1.10 Modeling a Civil Event Case Study for Consequence Management using the IMPRINT Forces module

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Abstract A critical challenge in the Consequence Management (CM) domain is the appropriate allocation of necessary and skilled military and civilian personnel and materiel resources in unexpected emergencies. To aid this process we used the Forces module in the Improved Performance Research Integration Tool (IMPRINT). This module enables analysts to enter personnel and equipment capabilities, prioritized schedules and numbers available, along with unexpected emergency requirements in order to assess force response requirements. Using a suspected terrorist threat on a college campus, we developed a test case model which exercised the capabilities of the module, including the scope and scale of operations. The model incorporates data from multiple sources, including daily schedules and frequency of events such as fire calls. Our preliminary results indicate that the model can predict potential decreases in civilian emergency response coverage due to an involved unplanned incident requiring significant portions of police, fire and civil responses teams.

1. BACKGROUND

Consequence Management(CM) is one critical area of non-combat operations where the Army works with civilian and government agencies such as the Federal Emergency Management Agency (FEMA) for sustained periods of time. A challenge in the CM domain is the ability to allocate manpower and resources to deal with complex and dynamic situations while ensuring that personnel with the right skill sets and levels of readiness have been assigned to the jobs at hand. One such software tool that gives CM planners the ability to see the impacts of manpower and resource allocation on operational readiness is IMPRINT.
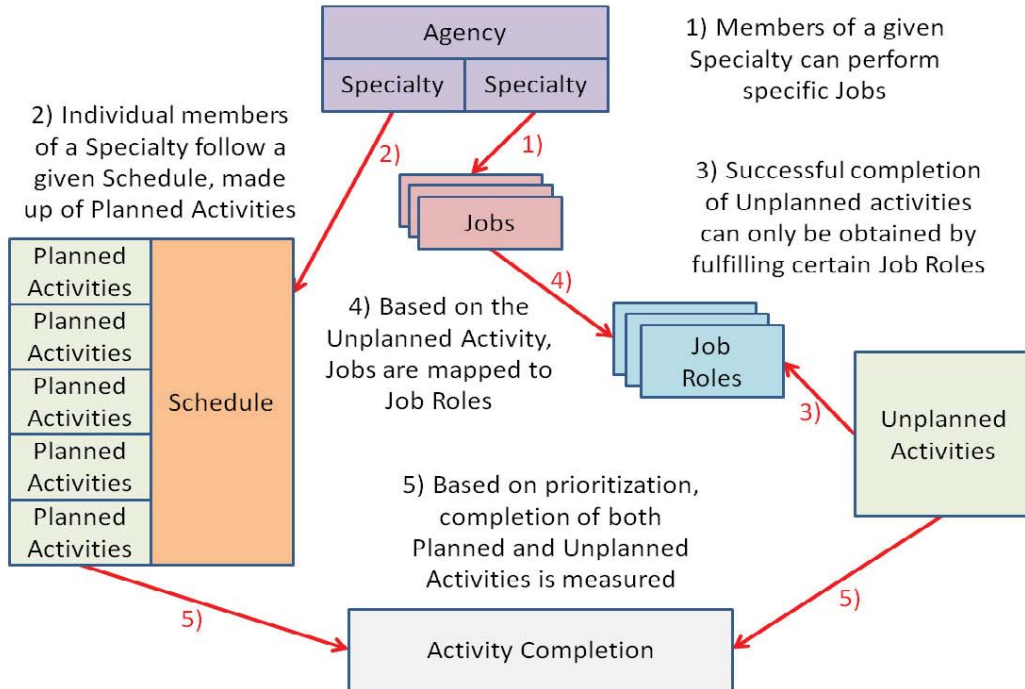
1.1. IMPRINT

IMPRINT is a simulation and modeling tool that provides means for estimation Manpower, Personnel, and Training (MPT) requirements and to identify constraints for new weapon systems early in the acquisition process. The IMPRINT tool grew out of common U.S. Air Force, Navy, and Army MPT concerns identified in the mid-1970s (Dahl, 1990). It is government owned software and consists of a set of automated aids to assist analysts in conducting human performance analyses (http://www.arl.army.mil/IMPRINT). IMPRINT has been available as a government product free of charge since the mid 1990s to the following organizations - U.S. government agencies, U.S. private industry with U.S. government contract, and U.S. colleges and universities working in Human System Integration. IMPRINT has four modules - Warfighter, Missions, Equipment, and Forces module that provides a powerful and flexible environment in which to develop human performance models, and has unique capabilities for assessing the impact of stressors (e.g., sleep deprivation, protective gear) on performance (Allender, 1999). This is achieved through an embedded simulation engine, based upon the commercial Micro Saint Sharp (http://www.alionscience.com/index.cfm?fuseaction=Products.view&productid=35) discrete event simulation tool and supplemented by human performance algorithms. In this paper we describe the case study model used to exercise the Forces capabilities of IMPRINT.

2. FORCES APPROACH AND CASE STUDY MODEL

The Forces module in IMPRINT allows the analyst to perform manpower projections for large groups of people by analyzing the successful completion of both planned and unplanned activities. The level of detail is sufficient to be meaningful down to the individual level, but abstract enough that tradeoff analyses are simple to develop and perform.

In order to exercise these capabilities and to create a better understanding of the kinds of data that can be generated from this kind of analysis, we developed a case study model

Figure 1: Interplay among Components of the Forces Module of IMPRINT

at a sufficient level of detail and at an appropriate level of organizational structure that represents both regular and extraordinary activities using both local and national agencies.

The case study involves a hypothetical college campus terrorist threat incident and its impact on civil service agencies. In our model, which represents a five day period, the potential bomb threat occurs near the beginning of the third day.

2.1. Scenario Description and Overview

A small city is three days into a typical week with the fire department having responded to several fire calls, when what would normally be a routine civil disturbance call escalates into a situation involving four separate agencies over a 16 hour period. An initial call to deal with a troublesome incident on a campus ends with the student being apprehended by police. During this time a

potentially biohazardous packet of powder was found, resulting in a quarantine of all involved personnel. A Civil Support Team with experience and equipment were notified to respond, entered the area and obtained samples. The Civil Support Team also investigated another related incident-a suspicious package, believed to be a bomb found in an adjacent building. The entire time, a local support team of EMT, Fire and Police personnel were assigned to assist with securing the area and providing support to the Civil Support Team. During this time another fire call came which was met successfully, but with fewer than the normal number of personnel A mutual aid fire call from a neighboring county came in, but the fire department did not have the personnel to support the call..

2.2. Interplay among Force Components

The interplay among the various components of the Forces module of IMPRINT is shown in

Table 1 Agencies and their Specialties used in the Case Study

Agency	Specialties
Fire Department	*Chief, Driver, Ladder Operator, Pump Operator*
Police Department	*Chief, Detective, Patrol Officer,* *SWAT Team Leader, SWAT Team member*
Emergency Medical Technician	*EMT Driver, Transport Care Giver*
Dispatcher	*Switch Board Operator*
NBC Recon Civil Support Team	*NBC Recon Team leader, NBC Recon NCO,* *NBC team member*

Figure 1, with the net result being the measurement of activity delays and completion failures. The numbered arrows correspond with the relationships described in the figure.

Thus using the prioritization scheme among planned and unplanned activities and assigning personnel to fulfill specific roles, the ability to successfully complete activities is calculated.

The Forces module also contains components for assessing equipment usage for both planned and unplanned activities, but as they are functionally similar to Specialties, Jobs and Job Roles, we are omitting discussion of them in this paper for brevity and clarity.

2.3. Agency Definition

Five agencies were detailed and used in the case study model. Each agency has a specific number of specialties, indicated above in (Table 1). In this paper we discuss in more details below, one agency, *NBC Recon Civil Support Team.*

2.3.1. NBC Recon Civil Support Team

The *NBC Recon Civil Support Team* specialties are based on discussions with a previous member of the 7th Civil Support Team and an analysis of the 7th Civil Support Team's Standard Operating Procedures (7th CST SOP). The *NBC Recon Team leader* is the officer in charge of the team, being responsible for the development of overall plans and being responsible for all section operations. The *NBC Recon NCO* is responsible for coordinating and reporting

team actions back to the NBC Team Leader. The *NBC team member* carries out the plans of the Team Leader and the NCO. There is a further distinction of duties in the 7th CST SOP of Recon Team Chief, but that is delineated in *Jobs*, below.

2.4. Jobs

Jobs represent specific Job assignments from the given specialties. These are mapped to *Job Roles* described below.

2.5. Schedules

Schedules were developed for each of the agencies based on interviews and information obtained from members of the various organizations. The schedules were developed and the planned activities were pulled from each of the schedules, renamed as necessary to common terms (e.g., "lunch" in one schedule would become the generic "Eat" for all schedules') A sample schedule is shown below (Table 2).

Table 2 Sample Schedule

Planned Activity	Start	End	Duration
Sleep	0.0000	6.0000	6.0000
Personal Time	6.0000	7.0000	1.0000
Physical Training	7.0000	8.0000	1.0000
Hygiene	8.0000	9.0000	1.0000
Classes/Training	9.0000	12.0000	3.0000
Eat	12.0000	13.0000	1.0000
Standard Work	13.0000	17.0000	4.0000
Personal Time	17.0000	22.0000	5.0000
Sleep	22.0000	24.0000	2.0000

2.6. Planned Activities

Planned activities are the various events that are used to populate Schedules.

Planned activities were generated based on the development of the schedules described above. They are not represented in detail; rather they are given a priority which is compared against the priority of Unplanned Events (below) to determine which activity is performed at any given time. In this analysis, due to the acute nature and severity of the situation, no planned activity takes precedence over any unplanned activity. Finally, an activity may be a "Sleep Activity" which is used to determine who may be called to perform a specific duty. Given equal task priorities, a person who has had more sleep will be chosen to perform a task over someone who has not.

A sample list of the Planned and Unplanned Activities sorted by priority(lower the value, higher the priority), with the Sleep Activity indicated is shown below (Table 3).

Table 3 Sample Planned/Unplanned Activities (NBC Team)

Priority	Name	Type
1	*3) Quarantine*	*Unplanned*
1	*C) NBC Recon offsite training*	*Unplanned*
2	*4) NBC Recon Support*	*Unplanned*
2	*4) NBC Recon - powder*	*Unplanned*
2	*5) NBC Recon - bomb*	*Unplanned*
97	Eat	Planned
104	Hygiene	Planned
105	*Sleep*	Planned
108	Personal Time	Planned
112	Standard Work	Planned
115	Physical Training	Planned
116	Classes/Training	Planned

2.7. Job Roles

The *Job Roles* are defined as roles that need to be performed for successfully addressing the Unplanned Activities of the scenario. A specific *Job* may fulfill one of several potential *Job Roles*, and *Job Roles* may be performed by any number of *Jobs.* A brief description of each of the responsibilities of a person performing a given *Job Role* follows (Table 4). A sample of the cross referencing of Jobs and Job Roles as discussed above (Figure 1) is shown below (Table 5).

Table 5 Sample Jobs Cross-Referenced with Job Roles

NBC Jobs	NBC Comms	NBC Decon	NBC Leader	NBC Member
Recon NCO	X	X	X	X
Recon Team	-	X	-	X
Recon TL	X	-	X	-
Team Chief	-	X	X	X

2.8. Unplanned events

There are two sets of unplanned events. Those that relate to the terrorist threat call (numbered in the naming convention adopted in the model) and those that relate to other unplanned activities (lettered in the model).

Unplanned activities may be either fixed duration, or a variable duration that can depend on the number of people available to handle the unplanned activity. In this analysis, the major events are fixed times, since they lead from one directly into the other while the minor unplanned activities (Fire Calls) have a variable duration.

2.8.1. Terrorist Threat Call

The Terrorist threat call has several components which comprise the whole incident, described below.

2.8.2 Initial Terrorist Call

This is the initial Police Response to the disturbance on campus. It is a half hour

Table 4 Sample Job roles and their descriptions used in the case study

Job Role	Description
NBC Communication	Track and communicate with NBC team while in a hazardous area
NBC Decontamination	Decontaminate NBC team that entered the hazardous area.
NBC Leader	Coordinate NBC entry into the hazardous area.
NBC Member	Enter hazard site, or be part of backup team.

unplanned event during which the *Dispatcher*, one Police Leader and two *Police Member*s are involved. One Police car (*Police Mobility*) is involved. The suspect is found and apprehended by police.

2.8.3 Call Followup

After the police apprehended the suspect, various emergency personnel were called to the scene, including four more police officers (including two *Police Members* and two *Police Sub-leaders*), two *EMTs* and four from the Fire Department members (including two *Fire Members,* one *Fire Leader* and one *Fire sub-leader*). This requires one *Ambulance*, the *Command Center*, another police car (*Police Mobility*) and two fire vehicles (*Fire Mobility*) to bring the various members to the scene. This procedure takes an hour and a half, during which it becomes known that there is a package with a suspicious powder that may be a biohazard threat (e.g., anthrax).

2.8.4 Quarantine

All of the personnel who have come into contact with the suspect in the room and with the powder are quarantined in the building. This is several of the people from the *Call Followup*, but not all. It includes both *EMT* and six of the seven police officers (all but one of the *Police Members*). No vehicles are quarantined. Note that the Quarantine has the highest possible priority in this analysis, as once the personnel are quarantined, they cannot be released for another activity until the quarantine is lifted. The quarantine will last until officially lifted, nine and a half hours later.

2.8.5 NBC Recon – Powder

Once the potential biohazard threat has been identified as an issue requiring additional attention and the proper clearances have been given, the NBC Recon Civil Support Team was notified and responds to the scene. They arrive on the scene three and half hours later. They bring their equipment truck and trailer (*NBC Mobility*), along with eight personnel (including one person for

NBC Communication, one *NBC Leader*, two *NBC Decontamination* and four *NBC Members*).

In addition to *NBC Mobility*, four *NBC Personnel Protection* suits were used (two for entry, two for decontamination), and two sets of *NBC Detection* Equipment (one for entry one for backup) were required. Including transport, arrival, setup, entry and decontamination, this activity takes five hours.

2.8.6 NBC Recon Support

Local service support is required to assist the NBC Recon Civil Support Team with various tasks, including crowd control, emergency services, and providing access to buildings. This involves more coordination with the *Dispatcher*, an additional *EMT*, the *Fire Leader* (if available), the *Police Leader* (if available), one or two *Police sub-Leaders*, one or two members of the Fire Department (*Fire Member*) and four or five members of the Police department (*Police Member*). The SWAT team comprises the bulk of the police force in this activity, so it requires a SWAT van (*SWAT Mobility*), in addition to a police vehicle and fire vehicle (*Police Mobility* and *Fire Mobility* respectively). Finally coordination among all the services requires both the use of the base *Command Center* and the on-location *Mobile Command Center*.

This activity is numbered the same and NBC Recon – powder, since they both start at the same time. They are kept as separate activities so it is easy to modify them for our sensitivity/tradeoff analysis below. The length of this task spans the total time of both NBC Recon tasks, seven hours.

2.8.7 NBC Recon – Bomb

Near the time when the biohazard threat is being wrapped up, another suspicious package (a potential bomb) is found in a nearby building. Even though this activity requires more personnel (using five *NBC Personnel Protection* suits instead of four), the team is already on-site and setup, so this

activity only takes two hours. Other than using the one additional suit, this activity uses the same *Job Roles* and *Asset Features* as *4) NBC Recon – Powder* above.

2.9. Other Unplanned Activities

There are three other Unplanned Activities that are taking place during the time around the potential terrorist threat. Two are two different kinds of fire calls, and one relates to the NBC Recon crew, listed below.

2.9.1 Local Fire Call

A Local Fire Call occurs when a fire emergency is reported in the general reporting area for the Fire Department. We used an average of one fire call per day, using a Log Normal distribution, with a 10 hour standard deviation. Normally the standard deviation could be larger to allow for greater variation, but we wanted to ensure that a Regular Fire Call would occur during the terrorist threat call. The call requires two *EMT*, one *Fire Leader* (if available), three or four *Fire Members*, one *Police Leader* and one *Police sub-leader* (if available), and one *Police Member*. The vehicles required for a Regular fire Call include one *Ambulance*, one or two *Fire Mobility*, one *Ladder* (if available), one *Water Pump*, one police car (*Police Mobility*) and a *Mobile Command Center*.

Also for the *Local Fire Call*, the time of the call can be reduced by increasing the number of crew members. In this case each crew member reduces the time by 15%, up to a total contribution from four extra crew members of a 48% reduction in time [1 – (1 – 0.15)^4]. This represents the increased efficiency and availability of members to communicate,

2.9.2 Mutual Aid Call

A Mutual Aid call occurs when a fire emergency is reported that is outside the general reporting area for the Fire Department. Due to the nature of these call being outside the normal operating area, the calls typically take longer and require more fire personnel (so a second vehicle is less likely to be sent) but fewer fire support personnel. Two more Fire personnel (*Fire Member*) are required, but one less *EMT* is needed and a *Police Chief* is not needed, as these are supported by the originating locale. Mutual aid calls occur approximately once every eight days depending on the time of year. We placed our mutual aid during the terrorist threat incident to force a consequence in our analysis. Also notice that the priority is lower than a regular fire call, since it is being called from its general reporting area, a *Local Fire Call* would take precedence over a mutual aid call.

2.9.3 NBC Recon Offsite Training

The members of the NBC Recon Civil Support Team occasionally take extensive off-site training which makes them physically unable to respond to a call. For this analysis, three members of the NBC Recon team (*NBC Member*) were unavailable for the duration of the threat call.

3. ANALYSIS

3.1. Overall assessment

This is a fairly short incident with a focused response. The analysis here mostly relates to resource management of personnel and equipment. Other than the failed Mutual Aid Call, the local services and NBC Recon Civil Support team are able to address and handle the situation without much of a disruption of normal activities. The *Local Fire Call* that occurs during the *Call Followup* and immediately before the quarantine is the most affected activity that still succeeds. It uses seven people, one less *Fire Member* and none of the other desired roles. This is close to the minimum required number of six, such that the response time is not significantly reduced as most of the other Local Fire Calls are by the presence of extra personnel.
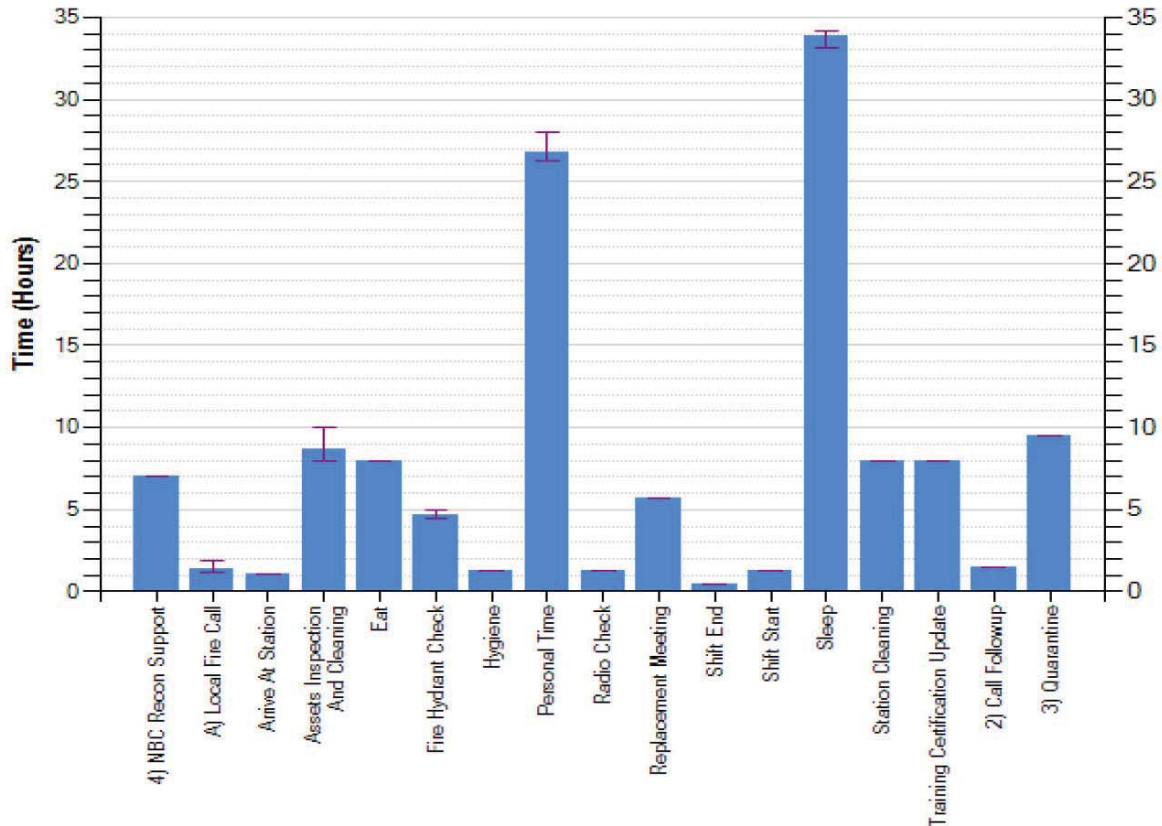
Figure 2. Mean and Std Dev Times for Planned Activities

3.2. Effect of increased crew members

The Local Fire Call activity is the only activity in this analysis that is affected by the number of crew members. There are four instances of Local Fire Calls, which have three different numbers of responders among the four instances.

The first Fire Call is reduced in time by 39% due to the presence of three extra crew members (9 desired – 6 required). The second call is reduced by the full 48% described above, due to having all four extra crew members (9 desired – 6 required). The third call, however only shows a 15% improvement in time due to the fact that there is only one extra crew member. Here, the maximum number of crew members that can affect the time (four) is also equal to the extra desired crew members (four). If the desired number of crew members were to increase to 11 or more, it is important to note that the times would remain unchanged, since the maximum number of crewmembers that can

affect the time is still four. If however, the desired number stayed the same but the maximum number of crewmembers can affect the time were reduced to three, the second fire call would see only a 39% reduction in time, instead of the indicated 48%.

3.3. Time of effects

While many of the graphs and data indicate a small to moderate impact of the threat incident on various duties and other planned activities, there are a few things to point out. First, in the Fire Department Driver Activity chart below, both Personal Time and Asset Inspection and Cleaning show more variation ranging from 26 to 28 hours and 8 to 10 hours respectively. While the change in personal time is not drastic, over time it could become prominent. What is also of concern is that Asset Inspection and Cleaning is reduced. During an extended incident, this activity could suffer to the point where asset failure may be more likely to occur.

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Similarly, in the Activity times for Police Dept Officers, patrol time is negatively impacted by the threat incident (Figure 2). Again, while in the short term of this analysis, a reduction in patrol time of a few hours a week may not seem much, increasing the required number of police or extending the time of the incident to much longer periods of time would have consequences on the quality of the police coverage in the area.

3.4. Consequences of terrorist threat call

The terrorist threat activity prevented the Mutual Aid Call (at 80.0 hours), due to the support required for the NBC Recon Activity. This call would likely have been handled by another Fire Department adjacent to the Fire Department which initiated the call.

4. TRADEOFFS

4.1. Extended quarantine

In this scenario, the initial biohazard tests come back positive, and the quarantine is extended to two days. A larger police and fire support team is required and for a longer period of time, due to an increase in the geographic area and to keep a growing population of onlookers from the site.

4.1.1 Changes

The Quarantine is extended to two full days, the NBC Recon Support is extended to a day and a half and expanded to two required personnel and four desired personnel for both Fire and Police Members.

4.1.2 Results

During this period, in addition to the failed mutual support call, two Local Fire Calls failed (89.9 hours and 109.1 hours) due to the extended time and requirements of the NBC Support. The initial threat has ended, but due to the uncertainty of the situation, the quarantine continues well into normal daytime hours. This would generally lead to word being spread of the incident and an increase is onlookers. This results in a larger group being required to keep the situation in control.

The extra fire personnel required means that two Local fire calls are missed: one that occurs almost immediately after the NBC Recon activities are finished and another near the end of the quarantine time. Here the anticipation of the quarantine extending into the day suggest an anticipatory response to bring in more fire personnel.

4.2. More Frequent Local Fire Calls

In this scenario, the terror threat call occurs at a time when Local Fire Calls are more common (summer months).

4.2.1. Changes

The frequency of Local Fire Calls is doubled, changing the Mean Time from one day to twelve hours and a standard deviation from ten hours to five hours.

4.2.2. Results

In addition to the Mutual aid call failing at 80 hours, a Local Fire Call that comes in during the NBC Recon activities (81.9 hours into simulation) fails, as Fire personnel are still supporting the NBC Recon effort. This indicates that when Fire Departments are near capacity (greater frequency of responses), an unplanned event is more likely to have negative consequences. This would indicate that during such times, contingency plans such as alerting adjacent fire districts of the higher likelihood of a mutual aid call or preemptively requesting more available volunteers (if a volunteer fire department) is warranted.

5. CONCLUSIONS

In this paper we demonstrated the uses of the Forces module through the use of a case study involving several distinct agencies, including both civilian and military civil support.

The case demonstrated that the level of detail is specific enough to observe substantive changes in task completion times, impacting overall manpower estimates for both task completion and quality of life (sleep and personal time cycles).

6. ACKNOWLEDGMENTS

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