937	6995	6925	6988	6948	6935	6838	6994	7039	6870	7126	7225	5997
8	*E200_5_1_8*	*7258*	*6048*	6956	7015	7088	7140	7072	6884	7068	7202	7072	7011	7319	7092	7127	6048
9	*E200_5_1_9*	*7724*	*6786*	7073	7732	7574	7712	7545	7594	7776	7791	7673	7839	7738	7471	7658	6786
10	*E200_5_1_10*	*7197*	*6256*	6796	7142	7186	7229	7119	7109	7328	7272	7119	7184	7099	7050	7082	6256
11	*E200_5_2_1*	*7897*	*5729*	6674	6868	6788	6997	6906	6574	6910	7172	6915	7679	7035	7547	7273	5729
12	*E200_5_2_2*	*8080*	*6760*	7132	7707	7457	7678	7511	7775	7555	8031	7540	7912	8199	8103	7765	6760
13	*E200_5_2_3*	*7422*	*6798*	7341	7569	7327	7327	7196	7636	7171	7383	7236	7495	7486	7377	7433	6798
14	*E200_5_2_4*	*8563*	*6145*	7256	7489	7258	7837	7269	7283	7293	7659	7269	8289	8039	8379	7897	6145
15	*E200_5_2_5*	*7350*	*6352*	7094	7283	6821	7282	6860	7294	6883	7223	6781	7352	7278	7482	7190	6352
16	*E200_5_2_6*	*8183*	*6027*	6941	7371	7176	7420	7141	7282	7673	7461	7085	8146	7746	7863	7699	6027
17	*E200_5_2_7*	*7913*	*7134*	7770	7743	7652	7768	7686	7745	7558	7766	7709	7885	7824	7903	7815	7134
18	*E200_5_2_8*	*7905*	*6728*	7376	7383	7608	7437	7566	7451	7325	7306	7576	7746	7766	7693	7632	6728
19	*E200_5_2_9*	*8486*	*5914*	6458	7921	6650	7465	6947	6775	7107	7964	6956	8250	8348	8056	7942	5914
20	*E200_5_2_10*	*7715*	*5423*	6729	7093	6091	6263	6060	6472	6768	6858	6087	7200	7368	6983	6975	5423
21	*E200_5_3_1*	*8220*	*6077*	6716	6598	6938	6894	6957	6833	6854	6715	6966	7511	7643	7432	7398	6077
22	*E200_5_3_2*	*7772*	*6381*	7113	6894	6882	6899	6864	6928	6807	6912	6870	7394	7558	7479	7298	6381
23	*E200_5_3_3*	*7271*	*4461*	4716	5491	4927	5428	5259	5044	5287	5531	5143	6797	6746	6599	6377	4461
24	*E200_5_3_4*	*7660*	*5833*	6588	7003	6468	6616	6502	6649	6400	6603	6463	7423	7264	7337	7178	5833
25	*E200_5_3_5*	*8358*	*6720*	7405	7201	7234	7038	7501	7448	7135	7244	7379	8127	8037	7853	7723	6720
26	*E200_5_3_6*	*7723*	*5470*	6040	6150	6223	6267	6337	5944	6179	6219	6087	6298	6695	7073	6442	5470
27	*E200_5_3_7*	*7797*	*6093*	6526	6752	7099	6685	6937	6782	6747	6816	6699	6996	6996	7262	7143	6093
28	*E200_5_3_8*	*7849*	*5149*	6016	6290	5803	5937	6309	6067	6000	5956	6124	6758	6808	6902	6420	5149
29	*E200_5_3_9*	*7988*	*6265*	6830	6863	6910	6966	6750	6847	7077	6854	6819	7469	7131	7222	7367	6265
30	*E200_5_3_10*	*8192*	*5599*	6395	6663	6474	6519	6356	6414	6562	6667	6508	7417	7863	7444	7433	5599
31	*E200_5_4_1*	*4712*	*2308*	2525	2783	3251	3069	3301	3135	3122	2949	3145	4437	4843	4593	4704	2308
32	*E200_5_4_2*	*3789*	*2320*	2320	2690	2858	3151	2700	2812	3031	2815	2764	3730	3784	3857	4017	2449
33	*E200_5_4_3*	*4671*	*2035*	2380	2662	3216	3000	3034	3025	3245	2735	3188	3796	3815	4042	3964	2035
34	*E200_5_4_4*	*5091*	*2322*	2408	3173	3213	3074	2979	3079	3458	3190	3185	4500	4530	4230	4320	2322
35	*E200_5_4_5*	*3946*	*1761*	1827	2229	2717	2383	2573	2361	2978	2743	2508	3902	4162	3368	3965	1761
36	*E200_5_4_6*	*5086*	*2311*	2329	3278	3156	2923	2793	3110	3115	3584	3074	4993	4762	4714	5027	2311
37	*E200_5_4_7*	*4881*	*2404*	2780	3058	3410	3094	3582	3073	3220	3066	3196	4349	4373	4380	4412	2404
38	*E200_5_4_8*	*4616*	*1991*	2671	3070	3272	2837	3414	3150	3446	2807	3170	4452	4326	4475	4657	1991
39	*E200_5_4_9*	*3954*	*2099*	2206	2749	2562	2631	2837	2620	2606	2706	2824	4154	4036	4072	4003	2099
40	*E200_5_4_10*	*3993*	*2068*	2068	3162	3063	3044	2999	2708	3036	3327	3248	3596	4124	3876	3897	2080

Table A.20 Overload objective function deviations for 200-activity instances (2/4)

No.	Project name & performance	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
		Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
1	*E200_5_1_1*	6.8%	14.1%	16.1%	16.0%	15.4%	13.2%	17.5%	14.1%	15.5%	15.8%	13.2%	14.1%	13.7%	0.0%
2	*E200_5_1_2*	12.3%	19.4%	17.4%	12.4%	18.9%	19.5%	15.9%	15.6%	18.9%	17.0%	18.1%	18.5%	16.6%	0.0%
3	*E200_5_1_3*	4.2%	15.0%	16.6%	16.2%	17.6%	16.7%	20.9%	18.4%	17.6%	16.3%	16.5%	16.1%	16.8%	0.0%
4	*E200_5_1_4*	12.1%	14.6%	15.4%	17.1%	15.1%	16.1%	13.7%	14.3%	14.7%	18.0%	18.3%	17.4%	18.0%	0.0%
5	*E200_5_1_5*	7.1%	13.5%	14.0%	13.0%	13.6%	15.2%	15.0%	14.2%	13.4%	15.8%	15.0%	16.4%	15.9%	0.0%
6	*E200_5_1_6*	9.4%	11.6%	13.3%	10.2%	13.6%	11.3%	12.7%	12.3%	13.6%	10.1%	12.6%	10.3%	7.7%	0.0%
7	*E200_5_1_7*	12.2%	15.7%	16.6%	15.5%	16.5%	15.9%	15.6%	14.0%	16.6%	17.4%	14.6%	18.8%	20.5%	0.0%
8	*E200_5_1_8*	15.0%	16.0%	17.2%	18.1%	16.9%	13.8%	16.9%	19.1%	16.9%	15.9%	21.0%	17.3%	17.8%	0.0%
9	*E200_5_1_9*	4.2%	13.9%	11.6%	13.6%	11.2%	11.9%	14.6%	14.8%	13.1%	15.5%	14.0%	10.1%	12.8%	0.0%
10	*E200_5_1_10*	8.6%	14.2%	14.9%	15.6%	13.8%	13.6%	17.1%	16.2%	13.8%	14.8%	13.5%	12.7%	13.2%	0.0%
11	*E200_5_2_1*	16.5%	19.9%	18.5%	22.1%	20.5%	14.7%	20.6%	25.2%	20.7%	34.0%	22.8%	31.7%	27.0%	0.0%
12	*E200_5_2_2*	5.5%	14.0%	10.3%	13.6%	11.1%	15.0%	11.8%	18.8%	11.5%	17.0%	21.3%	19.9%	14.9%	0.0%
13	*E200_5_2_3*	8.0%	11.3%	7.8%	7.8%	5.9%	12.3%	5.5%	8.6%	6.4%	10.3%	10.1%	8.5%	9.3%	0.0%
14	*E200_5_2_4*	18.1%	21.9%	18.1%	27.5%	18.3%	18.5%	18.7%	24.6%	18.3%	34.9%	30.8%	36.4%	28.5%	0.0%
15	*E200_5_2_5*	11.7%	14.7%	7.4%	14.6%	8.0%	14.8%	8.4%	13.7%	6.8%	15.7%	14.6%	17.8%	13.2%	0.0%
16	*E200_5_2_6*	15.2%	22.3%	19.1%	23.1%	18.5%	20.8%	27.3%	23.8%	17.6%	35.2%	28.5%	30.5%	27.7%	0.0%
17	*E200_5_2_7*	8.9%	8.5%	7.3%	8.9%	7.7%	8.6%	5.9%	8.9%	8.1%	10.5%	9.7%	10.8%	9.5%	0.0%
18	*E200_5_2_8*	9.6%	9.7%	13.1%	10.5%	12.5%	10.7%	8.9%	8.6%	12.6%	15.1%	15.4%	14.3%	13.4%	0.0%
19	*E200_5_2_9*	9.2%	33.9%	12.4%	26.2%	17.5%	14.6%	20.2%	34.7%	17.6%	39.5%	41.2%	36.2%	34.3%	0.0%
20	*E200_5_2_10*	24.1%	30.8%	12.3%	15.5%	11.7%	19.3%	24.8%	26.5%	12.2%	32.8%	35.9%	28.8%	28.6%	0.0%
21	*E200_5_3_1*	10.5%	8.6%	14.2%	13.4%	14.5%	12.4%	12.8%	10.5%	14.6%	23.6%	25.8%	22.3%	21.7%	0.0%
22	*E200_5_3_2*	11.5%	8.0%	7.9%	8.1%	7.6%	8.6%	6.7%	8.3%	7.7%	15.9%	18.4%	17.2%	14.4%	0.0%
23	*E200_5_3_3*	5.7%	23.1%	10.4%	21.7%	17.9%	13.1%	18.5%	24.0%	15.3%	52.4%	51.2%	47.9%	43.0%	0.0%
24	*E200_5_3_4*	12.9%	20.1%	10.9%	13.4%	11.5%	14.0%	9.7%	13.2%	10.8%	27.3%	24.5%	25.8%	23.1%	0.0%
25	*E200_5_3_5*	10.2%	7.2%	7.6%	4.7%	11.6%	10.8%	6.2%	7.8%	9.8%	20.9%	19.6%	16.9%	14.9%	0.0%
26	*E200_5_3_6*	10.4%	12.4%	13.8%	14.6%	15.9%	8.7%	13.0%	13.7%	11.3%	15.1%	22.4%	29.3%	17.8%	0.0%
27	*E200_5_3_7*	7.1%	10.8%	16.5%	9.7%	13.9%	11.3%	10.7%	11.9%	9.9%	14.8%	14.8%	19.2%	17.2%	0.0%
28	*E200_5_3_8*	16.8%	22.2%	12.7%	15.3%	22.5%	17.8%	16.5%	15.7%	18.9%	31.2%	32.2%	34.0%	24.7%	0.0%
29	*E200_5_3_9*	9.0%	9.5%	10.3%	11.2%	7.7%	9.3%	13.0%	9.4%	8.8%	19.2%	13.8%	15.3%	17.6%	0.0%
30	*E200_5_3_10*	14.2%	19.0%	15.6%	16.4%	13.5%	14.6%	17.2%	19.1%	16.2%	32.5%	40.4%	33.0%	32.8%	0.0%
31	*E200_5_4_1*	9.4%	20.6%	40.9%	33.0%	43.0%	35.8%	35.3%	27.8%	36.3%	92.2%	109.8%	99.0%	103.8%	0.0%
32	*E200_5_4_2*	0.0%	15.9%	23.2%	35.8%	16.4%	21.2%	30.6%	21.3%	19.1%	60.8%	63.1%	66.3%	73.1%	5.6%
33	*E200_5_4_3*	17.0%	30.8%	58.0%	47.4%	49.1%	48.6%	59.5%	34.4%	56.7%	86.5%	87.5%	98.6%	94.8%	0.0%
34	*E200_5_4_4*	3.7%	36.6%	38.4%	32.4%	28.3%	32.6%	48.9%	37.4%	37.2%	93.8%	95.1%	82.2%	86.0%	0.0%
35	*E200_5_4_5*	3.7%	26.6%	54.3%	35.3%	46.1%	34.1%	69.1%	55.8%	42.4%	121.6%	136.3%	91.3%	125.2%	0.0%
36	*E200_5_4_6*	0.8%	41.8%	36.6%	26.5%	20.9%	34.6%	34.8%	55.1%	33.0%	116.1%	106.1%	104.0%	117.5%	0.0%
37	*E200_5_4_7*	15.6%	27.2%	41.8%	28.7%	49.0%	27.8%	33.9%	27.5%	32.9%	80.9%	81.9%	82.2%	83.5%	0.0%
38	*E200_5_4_8*	34.2%	54.2%	64.3%	42.5%	71.5%	58.2%	73.1%	41.0%	59.2%	123.6%	117.3%	124.8%	133.9%	0.0%
39	*E200_5_4_9*	5.1%	31.0%	22.1%	25.3%	35.2%	24.8%	24.2%	28.9%	34.5%	97.9%	92.3%	94.0%	90.7%	0.0%
40	*E200_5_4_10*	0.0%	52.9%	48.1%	47.2%	45.0%	30.9%	46.8%	60.9%	57.1%	73.9%	99.4%	87.4%	88.4%	0.6%
	Average Deviatian	10.4%	20.3%	20.7%	20.0%	20.6%	19.2%	22.3%	21.7%	20.4%	40.0%	41.0%	39.4%	39.6%	0.2%

Table A.21 Overload objective function values for 200-activity instances (3/4)

No.	Project name & performance	Early Start Objective Function	Upper Bound	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
				Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start	Multi	
1	*E200_10_1_1*	*16443*	*14875*	15822	16540	16321	16410	16314	16535	16401	16555	16321	16330	16406	16269	16269	14875
2	*E200_10_1_2*	*13339*	*12083*	12570	13363	13147	13369	13135	13181	13315	13574	13135	13191	13217	13074	13072	12083
3	*E200_10_1_3*	*15171*	*13887*	14516	15096	15034	15037	14974	14977	15178	14987	15073	14906	14950	14851	14832	13887
4	*E200_10_1_4*	*14363*	*13388*	13852	14339	14245	14393	14179	14166	14336	14477	14108	14344	14139	14492	14354	13388
5	*E200_10_1_5*	*14785*	*13220*	13595	14587	14617	14833	14550	14430	14700	14966	14550	14687	14645	14763	14717	13220
6	*E200_10_1_6*	*14698*	*13574*	14093	14494	14580	14602	14502	14327	14531	14439	14462	14409	14452	14603	14454	13574
7	*E200_10_1_7*	*14434*	*12787*	13323	14217	14130	14089	14147	14432	13900	14156	14151	14013	14551	14215	13823	12787
8	*E200_10_1_8*	*14695*	*13244*	14125	14238	14215	14565	14233	14151	14416	14559	14233	14584	14346	14603	14470	13244
9	*E200_10_1_9*	*14213*	*12736*	13247	13926	14091	13966	13987	13755	14034	13938	13987	13993	13852	13867	13913	12736
10	*E200_10_1_10*	*15483*	*13740*	14469	15107	15274	15148	15125	15035	15345	14936	15125	15093	15269	15358	15047	13740
11	*E200_10_2_1*	*15756*	*11780*	12993	13912	13159	14979	13509	13086	14396	14741	13388	14559	14669	13941	13578	11780
12	*E200_10_2_2*	*15103*	*12315*	14472	14531	14025	14379	13840	14198	15011	14753	13870	14727	15470	14630	14963	12315
13	*E200_10_2_3*	*15543*	*13217*	14363	15097	14414	15201	14231	14764	14889	15445	14257	14892	15210	14950	14825	13217
14	*E200_10_2_4*	*16415*	*12165*	13509	15019	13668	15421	13552	13522	15218	16138	13555	13753	14926	15319	15222	12165
15	*E200_10_2_5*	*15246*	*13469*	14340	14655	14433	14881	14489	14400	14684	14786	14535	14867	14950	14472	14642	13469
16	*E200_10_2_6*	*16538*	*13034*	14800	15408	14501	15289	14498	14210	15242	15935	14533	15178	15313	14804	14876	13034
17	*E200_10_2_7*	*15316*	*11978*	13079	14340	12812	14406	12885	12604	14233	14921	14862	14981	14811	14616	14616	11978
18	*E200_10_2_8*	*16374*	*14204*	15433	15821	15405	16016	15078	15458	15935	15749	15188	16198	16000	16183	15815	14204
19	*E200_10_2_9*	*15170*	*11321*	13346	14560	12681	14153	12877	13282	13986	15094	12768	14826	14744	14340	14158	11321
20	*E200_10_2_10*	*16567*	*12718*	15007	15748	14561	15426	14803	14834	15379	15707	14721	15823	15645	15595	15634	12718
21	*E200_10_3_1*	*15860*	*12401*	13627	13230	14027	14673	14044	13618	13751	14605	13496	14393	14445	14561	14237	12401
22	*E200_10_3_2*	*15680*	*10152*	11557	11926	11942	12658	11176	11543	11546	12978	11671	14124	14788	13539	13671	10152
23	*E200_10_3_3*	*15562*	*12587*	13840	14065	13529	13853	13656	14132	13657	13710	13704	14760	14559	14665	14357	12587
24	*E200_10_3_4*	*16247*	*12203*	13826	13907	13331	14311	13601	13849	13436	13710	13810	15246	15444	14911	14715	12203
25	*E200_10_3_5*	*16148*	*11759*	13704	13546	12990	13807	12931	13075	13510	13845	12865	14968	14695	14886	14913	11759
26	*E200_10_3_6*	*15019*	*11153*	13395	13399	12830	13089	12983	12639	13060	13273	13076	14706	14485	14316	13903	11153
27	*E200_10_3_7*	*15715*	*11170*	12851	12873	12947	12574	13446	12795	12860	12814	12804	14923	14848	14239	14404	11170
28	*E200_10_3_8*	*16274*	*10539*	12162	13558	12855	12395	12652	12629	12544	12892	12857	14454	15510	14368	13453	10539
29	*E200_10_3_9*	*16750*	*11597*	13437	14040	13420	13988	13426	13235	13346	14428	13458	15470	16111	15787	15110	11597
30	*E200_10_3_10*	*17167*	*13884*	14933	15284	15102	15443	14795	15186	15214	15283	14462	16326	15784	15963	15766	13884
31	*E200_10_4_1*	*9857*	*4893*	5777	6127	6560	6409	6392	6283	6519	6216	6352	7838	8055	7969	7378	4893
32	*E200_10_4_2*	*10234*	*5636*	5636	7262	7305	7532	7375	7156	6687	7877	6804	8790	9352	9487	9270	6332
33	*E200_10_4_3*	*10167*	*4623*	5442	6345	6618	7506	6202	6315	7291	7219	6695	7612	6676	7347	6944	4623
34	*E200_10_4_4*	*9273*	*4400*	4400	6228	5512	6001	5514	5642	6037	6210	5771	7617	7895	8572	8012	4597
35	*E200_10_4_5*	*7900*	*4183*	4344	5385	5300	5078	5103	5194	5342	5324	5492	6815	7524	6691	7413	4183
36	*E200_10_4_6*	*8475*	*3817*	3817	5470	5439	5026	4998	4757	4864	5516	5245	6440	6805	5991	6411	3899
37	*E200_10_4_7*	*8626*	*4070*	4127	5475	5430	5674	5195	5268	5432	5871	5123	7258	7696	7833	6598	4070
38	*E200_10_4_8*	*8971*	*4549*	4588	6386	6142	6250	5750	6199	6616	6675	6138	7327	7720	7807	7807	4549
39	*E200_10_4_9*	*8700*	*4797*	5100	6438	6205	6447	6340	6383	6383	7120	5893	8876	9011	8533	8878	4797
40	*E200_10_4_10*	*8317*	*4454*	4761	6196	5694	5402	5808	6152	5795	5907	5768	6961	6759	7867	6846	4454

Table A.22 Overload objective function deviations for 200-activity instances (3/4)

No.	Project name & performance	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
		Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
1	*E200_10_1_1*	6.4%	11.2%	9.7%	10.3%	9.7%	11.2%	10.3%	11.3%	9.7%	9.8%	10.3%	9.4%	9.4%	0.0%
2	*E200_10_1_2*	4.0%	10.6%	8.8%	10.6%	8.7%	9.1%	10.2%	12.3%	8.7%	9.2%	9.4%	8.2%	8.2%	0.0%
3	*E200_10_1_3*	4.5%	8.7%	8.3%	8.3%	7.8%	7.8%	9.3%	7.9%	8.5%	7.3%	7.7%	6.9%	6.8%	0.0%
4	*E200_10_1_4*	3.5%	7.1%	6.4%	7.5%	5.9%	5.8%	7.1%	8.1%	5.4%	7.1%	5.6%	8.2%	7.2%	0.0%
5	*E200_10_1_5*	2.8%	10.3%	10.6%	12.2%	10.1%	9.2%	11.2%	13.2%	10.1%	11.1%	10.8%	11.7%	11.3%	0.0%
6	*E200_10_1_6*	3.8%	6.8%	7.4%	7.6%	6.8%	5.5%	7.1%	6.4%	6.5%	6.2%	6.5%	7.6%	6.5%	0.0%
7	*E200_10_1_7*	4.2%	11.2%	10.5%	10.2%	10.6%	12.9%	8.7%	10.7%	10.7%	9.6%	13.8%	11.2%	8.1%	0.0%
8	*E200_10_1_8*	6.7%	7.5%	7.3%	10.0%	7.5%	6.8%	8.8%	9.9%	7.5%	10.1%	8.3%	10.3%	9.3%	0.0%
9	*E200_10_1_9*	4.0%	9.3%	10.6%	9.7%	9.8%	8.0%	10.2%	9.4%	9.8%	9.9%	8.8%	8.9%	9.2%	0.0%
10	*E200_10_1_10*	5.3%	9.9%	11.2%	10.2%	10.1%	9.4%	11.7%	8.7%	10.1%	9.8%	11.1%	11.8%	9.5%	0.0%
11	*E200_10_2_1*	10.3%	18.1%	11.7%	27.2%	14.7%	11.1%	22.2%	25.1%	13.7%	23.6%	24.5%	18.3%	15.3%	0.0%
12	*E200_10_2_2*	17.5%	18.0%	13.9%	16.8%	12.4%	15.3%	21.9%	19.8%	12.6%	19.6%	25.6%	18.8%	21.5%	0.0%
13	*E200_10_2_3*	8.7%	14.2%	9.1%	15.0%	7.7%	11.7%	12.7%	16.9%	7.9%	12.7%	15.1%	13.1%	12.2%	0.0%
14	*E200_10_2_4*	11.0%	23.5%	12.4%	26.8%	11.4%	11.2%	25.1%	32.7%	11.4%	13.1%	22.7%	25.9%	25.1%	0.0%
15	*E200_10_2_5*	6.5%	8.8%	7.2%	10.5%	7.6%	6.9%	9.0%	9.8%	7.9%	10.4%	11.0%	7.4%	8.7%	0.0%
16	*E200_10_2_6*	13.5%	18.2%	11.3%	17.3%	11.2%	9.0%	16.9%	22.3%	11.5%	16.4%	17.5%	13.6%	14.1%	0.0%
17	*E200_10_2_7*	9.2%	19.7%	7.0%	20.3%	7.6%	5.2%	18.8%	24.6%	24.1%	25.1%	23.7%	22.0%	22.0%	0.0%
18	*E200_10_2_8*	8.7%	11.4%	8.5%	12.8%	6.2%	8.8%	12.2%	10.9%	6.9%	14.0%	12.6%	13.9%	11.3%	0.0%
19	*E200_10_2_9*	17.9%	28.6%	12.0%	25.0%	13.7%	17.3%	23.5%	33.3%	12.8%	31.0%	30.2%	26.7%	25.1%	0.0%
20	*E200_10_2_10*	18.0%	23.8%	14.5%	21.3%	16.4%	16.6%	20.9%	23.5%	15.7%	24.4%	23.0%	22.6%	22.9%	0.0%
21	*E200_10_3_1*	9.9%	6.7%	13.1%	18.3%	13.2%	9.8%	10.9%	17.8%	8.8%	16.1%	16.5%	17.4%	14.8%	0.0%
22	*E200_10_3_2*	13.8%	17.5%	17.6%	24.7%	10.1%	13.7%	13.7%	27.8%	15.0%	39.1%	45.7%	33.4%	34.7%	0.0%
23	*E200_10_3_3*	10.0%	11.7%	7.5%	10.1%	8.5%	12.3%	8.5%	8.9%	8.9%	17.3%	15.7%	16.5%	14.1%	0.0%
24	*E200_10_3_4*	13.3%	14.0%	9.2%	17.3%	11.5%	13.5%	10.1%	12.3%	13.2%	24.9%	26.6%	22.2%	20.6%	0.0%
25	*E200_10_3_5*	16.5%	15.2%	10.5%	17.4%	10.0%	11.2%	14.9%	17.7%	9.4%	27.3%	25.0%	26.6%	26.8%	0.0%
26	*E200_10_3_6*	20.1%	20.1%	15.0%	17.4%	16.4%	13.3%	17.1%	19.0%	17.2%	31.9%	29.9%	28.4%	24.7%	0.0%
27	*E200_10_3_7*	15.0%	15.2%	15.9%	12.6%	20.4%	14.5%	15.1%	14.7%	14.6%	33.6%	32.9%	27.5%	29.0%	0.0%
28	*E200_10_3_8*	15.4%	28.6%	22.0%	17.6%	20.0%	19.8%	19.0%	22.3%	22.0%	37.1%	47.2%	36.3%	27.6%	0.0%
29	*E200_10_3_9*	15.9%	21.1%	15.7%	20.6%	15.8%	14.1%	15.1%	24.4%	16.0%	33.4%	38.9%	36.1%	30.3%	0.0%
30	*E200_10_3_10*	7.6%	10.1%	8.8%	11.2%	6.6%	9.4%	9.6%	10.1%	4.2%	17.6%	13.7%	15.0%	13.6%	0.0%
31	*E200_10_4_1*	18.1%	25.2%	34.1%	31.0%	30.6%	28.4%	33.2%	27.0%	29.8%	60.2%	64.6%	62.9%	50.8%	0.0%
32	*E200_10_4_2*	0.0%	28.9%	29.6%	33.6%	30.9%	27.0%	18.6%	39.8%	20.7%	56.0%	65.9%	68.3%	64.5%	12.3%
33	*E200_10_4_3*	17.7%	37.2%	43.2%	62.4%	34.2%	36.6%	57.7%	56.2%	44.8%	64.7%	44.4%	58.9%	50.2%	0.0%
34	*E200_10_4_4*	0.0%	41.5%	25.3%	36.4%	25.3%	28.2%	37.2%	41.1%	31.2%	73.1%	79.4%	94.8%	82.1%	4.5%
35	*E200_10_4_5*	3.8%	28.7%	26.7%	21.4%	22.0%	24.2%	27.7%	27.3%	31.3%	62.9%	79.9%	60.0%	77.2%	0.0%
36	*E200_10_4_6*	0.0%	43.3%	42.5%	31.7%	30.9%	24.6%	27.4%	44.5%	37.4%	68.7%	78.3%	57.0%	68.0%	2.1%
37	*E200_10_4_7*	1.4%	34.5%	33.4%	39.4%	27.6%	29.4%	33.5%	44.3%	25.9%	78.3%	89.1%	92.5%	62.1%	0.0%
38	*E200_10_4_8*	0.9%	40.4%	35.0%	37.4%	26.4%	36.3%	45.4%	46.7%	34.9%	61.1%	69.7%	71.6%	71.6%	0.0%
39	*E200_10_4_9*	6.3%	34.2%	29.4%	34.4%	32.2%	33.1%	33.1%	48.4%	22.8%	85.0%	87.8%	77.9%	85.1%	0.0%
40	*E200_10_4_10*	6.9%	39.1%	27.8%	21.3%	30.4%	38.1%	30.1%	32.6%	29.5%	56.3%	51.8%	76.6%	53.7%	0.0%
	Average Deviatian	9.0%	19.8%	16.5%	20.1%	15.5%	15.9%	18.9%	22.5%	16.2%	30.6%	32.5%	31.4%	29.1%	0.5%

Table A.23 Overload objective function values for 200-activity instances (4/4)

No.	Project name & performance	Early Start Objective Function	Upper Bound	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
				Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start	Multi	
1	*E200_15_1_1*	*23722*	*21398*	22515	23269	23367	23550	23426	23520	23422	23120	23442	23185	23342	23300	23330	21398
2	*E200_15_1_2*	*22491*	*20956*	21861	22495	22459	21989	22199	22173	22349	22233	22206	21959	22364	22093	21981	20956
3	*E200_15_1_3*	*23662*	*21512*	22493	23186	23431	23312	23376	23392	23547	23314	23361	23999	23365	23695	23818	21512
4	*E200_15_1_4*	*22019*	*20339*	21514	21873	21816	21858	21891	21851	21891	21948	21828	21995	21964	22253	21875	20339
5	*E200_15_1_5*	*22000*	*20612*	21540	21662	21734	21830	21834	21781	21516	21768	21833	22201	21930	21848	22083	20612
6	*E200_15_1_6*	*21845*	*19785*	20306	21267	21774	21611	21640	21251	21453	21453	21680	21187	21089	21142	21226	19785
7	*E200_15_1_7*	*22076*	*20443*	21233	21891	21852	22021	21641	21590	22082	22176	21641	21956	21803	21873	21939	20443
8	*E200_15_1_8*	*22690*	*20474*	21325	22821	22344	22545	22362	22163	22463	22592	22362	22468	22405	22347	22448	20474
9	*E200_15_1_9*	*22316*	*20563*	21782	22546	21842	22156	21844	22176	22137	22321	21815	22357	22325	22286	22581	20563
10	*E200_15_1_10*	*21909*	*20725*	20983	21909	21642	21572	21607	21960	21804	21841	21618	22128	21748	21809	22170	20725
11	*E200_15_2_1*	*23658*	*17667*	20251	21359	19681	22513	19952	19725	21995	21841	19943	21320	21466	21267	20561	17667
12	*E200_15_2_2*	*25554*	*18858*	21541	23455	21084	24132	21026	21081	22482	24175	21053	24733	24846	24042	23653	18858
13	*E200_15_2_3*	*23851*	*18581*	21613	23312	20840	23319	20712	21130	22383	24795	20712	24600	24874	23583	23904	18581
14	*E200_15_2_4*	*24714*	*18831*	21737	22321	21249	22085	21240	21242	22764	22695	21259	24417	23851	23712	23290	18831
15	*E200_15_2_5*	*24213*	*18334*	21013	22798	20558	22757	20791	21453	21606	24165	20744	24171	23421	24366	23310	18334
16	*E200_15_2_6*	*24247*	*19979*	22074	22555	21726	23843	21121	21602	23474	23625	21149	24414	24236	23540	23489	19979
17	*E200_15_2_7*	*25408*	*21344*	22718	23956	22445	24494	22543	22949	23697	24940	22526	24506	24609	24186	23146	21344
18	*E200_15_2_8*	*23144*	*17262*	20236	22511	19661	21819	19391	18849	21361	23610	19301	23459	21907	22376	21755	17262
19	*E200_15_2_9*	*24821*	*18845*	23104	23692	20842	24188	21039	21541	22884	24364	21076	23624	24659	23681	22985	18845
20	*E200_15_2_10*	*26359*	*21057*	23872	24617	22752	24270	22880	23708	24754	25505	22813	25922	25453	25727	25312	21057
21	*E200_15_3_1*	*24403*	*18737*	21005	20719	21088	21587	21125	20385	20417	22063	21052	22661	22873	22960	22408	18737
22	*E200_15_3_2*	*24186*	*19860*	21865	21905	21590	22507	21194	22215	22252	22086	21457	23566	22599	23083	22567	19860
23	*E200_15_3_3*	*24395*	*20767*	22801	23070	22296	23081	22599	23231	22468	22367	22296	23936	24197	24053	23705	20767
24	*E200_15_3_4*	*24539*	*18795*	20675	22036	21362	20983	21022	21160	21212	21705	20572	22923	22481	23348	22154	18795
25	*E200_15_3_5*	*22554*	*15180*	17636	17764	17053	17654	17023	16900	17236	18270	16640	20177	20074	20699	19608	15180
26	*E200_15_3_6*	*24090*	*17029*	19502	20161	20152	20931	19631	18551	19732	21078	19647	24204	24292	24614	23859	17029
27	*E200_15_3_7*	*25391*	*17438*	20177	21264	20466	20447	19751	20482	19045	22129	19642	25354	24830	23805	24124	17438
28	*E200_15_3_8*	*24016*	*19480*	21049	22195	21280	21803	21187	21613	21652	21903	21012	23611	23960	22656	23071	19480
29	*E200_15_3_9*	*23990*	*19077*	22479	22144	21289	20909	21193	21502	20973	22311	21449	23849	22882	22955	23352	19077
30	*E200_15_3_10*	*24262*	*18140*	19497	22045	21035	21558	20576	20496	21396	20898	20656	24151	24383	22205	22473	18140
31	*E200_15_4_1*	*14852*	*7428*	7995	8710	9451	9451	9856	9608	10237	9160	9533	11916	12716	13323	12346	7428
32	*E200_15_4_2*	*13638*	*6545*	6545	9808	9128	9128	8898	9143	8367	9906	8910	11902	11203	11583	12418	6872
33	*E200_15_4_3*	*15705*	*7389*	8497	9853	9353	9353	9450	9412	10006	9702	9733	11848	11466	10786	11427	7389
34	*E200_15_4_4*	*13094*	*6961*	6965	8502	8367	8367	8552	8413	9247	8120	8971	10408	9526	10346	9213	6961
35	*E200_15_4_5*	*15503*	*7300*	7543	9767	10267	10267	9048	9666	9583	10370	9151	13047	13300	12634	12349	7300
36	*E200_15_4_6*	*13511*	*6715*	6902	8936	8197	8197	8060	8823	9216	9373	8541	10777	11993	13224	10650	6715
37	*E200_15_4_7*	*13316*	*7072*	7480	9701	8492	8492	8688	8918	8703	9329	8898	12937	13069	13157	12813	7072
38	*E200_15_4_8*	*15268*	*8601*	9519	10238	10315	10315	10650	10735	10457	11129	11332	12659	12345	12163	12364	8601
39	*E200_15_4_9*	*12815*	*6661*	8680	10813	10067	10067	9746	10484	10499	13022	9537	12453	12704	13129	12408	6661
40	*E200_15_4_10*	*13350*	*7358*	8849	9253	10179	10179	9462	9114	9595	8547	9653	11937	12355	11371	10714	7358

Table A.24 Overload objective function deviations for 200-activity instances (4/4)

No.	Project name & performance	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
		Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
1	*E200_15_1_1*	5.2%	8.7%	9.2%	10.1%	9.5%	9.9%	9.5%	8.0%	9.6%	8.4%	9.1%	8.9%	9.0%	0.0%
2	*E200_15_1_2*	4.3%	7.3%	7.2%	4.9%	5.9%	5.8%	6.6%	6.1%	6.0%	4.8%	6.7%	5.4%	4.9%	0.0%
3	*E200_15_1_3*	4.6%	7.8%	8.9%	8.4%	8.7%	8.7%	9.5%	8.4%	8.6%	11.6%	8.6%	10.1%	10.7%	0.0%
4	*E200_15_1_4*	5.8%	7.5%	7.3%	7.5%	7.6%	7.4%	7.6%	7.9%	7.3%	8.1%	8.0%	9.4%	7.6%	0.0%
5	*E200_15_1_5*	4.5%	5.1%	5.4%	5.9%	5.9%	5.7%	4.4%	5.6%	5.9%	7.7%	6.4%	6.0%	7.1%	0.0%
6	*E200_15_1_6*	2.6%	7.5%	10.1%	9.2%	9.4%	7.4%	8.4%	8.4%	9.6%	7.1%	6.6%	6.9%	7.3%	0.0%
7	*E200_15_1_7*	3.9%	7.1%	6.9%	7.7%	5.9%	5.6%	8.0%	8.5%	5.9%	7.4%	6.7%	7.0%	7.3%	0.0%
8	*E200_15_1_8*	4.2%	11.5%	9.1%	10.1%	9.2%	8.2%	9.7%	10.3%	9.2%	9.7%	9.4%	9.1%	9.6%	0.0%
9	*E200_15_1_9*	5.9%	9.6%	6.2%	7.7%	6.2%	7.8%	7.7%	8.5%	6.1%	8.7%	8.6%	8.4%	9.8%	0.0%
10	*E200_15_1_10*	1.2%	5.7%	4.4%	4.1%	4.3%	6.0%	5.2%	5.4%	4.3%	6.8%	4.9%	5.2%	7.0%	0.0%
11	*E200_15_2_1*	14.6%	20.9%	11.4%	27.4%	12.9%	11.6%	24.5%	23.6%	12.9%	20.7%	21.5%	20.4%	16.4%	0.0%
12	*E200_15_2_2*	14.2%	24.4%	11.8%	28.0%	11.5%	11.8%	19.2%	28.2%	11.6%	31.2%	31.8%	27.5%	25.4%	0.0%
13	*E200_15_2_3*	16.3%	25.5%	12.2%	25.5%	11.5%	13.7%	20.5%	33.4%	11.5%	32.4%	33.9%	26.9%	28.6%	0.0%
14	*E200_15_2_4*	15.4%	18.5%	12.8%	17.3%	12.8%	12.8%	20.9%	20.5%	12.9%	29.7%	26.7%	25.9%	23.7%	0.0%
15	*E200_15_2_5*	14.6%	24.3%	12.1%	24.1%	13.4%	17.0%	17.8%	31.8%	13.1%	31.8%	27.7%	32.9%	27.1%	0.0%
16	*E200_15_2_6*	10.5%	12.9%	8.7%	19.3%	5.7%	8.1%	17.5%	18.2%	5.9%	22.2%	21.3%	17.8%	17.6%	0.0%
17	*E200_15_2_7*	6.4%	12.2%	5.2%	14.8%	5.6%	7.5%	11.0%	16.8%	5.5%	14.8%	15.3%	13.3%	8.4%	0.0%
18	*E200_15_2_8*	17.2%	30.4%	13.9%	26.4%	12.3%	9.2%	23.7%	36.8%	11.8%	35.9%	26.9%	29.6%	26.0%	0.0%
19	*E200_15_2_9*	22.6%	25.7%	10.6%	28.4%	11.6%	14.3%	21.4%	29.3%	11.8%	25.4%	30.9%	25.7%	22.0%	0.0%
20	*E200_15_2_10*	13.4%	16.9%	8.0%	15.3%	8.7%	12.6%	17.6%	21.1%	8.3%	23.1%	20.9%	22.2%	20.2%	0.0%
21	*E200_15_3_1*	12.1%	10.6%	12.5%	15.2%	12.7%	8.8%	9.0%	17.8%	12.4%	20.9%	22.1%	22.5%	19.6%	0.0%
22	*E200_15_3_2*	10.1%	10.3%	8.7%	13.3%	6.7%	11.9%	12.0%	11.2%	8.0%	18.7%	13.8%	16.2%	13.6%	0.0%
23	*E200_15_3_3*	9.8%	11.1%	7.4%	11.1%	8.8%	11.9%	8.2%	7.7%	7.4%	15.3%	16.5%	15.8%	14.1%	0.0%
24	*E200_15_3_4*	10.0%	17.2%	13.7%	11.6%	11.8%	12.6%	12.9%	15.5%	9.5%	22.0%	19.6%	24.2%	17.9%	0.0%
25	*E200_15_3_5*	16.2%	17.0%	12.3%	16.3%	12.1%	11.3%	13.5%	20.4%	9.6%	32.9%	32.2%	36.4%	29.2%	0.0%
26	*E200_15_3_6*	14.5%	18.4%	18.3%	22.9%	15.3%	8.9%	15.9%	23.8%	15.4%	42.1%	42.7%	44.5%	40.1%	0.0%
27	*E200_15_3_7*	15.7%	21.9%	17.4%	17.3%	13.3%	17.5%	9.2%	26.9%	12.6%	45.4%	42.4%	36.5%	38.3%	0.0%
28	*E200_15_3_8*	8.1%	13.9%	9.2%	11.9%	8.8%	10.9%	11.1%	12.4%	7.9%	21.2%	23.0%	16.3%	18.4%	0.0%
29	*E200_15_3_9*	17.8%	16.1%	11.6%	9.6%	11.1%	12.7%	9.9%	17.0%	12.4%	25.0%	19.9%	20.3%	22.4%	0.0%
30	*E200_15_3_10*	7.5%	21.5%	16.0%	18.8%	13.4%	13.0%	17.9%	15.2%	13.9%	33.1%	34.4%	22.4%	23.9%	0.0%
31	*E200_15_4_1*	7.6%	17.3%	27.2%	27.2%	32.7%	29.3%	37.8%	23.3%	28.3%	60.4%	71.2%	79.4%	66.2%	0.0%
32	*E200_15_4_2*	0.0%	49.9%	39.5%	39.5%	36.0%	39.7%	27.8%	51.4%	36.1%	81.8%	71.2%	77.0%	89.7%	5.0%
33	*E200_15_4_3*	15.0%	33.3%	26.6%	26.6%	27.9%	27.4%	35.4%	31.3%	31.7%	60.3%	55.2%	46.0%	54.6%	0.0%
34	*E200_15_4_4*	0.1%	22.1%	20.2%	20.2%	22.9%	20.9%	32.8%	16.6%	28.9%	49.5%	36.8%	48.6%	32.4%	0.0%
35	*E200_15_4_5*	3.3%	33.8%	40.6%	40.6%	23.9%	32.4%	31.3%	42.1%	25.4%	78.7%	82.2%	73.1%	69.2%	0.0%
36	*E200_15_4_6*	2.8%	33.1%	22.1%	22.1%	20.0%	31.4%	37.2%	39.6%	27.2%	60.5%	78.6%	96.9%	58.6%	0.0%
37	*E200_15_4_7*	5.8%	37.2%	20.1%	20.1%	22.9%	26.1%	23.1%	31.9%	25.8%	82.9%	84.8%	86.0%	81.2%	0.0%
38	*E200_15_4_8*	10.7%	19.0%	19.9%	19.9%	23.8%	24.8%	21.6%	29.4%	31.8%	47.2%	43.5%	41.4%	43.8%	0.0%
39	*E200_15_4_9*	30.3%	62.3%	51.1%	51.1%	46.3%	57.4%	57.6%	95.5%	43.2%	87.0%	90.7%	97.1%	86.3%	0.0%
40	*E200_15_4_10*	20.3%	25.8%	38.3%	38.3%	28.6%	23.9%	30.4%	16.2%	31.2%	62.2%	67.9%	54.5%	45.6%	0.0%
	Average Deviatian	10.1%	19.5%	15.4%	18.9%	14.4%	15.6%	18.1%	22.1%	14.9%	32.4%	32.0%	31.8%	29.0%	0.1%

Table A.25 Overload objective function values for 500-activity instances (1/4)

No.	Project name & performance	Early Start Objective Function	Upper Bound	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
				Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start	Multi	
1	*E500_1_1_1*	*3911*	*3128*	3532	3542	3547	3474	3625	3531	3485	3470	3581	3708	3672	3690	3687	3128
2	*E500_1_1_2*	*4335*	*3870*	4182	4239	4273	4176	4259	4246	4165	4157	4257	4258	4262	4287	4253	3870
3	*E500_1_1_3*	*4119*	*3362*	3528	3813	3925	3731	3978	3821	3851	3739	3977	3979	4023	3965	3937	3362
4	*E500_1_1_4*	*3857*	*3008*	3411	3553	3628	3290	3707	3539	3381	3270	3699	3540	3480	3545	3496	3008
5	*E500_1_1_5*	*4234*	*3190*	3741	3841	3958	3670	3976	3853	3841	3703	3961	4024	4033	4043	4023	3190
6	*E500_1_1_6*	*4148*	*4070*	4145	4122	4134	4111	4140	4108	4101	4122	4139	4131	4130	4137	4130	4070
7	*E500_1_1_7*	*3584*	*2656*	3200	3173	3289	3027	3320	3206	3081	3090	3314	3425	3397	3403	3389	2656
8	*E500_1_1_8*	*3828*	*3176*	3582	3592	3559	3480	3658	3609	3499	3492	3652	3694	3743	3688	3680	3176
9	*E500_1_1_9*	*3811*	*3144*	3529	3585	3615	3373	3643	3678	3417	3374	3652	3599	3619	3630	3609	3144
10	*E500_1_1_10*	*3800*	*3188*	3551	3660	3730	3575	3740	3649	3578	3588	3747	3624	3681	3642	3615	3188
11	*E500_1_2_1*	*4018*	*3106*	3546	3429	3681	3360	3674	3585	3456	3353	3725	3624	3665	3671	3607	3106
12	*E500_1_2_2*	*4059*	*3030*	3457	3344	3662	3198	3664	3465	3395	3276	3706	3688	3778	3753	3619	3030
13	*E500_1_2_3*	*4717*	*3261*	3689	3940	3918	3468	4138	3963	3629	3387	4113	4295	4203	4058	4099	3261
14	*E500_1_2_4*	*4751*	*3532*	4033	4051	4222	3846	4264	4057	3867	3816	4262	4208	4273	4389	4166	3532
15	*E500_1_2_5*	*3844*	*2950*	3562	3377	3457	3267	3458	3450	3267	3301	3533	3545	3626	3626	3551	2950
16	*E500_1_2_6*	*4758*	*3602*	4004	4162	4372	3857	4310	4284	3880	3802	4358	4242	4263	4289	4118	3602
17	*E500_1_2_7*	*4828*	*4015*	4451	4363	4426	4300	4470	4412	4265	4260	4475	4549	4616	4544	4468	4015
18	*E500_1_2_8*	*4631*	*3422*	3955	3959	4156	3771	4134	4209	3933	3795	4166	4208	4177	4250	4059	3422
19	*E500_1_2_9*	*4204*	*2839*	3546	3442	3648	3214	3693	3600	3258	3328	3688	3568	3768	3662	3572	2839
20	*E500_1_2_10*	*4861*	*4248*	4626	4591	4643	4501	4688	4648	4504	4560	4681	4638	4666	4589	4564	4248
21	*E500_1_3_1*	*2783*	*1542*	1940	2085	2053	1805	2156	2033	1991	1971	2199	2515	2481	2525	2365	1542
22	*E500_1_3_2*	*2831*	*1605*	2110	2082	2145	1921	2422	2108	2179	1980	2392	2594	2526	2424	2416	1605
23	*E500_1_3_3*	*3318*	*2254*	2683	2466	2781	2365	2895	2609	2587	2372	2807	2984	3044	2999	2927	2254
24	*E500_1_3_4*	*2993*	*1455*	1697	1847	2087	1665	2348	1998	2008	1505	2257	2823	2670	2500	2488	1455
25	*E500_1_3_5*	*3221*	*2011*	2499	2457	2733	2269	2618	2467	2434	2296	2573	2790	2786	2746	2725	2011
26	*E500_1_3_6*	*2611*	*1513*	1864	1807	1972	1684	2027	1924	1787	1652	2012	2317	2280	2373	2317	1513
27	*E500_1_3_7*	*3205*	*2013*	2367	2537	2719	2372	2730	2531	2454	2367	2797	2815	2728	2877	2563	2013
28	*E500_1_3_8*	*3294*	*1820*	2279	2258	2502	2093	2687	2237	2269	2078	2676	2878	3009	2844	2704	1820
29	*E500_1_3_9*	*3508*	*2143*	2510	2400	2689	2347	2906	2548	2639	2317	2798	2970	3051	3109	2911	2143
30	*E500_1_3_10*	*2962*	*1687*	2184	2127	2305	1870	2356	2128	2008	1908	2424	2483	2629	2372	2456	1687
31	*E500_1_4_1*	*2093*	*1140*	1271	1288	1727	1267	1736	1303	1620	1218	1630	2328	2494	1869	1823	1140
32	*E500_1_4_2*	*2719*	*1012*	1177	1392	1741	1206	1871	1309	1606	1049	1708	2163	2125	2119	2144	1012
33	*E500_1_4_3*	*2715*	*1174*	1309	1492	2016	1696	1892	1623	1955	1324	1883	2275	2256	2377	2103	1174
34	*E500_1_4_4*	*2094*	*945*	1163	1181	1360	1076	1453	1084	1390	1234	1436	2346	2217	2017	2166	945
35	*E500_1_4_5*	*2703*	*1116*	1262	1416	1727	1242	1985	1492	1637	1185	2019	2153	2140	2150	1962	1116
36	*E500_1_4_6*	*2532*	*954*	1215	1054	1488	1098	1740	1053	1438	1068	1637	2026	2129	2176	2026	954
37	*E500_1_4_7*	*2539*	*926*	1095	1150	1404	1133	1674	1187	1325	1013	1676	2420	2294	2165	2236	926
38	*E500_1_4_8*	*2576*	*912*	1180	1179	1318	1093	1703	1257	1337	1017	1426	2275	2263	2325	1951	912
39	*E500_1_4_9*	*2269*	*993*	1142	1122	1412	1073	1417	1168	1331	993	1402	2201	2054	1968	2014	1118
40	*E500_1_4_10*	*2476*	*1330*	1423	1472	1783	1431	2020	1527	1829	1440	1947	2311	2105	2248	2196	1330

Table A.26 Overload objective function deviations for 500-activity instances (1/4)

No.	Project name & performance	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
		Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
1	*E500_1_1_1*	12.9%	13.2%	13.4%	11.1%	15.9%	12.9%	11.4%	10.9%	14.5%	18.5%	17.4%	18.0%	17.9%	0.0%
2	*E500_1_1_2*	8.1%	9.5%	10.4%	7.9%	10.1%	9.7%	7.6%	7.4%	10.0%	10.0%	10.1%	10.8%	9.9%	0.0%
3	*E500_1_1_3*	4.9%	13.4%	16.7%	11.0%	18.3%	13.7%	14.5%	11.2%	18.3%	18.4%	19.7%	17.9%	17.1%	0.0%
4	*E500_1_1_4*	13.4%	18.1%	20.6%	9.4%	23.2%	17.7%	12.4%	8.7%	23.0%	17.7%	15.7%	17.9%	16.2%	0.0%
5	*E500_1_1_5*	17.3%	20.4%	24.1%	15.0%	24.6%	20.8%	20.4%	16.1%	24.2%	26.1%	26.4%	26.7%	26.1%	0.0%
6	*E500_1_1_6*	1.8%	1.3%	1.6%	1.0%	1.7%	0.9%	0.8%	1.3%	1.7%	1.5%	1.5%	1.6%	1.5%	0.0%
7	*E500_1_1_7*	20.5%	19.5%	23.8%	14.0%	25.0%	20.7%	16.0%	16.3%	24.8%	29.0%	27.9%	28.1%	27.6%	0.0%
8	*E500_1_1_8*	12.8%	13.1%	12.1%	9.6%	15.2%	13.6%	10.2%	9.9%	15.0%	16.3%	17.9%	16.1%	15.9%	0.0%
9	*E500_1_1_9*	12.2%	14.0%	15.0%	7.3%	15.9%	17.0%	8.7%	7.3%	16.2%	14.5%	15.1%	15.5%	14.8%	0.0%
10	*E500_1_1_10*	11.4%	14.8%	17.0%	12.1%	17.3%	14.5%	12.2%	12.5%	17.5%	13.7%	15.5%	14.2%	13.4%	0.0%
11	*E500_1_2_1*	14.2%	10.4%	18.5%	8.2%	18.3%	15.4%	11.3%	8.0%	19.9%	16.7%	18.0%	18.2%	16.1%	0.0%
12	*E500_1_2_2*	14.1%	10.4%	20.9%	5.5%	20.9%	14.4%	12.0%	8.1%	22.3%	21.7%	24.7%	23.9%	19.4%	0.0%
13	*E500_1_2_3*	13.1%	20.8%	20.1%	6.3%	26.9%	21.5%	11.3%	3.9%	26.1%	31.7%	28.9%	24.4%	25.7%	0.0%
14	*E500_1_2_4*	14.2%	14.7%	19.5%	8.9%	20.7%	14.9%	9.5%	8.0%	20.7%	19.1%	21.0%	24.3%	18.0%	0.0%
15	*E500_1_2_5*	20.7%	14.5%	17.2%	10.7%	17.2%	16.9%	10.7%	11.9%	19.8%	20.2%	22.9%	22.9%	20.4%	0.0%
16	*E500_1_2_6*	11.2%	15.5%	21.4%	7.1%	19.7%	18.9%	7.7%	5.6%	21.0%	17.8%	18.4%	19.1%	14.3%	0.0%
17	*E500_1_2_7*	10.9%	8.7%	10.2%	7.1%	11.3%	9.9%	6.2%	6.1%	11.5%	13.3%	15.0%	13.2%	11.3%	0.0%
18	*E500_1_2_8*	15.6%	15.7%	21.4%	10.2%	20.8%	23.0%	14.9%	10.9%	21.7%	23.0%	22.1%	24.2%	18.6%	0.0%
19	*E500_1_2_9*	24.9%	21.2%	28.5%	13.2%	30.1%	26.8%	14.8%	17.2%	29.9%	25.7%	32.7%	29.0%	25.8%	0.0%
20	*E500_1_2_10*	8.9%	8.1%	9.3%	6.0%	10.4%	9.4%	6.0%	7.3%	10.2%	9.2%	9.8%	8.0%	7.4%	0.0%
21	*E500_1_3_1*	25.8%	35.2%	33.1%	17.1%	39.8%	31.8%	29.1%	27.8%	42.6%	63.1%	60.9%	63.7%	53.4%	0.0%
22	*E500_1_3_2*	31.5%	29.7%	33.6%	19.7%	50.9%	31.3%	35.8%	23.4%	49.0%	61.6%	57.4%	51.0%	50.5%	0.0%
23	*E500_1_3_3*	19.0%	9.4%	23.4%	4.9%	28.4%	15.7%	14.8%	5.2%	24.5%	32.4%	35.0%	33.1%	29.9%	0.0%
24	*E500_1_3_4*	16.6%	26.9%	43.4%	14.4%	61.4%	37.3%	38.0%	3.4%	55.1%	94.0%	83.5%	71.8%	71.0%	0.0%
25	*E500_1_3_5*	24.3%	22.2%	35.9%	12.8%	30.2%	22.7%	21.0%	14.2%	27.9%	38.7%	38.5%	36.5%	35.5%	0.0%
26	*E500_1_3_6*	23.2%	19.4%	30.3%	11.3%	34.0%	27.2%	18.1%	9.2%	33.0%	53.1%	50.7%	56.8%	53.1%	0.0%
27	*E500_1_3_7*	17.6%	26.0%	35.1%	17.8%	35.6%	25.7%	21.9%	17.6%	38.9%	39.8%	35.5%	42.9%	27.3%	0.0%
28	*E500_1_3_8*	25.2%	24.1%	37.5%	15.0%	47.6%	22.9%	24.7%	14.2%	47.0%	58.1%	65.3%	56.3%	48.6%	0.0%
29	*E500_1_3_9*	17.1%	12.0%	25.5%	9.5%	35.6%	18.9%	23.1%	8.1%	30.6%	38.6%	42.4%	45.1%	35.8%	0.0%
30	*E500_1_3_10*	29.5%	26.1%	36.6%	10.8%	39.7%	26.1%	19.0%	13.1%	43.7%	47.2%	55.8%	40.6%	45.6%	0.0%
31	*E500_1_4_1*	11.5%	13.0%	51.5%	11.1%	52.3%	14.3%	42.1%	6.8%	43.0%	104.2%	118.8%	63.9%	59.9%	0.0%
32	*E500_1_4_2*	16.3%	37.5%	72.0%	19.2%	84.9%	29.3%	58.7%	3.7%	68.8%	113.7%	110.0%	109.4%	111.9%	0.0%
33	*E500_1_4_3*	11.5%	27.1%	71.7%	44.5%	61.2%	38.2%	66.5%	12.8%	60.4%	93.8%	92.2%	102.5%	79.1%	0.0%
34	*E500_1_4_4*	23.1%	25.0%	43.9%	13.9%	53.8%	14.7%	47.1%	30.6%	52.0%	148.3%	134.6%	113.4%	129.2%	0.0%
35	*E500_1_4_5*	13.1%	26.9%	54.7%	11.3%	77.9%	33.7%	46.7%	6.2%	80.9%	92.9%	91.8%	92.7%	75.8%	0.0%
36	*E500_1_4_6*	27.4%	10.5%	56.0%	15.1%	82.4%	10.4%	50.7%	11.9%	71.6%	112.4%	123.2%	128.1%	112.4%	0.0%
37	*E500_1_4_7*	18.3%	24.2%	51.6%	22.4%	80.8%	28.2%	43.1%	9.4%	81.0%	161.3%	147.7%	133.8%	141.5%	0.0%
38	*E500_1_4_8*	29.4%	29.3%	44.5%	19.8%	86.7%	37.8%	46.6%	11.5%	56.4%	149.5%	148.1%	154.9%	113.9%	0.0%
39	*E500_1_4_9*	15.0%	13.0%	42.2%	8.1%	42.7%	17.6%	34.0%	0.0%	41.2%	121.7%	106.8%	98.2%	102.8%	12.6%
40	*E500_1_4_10*	7.0%	10.7%	34.1%	7.6%	51.9%	14.8%	37.5%	8.3%	46.4%	73.8%	58.3%	69.0%	65.1%	0.0%
	Average Deviatian	16.6%	18.1%	30.0%	12.2%	36.0%	20.3%	23.4%	10.7%	34.1%	51.6%	50.9%	48.4%	44.5%	0.3%

Table A.27 Overload objective function values for 500-activity instances (2/4)

No.	Project name & performance	Early Start Objective	Upper Bound	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
				Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start	Multi	
1	E500_5_1_1	21407	18829	19903	20728	20744	20398	20654	20776	20405	20584	20678	20929	20624	20857	20720	18829
2	E500_5_1_2	21883	19176	20458	21140	21243	21210	21328	21087	21289	20877	21220	21020	20999	21256	20944	19176
3	E500_5_1_3	19887	17688	18562	19648	19297	19178	19443	19381	19181	19337	19451	19471	19262	19284	19247	17688
4	E500_5_1_4	18437	17253	18256	18382	18437	18136	18362	18410	18065	18388	18389	18280	18303	18127	18126	17253
5	E500_5_1_5	18815	16221	17619	18223	17890	18297	17808	17627	17922	18488	17852	18276	18353	18296	18292	16221
6	E500_5_1_6	18951	17182	17904	18655	18424	18263	18642	18580	18291	18354	18667	18241	18041	18307	18220	17182
7	E500_5_1_7	19983	18903	19589	19836	19723	19905	19771	19748	19872	19779	19818	19879	19817	19856	19719	18903
8	E500_5_1_8	18718	16752	17908	18516	18336	18307	18353	18276	18332	18386	18375	18541	18552	18869	18659	16752
9	E500_5_1_9	20057	17375	19004	19436	19512	19662	19415	19206	19442	19670	19413	19684	19866	19670	19439	17375
10	E500_5_1_10	19584	17609	18854	19383	19301	19445	19179	19117	19238	19189	19146	19096	19225	19208	19158	17609
11	E500_5_2_1	20539	17167	18527	19166	18940	19050	19143	19409	19262	19179	19093	19996	19820	19791	19784	17167
12	E500_5_2_2	20862	17065	18834	19676	18604	19712	18745	19100	19205	19234	18735	20635	19853	20367	20055	17065
13	E500_5_2_3	21063	17166	18589	19115	19026	19628	19439	18843	19260	19121	19346	20288	20150	20264	19863	17166
14	E500_5_2_4	20376	17350	18759	19829	19080	19169	19292	19438	19320	19035	19410	19740	19811	19579	19492	17350
15	E500_5_2_5	20180	18054	20180	19579	19601	19723	19363	19860	19572	19458	19486	19650	19860	19700	19611	18054
16	E500_5_2_6	21761	17814	20054	20920	19802	20555	19745	20767	20163	21303	19848	21523	21745	21698	21437	17814
17	E500_5_2_7	19669	15933	17743	18543	17956	18381	18001	18020	18246	18751	17974	19416	19387	19440	19207	15933
18	E500_5_2_8	19667	15045	16832	17943	17374	17726	17506	17250	17209	18072	17605	19487	18865	18825	18677	15045
19	E500_5_2_9	21329	17654	19782	19833	19786	19926	19904	20072	20062	20073	19864	20298	20659	20466	20034	17654
20	E500_5_2_10	19793	16546	17846	18852	18562	18748	18314	18829	18507	18798	18521	19167	19187	19262	19065	16546
21	E500_5_3_1	13799	9913	11554	11902	11915	12325	11365	11789	11661	11800	11438	14029	14277	13782	13481	9913
22	E500_5_3_2	15036	10814	12900	13290	12746	13049	12587	13376	13212	13520	12877	15676	16174	16542	15773	10814
23	E500_5_3_3	15640	11139	12689	13128	12921	13244	13119	13170	13114	13468	13086	15841	14731	15245	15052	11139
24	E500_5_3_4	14570	10371	12070	12561	12611	12305	12096	12000	11861	12383	12384	14065	13810	13885	13828	10371
25	E500_5_3_5	14718	9984	11767	12080	11706	12184	11629	11651	12022	12226	11733	13808	14069	14094	13669	9984
26	E500_5_3_6	14552	10305	12255	12395	12420	12720	11876	12194	12300	12333	11948	13890	14018	14211	13571	10305
27	E500_5_3_7	14627	10624	12181	13201	12203	12857	11996	12332	12754	12930	11854	15053	14322	14382	14167	10624
28	E500_5_3_8	14246	10576	11948	12432	12460	12361	12265	12487	12289	12230	12268	13532	13560	13712	13325	10576
29	E500_5_3_9	15999	11794	13242	14097	14044	13617	14061	14097	13398	13724	13646	15122	15399	15359	15119	11794
30	E500_5_3_10	15493	11447	13672	13527	12989	13413	13258	13453	13404	13453	12950	15049	15702	15231	15165	11447
31	E500_5_4_1	10699	6586	7242	8244	8223	7945	8458	7930	8240	8549	7972	11023	11252	10800	11323	6586
32	E500_5_4_2	11292	5904	6986	8140	7980	7999	7988	7753	7757	7865	7694	10989	10964	10414	10975	5904
33	E500_5_4_3	11577	7227	8147	8588	8798	8701	9256	8552	9310	8996	9172	10723	11027	10614	10555	7227
34	E500_5_4_4	11510	5921	6727	7515	7650	7531	7645	7559	7794	8631	7592	10905	11421	10393	11150	5921
35	E500_5_4_5	11237	6911	7448	8924	8408	8519	8513	8526	8914	9046	8484	11265	11260	11662	11763	6911
36	E500_5_4_6	11717	5882	6960	7803	8132	7433	8426	7461	8342	7829	8198	11275	11890	11323	11627	5882
37	E500_5_4_7	11661	6279	6584	7911	7958	8072	8288	7875	8188	7549	7659	10846	11043	10511	11330	6279
38	E500_5_4_8	11975	6842	7099	8334	8180	8202	8121	8108	8129	8871	8459	10969	10854	10756	10844	6842
39	E500_5_4_9	11801	6227	7049	8238	8336	8183	8308	8146	8530	8903	7969	11776	11823	11605	11561	6227
40	E500_5_4_10	10540	6025	6840	7481	8109	7541	7405	7523	7811	8105	7296	10540	10053	9441	9890	6025

Table A.28 Overload objective function deviations for 500-activity instances (2/4)

No.	Project name & performance	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
		Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
1	*E500_5_1_1*	5.7%	10.1%	10.2%	8.3%	9.7%	10.3%	8.4%	9.3%	9.8%	11.2%	9.5%	10.8%	10.0%	0.0%
2	*E500_5_1_2*	6.7%	10.2%	10.8%	10.6%	11.2%	10.0%	11.0%	8.9%	10.7%	9.6%	9.5%	10.8%	9.2%	0.0%
3	*E500_5_1_3*	4.9%	11.1%	9.1%	8.4%	9.9%	9.6%	8.4%	9.3%	10.0%	10.1%	8.9%	9.0%	8.8%	0.0%
4	*E500_5_1_4*	5.8%	6.5%	6.9%	5.1%	6.4%	6.7%	4.7%	6.6%	6.6%	6.0%	6.1%	5.1%	5.1%	0.0%
5	*E500_5_1_5*	8.6%	12.3%	10.3%	12.8%	9.8%	8.7%	10.5%	14.0%	10.1%	12.7%	13.1%	12.8%	12.8%	0.0%
6	*E500_5_1_6*	4.2%	8.6%	7.2%	6.3%	8.5%	8.1%	6.5%	6.8%	8.6%	6.2%	5.0%	6.5%	6.0%	0.0%
7	*E500_5_1_7*	3.6%	4.9%	4.3%	5.3%	4.6%	4.5%	5.1%	4.6%	4.8%	5.2%	4.8%	5.0%	4.3%	0.0%
8	*E500_5_1_8*	6.9%	10.5%	9.5%	9.3%	9.6%	9.1%	9.4%	9.8%	9.7%	10.7%	10.7%	12.6%	11.4%	0.0%
9	*E500_5_1_9*	9.4%	11.9%	12.3%	13.2%	11.7%	10.5%	11.9%	13.2%	11.7%	13.3%	14.3%	13.2%	11.9%	0.0%
10	*E500_5_1_10*	7.1%	10.1%	9.6%	10.4%	8.9%	8.6%	9.3%	9.0%	8.7%	8.4%	9.2%	9.1%	8.8%	0.0%
11	*E500_5_2_1*	7.9%	11.6%	10.3%	11.0%	11.5%	13.1%	12.2%	11.7%	11.2%	16.5%	15.5%	15.3%	15.2%	0.0%
12	*E500_5_2_2*	10.4%	15.3%	9.0%	15.5%	9.8%	11.9%	12.5%	12.7%	9.8%	20.9%	16.3%	19.3%	17.5%	0.0%
13	*E500_5_2_3*	8.3%	11.4%	10.8%	14.3%	13.2%	9.8%	12.2%	11.4%	12.7%	18.2%	17.4%	18.0%	15.7%	0.0%
14	*E500_5_2_4*	8.1%	14.3%	10.0%	10.5%	11.2%	12.0%	11.4%	9.7%	11.9%	13.8%	14.2%	12.8%	12.3%	0.0%
15	*E500_5_2_5*	11.8%	8.4%	8.6%	9.2%	7.3%	10.0%	8.4%	7.8%	7.9%	8.8%	10.0%	9.1%	8.6%	0.0%
16	*E500_5_2_6*	12.6%	17.4%	11.2%	15.4%	10.8%	16.6%	13.2%	19.6%	11.4%	20.8%	22.1%	21.8%	20.3%	0.0%
17	*E500_5_2_7*	11.4%	16.4%	12.7%	15.4%	13.0%	13.1%	14.5%	17.7%	12.8%	21.9%	21.7%	22.0%	20.5%	0.0%
18	*E500_5_2_8*	11.9%	19.3%	15.5%	17.8%	16.4%	14.7%	14.4%	20.1%	17.0%	29.5%	25.4%	25.1%	24.1%	0.0%
19	*E500_5_2_9*	12.1%	12.3%	12.1%	12.9%	12.7%	13.7%	13.6%	13.7%	12.5%	15.0%	17.0%	15.9%	13.5%	0.0%
20	*E500_5_2_10*	7.9%	13.9%	12.2%	13.3%	10.7%	13.8%	11.9%	13.6%	11.9%	15.8%	16.0%	16.4%	15.2%	0.0%
21	*E500_5_3_1*	16.6%	20.1%	20.2%	24.3%	14.6%	18.9%	17.6%	19.0%	15.4%	41.5%	44.0%	39.0%	36.0%	0.0%
22	*E500_5_3_2*	19.3%	22.9%	17.9%	20.7%	16.4%	23.7%	22.2%	25.0%	19.1%	45.0%	49.6%	53.0%	45.9%	0.0%
23	*E500_5_3_3*	13.9%	17.9%	16.0%	18.9%	17.8%	18.2%	17.7%	20.9%	17.5%	42.2%	32.2%	36.9%	35.1%	0.0%
24	*E500_5_3_4*	16.4%	21.1%	21.6%	18.6%	16.6%	15.7%	14.4%	19.4%	19.4%	35.6%	33.2%	33.9%	33.3%	0.0%
25	*E500_5_3_5*	17.9%	21.0%	17.2%	22.0%	16.5%	16.7%	20.4%	22.5%	17.5%	38.3%	40.9%	41.2%	36.9%	0.0%
26	*E500_5_3_6*	18.9%	20.3%	20.5%	23.4%	15.2%	18.3%	19.4%	19.7%	15.9%	34.8%	36.0%	37.9%	31.7%	0.0%
27	*E500_5_3_7*	14.7%	24.3%	14.9%	21.0%	12.9%	16.1%	20.0%	21.7%	11.6%	41.7%	34.8%	35.4%	33.3%	0.0%
28	*E500_5_3_8*	13.0%	17.5%	17.8%	16.9%	16.0%	18.1%	16.2%	15.6%	16.0%	28.0%	28.2%	29.7%	26.0%	0.0%
29	*E500_5_3_9*	12.3%	19.5%	19.1%	15.5%	19.2%	19.5%	13.6%	16.4%	15.7%	28.2%	30.6%	30.2%	28.2%	0.0%
30	*E500_5_3_10*	19.4%	18.2%	13.5%	17.2%	15.8%	17.5%	17.1%	17.5%	13.1%	31.5%	37.2%	33.1%	32.5%	0.0%
31	*E500_5_4_1*	10.0%	25.2%	24.9%	20.6%	28.4%	20.4%	25.1%	29.8%	21.0%	67.4%	70.8%	64.0%	71.9%	0.0%
32	*E500_5_4_2*	18.3%	37.9%	35.2%	35.5%	35.3%	31.3%	31.4%	33.2%	30.3%	86.1%	85.7%	76.4%	85.9%	0.0%
33	*E500_5_4_3*	12.7%	18.8%	21.7%	20.4%	28.1%	18.3%	28.8%	24.5%	26.9%	48.4%	52.6%	46.9%	46.0%	0.0%
34	*E500_5_4_4*	13.6%	26.9%	29.2%	27.2%	29.1%	27.7%	31.6%	45.8%	28.2%	84.2%	92.9%	75.5%	88.3%	0.0%
35	*E500_5_4_5*	7.8%	29.1%	21.7%	23.3%	23.2%	23.4%	29.0%	30.9%	22.8%	63.0%	62.9%	68.7%	70.2%	0.0%
36	*E500_5_4_6*	18.3%	32.7%	38.3%	26.4%	43.3%	26.8%	41.8%	33.1%	39.4%	91.7%	102.1%	92.5%	97.7%	0.0%
37	*E500_5_4_7*	4.9%	26.0%	26.7%	28.6%	32.0%	25.4%	30.4%	20.2%	22.0%	72.7%	75.9%	67.4%	80.4%	0.0%
38	*E500_5_4_8*	3.8%	21.8%	19.6%	19.9%	18.7%	18.5%	18.8%	29.7%	23.6%	60.3%	58.6%	57.2%	58.5%	0.0%
39	*E500_5_4_9*	13.2%	32.3%	33.9%	31.4%	33.4%	30.8%	37.0%	43.0%	28.0%	89.1%	89.9%	86.4%	85.7%	0.0%
40	*E500_5_4_10*	13.5%	24.2%	34.6%	25.2%	22.9%	24.9%	29.6%	34.5%	21.1%	74.9%	66.9%	56.7%	64.1%	0.0%
	Average Deviatian	11.1%	17.9%	16.7%	17.0%	16.6%	16.1%	17.3%	18.8%	15.9%	34.5%	34.8%	33.3%	33.5%	0.0%

Table A.29 Overload objective function values for 500-activity instances (3/4)

No.	Project name & performance	Early Start Objective Function	Upper Bound	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
				Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start	Multi	
1	*E500_10_1_1*	*38980*	*34553*	36188	38032	37645	38323	37499	37210	37972	38255	37377	37595	37073	37546	37004	34553
2	*E500_10_1_2*	*40206*	*36765*	38819	39762	39339	39606	39654	39539	39279	39986	39641	39100	40024	39673	39087	36765
3	*E500_10_1_3*	*39951*	*37078*	39146	39821	39117	39721	39423	39597	39764	39825	39285	39182	39261	39261	39071	37078
4	*E500_10_1_4*	*43793*	*40393*	42522	42992	43071	43215	42819	43267	43139	43026	42938	42907	43473	42590	42971	40393
5	*E500_10_1_5*	*39284*	*36638*	37847	38808	38698	38450	38614	38840	38396	38359	38446	38394	38453	38453	38445	36638
6	*E500_10_1_6*	*39351*	*35871*	37684	38417	38071	38517	38081	37904	38113	38648	38024	38742	38318	38559	38278	35871
7	*E500_10_1_7*	*43314*	*39416*	42450	42172	42062	43266	42225	42306	42654	43167	42231	42447	42706	42878	42532	39416
8	*E500_10_1_8*	*38827*	*36314*	37456	38394	37908	37978	38359	38418	38091	38204	38079	38158	37833	38271	38003	36314
9	*E500_10_1_9*	*42695*	*41555*	42607	42629	42572	42475	42541	42530	42402	42660	42536	42601	42307	42316	42378	41555
10	*E500_10_1_10*	*40521*	*36401*	38475	40046	39695	39541	39632	40270	39487	39761	39657	39994	39942	40594	40308	36401
11	*E500_10_2_1*	*39949*	*33884*	37170	37608	36939	38433	36971	37994	37658	38334	36993	38739	38900	39152	38251	33884
12	*E500_10_2_2*	*42216*	*36783*	39546	40513	40369	41304	40065	40238	41306	40518	39887	40730	40852	40829	40611	36783
13	*E500_10_2_3*	*42711*	*35638*	38997	40588	39568	41759	39493	39648	40787	41472	39818	41038	40931	41338	40424	35638
14	*E500_10_2_4*	*41134*	*35368*	38559	39158	39069	40119	38808	39438	39736	39797	38779	39800	40416	39884	39453	35368
15	*E500_10_2_5*	*38851*	*31010*	35532	36527	35050	38021	34915	35525	36510	37161	34865	38696	38640	38035	38279	31010
16	*E500_10_2_6*	*41107*	*34488*	38195	38854	37520	39253	38147	38921	39103	38990	37863	39973	39406	39026	39549	34488
17	*E500_10_2_7*	*42710*	*36976*	39604	40603	40324	42203	40295	40973	41319	41193	40396	41688	41492	40738	40670	36976
18	*E500_10_2_8*	*39728*	*33287*	37518	38259	36447	38064	36503	37096	37751	38354	36165	39565	39565	38255	38769	33287
19	*E500_10_2_9*	*40836*	*35362*	38949	39339	38526	39605	38589	39140	39030	40035	38855	40558	40063	39752	39598	35362
20	*E500_10_2_10*	*41181*	*35703*	39212	39001	38404	40028	38308	39656	39592	40053	38413	40045	40024	39939	39218	35703
21	*E500_10_3_1*	*27627*	*21029*	23999	25838	24430	26029	24241	25681	24490	25464	24452	29066	29182	29472	28263	21029
22	*E500_10_3_2*	*28617*	*21264*	24552	25528	25122	25725	24839	24998	25696	26035	24709	29404	29399	29077	28348	21264
23	*E500_10_3_3*	*33064*	*24585*	27903	30227	28471	29863	27952	29096	28407	29937	27922	33163	32712	32615	32109	24585
24	*E500_10_3_4*	*30975*	*22495*	25115	26989	25999	26851	25155	25863	27379	27421	25496	29500	29261	28836	28463	22495
25	*E500_10_3_5*	*32256*	*23930*	26533	27324	27094	28516	26120	27274	27977	27806	26626	30800	30353	30889	30130	23930
26	*E500_10_3_6*	*31172*	*23717*	26796	28782	27056	28320	27334	27643	27643	28521	27909	30718	29689	30835	29675	23717
27	*E500_10_3_7*	*29882*	*23080*	26863	27490	26621	27132	25730	26281	27442	28051	25815	30632	29990	30482	30482	23080
28	*E500_10_3_8*	*29894*	*21237*	24713	25858	25191	26210	24440	24514	26123	26282	24005	28918	28427	28501	28222	21237
29	*E500_10_3_9*	*29362*	*22054*	25071	26337	24554	26494	24385	25782	25799	26373	24657	28619	28082	28260	27339	22054
30	*E500_10_3_10*	*31522*	*24209*	27663	28433	27653	28476	27511	27442	27666	28593	27285	31023	30320	30975	30587	24209
31	*E500_10_4_1*	*20619*	*13352*	15219	17532	16740	15834	16607	16248	16275	17488	16543	20760	20753	20408	21503	13352
32	*E500_10_4_2*	*20588*	*13921*	14553	16628	16778	16245	16448	16039	15730	17111	16000	19177	19427	19959	18872	13921
33	*E500_10_4_3*	*22739*	*14159*	15401	18104	17765	17372	18131	17624	17067	18537	17313	19980	20220	19673	19718	14159
34	*E500_10_4_4*	*24332*	*15340*	16747	17822	17724	18008	17750	17604	18046	17221	17405	20568	20814	21269	20108	15340
35	*E500_10_4_5*	*25007*	*13808*	15102	17078	18637	16982	17521	17735	17480	17550	17343	23363	23389	21861	21838	13808
36	*E500_10_4_6*	*20833*	*12407*	13560	16449	15034	15394	14181	15133	15754	16087	14618	19688	18962	19348	19763	12407
37	*E500_10_4_7*	*23111*	*15427*	16265	18522	18792	18706	18240	18152	18983	19087	18106	21692	21504	21427	21425	15427
38	*E500_10_4_8*	*22721*	*13266*	15118	17689	17257	17087	16424	16769	16862	16980	16664	19932	20736	20959	20085	13266
39	*E500_10_4_9*	*21888*	*14223*	14876	17589	17549	17027	16260	17181	16798	17047	15825	21298	20975	21354	20764	14223
40	*E500_10_4_10*	*23482*	*14418*	15644	18001	17828	17432	17138	17528	17897	19086	17616	22145	21903	22131	21503	14418

Table A.30 Overload objective function deviations for 500-activity instances (3/4)

No.	Project name & performance	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
		Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
1	*E500_10_1_1*	4.7%	10.1%	8.9%	10.9%	8.5%	7.7%	9.9%	10.7%	8.2%	8.8%	7.3%	8.7%	7.1%	0.0%
2	*E500_10_1_2*	5.6%	8.2%	7.0%	7.7%	7.9%	7.5%	6.8%	8.8%	7.8%	6.4%	8.9%	7.9%	6.3%	0.0%
3	*E500_10_1_3*	5.6%	7.4%	5.5%	7.1%	6.3%	6.8%	7.2%	7.4%	6.0%	5.7%	5.9%	5.9%	5.4%	0.0%
4	*E500_10_1_4*	5.3%	6.4%	6.6%	7.0%	6.0%	7.1%	6.8%	6.5%	6.3%	6.2%	7.6%	5.4%	6.4%	0.0%
5	*E500_10_1_5*	3.3%	5.9%	5.6%	4.9%	5.4%	6.0%	4.8%	4.7%	4.9%	4.8%	5.0%	5.0%	4.9%	0.0%
6	*E500_10_1_6*	5.1%	7.1%	6.1%	7.4%	6.2%	5.7%	6.3%	7.7%	6.0%	8.0%	6.8%	7.5%	6.7%	0.0%
7	*E500_10_1_7*	7.7%	7.0%	6.7%	9.8%	7.1%	7.3%	8.2%	9.5%	7.1%	7.7%	8.3%	8.8%	7.9%	0.0%
8	*E500_10_1_8*	3.1%	5.7%	4.4%	4.6%	5.6%	5.8%	4.9%	5.2%	4.9%	5.1%	4.2%	5.4%	4.7%	0.0%
9	*E500_10_1_9*	2.5%	2.6%	2.4%	2.2%	2.4%	2.3%	2.0%	2.7%	2.4%	2.5%	1.8%	1.8%	2.0%	0.0%
10	*E500_10_1_10*	5.7%	10.0%	9.0%	8.6%	8.9%	10.6%	8.5%	9.2%	8.9%	9.9%	9.7%	11.5%	10.7%	0.0%
11	*E500_10_2_1*	9.7%	11.0%	9.0%	13.4%	9.1%	12.1%	11.1%	13.1%	9.2%	14.3%	14.8%	15.5%	12.9%	0.0%
12	*E500_10_2_2*	7.5%	10.1%	9.7%	12.3%	8.9%	9.4%	12.3%	10.2%	8.4%	10.7%	11.1%	11.0%	10.4%	0.0%
13	*E500_10_2_3*	9.4%	13.9%	11.0%	17.2%	10.8%	11.3%	14.4%	16.4%	11.7%	15.2%	14.9%	16.0%	13.4%	0.0%
14	*E500_10_2_4*	9.0%	10.7%	10.5%	13.4%	9.7%	11.5%	12.4%	12.5%	9.6%	12.5%	14.3%	12.8%	11.5%	0.0%
15	*E500_10_2_5*	14.6%	17.8%	13.0%	22.6%	12.6%	14.6%	17.7%	19.8%	12.4%	24.8%	24.6%	22.7%	23.4%	0.0%
16	*E500_10_2_6*	10.7%	12.7%	8.8%	13.8%	10.6%	12.9%	13.4%	13.1%	9.8%	15.9%	14.3%	13.2%	14.7%	0.0%
17	*E500_10_2_7*	7.1%	9.8%	9.1%	14.1%	9.0%	10.8%	11.7%	11.4%	9.2%	12.7%	12.2%	10.2%	10.0%	0.0%
18	*E500_10_2_8*	12.7%	14.9%	9.5%	14.4%	9.7%	11.4%	13.4%	15.2%	8.6%	18.9%	18.9%	14.9%	16.5%	0.0%
19	*E500_10_2_9*	10.1%	11.2%	8.9%	12.0%	9.1%	10.7%	10.4%	13.2%	9.9%	14.7%	13.3%	12.4%	12.0%	0.0%
20	*E500_10_2_10*	9.8%	9.2%	7.6%	12.1%	7.3%	11.1%	10.9%	12.2%	7.6%	12.2%	12.1%	11.9%	9.8%	0.0%
21	*E500_10_3_1*	14.1%	22.9%	16.2%	23.8%	15.3%	22.1%	16.5%	21.1%	16.3%	38.2%	38.8%	40.1%	34.4%	0.0%
22	*E500_10_3_2*	15.5%	20.1%	18.1%	21.0%	16.8%	17.6%	20.8%	22.4%	16.2%	38.3%	38.3%	36.7%	33.3%	0.0%
23	*E500_10_3_3*	13.5%	22.9%	15.8%	21.5%	13.7%	18.3%	15.5%	21.8%	13.6%	34.9%	33.1%	32.7%	30.6%	0.0%
24	*E500_10_3_4*	11.6%	20.0%	15.6%	19.4%	11.8%	15.0%	21.7%	21.9%	13.3%	31.1%	30.1%	28.2%	26.5%	0.0%
25	*E500_10_3_5*	10.9%	14.2%	13.2%	19.2%	9.2%	14.0%	16.9%	16.2%	11.3%	28.7%	26.8%	29.1%	25.9%	0.0%
26	*E500_10_3_6*	13.0%	21.4%	14.1%	19.4%	15.3%	16.6%	16.6%	20.3%	17.7%	29.5%	25.2%	30.0%	25.1%	0.0%
27	*E500_10_3_7*	16.4%	19.1%	15.3%	17.6%	11.5%	13.9%	18.9%	21.5%	11.9%	32.7%	29.9%	32.1%	32.1%	0.0%
28	*E500_10_3_8*	16.4%	21.8%	18.6%	23.4%	15.1%	15.4%	23.0%	23.8%	13.0%	36.2%	33.9%	34.2%	32.9%	0.0%
29	*E500_10_3_9*	13.7%	19.4%	11.3%	20.1%	10.6%	16.9%	17.0%	19.6%	11.8%	29.8%	27.3%	28.1%	24.0%	0.0%
30	*E500_10_3_10*	14.3%	17.4%	14.2%	17.6%	13.6%	13.4%	14.3%	18.1%	12.7%	28.1%	25.2%	27.9%	26.3%	0.0%
31	*E500_10_4_1*	14.0%	31.3%	25.4%	18.6%	24.4%	21.7%	21.9%	31.0%	23.9%	55.5%	55.4%	52.8%	61.0%	0.0%
32	*E500_10_4_2*	4.5%	19.4%	20.5%	16.7%	18.2%	15.2%	13.0%	22.9%	14.9%	37.8%	39.6%	43.4%	35.6%	0.0%
33	*E500_10_4_3*	8.8%	27.9%	25.5%	22.7%	28.1%	24.5%	20.5%	30.9%	22.3%	41.1%	42.8%	38.9%	39.3%	0.0%
34	*E500_10_4_4*	9.2%	16.2%	15.5%	17.4%	15.7%	14.8%	17.6%	12.3%	13.5%	34.1%	35.7%	38.7%	31.1%	0.0%
35	*E500_10_4_5*	9.4%	23.7%	35.0%	23.0%	26.9%	28.4%	26.6%	27.1%	25.6%	69.2%	69.4%	58.3%	58.2%	0.0%
36	*E500_10_4_6*	9.3%	32.6%	21.2%	24.1%	14.3%	22.0%	27.0%	29.7%	17.8%	58.7%	52.8%	55.9%	59.3%	0.0%
37	*E500_10_4_7*	5.4%	20.1%	21.8%	21.3%	18.2%	17.7%	23.1%	23.7%	17.4%	40.6%	39.4%	38.9%	38.9%	0.0%
38	*E500_10_4_8*	14.0%	33.3%	30.1%	28.8%	23.8%	26.4%	27.1%	28.0%	25.6%	50.2%	56.3%	58.0%	51.4%	0.0%
39	*E500_10_4_9*	4.6%	23.7%	23.4%	19.7%	14.3%	20.8%	18.1%	19.9%	11.3%	49.7%	47.5%	50.1%	46.0%	0.0%
40	*E500_10_4_10*	8.5%	24.9%	23.7%	20.9%	18.9%	21.6%	24.1%	32.4%	22.2%	53.6%	51.9%	53.5%	49.1%	0.0%
	Average Deviatian	9.4%	16.1%	13.9%	15.8%	12.4%	14.0%	14.8%	16.8%	12.3%	25.9%	25.4%	25.4%	23.9%	0.0%

Table A.31 Overload objective function values for 500-activity instances (4/4)

No.	Project name & performance	Early Start Objective Function	Upper Bound	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
				Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start	Multi	
1	*E500_15_1_1*	*61390*	*56309*	58138	59488	60050	59412	58893	59120	59457	59837	58949	58995	59230	59464	58851	56309
2	*E500_15_1_2*	*58896*	*54047*	56158	57509	57476	58037	57334	57343	57886	57755	57221	57113	57572	57258	57113	54047
3	*E500_15_1_3*	*59706*	*54918*	56390	57814	57599	58005	58167	58092	57886	57967	58197	58981	58459	57819	58369	54918
4	*E500_15_1_4*	*60303*	*57327*	59473	59644	59469	59832	59551	59793	59629	59512	59603	59649	59556	59745	59393	57327
5	*E500_15_1_5*	*59014*	*54477*	57405	58354	57697	58042	57756	57184	57994	58419	57708	57989	58367	57797	57562	54477
6	*E500_15_1_6*	*62920*	*59012*	60025	61109	60824	61813	61134	60920	61520	62056	61228	60971	61300	60748	61067	59012
7	*E500_15_1_7*	*57635*	*53454*	55749	56793	56285	56406	56698	56643	56445	56665	56587	56085	56619	56311	55997	53454
8	*E500_15_1_8*	*62171*	*54598*	57749	59754	58682	59703	58844	58800	59699	60098	58565	60584	60268	60505	60338	54598
9	*E500_15_1_9*	*61032*	*56641*	58806	59994	59393	60238	60018	59808	60128	60250	59717	59379	59448	59979	59193	56641
10	*E500_15_1_10*	*54401*	*51011*	52924	54118	53672	54224	53742	54001	53682	54072	53724	54368	53997	53734	54084	51011
11	*E500_15_2_1*	*61000*	*51840*	57035	57812	56038	59536	56256	58305	58532	58870	56151	59231	58766	59702	58312	51840
12	*E500_15_2_2*	*61268*	*52913*	57932	58882	57631	60910	57289	58618	59457	59689	57101	58949	58862	59222	58464	52913
13	*E500_15_2_3*	*58457*	*49471*	55400	55746	54310	57181	53841	55042	56485	56812	54321	57499	56795	57651	55634	49471
14	*E500_15_2_4*	*60361*	*51425*	56547	56901	56532	58824	56226	56321	58477	57148	56208	58143	56921	57591	57311	51425
15	*E500_15_2_5*	*61760*	*52307*	58033	58392	57456	60684	58047	58140	58549	59502	57950	61040	59753	60017	58736	52307
16	*E500_15_2_6*	*63778*	*52226*	57760	60086	57690	60748	57968	59535	60468	60412	57945	61144	60510	60639	59680	52226
17	*E500_15_2_7*	*59655*	*53587*	56904	57853	58013	59002	57302	57745	58096	58295	57583	58978	57744	57871	57409	53587
18	*E500_15_2_8*	*61565*	*52859*	57542	59566	56439	60469	56142	58837	59759	60877	56075	59834	60355	59947	59365	52859
19	*E500_15_2_9*	*61648*	*54000*	58481	58808	58798	60617	58197	58929	60152	59697	58311	60652	60507	59856	59856	54000
20	*E500_15_2_10*	*65398*	*57121*	62072	62428	62459	64756	61811	62583	63693	63673	62006	63150	63180	63260	62909	57121
21	*E500_15_3_1*	*42441*	*32622*	37063	38272	37299	40667	36258	38349	38445	39787	36615	43797	41649	42681	41709	32622
22	*E500_15_3_2*	*44095*	*32517*	38687	38762	37965	40782	38066	38116	40678	40335	38370	43884	46512	44986	43426	32517
23	*E500_15_3_3*	*45383*	*35318*	40392	41445	39684	42025	39233	40127	40917	42427	39734	44405	43635	44724	42810	35318
24	*E500_15_3_4*	*45034*	*32932*	38046	39829	38040	40094	37103	37794	39757	40626	37561	45125	43849	43160	44226	32932
25	*E500_15_3_5*	*45271*	*34950*	40292	40778	39787	42343	39572	39522	40449	41496	38857	46697	47058	45792	45169	34950
26	*E500_15_3_6*	*47488*	*36922*	42147	43525	42285	43864	41894	43199	43412	43248	41573	48381	48700	48099	46963	36922
27	*E500_15_3_7*	*44557*	*33130*	37039	40611	38403	39705	36902	37909	38720	40291	37643	45327	45725	44570	43811	33130
28	*E500_15_3_8*	*44946*	*33197*	38170	39738	39203	40850	37491	37286	40793	40125	38115	43222	44185	43444	42306	33197
29	*E500_15_3_9*	*41765*	*31884*	37044	39856	37637	38758	36336	39131	38147	39715	36025	43926	42548	43298	42567	31884
30	*E500_15_3_10*	*45155*	*34822*	39882	41275	40695	41360	38884	40412	40562	41139	39571	44814	44796	44241	42530	34822
31	*E500_15_4_1*	*31334*	*20829*	23223	26693	26145	25992	24955	24980	25904	26453	24836	28564	29334	28851	28409	20829
32	*E500_15_4_2*	*34229*	*18176*	20715	24295	23057	23038	23054	23592	23128	25077	21894	29625	29231	28964	28106	18176
33	*E500_15_4_3*	*35590*	*20265*	22441	26486	24601	23924	24471	25578	23926	25521	24145	29652	30176	28829	29417	20265
34	*E500_15_4_4*	*38684*	*20604*	22179	26391	25930	25435	26277	25602	26145	24795	26382	33083	32561	33953	33046	20604
35	*E500_15_4_5*	*37079*	*21808*	23211	26607	26044	26582	26505	26240	25707	27469	26232	34262	34262	34424	34034	21808
36	*E500_15_4_6*	*31655*	*18823*	20585	23875	22798	24166	23038	22535	23307	27025	22972	28339	28323	28723	27406	18823
37	*E500_15_4_7*	*37358*	*23571*	24561	27341	26352	27503	27261	26635	28064	27264	28333	33064	35009	34952	31827	23571
38	*E500_15_4_8*	*29295*	*19060*	21738	24978	24800	23783	23601	24769	22565	25713	24544	30580	32173	31881	30070	19060
39	*E500_15_4_9*	*34455*	*21069*	23082	25624	24257	25367	24801	24542	24480	26303	24405	31422	31830	31538	31023	21069
40	*E500_15_4_10*	*31993*	*20419*	21239	24980	24454	24155	23821	24208	24390	24850	24641	30331	29589	29014	28813	20419

Table A.32 Overload objective function deviations for 500-activity instances (4/4)

No.	Project name & performance	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
		Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
1	*E500_15_1_1*	3.2%	5.6%	6.6%	5.5%	4.6%	5.0%	5.6%	6.3%	4.7%	4.8%	5.2%	5.6%	4.5%	0.0%
2	*E500_15_1_2*	3.9%	6.4%	6.3%	7.4%	6.1%	6.1%	7.1%	6.9%	5.9%	5.7%	6.5%	5.9%	5.7%	0.0%
3	*E500_15_1_3*	2.7%	5.3%	4.9%	5.6%	5.9%	5.8%	5.4%	5.6%	6.0%	7.4%	6.4%	5.3%	6.3%	0.0%
4	*E500_15_1_4*	3.7%	4.0%	3.7%	4.4%	3.9%	4.3%	4.0%	3.8%	4.0%	4.1%	3.9%	4.2%	3.6%	0.0%
5	*E500_15_1_5*	5.4%	7.1%	5.9%	6.5%	6.0%	5.0%	6.5%	7.2%	5.9%	6.4%	7.1%	6.1%	5.7%	0.0%
6	*E500_15_1_6*	1.7%	3.6%	3.1%	4.7%	3.6%	3.2%	4.2%	5.2%	3.8%	3.3%	3.9%	2.9%	3.5%	0.0%
7	*E500_15_1_7*	4.3%	6.2%	5.3%	5.5%	6.1%	6.0%	5.6%	6.0%	5.9%	4.9%	5.9%	5.3%	4.8%	0.0%
8	*E500_15_1_8*	5.8%	9.4%	7.5%	9.4%	7.8%	7.7%	9.3%	10.1%	7.3%	11.0%	10.4%	10.8%	10.5%	0.0%
9	*E500_15_1_9*	3.8%	5.9%	4.9%	6.4%	6.0%	5.6%	6.2%	6.4%	5.4%	4.8%	5.0%	5.9%	4.5%	0.0%
10	*E500_15_1_10*	3.8%	6.1%	5.2%	6.3%	5.4%	5.9%	5.2%	6.0%	5.3%	6.6%	5.9%	5.3%	6.0%	0.0%
11	*E500_15_2_1*	10.0%	11.5%	8.1%	14.8%	8.5%	12.5%	12.9%	13.6%	8.3%	14.3%	13.4%	15.2%	12.5%	0.0%
12	*E500_15_2_2*	9.5%	11.3%	8.9%	15.1%	8.3%	10.8%	12.4%	12.8%	7.9%	11.4%	11.2%	11.9%	10.5%	0.0%
13	*E500_15_2_3*	12.0%	12.7%	9.8%	15.6%	8.8%	11.3%	14.2%	14.8%	9.8%	16.2%	14.8%	16.5%	12.5%	0.0%
14	*E500_15_2_4*	10.0%	10.6%	9.9%	14.4%	9.3%	9.5%	13.7%	11.1%	9.3%	13.1%	10.7%	12.0%	11.4%	0.0%
15	*E500_15_2_5*	10.9%	11.6%	9.8%	16.0%	11.0%	11.2%	11.9%	13.8%	10.8%	16.7%	14.2%	14.7%	12.3%	0.0%
16	*E500_15_2_6*	10.6%	15.0%	10.5%	16.3%	11.0%	14.0%	15.8%	15.7%	11.0%	17.1%	15.9%	16.1%	14.3%	0.0%
17	*E500_15_2_7*	6.2%	8.0%	8.3%	10.1%	6.9%	7.8%	8.4%	8.8%	7.5%	10.1%	7.8%	8.0%	7.1%	0.0%
18	*E500_15_2_8*	8.9%	12.7%	6.8%	14.4%	6.2%	11.3%	13.1%	15.2%	6.1%	13.2%	14.2%	13.4%	12.3%	0.0%
19	*E500_15_2_9*	8.3%	8.9%	8.9%	12.3%	7.8%	9.1%	11.4%	10.6%	8.0%	12.3%	12.1%	10.8%	10.8%	0.0%
20	*E500_15_2_10*	8.7%	9.3%	9.3%	13.4%	8.2%	9.6%	11.5%	11.5%	8.6%	10.6%	10.6%	10.7%	10.1%	0.0%
21	*E500_15_3_1*	13.6%	17.3%	14.3%	24.7%	11.1%	17.6%	17.8%	22.0%	12.2%	34.3%	27.7%	30.8%	27.9%	0.0%
22	*E500_15_3_2*	19.0%	19.2%	16.8%	25.4%	17.1%	17.2%	25.1%	24.0%	18.0%	35.0%	43.0%	38.3%	33.5%	0.0%
23	*E500_15_3_3*	14.4%	17.3%	12.4%	19.0%	11.1%	13.6%	15.9%	20.1%	12.5%	25.7%	23.5%	26.6%	21.2%	0.0%
24	*E500_15_3_4*	15.5%	20.9%	15.5%	21.7%	12.7%	14.8%	20.7%	23.4%	14.1%	37.0%	33.2%	31.1%	34.3%	0.0%
25	*E500_15_3_5*	15.3%	16.7%	13.8%	21.2%	13.2%	13.1%	15.7%	18.7%	11.2%	33.6%	34.6%	31.0%	29.2%	0.0%
26	*E500_15_3_6*	14.2%	17.9%	14.5%	18.8%	13.5%	17.0%	17.6%	17.1%	12.6%	31.0%	31.9%	30.3%	27.2%	0.0%
27	*E500_15_3_7*	11.8%	22.6%	15.9%	19.8%	11.4%	14.4%	16.9%	21.6%	13.6%	36.8%	38.0%	34.5%	32.2%	0.0%
28	*E500_15_3_8*	15.0%	19.7%	18.1%	23.1%	12.9%	12.3%	22.9%	20.9%	14.8%	30.2%	33.1%	30.9%	27.4%	0.0%
29	*E500_15_3_9*	16.2%	25.0%	18.0%	21.6%	14.0%	22.7%	19.6%	24.6%	13.0%	37.8%	33.4%	35.8%	33.5%	0.0%
30	*E500_15_3_10*	14.5%	18.5%	16.9%	18.8%	11.7%	16.1%	16.5%	18.1%	13.6%	28.7%	28.6%	27.0%	22.1%	0.0%
31	*E500_15_4_1*	11.5%	28.2%	25.5%	24.8%	19.8%	19.9%	24.4%	27.0%	19.2%	37.1%	40.8%	38.5%	36.4%	0.0%
32	*E500_15_4_2*	14.0%	33.7%	26.9%	26.7%	26.8%	29.8%	27.2%	38.0%	20.5%	63.0%	60.8%	59.4%	54.6%	0.0%
33	*E500_15_4_3*	10.7%	30.7%	21.4%	18.1%	20.8%	26.2%	18.1%	25.9%	19.1%	46.3%	48.9%	42.3%	45.2%	0.0%
34	*E500_15_4_4*	7.6%	28.1%	25.8%	23.4%	27.5%	24.3%	26.9%	20.3%	28.0%	60.6%	58.0%	64.8%	60.4%	0.0%
35	*E500_15_4_5*	6.4%	22.0%	19.4%	21.9%	21.5%	20.3%	17.9%	26.0%	20.3%	57.1%	57.1%	57.9%	56.1%	0.0%
36	*E500_15_4_6*	9.4%	26.8%	21.1%	28.4%	22.4%	19.7%	23.8%	43.6%	22.0%	50.6%	50.5%	52.6%	45.6%	0.0%
37	*E500_15_4_7*	4.2%	16.0%	11.8%	16.7%	15.7%	13.0%	19.1%	15.7%	20.2%	40.3%	48.5%	48.3%	35.0%	0.0%
38	*E500_15_4_8*	14.1%	31.0%	30.1%	24.8%	23.8%	30.0%	18.4%	34.9%	28.8%	60.4%	68.8%	67.3%	57.8%	0.0%
39	*E500_15_4_9*	9.6%	21.6%	15.1%	20.4%	17.7%	16.5%	16.2%	24.8%	15.8%	49.1%	51.1%	49.7%	47.2%	0.0%
40	*E500_15_4_10*	4.0%	22.3%	19.8%	18.3%	16.7%	18.6%	19.4%	21.7%	20.7%	48.5%	44.9%	42.1%	41.1%	0.0%
	Average Deviatian	9.4%	15.7%	12.9%	16.0%	12.1%	13.5%	14.6%	17.0%	12.3%	25.9%	26.0%	25.7%	23.4%	0.0%

APPENDIX B

PROCESS DURATION FOR EACH INSTANCE

Table B.1 Leveling process duration for 50-activity instances (1/4)

No.	Project name & performance	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
		Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
1	*E50_1_1_1*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
2	*E50_1_1_2*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
3	*E50_1_1_3*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
4	*E50_1_1_4*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
5	*E50_1_1_5*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
6	*E50_1_1_6*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
7	*E50_1_1_7*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
8	*E50_1_1_8*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
9	*E50_1_1_9*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
10	*E50_1_1_10*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
11	*E50_1_2_1*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
12	*E50_1_2_2*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
13	*E50_1_2_3*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
14	*E50_1_2_4*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
15	*E50_1_2_5*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
16	*E50_1_2_6*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
17	*E50_1_2_7*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
18	*E50_1_2_8*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
19	*E50_1_2_9*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
20	*E50_1_2_10*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
21	*E50_1_3_1*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
22	*E50_1_3_2*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
23	*E50_1_3_3*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
24	*E50_1_3_4*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
25	*E50_1_3_5*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
26	*E50_1_3_6*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
27	*E50_1_3_7*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
28	*E50_1_3_8*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
29	*E50_1_3_9*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
30	*E50_1_3_10*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
31	*E50_1_4_1*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
32	*E50_1_4_2*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
33	*E50_1_4_3*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
34	*E50_1_4_4*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
35	*E50_1_4_5*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
36	*E50_1_4_6*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
37	*E50_1_4_7*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
38	*E50_1_4_8*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
39	*E50_1_4_9*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
40	*E50_1_4_10*	1	1	1	1	1	1	1	1	1	1	1	1	3	1

Table B.2 Leveling process duration for 50-activity instances (2/4)

No.	Project name & performance	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
		Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
1	*E50_5_1_1*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
2	*E50_5_1_2*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
3	*E50_5_1_3*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
4	*E50_5_1_4*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
5	*E50_5_1_5*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
6	*E50_5_1_6*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
7	*E50_5_1_7*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
8	*E50_5_1_8*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
9	*E50_5_1_9*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
10	*E50_5_1_10*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
11	*E50_5_2_1*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
12	*E50_5_2_2*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
13	*E50_5_2_3*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
14	*E50_5_2_4*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
15	*E50_5_2_5*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
16	*E50_5_2_6*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
17	*E50_5_2_7*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
18	*E50_5_2_8*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
19	*E50_5_2_9*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
20	*E50_5_2_10*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
21	*E50_5_3_1*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
22	*E50_5_3_2*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
23	*E50_5_3_3*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
24	*E50_5_3_4*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
25	*E50_5_3_5*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
26	*E50_5_3_6*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
27	*E50_5_3_7*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
28	*E50_5_3_8*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
29	*E50_5_3_9*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
30	*E50_5_3_10*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
31	*E50_5_4_1*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
32	*E50_5_4_2*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
33	*E50_5_4_3*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
34	*E50_5_4_4*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
35	*E50_5_4_5*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
36	*E50_5_4_6*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
37	*E50_5_4_7*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
38	*E50_5_4_8*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
39	*E50_5_4_9*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
40	*E50_5_4_10*	1	1	1	1	1	1	1	1	1	1	1	1	3	1

Table B.3 Leveling process duration for 50-activity instances (3/4)

No.	Project name & performance	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
		Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
1	*E50_10_1_1*	1	1	1	1	1	1	1	1	1	1	2	1	4	1
2	*E50_10_1_2*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
3	*E50_10_1_3*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
4	*E50_10_1_4*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
5	*E50_10_1_5*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
6	*E50_10_1_6*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
7	*E50_10_1_7*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
8	*E50_10_1_8*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
9	*E50_10_1_9*	1	1	1	1	1	1	1	1	1	1	1	2	4	1
10	*E50_10_1_10*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
11	*E50_10_2_1*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
12	*E50_10_2_2*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
13	*E50_10_2_3*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
14	*E50_10_2_4*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
15	*E50_10_2_5*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
16	*E50_10_2_6*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
17	*E50_10_2_7*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
18	*E50_10_2_8*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
19	*E50_10_2_9*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
20	*E50_10_2_10*	1	1	1	1	1	1	1	1	1	2	1	1	4	1
21	*E50_10_3_1*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
22	*E50_10_3_2*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
23	*E50_10_3_3*	1	1	1	1	1	1	1	1	1	1	2	1	4	1
24	*E50_10_3_4*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
25	*E50_10_3_5*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
26	*E50_10_3_6*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
27	*E50_10_3_7*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
28	*E50_10_3_8*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
29	*E50_10_3_9*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
30	*E50_10_3_10*	1	1	1	1	1	1	1	1	1	3	1	1	5	1
31	*E50_10_4_1*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
32	*E50_10_4_2*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
33	*E50_10_4_3*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
34	*E50_10_4_4*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
35	*E50_10_4_5*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
36	*E50_10_4_6*	1	1	1	1	1	1	1	1	1	1	1	2	4	1
37	*E50_10_4_7*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
38	*E50_10_4_8*	1	1	1	1	1	1	1	1	1	2	1	1	4	1
39	*E50_10_4_9*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
40	*E50_10_4_10*	1	1	1	1	1	1	1	1	1	1	1	1	3	1

Table B.4 Leveling process duration for 50-activity instances (4/4)

No.	Project name & performance	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
		Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
1	*E50_15_1_1*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
2	*E50_15_1_2*	1	1	1	1	1	1	1	1	1	1	2	1	4	1
3	*E50_15_1_3*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
4	*E50_15_1_4*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
5	*E50_15_1_5*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
6	*E50_15_1_6*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
7	*E50_15_1_7*	1	1	1	1	1	1	1	1	1	2	1	1	4	1
8	*E50_15_1_8*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
9	*E50_15_1_9*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
10	*E50_15_1_10*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
11	*E50_15_2_1*	1	1	1	1	1	1	1	1	1	1	2	1	4	1
12	*E50_15_2_2*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
13	*E50_15_2_3*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
14	*E50_15_2_4*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
15	*E50_15_2_5*	1	1	1	1	1	1	1	1	1	1	1	2	4	1
16	*E50_15_2_6*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
17	*E50_15_2_7*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
18	*E50_15_2_8*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
19	*E50_15_2_9*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
20	*E50_15_2_10*	1	1	1	1	1	1	1	1	1	1	1	2	4	1
21	*E50_15_3_1*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
22	*E50_15_3_2*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
23	*E50_15_3_3*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
24	*E50_15_3_4*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
25	*E50_15_3_5*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
26	*E50_15_3_6*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
27	*E50_15_3_7*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
28	*E50_15_3_8*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
29	*E50_15_3_9*	1	1	1	1	1	1	1	1	1	3	2	1	6	1
30	*E50_15_3_10*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
31	*E50_15_4_1*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
32	*E50_15_4_2*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
33	*E50_15_4_3*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
34	*E50_15_4_4*	1	1	1	1	1	1	1	1	1	1	1	2	4	1
35	*E50_15_4_5*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
36	*E50_15_4_6*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
37	*E50_15_4_7*	1	1	1	1	1	1	1	1	1	2	1	1	4	1
38	*E50_15_4_8*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
39	*E50_15_4_9*	1	1	1	1	1	1	1	1	1	1	2	1	4	1
40	*E50_15_4_10*	1	1	1	1	1	1	1	1	1	1	1	1	3	1

Table B.5 Leveling process duration for 100-activity instances (1/4)

No.	Project name & performance	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
		Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
1	*E100_1_1_1*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
2	*E100_1_1_2*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
3	*E100_1_1_3*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
4	*E100_1_1_4*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
5	*E100_1_1_5*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
6	*E100_1_1_6*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
7	*E100_1_1_7*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
8	*E100_1_1_8*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
9	*E100_1_1_9*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
10	*E100_1_1_10*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
11	*E100_1_2_1*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
12	*E100_1_2_2*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
13	*E100_1_2_3*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
14	*E100_1_2_4*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
15	*E100_1_2_5*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
16	*E100_1_2_6*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
17	*E100_1_2_7*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
18	*E100_1_2_8*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
19	*E100_1_2_9*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
20	*E100_1_2_10*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
21	*E100_1_3_1*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
22	*E100_1_3_2*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
23	*E100_1_3_3*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
24	*E100_1_3_4*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
25	*E100_1_3_5*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
26	*E100_1_3_6*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
27	*E100_1_3_7*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
28	*E100_1_3_8*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
29	*E100_1_3_9*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
30	*E100_1_3_10*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
31	*E100_1_4_1*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
32	*E100_1_4_2*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
33	*E100_1_4_3*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
34	*E100_1_4_4*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
35	*E100_1_4_5*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
36	*E100_1_4_6*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
37	*E100_1_4_7*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
38	*E100_1_4_8*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
39	*E100_1_4_9*	1	1	1	1	1	1	1	1	1	1	1	1	3	1
40	*E100_1_4_10*	1	1	1	1	1	1	1	1	1	1	1	1	3	1

Table B.6 Leveling process duration for 100-activity instances (2/4)

No.	Project name & performance	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
		Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
1	*E100_5_1_1*	4	1	1	1	1	1	1	1	1	5	5	5	15	1
2	*E100_5_1_2*	2	1	1	1	1	1	1	1	1	5	5	5	15	1
3	*E100_5_1_3*	3	1	1	1	1	1	1	1	1	4	4	5	13	1
4	*E100_5_1_4*	4	1	1	1	1	1	1	1	1	5	5	5	15	1
5	*E100_5_1_5*	5	1	1	1	1	1	1	1	1	5	5	5	15	1
6	*E100_5_1_6*	3	1	1	1	1	1	1	1	1	5	5	5	15	1
7	*E100_5_1_7*	4	1	1	1	1	1	1	1	1	5	5	5	15	1
8	*E100_5_1_8*	4	1	1	1	1	1	1	1	1	5	5	4	14	1
9	*E100_5_1_9*	3	1	1	1	1	1	1	1	1	5	4	5	14	1
10	*E100_5_1_10*	3	1	1	1	1	1	1	1	1	5	5	5	15	1
11	*E100_5_2_1*	4	1	1	1	1	1	1	1	1	5	5	5	15	1
12	*E100_5_2_2*	3	1	1	1	1	1	1	1	1	4	5	5	14	1
13	*E100_5_2_3*	4	1	1	1	1	1	1	1	1	5	5	4	14	1
14	*E100_5_2_4*	4	1	1	1	1	1	1	1	1	5	5	5	15	1
15	*E100_5_2_5*	3	1	1	1	1	1	1	1	1	4	5	5	14	1
16	*E100_5_2_6*	3	1	1	1	1	1	1	1	1	5	5	4	14	1
17	*E100_5_2_7*	4	1	1	1	1	1	1	1	1	5	5	5	15	1
18	*E100_5_2_8*	4	1	1	1	1	1	1	1	1	4	5	5	14	1
19	*E100_5_2_9*	3	1	1	1	1	1	1	1	1	5	4	5	14	1
20	*E100_5_2_10*	4	1	1	1	1	1	1	1	1	5	5	5	15	1
21	*E100_5_3_1*	3	1	1	1	1	1	1	1	1	5	5	4	14	1
22	*E100_5_3_2*	2	1	1	1	1	1	1	1	1	4	5	4	13	1
23	*E100_5_3_3*	3	1	1	1	1	1	1	1	1	5	5	5	15	1
24	*E100_5_3_4*	3	1	1	1	1	1	1	1	1	5	5	5	15	1
25	*E100_5_3_5*	3	1	1	1	1	1	1	1	1	4	5	5	14	1
26	*E100_5_3_6*	2	1	1	1	1	1	1	1	1	5	5	5	15	1
27	*E100_5_3_7*	2	1	1	1	1	1	1	1	1	5	5	5	15	1
28	*E100_5_3_8*	2	1	1	1	1	1	1	1	1	5	5	5	15	1
29	*E100_5_3_9*	4	1	1	1	1	1	1	1	1	5	5	5	15	1
30	*E100_5_3_10*	2	1	1	1	1	1	1	1	1	5	5	5	15	1
31	*E100_5_4_1*	2	1	1	1	1	1	1	1	1	4	5	4	13	1
32	*E100_5_4_2*	2	1	1	1	1	1	1	1	1	5	5	5	15	1
33	*E100_5_4_3*	1	1	1	1	1	1	1	1	1	5	4	5	14	1
34	*E100_5_4_4*	2	1	1	1	1	1	1	1	1	5	5	5	15	1
35	*E100_5_4_5*	2	1	1	1	1	1	1	1	1	4	5	4	13	1
36	*E100_5_4_6*	2	1	1	1	1	1	1	1	1	5	5	5	15	1
37	*E100_5_4_7*	2	1	1	1	1	1	1	1	1	5	4	4	13	1
38	*E100_5_4_8*	1	1	1	1	1	1	1	1	1	4	5	5	14	1
39	*E100_5_4_9*	1	1	1	1	1	1	1	1	1	5	5	5	15	1
40	*E100_5_4_10*	1	1	1	1	1	1	1	1	1	5	5	4	14	1

Table B.7 Leveling process duration for 100-activity instances (3/4)

No.	Project name & performance	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
		Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
1	*E100_10_1_1*	6	1	1	1	1	1	1	1	1	9	8	8	25	1
2	*E100_10_1_2*	6	1	1	1	1	1	1	1	1	8	9	9	26	1
3	*E100_10_1_3*	6	1	1	1	1	1	1	1	1	8	11	9	28	1
4	*E100_10_1_4*	5	1	1	1	1	1	1	1	1	12	12	12	36	1
5	*E100_10_1_5*	7	1	1	1	1	1	1	1	1	19	17	16	52	1
6	*E100_10_1_6*	8	1	1	1	1	1	1	1	1	12	10	11	33	1
7	*E100_10_1_7*	7	1	1	1	1	1	1	1	1	9	9	9	27	1
8	*E100_10_1_8*	5	1	1	1	1	1	1	1	1	16	15	17	48	1
9	*E100_10_1_9*	6	1	1	1	1	1	1	1	1	10	13	10	33	1
10	*E100_10_1_10*	7	1	1	1	1	1	1	1	1	18	17	18	53	1
11	*E100_10_2_1*	7	1	1	1	1	1	1	1	1	9	10	10	29	1
12	*E100_10_2_2*	6	1	1	1	1	1	1	1	1	12	14	14	40	1
13	*E100_10_2_3*	7	1	1	1	1	1	1	1	1	26	31	24	81	1
14	*E100_10_2_4*	7	1	1	1	1	1	1	1	1	21	21	31	73	1
15	*E100_10_2_5*	7	1	1	1	1	1	1	1	1	14	15	19	48	1
16	*E100_10_2_6*	4	1	1	1	1	1	1	1	1	10	9	10	29	1
17	*E100_10_2_7*	6	1	1	1	1	1	1	1	1	17	16	14	47	1
18	*E100_10_2_8*	6	1	1	1	1	1	1	1	1	23	25	26	74	1
19	*E100_10_2_9*	6	1	1	1	1	1	1	1	1	17	16	15	48	1
20	*E100_10_2_10*	7	1	1	1	1	1	1	1	1	19	19	23	61	1
21	*E100_10_3_1*	4	1	1	1	1	1	1	1	1	10	13	13	36	1
22	*E100_10_3_2*	4	1	1	1	1	1	1	1	1	10	11	12	34	1
23	*E100_10_3_3*	4	1	1	1	1	1	1	1	1	8	9	7	23	1
24	*E100_10_3_4*	5	1	1	1	1	1	1	1	1	16	19	18	53	1
25	*E100_10_3_5*	6	1	1	1	1	1	1	1	1	13	14	15	42	1
26	*E100_10_3_6*	5	1	1	1	1	1	1	1	1	10	10	11	31	1
27	*E100_10_3_7*	4	1	1	1	1	1	1	1	1	12	12	13	37	1
28	*E100_10_3_8*	5	1	1	1	1	1	1	1	1	11	12	11	35	1
29	*E100_10_3_9*	4	1	1	1	1	1	1	1	1	11	12	13	37	1
30	*E100_10_3_10*	4	1	1	1	1	1	1	1	1	15	17	13	45	1
31	*E100_10_4_1*	3	1	1	1	1	1	1	1	1	12	12	13	37	1
32	*E100_10_4_2*	4	1	1	1	1	1	1	1	1	14	14	11	40	1
33	*E100_10_4_3*	3	1	1	1	1	1	1	1	1	9	12	12	32	1
34	*E100_10_4_4*	3	1	1	1	1	1	1	1	1	8	11	10	29	1
35	*E100_10_4_5*	2	1	1	1	1	1	1	1	1	8	9	9	27	1
36	*E100_10_4_6*	3	1	1	1	1	1	1	1	1	12	16	11	39	1
37	*E100_10_4_7*	2	1	1	1	1	1	1	1	1	8	11	11	30	1
38	*E100_10_4_8*	3	1	1	1	1	1	1	1	1	8	10	8	26	1
39	*E100_10_4_9*	2	1	1	1	1	1	1	1	1	10	11	10	31	1
40	*E100_10_4_10*	3	1	1	1	1	1	1	1	1	11	14	12	37	1

Table B.8 Leveling process duration for 100-activity instances (4/4)

No.	Project name & performance	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
		Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
1	*E100_15_1_1*	10	1	1	1	1	1	1	1	1	8	10	16	33	1
2	*E100_15_1_2*	10	1	1	1	1	1	1	1	1	8	7	10	25	1
3	*E100_15_1_3*	10	1	1	1	1	1	1	1	1	10	10	9	28	1
4	*E100_15_1_4*	11	1	1	1	1	1	1	1	1	8	8	11	27	1
5	*E100_15_1_5*	11	1	1	1	1	1	1	1	1	4	5	6	15	1
6	*E100_15_1_6*	10	1	1	1	1	1	1	1	1	6	7	8	21	1
7	*E100_15_1_7*	10	1	1	1	1	1	1	1	1	8	10	9	27	1
8	*E100_15_1_8*	9	1	1	1	1	1	1	1	1	8	9	9	26	1
9	*E100_15_1_9*	13	1	1	1	1	1	1	1	1	7	9	9	25	1
10	*E100_15_1_10*	7	1	1	1	1	1	1	1	1	5	7	5	17	1
11	*E100_15_2_1*	9	1	1	1	1	1	1	1	1	21	22	17	59	1
12	*E100_15_2_2*	11	1	1	1	1	1	1	1	1	40	43	43	126	1
13	*E100_15_2_3*	7	1	1	1	1	1	1	1	1	13	13	13	39	1
14	*E100_15_2_4*	9	2	1	1	1	1	1	1	1	34	30	31	95	1
15	*E100_15_2_5*	8	1	1	1	1	1	1	1	1	19	22	22	63	1
16	*E100_15_2_6*	9	1	1	1	1	1	2	1	1	32	42	53	127	1
17	*E100_15_2_7*	11	1	1	1	1	1	1	1	1	39	37	32	108	1
18	*E100_15_2_8*	9	1	1	1	1	1	1	1	1	39	43	36	118	1
19	*E100_15_2_9*	12	1	1	1	2	1	1	1	1	37	46	55	138	1
20	*E100_15_2_10*	9	1	1	1	1	1	1	1	1	38	30	31	99	1
21	*E100_15_3_1*	7	1	1	1	1	1	1	1	1	22	23	22	67	1
22	*E100_15_3_2*	8	1	1	1	1	1	1	1	1	20	22	19	62	1
23	*E100_15_3_3*	6	1	1	1	1	1	1	1	1	25	23	28	76	1
24	*E100_15_3_4*	7	1	1	1	1	2	1	1	1	24	22	30	77	1
25	*E100_15_3_5*	7	1	1	1	1	1	1	1	1	22	33	24	82	1
26	*E100_15_3_6*	6	1	1	2	1	1	1	1	1	23	24	23	69	1
27	*E100_15_3_7*	7	1	1	1	1	1	1	1	1	21	21	23	65	1
28	*E100_15_3_8*	6	1	1	2	1	1	1	2	1	20	20	24	64	1
29	*E100_15_3_9*	6	1	1	1	1	1	1	1	1	17	20	20	57	1
30	*E100_15_3_10*	5	1	1	1	1	1	1	1	1	18	15	20	53	1
31	*E100_15_4_1*	5	1	1	1	2	1	1	1	1	19	16	21	56	1
32	*E100_15_4_2*	5	1	1	1	1	1	1	1	1	20	20	23	63	1
33	*E100_15_4_3*	6	1	1	1	1	1	1	1	1	30	31	26	87	1
34	*E100_15_4_4*	3	1	1	1	1	1	1	1	2	18	18	16	52	1
35	*E100_15_4_5*	5	1	1	1	2	1	1	1	2	15	24	21	60	1
36	*E100_15_4_6*	5	1	1	1	1	1	2	1	1	19	25	19	62	1
37	*E100_15_4_7*	4	2	1	1	1	1	1	1	1	12	18	17	47	1
38	*E100_15_4_8*	6	1	1	1	1	1	1	1	2	21	21	20	63	1
39	*E100_15_4_9*	6	1	1	2	1	1	1	1	1	23	32	25	79	1
40	*E100_15_4_10*	4	1	1	1	1	1	1	1	1	17	18	21	57	1

Table B.9 Leveling process duration for 200-activity instances (1/4)

No.	Project name & performance	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
		Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
1	*E200_1_1_1*	4	1	1	1	1	1	1	1	1	5	5	5	16	1
2	*E200_1_1_2*	4	1	1	1	1	1	1	1	1	8	8	8	25	1
3	*E200_1_1_3*	3	1	1	1	1	1	1	1	1	8	8	7	23	1
4	*E200_1_1_4*	3	1	1	1	1	1	1	1	1	5	4	4	12	1
5	*E200_1_1_5*	3	1	1	1	1	1	1	1	1	9	7	10	25	1
6	*E200_1_1_6*	3	1	1	1	1	1	1	1	1	4	3	4	11	1
7	*E200_1_1_7*	3	1	1	1	1	1	1	1	1	6	7	6	20	1
8	*E200_1_1_8*	3	1	1	1	1	1	1	1	1	8	9	8	25	1
9	*E200_1_1_9*	3	1	1	1	1	1	1	1	1	7	9	8	24	1
10	*E200_1_1_10*	3	1	1	1	1	1	1	1	1	5	6	5	16	1
11	*E200_1_2_1*	3	1	1	1	1	1	1	1	1	7	8	6	21	1
12	*E200_1_2_2*	2	1	1	1	1	1	1	1	1	3	4	3	10	1
13	*E200_1_2_3*	2	1	1	1	1	1	1	1	1	7	7	7	21	1
14	*E200_1_2_4*	2	1	1	1	1	1	1	1	1	7	6	6	19	1
15	*E200_1_2_5*	2	1	1	1	1	1	1	1	1	4	5	5	14	1
16	*E200_1_2_6*	2	1	1	1	1	1	1	1	1	9	10	10	28	1
17	*E200_1_2_7*	2	1	1	1	1	1	1	1	1	4	4	5	13	1
18	*E200_1_2_8*	2	1	1	1	1	1	1	1	1	4	4	4	11	1
19	*E200_1_2_9*	2	1	1	1	1	1	1	1	1	5	5	5	15	1
20	*E200_1_2_10*	2	1	1	1	1	1	1	1	1	4	4	4	12	1
21	*E200_1_3_1*	2	1	1	1	1	1	1	1	1	6	5	7	18	1
22	*E200_1_3_2*	2	1	1	1	1	1	1	1	1	5	6	7	18	1
23	*E200_1_3_3*	2	1	1	1	1	1	1	1	1	7	7	6	20	1
24	*E200_1_3_4*	2	1	1	1	1	1	1	1	1	8	6	6	20	1
25	*E200_1_3_5*	2	1	1	1	1	1	1	1	1	6	6	7	19	1
26	*E200_1_3_6*	2	1	1	1	1	1	1	1	1	5	5	6	16	1
27	*E200_1_3_7*	2	1	1	1	1	1	1	1	1	7	8	7	22	1
28	*E200_1_3_8*	1	1	1	1	1	1	1	1	1	4	4	4	12	1
29	*E200_1_3_9*	1	1	1	1	1	1	1	1	1	5	4	5	14	1
30	*E200_1_3_10*	1	1	1	1	1	1	1	1	1	5	5	5	15	1
31	*E200_1_4_1*	1	1	1	1	1	1	1	1	1	10	12	12	34	1
32	*E200_1_4_2*	1	1	1	1	1	1	1	1	1	9	10	9	28	1
33	*E200_1_4_3*	1	1	1	1	1	1	1	1	1	11	12	11	34	1
34	*E200_1_4_4*	1	1	1	1	1	1	1	1	1	9	13	10	32	1
35	*E200_1_4_5*	1	1	1	1	1	1	1	1	1	10	9	6	25	1
36	*E200_1_4_6*	1	1	1	1	1	1	1	1	1	9	12	11	32	1
37	*E200_1_4_7*	1	1	1	1	1	1	1	1	1	9	11	10	30	1
38	*E200_1_4_8*	1	1	1	1	1	1	1	1	1	10	12	8	30	1
39	*E200_1_4_9*	1	1	1	1	1	1	1	1	1	11	14	12	37	1
40	*E200_1_4_10*	2	1	1	1	1	1	1	1	1	11	13	11	35	1

Table B.10 Leveling process duration for 200-activity instances (2/4)

No.	Project name & performance	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
		Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
1	*E200_5_1_1*	15	1	1	1	1	1	1	1	1	7	7	5	19	1
2	*E200_5_1_2*	16	1	1	1	1	1	1	1	1	7	10	8	25	1
3	*E200_5_1_3*	15	1	1	1	1	1	1	1	1	7	7	7	21	1
4	*E200_5_1_4*	14	1	1	1	1	1	1	1	1	7	8	8	23	1
5	*E200_5_1_5*	14	1	1	1	1	1	1	1	1	7	7	7	21	1
6	*E200_5_1_6*	11	1	1	1	1	1	1	1	1	5	4	4	13	1
7	*E200_5_1_7*	14	1	1	1	1	1	1	1	1	6	7	6	19	1
8	*E200_5_1_8*	14	1	2	1	1	2	1	1	1	6	8	7	21	1
9	*E200_5_1_9*	13	1	1	1	1	1	1	1	1	6	6	6	18	1
10	*E200_5_1_10*	13	1	1	1	1	1	1	1	1	7	6	6	19	1
11	*E200_5_2_1*	15	1	1	1	1	1	1	2	1	24	23	25	72	1
12	*E200_5_2_2*	16	1	1	1	1	1	1	1	1	17	17	17	51	1
13	*E200_5_2_3*	11	1	1	2	1	2	1	1	1	9	13	12	34	1
14	*E200_5_2_4*	17	1	2	1	1	1	1	2	1	30	33	28	91	1
15	*E200_5_2_5*	12	1	1	1	1	1	1	1	1	12	15	14	41	1
16	*E200_5_2_6*	17	1	2	1	1	1	1	1	1	29	31	28	88	1
17	*E200_5_2_7*	11	1	1	1	1	1	1	1	1	11	10	10	31	1
18	*E200_5_2_8*	11	1	1	1	1	1	1	1	1	13	11	12	36	1
19	*E200_5_2_9*	18	1	1	1	1	1	1	1	1	36	36	31	103	1
20	*E200_5_2_10*	14	1	2	1	1	1	1	2	1	31	31	49	111	1
21	*E200_5_3_1*	11	1	1	1	1	1	1	1	1	19	20	19	58	1
22	*E200_5_3_2*	9	1	1	1	1	1	1	1	1	15	17	15	47	1
23	*E200_5_3_3*	17	1	1	1	1	2	1	1	1	30	33	29	92	1
24	*E200_5_3_4*	9	1	1	1	1	1	1	1	1	14	14	16	44	1
25	*E200_5_3_5*	9	2	1	1	1	1	1	1	1	12	14	15	41	1
26	*E200_5_3_6*	11	1	1	1	2	1	2	1	1	17	18	18	53	1
27	*E200_5_3_7*	8	1	1	1	1	1	1	1	1	16	16	18	50	1
28	*E200_5_3_8*	11	2	1	1	1	1	1	1	2	18	17	22	57	1
29	*E200_5_3_9*	10	1	1	2	1	1	2	1	1	19	20	20	59	1
30	*E200_5_3_10*	12	1	1	1	1	1	1	1	1	21	23	20	64	1
31	*E200_5_4_1*	8	1	1	1	1	1	1	1	2	26	34	29	89	1
32	*E200_5_4_2*	6	1	1	1	2	1	1	1	1	22	26	27	75	1
33	*E200_5_4_3*	6	2	1	1	1	1	1	2	1	23	27	25	75	1
34	*E200_5_4_4*	8	1	2	1	1	1	1	1	1	25	34	31	90	1
35	*E200_5_4_5*	8	1	1	1	1	1	1	2	2	30	38	30	98	1
36	*E200_5_4_6*	7	1	1	1	1	1	1	1	1	33	35	26	94	1
37	*E200_5_4_7*	8	1	1	1	2	1	1	1	1	26	34	28	88	1
38	*E200_5_4_8*	7	1	1	1	1	1	2	1	1	24	30	27	81	1
39	*E200_5_4_9*	6	1	1	1	1	1	1	1	1	25	31	26	82	1
40	*E200_5_4_10*	8	1	1	1	1	1	1	1	1	32	37	33	102	1

Table B.11 Leveling process duration for 200-activity instances (3/4)

No.	Project name & performance	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
		Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
1	*E200_10_1_1*	30	2	2	2	2	2	2	2	2	16	17	12	45	1
2	*E200_10_1_2*	24	2	2	2	2	2	2	2	2	14	16	15	45	1
3	*E200_10_1_3*	27	2	2	2	2	2	2	2	2	12	13	14	39	1
4	*E200_10_1_4*	21	2	2	2	2	2	2	2	2	11	14	14	39	1
5	*E200_10_1_5*	32	2	2	2	2	2	2	2	2	18	21	17	56	1
6	*E200_10_1_6*	23	2	2	2	2	2	2	2	2	12	14	13	39	1
7	*E200_10_1_7*	29	2	2	2	2	2	2	2	2	17	22	17	56	1
8	*E200_10_1_8*	28	2	2	2	2	2	2	2	2	15	15	15	45	1
9	*E200_10_1_9*	22	2	2	2	2	2	2	2	2	17	15	13	45	1
10	*E200_10_1_10*	32	2	2	2	2	2	2	2	2	22	17	19	58	1
11	*E200_10_2_1*	25	2	2	2	2	2	2	2	2	58	60	50	168	1
12	*E200_10_2_2*	20	2	2	2	2	2	2	2	2	48	46	51	145	1
13	*E200_10_2_3*	21	2	2	2	2	2	2	2	2	38	45	48	131	1
14	*E200_10_2_4*	28	2	2	2	2	2	2	2	2	62	63	57	182	1
15	*E200_10_2_5*	20	2	2	2	2	2	2	2	2	32	29	34	95	1
16	*E200_10_2_6*	23	2	2	2	2	2	2	2	2	55	66	57	178	1
17	*E200_10_2_7*	25	2	2	2	2	2	2	2	2	59	53	56	168	1
18	*E200_10_2_8*	21	2	2	2	2	2	2	2	2	40	35	39	114	1
19	*E200_10_2_9*	23	2	2	2	2	2	2	2	2	85	78	91	254	1
20	*E200_10_2_10*	25	2	2	2	2	2	2	2	2	51	59	52	162	1
21	*E200_10_3_1*	17	2	2	2	2	2	2	2	2	45	45	45	135	1
22	*E200_10_3_2*	24	2	2	2	2	2	2	2	2	72	75	74	221	1
23	*E200_10_3_3*	15	2	2	2	2	2	2	2	2	36	37	40	113	1
24	*E200_10_3_4*	19	2	2	2	2	2	2	2	2	36	39	53	128	1
25	*E200_10_3_5*	19	2	2	2	2	2	2	2	2	38	43	41	122	1
26	*E200_10_3_6*	17	2	2	2	2	2	2	2	2	49	45	52	146	1
27	*E200_10_3_7*	20	2	2	2	2	2	2	2	2	58	56	49	163	1
28	*E200_10_3_8*	20	2	2	2	2	2	2	2	2	69	72	59	200	1
29	*E200_10_3_9*	24	2	2	2	2	2	2	2	2	61	59	66	186	1
30	*E200_10_3_10*	17	2	2	2	2	2	2	2	2	44	40	40	124	1
31	*E200_10_4_1*	14	2	2	2	2	2	2	2	2	55	55	67	177	1
32	*E200_10_4_2*	13	2	2	2	2	2	2	2	2	67	79	62	208	1
33	*E200_10_4_3*	14	2	2	2	2	2	2	2	2	215	237	197	649	1
34	*E200_10_4_4*	13	2	2	2	2	2	2	2	2	65	85	70	220	1
35	*E200_10_4_5*	14	2	2	2	2	2	2	2	2	54	64	56	174	1
36	*E200_10_4_6*	13	2	2	2	2	2	2	2	2	57	63	59	179	1
37	*E200_10_4_7*	14	2	2	2	2	2	2	2	2	66	76	75	217	1
38	*E200_10_4_8*	15	2	2	2	2	2	2	2	2	60	72	60	192	1
39	*E200_10_4_9*	15	2	2	2	2	2	2	2	2	73	81	70	224	1
40	*E200_10_4_10*	13	2	2	2	2	2	2	2	2	61	68	65	194	1

Table B.12 Leveling process duration for 200-activity instances (4/4)

No.	Project name & performance	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
		Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
1	*E200_15_1_1*	44	2	2	2	2	2	2	2	2	31	28	29	88	1
2	*E200_15_1_2*	41	2	2	2	2	2	2	2	2	32	28	25	85	1
3	*E200_15_1_3*	42	2	2	2	2	2	2	2	2	28	30	26	84	2
4	*E200_15_1_4*	36	2	2	2	2	2	2	2	2	27	32	28	87	1
5	*E200_15_1_5*	35	2	3	2	2	3	2	2	2	34	29	28	91	1
6	*E200_15_1_6*	42	2	2	2	2	2	2	2	2	29	34	28	91	1
7	*E200_15_1_7*	31	2	2	2	2	2	2	2	2	19	29	21	69	1
8	*E200_15_1_8*	44	2	2	2	2	2	2	3	2	25	28	24	77	1
9	*E200_15_1_9*	37	2	2	2	2	2	2	2	2	34	33	29	96	1
10	*E200_15_1_10*	39	2	2	3	2	2	2	2	2	28	25	29	82	1
11	*E200_15_2_1*	37	2	2	2	2	3	2	2	2	95	102	104	301	1
12	*E200_15_2_2*	49	2	2	2	2	2	2	2	2	155	161	129	445	1
13	*E200_15_2_3*	38	2	2	2	2	2	2	3	2	141	152	162	455	1
14	*E200_15_2_4*	34	2	3	2	2	2	2	2	2	161	153	205	519	1
15	*E200_15_2_5*	48	2	2	2	2	2	2	2	2	221	198	227	646	1
16	*E200_15_2_6*	33	2	2	2	2	2	2	2	2	105	108	88	301	1
17	*E200_15_2_7*	36	2	2	2	2	2	2	2	2	119	118	113	350	1
18	*E200_15_2_8*	31	2	2	2	2	2	3	2	2	108	100	104	312	1
19	*E200_15_2_9*	36	2	3	2	2	2	2	2	2	152	166	177	495	1
20	*E200_15_2_10*	40	2	2	2	2	2	2	2	2	117	135	138	390	1
21	*E200_15_3_1*	26	2	2	2	2	2	2	2	2	86	81	83	250	1
22	*E200_15_3_2*	25	2	2	2	2	2	2	2	2	55	59	62	176	1
23	*E200_15_3_3*	21	2	2	2	2	2	2	2	2	58	60	69	187	1
24	*E200_15_3_4*	26	2	2	2	2	3	2	2	2	72	78	73	223	1
25	*E200_15_3_5*	29	2	2	3	2	2	2	2	2	105	96	108	309	1
26	*E200_15_3_6*	39	2	2	2	2	2	2	2	2	132	140	131	403	1
27	*E200_15_3_7*	29	2	2	2	2	2	2	3	2	138	122	116	376	1
28	*E200_15_3_8*	28	2	2	2	2	2	2	2	2	82	89	83	254	1
29	*E200_15_3_9*	25	2	3	2	2	3	2	2	2	68	74	69	211	1
30	*E200_15_3_10*	28	2	2	2	2	2	2	2	2	101	131	92	324	1
31	*E200_15_4_1*	21	2	2	2	2	2	2	2	2	88	98	95	281	1
32	*E200_15_4_2*	22	2	2	2	2	2	2	3	2	107	102	110	319	1
33	*E200_15_4_3*	21	2	2	2	2	2	2	2	2	84	104	93	281	1
34	*E200_15_4_4*	19	2	2	2	2	3	2	2	2	83	92	84	259	1
35	*E200_15_4_5*	23	2	2	2	2	2	2	3	2	116	135	115	366	1
36	*E200_15_4_6*	19	2	3	2	2	2	2	2	2	98	108	94	300	1
37	*E200_15_4_7*	22	2	2	2	2	2	2	2	2	99	119	109	327	1
38	*E200_15_4_8*	17	2	2	2	2	2	3	2	2	72	73	73	218	1
39	*E200_15_4_9*	21	2	2	3	2	2	2	2	2	98	105	92	295	1
40	*E200_15_4_10*	15	2	2	2	2	2	2	2	2	80	100	93	273	1

Table B.13 Leveling process duration for 500-activity instances (1/4)

No.	Project name & performance	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
		Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
1	*E500_1_1_1*	26	1	1	1	1	1	1	1	1	13	12	15	40	1
2	*E500_1_1_2*	26	1	1	1	1	1	1	1	1	10	8	9	27	1
3	*E500_1_1_3*	17	1	1	1	1	1	1	1	1	12	12	13	37	1
4	*E500_1_1_4*	29	1	1	1	1	1	1	1	1	17	17	18	52	1
5	*E500_1_1_5*	20	1	1	1	1	1	1	1	1	19	19	20	58	1
6	*E500_1_1_6*	11	1	1	1	1	1	1	1	1	7	8	7	22	1
7	*E500_1_1_7*	37	1	1	1	1	1	1	1	1	22	26	24	72	1
8	*E500_1_1_8*	28	1	1	1	1	1	1	1	1	17	16	16	49	1
9	*E500_1_1_9*	28	1	1	1	1	1	1	1	1	11	12	11	34	1
10	*E500_1_1_10*	15	1	1	1	1	1	1	1	1	12	11	12	35	1
11	*E500_1_2_1*	18	1	1	1	1	1	1	1	1	25	25	26	76	1
12	*E500_1_2_2*	17	1	1	1	1	1	1	1	1	25	28	28	81	1
13	*E500_1_2_3*	21	1	1	1	1	1	1	1	1	49	53	40	142	1
14	*E500_1_2_4*	23	1	2	1	1	1	1	1	1	28	24	31	83	1
15	*E500_1_2_5*	19	1	1	1	1	1	1	1	1	33	32	31	96	1
16	*E500_1_2_6*	25	1	1	1	1	1	1	1	1	26	28	29	83	1
17	*E500_1_2_7*	17	1	2	1	1	1	1	1	1	24	24	21	69	1
18	*E500_1_2_8*	24	1	1	1	1	1	1	1	1	36	30	34	100	1
19	*E500_1_2_9*	25	1	1	1	1	1	1	1	1	31	32	33	96	1
20	*E500_1_2_10*	15	1	1	1	1	1	1	1	1	17	18	22	57	1
21	*E500_1_3_1*	14	1	1	1	1	1	1	2	1	26	24	28	78	1
22	*E500_1_3_2*	16	2	1	1	1	1	1	1	1	21	25	23	69	1
23	*E500_1_3_3*	17	1	1	1	1	1	1	1	1	31	34	38	103	1
24	*E500_1_3_4*	18	1	1	1	1	1	1	2	1	36	35	29	100	1
25	*E500_1_3_5*	15	1	1	1	1	1	1	1	1	25	24	25	74	1
26	*E500_1_3_6*	16	2	1	2	1	1	1	1	1	25	26	25	76	1
27	*E500_1_3_7*	16	1	1	1	1	1	1	1	1	28	26	29	83	1
28	*E500_1_3_8*	16	1	1	1	1	2	1	1	1	33	36	30	99	1
29	*E500_1_3_9*	15	2	1	1	1	1	1	1	1	33	31	30	94	1
30	*E500_1_3_10*	18	1	1	1	1	1	1	2	1	27	28	30	85	1
31	*E500_1_4_1*	7	1	1	1	1	1	2	2	1	43	52	51	146	1
32	*E500_1_4_2*	9	2	2	2	2	2	1	1	1	63	70	70	203	1
33	*E500_1_4_3*	7	2	1	2	1	1	1	2	1	54	70	64	188	1
34	*E500_1_4_4*	8	2	1	2	1	2	2	2	1	53	61	59	173	1
35	*E500_1_4_5*	8	1	1	1	1	2	1	1	1	56	69	66	191	1
36	*E500_1_4_6*	9	1	2	1	1	1	1	1	2	58	78	60	196	1
37	*E500_1_4_7*	10	2	1	2	1	1	1	1	2	65	78	78	221	1
38	*E500_1_4_8*	8	1	1	2	1	1	1	2	1	66	85	72	223	1
39	*E500_1_4_9*	8	2	1	1	1	1	1	1	1	54	77	62	193	1
40	*E500_1_4_10*	7	1	1	1	2	2	2	2	1	50	57	46	153	1

Table B.14 Leveling process duration for 500-activity instances (2/4)

No.	Project name & performance	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
		Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
1	*E500_5_1_1*	173	1	1	1	1	1	1	1	1	45	47	45	137	2
2	*E500_5_1_2*	144	1	1	1	1	1	1	1	1	63	65	67	195	1
3	*E500_5_1_3*	159	1	1	1	1	1	1	2	1	51	56	53	160	2
4	*E500_5_1_4*	92	1	1	2	1	1	1	1	1	34	37	41	112	1
5	*E500_5_1_5*	198	1	1	1	1	1	1	1	1	100	82	99	281	2
6	*E500_5_1_6*	118	1	1	1	1	1	1	1	1	48	48	41	137	1
7	*E500_5_1_7*	83	1	1	1	1	2	1	1	1	30	31	30	91	1
8	*E500_5_1_8*	116	1	1	1	1	1	1	1	1	60	50	48	158	1
9	*E500_5_1_9*	186	1	1	1	1	1	1	1	1	68	68	71	207	1
10	*E500_5_1_10*	79	1	1	1	1	1	1	1	1	51	50	50	151	1
11	*E500_5_2_1*	197	2	2	2	2	2	2	2	2	97	119	119	335	2
12	*E500_5_2_2*	161	2	2	2	2	2	2	2	2	142	138	149	429	1
13	*E500_5_2_3*	164	2	2	2	2	2	2	2	2	139	119	148	406	1
14	*E500_5_2_4*	176	2	2	2	2	2	2	2	2	116	94	112	322	1
15	*E500_5_2_5*	180	2	2	2	2	2	2	2	2	61	64	64	189	1
16	*E500_5_2_6*	185	2	2	2	2	2	2	2	2	133	122	133	388	1
17	*E500_5_2_7*	152	2	2	2	2	2	2	2	2	151	160	162	473	1
18	*E500_5_2_8*	212	2	2	2	2	2	2	2	2	177	300	244	721	3
19	*E500_5_2_9*	149	2	2	2	2	2	2	2	2	97	96	97	290	1
20	*E500_5_2_10*	173	2	2	2	2	2	2	2	2	156	165	130	451	1
21	*E500_5_3_1*	131	3	3	4	3	4	3	4	3	109	122	123	354	1
22	*E500_5_3_2*	133	3	3	4	3	3	3	4	3	216	247	210	673	1
23	*E500_5_3_3*	136	3	3	4	3	4	3	3	3	135	145	142	422	2
24	*E500_5_3_4*	149	3	3	4	3	3	3	4	3	107	111	101	319	2
25	*E500_5_3_5*	139	3	3	3	3	3	3	3	3	149	151	161	461	2
26	*E500_5_3_6*	131	3	3	4	3	4	3	4	3	115	137	118	370	2
27	*E500_5_3_7*	131	3	3	4	3	3	3	3	3	127	135	127	389	1
28	*E500_5_3_8*	117	3	3	3	3	4	3	4	3	101	100	91	292	2
29	*E500_5_3_9*	160	3	3	4	3	4	3	4	3	130	141	147	418	2
30	*E500_5_3_10*	160	3	3	4	3	3	3	3	3	116	109	106	331	1
31	*E500_5_4_1*	52	4	4	4	4	4	4	4	4	145	205	169	519	1
32	*E500_5_4_2*	62	4	4	5	5	5	5	4	5	202	229	213	644	2
33	*E500_5_4_3*	56	5	5	4	4	4	5	5	5	220	217	192	629	1
34	*E500_5_4_4*	61	4	4	5	4	4	4	5	4	189	216	219	624	1
35	*E500_5_4_5*	67	5	4	4	5	5	5	5	4	215	215	218	648	1
36	*E500_5_4_6*	55	4	5	4	4	5	4	4	5	162	196	179	537	1
37	*E500_5_4_7*	67	4	4	4	5	4	5	5	5	196	233	233	662	1
38	*E500_5_4_8*	60	4	4	5	4	5	4	4	4	203	227	208	638	1
39	*E500_5_4_9*	61	5	4	4	4	4	5	4	5	193	225	192	610	1
40	*E500_5_4_10*	55	4	4	4	4	4	4	4	4	192	248	215	655	1

Table B.15 Leveling process duration for 500-activity instances (3/4)

No.	Project name & performance	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
		Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
1	*E500_10_1_1*	336	3	3	3	3	3	3	3	3	112	119	104	335	5
2	*E500_10_1_2*	168	3	3	3	3	3	3	3	3	134	124	135	393	3
3	*E500_10_1_3*	167	3	3	3	3	3	3	3	3	128	118	123	369	2
4	*E500_10_1_4*	161	3	3	3	3	3	4	3	3	109	119	110	338	2
5	*E500_10_1_5*	298	3	3	4	3	3	3	3	3	90	97	102	289	6
6	*E500_10_1_6*	168	3	3	3	3	3	3	3	4	133	143	125	401	3
7	*E500_10_1_7*	174	3	3	3	3	3	3	3	3	147	123	132	402	2
8	*E500_10_1_8*	183	3	3	3	3	3	4	3	3	90	85	84	259	5
9	*E500_10_1_9*	113	3	4	3	3	3	3	3	3	59	69	64	192	1
10	*E500_10_1_10*	348	3	3	3	3	3	3	3	3	124	131	147	402	5
11	*E500_10_2_1*	283	4	4	4	4	4	4	4	4	229	294	246	769	3
12	*E500_10_2_2*	318	4	4	4	4	4	4	4	4	184	214	215	613	2
13	*E500_10_2_3*	299	5	4	4	4	4	4	4	4	247	219	242	708	3
14	*E500_10_2_4*	271	5	4	4	5	5	4	5	4	297	252	246	795	2
15	*E500_10_2_5*	288	4	5	4	5	4	4	4	5	298	337	321	956	4
16	*E500_10_2_6*	250	4	5	4	4	4	4	4	4	271	287	298	856	3
17	*E500_10_2_7*	271	5	5	5	4	4	4	5	4	226	262	245	733	2
18	*E500_10_2_8*	225	4	4	4	4	4	4	5	4	243	261	294	798	2
19	*E500_10_2_9*	258	5	4	4	4	4	4	4	4	280	226	247	753	2
20	*E500_10_2_10*	290	4	4	4	4	5	4	4	4	325	255	256	836	2
21	*E500_10_3_1*	231	6	6	7	6	6	6	7	6	286	325	285	896	4
22	*E500_10_3_2*	243	6	5	6	6	6	7	6	6	330	347	316	993	3
23	*E500_10_3_3*	284	6	6	6	6	7	6	7	6	298	321	252	871	2
24	*E500_10_3_4*	232	6	6	6	6	6	6	7	6	269	279	272	820	3
25	*E500_10_3_5*	225	7	6	7	5	7	6	7	6	240	261	264	765	3
26	*E500_10_3_6*	298	6	6	7	6	6	6	7	6	330	415	444	1189	4
27	*E500_10_3_7*	271	6	6	6	5	6	6	6	6	268	265	266	799	3
28	*E500_10_3_8*	215	6	6	6	6	6	6	7	7	259	342	279	880	2
29	*E500_10_3_9*	236	6	5	7	6	6	6	6	6	257	286	277	820	3
30	*E500_10_3_10*	199	6	6	6	6	6	6	7	6	241	229	214	684	2
31	*E500_10_4_1*	99	8	8	8	8	8	8	9	8	340	398	362	1100	2
32	*E500_10_4_2*	88	7	8	8	8	8	8	9	8	365	392	363	1120	2
33	*E500_10_4_3*	102	8	8	8	7	8	8	9	8	407	448	442	1297	2
34	*E500_10_4_4*	95	8	8	8	7	9	9	8	7	353	369	341	1063	2
35	*E500_10_4_5*	113	9	8	8	8	8	8	9	8	341	378	382	1101	2
36	*E500_10_4_6*	104	7	7	8	8	8	8	9	8	376	417	376	1169	2
37	*E500_10_4_7*	93	8	8	8	8	7	8	8	7	395	400	367	1162	2
38	*E500_10_4_8*	120	8	8	9	8	8	7	9	8	401	462	428	1291	2
39	*E500_10_4_9*	119	9	8	8	8	8	8	9	8	410	454	407	1271	3
40	*E500_10_4_10*	100	8	9	8	8	8	8	9	9	384	404	394	1182	2

Table B.16 Leveling process duration for 500-activity instances (4/4)

No.	Project name & performance	MSP 2013	Primavera P6 V.8.3								ASTA Powerproject V. 12.5				Burgess & K
		Standard	ID (Asc.)	ID (Desc.)	TF (Asc.)	TF (Desc.)	ES (Asc.)	ES (Desc.)	LF (Asc.)	LF (Desc.)	Total Float	Task ID	Task Start Date	Multi	
1	*E500_15_1_1*	515	3	3	3	3	3	3	3	3	192	218	221	631	3
2	*E500_15_1_2*	399	3	3	3	3	3	3	3	3	164	158	170	492	11
3	*E500_15_1_3*	516	2	3	3	3	3	3	3	2	212	168	202	582	6
4	*E500_15_1_4*	179	3	2	3	3	3	3	3	3	148	120	105	373	2
5	*E500_15_1_5*	239	3	3	3	3	2	3	3	2	217	204	199	620	3
6	*E500_15_1_6*	318	3	3	3	2	3	2	3	3	168	148	200	516	3
7	*E500_15_1_7*	392	3	3	3	3	3	2	3	3	162	167	197	526	11
8	*E500_15_1_8*	475	3	3	3	3	3	3	3	3	306	296	243	845	8
9	*E500_15_1_9*	386	3	3	3	3	3	3	3	3	168	117	108	393	7
10	*E500_15_1_10*	217	3	3	3	3	3	3	3	3	257	245	186	688	2
11	*E500_15_2_1*	458	5	5	5	5	5	5	5	5	452	421	628	1501	4
12	*E500_15_2_2*	399	4	5	5	5	5	5	5	5	420	421	396	1237	7
13	*E500_15_2_3*	302	5	5	5	5	5	5	5	4	449	472	489	1410	4
14	*E500_15_2_4*	421	5	5	5	4	4	4	5	5	450	452	472	1374	5
15	*E500_15_2_5*	280	4	4	5	5	5	5	5	4	444	409	440	1293	4
16	*E500_15_2_6*	686	5	5	5	5	5	5	4	5	501	476	543	1520	6
17	*E500_15_2_7*	274	5	4	5	5	5	4	5	5	334	350	322	1006	2
18	*E500_15_2_8*	342	5	5	5	4	4	5	5	5	443	449	484	1376	4
19	*E500_15_2_9*	369	5	5	5	5	5	5	5	5	395	381	359	1135	3
20	*E500_15_2_10*	398	5	5	5	5	5	5	5	5	336	388	356	1080	4
21	*E500_15_3_1*	318	9	9	9	9	9	9	9	9	466	559	539	1564	4
22	*E500_15_3_2*	300	9	9	9	9	9	9	9	9	420	707	512	1639	5
23	*E500_15_3_3*	302	8	7	9	7	9	9	9	9	468	509	539	1516	3
24	*E500_15_3_4*	328	9	8	8	7	8	8	9	7	539	623	534	1696	4
25	*E500_15_3_5*	425	8	9	9	9	9	7	8	7	521	603	583	1707	5
26	*E500_15_3_6*	323	9	9	9	8	9	9	7	9	559	648	562	1769	5
27	*E500_15_3_7*	339	7	9	9	9	9	9	9	8	551	649	609	1809	4
28	*E500_15_3_8*	299	7	7	9	9	8	9	9	8	478	588	553	1619	4
29	*E500_15_3_9*	299	9	9	8	9	9	9	9	9	540	474	531	1545	4
30	*E500_15_3_10*	314	9	9	7	9	9	9	9	9	473	485	499	1457	3
31	*E500_15_4_1*	141	11	11	11	11	11	11	11	11	578	670	649	1897	4
32	*E500_15_4_2*	177	11	1	11	11	11	11	11	11	725	718	711	2154	5
33	*E500_15_4_3*	173	10	11	9	11	11	11	10	10	677	732	766	2175	4
34	*E500_15_4_4*	185	10	11	9	9	9	10	11	11	892	858	827	2577	3
35	*E500_15_4_5*	168	9	9	11	10	9	11	11	11	803	755	735	2293	3
36	*E500_15_4_6*	153	11	10	11	9	11	11	11	11	642	757	703	2102	3
37	*E500_15_4_7*	157	11	11	11	11	11	11	11	11	620	644	651	1915	4
38	*E500_15_4_8*	157	11	11	10	11	11	11	11	9	669	853	750	2272	5
39	*E500_15_4_9*	176	11	11	11	11	11	11	11	9	799	774	828	2401	4
40	*E500_15_4_10*	152	11	11	10	10	11	10	11	9	790	851	735	2376	4