Pad Safety Personnel
Launch Support
For STS-200

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Table of Content

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Introduction

The launch of a space shuttle is a complex and lengthy procedure. There are many places and components to look at and prepare. The components are the orbiter, solid rocket boosters, external tank, and ground equipment. Some of the places are the launch pad, fuel locations, and surrounding structures.

Preparations for a launch include equipment checks, system checks, sniff checks for hazardous commodities, and countless walkdowns. Throughout these preparations, pad safety personnel must always be on call. This requires three shifts of multiple people to be ready when needed. Also, the pad safety personnel must be available for the non-launch tasks that are always present for both launch pads.

Objective

The objective of the project was to determine how may pad safety personnel are needed on each of the three shifts to support a given schedule. In order to fulfill the requirements of supporting launch and non-launch tasks, utilizations cannot exceed 70% of the pad safety personnel's time.

In order to determine utilization, an established schedule of tasks was reviewed to determine which tasks require pad safety personnel need to support. A schedule was then compiled of only those specific tasks. Afterwards, those tasks were put into the ProModel simulation software to calculate utilization for each pad safety personnel. The results of the simulation were then analyzed to determine how many pad safety personnel should be assigned to each shift.

Schedule of Tasks

The schedule for STS-200 was used to document the pad safety personnel tasks. While reviewing the established schedule, a list of tasks requiring pad safety personnel and when the tasks were scheduled was documented. The tasks were then given titles to explain what is required for each task. The schedule can be seen in Appendix A. Task times and manpower requirements were also noted with each task in the format of (time, manpower).

The tasks that need to be performed are as follows:

- Assemble Personnel is when pad safety personnel joins other support personnel to start launch preparations. Safety procedures and necessary information is shared with everyone before any tasks begin.

- Line Pressurization is done to prepare systems for testing throughout the time before launch. For instance, gas lines are filled with high pressure gas to test the integrity of the system needed for a successful launch.

- Operational Preps is when pad safety personnel and other support personnel prepare for an important operation by performing pre-tasks. These pre-tasks may include many levels and areas.

- Establish System Clear requires pad safety personnel to close out certain systems prior to tasks being performed. Signs are posted, and the area may be cleared.

- Break System Clear is performed after tasks requiring system lock out are completed. The signs are removed, and the system is considered safe.

- Initial Walkdowns are performed prior to most of the pre-launch tasks. As an example, debris and general safety issues may be found that may hinder launch preparations. These issues must be dealt with quickly.

- Establish Operation Clear is used to clear areas for hazardous or operational tasks. Hazardous tasks are defined as tasks where a potential of hazardous commodities may escape into the processing area. The clear may be of different dimensions and encompass multiple levels of the pad and non-pad structure. Signs are also hung to keep others out of the area.

- Break Operation Clear is when pad safety personnel allow other support personnel into the operation areas. Signs are removed, and the area is open to all.

- Remove Plugs requires pad safety personnel to be present whenever shuttle components or ground equipment have plugs that need to be removed prior to launch.

- Clear Pad Structure is performed when an area must be completely cleared of personnel before a task can be performed. These clears are different from the clears previously mentioned because some areas are cleared and not opened until after launch.

- Vapor Check is a task where pad safety personnel are required to test an area for hazardous commodities before other personnel may enter. Meters are used to ensure the area is safe for entry.

- Room Pressurization is like Line Pressurization; however, a room is isolated for this task. The pressurization may stay in place until after launch as well.

- Vehicle Arrival is a delivery of launch critical components. The vehicles must be escorted to the required area.

- Post Safety Signs is usually performed prior to a clear. Safety signs can be for hazardous, operational, or system clears. Also, certain safety signs can also only be posted by pad safety personnel.

- Vehicle Removal requires an escort by pad safety personnel to leave the pad and non-pad areas.

- System Changeover is performed by support personnel as a prelude to other tasks. Pad safety personnel must be present during this time.

- System Purge is performed to clear a system of gas prior to launch.

- Open Pad Structure is when parts of the pad that were previously closed out need to be reopened for future tasks.

- Remove Equipment is performed when temporary equipment must be removed from the launch pad. The equipment must be stored to prevent it from damaging the space shuttle during launch.

- Structure Rotation must be performed prior to critical walkdowns. The task requires many pad safety personnel because of the size of the affected area.

- Walkdown is a task where pad safety personnel joins other support personnel to walk around critical area prior to closing out area. Walkdowns are also performed after launch to ensure the pad is safe to enter for other support personnel. The walkdowns can be for systems or general areas on or off the pad structure.

- System Test is performed by support personnel to ensure proper function prior to launch. Pad safety personnel must be present to ensure overall safety of the task.

- Final Pre-Launch Walkdown is performed by pad safety personnel and other support personnel to ensure pad and non-pad areas are safe to clear for launch.

- Clear to Roadblock is performed by pad safety personnel to clear support personnel from pad and non-pad areas. The support personnel are escorted to behind the roadblock until after launch.

- Return to Roadblock is performed by all pad safety personnel in which some support personnel are escorted back to the roadblock for post-launch pad entry.

- Pad Status is a task where pad safety personnel check to see if the pad is safe for re-entry after a successful launch.

- Open Roadblock is when pad safety personnel clear the pad for re-entry for some support personnel.

- Post Launch Preps is like Operational Preps in which a series of tasks must be performed prior to future tasks.

- Install Equipment is performed to replace the equipment removed prior to launch.

- Open Pad is when the pad and non-pad areas are deemed safe by pad safety personnel to all support personnel.

Manpower

Pad safety personnel must cover three shifts. The first shift covers eight in the morning to four in the afternoon. Second shift covers four in the afternoon to midnight. Third shift covers from midnight to eight in the morning.

Also, pad safety personnel are allowed to work over eight hours in any shift in order to ensure all tasks, launch and non-launch, are supported. In addition, extending the hours in a shift also allows for possible and unexpected schedule slips. The maximum hours that can be worked in any one shift are twelve hours.

There are a total of ten pad safety personnel. The experience level ranges from new to over twenty years. Also, not all pad safety personnel are certified to work all tasks. For that reason, there must be varied levels of experience per shift, which in turn may affect utilization.

As an initial distribution of pad safety personnel, four were assigned to first shift. Three were assigned to second and third shift. The reason for the uneven distribution is because there is more non-launch work done on first shift than the second or third shift.

For additional help, personnel from other safety organizations may help with pre- and post-launch tasks. This select group has the same or some of the same training as the pad safety personnel. In addition, some have transferred away from the pad safety personnel group, but have remained current on certifications.

ProModel Simulation

The tasks were programmed into the ProModel simulation software, along with the manload distribution and shift information. As pad safety personnel utilization was the goal of the project, calculations were made as the simulation ran. Two options were analyzed in determining the necessary calculations.

The first option was the first available resource would be selected. This option means that whoever was available at that time, such as not currently occupied, would be chosen to work the task.

The following utilization calculations were documented:

		Day 1	Day 2	Day 3	Day 4
Third Shift	**1**		87.50%	59.38%	75.00%
	2		87.50%	34.38%	43.75%
	3		40.63%	15.63%	6.25%
First Shift	**1**		56.25%	37.50%	31.25%
	2		59.38%	37.50%	31.25%
	3		34.38%	28.13%	9.38%
	4		9.38%	0.00%	0.00%
Second Shift	**1**	34.38%	75.00%	81.25%	71.88%
	2	34.38%	59.38%	81.25%	59.38%
	3	0.00%	21.88%	87.50%	46.88%

Table 1: Utilization Based on First Available

The results from the first option show that second and third shift pad safety personnel are over 70% utilized. On day 2, Line Pressurization and Operational Preps keep two third shift pad safety personnel busy. Also, on day 4, there are a series of task that has the potential to keep one third shift pad safety person too busy. However, the utilization of the other third shift pad safety personnel shows that non-launch tasks can still be covered. Also, second shift pad safety personnel may assist in early day 2 pre-launch tasks.

For second shift pad safety personnel, the biggest concern seems to be day three. Pre-launch walkdowns will keep all second shift pad safety personnel over-utilized. Extended first shift pad safety personnel and additional help, as is currently done, will need to be brought in to help in the walkdowns.

For days two and four, with a utilization percentage over 70%, one second shift pad safety person may be called for too many launch tasks. However, utilization percentages of the other second shift pad safety personnel show that launch and non-launch tasks may be shared by all and prevent over-utilization of one second shift pad safety person.

The second option was to keep the pad safety personnel distribution the same, but change to the least utilization option. This means that the pad safety person with the least work done on launch tasks perform each task as it must be worked, which could balance utilization. The following utilization calculations were documented:

		Day 1	Day 2	Day 3	Day 4
Third Shift	1		78.13%	43.75%	34.38%
	2		87.50%	34.38%	43.75%
	3		50.00%	31.25%	46.88%
First Shift	1		40.63%	28.13%	21.88%
	2		37.50%	28.13%	12.50%
	3		40.63%	28.13%	18.75%
	4		40.63%	18.75%	18.75%
Second Shift	1	9.38%	53.13%	81.25%	50.00%
	2	34.38%	50.00%	81.25%	65.63%
	3	25.00%	53.13%	87.50%	62.50%

Table 2: Utilization Based on Least Utilized

The results from the second option show that second and third shift pad safety personnel still exceed the 70% utilization requirement and that the work seems to be more balanced between all shifts. The reasons for the high percentages seem to be the same as in the first option.

As there appeared to be enough support for second shift, an option was developed to try and offset the high percentages in the third shift. The option calls for assigning four and three pad safety personnel on third and first shift, respectively. As in the previous division of manpower, first available and least utilization options were analyzed.

For the first available option, the following results were documented:

		Day 1	Day 2	Day 3	Day 4
Third Shift	**1**		87.50%	59.38%	75.00%
	2		87.50%	34.38%	43.75%
	3		40.63%	15.63%	6.25%
	4		31.25%	0.00%	0.00%
First Shift	**1**		56.25%	37.50%	31.25%
	2		53.13%	37.50%	31.25%
	3		40.63%	28.13%	9.38%
Second Shift	**1**	34.38%	75.00%	81.25%	71.88%
	2	34.38%	59.38%	81.25%	59.38%
	3	0.00%	21.88%	87.50%	46.88%

Table 3: Utilization Based of First Available

The results show that there seems to be no change in the percentages on days two and four.

Also, the fourth third shift safety person does not seem to be used much at all.

For the least utilization option, the following results were documented:

		Day 1	Day 2	Day 3	Day 4
Third Shift	**1**		46.88%	34.38%	25.00%
	2		68.75%	25.00%	21.88%
	3		81.25%	28.13%	37.50%
	4		50.00%	21.88%	40.63%
First Shift	**1**		53.13%	37.50%	31.25%
	2		46.88%	37.50%	21.88%
	3		50.00%	28.13%	18.75%
Second Shift	**1**	9.38%	53.13%	81.25%	50.00%
	2	34.38%	50.00%	81.25%	65.63%
	3	25.00%	53.13%	87.50%	62.50%

Table 4: Utilization Based on Least Utilized

The results show that although there is still one utilization percentage over 70%, the concern of over-utilization seems to be mitigated. Non-launch tasks can certainly be covered because of the lower utilization percentages on day two.

Analysis

Based on the four simulation results, it is recommended that the decision be made based on third and first shift coverage alone. In all scenarios, having three second shift pad safety personnel is more than adequate, except for day three. Day three walkdown are numerous and generally require additional help. As such, the following distribution of the pad safety personnel should be implemented: four for first shift and three for third shift. The tasks should be assigned by the least utilized method. This will allow for a more balanced coverage of both launch and non-launch task on both launch pads.

There are several reasons for the recommendation. The first reason is that no matter which results are reviewed, there will always be an over-utilized pad safety person on third shift. Given that and the fact that there are additional safety personnel qualified to perform the tasks, non-launch task can be covered at the same time as launch tasks.

The next reason is that there are more non-launch tasks during first shifts that need pad safety support. For this reason, more pad safety personnel should be given to first shift coverage.

The final reason is that, when a fourth pad safety person is assigned to third shift, utilization is low and does not justify the assignment.

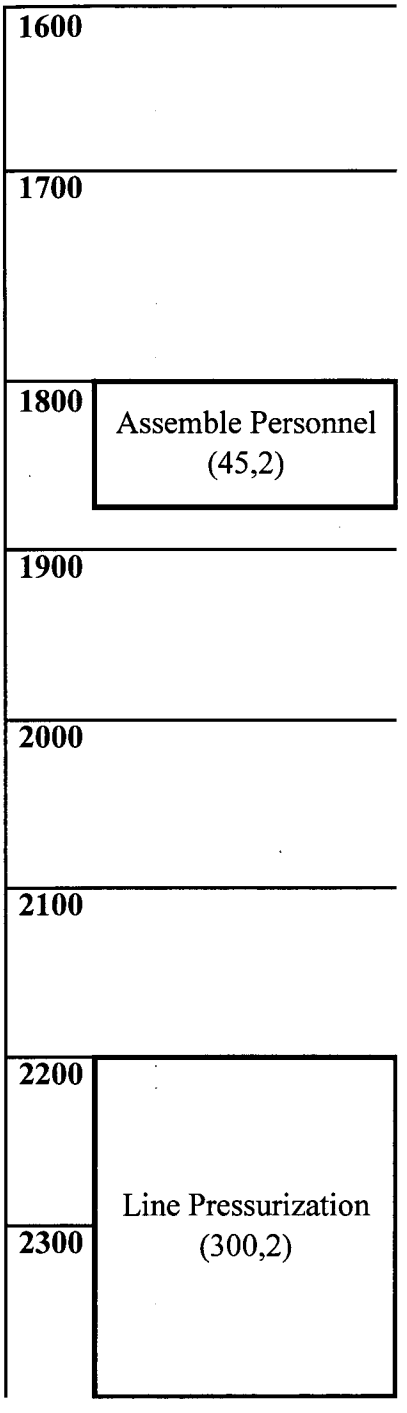
Conclusion

As stated in the introduction, a successful launch of a space shuttle is a complex and lengthy procedure. Although many successful launches have been made, no two launches have ever been the same. It is also not likely than any two launches will ever be the same in the future. However, through experience and lessons learned, a procedure consisting of the many pages and different books has been developed to make the process go as smooth as possible.

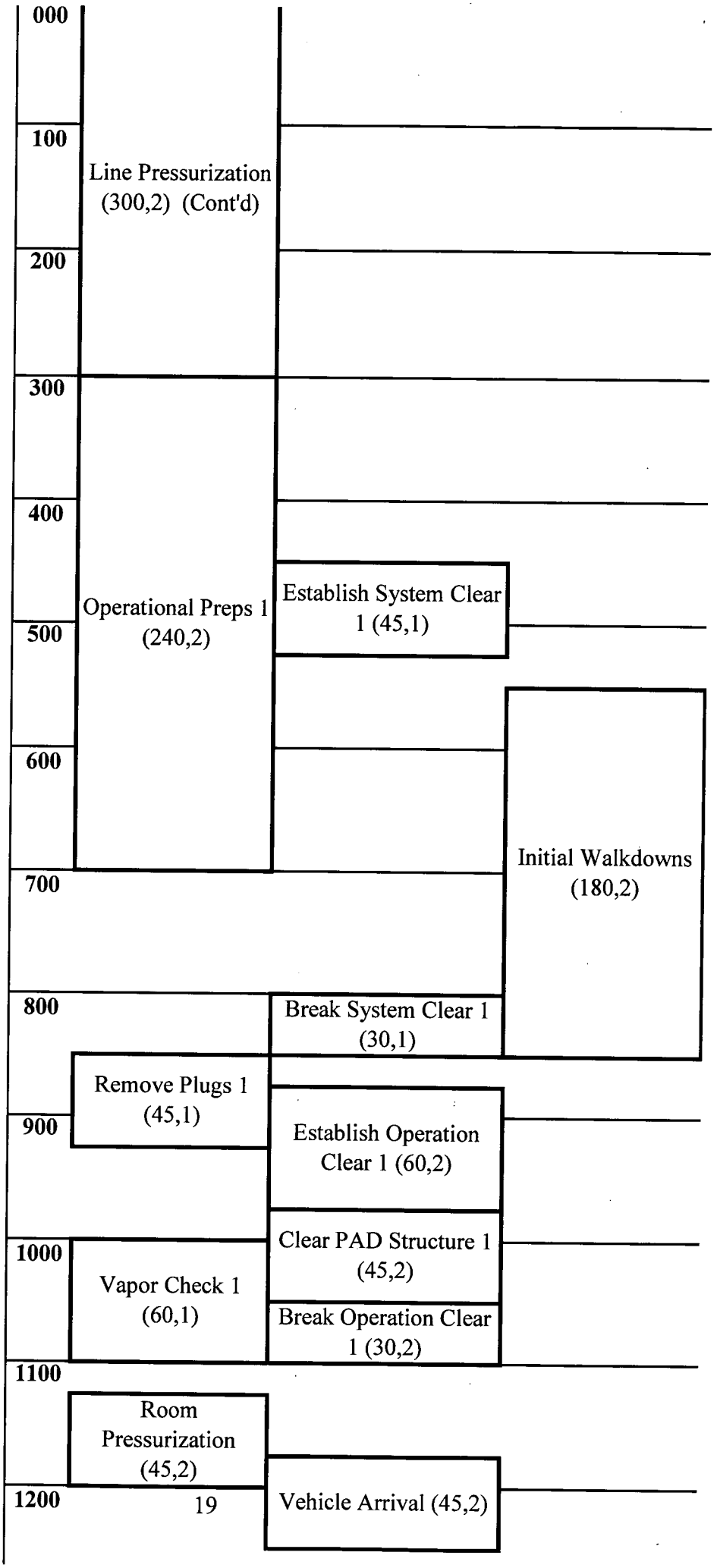
Within that launch countdown procedure, tasks that require pad safety personnel are numerous and require meticulous planning. For that reason, there will never be an easy or definite answer to the question posed in the project. However, by using an established schedule of tasks, a reasonable distribution of available manpower may be determined. Coupled with the multiple levels of contingencies, such as additional personnel available and the extending of shift hours, the successful launch of a space shuttle is more than possible.

Appendix A: Pad Safety Personnel Launch Tasks and Schedule

Day 1

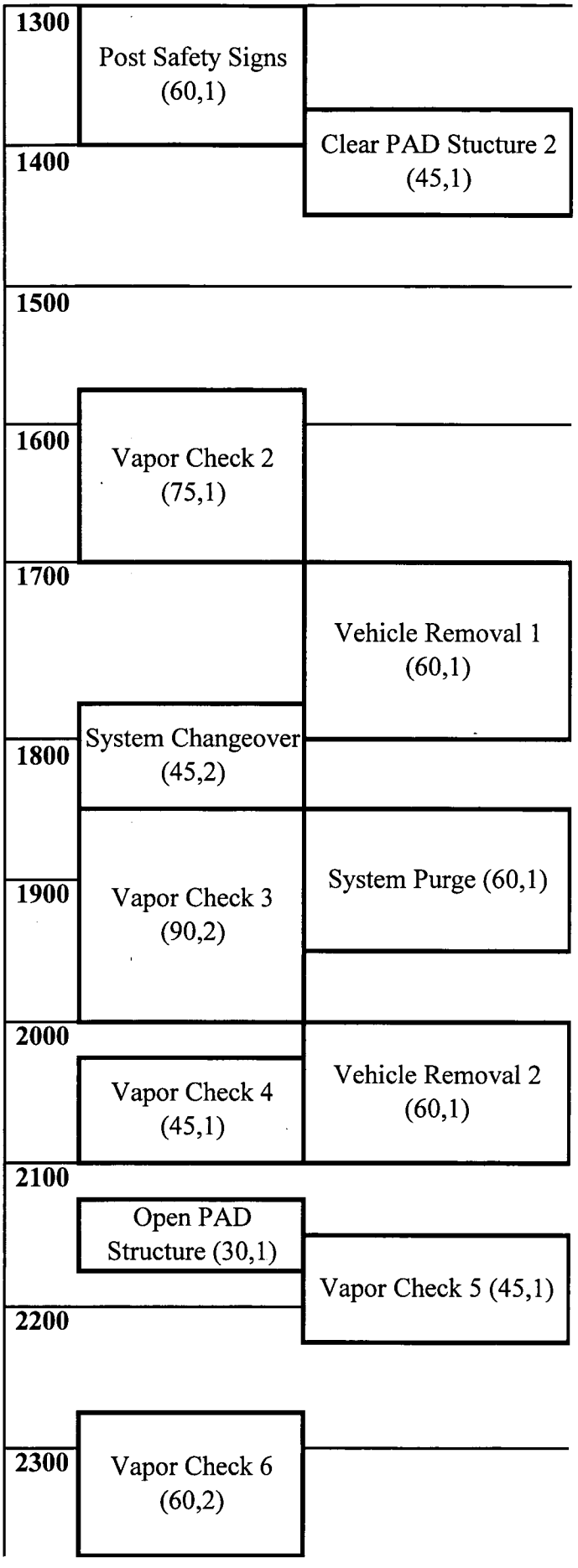


Day 2

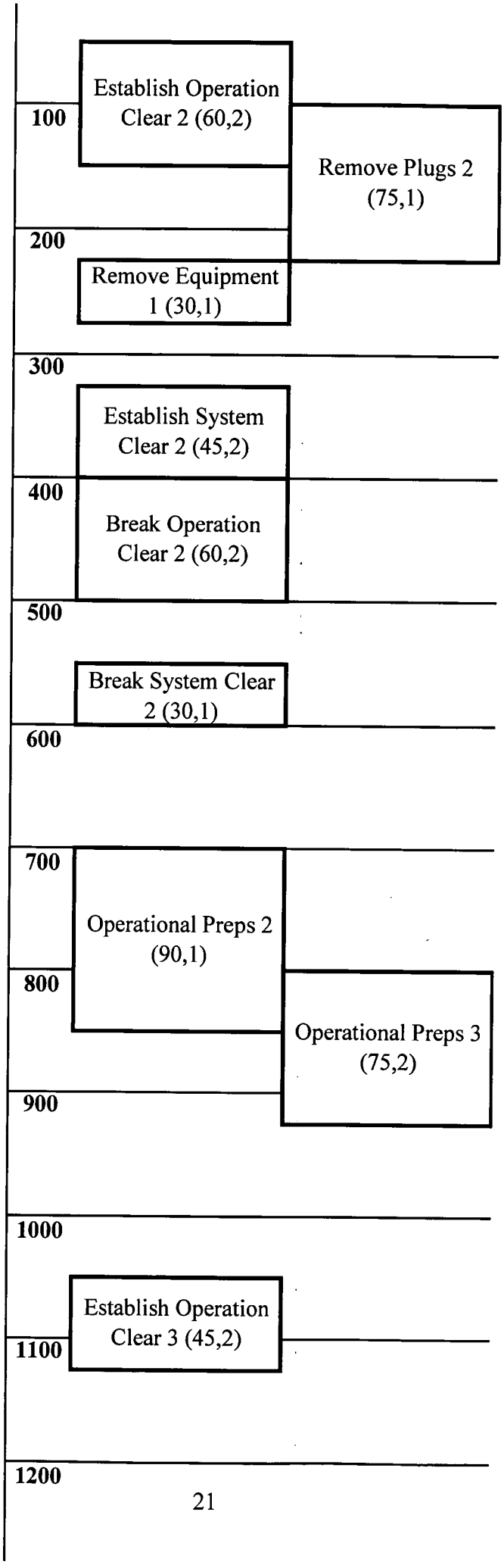

000
100
200
300
400
500
600
700
800
900
1000
1100
1200
Line Pressurization (300,2) (Cont'd)
Operational Preps 1 (240,2)
Establish System Clear 1 (45,1)
Initial Walkdowns (180,2)
Break System Clear 1 (30,1)
Remove Plugs 1 (45,1)
Establish Operation Clear 1 (60,2)
Clear PAD Structure 1 (45,2)
Vapor Check 1 (60,1)
Break Operation Clear 1 (30,2)
Room Pressurization (45,2)
Vehicle Arrival (45,2)

Day 2

(Continued)



Day 3


Establish Operation Clear 2 (60,2)
Remove Plugs 2 (75,1)
Remove Equipment 1 (30,1)
Establish System Clear 2 (45,2)
Break Operation Clear 2 (60,2)
Break System Clear 2 (30,1)
Operational Preps 2 (90,1)
Operational Preps 3 (75,2)
Establish Operation Clear 3 (45,2)
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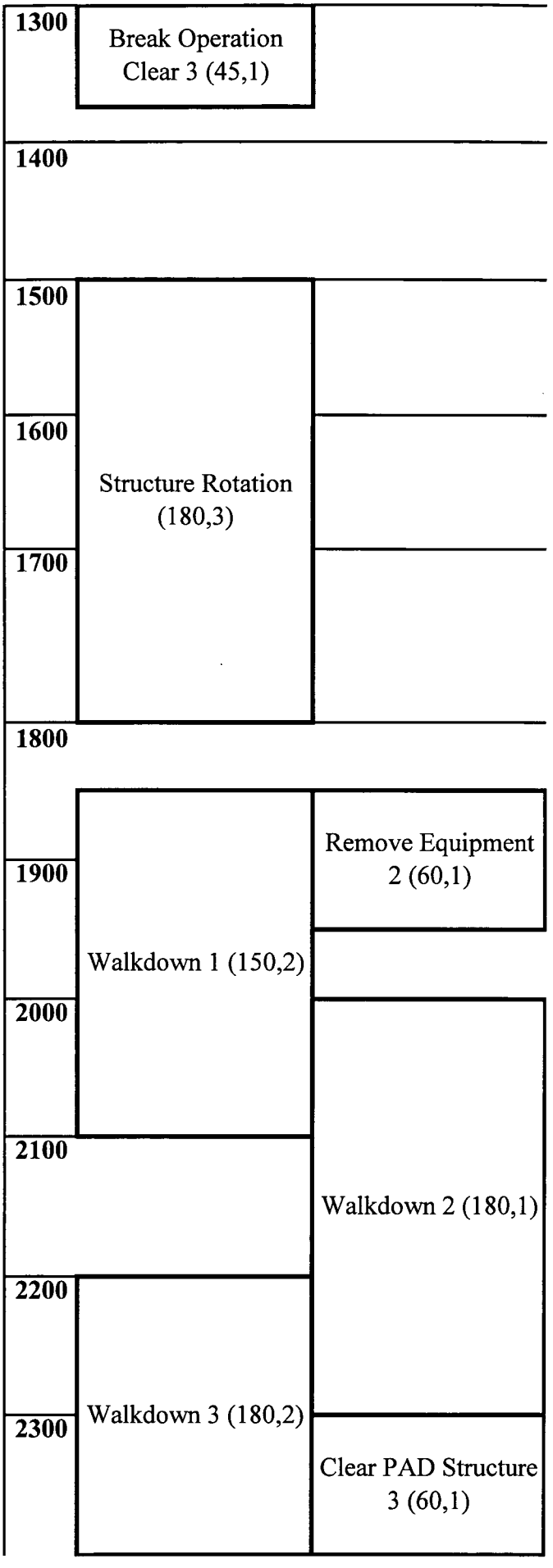
1200

Day 3

(Continued)

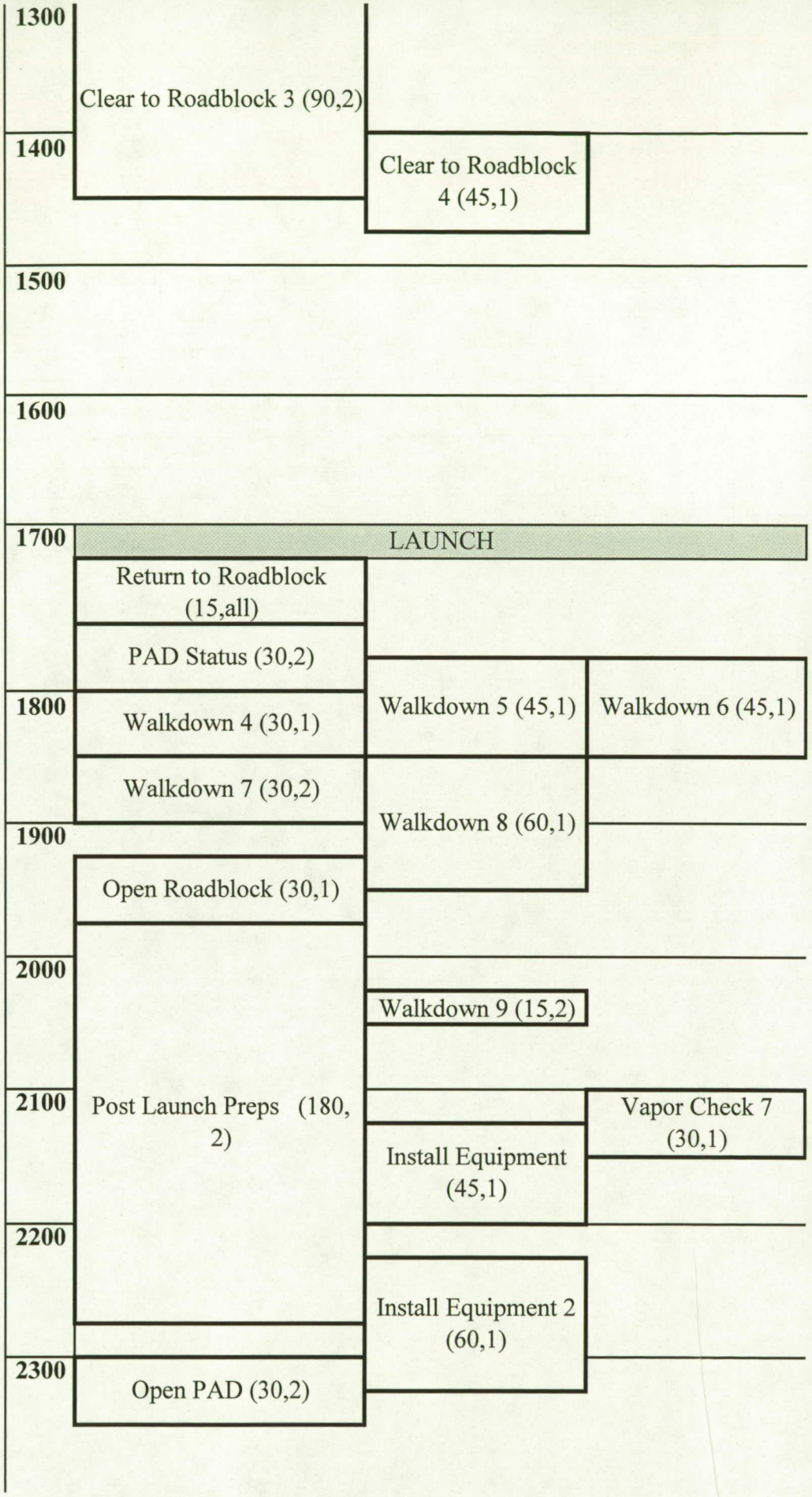


Day 4

	Walkdown 3 (180,2) (cont'd)	Clear PAD Structure 4 (30,1)
100	Clear PAD Structure 5 (45,1)	
200	Establish System Clear 3 (30,1)	
	System Test (30,2)	
300	Break System Clear 3 (45,1)	
400	Final Pre-Launch Walkdown (120,2)	
500		
600	Clear to Roadblock 1 (30,1)	
700		
800		
900		
1000	Clear to Roadblock 2 (60,2)	
1100		
1200		

Day 4

(Continued)



Time Log

Week	Data Collection	Develop Flowchart	Develop Simulation	Report Writing
4/23/06 - 4/29/06				1
5/21/07 - 5/27/07	9			
5/28/06 - 6/3/06	15			
6/4/06 - 6/10/06		25		
6/11/06 - 6/17/06		13		
4/22/07 - 4/28-07				6
4/29/07 - 5/5/07		42	10	
5/6/07 - 5/12/07			12	19
			Total Hours:	**152**

References

The schedule used is from a previous space shuttle flight. Manpower and task times were obtained through the pad safety office. At some point, the names of the tasks, manpower, task times, and task durations were altered. The schedule produced contains only pad safety personnel tasks and is not an accurate copy to the actual schedule. The results are similar to the actual results for the selected tasks.

The procedure used to determine the tasks cannot be named due to company restrictions.

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14. ABSTRACT

The launch of a space shuttle is a complex and lengthy procedure. There are many places and components to look at and prepare. The components are the orbiter, solid rocket boosters, external tank, and ground equipment. Some of the places are the launch pad, fuel locations, and surrounding structures.

Preparations for a launch include equipment checks, system checks, sniff checks for hazardous commodities, and countless walkdowns. Throughout these preparations, pad safety personnel must always be on call. This requires three shifts of multiple people to be ready when needed. Also, the pad safety personnel must be available for the non-launch tasks that are always present for both launch pads.

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