The Capstone Committee for Jennifer Law, M.D. Certifies that this is the approved version of the following capstone:

Development of an Emergency Medical Services Plan for Commercial Spaceflight Events in Spaceport America

Committee:

James Vanderploeg, M.D., M.P.H., Chair

John Fraser, M.D., J.D., M.P.H.

Smith Johnston, M.D., M.S.

Dean, Graduate School

Development of an Emergency Medical Services Plan for Commercial Spaceflight Events in Spaceport America

by

Jennifer Law, M.D.

Capstone Project

Presented to the Faculty of the Graduate School of

The University of Texas Medical Branch

in Partial Fulfillment

of the Requirements

for the Degree of

Master of Public Health

The University of Texas Medical Branch

June 2011

Dedication

This capstone project is dedicated to Greg Shaskan, M.D., M.P.H., who encouraged me to pursue this topic and would have been one of my most trusted mentors.

Acknowledgments

This project would not have been possible without the guidance and encouragement of my Capstone Committee and the assistance from a number of individuals who responded to my inquiries, especially: Michael Holston (Spaceport America), Jon Turnipseed (Virgin Galactic), Robert Rice (Mojave Air and Space Port), Sandy Barley (New Mexico Emergency Medical System), Dr. Marc-David Munk (New Mexico Department of Health), and Dr. Rebecca Blue (Orlando Regional Medical Center). I would also like to thank my family for their unwavering support and regular supply of snacks from California.

Development of an Emergency Medical Services Plan for Commercial Spaceflight Events in Spaceport America

Publication No._____

Jennifer Law, M.D., M.P.H.

The University of Texas Medical Branch, 2011

Supervisor: James Vanderploeg

Introduction: Commercial spaceflight is a developing industry. Spaceport America, NM, is the world's first dedicated commercial spaceport and will be the site of the first suborbital passenger flights in the next few years. Located in a remote area in New Mexico far from major hospitals and trauma centers, Spaceport America will require an emergency medical services (EMS) plan to prepare for and deal with medical emergencies that may arise during commercial spaceflight activities. **Objectives:** The aim of this capstone project was to assess Spaceport America's EMS needs and to develop an EMS plan for commercial spaceflight events in Spaceport America. **Methods:** A literature review of medical care at comparable mass gathering events and examination of analogous EMS plans were performed to identify elements in mass gathering medicine and EMS plans. Medical reconnaissance of Spaceport America was done to predict patient presentation and hospital transport rates and identify local and regional medical resources. Guided by these elements, an EMS plan was written to address potential medical contingencies among spectators during commercial spaceflight events in Spaceport America. **Conclusion:** An evidence-based EMS plan was developed to support future commercial spaceflight events in Spaceport America, tailoring the expected medical needs to the capabilities and constraints in and around the spaceport.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

ACEP	American College of Emergency Physicians
ACLS	Advanced Cardiac Life Support
ALS	Advanced life support
AMS	Altered mental status
BLS	Basic life support
CPR	Cardiopulmonary resuscitation
EMS	Emergency medical services
EMT	Emergency medical technician
FEMA	Federal Emergency Management Agency
GCS	Glasgow Coma Score
ICS	Incident Command System
LZ	Landing zone
MC	Medical center
MCI	Mass casualty incident
NAEMSP	National Association of EMS Physicians
NM	New Mexico
OTC	Over the counter
PEA	Pulseless electrical activity
PPR	Patient presentation rate
RMC	Regional medical center
RN	Registered nurse
THR	Transport to hospital rate
VG	Virgin Galactic

Chapter 1. Introduction

Within the next few years, the first paying suborbital passengers will be launching into space from the world's first dedicated commercial spaceport in Spaceport America, New Mexico (NM). Located in a remote area far from major medical facilities, Spaceport America will require a comprehensive emergency medical services plan to prepare for potential medical contingencies during commercial spaceflight events.

1.1. Specific Aims

This capstone project had two major aims: 1) to identify emergency medical services (EMS) needs related to commercial space flights in Spaceport America, and 2) to develop an EMS plan for commercial space flights in Spaceport America.

1.2. Background and Significance

Commercial spaceflight is a developing industry. On June 21, 2004, Mike Melvill became the first human to reach space in a privately developed spacecraft, *SpaceShipOne*, which subsequently won the $10 million Ansari X Prize that was designed to stimulate non-government organizations to develop and launch reusable manned spacecraft. A number of companies, many of which participated in the X Prize competition, have been working to bring tourists into space, spawning the development of new spacecraft and launch systems. In 2005, 100 customers signed up with Virgin Galactic (VG) to be the first paying suborbital passengers. They will be flying out of Spaceport America, the "world's first purpose-built commercial spaceport" (22), onboard the six-passenger spacecraft *SpaceShipTwo*. Like its predecessor, *SpaceShipTwo* will be carried to an altitude of 50,000 feet by a specially designed aircraft before it is released; at that point it will ignite its own rocket engine to reach an altitude of 62 miles or more, coast at 0 G for about 4 minutes, then reenter the atmosphere and land as a glider on the runway of Spaceport America for a total flight time of 150 minutes (1, 55). In time, other

companies such as Rocket Racing Incorporated/Armadillo Aerospace are also expected to launch commercial human spaceflights from Spaceport America (26).

Touted as the ideal site for a spaceport because of its remote location with sparse population and restricted airspace, good weather year-round, and high altitude (4,595 feet above sea level) for greater payload capacity compared to coastal launch sites (16, 26), Spaceport America faces some unique challenges from the medical standpoint. First, Spaceport America is located far from major hospitals and trauma centers. Thus, commercial spaceflight events in Spaceport America can be considered to be wilderness events, defined as gatherings "involving 1) more than 200 persons involved in the same activity or event and 2) time from injury to hospital care that is likely to be more than 1 hour" (7). As such, plans will need to be in place to provide more than first aid on site and to transport patients to the appropriate definitive medical care facilities in a timely manner. Second, due to the nature of spaceflight, there is an inherent risk of trauma not only to the spacecraft passengers but also the spectators, with the potential for mass casualties. While a small medical clinic is currently being built in Spaceport America, it is designed to serve the spaceflight passengers and their guests, not the spectators who attend commercial spaceflight events at the spaceport. Third, because of their historical significance, these spaceflight events are expected to attract large crowds, with the potential for a wide range of ages and physical health. A variety of medical conditions are expected to be encountered, ranging from dehydration to myocardial infarction and stroke. For all these reasons, a comprehensive EMS plan incorporating triage, stabilization, and transport protocols should be in place to prepare for possible medical contingencies.

Due to the unprecedented setting of commercial spaceflight, the literature is limited to guidelines on medical standards for commercial spaceflight pilots and passengers and case reports of Commercial Space Participants who paid for passage to space on Russia's *Soyuz* rockets. While there is no literature on EMS considerations for commercial spaceflight, there are many published articles (generally case reports) for

comparable mass gatherings such as air shows, concerts, and wilderness events. These events served as guides for EMS planning in Spaceport America.

Dr. James Vanderploeg, the Chief Medical Officer of VG, has identified four medical facilities closest to Spaceport America and prepared a list of anticipated medical events and resources, focusing mostly on passengers, crew, and VG staff. The clinic in the terminal at Spaceport America will be geared towards providing pre- and post-flight examinations for passengers and crew. To date, there has been limited EMS planning for medical contingencies among spectators attending commercial spaceflight events.

1.3. SCOPE

Commercial spaceflight events in Spaceport America will consist of launches and landings of space tourists, attended by the passengers' families and friends, media, and other spectators. From the medical standpoint, there are four major groups of potential patients, each with specific operational needs: space passengers, flight crew, ground support staff, and spectators. Since the commercial space companies are already responsible for their customers and employees, this project focused on medical support for the last group, the spectators. The main question of interest was: what EMS capabilities will be needed on-site and for transport to definitive medical care facilities for spectators who become ill or injured while attending a commercial spaceflight event?

Chapter 2. Methods

A three-pronged approach was taken to gather necessary information to prepare an EMS plan for Spaceport America. First, a literature review of comparable mass gatherings was done to identify elements of mass gathering medicine that should be considered in Spaceport America, with an emphasis on the types and frequencies of conditions typically encountered in a mass gathering event, as well as factors that predict EMS utilization. Second, published guides for EMS planning and analogous EMS plans were identified and studied. Third, background research on Spaceport America was conducted, guided by the elements identified in the first two parts.

2.1. Literature Review

Search strategies were geared towards answering the following questions:

- In mass gatherings, what injuries or medical conditions may be encountered among attendees? What are the expected relative frequencies?
- In wilderness events, what injuries or medical conditions may be encountered among attendees? What are the expected relative frequencies?
- What factors predict medical utilization at mass gathering events?

The Ovid MEDLINE database was used to find articles. Searches included combinations of the following terms: MASS GATHERING MEDICINE, CROWD MEDICINE, EVENT MEDICINE, WILDERNESS MEDICINE, and MEDICAL UTILIZATION (or USAGE). The searches were deliberately broad because there appeared to be no standard keywords to describe the topic of mass/event/crowd medicine. Those searches that yielded more than 100 articles were then filtered to include only those that were reviews or meta-analyses, and in English. Table 1 summarizes the final searches that provided manageable numbers of articles in the categories of mass gathering medicine, mass gathering medicine in the wilderness setting, and medical utilization in mass gatherings. The articles that resulted from these searches were examined to remove those that met one or more of the following exclusion criteria: 1) duplicated, 2) off-topic, or 3) not applicable to the population or setting in Spaceport America. Data were then abstracted from the

remaining articles. Appendix A shows the data abstraction form that was used to summarize and organize the data in all the articles.

Table 1. Ovid MEDLINE search strategies

Category	Searches*
Mass gathering medicine	(mass gathering.mp) OR (event medicine.mp) OR (crowd medicine.mp) Limit to (English language and (meta analysis or review))
Mass gathering medicine in the wilderness setting	((mass gathering.mp) OR (event.mp) OR (crowd.mp)) AND (exp Wilderness Medicine/ or exp Wilderness/ or wilderness.mp)
Medical utilization in mass gatherings	(((mass gathering.mp) OR (event.mp) OR (crowd.mp)) AND ((medical utilization.mp) OR (medical usage.mp))) OR ((exp Wilderness Medicine/ or exp Wilderness/ or wilderness.mp) AND ((medical utilization.mp) OR (medical usage.mp)))

* Per Ovid syntax, ".mp" denotes keyword; "exp" explodes the search term and retrieves all records that contain the term and "any of its narrower, more specific terms" (48).

2.1.1. Medical Conditions in Mass Gatherings

To identify medical conditions reported in past mass gatherings and assess their relative importance, each article was reviewed to extract all the medical conditions that were mentioned, along with the setting of the mass gathering event (urban vs. wilderness). The medical conditions were categorized as traumatic, non-traumatic, and environment-related. To simplify analysis, related diagnoses were lumped into single conditions whenever possible. For example, myocardial infarction, chest pain, and arrhythmias were grouped as "cardiac problems," since many of the articles did not differentiate among them. Other groupings included the following:

- "Soft tissue injuries" encompassed abrasions, contusions, lacerations, and other wounds.
- "Respiratory illness" included shortness of breath and respiratory distress.
- "Gastrointestinal illness" included nausea and diarrhea.
- "Ear problems" included otitis and other unspecified ear issues.

Table 2 shows the final, organized listing of conditions in the three categories. From the tally sheet, the number of articles that listed each condition was summed, grouped by event setting.

Table 2. List of medical conditions for data extraction

Traumatic Conditions	Non-Traumatic Conditions	Environment-Related Conditions
Blisters	Abdominal pain	Altitude-related illness
Burns	Alcohol/drugs	Dehydration
Crush injuries	Altered mental status	Hyperthermia/heat illnesses
Eye problems	Anaphylaxis/allergies	Hypothermia/cold illnesses
Foreign bodies	Asthma	Insect bites
Fractures/dislocations	Cardiac problems	Snake bites
Head injuries	Dental problems	Sunburns
Minor injuries	Dermatologic problems	
Musculoskeleletal injuries	Diabetic events	
Neck injuries	Dizziness or fatigue	
Requests for bandages	Ear problems	
Soft tissue injuries	Epigastric distress (noncardiac)	
Sprains/strains	Epistaxis	
	Flu-like illness	
	Gastrointestinal illness	
	Headache	
	Hypotension or hypertension	
	Infections	
	OB/gyn problems	
	Respiratory illness	
	Seizures	
	Syncope/near-syncope	
	Others/unspecified	

2.1.2. Medical Utilization in Mass Gatherings

To predict medical utilization at a mass gathering, the articles were reviewed for patient presentation rates (PPRs) and transport to hospital rates (THRs), which were collected in the same data extraction form described above. Factors that could modify medical utilization were also recorded. To facilitate comparison, whenever possible, the rates were converted to the number of patients per 1,000 attendees. The rates were grouped by event setting (urban vs. wilderness).

2.2. EMS Planning Guides and Examples

While there is no definitive authority on mass gathering medical care, several publications have offered "checklists" for planning medical care at mass gatherings. The EMS Committee of the American College of Emergency Physicians (ACEP) and the National Association of EMS Physicians (NAEMSP) have each produced a consensus

guide for planning emergency care at mass gatherings (3, 25). Butler and Gesner also addressed this topic from the EMS perspective (8). Collectively, these publications provided a list of the major essential elements of an EMS plan.

Additionally, examples of EMS plans—also known as medical action plans, incident action plans, or medical operations plans—were obtained from analogous settings such as the Mojave Air and Space Port (where *SpaceShipOne* won the X Prize), the Wings Over Houston air show, and the Cocoa Beach Air Show. Common elements were identified from these plans, which served as templates for the EMS plan for Spaceport America.

2.3. SPACEPORT AMERICA MEDICAL RECONNAISSANCE

The third part of research consisted of medical reconnaissance, a term describing the evaluation of "elements that affect numbers and types of patients that are expected at a particular mass gathering prior to the event" (20). In order to understand the EMS needs specific to Spaceport America, details about the commercial spaceflight events planned for Spaceport America were obtained, as was information about resources available in and around Spaceport America. The two major areas of interest were event details and local/regional medical resources. Information in these areas was then used to predict medical usage and estimate staffing and equipment needs.

2.3.1. Event Details

Physical and logistic details related to commercial space flight events in Spaceport America were obtained by personal interview of Dr. Vanderploeg and phone interview of Michael Holston, Spaceport America's Project Manager. Information of interest included: geographical constraints, entrance and exit locations for spectators and participants, expected attendance, expected duration of events, water and sanitation provisions, alcohol availability, and special considerations for VIPs (20). Additional information guided by the results of the literature review and EMS planning guides was also collected.

Since weather may play a role in attendance and illness rates, temperature and humidity data were obtained from the National Oceanic and Atmospheric Administration (NOAA) National Climate Data Center database, which tabulated data for three cities in NM: Albuquerque, Clayton, and Roswell, located 146 miles, 322 miles, and 144 miles away from Spaceport America (12). Because its straight-line distance was closest, Roswell was chosen to represent Spaceport America in terms of weather data.

To assess the risk of plant poisonings, insect and reptile envenomations, and animal bites specific to the spaceport area, information about local fauna and flora for Sierra County, in which Spaceport America is located, was obtained from the NM Poison and Drug Information Center's website.

2.3.2. Local and Regional Medical Resources

Hospitals and EMS providers comprised the local and regional medical resources available to Spaceport America. Sources of information are described below. Driving distances and estimated driving times were calculated using Google Maps (19) originating from the exact coordinates of Spaceport America (32° 59' 24.8" N, 106° 58' 10.5" W (16)). Straight-line distances, representing the distances to be traveled by air, were calculated using the Google Maps Distance Calculator (12).

2.3.2.1. EMS Providers

For ground transport, information about EMS providers that would respond to emergencies in Spaceport America was acquired by email from Sandy Barley, the NM Region II EMS/Trauma Coordinator. Additional details about the providers' specific capabilities were obtained by contacting the medical director of each provider individually.

A list of accredited air ambulance providers was obtained from the websites of the NM Emergency Medical System (34) and the Commission on Accreditation of Medical Transport Systems (11), which also cataloged each provider's website and services (e.g., rotary wing vs. fixed wing, critical care capable vs. advanced life support only). Ms.

Barley provided updated local information. Each confirmed provider was then contacted by phone or email to obtain information about its capabilities and services.

2.3.2.2. Hospitals

A spreadsheet of the hospitals nearest to Spaceport America and EMS transportation was previously compiled by Dr. Vanderploeg (personal communication, 2010). This database was expanded by compiling data about all hospitals within a 100-mile radius of the spaceport by straight-line distance. A list of hospitals was initially obtained by accessing the NM Department of Health's online database for hospitals (31) and designated trauma centers (35). The following types of facilities were excluded: hospitals with 20 or fewer beds, outpatient clinics, Indian Health Service and Public Health Service facilities, psychiatric hospitals, and rehabilitation hospitals.

Initially, each hospital was requested by telephone and/or email to complete a questionnaire about the hospital's capabilities. The questionnaire (see Appendix B) included questions about the following: hospital and contact information, communications, air transport, inpatient bed capacity, specialist availability, and special units. The basis for this questionnaire was the Hospital Capabilities Chart contained in the unpublished Kennedy Space Center Medical Launch Package for STS-133 (24). However, when no response was received, internet search was conducted to obtain the necessary information, and each hospital's EMS director (whose contact information was provided by Dr. Marc-David Munk, the NM State EMS Medical Director) was mailed a letter and an individualized form based on the search results; the EMS directors were asked to fill in any missing information and correct any errors prior to returning the form in a self-addressed, stamped envelope. The results were compiled into a table.

2.4. EMS PLAN FOR SPACEPORT AMERICA

Incorporating all of the information above and example EMS plans, an EMS plan was written for Spaceport America, tailoring the expected medical needs to the capabilities and constraints in and around the spaceport. It was assumed that a Medical Director would be a physician designated by the Spaceport Board of Directors (or event

director), and that, based on discussion with Mr. Holston, the Medical Tent would be staffed primarily by the EMS crew of an Incident Ambulance contracted by the spaceport to support each launch event. Thus, the medical protocols were written to meet the scope of practice and operations guidelines for EMS personnel as defined by the State of New Mexico (32, 33).

ICS Form 206 (15), a standard form published by the Federal Emergency Management Agency Incident Command System (ICS) and used by the Cocoa Beach Air Show Incident Action Plan, was integrated into the EMS plan for Spaceport America, as it concisely summarized the necessary information in a medical plan and would likely be familiar to the medical personnel supporting the event. The Medical Record Form was adapted from the Wings Over Houston medical documentation form (unpublished). The Release At Scene (RAS)/Against Medical Advice (AMA) form was adapted from the Marin County RAS/AMA form (27).

Chapter 3. Results

3.1. Literature Review

The Ovid MEDLINE searches summarized in Table 1 each yielded 12 "hits" resulting in 36 total articles. Of these, one was duplicated; 11 were off-topic; and 5 were not applicable. The remaining number of articles for literature review was 19. An additional six articles referenced in these 19 MEDLINE articles were also reviewed due to their relevance to the project.

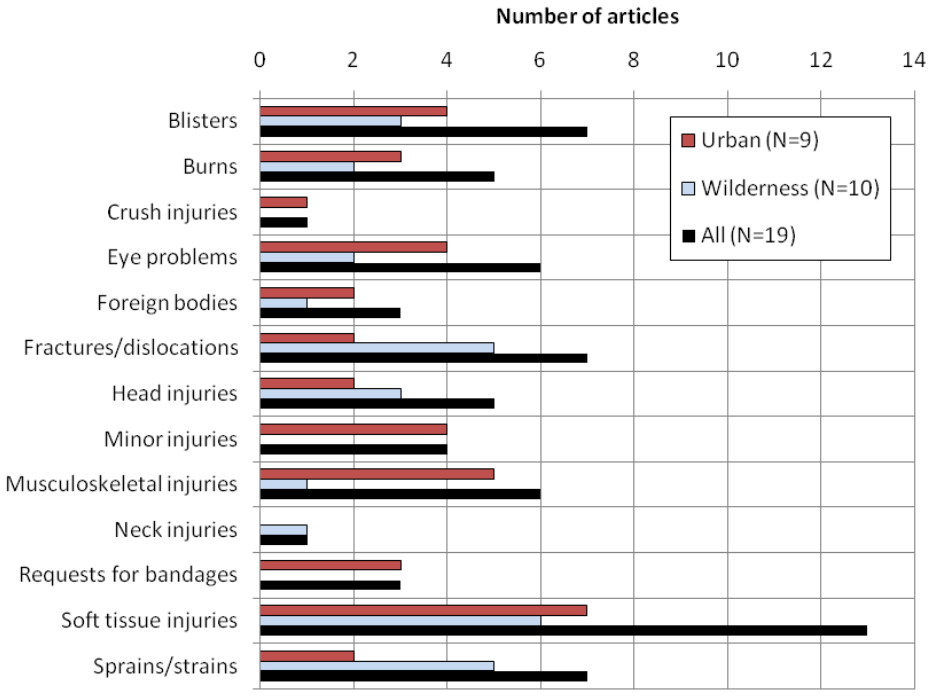
3.1.1. Medical Conditions in Mass Gatherings

Nineteen articles were reviewed: nine pertained to the urban setting, and ten to the wilderness setting. Since many of the articles did not provide rates or absolute numbers of patients with each condition, the number of articles that mentioned each given condition, as shown in Figure 1, was used as a surrogate measure for how common a condition was.

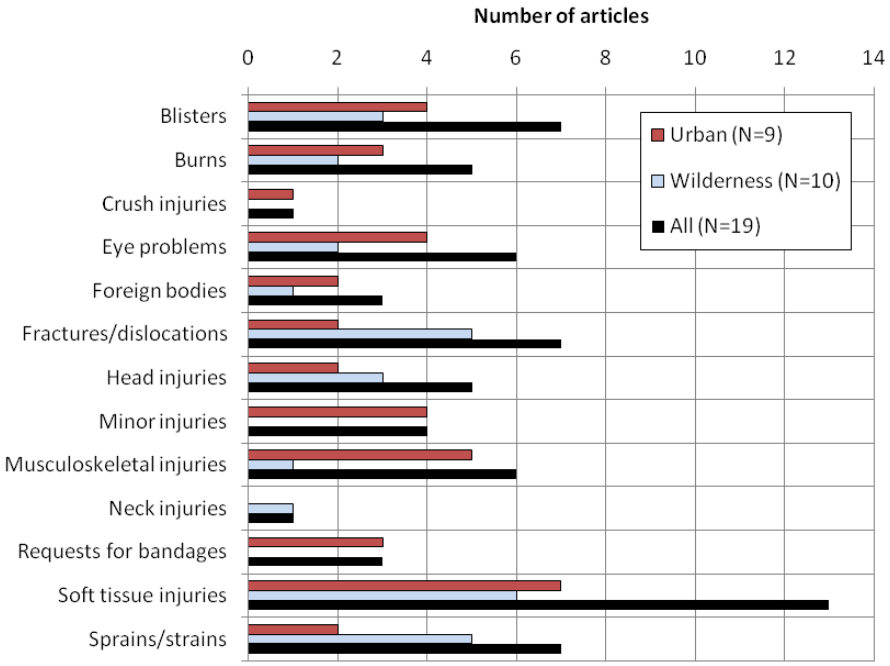
Overall, soft tissue injuries and cardiac problems were the most commonly listed in the articles (each mentioned in 13 of the 19 articles). Among the traumatic conditions, soft tissue injuries were most common, both in urban (7/9) and wilderness (6/10) events. Blisters, eye problems, and minor injuries were next most common (4/9) in the urban setting, whereas fractures/dislocations and sprains/strains were next second common (5/10) in the wilderness. Among the non-traumatic conditions, headache (9/9) was most commonly in the urban setting, followed by cardiac problems (8/9) and respiratory illness (8/9); in the wilderness, cardiac problems (5/10) were most common, followed by gastrointestinal illness (4/10). Among the environmental conditions, hyperthermia/heat-related illness (7/9) was most common in the urban setting, followed by insect bites (6/9); in the wilderness, dehydration (6/10) was most common, followed by hypothermia/cold-related illness (5/10).

Figure 1. Medical conditions listed in 19 reviewed articles

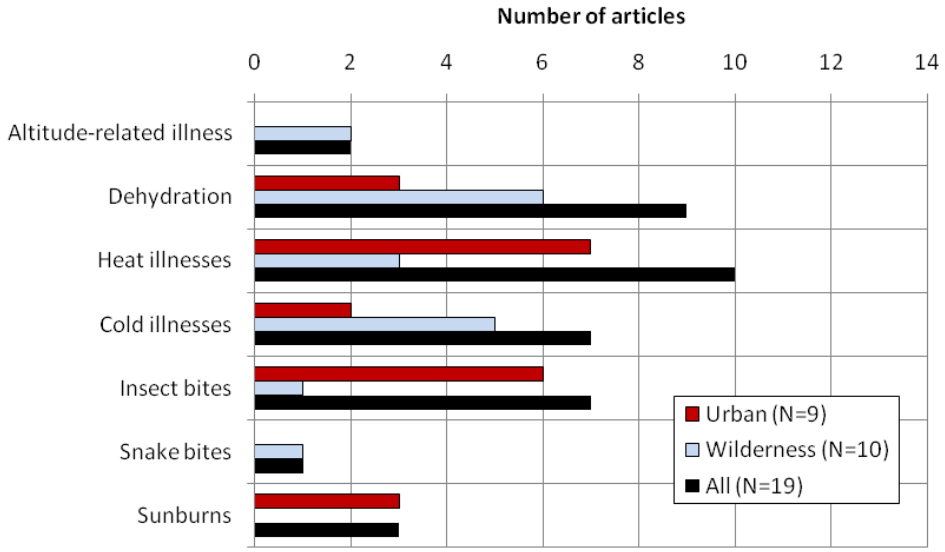
a. Traumatic conditions



b. Non-traumatic conditions



c. Environmental conditions



3.1.2. Medical Utilization in Mass Gatherings

Six articles addressed medical utilization in urban settings, and five articles in the wilderness setting, although only a subset of these reported transport to hospital rates.

3.1.2.1. Patient Presentation Rates (PPRs)

In the urban setting, as Table 3 shows, PPRs ranged from 0.14 to 90 patients per 1,000 attendees (4, 5, 13, 29, 52), although most articles reported 0.4 to 1 per 1,000 attendees. Michael et al. reported 3.2 patients per 1,000 spectator units, defined as 8 hours or less (28); it was difficult to compare this statistic with the others given that a different denominator was used. Almost all reviews included data from sporting events or concerts. Only Boyle et al. focused on air shows, reporting a PPR of 0.845 per 1,000 attendees, of which 0.75 per 1,000 were released without physician intervention, 0.02 per 1,000 were evaluated by physicians for medication and release, 0.06 per 1,000 were transported to a hospital, and 0.01 per 1,000 refused treatment or transport (5). The modifying factors described in these articles were: event type; event duration; whether the event had clear boundaries; whether the spectators were seated or mobile; if the event was indoors and/or outdoors; weather, expected humidity, and apparent temperature;

attendance; and whether the event occurred during the day and night, or day- vs. night-only (4, 28, 29).

Table 3. Summary of patient presentation rates in urban events

Article	Event Type	Patient Presentation Rate	Modifying Factors
Arbon 2001	Athletic events, concerts, parades	0.992 patients per 1,000 attendees	Event type • Lowest: 0 at a motor vehicle rally • Highest: 26.85 per 1,000 at an outdoor rock festival Event parameters • Bounded/focused events had 1.264 patients per 1,000 • Unbounded/extended events had 0.266 patients per 1,000
Boyle 1993	Air show	0.845 patients per 1,000 spectators; 0.02 patients per 1,000 spectators required physician interventions	Not described
De Lorenzo 1997	Athletic events, concerts, papal masses	0.14-90 patients per 1,000 spectators, but most events had 0.5 to 2 patients per 1,000 spectators	Not described
Michael 1997	Air show, athletic events, concerts, papal masses	3.2 patients per 1,000 spectator units (1 spectator unit = 8 hours or less)	(PPTSU = patients per 1,000 spectator units) Attendance • For events with <1,000,000 spectator units: 4.1 PPTSU • For events with >1,000,000 spectator units: 1.0 PPTSU Event type • Sporting contests: 1.6 PPTSU • Rock concerts: 3.6 PPTSU • Papal masses: 4.0 PPTSU Event duration • One-day events: 2.9 PPTSU • Multi-day events: 4.0 PPTSU Weather (criteria not defined) • Temperate weather: 2.4 PPTSU • Hot weather: 7.0 PPTSU
Milsten 2003	Athletic events, concerts	0.61 patients per 1,000 attendees	Event type • Baseball games 0.485 per 1,000 • Football games 0.675 per 1,000 • Rock concerts 3 per 1,000 Apparent temperature • ≤80°F: 0.49 per 1,000 • >80°F: 0.81 per 1,000
Shah 2010	Athletic event	0.367 patients per 1,000 attendees	Not described

Arbon et al. (4) derived multivariate regression models to predict the number of patient presentations for an event, and the number of patients that would need transportation to a hospital; these formulas were used in Section 3.3.2 to predict medical utilization rates in Spaceport America based on its specific parameters.

In the wilderness setting, the PPRs could not be compared as readily as the urban data. As Table 4 shows, three of the articles reported rates in evaluations per person-time (1.5 to 18.5 evaluations per 1,000 participant-days) (6, 7, 9) while two of the articles reported the number of injuries or illnesses divided by the number of visitors (0.027-0.092 injuries/illnesses per 1,000 visitors) (17, 53). Presumably the numbers of injuries or illnesses were subsets of the number of people who presented for medical care. No modifying factors were described in any of these articles.

Table 4. Summary of patient presentation rates in wilderness events

Article	Event Type	Patient Presentation Rate	Modifying Factors
Burdick 2003	Sporting event	17.4 per 1,000 participant-days	Not described
Burdick 2005	Sporting events	1.5 to 18.5 medical encounters per 1,000 person-days (average 5.5 per 1,000)	Not described
Chang 2000	National park	17 evaluations per 1,000 person-days	Not described
Forrester 2009	National park	0.027 injuries/illnesses per 1,000 visitors	Not described
Townes 2002	National parks	0.092 injuries/illnesses per 1,000 visitors	Not described

3.1.2.2. Transport to Hospital Rates (THRs)

In the urban setting, as Table 5 shows, transport to hospital rates (THRs) ranged from 0.01 to 0.55 patients per 1,000 attendees, with the same modifying factors as patient presentation rates. In the wilderness setting, THR data were scant; only two articles discussed THR. Burdick 2003 reported no transport among the six patients who presented to first aid stations for medical evaluations in a fundraiser hike event (7). Forrester and Holstege had the most detailed data, reporting 0.015 transports per 1,000 visitors, with

the following modifying factors: transport mode, patient age, and trauma vs. medical (see Table 6) (17).

Table 5. Summary of transport to hospital rates in urban events

Article	Setting	Transport to Hospital Rate	Modifying Factors
Arbon 2001	Athletic events, concerts, parades	0.027 patients per 1,000 attendees	Not described
Boyle 1993	Air show	0.06 patients per 1,000 spectators	Not described
De Lorenzo 1997	Athletic events, concerts, papal masses	0.01-0.55 patients per 1,000 spectators	Not described
Michael 1997	Air show, athletic events, concerts, papal masses	0.083 transports per 1,000 spectator units (1 spectator unit = 8 hours or less)	(TPTSU = transports per 1,000 spectator units) Event type: • Sporting events: 0.024 TPTSU • Rock concerts: 0.076 TPTSU • Papal masses: 0.198 TPTSU Event duration: • One-day events: 0.087 TPTSU • Multi-day events: 0.067 TPTSU Weather: • Temperate weather: 0.076 TPTSU • Hot weather: 0.126 TPTSU
Milsten 2003	Athletic events, concerts	0.046 transports per 1,000 attendees	Event type • Baseball games 0.029 per 1,000 • Football games 0.046 per 1,000 • Rock concerts 0.42 per 1,000

Table 6. Summary of transport to hospital rates in wilderness events

Article	Setting	Transport to Hospital Rate	Modifying Factors
Burdick 2003	Sporting event	0	Not described
Forrester 2009	National park	Overall transport*: 0.015 per 1,000 visitors * Rates calculated by dividing total of transports by total number of visitors	Transport mode*: • Ambulance: 0.01 per 1,000 • Helicopter: 0.005 per 1,000 Patient age*: • Adult: 0.013 per 1,000 • Pediatric: 0.002 per 1,000 Trauma vs. medical*: • Trauma: 0.006 per 1,000 • Medical: 0.009 per 1,000

3.1.3. Staffing Needs in Mass Gatherings

Several of the articles suggested optimal staffing ratios in mass gatherings. Sanders et al. recommended a minimum of two paramedics or one paramedic/basic emergency medical technician (EMT) team per 10,000 spectators; furthermore, if an event desired the ability to triage patients, evaluate them to assess the acuity of their medical complaints, and treat then release patients with non-emergency problems, an addition of one to two physicians for every 50,000 spectators was recommended (50). These guidelines suggested by Sanders et al. were "perhaps the most realistic" and "with the lowest cost," according to an editorial in the Annals of Emergency Medicine (18). More conservatively, the Illinois State Medical Society suggested one to two physicians per 5,000 spectators, two registered nurses (R.N.) per 5,000 spectators, and two EMTs per 5,000 spectators (18). Ounanian et al. recommended one physician per 40,000 spectators, one R.N. per 16,000 spectators, and one EMT per 65,000 spectators (47).

3.2. EMS Planning Guides and Examples

3.2.1. Essential Elements of a Medical Action Plan

Three publications provided guidance on the development of an EMS plan (3, 8, 25). In particular, Jaslow et al. (25) enumerated fifteen essential elements of a medical action plan, which could be categorized into four interlinked areas discussed below and should be reviewed with EMS personnel prior to the event.

3.2.1.1. Medical oversight

Physician medical oversight: Provision of direct (availability during the event either in-person or by telecommunications) and indirect medical oversight (medical action plan and care protocols).

Negotiations for event medical services: Meeting with event organizers to obtain full support for "implementation of a plan to provide patients with state-of-the-art care,"

liability coverage, and monetary and/or non-monetary compensation for services. Contractual agreements with EMS agencies.

Human resources: Numbers and types of medical personnel needed to provide adequate medical care at the event; description of responsibilities for medical personnel.

Command and control: Clear chain of command; incident command in disaster response.

Continuous quality improvement: Event debriefing or "After Action Review"; event data collection and analysis.

3.2.1.2. Event characteristics

Medical reconnaissance: Identification of "key facts about the mass gathering event" and variables that may affect patient volume.

Public health elements: Addressing (though not directly responsible for) public health issues including food and water storage, sanitation, and waste management.

3.2.1.3. Medical operations

Level of care: Definition of "minimum standards for emergency medical capability at a mass gathering event and preferred sophistication of the medical sector."

Emergency medical operations: Defined mission and goals, relationship between the medical sector and other sectors of the event, contingency plans, mutual aid agreements.

Medical equipment: Definition of the "minimum necessary equipment and suggestions for its deployment," based on the highest level of care that is anticipated at the event.

Treatment facilities: Identification of both on-site (e.g., first aid tent) and off-site treatment facilities (e.g., hospital).

Documentation: Completion and collection of patient care record forms that not only address details about each patient contact but also response times, supplies used, major medical decision making, and any problems.

Transportation resources: Arrangement and positioning of ground and air transportation resources, mutual aid agreements in case of additional need.

3.2.1.4. Logistics

Access to care: Publicizing of locations and routes to medical care, positioning of medical resources to minimize the distance and time to reach medical care or patients.

Communications: Command post, communications equipment, radio designations and frequencies.

3.2.2. Example Medical Plans

The Cocoa Beach Air Show's Incident Action Plan (CBAS IAP) and the Wings Over Houston's Medical Operations Plan (WOH MOP) contained similar information—e.g., objectives, personnel, contact list, medical resources, contingency procedures, schedule of events, and venue maps (10, 51). While the WOH MOP was written out in paragraph form, the CBAS IAP covered all the major functional areas of emergency response—not just medical—and used primarily the standardized forms published by the FEMA Incident Command System.

The Mojave Air and Space Port takes a different approach, since it has an established infrastructure for supporting large events including aircraft rescue and firefighting operations, two advanced life support (ALS) paramedic units, and a medical evacuation helicopter on-site (30). Jon Turnipseed, VG's Head of Safety, provided the following details about emergency response at Mojave. For each major event, the Airport Operations Director for Mojave, Robert Rice, builds an emergency response plan using a set of checklist templates, such as:

- Pre-Event Checklist, to be completed 24 hours prior to the event;

- Checklist for three contingency modes: Mode 1 ("on airfield incident"), Mode 2 ("off airfield incident visible or within 3 miles of airfield"), and Mode 3 ("off airfield incident beyond 3 miles of airfield"), each with procedures for such functional areas as fire, security, support operations, business operations, and airfield operations.

During the event itself, an Emergency Operations Center oversees and coordinates each of the functional areas.

In the medical area, there is a first aid tent supported by an ambulance and EMS crew for large events (or two ambulance crews for very large events). Spectators seeking medical attention may self-present to this first aid tent, or be identified by roving event staff who may request, by handheld radio, EMS assistance or golf cart transport to the tent. Hall Ambulances Services is already located on the Mojave property; it has four to five units ready for callouts, with an additional crew dedicated on-site for large events. When indicated—e.g., when more than 1,000 attendees or extreme temperatures are expected—more units are requested to be on standby. Kern County Fire Department Station (KCFD) 14, located ½ mile outside the air/spaceport entrance, has an EMT on staff and is the backup EMS provider. Mercy Air, located on the air/spaceport, has one helicopter available for immediate callout, which is generally held on-site for large events. However, both KCFD 14 and Mercy Air may be required to respond to other emergency callouts outside the air/spaceport. Thus, Halls is the primary EMS provider and is backed up by KCFD 14 and Mercy Air.

3.3. SPACEPORT AMERICA MEDICAL RECONNAISSANCE

3.3.1. Event Details

Operations in Spaceport America are currently still in the pre-planning stage and thus very fluid, pending review from the spaceport's new Board of Directors appointed in February 2011 and completion of the Terminal Hangar Facility (THF) expected in January 2012. Nonetheless, there have been one major public event and ongoing vertical

launch events in Spaceport America to provide preliminary information about event organization and anticipated concepts of operations.

3.3.1.1. Event Organization

Both horizontal and vertical launch services will be provided in Spaceport America once development is complete. To date, construction has mostly focused on horizontal launch facilities such as the runway and THF. However, the vertical launch facility, located in the southeast corner of the property and several miles away from the horizontal launch area, has already launched four small rockets built by UP Aerospace and continues to be the launch site of small payloads and experiments.

Eight to ten launch events are planned for 2011, although only about half of these will be open to the public. The number of launch events is expected to double or triple in 2012. The small aerospace companies such as UP Aerospace and Armadillo are actively testing their rockets and tend to schedule their launches on an ad hoc basis, generally with 4 to 6 weeks' notice. The larger companies, including Lockheed Martin and Boeing, tend to have stricter schedules and may provide 3 to 4 months' notice. In terms of commercial spaceflight, VG is currently targeting late 2012 for its first passenger flights. Once the flights begin, VG is expected to fly once per week for at least the first 3 to 6 months, then ramp up depending on demand and turnaround time.

Spaceport America's long-term vision includes a visitors' center that operates year-round independent of launch events, and infrastructure for emergency response including at least one fire truck and one ambulance. However, planning for these resources will not begin until late 2012. Currently, medical support in Spaceport America for mostly construction workers (now about 100 workers per day, peak was more than 500) is available in the form of first responders onsite with basic first aid capability and radio dispatch to 911.

A request for proposals has been announced for a contractor to provide protective services including security, firefighting, emergency medical response, hazardous materials management, and incident command (39). Until the infrastructure for medical support and visitor services becomes operational, launch events in Spaceport America

will require prearranged, temporary rentals of ground and air ambulances, fire services, tents, sound systems, catering, water, and restroom facilities. There will be a small clinic inside the THF to provide medical evaluation and treatment for VG's customers but not spectators.

3.3.1.2. Geographic Layout

Spaceport America, located in a desert plain, is accessible by one road: County Road A-013. The north part of the road is paved from Truth or Consequences, about 26 miles long. The south part of the road leading to Interstate 25, about 15 miles away, will not be paved until mid- to late-2012. From I-25, it is 25 miles to Hatch Village and 40 miles to Las Cruces (39).

Section I-C in Appendix C provides an aerial view of the major landmarks in Spaceport America. From County Road A-013, Ben Cain Road leads to several access roads within the spaceport property. The 10,000 foot runway lies in an approximate north-south direction, with the THF located off to the west at about midfield. The vertical launch area is located several miles southeast of the runway.

VG will be the major tenant of the THF, where the commercial space passengers will be housed and their guests will view the launches. There will likely be separate viewing areas for spectators about 0.5 miles away from the THF, but plans for these spectator areas and any special VIP areas have not been finalized. Alcohol will likely be served in the THF but it is unknown yet whether alcohol will be available in the spectator areas.

There is a "fuel farm" area northwest of the runway where most aviation and rocket fuels will be stored. Currently there are several fuel tanks containing Jet A fuel to support *WhiteKnightTwo* (the carrier aircraft for *SpaceShipTwo*), but in time other storage areas and/or bunkers may be built in this vicinity, with a minimum of ¼ mile separation between fuel storage facilities per federal requirements.

3.3.1.3. Weather

Spaceflight operations in Spaceport America are expected to occur year-round, although mornings are preferred over afternoons because it is generally less windy in the morning. Table 7 shows the normal daily temperature range, temperature extremes, and average relative humidity for each month of the year in Roswell, the city closest to Spaceport America in the NOAA climate database. Annually, the average normal temperature ranges from a minimum of 45.3°F to 76.3°F, with a mean of 60.8°F (41-43); the hottest months are June through August, with 76% of the days having a maximum temperature exceeding 90°F (44). The highest temperature on record is 114°F (45) and the lowest is -9°F (46). The average relative humidity is 66% in the morning and 33% in the afternoon (40).

Table 7. Temperature data and average relative humidity in Roswell, NM, representing Spaceport America

	Annual	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Temperature (°F) (41-46)													
Normal daily maximum	**76.3**	55.6	62.0	70.0	77.7	86.0	94.0	94.8	92.3	85.7	76.5	64.5	56.3
Normal daily minimum	**45.3**	24.4	29.3	35.7	43.3	53.2	62.0	66.7	65.5	58.3	46.3	33.3	25.1
Normal daily mean	**60.8**	40.0	45.7	52.9	60.5	69.6	78.0	80.8	78.9	72.0	61.4	48.9	40.7
Highest on record	**114**	82	87	93	99	107	114	111	107	103	99	88	83
Lowest on record	**-9**	-9	3	9	23	34	47	56	54	40	14	4	-8
Mean days with max temperature ≥90°F	**95**	0	0	0	1	11	22	26	22	11	2	0	0
Humidity (%) (40)													
Morning	**66**	71	65	58	54	58	65	68	73	74	69	69	69
Afternoon	**33**	41	33	26	22	24	27	32	35	38	36	39	42

3.3.1.4. Attendance

Vertical launch events in Spaceport America are typically attended by 600 to 800 spectators per launch when they are open to the public. The runway dedication ceremony held on October 22, 2010, attracted approximately 700 spectators. Given these statistics, it was estimated that 800 spectators will attend commercial spaceflight events when VG or other companies start flying passengers.

3.3.1.5. Local Fauna and Flora

Between July 1, 2009, and June 30, 2010, the NM Poison and Drug Information Center received the following reports (36):

- Insect bites: ant or fire ant (2 cases), centipede or millipede (2 cases), scorpion (4 cases), and unspecified (1 case).
- No mammal or aquatic bites.
- Snake bites: rattlesnake (4 cases).
- Spider bites: black widow spider (1 case), tarantula (1 case), and unspecified spiders (3 cases).
- Plants: plants with nontoxic or minimal effect (3 cases).

In all of these cases, no effect or minor to moderate effects were reported; none resulted in any major effects or death (37). Only the four cases of rattlesnake bites and one unspecified spider bite were managed in a health care facility; the remainder of cases was treated on-site or in a non-health care facility, or the patient refused referral (38). In short, envenomations and plant poisonings do not appear to be a major concern for Spaceport America.

3.3.2. Anticipated Medical Utilization

Based on the event and weather information described above, the number of patients presenting for medical care and the number of hospital transports were estimated using Arbon's predictive models, as shown in Equations 1 and 2. Plugging in the values summarized in Table 8, the average predicted number of patient presentations for each event was 57 (equivalent to 71.8 patients per 1,000 attendees), and the average predicted number of hospital transports was 2 (equivalent to 2.7 patients per 1,000 attendees). Figures 2 and 3 show the predicted number of patients and hospital transports by month and time of day. These predicted numbers appeared to be on the high side or exceeded the rates reported in the literature, although they were within the correct order of magnitude. Thus, these estimates provided upper bounds for planning purposes.

Equation 1. Predicted number of patient presentations (4)

Predicted number of patient presentations = -78.184699 + (-31.488567 × SEATS) + (84.556898 × BOUNDED) + (42.370240 × INDOOR) + (81.319501 × OUTDOOR) + (-20.390940 × SPORT) + (-0.616134 × HUMID) + (-0.000456 × ATTEND) + (0.000016246 × (HUMID × ATTEND)) + (20.067439 × DAY-NIGHT)

Equation 2. Predicted number of hospital transports (4)

Predicted number of patients transported to a hospital = (0.010980 × NUMBER OF PRESENTATIONS) + (-1.012146 × SEATS) + (1.489817 × BOUNDED)

Table 8. Input values for predicting medical utilization in Spaceport America

Variable	Description	Input Value for Spaceport America
SEATS	Attendees are seated vs. mobile	0
BOUNDED	Event is fenced vs. unbounded	1
INDOOR	Event is indoors vs. outdoors	0
OUTDOOR	Event is outdoors vs. indoors (if both indoors and outdoors, both INDOOR and OUTDOOR variables would both be 1)	1
SPORT	Sporting event vs. non-sporting event	0
HUMID	Expected % humidity	See Table 7
ATTEND	Expected number of attendees	800
DAYNIGHT	Event occurs during both the day and night vs. day-only or night-only	0

Figure 2. Predicted patient presentations by month and time of day

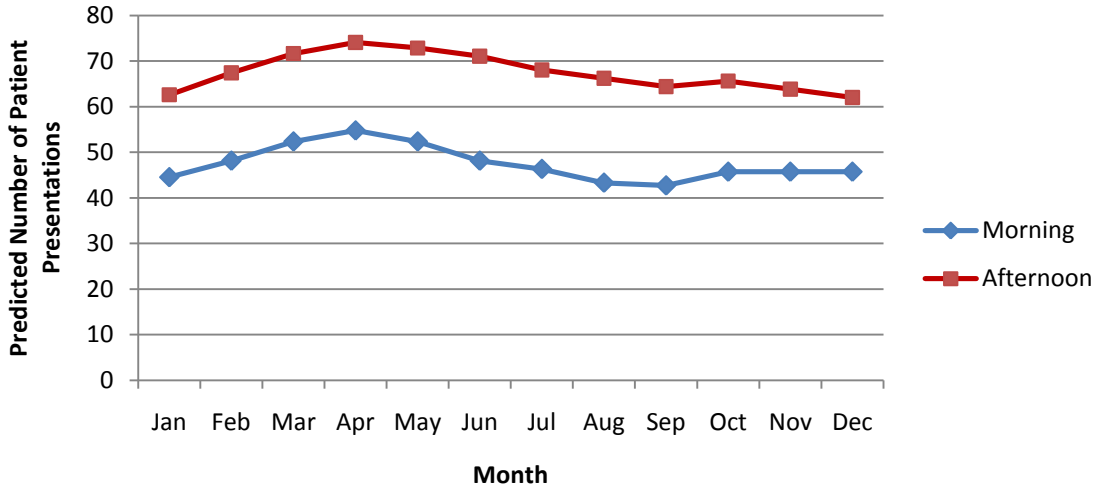
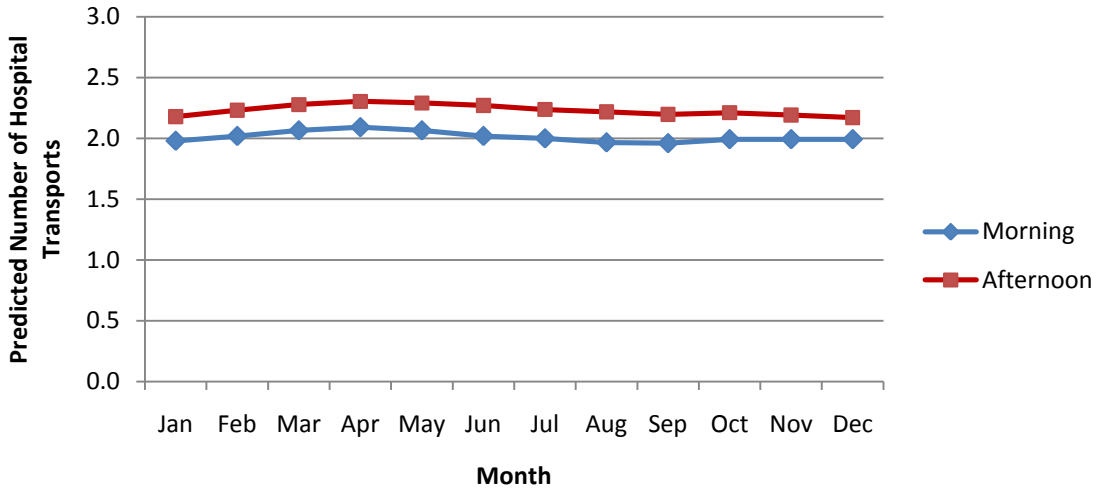


Figure 3. Predicted hospital transports by month and time of day



3.3.3. Staffing

Similarly, an attendance of 800 spectators was used to estimate the staffing needs for a commercial spaceflight event. Even at the most conservative level of two EMTs per 5,000 spectators and one to two physicians per 5,000 spectators as recommended by the Illinois State Medical Society (18), having one ambulance with two EMTs appeared to be more than adequate, with the caveat that these staffing ratios did not take into account the long transport time from Spaceport America, and that a mass casualty incident would require significantly more resources.

3.3.4. Local/Regional Medical Resources

3.3.4.1. Ground EMS

The local EMS services that would respond to emergencies in Spaceport America are Sierra Vista Hospital Ambulance and Las Cruces-based American Medical Response (AMR) (S. Barley, personal communication). AMR could not be reached despite numerous attempts to contact by phone or email, so Table 9, which summarizes each ground EMS provider's contact information, level of care, and response time to Spaceport America, lists the last known contact information for AMR. Contracting with

AMR may be considered if a large crowd is anticipated to attend an event, but an ambulance would have to be pre-positioned given the long distance from Las Cruces to Spaceport America.

Table 9. Ground EMS Providers

Provider	Base	Level of Service*	Driving Distance to Spaceport America	Expected Response Time	Contact Information
Sierra Vista Hospital Ambulance	Truth or Consequences	ALS (EMT-I, EMT-P)	31 miles	35 minutes	John McCarty Director Dispatch: 9-1-1 (575)894-2111
American Medical Response (included for completeness)	Las Cruces	Unknown	64 miles	Unknown	Joaquin Graham Operations Manager (575)523-0225

* ALS = Advanced life support, EMT-I = EMT-Intermediate, EMT-P = EMT-Paramedic

3.3.4.2. Air EMS

Native Air, formerly called Southwest MedEvac, is closest to Spaceport America and would provide air ambulance service to the spaceport (S. Barley, personal communication). It has a rotary wing base in Las Cruces and a fixed-wing base in El Paso. Med Flight Air Ambulance, also based in El Paso, may provide fixed-wing backup. Information about Native Air and Med Flight are summarized in Table 10. In addition, PHI, AirCare1, and Lifeguard, all of which operate from Albuquerque, were contacted but did not respond to requests for information.

Table 10. Air EMS Providers

Provider/ Call Center	Base Location/ Distance (miles)	Aircraft Type	Level of Care	Estimated Launch Time/Transport Time to SPA	Capacity	Landing Distance
Native Air 800-806-7106	Las Cruces (LRQ)/50	RW	CC	<10 min/23-25 min	1 patient	n/a
	El Paso (ELP)/90	FW	CC	<10 min/	1 patient (±1 family member)	4,000 ft
	POC: Will Winters (will.winters@omniflight.com, 575-654-4807)					
Med Flight 800-842-4431	El Paso (ELP)/90	FW	CC	1 hr/15-20 min	1 patient	3,500 ft
	POC: Larry Levy, M.D., FAAEM (larry@medflightair.com, 505-842-4433)					

3.3.4.3. Hospitals

Eleven hospitals within a 100-mile radius of Spaceport America were identified: Sierra Vista Hospital (in Truth or Consequences, NM), Mountain View Regional Medical Center (Las Cruces, NM), Memorial Medical Center (Las Cruces), Gerald Champion Regional Medical Center (Alamogordo, NM), Mimbres Memorial Hospital (Deming, NM), Socorro General Hospital (Socorro, NM), Gila Regional Medical Center (Silver City, NM), Lincoln County Medical Center (Ruidoso, NM), University Medical Center of El Paso (El Paso, TX), Las Palmas Medical Center (El Paso), and Del Sol Medical Center (El Paso). The University of New Mexico Hospital, while located outside this area, was added to the list since it was the nearest certified Burn Center. 8/12 of these hospitals returned their confirmation forms described in Section 2.3.2.2. Las Palmas and Del Sol were removed from the list of hospitals since they did not return their forms and they had limited specialty services. The current hospital capabilities are summarized in Section II-D in Appendix C.

Based on a review of the capabilities of the hospitals on the list, an algorithm was developed to select the appropriate destination for transport for each patient (see Section III-A in Appendix C). All unstable patients should be transported to the nearest hospital, Sierra Vista Hospital, where the patients will be evaluated and stabilized first. Patients presenting within 3 hours of stroke-like symptoms should also be transferred to Sierra Vista for possible thrombolysis (J. McCarty, personal communication). Stable patients that meet the Burn Center Referral Criteria established by the American Burn Association (2) should be transported to the University of New Mexico Hospital. Stable patients that meet the Critical Trauma Criteria, as adapted from the criteria established by San Francisco and Imperial County (23, 49), may be transported to Gerald Champion Regional Medical Center, University Medical Center El Paso, or University of New Mexico Hospital, depending on bed availability and provider preferences. Other patients may be transported to Mountain View Regional Medical Center, Memorial Medical Center, or per physician discretion guided by the Hospital Capabilities Chart.

3.4. EMS PLAN FOR SPACEPORT AMERICA

See Appendix C for the proposed EMS plan, which can be detached as a separate document. The plan consists of the following sections:

- Section I (Overview): event information; important contact numbers; maps
- Section II (Medical Oversight, Personnel, and Resources): organizational structure; personnel responsibilities; EMS providers; hospitals
- Section III (Medical Operations): medical plan; levels of care, protocols, and disposition; medical facility; equipment and supplies; staffing; documentation
- Section IV (Logistics): communications; transportation; event schedule
- Section V (Post-Event Debriefing): post-event debriefing, after-action report
- Section VI (Forms): medical record form; release at scene/against medical advice form.

Table 11 shows how all fifteen essential elements of an EMS plan were incorporated into the EMS plan for Spaceport America.

The plan was designed such that the minimum level of care to be provided would be an emergency medical technician (EMT-Basic), with the minimum staffing being one EMS crew composed of a minimum of two licensed EMTs (32). Additional staff including a physician would certainly be helpful, although the added cost associated with more personnel and low likelihood of significant medical events would have to be weighed against the gain in medical capability.

Given the relatively small area from which the spectators are expected to watch the launches, and given the expected attendance and patient presentation rate, a baseline of one medical tent was established, to be staffed by an incident ambulance that will primarily be located next to the medical tent. The medical tent would be located close enough to the spectator area in order to provide early defibrillation to victims of cardiac arrest within 3 to 5 minutes from the time of collapse (21).

For some of the parts in the EMS plan, details about the event have not been planned by Spaceport America. Thus templates were included as placeholders to be filled

out when details become available. All information in the EMS plan should be reviewed and updated as needed by the Medical Director prior to an event.

Table 11. Addressing the essential elements of an EMS plan

	Physician medical oversight	Negotiations for event medical services	Human resources	Command and control	Continuous quality improvement	Medical reconnaissance	Public health elements	Level of care	Emergency medical operations	Medical equipment	Treatment facilities	Documentation	Transportation resources	Access to care	Communications
Section I (Overview)															
Event information						X									
Contact numbers				X									X		
Maps														X	
Communications plan													X		X
Section II (Medical Oversight, Personnel, and Resources)															
Organizational structure	X		X	X					X				X		
Personnel responsibilities	X	X	X						X				X		
EMS providers		X									X		X		
Hospitals		X									X				
Section III (Medical Operations)															
Medical plan	X								X						
Levels of care								X							
Protocols								X							
Disposition								X							
Medical facility							X				X				
Equipment & supplies										X					
Staffing			X												
Documentation												X			
Section IV (Logistics)															
Communications															X
Transportation													X		
Event schedule						X									
Section V (Post-Event Debriefing)															
Post-event debrief	X														X
After-action report	X														X
Section VI (Forms)															
Medical record form												X			X
RAS/AMA form												X			

Chapter 4. Discussion

This capstone project systematically assessed the potential medical needs during commercial spaceflight events in Spaceport America and identified the medical resources that would respond to medical contingencies should they arise. The EMS plan drafted specifically for Spaceport America should provide a basis for emergency medical response and preparedness as plans for commercial spaceflight events continue to mature.

In the literature search part of the project, search terms were chosen to be broad in an attempt to capture as many articles as possible since there was no standard vocabulary or terminology in the literature. Still, some articles might have been missed. Furthermore, it was recognized that medical conditions were likely to be underreported in the literature, especially in the wilderness setting. Inconsistent nomenclature of conditions raised the possibility of overlaps or omissions. Quantitative frequencies of medical conditions were also not available. Despite these limitations, comparable mass gatherings enabled educated estimates of the medical needs in Spaceport America. In time, it is hoped that medical incidents and utilization at the spaceport will be reported in the literature to fill in the knowledge gaps in this developing commercial spaceflight industry.

The EMS plan developed in this capstone project attempted to synthesize the best formats and approaches from among the example EMS plans, while ensuring that each essential element of an EMS plan described by Jaslow et al. was addressed. Like Mojave, Spaceport America will use EMTs for staffing of the medical tent, as opposed to relying on volunteers for medical support as the Cocoa Beach Air Show and Wings Over Houston did. It should be reiterated that many aspects of operations in Spaceport America are still being designed, so this EMS plan may require revision when more information becomes available. In addition, EMS and hospital capabilities may change over time, as evident by Southwest MedEvac's recent merger with Omni Flight to form Native Air. Thus, the EMS plan for each event would have to be updated to reflect the resources that are actually available at the time of the event.

Future work includes revision of the EMS plan as more information become available as described above, giving a "heads-up" to each possible receiving hospital

prior to launch events, incorporation of this plan with the spaceport's overall incident action plan, and "disaster drills" involving all the functional areas at the spaceport. While simulation was not addressed in this project, the value of simulation has long been recognized in aviation and government-sponsored spaceflight in minimizing the risk of an actual disaster. The Federal Aviation Administration requires certified airports to conduct live disaster drills every three years and paper exercises in the interim years (54). It may be advantageous to conduct joint disaster drills between Spaceport America and the Department of Homeland Security or the nearby Holloman Air Force Base to foster inter-organizational cooperation and to share expertise.

In conclusion, a multifaceted, evidence-based EMS plan was developed to address emergency medical response and preparedness during public commercial spaceflight events at Spaceport America. This plan is intended to be a "living document" which will be updated as the spaceport's operational plans mature. In time, actual experience will guide the evolution of the plan to ensure that spectators attending commercial spaceflight events in Spaceport America will have the best emergency medical care available.

Appendices

APPENDIX A. DATA ABSTRACTION FORM

Capstone Lit Review

DATA EXTRACTION FORM

Article information

Author

Title

Year

Article type

- [ ] Case report/series
- [ ] Review
- [ ] Other:

Medical usage factors

Factors that influence or predict medical usage at an event

Event elements

Elements that need to be considered in an event plan

Definitions

Definition of mass gathering

Definition of wilderness event

Statistics

Injury rates
Include information about type of event

Medical evaluation rates
Include information about type of event

Evacuation rates
Include information about type of event

Medical conditions

Setting

- [ ] Urban
- [ ] Wilderness
- [ ] Other:

Event type

- [ ] Air show
- [ ] Athletic event
- [ ] Concert
- [ ] National park
- [ ] Other:

Patient demographics

- [ ] Employee/staff
- [ ] Participants
- [ ] Spectators
- [ ] Other:

Mechanisms

- [ ] Fall
- [ ] Drowning
- [ ] Vehicle accident
- [ ] Assault/homicide/suicide
- [ ] Other:

Medical conditions > Trauma

Traumatic conditions identified in article

- [ ] Sprain/strain
- [ ] Soft tissue injury (abrasion, laceration, contusion)
- [ ] Burn
- [ ] Fracture/dislocation
- [ ] Head injury
- [ ] Other:

Medical conditions > Medical

Medical conditions identified in article

- [ ] Gastrointestinal illness
- [ ] Flu-like illness
- [ ] Seizure
- [ ] Cardiac event
- [ ] Diabetic event (hypoglycemia or hyperglycemia)
- [ ] Infection
- [ ] Syncope/near-syncope
- [ ] Alcohol/drug
- [ ] Shortness of breath/respiratory illness
- [ ] Dizziness
- [ ] Asthma
- [ ] Anaphylaxis/allergy
- [ ] Headache
- [ ] OB/gyn problem
- [ ] Other:

Medical conditions > Environmental

Environmental conditions identified in article

- [ ] Altitude-related illness
- [ ] Hyperthermia
- [ ] Hypothermia
- [ ] Dehydration
- [ ] Toxicological problem
- [ ] Other:

Other

Does the article suggest medical kit items?

- ( ) Yes
- ( ) No

Limitations

Other

Submit

Powered by Google Docs

APPENDIX B. HOSPITAL CAPABILITIES QUESTIONNAIRE

Spaceport America Regional Medical Resources

Dear Hospital Administrator:
Thank you so much for providing the following information which will be incorporated into an emergency medical response plan for commercial spaceflight events in Spaceport America. If you have any questions, please email me at jelaw@utmb.edu.

Your assistance is much appreciated.

Sincerely,
Jennifer Law, M.D.
UTMB/NASA Aerospace Medicine Residency

* Required

Hospital Address

Street Address *

City *

State *

Zip Code *

Communications

Hospital Main Line *

Emergency Department Phone Number (Emergency) *

Emergency Department Phone Number (Non-Emergency)

Radio Frequency and/or Channel

Contact Information

Who should be alerted prior to a launch and/or mass gathering event?

Contact Person *

Contact Email

Contact Phone *

Air Transport (rotary and/or fixed wing aircraft)

Does your hospital have a(n): (check all that apply) *

- [ ] Helipad, rooftop
- [ ] Helipad, field
- [ ] Airport, adjacent to hospital
- [ ] Airport, off-site
- [ ] Unable to receive air transport
- [ ] Other:

If applicable, what is your helipad's load rating (maximum weight limit)?

From the helipad/airport, how will patients be transported to the emergency department?

- ( ) Ambulance
- ( ) Gurney
- ( ) Other:

From the helipad/airport, how long does it usually take to transport to a patient to the emergency department?

Inpatient Beds

How many TOTAL inpatient beds does your hospital have? *

How many INTENSIVE CARE beds does your hospital have? *

How many TELEMETRY beds does your hospital have? *

Emergency Department

How many TOTAL beds does your emergency department have? *

How many MONITORED beds does your emergency department have? *

How many TRAUMA beds does your emergency department have? *
(Enter 0 if not applicable)

How many OPERATING ROOMS does your hospital have? *

If your specialists are not in-house, how soon are they generally available?
Please specify specialty and response time. For example, "Ophthalmology is available within 1 hour."

What are your business hours? *
For example, M-F 7am-5pm

Special Designations

Is your hospital a designated: *

	Yes	No
Trauma Center?	○	○
STEMI (ST Elevation Myocardial Infarction) Center?	○	○
Stroke Center?	○	○

How available are your specialists? *

	In-house 24/7	Available during business hours	Not available
General Surgery	○	○	○
Neurosurgery	○	○	○
Orthopedic Surgery	○	○	○
Cardiothoracic Surgery	○	○	○
Ophthalmology	○	○	○
Otolaryngology/ENT	○	○	○
Plastic Surgery	○	○	○
Vascular Surgery	○	○	○
Anesthesiology	○	○	○
General Internal Medicine	○	○	○
Cardiology	○	○	○
Neurology	○	○	○
Pediatrics	○	○	○
Obstetrics	○	○	○

Special Units

Does your hospital have a: *

	Yes	No
Burn Unit?	○	○
Cardiac Catheterization Lab?	○	○
Hyperbaric Chamber?	○	○
Psychiatric Unit?	○	○

If your hospital has a hyperbaric chamber, what is its capacity?

Any other special services?

APPENDIX C. EMERGENCY MEDICAL SERVICES PLAN FOR COMMERCIAL SPACEFLIGHT EVENTS IN SPACEPORT AMERICA

EMERGENCY MEDICAL SERVICES PLAN

[Event Name]

[Event Date and Time]

Last updated in May 2011

Table of Contents

Section I. Overview

Spaceport America, the world's first dedicated commercial spaceport, offers horizontal and vertical launch services. Some of the launch events may be attended by 700-800 spectators comprising of media, space enthusiasts, and the general public. Given the remote location of the spaceport and the potentially hazardous operations of aircraft and rockets, this document was written to outline the plan for emergency medical response for spectators during commercial spaceflight events. It is essential that this document be updated and reviewed by all emergency response personnel prior to supporting each launch event. The goal is to be prepared for potential medical contingencies to promote the health and safety of all spectators and minimize potential disruption and injury in case of a contingency.

Event Information [template]

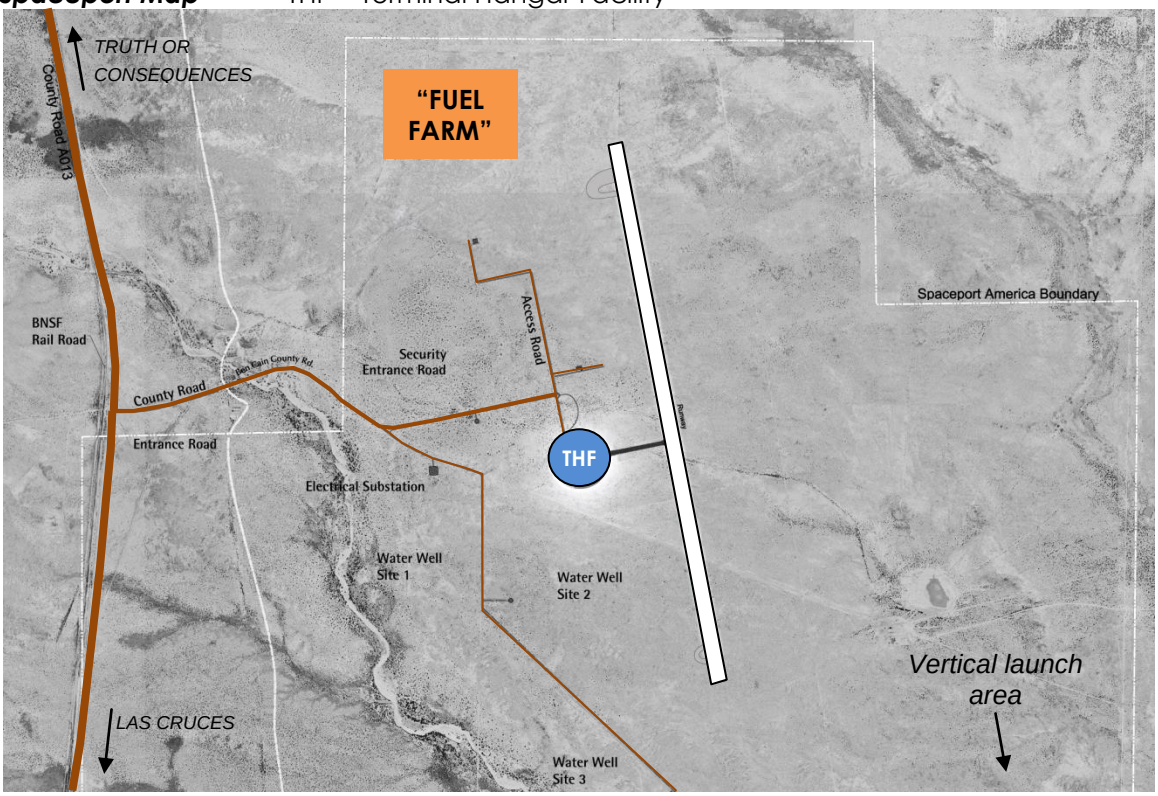
Launch/Event Name:	
Crew:	
Type of Launch:	☐ Horizontal launch ☐ Vertical launch
Passengers (if applicable):	☐ Not applicable
Payload (if applicable):	☐ Not applicable
Launch:	Target Time: Launch window:
Landing	Target Time:
Known special medical conditions (spectators):	

Important Contact Numbers [template]

Function	Name	Phone Number
Management		
Spaceport Director		
Medical Director		
Event		
Event Director		
Command Post		
Medical Control		
Fire		
Security		
Support Operations		
Business Operations		
Airfield Operations		
Public Works		
Air Boss		
Ground EMS		
Sierra Vista Ambulance	John McCarty	(575)313-1640
AMR *(unconfirmed)*	*Joaquin Graham*	*(575)523-0225*
Air EMS		
Native Air	Will Winters	(575)654-4807
Med Flight	Larry Levy, MD	(505)842-4433
Emergency Departments	ED Director	Phone Numbers
Sierra Vista Hospital Truth or Consequences, NM	John McCarty (575)313-1640	Main Line: (575)894-2111 Emergency: x266 Non-Emergency: x270
Mountain View RMC Las Cruces, NM	Mr. Kelly Clark (575)556-6801	Main Line: (575)556-7600 Emergency: (575)556-6800
Memorial Medical Center Las Cruces, NM	Lee Golden (575)521-5598	Main Line: (575)522-8641 Emergency: (575)521-2286
Gerald Champion RMC Alamogordo, NM	Jean Jaszai	Main Line: (575)439-6100 Emergency: (575)443-7901
University Medical Center El Paso, TX	Dave Bryan, MD (915)545-7333	Main Line: (915)544-1200 Emergency: (915)521-7700
Univ of New Mexico Hospital Albuquerque, TX	Kevin Schitoskey (505)272-2411	Main Line: (505)272-2111 Emergency: (505)272-5062

C. Maps

Spaceport Map THF = Terminal Hangar Facility

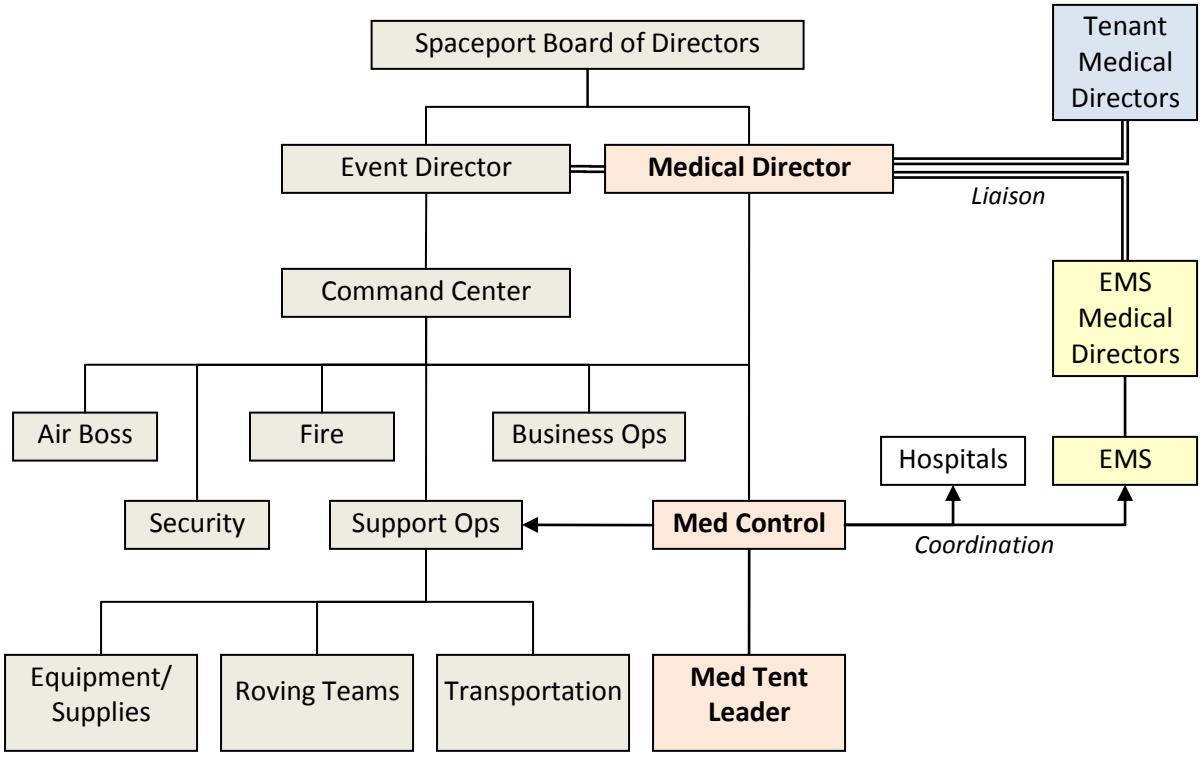


Modified from www.SpaceportAmerica.com/images/photoGallery/MapLocationOfSPA_large.jpg
Spaceport America conceptual image by URS/Foster + Partners.

Area Map (from Google Maps)

Section II. Medical Oversight, Personnel, and Resources

A. Organizational Structure



B. Personnel Responsibilities

1. ***Medical Director.*** The Medical Director is responsible for all medical activities related to the event. The Medical Director participates in the design of the medical action plan, establishes treatment protocols and equipment requirements, and sets standards for credentialing medical personnel. The Medical Director serves as liaison with the medical directors of each participating EMS provider and the medical directors of each spaceport tenant participating in the event. During the event, the Medical Director, if not serving as the Medical Control, coordinates with the Medical Control to ensure medical needs at the system level are being met. In the case of a mass casualty event or disaster, the Medical Director coordinates with local, state, and federal response agencies on medical issues. The Medical Director prepares an after-action report following the conclusion of the event.

2. ***Medical Control.*** The Medical Control is responsible for coordinating medical support during the event. The Medical Control coordinates with Supporting Operations in the Command Center to respond to reports from roving personnel of patients in the crowd and to dispatch on-site transportation (e.g., golf cart, official vehicle, or ambulance). The Medical Control also coordinates patient transport out of the spaceport with EMS providers and receiving hospitals. When an Incident Ambulance is to leave the spaceport with a patient, the Medical Control arranges for a backup

ambulance to rotate in as the new Incident Ambulance. Finally, equipment or supply needs at the medical tent are relayed to Support Operations via the Medical Control.

3. ***Medical Tent Leader.*** The Medical Tent Leader is responsible for the operation of the medical tent, including staffing, equipment, and supplies.

4. ***Incident Ambulance.*** An Incident Ambulance and its EMS crew is pre-positioned at the Medical Tent prior to the start of the event. The Incident EMS Crew will assist the Medical Tent Leader in assessing and treating patients, and will transport a patient as medically indicated, in coordination with the Medical Control.

5. ***Roving Teams.*** While not dedicated medical personnel, teams of primary event staff will rove the crowd areas during the event. Upon identification of an ill or injured spectator, the roving team will inform the Medical Control for dispatching on-site transportation or an ambulance.

C. EMS Providers (Details in Section III.A)

Ground Ambulance

1. **Sierra Vista Hospital Ambulance** – will provide incident ambulance(s) for the event.

Air Ambulance

1. **Native Air** – will be the primary air ambulance for the event.
2. **Med Flight** – may provide air transport of patients on an urgent but non-emergent basis.

D. Hospitals (as of May 2011)

	* Nearest *	* Primary *	* Secondary *
HOSPITAL	**Sierra Vista**	**Mountain View**	**Memorial**
ADDRESS	800 East 9th Ave	4311 E Lohman Ave	2450 S Telshor Blvd
City	Truth or Consequences	Las Cruces	Las Cruces
State, Zip	NM, 87901	NM, 88011	NM, 88011
DIST/TRAVEL TIME			
Ground (mi / h:mm)	31 / 1:18	107 / 2:37	108 / 2:37
Air (mi / h:mm)	18 / 0:09	49 / 0:25	51 / 0:26
HELIPAD	Yes	Yes	Yes
Location	Airport	On-site	On-site
Transfer Mode	Ambulance (~1 min)	Gurney	Gurney
HOSPITAL BEDS			
Total / ICU	25 / 0	168 / 23	298 / 43
EMERGENCY DEPT	Yes	Yes	Yes
Point of Contact	John McCarty	Mr. Kelly Clark (Director) or David Silva (Manager)	Lee Golden
TRAUMA CENTER LEVEL	Developing IV	n/a	n/a
SPECIALTIES			
General Surgery	No	Yes	Yes
Cardiothoracic	No	Yes	Yes
Neurosurgery	No	Yes	No
Ophthalmology	No	Yes	Yes
Oral Surgery	No	Yes	Yes
Orthopedic	No	Yes	Yes
Otolaryngology	No	Yes	Yes
Plastic Surgery	No	Yes	Yes
Vascular Surgery	No	Yes	Yes
Anesthesiology	No	Yes	Yes
Cardiology	1 day/month	Yes	Yes
Cardiac Cath	No	Yes	Yes
Neurology	1 day/month	Yes	Yes
Pediatrics	1 day/month	Yes	Yes
BURN UNIT	No	No	No
LABOR & DELIVERY	No	Yes	Yes
PSYCHIATRIC UNIT	No	No	Yes
HYPERBARICS	No	Yes (Wound Care)	No
COMMUNICATIONS			
Call sign	KU7891	WPVK248	WPMA287
Frequency	155.400	T: 468.075 R: 463.075	460.100 or T: 468.125 R: 463.125
Channel	Not provided	Med 4	Med 6
Emerg Phone	(575)894-2111 x266	(575)556-6800	(575)521-2286
Non-Emergent	(575)894-2111 x270	(575)556-7600	(575)522-8641

	* Trauma *	* Trauma *	* Burn/Trauma *
HOSPITAL	**Gerald Champion**	**University Medical Center**	**University of New Mexico Hospital**
ADDRESS	2669 N Scenic	4815 Alameda Ave	2211 Lomas Blvd NE
City	Alamogordo	El Paso	Albuquerque
State, Zip	NM, 88310	TX, 79905	NM, 87106
DIST/TRAVEL TIME			
Ground (mi / h:mm)	212 / 4:28	154 / 3:14	177 / 3:33
Air (mi / h:mm)	60 / 0:30	94 / 0:46	145 / 1:13
HELIPAD	Yes	Yes	Yes
Location	On-site	Rooftop (up to 24,000 lbs)	Rooftop
Transfer Mode	Gurney	Gurney	Gurney
HOSPITAL BEDS			
Total / ICU	99 / 10	327 / 50	384 / 24
EMERGENCY DEPT	Yes	Yes	Yes
Point of Contact	Jean Jaszai	Dave Bryan MD	Kevin Schitoskey
TRAUMA CENTER LEVEL	III	I	I
SPECIALTIES			
General Surgery	Yes	Yes	Yes
Cardiothoracic	No	Yes	Yes
Neurosurgery	No	Yes	Yes
Ophthalmology	Yes	Yes	Yes
Oral Surgery	No	Yes	Yes
Orthopedic	Yes	Yes	Yes
Otolaryngology	Yes	Yes	Yes
Plastic Surgery	No	Yes	Yes
Vascular Surgery	No	No	Yes
Anesthesiology	Yes	Yes	Yes
Cardiology	Yes	Yes	Yes
Cardiac Cath	No	Yes	Yes
Neurology	Yes	Yes	Yes
Pediatrics	Yes	Yes	Yes
BURN UNIT	No	No	Yes
LABOR & DELIVERY	Yes	Yes	Yes
PSYCHIATRIC UNIT	Geriatric Psych	No	Yes
HYPERBARICS	No	No	No
COMMUNICATIONS			
Call sign	KXO882	Not provided	KU7891
Frequency	T: 468.150 R: 463.150	T: 468.025 PL 136.5 R: 463.025 PL 136.5	T: 468.000 R: 463.000
Channel	Med 7	Med 2	Med 1
Emerg Phone	(575)443-7901	(915)521-7700	(505)272-2411
Non-Emergent	(575)439-6100	(915)544-1200 or (915)521-7704	(505)272-2111

	Backup	Backup	Backup	Backup
HOSPITAL	**Mimbres**	**Socorro**	**Gila**	**Lincoln County**
ADDRESS	900 W Ash St	1202 Hwy 60 W	1313 East 32nd St	211 Sudderth Dr
City	Deming	Socorro	Silver City	Ruidoso
State, Zip	NM, 88031	NM, 87801	NM, 88061	NM, 88345
DIST/TRAVEL TIME				
Ground (mi / h:mm)	118 / 3:01	104 / 2:27	119 / 3:28	189 / 4:05
Air (mi / h:mm)	70 / 0:35	71 / 0:36	77 / 0:39	80 / 0:40
HELIPAD	Yes	Yes	Yes	Yes
Location	On-site	On-site	Next to hospital	Airport
Transfer Mode	Gurney	Gurney	Ambulance	Ambulance
HOSPITAL BEDS				
Total / ICU	49 / 6	24 / 0	68 / 6	25 / 4
EMERGENCY DEPT			Yes	
Point of Contact	Pat Speers	April Marlow	James Marshall	Linda Moss
TRAUMA CTR LEVEL	n/a	n/a	n/a	n/a
SPECIALTIES				
General Surgery	Yes	Yes	Yes	Yes
Cardiothoracic	No	No	No	No
Neurosurgery	No	No	No	No
Ophthalmology	Yes	No	Yes	No
Oral Surgery	No	No	No	No
Orthopedic	Yes	No	Yes	No
Otolaryngology	No	No	Yes	No
Plastic Surgery	No	No	No	No
Vascular Surgery	No	No	No	No
Anesthesiology	Yes	Yes	Yes	Yes
Cardiology	Yes	Consultant rarely	Yes	Yes
Cardiac Cath	No	No	No	No
Neurology	No	No	Yes	No
Pediatrics	Yes	Yes	Yes	No
BURN UNIT	No	No	No	No
LABOR & DELIVERY	Yes	Yes	Yes	Yes
PSYCHIATRIC UNIT	No	No	Yes	No
HYPERBARICS	No	No	No	No
COMMUNICATIONS				
Call sign	KXO881 (WAU659)	KXO867	Not provided	Not provided
Channel	Med 5	Med 5	Med 2, 7, 9	Med 5 via Buck Mountain
Emerg Phone	(575)546-5881	(575)835-8370	(575)538-4050	(575)257-8260
Non-Emergent	(575)546-5803	(575)835-1140	(575)538-4000	(575)257-8250

New Mexico State EMS Radio (EMSCOM) System Frequencies (as of Aug 2009)

Channel	Transmit	Receive	Channel	Transmit	Receive
Medical Frequencies			Med 6	468.125	463.125
Med 1	468.000	463.000	Med 7	468.150	463.150
Med 2	468.025	463.025	Med 8	468.175	463.175
Med 3	468.050	463.050	***Dispatch Frequencies***		
Med 4	468.075	463.075	Med 9*	467.950	462.950
Med 5	468.100	463.100	Med 10*	467.975	462.975

From http://www.nmems.org/documents/EMSCOMManual809.pdf

Section III. Medical Operations

A. Medical Plan/ICS Form 206

MEDICAL PLAN	1. Incident Name	2. Date Prepared	3. Time Prepared	4. Operational Period

5. Incident Medical Aid Station

Medical Aid Stations	Location	Paramedics Yes	Paramedics No
Medical Tent	Adjacent to spectator area	X	

6. Transportation

A. Ambulance Services

Name	Address	Phone	Paramedics Yes	Paramedics No
Sierra Vista Hospital Ambulance	800 East 9th Ave. Truth or Consequences, NM 87901	911 (dispatch) 575-894-2111	X	
Native Air	Las Cruces International Airport Las Cruces, NM 88004	800-806-7106	X	
Med Flight	6701 Convair Rd El Paso, TX 79925	800-842-4431	X	

B. Incident Ambulances

Name	Location	Paramedics Yes	Paramedics No
Sierra Vista Ambulance	Medical Tent	X	

7. Hospitals

Name	Address	Travel Time (h:m)		Phone	Helipad		Burn Center	
		Air	Ground		Yes	No	Yes	No
Sierra Vista Hospital	800 E. 9th Ave. Truth or Consequences	0:09	1:18	(575)894-2111	X			X
Mountain View RMC	4311 E. Lohman Ave. Las Cruces	0:25	2:37	(575)556-7600	X			X
Memorial Medical Center	2450 S. Telshor Blvd. Las Cruces	0:26	2:37	(575)522-8641	X			X
Gerald Champion RMC	2669 N. Scenic Dr. Alamogordo	0:30	4:28	(575)493-6100	X			X
University Med Center of El Paso	4815 Alameda Ave. El Paso, TX	0:46	3:14	(915)521-7700	X			X
Univ of New Mexico Hospital	2211 Lomas Blvd. NE Albuquerque, NM	1:13	3:33	(505)272-5062	X		X	

(more)

8. Medical Emergency Procedures

The **primary medical location** for the event will be the Medical Tent. All possible efforts should be made for patients to be transported to and treated at this location.

See the accompanying Hospital Selection Algorithm to select the appropriate destination for transport for each patient. In summary:

- The **nearest hospital** is Sierra Vista Hospital. Unstable patients and patients presenting within 3 hours of onset of stroke symptoms should be transported to Sierra Vista.
- The nearest **Burn Center** is University of New Mexico Hospital.
- The nearest **Trauma Centers** are Gerald Champion Regional Medical Center (Level III), University Medical Center El Paso (Level I), and University of New Mexico Hospital (Level I)
- If patient is stable and does not meet burn or critical trauma criteria, the **primary hospital** is Mountain View Regional Medical Center and the **secondary hospital** is Memorial Medical Center (no neurosurgery).

Medevac: Request for helicopter air transport of any patient will be made through Command. Primary landing zone (LZ) will be *(to be determined based on wind patterns)* . Additional emergency LZ will be cleared through Medical Control.

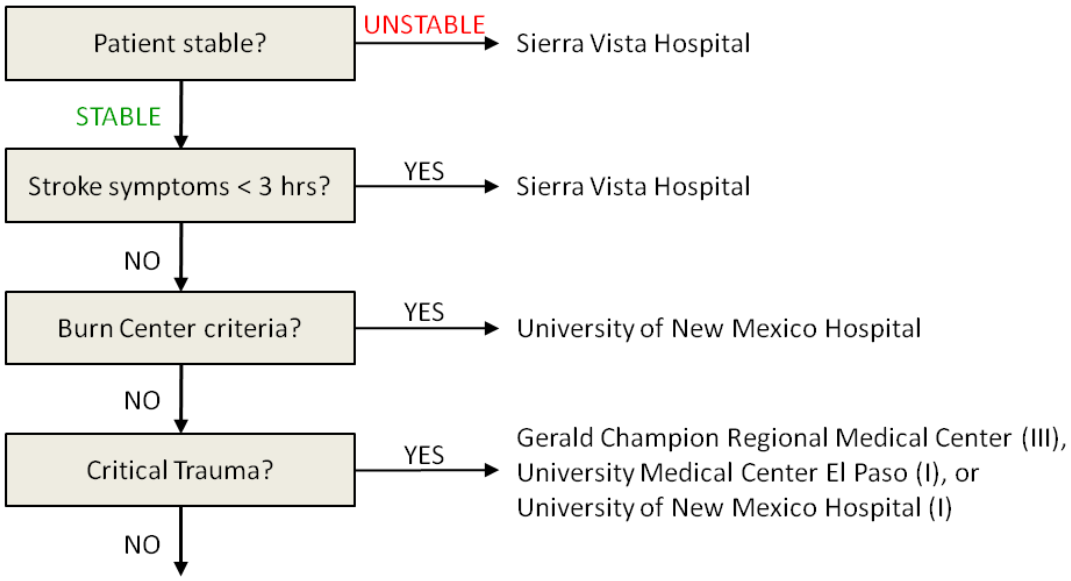
Disaster/MCI: Should there be a disaster/MCI, the Command Post will be used for incident command. There are three modes of contingency:

- ***Mode 1 (within flight line**)* – Medical personnel should assemble at the Medical Tent for further instructions from Incident Command.
- ***Mode 2 (outside flight line within spaceport property)*** – Medical personnel should assemble at the Medical Tent. The most senior medical staff present in the Medical Tent will supervise the designation of triage areas (red, yellow, green, black) and triage of patients who present to the Medical Tent using the START protocol. Treatment priority will be in the order of red (immediate), yellow (delayed), then green (minor).
- ***Mode 3 (outside spaceport property)*** – Medical personnel should assemble at the Medical Tent for further instructions from Incident Command.

In all three modes, medical personnel should remain in the Medical Tent area until further instructed by Incident Command, and follow any additional Spaceport Emergency Procedures.

Prepared by (Medical Unit Leader)	10. Reviewed by (Safety Officer)

Hospital Selection Algorithm



1. Mountain View Regional,
2. Memorial Medical Center, or
3. Per physician discretion; consult Hospital Capabilities Chart for specific patient needs

American Burn Association
Burn Center Referral Criteria

- Partial thickness burns >10% total body surface area
- Burns involving face, hands, feet, genitalia, perineum, or major joints
- Third degree burns in any age group
- Electrical burns, including lightning injury
- Chemical burns
- Inhalation injury
- Burn injury in patients with preexisting medical disorders that could complicate management, prolong recovery, or affect mortality
- Any patient with burns and concomitant trauma (such as fractures) in which the burn injury poses the greatest risk of morbidity or mortality. In such cases, if the trauma poses the greater immediate risk, the patient may be initially stabilized in a trauma center before being transferred to a burn unit. Physician judgment will be necessary in such situations and should be in concert with the regional medical control plan and triage protocols.
- Burned children in hospitals without qualified personnel or equipment for the care of children
- Burn injury in patients who will require special social, emotional, or rehabilitative intervention

Critical Trauma Criteria

Physiologic
- Glasgow Coma Scale:
  Adults ≤ 11
  Children≤10
- Systolic BP:
  <90 mm Hg (age >14)
  80 mm Hg (age 7-14)
  70 mm Hg (age <7)
- Respiratory rate <10 or >29

Anatomic
- Penetrating injuries to head, neck, torso, and extremities proximal to elbow and knee
- Amputation proximal to wrist or ankle
- Spinal injury with limb paralysis
- Flail chest
- Two or more obvious proximal fractures of femur or humerus
- Multisystem trauma

Adapted from:
Imperial County EMS Agency
San Francisco EMS Agency

B. Levels of Care, Protocols, and Disposition

The minimum level of care that to be provided is an emergency medical technician (EMT-Basic) with the ability to provide early defibrillation to victims of cardiac arrest within 3 to 5 minutes from the time of collapse.

Injuries and illnesses can be divided into the following categories for treatment and disposition. Clinical judgment should supersede these general protocols. Any medical issue that requires medical attention beyond field first aid, or any condition that worsens or does not improve following a reasonable period of observation, should be referred.

Care Level	Conditions	Treatment/Disposition
Ambulatory Care		
Ambulatory Class I	Dehydration (mild; responsive to fluids) Dizziness or fatigue (mild; responsive to fluids and rest) Hyperglycemia (mild; normal sensorium) Hypoglycemia (mild; normal sensorium) Hypotension (responsive to PO/IV fluids) Hyperthermia (mild; normal sensorium) Hypothermia (mild; normal sensorium) Seizure (if known seizure disorder and pt returns to baseline) Shortness of breath (mild; responsive to patient's bronchodilator) Syncope due to orthostatic hypotension or vasovagal response	Treatment per EMS protocol (e.g., oral glucose, IV or oral fluids), observation, then referral to personal physician vs. hospital transport
Ambulatory Class II	Abdominal pain (mild) Allergic reaction (mild, no respiratory involvement) Epistaxis (responds to external pressure) Gastrointestinal illness Headache (mild-moderate severity) Indigestion Intoxication (mild, awake)	±OTC medications (e.g. acetaminophen) as indicated, observation period, then referral to personal physician vs. hospital transport
Ambulatory Class III	Blisters Burns <1% TBSA Eye foreign bodies Insect bites Minor injuries (including musculoskeletal) Request for bandages Soft tissue injuries (e.g., contusion, lacerations) Sprains/strains Sunburns	First aid then referral to personal physician as indicated
Ambulatory Class IV	Dental problems Dermatologic problems (rash) Ear problems (tinnitus, foreign body) Flu-like illness Mild infection (no fever or rash)	Refer to personal physician

(more)

Care Level	Conditions	Treatment/Disposition
Moderate Illnesses/Injuries		
Moderate Class I	Abdominal pain (suspect surgical or ischemic process) Altered mental status Animal and snake bites Burns <20% and no evidence of impending respiratory compromise Dehydration (unresponsive to treatment) Dizziness or fatigue (unresponsive to treatment) Epistaxis (unresponsive to external pressure) Fractures/dislocations Headache (severe or new) Head injuries (GCS 13-14) Heat exhaustion (unresponsive to cooling, fluids) Heat stroke (with AMS) Hypertension (>180/110, no AMS or neurologic symptoms) Hypoglycemia or hyperglycemia (unresponsive to treatment) Hypothermia (with AMS) Infection (with fever and/or rash) Intoxication (not awake/alert) Seizure (persistent or new) Shortness of breath (requiring O_2; no assisted breathing needed)	Initiate treatment per EMS protocol (if female with abdominal pain, check UPT), arrange for hospital transport by ground
Moderate Class II	Head injuries (GCS 15) Other eye problems (red eye, painful eye) Syncope/near-syncope not explained by orthostatic hypotension or vasovagal response	Treatment per EMS protocol, consider hospital transport

(more)

Care Level	Conditions	Treatment/Disposition
Severe Illnesses/Injuries		
CPR (Severe Class I)	Asystole Pulseless electrical activity (PEA) arrest Ventricular fibrillation/tachycardia	Immediate ACLS/EMS protocol, initiate arrangement for emergent aeromedical evacuation, if no return of spontaneous circulation within 20 minutes then pronounce on scene
Severe Class II	Anaphylaxis Arrhythmia (non VF/VT) Burns >20% TBSA or evidence of/impending respiratory compromise Cardiac chest pain Cardiac problems (chest pain, palpitations) Crush injuries Electrocution Eye problems (glaucoma) Hazardous material exposure with patient complaints Head injuries (GCS <12) Hemorrhage with hemodynamic compromise (or potential for) Hypertension (>180/110, AMS or neurologic symptoms) Hypotension (SBP <90 despite fluids) Labor Neck injuries Sepsis Shortness of breath (airway obstruction, respiratory compromise or arrest) Stroke	Initiate treatment per EMS protocol, emergent arrangement for medical evacuation by air
Disaster/Multiple Casualty Incident		
Disaster/MCI	When more than 3 patients are involved in an incident When patient numbers exceed available resources , or When declared by Command Center	Implement/support **Spaceport MCI plan**; follow New Mexico EMS Operations Guidelines* until relieved by Incident Commander designated by the spaceport or government agency

* New Mexico EMS Operations Guidelines available at http://www.nmems.org/Treatment%20guidlines/Operations%20Guidelines%202006.pdf

C. Medical Facility

The **Medical Tent** will be the primary medical facility for the event. An incident ambulance and EMS crew will be located here, at all times if possible. The tent will provide shade and at least one cot for patient use. It will also house the medical equipment and supplies to be described in the next section, as well as two-way communications equipment with the Command Center. Water and restroom facilities should be easily accessible from the Medical Tent.

D. Equipment and Supplies

First Aid Kit

Bandaging
- Gauze (2x2, 4x4, Kerlix)
- Petroleum gauze
- Band-aids
- Elastic wrap
- Cloth tape
- Plastic tape

Wound Management
- Alcohol pads
- Antiseptic towelettes
- Benzoin
- Cotton swabs
- Irrigation syringes
- Moleskin
- Providine iodine
- Saline irrigation
- Silver sulfadiazine
- Splash guards
- Steri-strips

Orthopedic Care
- Crutches
- Finger/wrist splints
- Sling
- Splinting material

Immobilization Equipment
- Backboard
- C-collar or towel rolls
- Straps
- Tongue depressors

OTC Medications
- Acetaminophen
- Antibiotic ointment
- Aspirin
- Diphenhydramine
- Famotidine
- Glucose tablets/paste/gel
- Hydrocortisone cream 1%
- Ibuprofen
- Loperamide

Other
- Batteries for electrical equipment
- Clipboards
- Papers
- Pens
- Safety pin
- Ziplock bags

Patient Comfort
- Bed sheets
- Blankets
- Cots
- Pillows with cases
- Sanitary pads
- Tampons

Personal Protective Equipment
- Gloves
- Gowns
- Hand sanitizers
- Pocket masks/face shields

Instruments
- Flashlight
- Forceps
- Hemostat
- Scalpel
- Scissors
- Sphygmomanometer
- Stethoscope
- Thermometer
- Trauma shears

Extended Medical Kit

Airway Equipment
- Bag valve mask
- Endotracheal tubes/stylets
- Laryngeal Mask Airways
- Laryngoscope/blades
- Nasal airway
- Oral airway
- Nasal cannula
- Non-rebreather mask
- Oxygen
- Oxygen tank regulator
- Pulse oximeter
- Suction equipment

Airway Medications
- Atropine
- Etomidate*
- Lidocaine
- Rocuronium*
- Succinylcholine*

* Not within scope of practice for New Mexico EMS Basic, Intermediate, or Paramedic

Other Resuscitation Equip.
- Automatic external defibrillator
- Cardiac monitor w/ EKG
- Glucometer (with lancets and test strips)
- IV catheters (14/16/18/20 gauge)
- IV tubing
- Needles (18/22 gauge)
- Normal saline IV fluids
- Syringes

Other
- Foley catheter
- Urine pregnancy test kit

ACLS Medications
- Adenosine
- Amiodarone
- Atropine
- Calcium gluconate
- Dexamethasone
- Dextrose 50
- Epinephrine 1:1,000
- Epinephrine 1:10,000
- Lidocaine
- Magnesium sulfate
- Sodium bicarbonate
- Vasopressin

Advanced Medications
- Ondansetron
- Albuterol MDI
- Ipratropium MDI
- Naloxone
- Lorazepam/midazolam
- Morphine/fentanyl
- Nitroglycerin
- Proparacaine

E. Staffing

At least one medical provider certified in ACLS must be present at the Medical Tent at all times. An Incident Ambulance with crew trained to at least the EMT-Basic level should be present at the Medical Tent or on-site within spaceport property at all times. If the primary Incident Ambulance leaves the spaceport to transport a patient, a backup ambulance should be arranged by the Medical Control and take over as the primary Incident Ambulance as soon as possible.

F. Documentation

All patient contacts must be documented on the official Medical Record Form. Patients who refuse treatment or leave prior to completion of treatment should sign the Release At Scene/Against Medical Advice Form prior to leaving the Medical Tent.

Section IV. Logistics

A. Communications

The primary method of communications for medical personnel is two-way radio using the designated radio frequencies listed in Section II. Cellular phones are unreliable given the remote location of the spaceport; thus, they should be reserved as a secondary means of communication.

B. Transportation

For patient transportation, the following modes of transportation are available: event golf cart, official event vehicles, and ambulances. The dispatch of these vehicles will be coordinated by the Medical Control.

For staff transportation, golf carts and official event vehicles may be used as space allows.

C. Event Schedule

TBD

Section V. Post-Event Debriefing

At the end of the event, all medical forms must be collected. The Medical Tent Leader should solicit and take notes on feedback from the medical personnel who participated in the event. An event debriefing should be held within one week (or as soon as practical) between the Medical Director, Medical Control, and Medical Tent Leader to discuss summary data, recommendations, and conclusions from the event. The Medical Director should then prepare an after-action report for the Event Director and incorporate the "lessons learned" into the planning of the next launch event.

Section VI. Forms

A. Medical Record Form

MEDICAL RECORD FORM	Date: Encounter Time: Medical Staff:
PATIENT DEMOGRAPHICS	
Name:	**Age:**
Contact Phone:	**Gender: M F**
Address:	**Parent's Information (if patient age <18):**
CHIEF COMPLAINT	**Allergies:**
	Relevant Past Medical History: **Current Medications:**
REVIEW OF SYSTEMS	**VITALS**
General: Fatigue Lightheadedness Syncope Dizziness Hot Cold **Neurologic:** Confused Unresponsive Weak Headache **Cardiac** Palpitations Chest pain/pressure **Pulmonary** SOB Wheezing Cough **GI** Nausea Vomiting Diarrhea **MSK/Skin** Cramps Pain Wound	**Time** | **BP** | **P** | **RR** | **Temp** | | | | | | | | | | | | | | | | | | | | **Patient's weight:** **FOCUSED PHYSICAL EXAM**
TREATMENT	**PROGRESS NOTE**
Time | **Treatment Given** |	**Time** | **Note** |
IMPRESSION:	
DISPOSITION: ☐ Discharged ☐ Transported to _____ by _____ ☐ Left against medical advice	
Signature:	**Discharge Time:**

B. Release At Scene/Against Medical Advice Form

Release At Scene/Against Medical Advice Form

Patient's Name: _____ **Date of Birth:** _____

CRITERIA FOR REFUSING CARE
The patient must meet all of the following criteria: 1. Is an adult (age >18) 2. Exhibits no evidence of: - Altered level of consciousness - Alcohol or drug ingestion that impairs judgment 3. Understands the nature of the medical condition 4. Understands the risks and consequences of refusing care

1. ACKNOWLEDGMENT OF INFORMATION:

___ (initials) **Release at Scene:** I acknowledge that I may have a medical problem, which may require additional medical attention, and that an ambulance is available to transport me to the hospital. Instead, I elect to seek alternative medical care and refuse further treatment and/or transport.

or

___ (initials) **Against Medical Advice:** I have been advised that medical assistance on my behalf is necessary, and that refusal of said assistance could be hazardous to my health, and under certain circumstances, including disability and/or death. I have been advised to discuss my medical complaints with my regular health care provider as soon as possible. Nevertheless, I refuse to accept treatment or transport to a medical facility and assume all risks and consequences of any decision.

2. RELEASE OF LIABILITY:

By signing this form, I am releasing Spaceport America, the Spaceport Authority, the responding Provider Agency (or Agencies), the Receiving Hospital (if contacted) of any liability or medical claims resulting from my decision to refuse the medical care/transport offered.

I have read and understand the "Acknowledgment of Information" and "Release of Liability."

Signature: _____ Refused to sign, reason: _____

Relationship to patient (if child/dependent): Lawful: ☐ parent ☐ guardian ☐ conservator

☐ Physician Consulted: _____

☐ Telephone consent/refusal obtained. Witnessed by: _____

☐ Interpreter used: _____

Witness Information

Name: _____ Signature: _____

Address: _____ Phone: _____

References

1. Aerospace Medical Association Commercial Spaceflight Working Group. Suborbital Commercial Spaceflight Crewmember Medical Issues. Aviat Space Environ Med. 2011;82(4):475-484.
2. American Burn Association. Burn Center Referral Criteria. 2006 [retrieved 26 Apr 2011]; Available from: http://www.ameriburn.org/BurnCenterReferralCriteria.pdf
3. American College of Emergency Physicians EMS Committee. Provisions for Emergency Medical Care for Crowds. 1996 [retrieved 28 Jan 2011]; Available from: www.acep.org/workarea/downloadasset.aspx?id=4846
4. Arbon P, Bridgewater F, Smith C. Mass gathering medicine: a predictive model for patient presentation and transport rates. Prehosp Disaster Med. 2001 Jul-Sep;16(3):150-158.
5. Boyle M, De Lorenzo R, Garrison R. Physician integration into mass gathering medical care. The United States Air Show. Prehosp Disaster Med. 1993 Apr-Jun;8(2):165-168.
6. Burdick TE. Wilderness event medicine: planning for mass gatherings in remote areas. Travel Med Infect Dis. 2005;3(4):249-258.
7. Burdick TE, Brozen R. Wilderness event medicine. Wilderness & Environmental Medicine. 2003;14(4):236-239.
8. Butler WN, Gesner D. Developing a mass gathering EMS plan. JEMS. 1999 Nov;24(11):66.
9. Chang E, Koval E, Freer L, Kraus S. Planning for an annual episodic mass gathering: emergency department and clinic utilization in Yellowstone. Wilderness Environ Med. 2000;11(4):257-261.
10. City of Cocoa Beach. Cocoa Beach Air Show Incident Action Plan. Cocoa Beach, FL 2010.
11. Commission on Accreditation of Medical Transport Systems. Accredited Services. 2010 [retrieved 8 Feb 2011]; Available from: http://www.camts.org/content/view/73/71/
12. daftlogic.com. Google Maps Distance Calculator. 2010 [retrieved 20 Mar 2011]; Available from: http://www.daftlogic.com/projects-google-maps-distance-calculator.htm
13. De Lorenzo R. Mass gathering medicine: a review. Prehosp Disaster Med. 1997 Jan-Mar;12(1):68-72.
14. Emergency Management Institute. ICS Form 205, Incident Radio Communications Plan. [retrieved 22 Mar 2011]; Available from: http://training.fema.gov/EMIWeb/IS/ICSResource/assets/ics205.doc
15. Emergency Management Institute. ICS Form 206, Medical Plan. [retrieved 22 Mar 2011]; Available from: http://training.fema.gov/EMIWeb/IS/ICSResource/assets/ics206.doc
16. Federal Aviation Administration. Airport Data and Contact Information. 2010 [retrieved 18 Feb 2011]; Available from: http://www.faa.gov/airports/airport_safety/airportdata_5010/menu/index.cfm.

17. Forrester JD, Holstege CP. Injury and illness encountered in Shenandoah National Park. Wilderness & Environmental Medicine.20(4):318-326.
18. Franaszek J. Medical care at mass gatherings. Ann Emerg Med. 1986 May;15(5):600-601.
19. Google. Google Maps. 2011 [retrieved 15 Jan 2011]; Available from: http://maps.google.com
20. Grange J, Baumann G, Vaezazizi R. On-site physicians reduce ambulance transports at mass gatherings. Prehosp Emerg Care. 2003 Jul-Sep;7(3):322-326.
21. Grange JT. Planning for large events. Current Sports Medicine Reports. 1(3):156-161.
22. Hancock S, Moloney A. Work starts on New Mexico spaceport. BBC News. Sierra County NM 2009.
23. Imperial County Emergency Medical Services Agency. Prehospital Trauma Triage Criteria. 2004.
24. Innovation Health Applications. KSC Medical Launch Package for STS-133. Cape Canaveral, FL: NASA Kennedy Space Center 2010.
25. Jaslow D, Yancey A, Milsten A. Mass Gathering Medical Care: The Medical Director's Checklist. National Association of EMS Physicians Annual Meeting; 2000; Dana Point CA; 2000.
26. Landeene S. Spaceport America...Enabling a New Frontier. Spaceport America NM: New Mexico Spaceport Authority 2008.
27. Marin County Emergency Medical System. Refusal of Care Against Medical Advice (AMA) and Release at Scene (RAS). 2006.
28. Michael JA, Barbera JA. Mass gathering medical care: a twenty-five year review. Prehospital & Disaster Medicine. 1997;12(4):305-312.
29. Milsten A, Seaman K, Liu P, Bissell R, Maguire B. Variables influencing medical usage rates, injury patterns, and levels of care for mass gatherings. Prehosp Disaster Med. 2003 Oct-Dec;18(4):334-346.
30. Mojave Air and Space Port. Emergency Services. 2011 [retrieved 24 Mar 2011]; Available from: http://www.mojaveairport.com/emergencyservices.htm
31. New Mexico Department of Health Division of Health Improvement. Provider Search. [retrieved 5 Mar 2011]; Available from: https://dhi.health.state.nm.us/providersearch/index.php
32. New Mexico Emergency Medical Services. Operations Guidelines. 2006.
33. New Mexico Emergency Medical Services. Drug Guidelines. 2008.
34. New Mexico Emergency Medical Systems. Air Ambulance Providers Certified in New Mexico. [retrieved 8 Feb 2011]; Available from: http://www.nmems.org/AirAmbulance/Listing%20of%20air%20services%20for%20web.pdf
35. New Mexico Emergency Medical Systems. New Mexico Designated Trauma Facilities. [retrieved 8 Feb 2011]; Available from: http://www.nmems.org/trauma_designated_hospitals.shtml
36. New Mexico Poison and Drug Information Center. Substance by Age - Rpt 055. Sierra County Data FY10 2010 [retrieved 4 Feb 2011]; Available from: http://hsc.unm.edu/pharmacy/poison/countyData/pdf/Sierra/RPT055a%20-%20Generic%20Codes%20By%20Category%20By%20Age.pdf

37. New Mexico Poison and Drug Information Center. Substance by Medical Outcome - Rpt 057. Sierra County Data FY10 2010 [retrieved 4 Feb 2011]; Available from: http://hsc.unm.edu/pharmacy/poison/countyData/pdf/Sierra/RPT057a%20-%20Generic%20Codes%20By%20Category%20By%20Medical%20Outcome.pdf
38. New Mexico Poison and Drug Information Center. Substance by Mgt Site - Rpt 058. Sierra County Data FY10 2010 [retrieved 4 Feb 2011]; Available from: http://hsc.unm.edu/pharmacy/poison/countyData/pdf/Sierra/RPT058a%20-%20Generic%20Codes%20By%20Category%20By%20HCF%20Utilization.pdf
39. New Mexico Spaceport Authority. Request for Proposals (RFP #11-495-00-00161). 15 Nov 2010 [retrieved 15 Mar 2011]; Available from: http://www.spaceportamerica.com/images/pdf/rfp-pdf/RFP-11-495-00-00161-Protective-Services.pdf
40. NOAA National Climate Data Center. Average Relative Humidity (%). National Oceanic and Atmospheric Administration. 2008 [retrieved 27 Jan 2011]. http://www.ncdc.noaa.gov/oa/climate/online/ccd/avgrh.html
41. NOAA Satellites and Information. Normal Daily Maximum Temperature, Degrees F. National Oceanic and Atmospheric Administration 1971-2000. [retrieved 27 Jan 2011]. http://www.ncdc.noaa.gov/oa/climate/online/ccd/nrmmax.txt
42. NOAA Satellites and Information. Normal Daily Mean Temperature, Degrees F. National Oceanic and Atmospheric Administration 1971-2000. [retrieved 27 Jan 2011]. http://www.ncdc.noaa.gov/oa/climate/online/ccd/nrmavg.txt
43. NOAA Satellites and Information. Normal Daily Minimum Temperature, Degrees F. National Oceanic and Atmospheric Administration 1971-2000. [retrieved 27 Jan 2011]. http://www.ncdc.noaa.gov/oa/climate/online/ccd/nrmmin.txt
44. NOAA Satellites and Information. Mean Number of Days Maximum Temperature 90 Deg. F or Higher. National Oceanic and Atmospheric Administration. 2009 [retrieved 27 Jan 2011]. http://www.ncdc.noaa.gov/oa/climate/online/ccd/mxge90.txt
45. NOAA Satellites and Information. Temperature - Highest of Record, Degrees F. National Oceanic and Atmospheric Administration. 2009 [retrieved 27 Jan 2011]. http://www.ncdc.noaa.gov/oa/climate/online/ccd/hghtmp.txt
46. NOAA Satellites and Information. Temperature - Lowest of Record, Degrees F. National Oceanic and Atmospheric Administration. 2009 [retrieved 27 Jan 2011]. http://www.ncdc.noaa.gov/oa/climate/online/ccd/lowtmp.txt
47. Ounanian L, Salinas C, Shear C, Rodney W. Medical care at the 1982 US Festival. Ann Emerg Med. 1986 May;15(5):520-527.
48. OvidSP. Advanced Search Techniques. 2010 [retrieved 14 Jan 2011]; Available from: http://www.ovid.com/site/help/documentation/ospa/en/syntax.htm
49. San Francisco Emergency Medical Services Agency. Critical Trauma Patient Criteria and Triage Decision Scheme. 2008.
50. Sanders A, Criss E, Steckl P, Meislin H, Raife J, Allen D. An analysis of medical care at mass gatherings. Ann Emerg Med. 1986 May;15(5):515-519.
51. Shah R. Wings Over Houston Airshow 2009 Medical Operations Plan. Galveston, TX: University of Texas Medical Branch 2009.
52. Shah W. Mass gathering medical care: to calculate the Medical Usage Rate of Galway Races. Am J Disaster Med. 2010 Jan-Feb;5(1):61-64.

53. Townes DA. Wilderness medicine. Primary Care. 2002;29(4):1027-1048.
54. Veronneau SJ, Ricaurte EM. Aircraft Accidents: Investigation and Prevention. In: Davis JR, Johnson R, Stepanek J, Fogarty JA, eds. 4th ed. Philadelphia PA: Lippincott Williams & Watkins 2008:552-623.
55. Virgin Galactic. Overview, Experience. 2009 [retrieved 2010 Nov 22]; Available from: http://www.virgingalactic.com/overview/experience/

Vita

Jennifer Law was born in Hong Kong and considers Palo Alto, CA, her hometown. She graduated from the Massachusetts Institute of Technology in 2001 with a Bachelor of Science (S.B.) degree in electrical engineering and minors in biomedical engineering and psychology. Upon graduation, she worked on the Mars Exploration Rovers project at NASA's Jet Propulsion Laboratory and supported prelaunch operations at the Kennedy Space Center. Subsequently she attended medical school at the University of Southern California and earned her Doctor of Medicine (M.D.) degree in 2007. She completed her primary residency training in emergency medicine at the University of California Davis in 2010. She is currently an aerospace medicine resident at the University of Texas Medical Branch and was recently named Chief Resident of Aerospace Medicine for the 2011-2012 academic year. After graduation, she hopes to pursue a career as a flight surgeon at the Johnson Space Center.

This capstone was typed by the author.