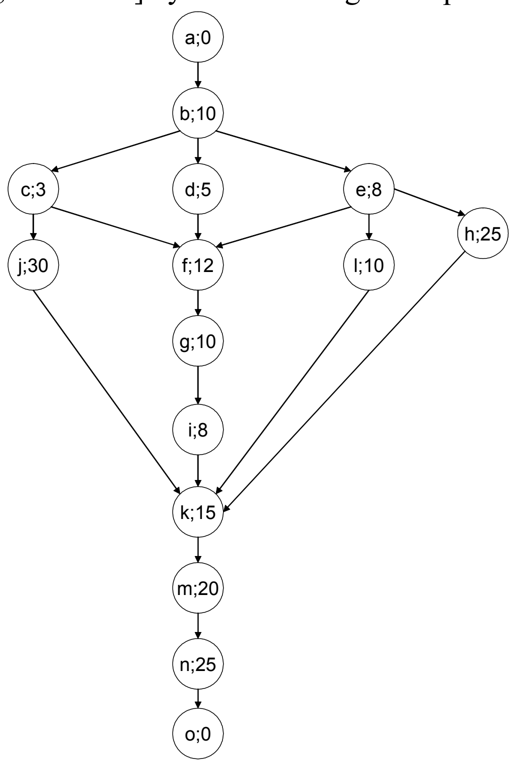
ESD.36J System and Project Management **Master Solution**
HW1 – UAV Development project Due: 9/18/03

1. Construct a task table from the UAV description. Clearly designate each task with its tag, description and identify immediate predecessors and expected task completion times. See [1, Exhibit I] for an example. Try to arrange the task table in "technological order".

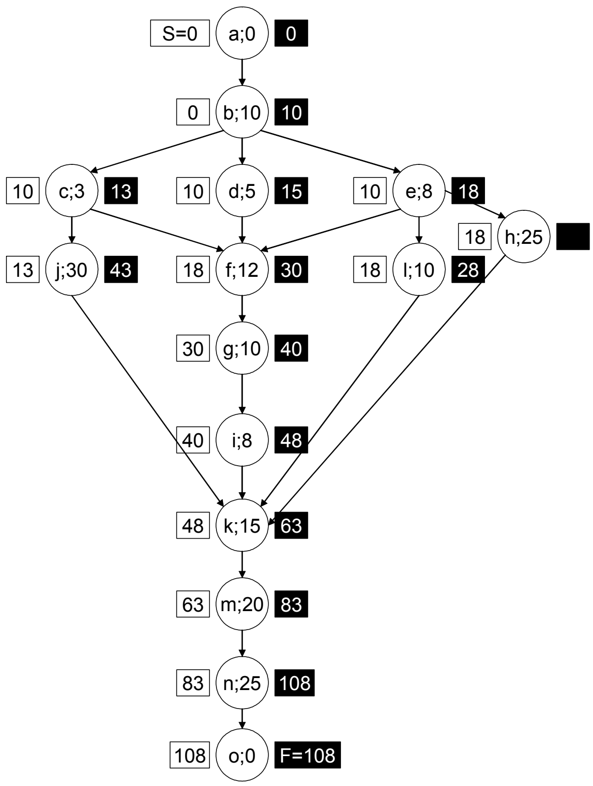
Job no.	Description	Immediate predecessor	Normal time (days)
a	project start		0
b	requirement definition	a	10
c	engine specification	b	3
d	vehicle layout	b	5
e	GFE interface	b	8
f	fuselage design	c, d, e	12
g	wing design	f	10
h	Avionics design	e	25
i	empennage design	g	8
j	engine delivery	c	30
k	vehicle integration	h, i, j, l	15
l	GFE delivery	e	10
m	ground testing	k	20
n	flight testing	m	25
o	end	n	0

2. Create a project graph [1, Exhibit II] by hand or using a computer program.



3. What is the earliest finish (EF) for the project as a whole (in units of work days)? Show how you arrive at this result?

EF = 108 work days. The procedure in arriving at an EF is given in the HBR article by Thompson and Wiest on page 4 – 5 of the course reader. The resulting graph is shown below:



4. What is the critical path? (e.g. a-b-k-x-z). Highlight the critical path in the project graph from 2. Explain in a few sentences what this means for you as the project manager. Where will you focus your attention?

The critical path is a-b-e-f-g-i-k-m-n-o. It is shown in the graph below.

Hint in finding critical path: Finding critical path is relatively easy in this simple graph. We should start from the FINISH, and searching "upward" to START. Whenever there is a "sink" (in Kerzner's terminology), i.e. a situation in which a job has two or more immediate predecessors, the critical path should continue on the path which leads to the predecessor that has a latest EF. Situations other than sink should be straightforward.

Critical path determines how quickly a project can finish because the critical path consumes the most time to complete, compared with the other paths in the graph. The other paths are called slack paths. Therefore, in order to increase the possibility that the project can finish on time, the project manager has an incentive to reduce the critical path, unless the slack in the slack path is installed purposefully as a safety valve. Kerzner suggests a few ways of reducing the critical path:

- Transferring resources from slack paths to critical paths
- Elimination of some parts of the project
- Addition of more resources

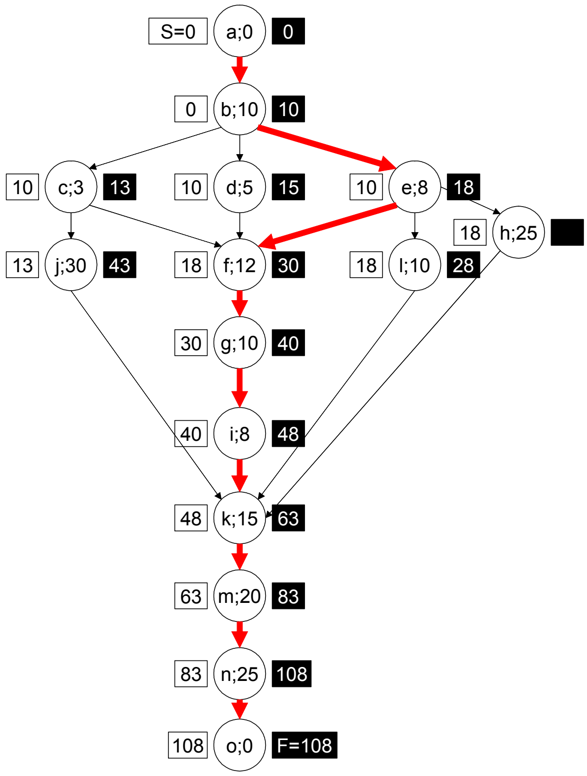
- Substitution of less time-consuming components or activities
- Parallelization of activities
- Shortening critical path activities
- Shortening early activities
- Shortening longest activities
- Shortening easiest activities
- Shortening activities that are least costly to speed up
- Shortening activities for which you have more resources
- Increasing the number of work hours per day

Apparently, for the UAV case, the above measures will be most effective when applied to the portion of the critical path that is in parallel with the slack paths. That is, b-e-f-g-i-k.

The project manager should be mindful of the consequential risks brought by the measures suggested above. For example, the contractor cannot or might not be willing to provide addition expertise required by many of the measures. Parallelization of activities involves the risk of assuming that a conventionally sequential work flow can be pursued in parallel. In this specific case of UAV design, for example, partial design of the fuselage can start before the negotiation of GFE interface with the government is completed. But the risk of GFE incompatible with the fuselage is inevitably increased.

The transferring of resources strategy probably won't work in this case because the non-critical jobs are most under the engine supplier or the government. The project manager probably does not have much control over the resources used by these jobs. The only non-critical job that the manager has a control over is *avionics design* (h;25). But the avionics design uses resources distinctively different from the resources used for fuselage, wing, and empennage designs in terms of knowledge, skills, and tools. Therefore it is difficult to accelerate the designs of fuselage, wing, and empennage by relocating resources from avionics design.

[*Note that this and the following qualitative questions are open-ended and do not have a single version of correct answer. I will grade you based on the thoughtfulness of your answers.*]



5. The *start* date of the project (a,0) has been fixed as January 7, 2008. What is the earliest calendar finish date of the project, assuming that you work only Monday through Friday and that there are no holidays?

June 4, 2008.

6. After some negotiation, the CEO has set a target date (T) of June 30, 2008 for completion of the project. Figure out, for each task, what the total slack (TS) and what the free slack (FS) is. Which task in your project has the largest free slack? How do you suggest to best use this free slack as a manager?

If the target time T is set to June 30, 2008, then the late finish (LF) of the entire project is 128 days. To find the late start (LS) and late finish (LF) of every job, we follow the procedure outlined in the HBR article on page 6 – 7.

The LS and LF of each job has been found and listed in the graph below. The total slack of each job is the difference between the ES and LS of the job. They are listed in Table 1. Notice that all the critical jobs have a total slack of 18 days, while the non-critical jobs have a total slack of more than 18 days.

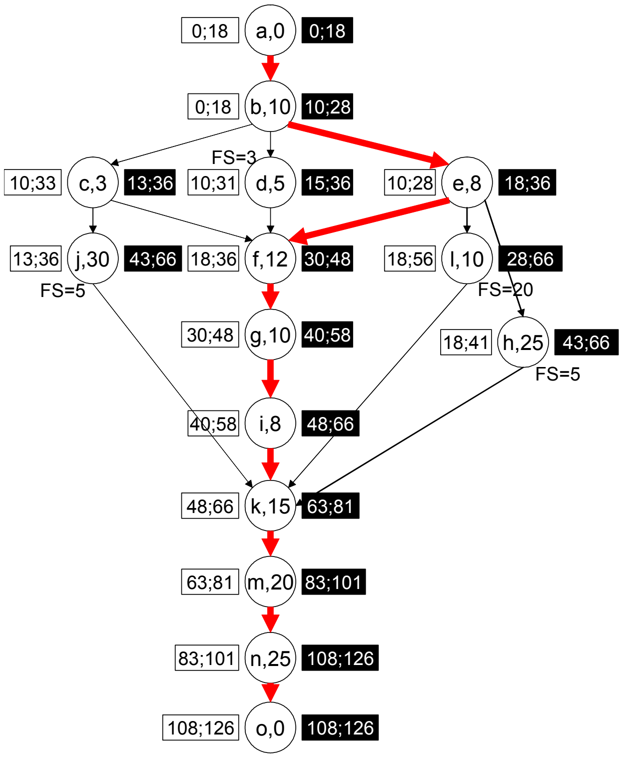
Job	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
Total slack	18	18	23	21	18	18	18	23	18	23	18	38	18	18	18

Table 1. Total slack of each job.

The free slack (FS) of a job is the difference between the job's EF time and the earliest of the ES times of all its immediate successors. Apparently, only the non-critical jobs that has a critical job as the only immediate successor have FS greater than 0. In this UAV case, the following jobs have non-zero FS.

Job	d	h	j	l
Free slack	3	5	5	20

Table 2. Free slack



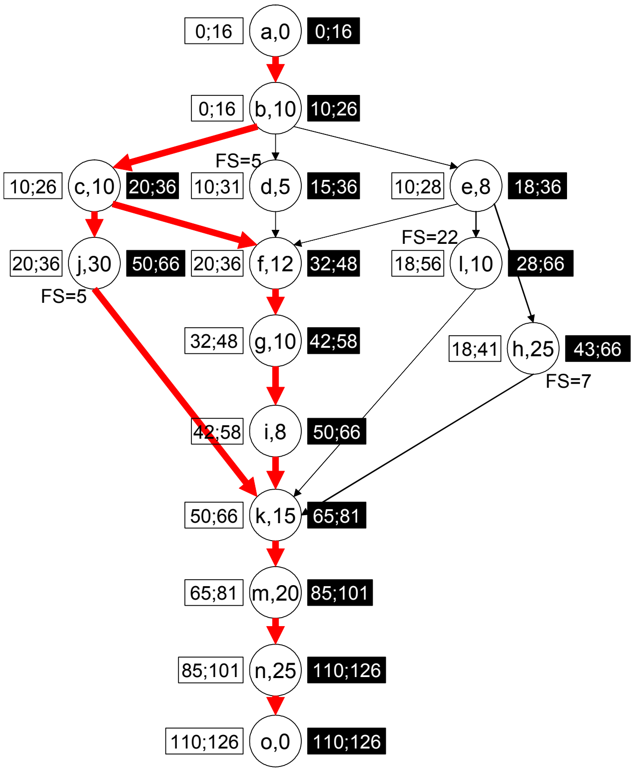
Because the GFE is supplied by the government, I as the project manager probably do not have much control over the resources used for producing the GFE. So I cannot use the resources for GFE to shorten the critical path.

7. Set specific <u>target dates</u> for delivery of the engine (for the supplier) and for the GFE payload (for the government agency). Why did you choose those dates?

Because the EF for the engine delivery is 43 days, we set the engine delivery date to March 6th, 2008 (the 44th day after start of the project). The EF for the GFE delivery is 28 days, which leads to a target GFE delivery date of February 14, 2008. It is tempting to set the engine delivery at the LF of 66 days, the target date for the engine delivery would then be April 7, 2008. This, however would be a mistake, since it would automatically place the engine delivery on the critical path. Similarly, because the LF for the GFE is also 66 days, its target date could be set to April 7, 2008. This is also not recommended, since then the GFE delivery would become critical. <u>By setting the target delivery date to the EF</u> for all suppliers, the ownership of the slack remains with the project manager rather than surrendering it to the suppliers a priori. This way the supplier has to negotiate some of the slack time back if he wants to slip delivery at a later time.

8. You just finished the *requirements definition* (b,10) step on time, i.e. it is now January 18, 2008 at 5:00p.m. and you get a phone call from the engine supplier. They inform you that the engine specification (task c) will take <u>10 working days instead of 3 working days</u> to work out due to a misunderstanding in an engine requirement. How does this impact the critical path of the project? Revise the project plan with the changed date. What is the impact on the earliest finish (EF) date? How does this change your focus as a project manager? Explain.

There are now two critical paths, both plotted in the graph below. They are a-b-c-f-g-i-k-m-n-o and a-b-c-j-k-m-n-o. The *engine specification* (c,10) has now replaced *GFE interface* (e,8) as a critical job. The EF of the project is now 110 work days. In calendar days, the project EF is now June 6, 2008. As the project manager, I do not have much control over the resource allocation of the engine supplier. But I can start fuselage design before the engine specification is given by the engine supplier, with the risk of incompatibility between engine and fuselage taken. Since the engine supplier is now also on the critical path it is important to keep close tabs on the suppliers progress during task j (weekly meetings, dispatching a liaison engineer to the company, asking for formal progress reports, thinking about a backup solution etc…). Monitoring more than one critical path at once is very challenging.



9. You have just completed all tasks up to (and including) *vehicle integration* (*k*) according to your revised schedule, i.e. all tasks were completed at their earliest finish time (EF). You are now starting *ground testing* and *flight testing*. Based on previous experience, the completion times for these tasks *m* and *n* are somewhat uncertain. The task duration histograms from previous projects are shown in Figure 2.

All tasks are completed up to and including *k* on day 65 (April 4, 2003).
Expected duration for task m: TE(m)=20, Expected variance: TV(m)=4

Expected duration for task n: TE(n)=25, Expected variance: TV(n)=25.
The expected EF of the project is then 110 days (as before), i.e. June 6, 2003. The variance TV is 4+25=29. The new target date is May 23, 2008 (day 100). Next compute z=(T-EF)/sigma(F)= (100-110)/sqrt(29)=-10/5.4=-1.86. **Looking up the normal distribution table results in a probability of only 3.1% that the new target date set by the CEO can be met**. This is important information for decision making within the company.