The Texas City Disaster: a re-examination

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Abstract

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The explosion of two ships loaded with ammonium nitrate fertilizer at the Texas City docks on April 16 and 17, 1947, produced the worst industrial disaster in United States history. Despite this, inaccuracies persist about exactly what happened, the event has never been analyzed in terms of crisis management, and landside-waterside relationships are overlooked. This article applies the concepts of risk reduction, contingency planning, and incident response to these problems. Analysis reveals that the key elements of the Texas City Disaster were ignorance and complacency about hazardous materials, system interaction, and a perceptual and organizational void between land and marine operations. Although safety practices have improved since 1947, uneven relationships between potential system interaction and disaster response capabilities persist at ports and along navigable waterways and constitute the potential for future hazardous material disasters.

The context

The explosion of two Liberty ships at the Texas City docks on April 16 and 17, 1947, initiated the worst industrial disaster in United States history. Both ships had large amounts of ammonium nitrate fertilizer in their holds. The GRANDCAMP was the first ship to blow up. A smoke column billowed 2,000 feet into the air and heavy fragments and flaming cargo were scattered out to a radius of one mile. Blast overpressure, heat, collapsing buildings, and shrapnel from this explosion inflicted most of the nearly-600 deaths and 3,000 to 4,000 injuries. Sixteen hours later, as outsiders poured into the community to help, a second ship, the HIGH FLYER, disintegrated in an equally powerful explosion. Although few persons were killed or injured when the latter blew up, damage to refineries, businesses, and residences was even more extensive. No window in Texas City remained unbroken. Total property losses were estimated at $50 to $75 million in 1947 dollars. Approximately one-third of all dwellings were demolished and 2,500 people

were homeless. (Wheaton,1948) Secondary explosions continued for another twenty-four hours and oil tank fires burned for five days.

Given such spectacular features, it should come as no surprise that a considerable body of writing exists on the Texas City Disaster. These accounts focus upon the ship explosions, casualties and property damage, heroic search and rescue, and spontaneous infusion of outside assistance. Such matters make for interesting history but fail to put this important event in perspective or to improve our understanding of conditions associated with hazardous materials disasters in contemporary times. But, are there valid lessons to be derived from a disaster that happened forty-six years ago? After all, conditions have changed vastly since 1947. Elaborate research and information and comprehensive safety regulations have displaced past ignorance and complacency about hazardous materials transportation. And we are better attuned to the potential for such disasters, habitually assessing situations for potential risk and formulating contingency plans for response should they actually occur.

Such improvements not withstanding, there are several reasons why the Texas City Disaster merits further examination. First, perhaps because it is an early instance of post-World War II hazardous chemical transportation disasters, most of the casual references that I have encountered misrepresent its fundamental characteristics in some way. For instance, a 1983 article (Rogalin) on port risk management states that the Disaster was triggered by the collision of the GRANDCAMP and the HIGH FLYER, while another study (Shrivastava,1987) attributes the Disaster to the explosion of a single ship. In his comprehensive review of industrial disasters, Patrick Lagadec (1982) asserts that the explosion of the HIGH FLYER "caused hundreds of deaths", but a study of the economic development of Texas City (Benham,1987) states that "there was no loss of life" when this ship blew up.

Second, Texas City is a low-probability/high consequence event capable of yielding valuable information about progress in crisis management since 1947. But it has never been examined with this in mind. Key elements of disaster analysis have been overlooked, such as antecedent conditions and the ramifications of an absence of contingency plans upon response efforts. As a result, we have an incomplete and somewhat distorted impression of what happened and why. If Texas City is to be compared to similar events at other times and places, analysis must identify the major contributing factors, demonstrate how patterns of interaction produced the catastrophe, and present the results in a form facilitating comparison.

Third, Texas City has contemporary significance because both land and marine environments were part of its origins and impact. Conditions are such that ports and navigable waterways are still at considerable risk to hazardous materials disasters. Hazards are high because they are sites for production, storage, and transport of large amounts of highly explosive, flammable, or toxic substances. Vulnerabilities are extensive because facilities are

often located in close proximity to each other as well as to large urban areas. In consequence, our knowledge of hazardous substances, safety practices, and preparations for major emergencies is much better today, but as David Orr (1979) notes, the potential for disaster is always present where technology and its control systems interact. That is, the juncture of landside and waterside operations is a place where achieving requisite integration between the two sets of activities is both important and extraordinarily difficult. Most particularly, when a cognitive and/or organizational void exists between landside and waterside operations, there is every likelihood that the scope and scale of disaster impact may not be matched by the similar dimensions of response capabilities. (Stephens,1989) Analogous to EXXON VALDEZ and other recent catastrophic oil spills, Texas City was a product of an exceptional confluence of interactions whose destructive potential was overlooked because screening systems were not designed to consider the possibility of harmful contacts across the divide between land and marine environments. Moreover, fires, explosions, or toxic releases can be expected to visit considerably more harm upon people and property than will ever happen from oil spills.

The reader should understand that while it is possible to rectify misunderstandings about the basic features of the Texas City Disaster, the necessarily limited scope of this effort allows only preliminary comparisons to more recent landside-waterside crises. I address the matter of the larger lessons of the Disaster and interaction between land and marine environments by means of three interdependent elements of crisis management analysis: risk reduction or mitigation, contingency planning, and incident response. (Harrald, Marcus, Wallace, 1990) Together, these concepts provide criteria of evidence about interactions among circumstances and events which triggered the disaster and constrained response. Risk reduction or mitigation encompasses identification of hazards—both landside and waterside—personnel training, safety practices, and citing of port facilities. Contingency planning includes warning, provisions for direction and control, and availability of physical and financial resources for containing casualties and property damage prior to a disaster. The third element, incident response, encompasses a variety of actions undertaken as a disaster unfolds; in this instance, analysis will focus upon search and rescue, medical treatment, fire suppression, access control, and damage assessment. It should be noted that some aspects of disaster management, particularly recovery, are excluded from the analysis.

Together, these elements reveal that Texas City constitutes a classic example of severely-flawed disaster management. This is especially so with respect to risk reduction and contingency planning. Keeping in mind Barry Turner's (1978) admonition that disasters are fully understandable only when considered within their social and administrative context, I first take up the question of why significant risk reduction or mitigation measures

were not in place at the time. Next, I describe the series of events leading to the explosion of the GRANDCAMP and the character of immediate response. This demonstrates that, despite considerable bravery and resourceful actions on the part of responders, the absence of any sort of contingency plan seriously constrained response after the GRANDCAMP blew up. Finally, the ensuing confusion shows how a perceptual and organizational void between land and marine operations at Texas City exacerbated devastation by allowing the HIGH FLYER to explode because no one thought to assess damage and check for secondary hazards in the marine environment..

Antecedents

Texas City is located on the mainland side of Galveston Bay, some ten miles north of the City of Galveston. The town has a deepwater port in a landlocked harbor. A railway spur to several major trunk lines running between Galveston and Houston provides excellent rail access to the Midwest. It experienced considerable industrial development prior to and during World War II and had become an important port on the Gulf of Mexico. The docks handled 2,661 ships and 10.4 million tons of oil in 1947, as well as dry bulk cargoes of cotton, grain, tin ore. (Benham, 1987:341). Industrial development was accompanied by increased hazards, however, in the form of nine petroleum refineries and a facility for making styrene. Hazard levels increased still more in 1946 when the port began to transship ammonium nitrate fertilizer from Government ordnance plants in the Midwest destined for Western Europe.

Texas City was not prepared for any sort of major industrial emergency at the time, although there was a volunteer fire department of twenty-nine men and four trucks. Refineries had their own fire fighting teams. It is difficult to ascertain why this was so, since serious fires had occurred at the docks and at some refineries. According to one report, some planning had been accomplished for hurricanes, but not industrial disasters. (Logan,1951) No account of events suggests that the estimated 18,000 residents or the substantial body of commuting workers were particularly concerned about threats from this quarter. This was an "age of technological innocence" (Wenk,1989:46) and long before Bophal, when hazardous materials were not as extensively used as was the case even a generation later. Indifference may have been abetted by the absence of external regulatory pressure. Federal Government activities and regulation in the field were embryonic. The resulting imbalance between risks and awareness was succinctly set forth in a report on the Disaster submitted to the National Board of Fire Underwriters: (Braidech,1948:16)

. . .a considerable number of processes and resulting products have. . .become accomplished facts before a full opportunity was presented to fully develop proper safeguarding measures and suitable controls. The grim

urgencies of our last war have crowded into the past five years at least two decades of normal research and development.

Ignorance of the explosive potential of ammonium nitrate fertilizer was therefore not atypical. Apparently no one knew that the substance had produced several devastating explosions in the past. Subsequently, one investigator (Armistead,1947) discovered that it had precipitated thirteen earlier catastrophes, including one at Oppau, Germany, which killed more than 500 people. A U.S. Bureau of Mines report stated that ignorance about the hazard of bulk ammonium nitrate fertilizer in the presence of fire or open flames "was practically universal, even including experts manufacturing or handling this material". (Kintz, 1948:32) The 100 lb. paper bags in which the fertilizer was shipped had no warning label, and surviving longshoremen testified that they had believed it to be in the same class as cement. Indeed, some 75,000 tons of the fertilizer had already transited the port without incident. (Kintz,1948) Those crew members and stevedores who left the GRANDCAMP when the fire broke out in Number 4 hold did so out of concern for small arms ammunition known to be on board.

Whatever hazards lurked at refineries, the styrene plant, and the docks, their mutual proximity was a fundamental ingredient of disaster. One postmortem states that this circumstance represented "a major exposure threat of high-valued properties" at the waterfront".(Braidech,1948:1) Since neither Texas law nor local ordinance mandated zoning for safety, land use reflected the commercial interests of leases granted by the Texas City Terminal Railway Company. As the Map indicates, several blocks of residences were also located adjacent to the Monsanto Chemical Company plant and within 2,500 feet of Dock O, where the GRANDCAMP was moored. Lacking harsh lessons from the past, apparently no one considered the possibility that fire or explosion from an accident might spread harm far beyond the initial source. Elizabeth Wheaton (1948:viii) quotes one long-time resident of the city as stating:

Hundreds of ships have been afire, or have had fires in their cargoes, at Texas City wharves. A few were serious and costly. With a fire to fight, no ship's master has ever been ordered to take his vessel from a Texas City wharf, out of reach of firemen and help from shore.

The potential scale of harm was exacerbated because refineries and port facilities were not segregated or buffered from each other. R.Adm. F.D. Higbee (USCG,Ret.), Warden of the Port of Los Angeles, (Higbee,1947) found the concentration of industry at the waterfront incomprehensible when more land was available. In sum, proximity of docks to facilities making highly explosive or flammable products embodied potentially tightly-coupled, complex relationships, creating what Charles Perrow (1984:342) calls the "catastrophic potential of a high risk system".

Permeating and sustaining these elements was the "Boomtown" social climate of Texas City. Evidence on this point is limited, but it is implicit in

much of the literature as a contributing factor to public indifference toward industrial hazards. Newcomers, arriving in unprecedented numbers in search of employment at a time most of the country was mired in a recession, were not inclined to raise objections. While the actions of the townspeople and others in the area following the explosion of the GRANDCAMP demonstrates the presence of a strong "ethical perspective" toward protection of life and property, (Comfort, et.al.1989:36) as is often the case, its citizens may have been willing to take risks in exchange for immediate, tangible payoffs. This is still the norm for individuals; refinery workers or others who perform dangerous jobs and understand their vulnerability may nevertheless conclude that greater risks are justified.(Tierney,1981) Certainly, neither Boomtown conditions nor an influx of newcomers served to counteract the sense of personal invulnerability which many persons assume as a defense against the dangers of everyday life.

In sum, public complacency in an extremely hazardous situation, a virtual absence of mitigation, and ignorance of the explosive qualities of ammonium nitrate fertilizer created a situation of considerable risk. But risk at Texas City was more than a matter of surprise arising from complacency; an emergency plan and resource commitments were absent as well.

The Explosion of the GRANDCAMP

Modern operating systems provide numerous opportunities for catastrophes. Fortunately, few come to fruition. Yet, as Karl Weick (1988) asserts, serious crises may arise from small volitional beginnings in human action, intertwining with other events to produce unusual and unexpected simultaneous failures. These failures are particularly difficult to anticipate when combinations are unforseen and temporary. Ammonium nitrate fertilizer will explode only when subjected to extreme heat and pressure; this is exactly what happened during an effort to extinguish a fire which broke out on the GRANDCAMP.

At about eight o'clock, the morning of the 16th of April, longshoremen uncovered the hatch on Number 4 hold of the French Liberty ship GRANDCAMP, moored at Pier O, to resume loading bags of ammonium nitrate fertilizer. Some 2,000 tons were already on board. A few minutes later, a small fire was discovered in the hold, which jugs of drinking water and a portable extinguisher failed to put out. Perhaps hoping to avoid damage to the cargo, rather than trying to drown the fire with water from a ship's hose, the Master ordered hatches battened down and covered with tarpaulins. The ship's steam fire-smothering system was then activated. Within the confines of the hold, the resulting combination of heat and pressure initiated thermal decomposition of the fertilizer and produced large amounts of combustible gas. As this process continued, the hatch covers blew off and reddish smoke billowed into the sky.

At this point, some thirty minutes after the fire was discovered, the

GRANDCAMP's whistle sounded an alarm and the crew was ordered off the ship. Twenty-seven members of the volunteer fire department arrived with several trucks and began setting up hoses. A photograph taken about fifteen minutes later, at approximately 8:45 a.m., shows streams being directed on the deck, which was apparently hot enough to vaporize the water. Although the police set up two vehicle barricades where Dock O began, no one sensed extraordinary danger, and a crowd of about 200 onlookers gathered nearby.

About nine o'clock, flame was added to the smoke column. Twelve minutes later, the ship disintegrated in a prodigious blast heard 150 miles away, creating a mushroom cloud about 2,000 feet in altitude. Those crew members still on board were obliterated, as were the fire fighters and almost all bystanders. Fragments of the ship were thrown several thousand feet into the air along with flaming balls of sisal and cotton, also part of the cargo. In addition to the carnage at pierside, given the close proximity of residences and petrochemical facilities to the docks, blast overpressure, heat, and shrapnel inflicted numerous casualties and heavy property damage within a 2,000 foot radius, and to a lesser degree, beyond this range as well.(Blocker,1949) Ship fragments, some weighing hundreds of pounds, ripped open pipes and tanks of flammable liquids, starting secondary fires and explosions. The town's electric power and some water systems were knocked out, although underground gas lines sustained only one break. The Monsanto Chemical Plant, directly across the slip from Dock O, burst into flame from flying debris and metal. A series of small explosions took place in the plant area, killing 145 of 450 shift workers. The force of the blasts and the resulting tidal wave tore the HIGH FLYER from her moorings in the next slip and lodged her against another vessel, the WILSON B. KEENE. Most of the houses in the adjoining residential area collapsed.

It is important to understand that this disaster, which inflicted such great harm to people and property on land, originated in the maritime environment. While proximity of residences and refineries to the docks was fundamental, poor marine safety practices and shortcomings in landside-waterside relationships exacerbated matters. Texas City did have a harbor master, but he was killed when the GRANDCAMP blew up and no one was available to direct waterside response. Considering that the port handled a large volume of petroleum and chemical products, marine fire fighting and other emergency capabilities were grossly inadequate. There were water tanks at the dock, but the nearest fireboat was stationed at Galveston, about forty minutes away. Mistakes in ship berthing—what Admiral Higbee termed "poor in-port seamanship" (1947:21)—immobilized the HIGH FLYER and the GRANDCAMP: both ships were undergoing repair, preventing them from moving under their own power, and the GRANDCAMP was moored with her bow pointing toward land and could not have been moved without assistance from tugs, which also had to come from Galveston.

Response

This was not a disaster where harm was exacerbated because would-be rescuers remained ignorant of the event for a long period of time. Shock waves and the huge column of smoke made a "statement" so abrupt as to command immediate cessation of non-essential activities and generate spontaneous assistance from surrounding communities. In Galveston, the concussion shattered glass and knocked people to the ground. Buildings shook fifteen miles away in Baytown. Smoke columns served as a beacon for automobile drivers who immediately diverted from their destinations and went to help. Ambulances and doctors set out from Galveston within thirty minutes without waiting for summons, joined by others from surrounding communities, military bases, and soon thereafter, from fifty miles away in Houston.

Emergencies originating from explosion and fire or release of toxic materials feature rapid onset, low predictability and warning time, and high intensity within a given radius.(Godschalk, 1991) Quality of response turns on whatever is immediately available. In this instance, while the force of the GRANDCAMP's explosion was virtually without precedent in the United States, a less powerful blast probably would not have made much difference; even before the fire department was obliterated, municipal and plant fire suppression capabilities were sufficient only for ordinary emergencies. Nothing was in place to facilitate coordinated action between municipal and company fire fighting capabilities, or for calling up assistance from other communities. One investigator summarized the situation in the following terms: (Tryon,1948:2)

The lack of either a Disaster Plan or prearranged mutual aid agreements was painfully evident....no concerted effort toward fire suppression was achieved for at least 48 hours following the initial blast....The wonderful examples of personal initiative and heroism which marked the early hours of rescue and salvage work lacked the necessary direction in many cases.

As a result, incident response was piecemeal, poorly-focused and slow to develop. Mayor J.C. Trahan and Police Chief W.L. Ladish were obliged to improvise virtually everything, using such expertise and resources as happened to become available. Not until about two o'clock in the afternoon did community-wide efforts get underway, and an "executive director" was not appointed to coordinate assistance offered by a multitude of government and private entities outside the community until the next day. (KPRC:1947) Although the enormity of the Disaster did obviate "turf battles" among participating groups and most decisions were made cooperatively whenever someone perceived a need, it was never clear who was "in charge" at the scene. (Garrison,1947) As described in one report: (Logan, 1951:46)

The mayor and the chief of police were commanders without a staff, with only a sketchy estimate of the situation, no plan of operation, and with little knowledge of the size and disposition of their forces. Yet reinforcements, badly needed and begging for assignment, were crowding around them.

Thanks to assistance from neighboring communities, some organizational resources were available early on. Together with the Red Cross, military units from nearby bases endowed the initial response with most of its timeliness and cohesion, providing doctors and nurses, medical supplies, transportation, and messing facilities within a few hours.(Stone,1987) State and local law enforcement officers began to converge on the scene within thirty minutes after the GRANDCAMP exploded. Patrols and roadblocks were quickly established, and although the town was not cleared of the curious and those seeking relatives until evening, little looting was reported.

Sustained by the courage and resourcefulness of many citizens and generous assistance from outside, immediate, obvious needs were fulfilled reasonably well. Citizens and rescue personnel plunged into the smoking wreckage around the docks to extract the injured and dead, even though periodic rumors of impending explosions and toxic gas releases slowed their work. Extensive casualties quickly overtaxed the town's medical facilities. The Auditorium was pressed into service as a collecting and treatment center for many of the more than 3,000 injured, the overflow eventually spreading onto the lawn behind City Hall. As the local hospital and those in Galveston quickly filled, about 800 persons with serious injuries (Blocker,1949), were routed to neighboring communities and to several military installations. An abandoned garage served as a makeshift morgue. Much of the burden of caring for the wounded, homeless, and bereaved was assumed by the Red Cross, which quickly flew in personnel and collected relief supplies from all over Texas.

The fact that some aspects of incident response were performed poorly or not at all reflected the absence of a contingency plan and previous resource commitments. Foremost among these were fire suppression and communications. Only on the 17th was a committee of company representatives cobbled together to formulate a plan for suppressing the multitude of fires around the docks and at refineries and tank farms. Even so, meaningful progress was not made until the next day when the Chief of the Houston Fire Department took charge and the single shell-topped road leading to the turning basin was cleared of debris, allowing pumpers to draw water.(Fogaley,1947) Communications were of like quality. Networks were informal and operated sporadically, even though striking telephone operators immediately returned to their jobs. A loose network of mobile radio transmitters from the Army, State Police, Coast Guard, and "ham" radio operators relayed messages in and out of town, but without central direction and cognizance, gaps and inconsistencies persisted throughout the crisis. Some efforts proved unnecessary. For instance, at considerable personal risk, a superintendent of the Houston Natural Gas Corporation directed volunteer workers in shutting down the town's natural gas transmission system. When only one line rupture was found and shortages developed at hospitals, the morgue, and messing facilities, service had to be restored.(Braidech,1948)

Amidst the shock and confusion following the GRANDCAMP's explosion,

some less-obvious but vital incident response activities were overlooked. Abetted by an organizational gap between activities in the harbor and those on shore, failure to assess damage and identify secondary hazards allowed a second ship to explode.

The Explosion of the HIGH FLYER

Sixteen hours elapsed between the explosion of the GRANDCAMP and the HIGH FLYER. Not until the final two hours, after a fire had broken out in one of her holds, was an attempt made to move the latter ship. We will probably never know exactly why so much time was squandered, but two circumstances certainly contributed to the lapse. One was extensive physical damage in the dock area; all accounts, including photographs, testify to extensive fires at pierside, thick black oil smoke drifting across the water driven by a northerly breeze, debris strewn about the turning basis, and severe damage to the HIGH FLYER. The other is attributable to the stress of the moment, uncertainty, confusion, and absence of direction.

Recall that the force of the GRANDCAMP's explosion had torn the HIGH FLYER from her moorings in the adjoining slip. Unable to move under her own power because her turbines were dismantled for repair, she had drifted across the slip and lodged against another ship, the WILSON B. KEENE. The HIGH FLYER's cargo included 2,000 tons of sulphur and 1,000 tons of ammonium nitrate fertilizer. The ship's hatches had been closed but were blown off by the force of the GRANDCAMP's explosion. Representatives of the shipowner, Lykes Brothers, tried to get two tugs which had arrived too late to move the GRANDCAMP to pull away the HIGH FLYER, but the captains refused and left after picking up survivors. About an hour later, sulphur fumes obliged the Master of the HIGH FLYER to order off the crew. No fire was observed at the time.

Damage assessment is a demanding task in a disaster when carried out under stressful and sometimes dangerous circumstances.(Comfort,1989) Yet, particularly when explosive, flammable, or toxic substances are involved, it is necessary to seek out secondary hazards which might create new threats. Confusion and the void between landside and waterside operations meant the danger posed by the HIGH FLYER's cargo was simply overlooked until a fire broke out in the ship's hold around six o'clock in the evening.

Not long after the GRANDCAMP exploded, two small Coast Guard boats arrived at the port. According to the Record of Proceedings of the Coast Guard Board of Investigation, one of these was a fire fighting tug based at the Galveston lifeboat station. It got underway for Texas City immediately after the GRANDCAMP blew up, arriving before 10:00 a.m.(USCG,1947) The Chief Petty Officer in command apparently did so spontaneously, without guidance or information about local conditions. The second boat was the buoy tender IRIS. Both commanders told the Investigating Board that fire

and smoke obscured the scene and prevented them from approaching the docks. The boats engaged in search and rescue operations in the outer part of the turning basin, but conditions apparently discouraged investigation of the KEENE or the HIGH FLYER. The commander of the IRIS testified that the boats were ordered out about 2:00 p.m. by a message received from an Army radio transmitter on shore. The IRIS did have casualties on board requiring hospitalization, but why this was done and on whose authority is not clear. The fact that, after reaching Galveston, he then drove to Texas City on his own initiative to assess damage indicates the prevalence of confusion and poor landside-waterside communications. Although somewhat self-serving, the Record of Proceedings (1947:548) probably accurately represents the relationship between those on land and those operating in the turning basin during the 16th:

. . .the Coast Guard vessels were in receipt of conflicting orders requesting action on the waters of the port which were followed by order to evacuate the area. Coordination of the shore and floating facilities left much to be desired.

For example, this document cites an order given about 7:30 p.m.—source unspecified—for all vessels to leave the waterfront because an explosion was imminent. This was followed fifteen minutes later by a request from "another authority" for tugs to remove the HIGH FLYER.(USCG,1947:548) In sum, I have found no evidence that anyone took action to deal with the HIGH FLYER between 10:30 a.m. and approximately 7:30 p.m. Rumor placed ammunition on board, but Colonel Homer Garrison of the State Police later wrote that "we couldn't get anybody to say authoritatively whether the ship was likely to blow up or not". (1947:35-36)

Some two hours elapsed after the HIGH FLYER's cargo caught fire before someone called Galveston, asking for volunteers to man tugs and tow off the ship. Ultimately, it was almost 11:00 p.m. on the 16th when volunteer crews were assembled and two tugs arrived. Although there was concern that the HIGH FLYER might explode, a blowtorch party boarded the ship and cut the chain of an anchor which had dropped into the water. The tug crews then rigged lines to the ship but were unable to move her more than about 50 feet. (Armistead,1947) By 12:50, shooting flames from the hold and knowledge that ammonium nitrate fertilizer was in the holds prompted the tugs to retrieve boarding parties, cut the tow lines, and move quickly away. At 1:10 a.m. on the 17th the HIGH FLYER disintegrated in a blast witnesses stated was even more powerful than that of the GRANDCAMP, taking the aft part of the KEENE as well.

Because the waterfront had been cleared of rescue personnel, the explosion killed only two or three persons and injured several dozen but added greatly to property damage. The remaining waterfront structures were levelled and the town was again showered with glowing pieces of shrapnel. Oil tanks exploded at all but one farm and terminal, and fires began to spread from one tank to another in synergistic reaction. No sooner would company

fire fighters at one facility bring the situation under control than another crisis would erupt elsewhere. As noted earlier, real progress in fire suppression began only on the 18th, when the single shell-topped road to the docks was cleared of debris, allowing pumper trucks from the Houston Fire Department to draw water from the turning basin. A pall of black smoke hovered over the town until the last fires were extinguished on the 21st. Oddly enough, ammonium nitrate fertilizer stored in a warehouse near the docks did catch fire, but without confinement, failed to explode. Coast Guard fireboats later extinguished the blaze and washed the remainder into the slips.

Conclusion

At the outset, I advanced three reasons why, despite a lapse of forty-six years, the Texas City Disaster merited re-examination. The first of these, dispelling misconceptions about its basic character, can be disposed of quickly. Hopefully, the detailed narrative of events, including particulars about the explosions of the GRANDCAMP and HIGH FLYER and the damage they inflicted, has accomplished this purpose. Providing comparisons to more recent crises and insights about landside-waterside operations are much more profound and difficult. Accordingly, in conclusion, I will focus upon several major features of the Texas City Disaster which have parallels in more recent crises, particularly the element of interaction between land and marine environments, and include observations about pertinent aspects of crisis management theory. Given the necessary brevity of this examination, the reader should understand that conclusions are necessarily tentative.

First and foremost is the question as to whether or not Texas City was so much a product of circumstances following World War II that it provides few insights of contemporary validity. The argument for limited comparability rests upon two basic conditions: pervasive ignorance and complacency concerning the dangers posed by hazardous materials transportation, and the embryonic character of risk analysis and emergency management as practical and theoretical fields of endeavor. Complacency was surely the basic reason why no contingency plan for major emergencies was in place even though several refineries were located near the docks. This outlook also helps explain the absence of tugs or fire fighting boats at the Turning Basin and why onlookers were allowed to gather in the vicinity when the fire broke out on the GRANDCAMP. Nevertheless, the logic of the argument for uniqueness is flawed; it implies that knowledge and awareness of hazardous chemicals or other products, as well as better safety practices and crisis management, can obviate catastrophes. Bhopal, Piper Alpha, Ixhuatepec, and a series of recent major oil spills testify to the contrary. Only in degree were surprise, confusion, poor response, and severe devastation of such recent disasters different from Texas City. The parallel with EXXON VALDEZ is especially interesting; just as no one at Texas City gave any thought to the explosive potential of ammonium

nitrate fertilizer, the worst-case scenario of Aleyeska Pipline Service Company was a 200,000 bbl. release over a period of ten hours under ideal weather conditions within Valdez Harbor. The fundamental paradox, note Mitroff, Shrivastava, and Udwadia (1987), is that the less vulnerable an organization thinks it is, the less it prepares and the more vulnerable it becomes.

Events at Texas City suggest a fundamental reason why many industrial disasters are still greeted by surprise, confusion, and poor response: we rely upon complex, extensively-interactive systems, including those used in producing and distributing hazardous materials. Perrow(1984), Turner(1978), Comfort, *et al* (1989) and Mitroff and Kilmann(1984) are only a few among many analysts who count complexity and wide-scale interaction as key elements of disaster. It is the latter quality which facilitates rapid and extensive diffusion of harm initiated by accidents involving hazardous materials, while complexity tends to disguise hazards and potential patterns of development. Moreover, ignorance and complacency do not have to be pervasive for catastrophes to occur—these need apply only to crucial junctures in order to initiate a "break" in a system and set a series of harmful consequences in motion. In the same vein as the Ashland or EXXON VALDEZ oil spills, Texas City is an early example of a "system accident", to use Perrow's descriptor(1984:62). Transportation-related catastrophes are not triggered by malfunctions in a deliberately-coupled production system, as are some industrial disasters like Bhopal and the near-meltdown of a reactor at Three-Mile Island. Interaction at Texas City derived from a combination of the power of the ship explosions and the close proximity of residences and petrochemical facilities to the docks. The latter circumstances were replicated at Bhopal, where most of the 3,000 deaths from the release of methyl isocyanate occurred in the slum area surrounding the Union Carbide plant (Shrivastava,1987). There is some similarity to EXXON VALDEZ and TORREY CANYON in the sense that these ecological disasters were a function of the sheer amount of oil spilled into the sea and the proximity of the tankers to the coastline. Quite beyond the magnifying effects of system interaction, the potential for high-consequence accidents involving hazardous materials will always be ambiguous in ports and along navigable waterways. In a "technical" sense, hazards vary constantly, and possibilities of extensive system interaction are only temporary, depending on the presence or absence and location of highly toxic, flammable, or explosive materials. Hence, it is probably not an exaggeration to state that Texas City was at risk only when ships loaded with ammonium nitrate fertilizer were moored at the docks, or that the ecology of Prince William Sound is in danger only when a supertanker is in transit.

Similar to most industrial disasters, Texas City involved much more than the systemic effects of accidents. To use Turner's (1978) description, the analysis shows that prior conditions, particularly unwarranted assumptions, "incubated" this disaster. In fact, the economic, social, political, and organizational "environment" which Shrivastava designates as a fundamental cause

of the Bhopal disaster, closely resembles the situation which prevailed at Texas City in April, 1947. Both communities had experienced rapid, haphazard industrial development and population growth beforehand. Public self-awareness was embryonic at best. Municipal service capabilities lagged well behind needs, and higher governmental authorities had provided little in the way of protection through regulations or assistance. The prevailing "boom town" psychology of Texas City and the indifference toward hazardous materials risks it fostered brings to mind Mitroff and Kilmann's (1984) concept of cultural norms, or ideology as defined by Starbuck, Greve, and Hedberg (1978) as a key variable of an organization's willingness to confront subtle but dangerous threats. This perspective, particularly with respect to shortcomings of scenario development and deterioration of response capabilities, is a recurring theme in all analyses of the EXXON VALDEZ disaster.(National Response Team,1989; Townsend and Heneman,1989; Harrald, Marcus,Wallace,1990) Richard Elmore's (1988:326) assertion that the "cascade of mundane events" which brought a near-meltdown of a reactor at Three-Mile Island derived from failures in design, management, and regulation, also has its parallel to antecedent circumstances at Texas City.

This raises the matter of contingency planning and incident response as elements of disasters. Since Texas City had no plan for major emergencies, customary evaluation of concepts, organization, resources, and implementation as elements of crisis management is irrelevant. Nevertheless, events at Texas City do suggest questions which merit further study. Consider situational dimensions articulated by Godschalk(1991), Hewitt and Burton(1971), and Kreps (1989); hazardous materials disasters feature sudden onset and limited warning, intense impact, brief duration, a small affected area, and poor predictability. Contingency planning is particularly important under these circumstances because the parameters of response are set by whatever is in place when disaster strikes. Even so, search and rescue, medical assistance, and access control were performed reasonably well at Texas City. But these were obvious needs and were carried out by those with pertinent skills and organizational capabilities who happened to be available at the time. Other, more subtle functions or those without the necessary organizational base, such as fire fighting and communications, were slow in coming on line or were never effective, causing delays and exacerbating property damage.

Finally, there is the matter of relationships between land and marine environments. Here, the larger lessons are much more tentative. The fundamental problem at Texas City was a perceptual and organizational void between the two environments. As a result, despite close physical proximity and extensive interaction of land- and waterside operations, differences in organizational outlook, skills, resources, and access helped disguise mutual hazards, facilitate triggering events, and hinder response. This condition, and not contingency planning failures, was responsible for failure to detect the threat represented by the HIGH FLYER's cargo until it was too late.

What are the implications for contemporary landside-waterside crises? Certainly, knowledge of hazardous materials and safety practices have improved since 1947, but relative to existing hazards levels, it is an open question if disaster potential at ports and along navigable waterways is much less today. Recent experience with major oil spills suggests that the essential problem remains discrepancies between the scope and scale of potential disasters and corresponding dimensions of response capabilities. Differences in organizational orientation, skills, operational criteria, and physical access between the two environments pose serious conceptual and methodological challenges . Certainly, proper understanding of this key relationship requires analysis which extends beyond the simple framework used here to include variables relating to organizational and socio-political context.(Mitchell,1990) Explosions, fires, and toxic releases create "tasks" for which there are seldom "regular" structures at ports or along navigable waterways. Certainly, without sustained and comprehensive investigation to improve response capabilities, the potential for another Texas City lurks in the shadowy void between land and marine environments.

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