Right Sizing Navy Fire & Emergency Services

OR 680/SYST 798
Final
December 8, 2011

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Purpose & Agenda

Purpose

•Present results and methodology from the Fire & Emergency Services Effectiveness BaseLine Evaluator "FESEBLE" tool

Agenda

•Introduction

•Background

•System

•Approach

•Model

•Results

•Conclusion

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Introduction

- “Secretary of Defense Robert Gates has set a goal of saving $150 billion from the Pentagon budget over the next five years. $35 billion of those proposed savings would come from the US Navy.” - PRI’s The World, January 10, 2011

Background

- Sponsor
  - Created FESPOM cost model to calculate resources required to meet policy requirements
  - Study needs to adjust to budget and model needs to explain possible effects of change
  - Requests loss function (L) as L = F(A, I)
    - A - FE&S Asset, I - Base Installation Features

- Problem
  - Develop a mathematical model of the expected loss at an installation given an application of F&ES resources
  - Determine the risk levels and minimize/level the fire and emergency risk against an enterprise budget
    - Altering the risk, resources, mix of F&ES capabilities across and within the Navy's 70+ installations

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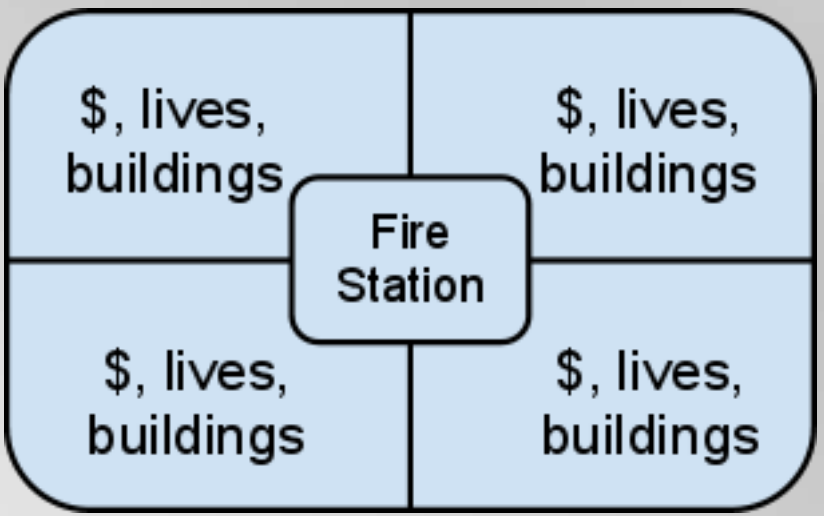
Goal

- Create an installation level simulation tool
  - Simulate the events, response, and loss
  - Vary the response due to changed resources



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Assumptions

- Assumptions:
  - Requested resources to an event
  - Pre-determined time for resolving false alarm
  - Pre-determined response/priority to overlapping events

- Uncertainties:
  - Events time duration
  - Providing resources to an event (first 5 minutes)
  - Providing proper resources to an event

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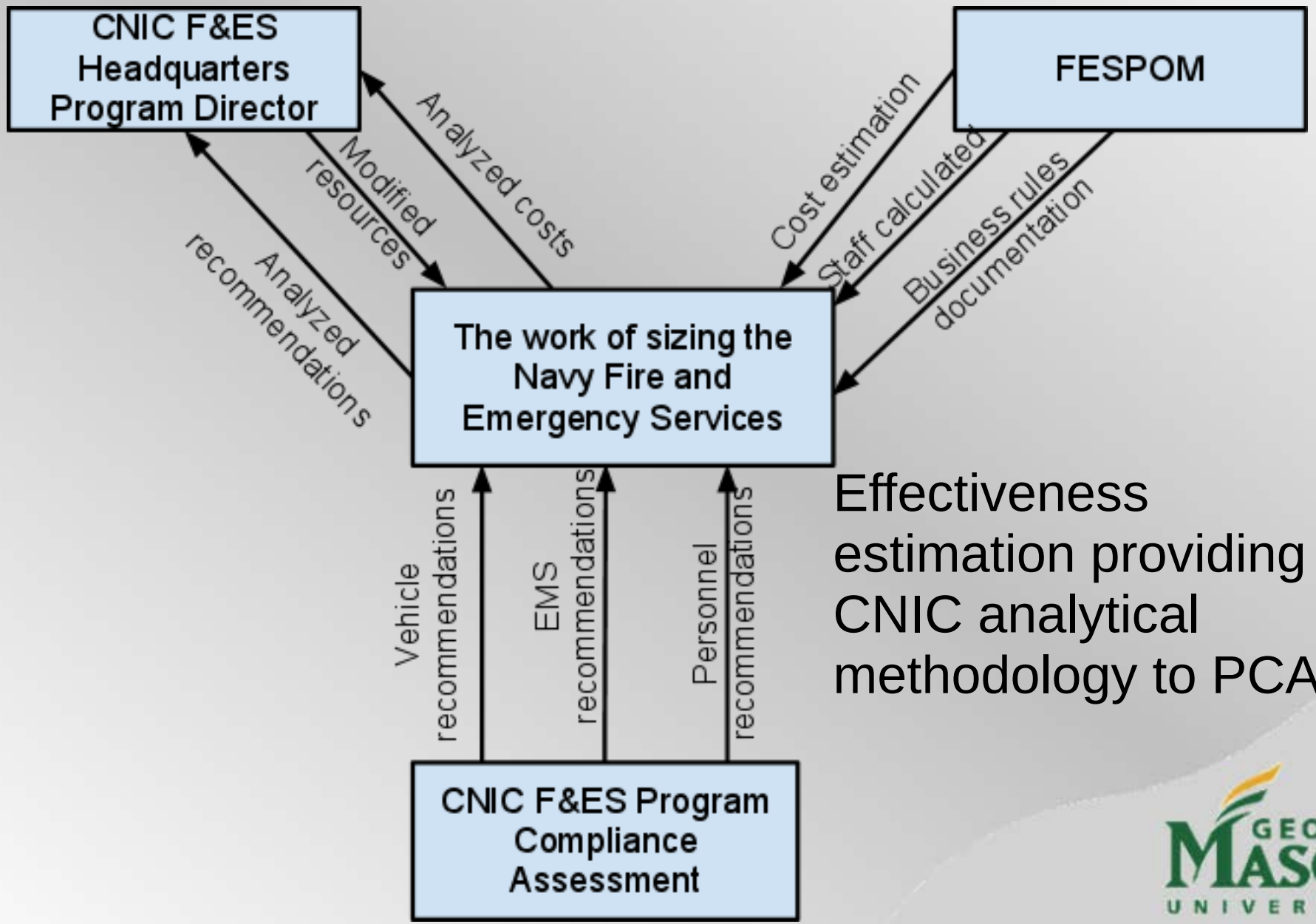
Existing Process



Effectiveness estimation providing CNIC analytical methodology to PCA

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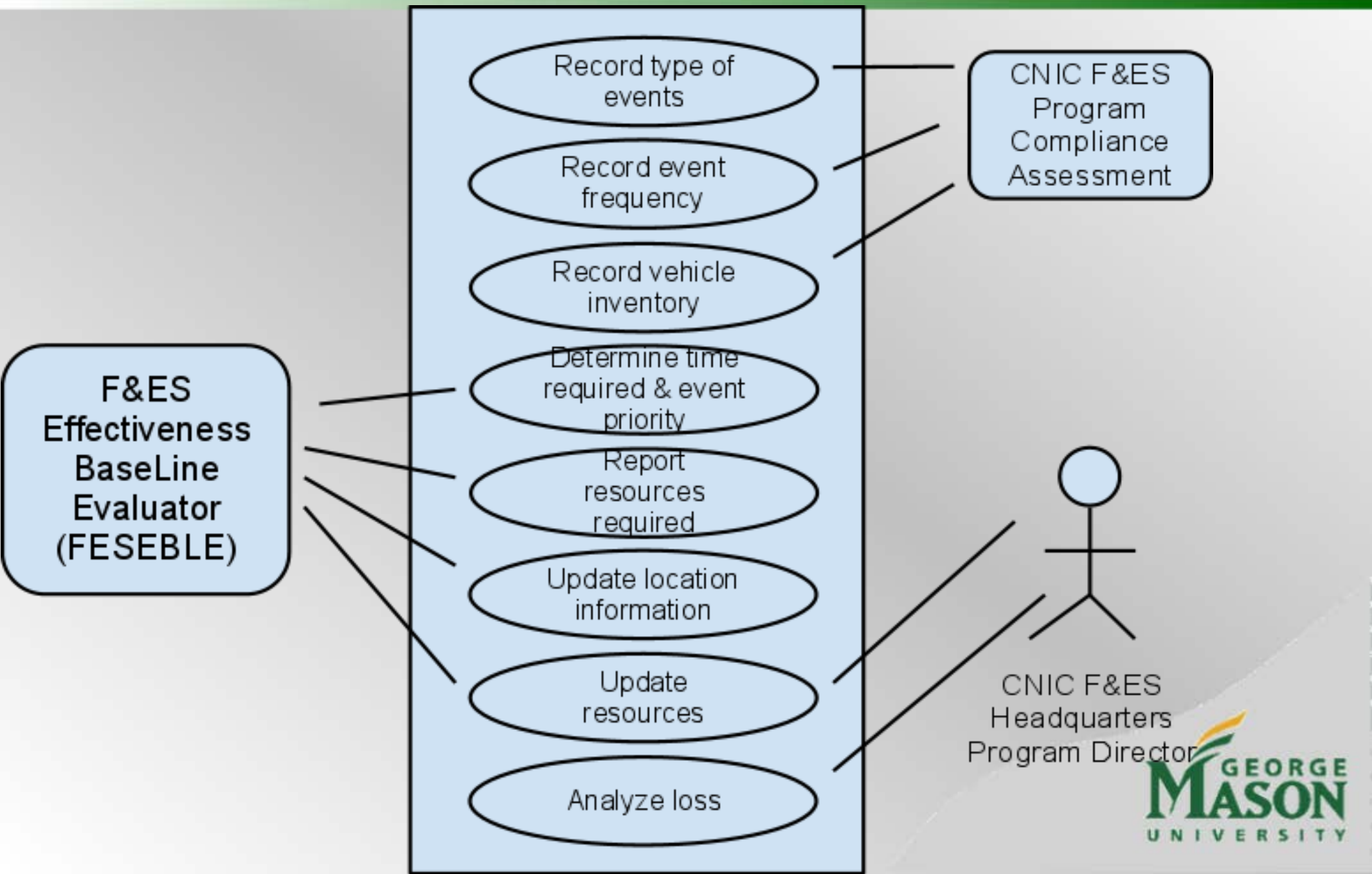
System Interactions



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Alternatives

- 3 Alternatives

	Licensing/Cost	Overall Power	Familiarity		Availability		Expandability
			Sponsor	Team	Sponsor	Team	
ExtendSim	$$$						
Arena	$$$						
Excel	$						

Legend	
	High
	Medium
	Low

- ExtendSim & Arena
  - Powerful, Expensive, Limited knowledge base, limited availability
- Excel (Chosen)
  - Slower processing power, cheap, widely available

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Standards

- NFPA 1710 – Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments

- Minimum of 4 firefighters per apparatus
- Arrive within 4 minutes – 1st company
- 8 minutes – all companies for 1st alarm
- Process and notify in 1 min, 95% of the time

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Approach

- Used grid to calculate location
- Fitness center, University hall, and Mason Inn renamed as Mason base fire stations
- Types/frequency of events and resources are based by reviewing Navy F&ES PCA data

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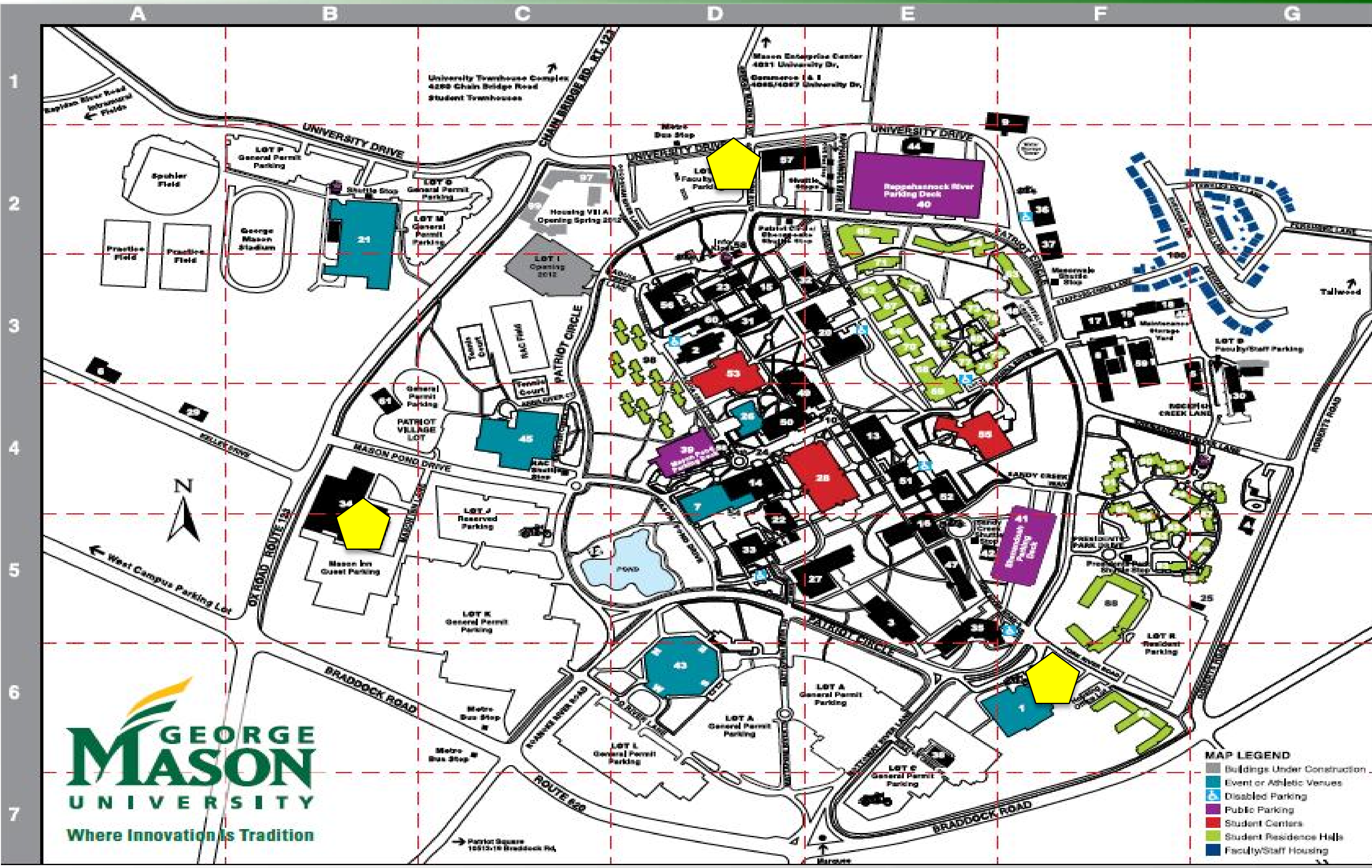
Map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Where Innovation Is Tradition
MAP LEGEND
Buildings Under Construction
Event or Athletic Venues
Disabled Parking
Public Parking
Student Centers
Student Residence Halls
Faculty/Staff Housing
UNIVERSITY DRIVE
PATRIOT CIRCLE
BRADDOCK ROAD
ROUTE 620
MASON POND DRIVE
West Campus Parking Lot
Rappahannock River Parking Deck
Shenandoah Parking Deck
POND

Data Collection

- Locations for Events and Stations
  - Longitude
  - Latitude
- Vehicles
  - Capability
  - Station
  - % maintenance
- Events
  - Type
  - Priority
  - Probability of False Alarm
  - Time Required
  - Frequency

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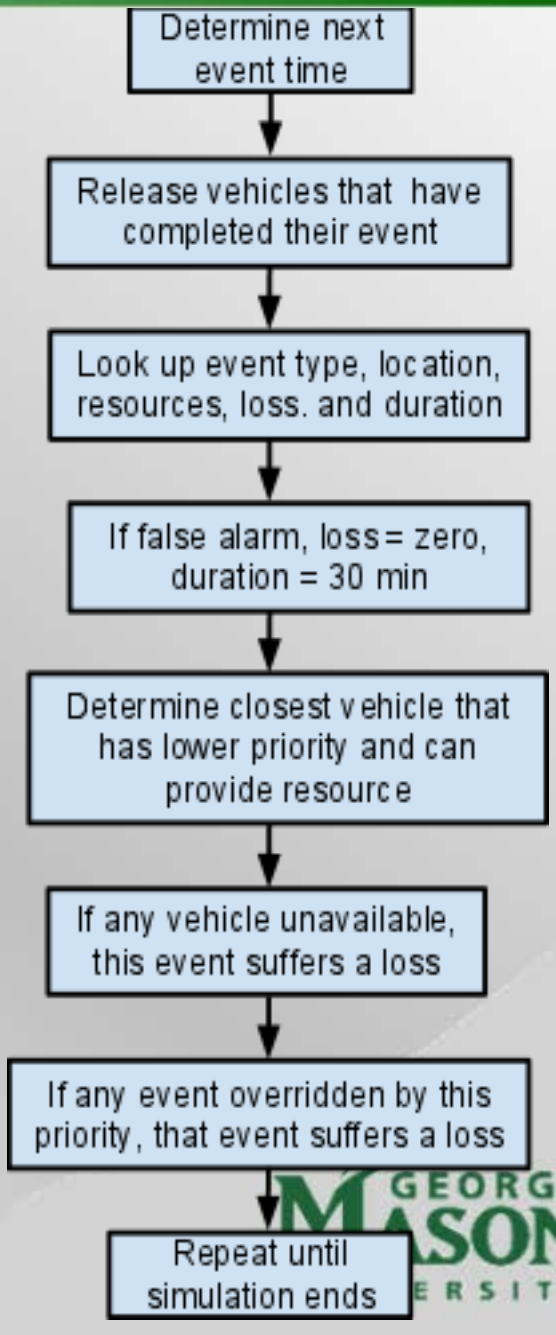
Model Flow

- Alarm Occurs
  - Triggers model to retrieve event type, location, and priority
- Identify vehicles required and current status
  - Send available vehicles, or
  - Reroute vehicles based on the distance and priority
- Determine Loss



Model Limitations

- Vehicle provide 1 capability
  - System Effect: Worst case assumption. Cross capable vehicles not modeled. Lowers benefit for some vehicles.
- Loss is binary: ALL vehicles must be at the event for the FULL duration
  - System Effect: Worst case assumption. The critical moments are the 1st 30 minutes.
- All vehicles are fully crewed
  - System Effect: Best case assumption. SMEs generally agreed with this assumption.

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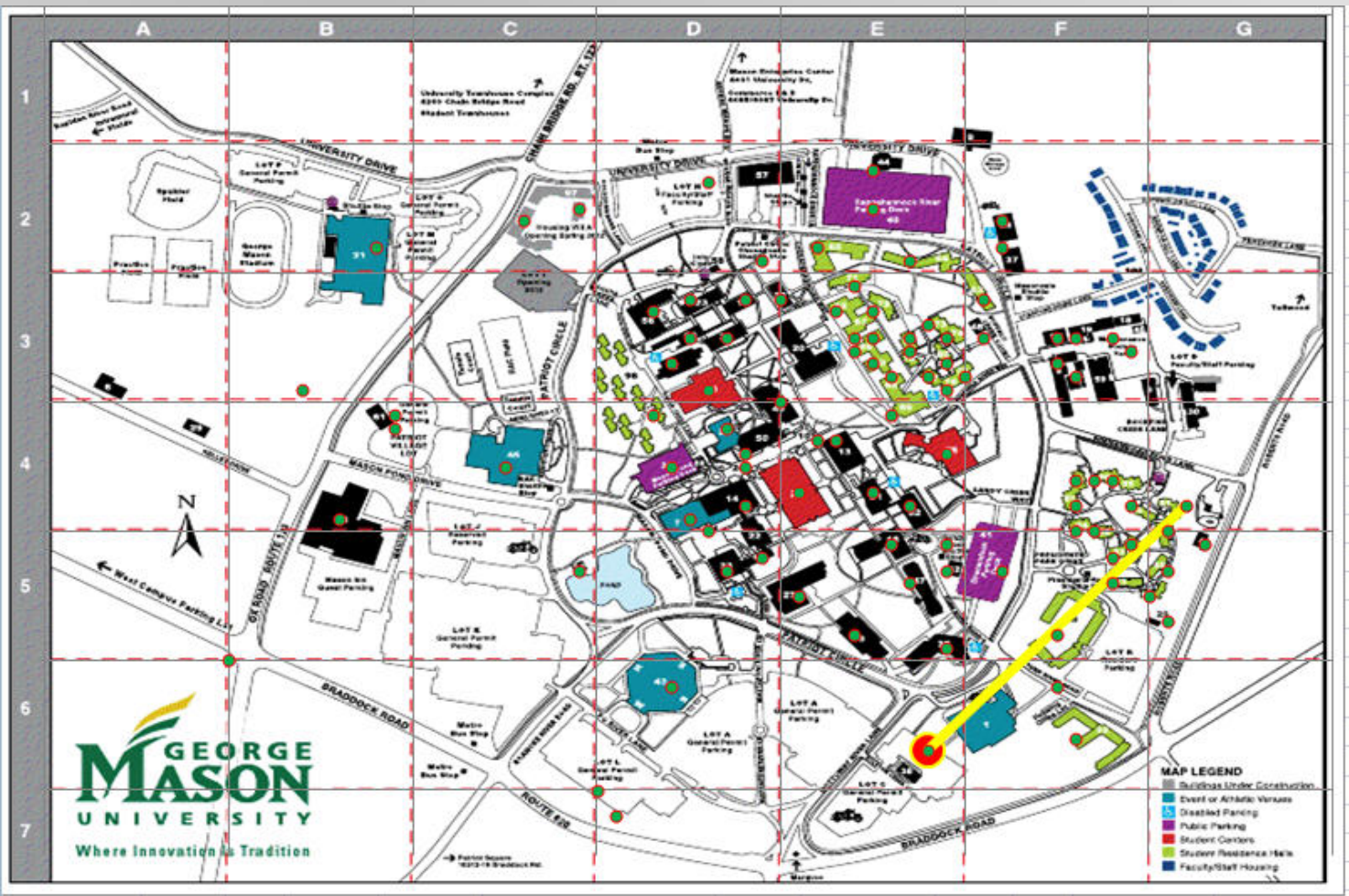
On-site station #1 with no loss

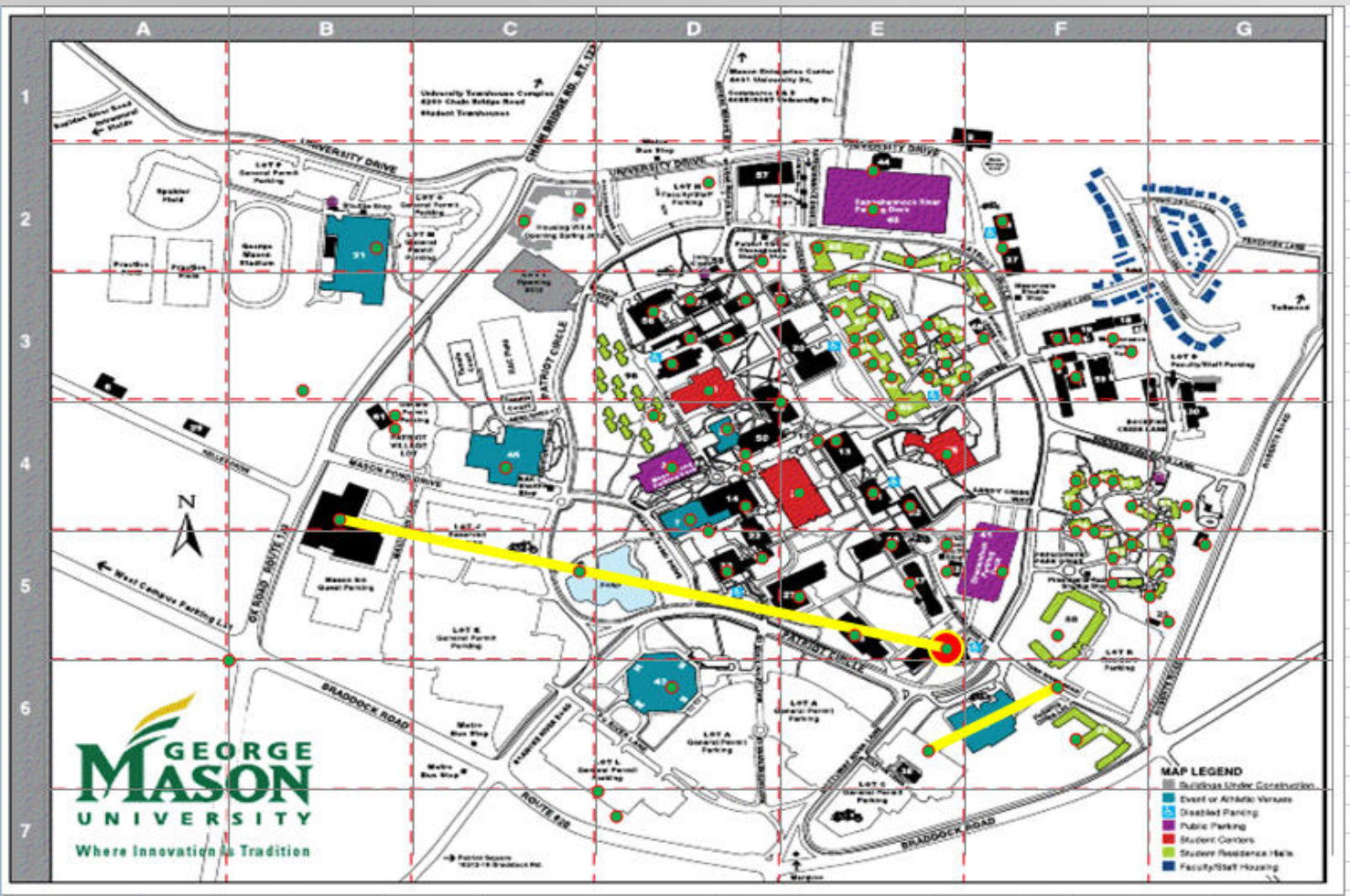


Time	Event #	Type	Location	Time Req	Vehicles	Loss	FalseAlarm?	Loss $	Lives	First Arr	Last Arr
602.0103719	518	2	7	1	, 7,	.	FALSE	0	0	2.360084744	2.360084744
602.0363582	519	13	0	1	, 12,	.	FALSE	0	0	23.9760297	23.9760297
602.3419446	520	2	0	0.5	, 5,	.	TRUE	0	0	2.163330765	2.163330765
603.6069007	521	2	80	1	, 0,	.	FALSE	0	0	1.565247584	1.565247584
606.248943	522	2	37	1	, 0,	.	FALSE	0	0	0.860232527	0.860232527
606.3469201	523	2	33	1	, 5,	.	FALSE	0	0	3.44818793	3.44818793
608.9261764	524	2	52	1	, 7,	., 7-525	FALSE	0.5	0	1.6	1.6
608.9720116	525	16	2	8	, 0, 1, 5, 7, 11, 13, 14,	.	FALSE	0	0	1.170469991	21.78072542
609.9467631	526	11	35	1	,	., F	FALSE	0	0.5	.	.

Events	
Event #	Event Name
0	Good Intent
1	Service calls
2	Hazardous condition
3	Unknown Incident
4	Severe weather
5	Explosion
6	CAT 1 ARFF
7	Other fires
8	Vehicle fires
9	Building fires
10	Serious Hazmat
11	Emergency Medical Treatment
12	EMT BLS
13	Other rescue calls
14	EMT ALS
15	Special Incident
16	Major Fire
17	CAT 2 ARFF
18	CAT 3 ARFF
19	CAT 4 ARFF

Vehicles			
Vehicle ID	Station	Ability	Name
0	1	F	Struc Eng
1	1	D	Ladder
2	1	A	ARFF
3	1	A	ARFF
4	1	C	Hazmat
5	34	F	Struc Eng
6	34	B	Batt Chief
7	57	F	Struc Eng
8	57	C	Hazmat
9	57	B	Fire Chief
10	99	D	Ladder
11	99	G	Tanker
12	99	E	Rescue
13	99	F	Struc Eng
14	99	G	Tanker

On-site station #2 with no loss



Time	Event #	Type	Location	Time Req	Vehicles	Loss	FalseAlarm?	Loss $	Lives	First Arr	Last Arr
602.0363582	519	13	0	1	, 12,	.	FALSE	0	0	23.9760297	23.9760297
602.3419446	520	2	0	0.5	, 5,	.	TRUE	0	0	2.163330765	2.163330765
603.6069007	521	2	80	1	, 0,	.	FALSE	0	0	1.565247584	1.565247584
606.248943	522	2	37	1	, 0,	.	FALSE	0	0	0.860232527	0.860232527
606.3469201	523	2	33	1	, 5,	.	FALSE	0	0	3.44818793	3.44818793
608.9261764	524	2	52	1	, 7,	., 7-525	FALSE	0.5	0	1.6	1.6
608.9720116	525	16	2	8	, 0, 1, 5, 7, 11, 13, 14,	.	FALSE	0	0	1.170469991	21.78072542
609.9467631	526	11	35	1	,	., F	FALSE	0	0.5	.	.
610.8014057	527	2	2	1	,	., F	FALSE	0.5	0	.	.

Events	
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4	1	C	Hazmat
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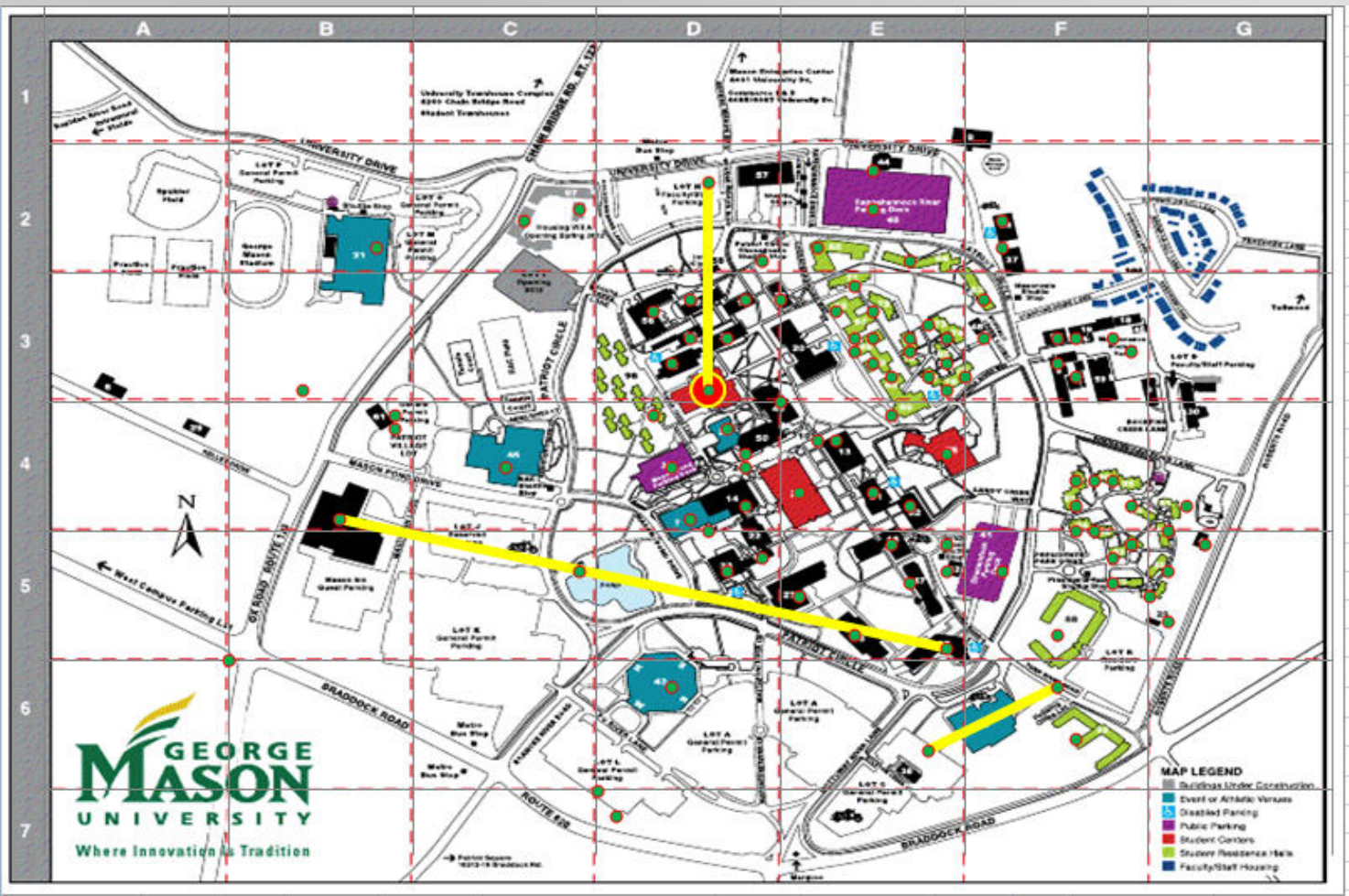
6	34	B	Batt Chief
7	57	F	Struc Eng
8	57	C	Hazmat
9	57	B	Fire Chief
10	99	D	Ladder
11	99	G	Tanker
12	99	E	Rescue
13	99	F	Struc Eng
14	99	G	Tanker

On-site station #3 with loss



Time	Event #	Type	Location	Time Req	Vehicles	Loss	FalseAlarm?	Loss $	Lives	First Arr	Last Arr
602.3419446	520	2	0	0.5	, 5,	.	TRUE	0	0	2.163330765	2.163330765
603.6069007	521	2	80	1	, 0,	.	FALSE	0	0	1.565247584	1.565247584
606.248943	522	2	37	1	, 0,	.	FALSE	0	0	0.860232527	0.860232527
606.3469201	523	2	33	1	, 5,	.	FALSE	0	0	3.44818793	3.44818793
608.9261764	524	2	52	1	, 7,	., 7-525	FALSE	0.5	0	1.6	1.6
608.9720116	525	16	2	8	, 0, 1, 5, 7, 11, 13, 14,	.	FALSE	0	0	1.170469991	21.78072542
609.9467631	526	11	35	1	,	., F	FALSE	0	0.5	.	.
610.8014057	527	2	2	1	,	., F	FALSE	0.5	0	.	.
612.9849564	528	2	4	1	,	., F	FALSE	0.5	0	.	.

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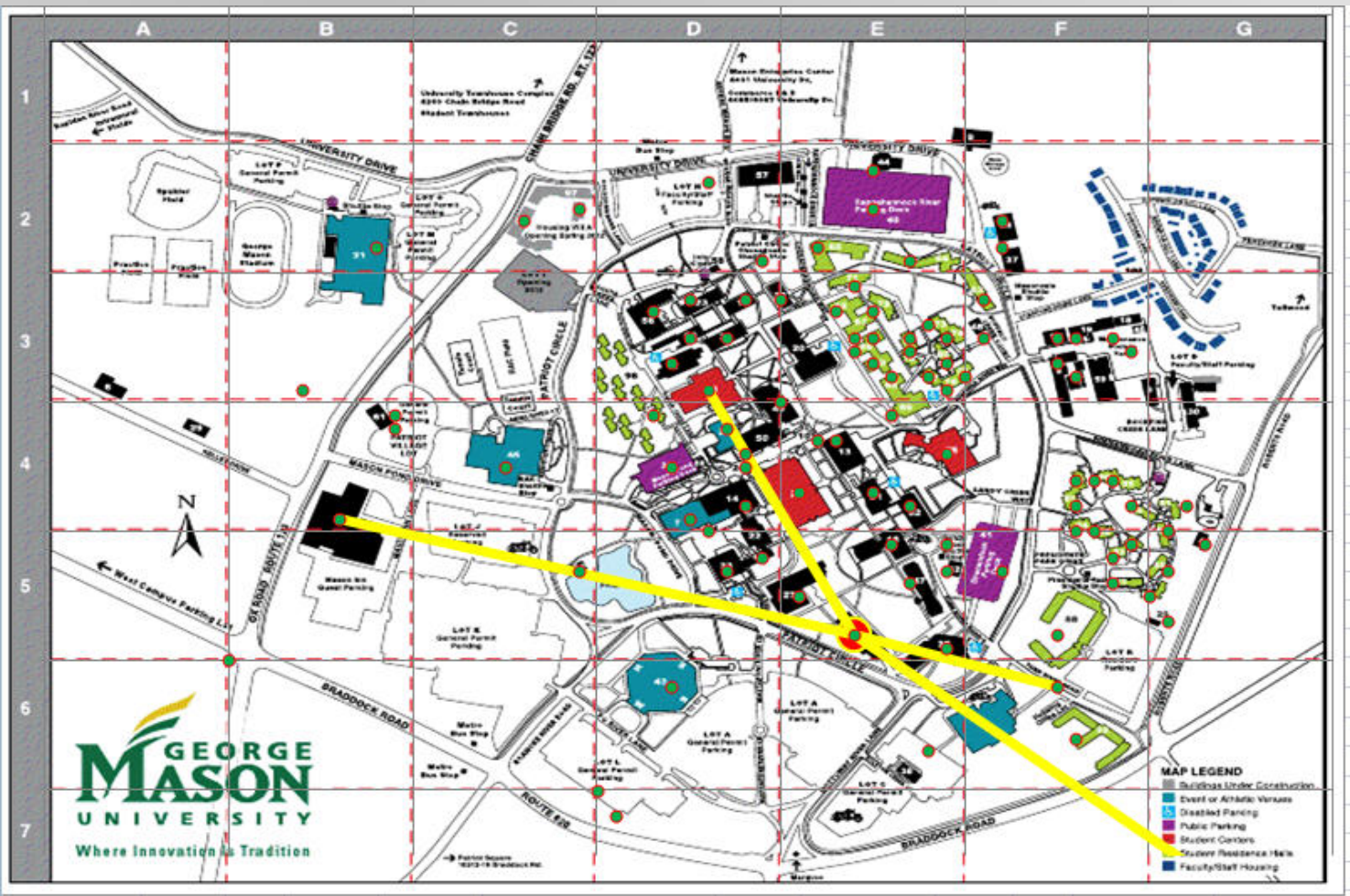
3 on-site & off-site stations, no loss



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606.3469201	523	2	33	1	, 5,	.	FALSE	0	0	3.44818793	3.44818793
608.9261764	524	2	52	1	, 7,	., 7-525	FALSE	0.5	0	1.6	1.6
608.9720116	525	16	2	8	, 0, 1, 5, 7, 11, 13, 14,	.	FALSE	0	0	1.170469991	21.78072542
609.9467631	526	11	35	1	,	., F	FALSE	0	0.5	.	.
610.8014057	527	2	2	1	,	., F	FALSE	0.5	0	.	.
612.9849564	528	2	4	1	,	., F	FALSE	0.5	0	.	.
614.0274751	529	2	2	1	,	., F	FALSE	0.5	0	.	.

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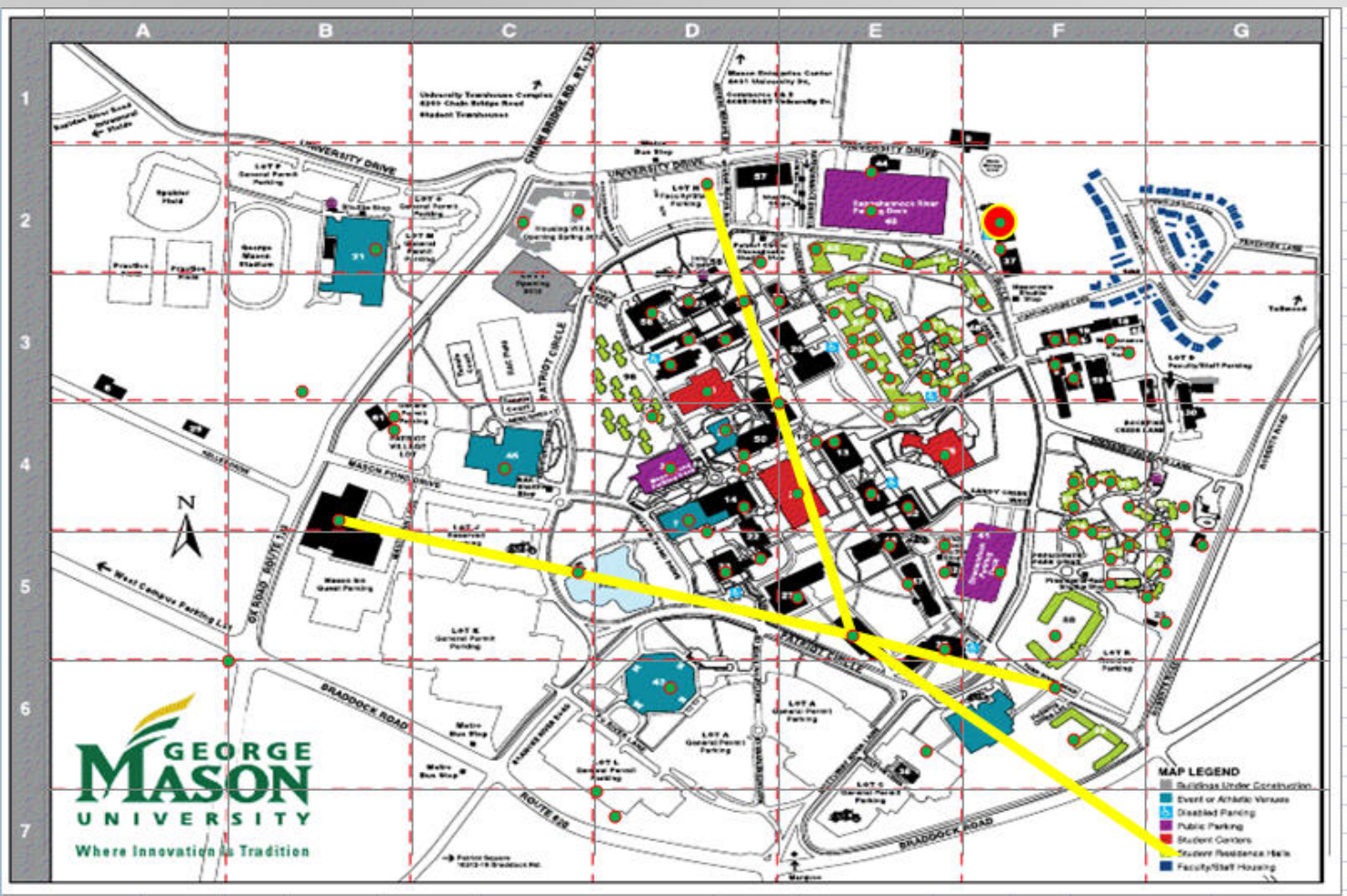
No resources, loss



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606.3469201	523	2	33	1	, 5,	.	FALSE	0	0	3.44818793	3.44818793
608.9261764	524	2	52	1	, 7,	., 7-525	FALSE	0.5	0	1.6	1.6
608.9720116	525	16	2	8	, 0, 1, 5, 7, 11, 13, 14,	.	FALSE	0	0	1.170469991	21.78072542
609.9467631	526	11	35	1	,	., F	FALSE	0	0.5	.	.
610.8014057	527	2	2	1	,	., F	FALSE	0.5	0	.	.
612.9849564	528	2	4	1	,	., F	FALSE	0.5	0	.	.
614.0274751	529	2	2	1	,	., F	FALSE	0.5	0	.	.
616.4606981	530	9	5	4	, 10,	., F, F	FALSE	10	0	25.26598504	25.26598504

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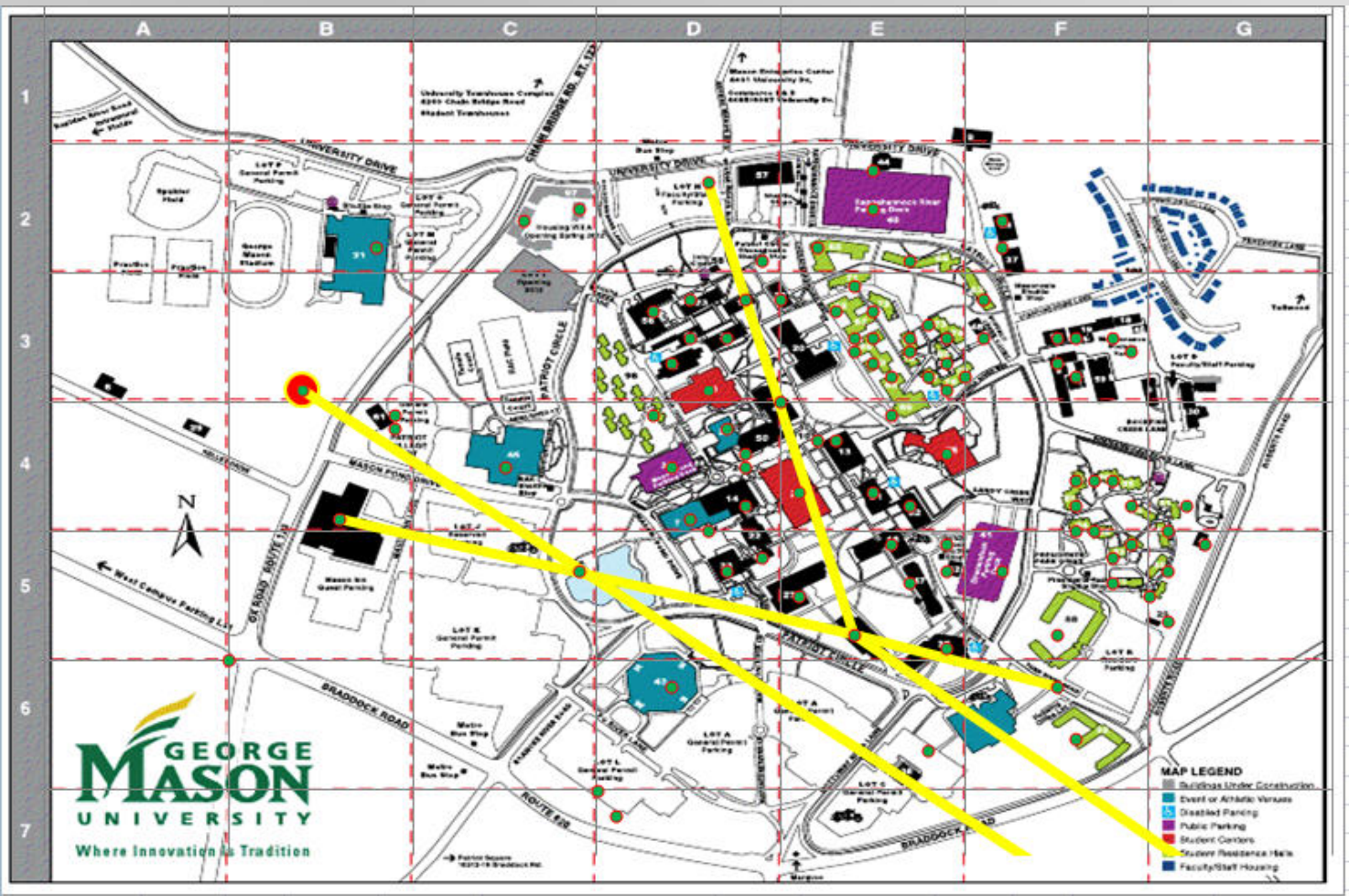
Off-site station with loss



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610.8014057	527	2	2	1	,	., F	FALSE	0.5	0	.	.
612.9849564	528	2	4	1	,	., F	FALSE	0.5	0	.	.
614.0274751	529	2	2	1	,	., F	FALSE	0.5	0	.	.
616.4606981	530	9	5	4	, 10,	., F, F	FALSE	10	0	25.26598504	25.26598504
618.3221681	531	2	97	1	, 7,	.	FALSE	0	0	1.824828759	1.824828759
618.8772312	532	2	90	1	, 0,	.	FALSE	0	0	1.403566885	1.403566885
620.9008415	533	2	23	1	, 7,	.	FALSE	0	0	2.209072203	2.209072203
620.9975007	534	2	7	1	, 0,	.	FALSE	0	0	2.5	2.5

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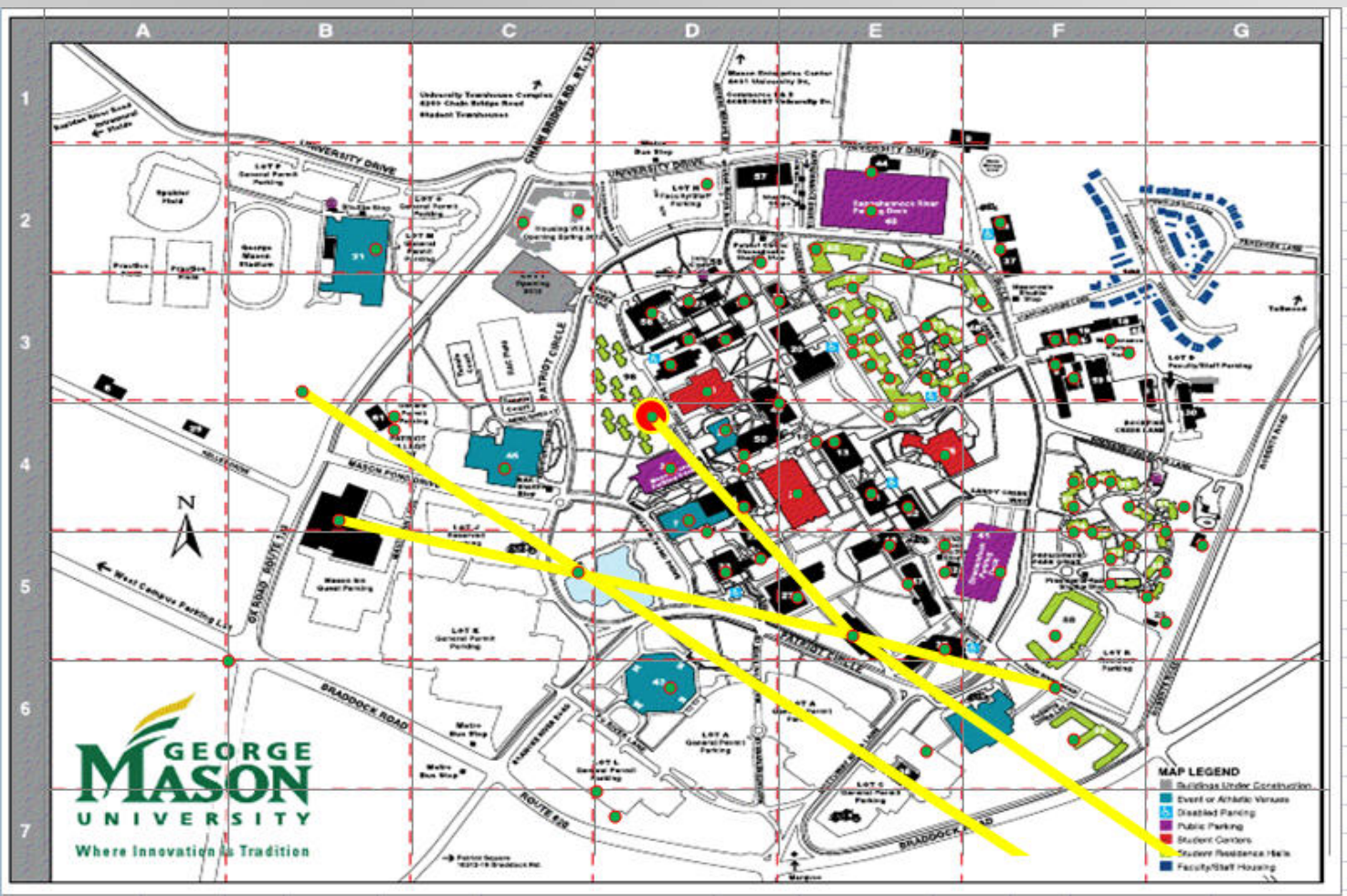
On-site station #3 with no loss



Time	Event #	Type	Location	Time Req	Vehicles	Loss	FalseAlarm?	Loss $	Lives	First Arr	Last Arr
610.8014057	527	2	2	1	,	., F	FALSE	0.5	0	.	.
612.9849564	528	2	4	1	,	., F	FALSE	0.5	0	.	.
614.0274751	529	2	2	1	,	., F	FALSE	0.5	0	.	.
616.4606981	530	9	5	4	, 10,	., F, F	FALSE	10	0	25.26598504	25.26598504
618.3221681	531	2	97	1	, 7,	.	FALSE	0	0	1.824828759	1.824828759
618.8772312	532	2	90	1	, 0,	.	FALSE	0	0	1.403566885	1.403566885
620.9008415	533	2	23	1	, 7,	.	FALSE	0	0	2.209072203	2.209072203
620.9975007	534	2	7	1	, 0,	.	FALSE	0	0	2.5	2.5
621.5772714	535	2	7	1	, 5,	.	FALSE	0	0	4.080441153	4.080441153

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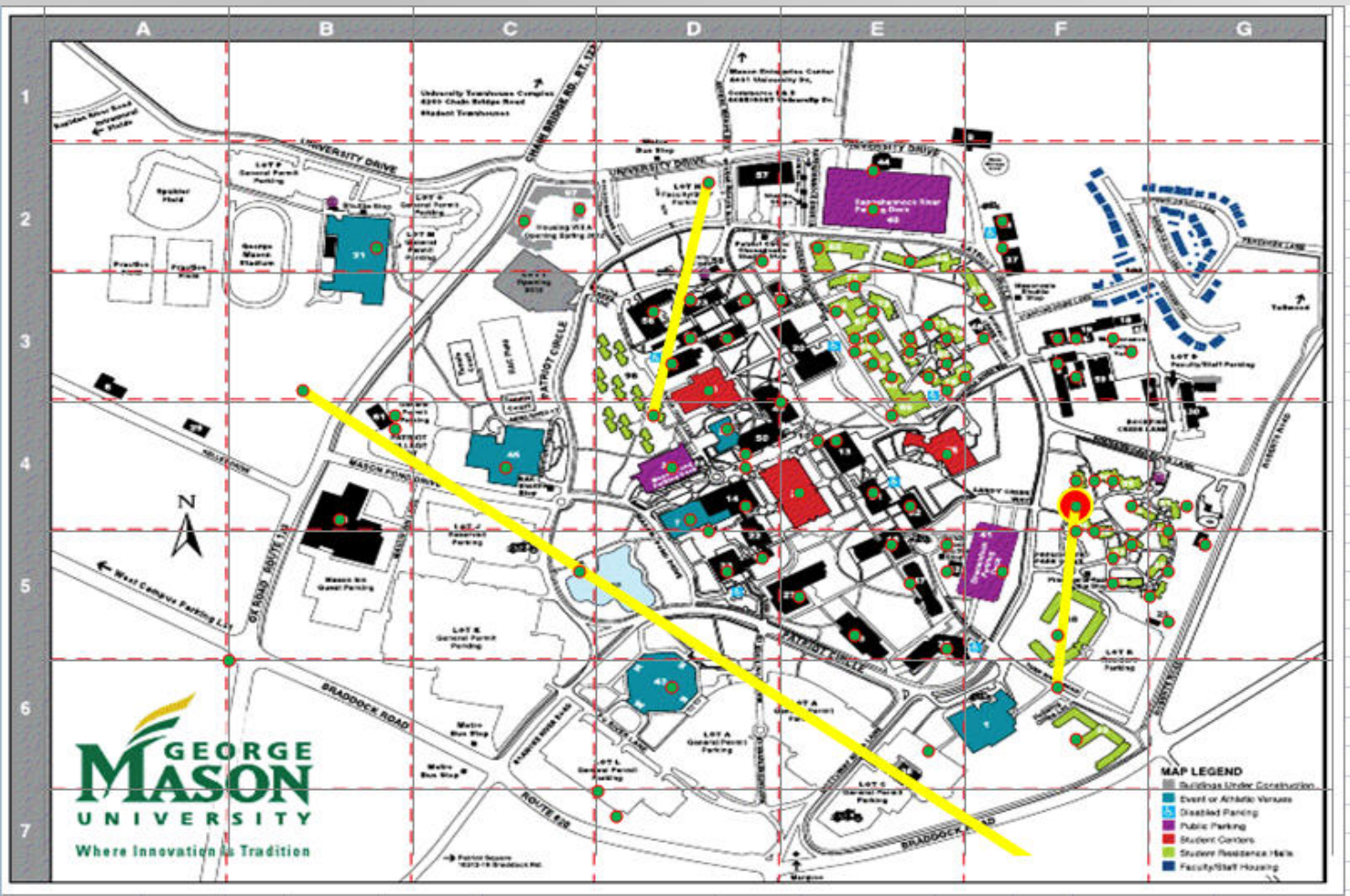
On-site station #1 with no loss



Time	Event #	Type	Location	Time Req	Vehicles	Loss	FalseAlarm?	Loss $	Lives	First Arr	Last Arr
612.9849564	528	2	4	1	,	., F	FALSE	0.5	0	.	.
614.0274751	529	2	2	1	,	., F	FALSE	0.5	0	.	.
616.4606981	530	9	5	4	, 10,	., F, F	FALSE	10	0	25.26598504	25.26598504
618.3221681	531	2	97	1	, 7,	.	FALSE	0	0	1.824828759	1.824828759
618.8772312	532	2	90	1	, 0,	.	FALSE	0	0	1.403566885	1.403566885
620.9008415	533	2	23	1	, 7,	.	FALSE	0	0	2.209072203	2.209072203
620.9975007	534	2	7	1	, 0,	.	FALSE	0	0	2.5	2.5
621.5772714	535	2	7	1	, 5,	.	FALSE	0	0	4.080441153	4.080441153
621.9394887	536	2	2	1	, 13,	.	FALSE	0	0	21.78072542	21.78072542

Events	
Event #	Event Name
0	Good Intent
1	Service calls
2	Hazardous condition
3	Unknown Incident
4	Severe weather
5	Explosion
6	CAT 1 ARFF
7	Other fires
8	Vehicle fires
9	Building fires
10	Serious Hazmat
11	Emergency Medical Treatment
12	EMT BLS
13	Other rescue calls
14	EMT ALS
15	Special Incident
16	Major Fire
17	CAT 2 ARFF
18	CAT 3 ARFF
19	CAT 4 ARFF

Vehicles			
Vehicle ID	Station	Ability	Name
0	1	F	Struc Eng
1	1	D	Ladder
2	1	A	ARFF
3	1	A	ARFF
4	1	C	Hazmat
5	34	F	Struc Eng
6	34	B	Batt Chief
7	57	F	Struc Eng
8	57	C	Hazmat
9	57	B	Fire Chief
10	99	D	Ladder
11	99	G	Tanker
12	99	E	Rescue
13	99	F	Struc Eng
14	99	G	Tanker

Scenario Design & Runs

- Scenarios

	Scenario 1	Scenario 2	Scenario 3
Design	• 3 on-site stations • 1 off-site station	• 3 on-site stations • 0 off-site station	• 2 on-site stations • 1 off-site station
Purpose	• Real world configuration • Baseline scenario	• Stress the capabilities of the base • Not all bases have a community station available	• Cost savings measure (shut down 1 station) • Vehicles from the closed base were NOT relocated

- Runs and Run Times
  - 1 year; 100 replications
  - 1 replication: 6 minutes; Full Model: 30 hours
  - For accurate distributions ~50 replications

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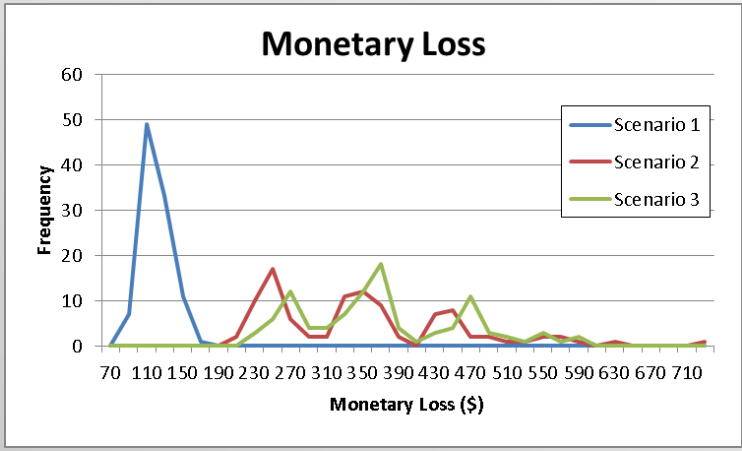
Outputs

- Main Metrics
  - Monetary Loss
  - Lives Lost
  - Median Arrival Time for the First Responder
  - # of Failed Events
  - # of Events when lives were lost
- Secondary Metrics
  - Counts when 1st responder arrived late
  - Arrival Time for the Last Responder
  - Vehicles that were not available

		Run 1
Total Monetary Loss		124.2
Total Lives Lost		2
Arrival Time for the 1st Responder	**Median**	1.17
	1st Quartile	0.60
	3rd Quartile	2.19
	μ	2.23
	σ	4.21
Arrival Time for the Last Responder	**Median**	1.17
	1st Quartile	0.61
	3rd Quartile	2.20
	μ	2.27
	σ	4.28
Count t(1st Responder) > 2		2328
#of Failed Events		93
#of Events Where Lives were lost		4
Vehicles	**ARFF**	0
	Battery Chief	0
	Hazmat	0
	Ladder	0
	Rescue	0
	Structural Engine	95
	Tanker	0

Results

- Scenario Results calculated from run outputs
- Monetary Loss Results
  - Scenarios 2 & 3 had higher average monetary loss and higher deviation
- Lives Lost Results
  - Scenario 2 had a significant increase in lives lost
  - Scenario 3 had a comparable lives lost value
- Scenario 2 had no community station so certain capabilities were unavoidable
- Scenario 3 had limited resources but the full range of capabilities



		Scenarios		
		1	2	3
Monetary Loss	μ	110	341	362
	σ	16	106	28
Lives Lost	μ	1	28	2
	σ	4	5	1

Results (cont.)

- Failed Events & Events when Lives were Lost
  - Scenario 1 performed the best (most resources)
  - Scenario 2 performed horribly
    - Metric rules Scenario 2 as an infeasible option
  - Scenario 3 had a high # of failed events but performed for high casualty events
    - Represents acceptable risk

	# of Failed Events		**# of Events when Lives were lost**	
	μ	σ	μ	σ
Scenario 1	94.77	15.50	1.87	4.09
Scenario 2	403.58	49.43	28.23	5.01
Scenario 3	366.21	25.53	2.54	1.53

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Conclusions & Recommendations

- Conclusions
  - Useful, accurate results based on the input data
  - Flexible, adaptable, and scalable
    - Additional metrics can be captured
    - All station and equipage assumptions are located in the spreadsheets; allowing for easy sensitivity analysis

- Recommendations
  - Continue to run model with different scenarios
    - User will comprehend the depth and breadth of the tool
    - Identify useful metrics and additional metrics needed
  - Improve on the input assumptions

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Next Steps & Lessons learned

- Next Steps
  - Run for an actual base; site surveys
  - Expand the model
    - Vehicles with multiple abilities
    - Personnel as data
    - Training dependencies and cross-training assumptions
    - Maintenance assumption and model application
    - Degradation of Loss
  - Obtain the Fairfax County Automatic Vehicle Location data

- Lessons Learned
  - Quickly nail down the real problem and solution and vet it against the sponsor
  - Don’t speak to the interviewees (SME) about the model
  - Programmers should use the same logic

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Experts

- Fred Woodaman (Sponsor)
  - Principal Analyst
  - Innovative Decisions
- Captain Tom Arnold
  - Operations Bureau
  - Fairfax County Fire and Rescue
- Steve Burke
  - Volunteer Firefighter
  - 20 years experience

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Questions

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