

NATIONAL TRANSPORTATION SAFETY BOARD

FOR RELEASE:

P.M.S. of APR 20 1971

HIGHWAY ACCIDENT REPORT

TWO-CAR COLLISION
SOUTHERN APPROACH
TO GOLDEN GATE BRIDGE
SAN FRANCISCO, CALIFORNIA
JULY 11, 1970



NATIONAL TRANSPORTATION SAFETY BOARD

Washington, D. C. 20591

REPORT NUMBER: NTSB-HAR-71-5

SS-H-9

HIGHWAY ACCIDENT REPORT

**TWO-CAR COLLISION
SOUTHERN APPROACH
TO GOLDEN GATE BRIDGE
SAN FRANCISCO, CALIFORNIA
JULY 11, 1970**

ADOPTED: FEBRUARY 10, 1971

**NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D. C. 20591
REPORT NUMBER: NTSB-HAR-71-5**

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No. NTSB-HAR-71-5		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle TWO-CAR COLLISION, SOUTHERN APPROACH TO GOLDEN GATE BRIDGE, SAN FRANCISCO, CALIFORNIA, JULY 11, 1970.				5. Report Date February 10, 1971	
				6. Performing Organization Code	
7. Author(s)				8. Performing Organization Report No.	
9. Performing Organization Name and Address Bureau of Surface Transportation Safety National Transportation Safety Board				10. Work Unit No.	
				11. Contract or Grant No.	
12. Sponsoring Agency Name and Address NATIONAL TRANSPORTATION SAFETY BOARD Washington, D. C. 20591				13. Type of Report and Period Covered HIGHWAY ACCIDENT REPORT	
				14. Sponsoring Agency Code	
15. Supplementary Notes					
16. Abstract A 1970 Porsche Targa (911-T) southbound off the Golden Gate Bridge at 12:30 a.m., July 11, 1970, accelerated to over 100 miles per hour. On a left curve of 1470-foot radius the driver apparently lost control, causing a left swerve and counterclockwise spin and skid into opposing (northbound) traffic lanes. A northbound Mustang with nine young people aboard was struck nearly head-on. All three persons in the Porsche and seven of the nine in the Mustang were fatally injured. Both drivers had been drinking, but their blood alcohol levels were below the .10% presumptive level of impairment under California law. The highway, built in 1937, had lanes 10 feet wide as against a current standard of 12 feet, and there was no median barrier or guardrail. The Safety Board determined that the probable cause of this accident was the excessive speed of the Porsche automobile, which led to loss of vehicle control on the curve of a highway which had substandard lane width and no median barrier.					
17. Key Words Golden Gate Bridge Approach, Head-on crash, Excessive speed, 10 fatalities, Drinking-driver crash, Median guardrail. Identifiers: Golden Gate Bridge, Porsche Targa				18. Distribution Statement	
19. Security Classification (of this report) UNCLASSIFIED		20. Security Classification (of this page) UNCLASSIFIED		21. No. of Pages 43	22. Price

FOREWORD

This accident occurred at 12:30 a.m., July 11, 1970. An investigator from the Highway Safety Division, Bureau of Surface Transportation Safety, was assigned the same day. Investigative support was provided by a Crash Analysis Team from Stanford Research Institute (SRI-CAT), under contract to the National Highway Traffic Safety Administration.

The accident was declared to be "major" under the criteria of regulations of the National Transportation Safety Board, on July 22, 1970.

This report is based on those by SRI-CAT and the California Highway Patrol, in addition to the direct findings of the Safety Board.

The conclusions, determinations as to probable cause, and the recommendations herein are those of the Safety Board.

Table of Contents

	<u>Page</u>
Foreword	iii
Table of Contents	v
I. Synopsis	1
II. Facts	3
The Accident Location	3
The Highway	3
Traffic Controls	3
Environmental Factors	5
The Accident Scene	5
History of the Highway	9
Accident Record of the Bridge Approach	12
The Vehicles	12
The Drivers	16
Witnesses	21
Post-Crash Activities	22
III. Analysis	23
Vehicle Kinematics, Pre-Crash	23
Vehicle In-Crash Kinematics	25
IV. Conclusions	26
V. Probable Cause	29
VI. Recommendations	30
VII. Appendices	33

Illustrations

<u>Figure</u>		<u>Page</u>
1	The Accident Site, Doyle Drive (U.S. 101) Southbound in Lane S-1	4
2A	The Accident Site	6
2B	Approximate Point of Impact and Positions of Rest	7
3	Photograph of the Accident Site Looking Northbound	8
4	Photograph of Accident Scene, Looking Northbound	10
5	Proposed Master Trafficways Plan, City of San Francisco (1955)	11
6	Photograph of V-1 Right Front Area	14
7	Photograph of Rear-Engine Compartment, V-1	15
8	Left Front Area of V-2	17
9	Right Front Area of V-2	18
10	Driver's Compartment and Left Instrument Panel Area of V-2	19

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D. C. 20591
HIGHWAY ACCIDENT REPORT

Adopted: February 10, 1971

TWO-CAR COLLISION, SOUTHERN APPROACH
TO GOLDEN GATE BRIDGE, SAN FRANCISCO, CALIFORNIA
JULY 11, 1970

I. SYNOPSIS

This accident occurred shortly before 12:30 a.m., July 11, 1970, on the southern approach to the Golden Gate Bridge, San Francisco, in clear, dry weather on a well-lighted curve of a six-lane highway, with light traffic. A 1970 Porsche Targa with three occupants, traveling southbound in the inner (S-1) lane at very high speed, went out of control on the curve and skidded 321 feet counterclockwise into the opposing lanes of traffic. It struck a northbound 1965 Mustang with nine occupants, traveling within the speed limit, in a nearly head-on collision. (See Figure 1, Photograph of Accident Site, page 2.)

The highway, 60 feet from curb to curb, has six 10-foot lanes separated by painted lines and reflector buttons, with the centerline marked by 2-foot plastic pylons inserted into the pavement. It has no median barrier and no shoulder area. It slopes downhill in a southbound curve to the left of 1,470-foot radius.

Witnesses' statements, skidmark evidence, and evaluation of energy dissipated in the crash, place the initial speed of the Porsche at somewhere in the vicinity of 100 miles per hour, and of the Mustang at approximately 45 miles per hour. As the Porsche entered the left curve, southbound, for some reason the driver applied brakes and steered slightly left. While skidding, the Porsche went into a counterclockwise spin into the northbound lanes. There was little time or distance to permit successful evasive action by the Mustang driver, who applied brakes at the last moment before impact.

The impact drove the Mustang slightly backward in a counterclockwise rotation of about 100° . The Porsche was bent in the middle about 60° , spun counterclockwise some 130° from its original line of travel, then flipped end over onto its top, coming to rest opposite the Mustang. The Porsche's engine and transaxle broke away at impact and traveled 272 feet and 209 feet, respectively, beyond the point of impact in the northbound lanes.

Ten persons--all three in the Porsche and seven of the nine in the Mustang--were fatally injured. No occupant was ejected and there was no fire. Autopsies showed both drivers had been drinking. The Highway Patrol found no safety-related defect in either vehicle.

The probable cause of this accident was the excessive speed of the Porsche automobile, which led to loss of vehicle control on the curve of a highway which had substandard lane width and no median barrier.

II. FACTS

The Accident Location

The highway at the accident site is designated as U. S. 101 and State Route 2, and is routed south and east from the Golden Gate Bridge over a controlled-access portion of Doyle Drive, 4,900 feet south and east of the bridge toll booths.

A full interchange, about 2,400 feet west of the accident site, permits traffic to use this section of Doyle Drive as a local arterial in traveling from 19th Avenue (a principal route in the western San Francisco residential area) to "the Marina," "Fisherman's Wharf," and "North Beach" areas. Local traffic using this section eastbound must mix with and cross southbound traffic using U. S. 101 from the Bridge into (and through) San Francisco via the Richardson Avenue-Lombard Street exit.

The Highway

The roadway is 60 feet wide from curb to curb, composed of six 10-foot lanes, curving to the left, southbound, in a graduated curve of 1,470 feet minimum radius at its centerline. Southbound, the highway slopes downward at about 4 percent approaching the scene, but at the scene the slope is under 1 percent, with about 1.7 percent superelevation. The outer edges of the roadway terminate in raised concrete curbs, 9 inches high, just outside of which are cement walls about 18 inches high above the curbing. The wall on the southbound side bears marks of many scrapings by vehicles.

The collision occurred in the middle of three northbound lanes, lane N-2. The roadway surface, entering the scene from the west, is of asphaltic concrete (skid factor, dry, approximately .75 at the speed limit); 167 feet west of the point of impact it changes to portland-cement concrete (approximately .74 skid factor).^{1/} There is a dropoff of about 1.8 inches, southbound, where the pavement changes. The portland-cement concrete is in sections of approximately 30 feet, with noticeable "thumps" felt in driving over the section joints at 45 miles per hour. (See Figure 1.)

Traffic Controls

The southern bridge approach is of freeway design with limited access. The six lanes are defined by white, intermittent lines and raised "buttons," with reflector markers about every 40 feet. Throughout most of the day, 2-foot plastic pylons about 100 feet apart, inserted in the centerline, demark three lanes of travel in each direction. During the morning rush hours, these pylons are manually relocated to provide four lanes inbound and

^{1/} Results of tests made by California Division of Highways are in Attachment 3 of the Appendix.



Figure 1. The Accident Site, Doyle Drive (U. S. 101) Southbound, in Lane 5-1, at the Approximate Point Where Skidmarks of Vehicle #1 Began. (Note center pylon, and change in pavement).

two outbound; in the evening rush hours, four lanes outbound and two inbound are provided. At the time of this accident the pylons were in the centerline, which is marked by a solid painted white line.

On the Bridge itself, the same four-lane flow is provided through reversible lanes in peak hours. Recently, to expedite northbound traffic movement, outbound tolls were eliminated but inbound tolls were doubled (to 50¢). A similar practice is used on other major San Francisco Bay bridges.

Speed limit on the Bridge was raised to 50 miles per hour (from 45) early in 1970, but retained at 45 on the southern approach. The signing in both directions is considered adequate.

There is no center barrier of any description on the Bridge or on the southern approach, and no shoulders or emergency stopping lane. A narrow pedestrian path is outside the northbound concrete sidewall, extending to the Bridge.

At the merge point where 19th Avenue traffic enters Doyle Drive, eastbound, one full lane is reserved for entering vehicles. Steel stanchions at this point narrow the main roadway to five lanes, creating a point of constriction for traffic southbound off the Bridge.

Environmental Factors

The weather was clear and without precipitation at the time of the accident; the road surface was dry. Temperature was in the mid-50's, with almost no wind. Visibility was clear, and there are 10,000-lumen sodium vapor lamps 120 feet apart on alternate sides of the roadway, with one light (No. D-340) 45 feet west of the collision point. These lights provide considerably more than ordinary street lighting.

Traffic was light and moving without interruption throughout the approach. There are no distracting features or conditions, other than those arising from interchange traffic at 19th Avenue, between the toll plaza and the accident site.

The Accident Scene

According to California Highway Patrol, the point of impact was identified by scrapes in the pavement in northbound lane N-2, 45 feet east of light standard D-340, and 2 feet north of the dividing line between lanes N-1 and N-2. Just east of this point was a black, single-wheel skidmark, 5 feet long, parallel to the lane dividing line. (See Figures 2-A, 2-B, and 3.)

Leading to the point of impact was a set of tire skidmarks, which began in southbound lane S-1, 321 feet west of the point of impact, crossed the centerline 112 feet west of the point of impact, and angled across northbound

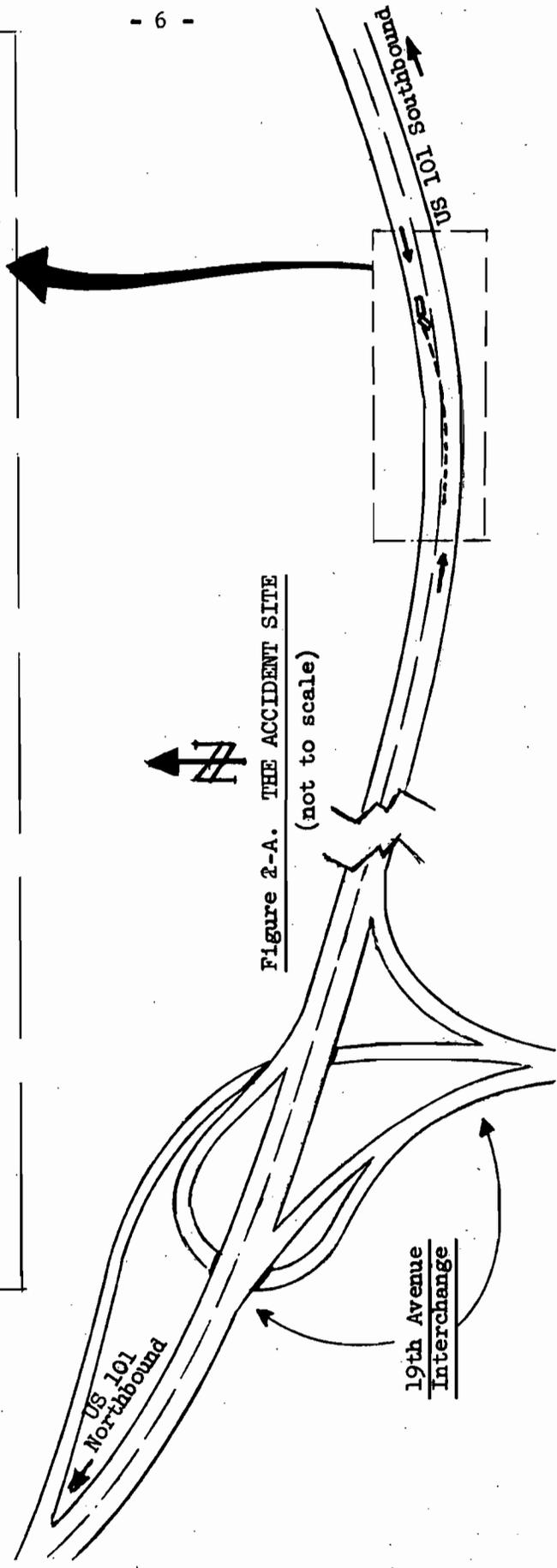
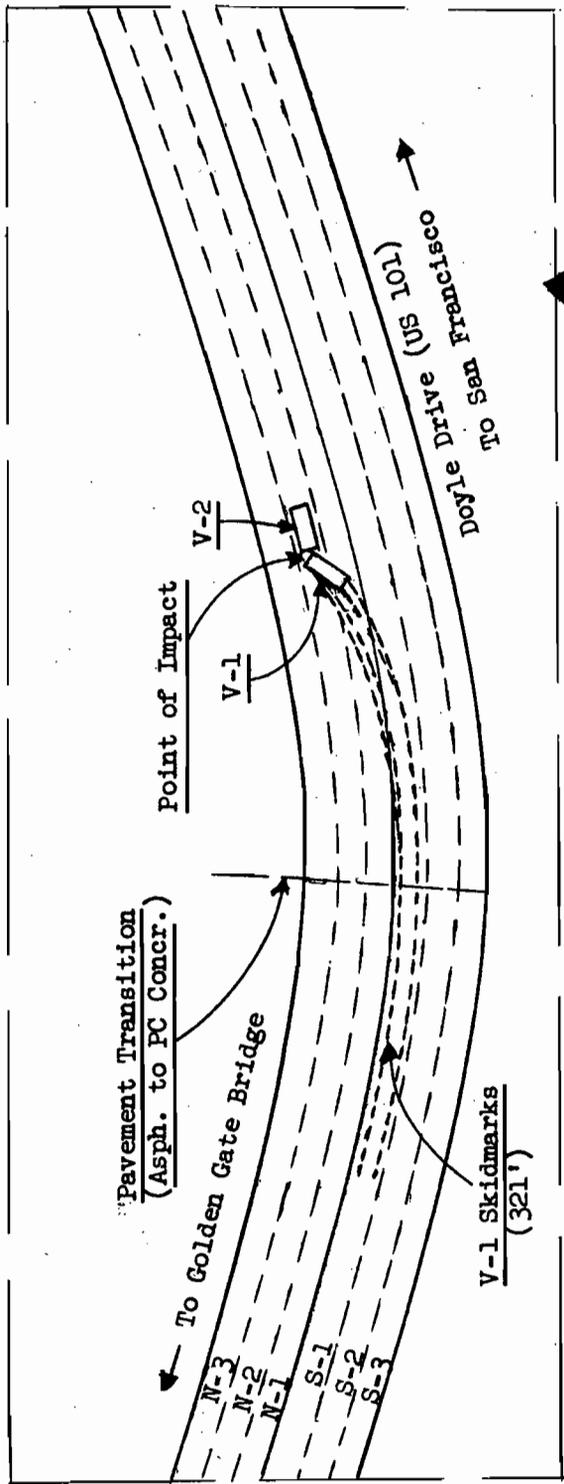


Figure 2-A. THE ACCIDENT SITE
(not to scale)

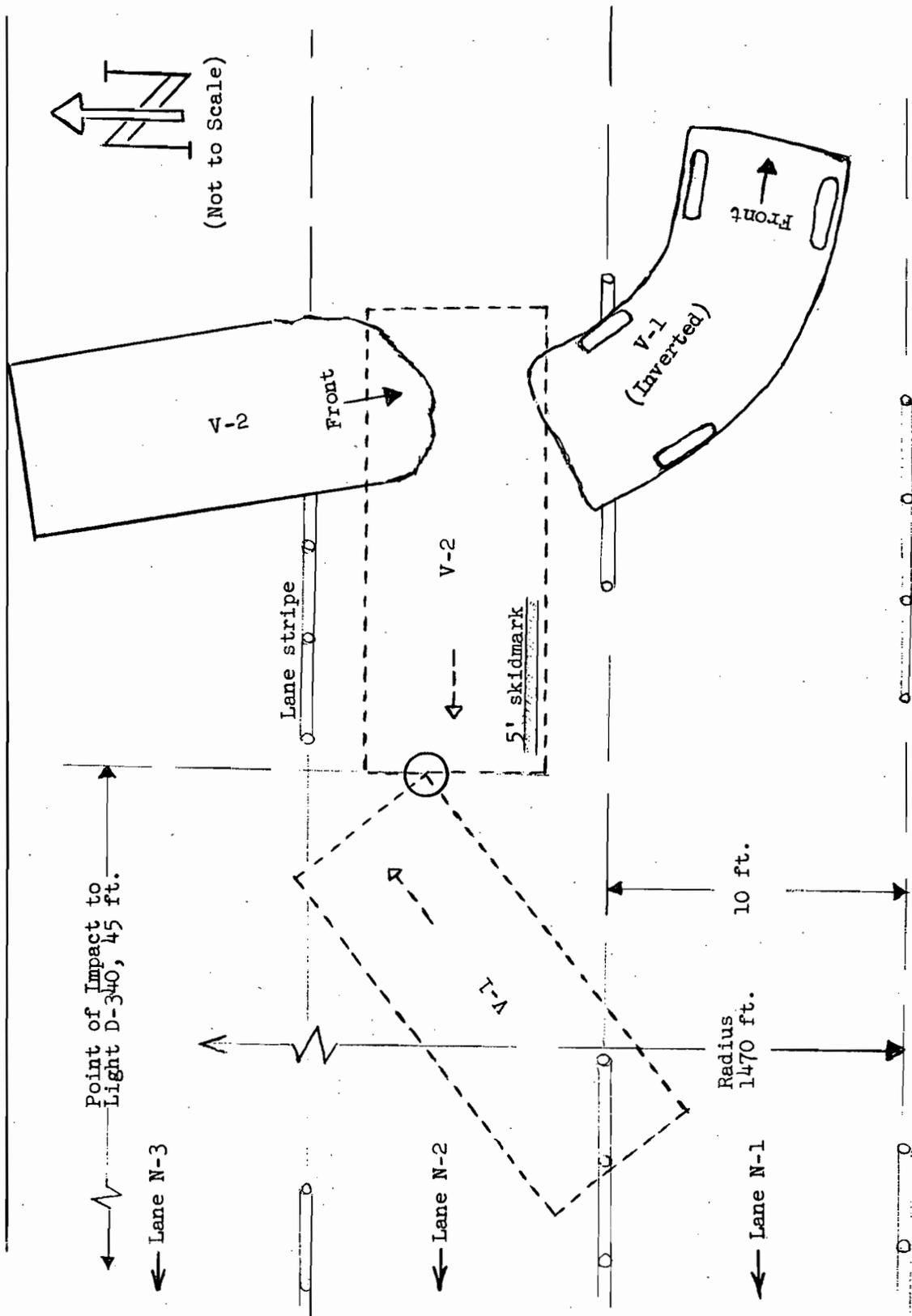


Figure 2-B. Approximate Point of Impact and Positions of Rest, V-1 (Porsche) and V-2 (Mustang)



Figure 3. The Accident Site Looking Northbound. The Approximate Point of Impact is marked "X", in Lane N-2.

lane N-1 to the point of impact. The final 60 feet (approximately) showed three skidmarks. The skidmarks are described by the Patrol as "centrifugal," which they did not define.

Vehicle 2, the Mustang, was found upright, almost perpendicular to the line of travel in lane N-3, its left rear tip against the highway sidewall and its right rear wheel about 8 feet east of the point of impact. All nine occupants were in the vehicle. (See Figure 4.)

Vehicle 1, the Porsche, was directly south of Vehicle 2, lying on its top in northbound lane N-1 at an angle of about 45° to the line of travel and its front pointing southeast. All three occupants were in the vehicle.

History of the Highway

The Golden Gate Bridge and the southern approach were built as an integral system, opened to traffic in 1937. There have been numerous improvements but no dimensional changes to the approach since that date. The Bridge and its approach were designed to carry an estimated maximum of 11,000,000 vehicles per year. At present, the flow is approximately 30,000,000 across the Bridge, with another 10,000,000 using the Doyle Drive segment of the approach as a crosstown arterial. The increased flow has required the use of reversible lanes during peak hours, and a gradual extension of the peak periods.

The southern approach, to its juncture with ground-level city streets, traverses U. S. Army property (The Presidio of San Francisco) in its entirety. Some years ago, the segment from the 19th Avenue interchange and east was turned over to the State Division of Highways for maintenance.

In the 1950's, plans were drafted to link the Bridge with major intracity and through freeways, and to tie into the proposed Interstate System. (See Figure 5 for the proposed trafficways plan adopted in 1955.) However, subsequent city administrations objected to the routes which had earlier been determined, and the proposed segments have been held in abeyance.

In 1955, aware of increasing accidents and congestion, the Golden Gate Bridge and Highway District (as it was then titled) requested the State to widen and reconstruct the southern approach, but this request was not met. The City and County of San Francisco concurred in this request, recognizing that this problem was separate from the larger one of freeway routing, and that the changes would be on Army property entirely.

In 1962, the Bridge District made a second request, this time asking specifically for an eight-lane divided approach, to become a part of Interstate Route 480 connecting with the Embarcadero Freeway over the San Francisco northern waterfront. The Army approved the use of Presidio property for this project. However, the City and County of San Francisco objected to the proposed routing of the freeway hookup, and the State Highway Commission took no action on the request.

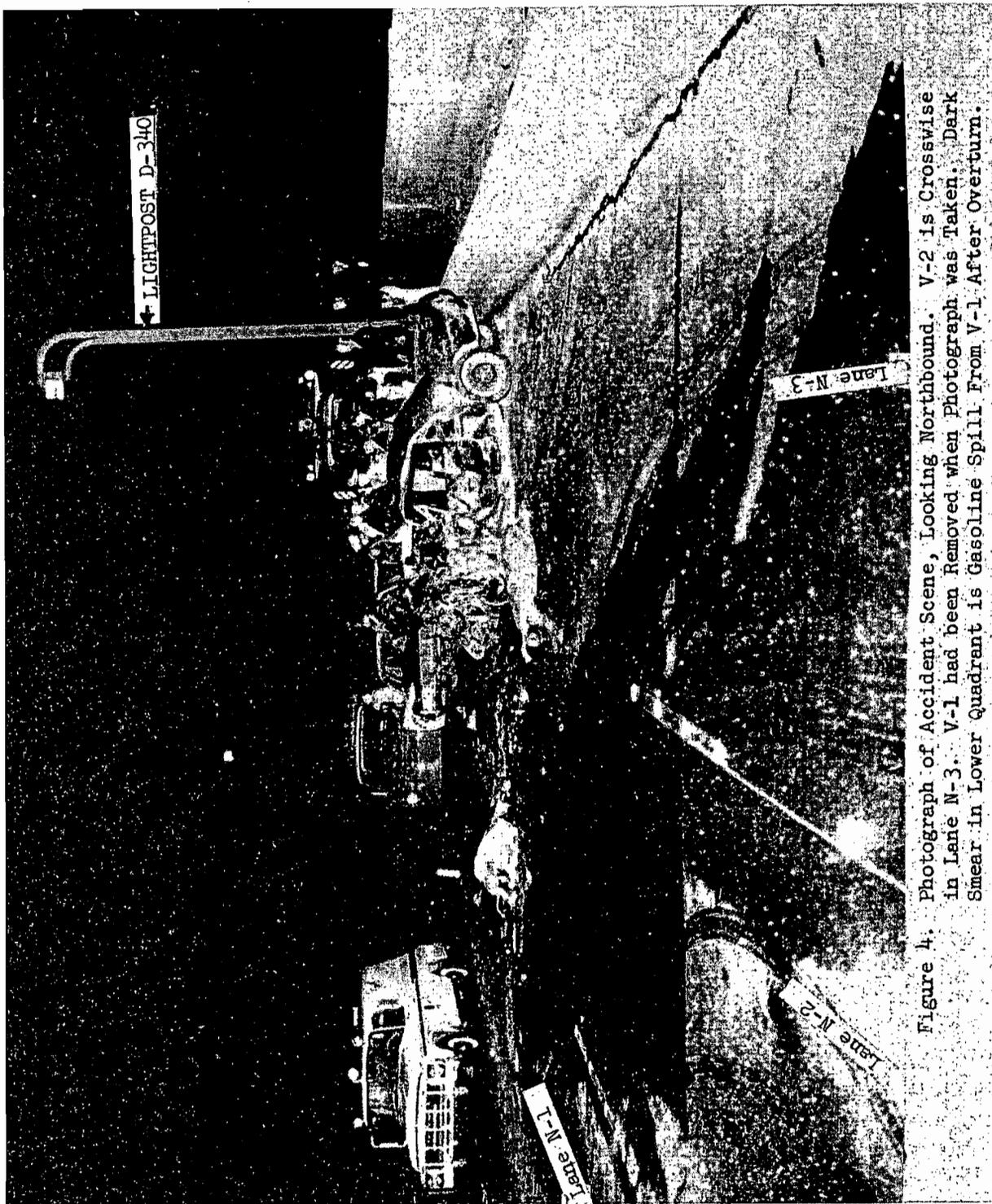


Figure 4. Photograph of Accident Scene, Looking Northbound. V-2 is Crosswise in Lane N-3. V-1 had been Removed when Photograph was Taken. Dark Smear in Lower Quadrant is Gasoline Spill From V-1 After Overturn.

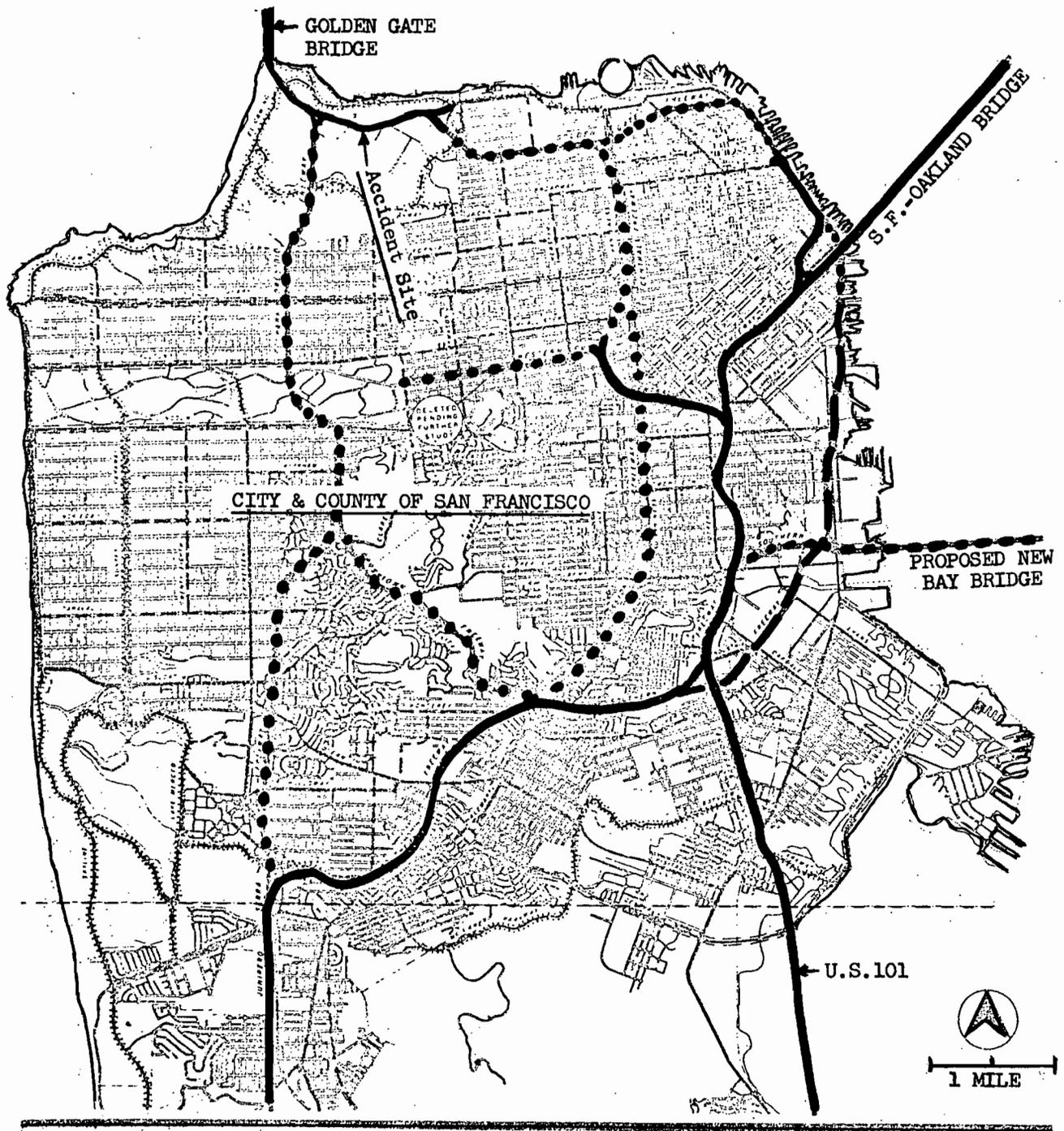


Fig. 5 PROPOSED MASTER TRAFFICWAYS PLAN, CITY OF SAN FRANCISCO

As Adopted in 1955

- COMPLETED TO 1970
- - - - UNDER CONSTRUCTION
- HELD IN ABEYANCE

Another attempt was made in 1965, continuing into 1966, and still another initiated in 1968, extending into 1969. The Highway Commission denied the requests.

On August 19, 1970 (6 weeks after the accident reported herein), the Golden Gate Bridge Highway and Transportation District (current title) appeared again before the California State Highway Commission in an appeal for corrective action. The City and County of San Francisco supported this appeal. In subsequent meetings with the State Highway Commission, the Division of Highways was given a "green light" to proceed with preparing contract plans and reaching agreement with the Bridge authority and City of San Francisco on financing the improvement. It is anticipated that this stage will reach fruition in late 1971, and that actual construction might begin in 1972.

Accident Record of the Bridge Approach

According to the California Highway Patrol, which patrols the Bridge and its approaches, in the past 5 years there have been 409 accidents on the southern approach. Most of these have been rear-ending, sideswiping, and single-car accidents, tending to occur mostly at the points where traffic must merge and cross in using the interchanges.

Of these 409 accidents, some 40 percent were injury producing and 60 percent were property damage only. Of the total involved, 7.5 percent were head-on or head-on-sideswipe collisions. Records show that only one person had been killed in the prior 5 years, but officials point out the potential for major accidents which exists, especially in view of constantly increasing traffic.

The Vehicles

Vehicle 1 (hereafter referred to as V-1), was a 1970 Porsche Targa 911-T painted a bright metallic blue, with pancake-type six-cylinder engine and transmission/axle (transaxle) mounted in the rear. Transmission was five speed, with manually operated "stick" shift. Lap and shoulder restraints were provided for both front seats, with lap belts for two rear seats. Roof was metal convertible, with removable top section, integral rollbar, and fixed rear window. Brakes were four-wheel disc. Wheels were cast "racing" type. Tires were steel-belted radial-ply, with inner tubes. The vehicle, approximately 1 month old, showed under 2,000 miles on the odometer. Its weight, empty, was 2,350 pounds; with the three occupants, it was estimated at 2,775 pounds. A top speed of 125 to 130 miles per hour is claimed for this model Porsche.

Registration (California temporary, No. 0594829) was in the name of Robert Symons, 1590 Sutter Street, San Francisco, who was the driver of V-1.

Exterior visual examination, and photographs taken of V-1 on July 12, 1970, showed virtually total destruction of this vehicle. Principal damage consisted of:

The right midsection was crushed inward, with the upper part of the right door bent in, approximately to the vehicle's midline, and extreme crushing and distortion to all sheet metal. Concurrent with inward crushing was a bending of the chassis, so that the front end was distorted approximately 60° clockwise. The windshield was missing, and the windshield frame was distorted about 60° clockwise from its original position, along with the entire front body section. Both A-pillars were bent rearward. The built-in rollbar was crushed downward on the right side, and the entire bar distorted rearward. The fixed rear window was missing. The cover over the rear engine compartment was distorted to the right and upward. The engine and transaxle were missing, and marks in the forward wall of the engine compartment showed heavy metallic-type scrapes upward and to the right. The left side of the vehicle had been elongated by the severe bending force, and the left side door was displaced and bent downward. The forward end of the chassis had been distorted upward about 30° from the original configuration. The right tires, both front and rear, were deflated and partially off the rim. The left front tire was also deflated, but was in place on the rim.

The steering wheel was bent inward in the lower right quadrant, but the steering column did not appear to be noticeably displaced or compressed. The front right seat had been displaced inward. The left front-seat back was distorted rearward and showed a clockwise twist. The left rear-seat back was dislodged from its mount. (See Figures 6 and 7.)

Vehicle 2 (hereafter referred to as V-2) was a 1965 Ford Mustang two-door hardtop painted maroon, with V-8 engine and manually operated transmission, and equipped with lap belts, front and rear, for four persons. Tires were standard bias-ply with about 60 to 80 percent tread on the rear and about 10 to 15 percent tread on the front. Its empty weight was approximately 2,800 pounds, and with nine occupants it weighed about 4,150 pounds.

Registration (California license plates CZF-394) was in the name of R. M. or M. S. Urrea, 2149 17th Avenue, San Francisco, and it was operated by Albert F. Urrea of the same address.

Exterior examination, and photographs taken of V-2 on July 11, 1970, showed the following principal damage:

The entire front end of the car was crushed back in what appeared to be a general battering rather than a single clean blow. The hood was distorted rearward and upward; the front fenders, grille,



Figure 6 Photograph of V-1 Right Front Area. Note Deep Penetration of Door Area.

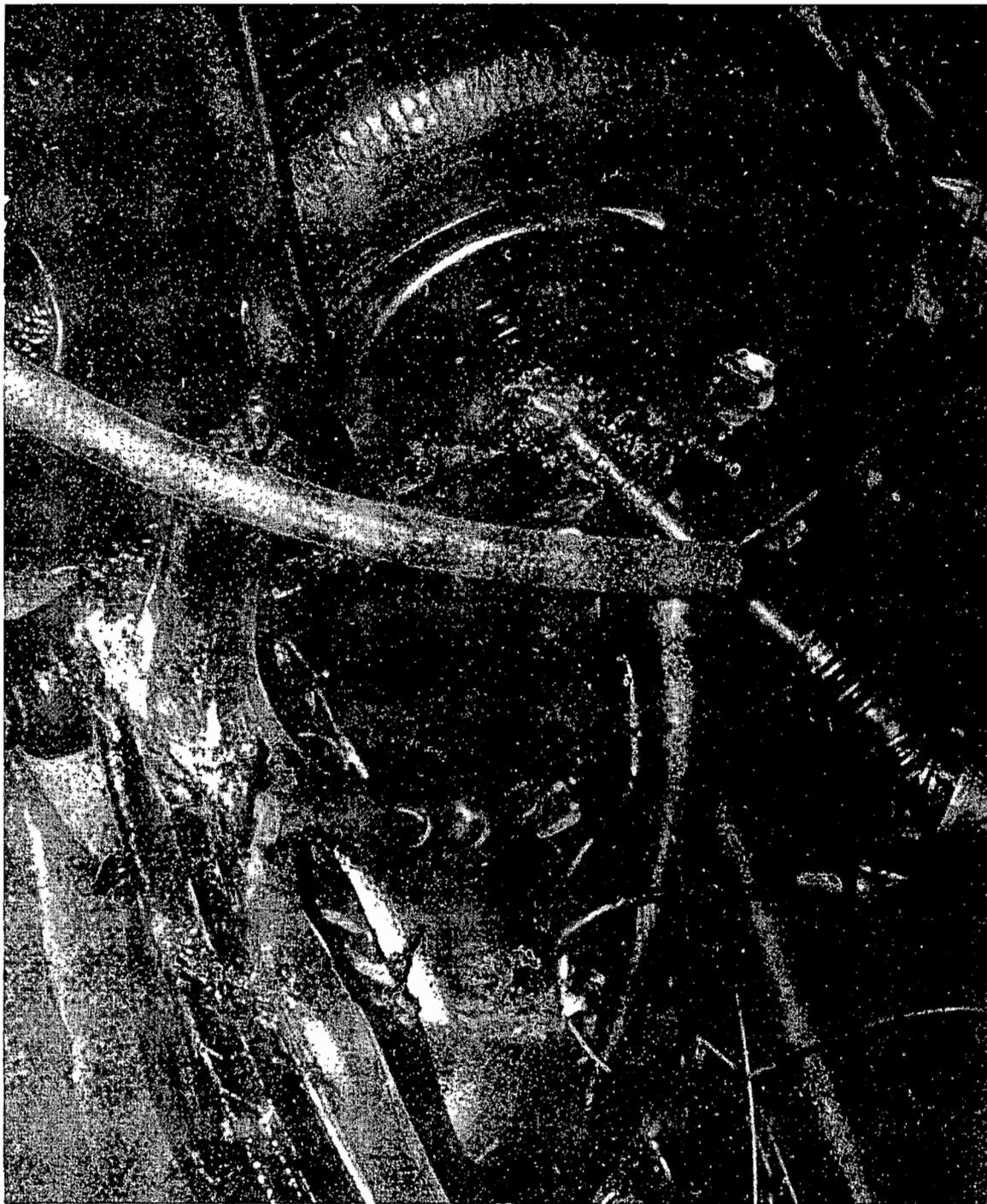


Figure 7: Photograph of Rear-Engine Compartment of V-1, Without Engine.

bumper, and radiator were bent rearward and upward around the engine compartment. The front wheels and support structure were distorted rearward, 20 to 22 inches.

There was rearward crushing of the left A-pillar, extending into the left door, the B-pillar, and side body panel. All window glass on the front, left, and right sides was completely broken out.

The right A-pillar was distorted rearward and the right door was buckled at a point about 10 inches back of its front edge; this door had reportedly been forced open to remove the occupants. The forward portion of the roof, from the windshield back, was buckled upward approximately 4 inches.

Looking at V-2 from the left side, there was an upward bending of the entire front end and body, approximately at mid-vehicle position, of about 5° to 10° . (See Figures 8 and 9.)

Interior damage to V-2 consisted of a forward and upward distortion of the instrument panel and dashboard, forward bending of both front-seat backs, with fracture of the hinges, and intrusion of the rear seat back by an unsecured spare tire from the trunk compartment. The steering column was bent into a nearly vertical position adjacent to the left A-pillar. The hub of the steering wheel had partially failed and the three spokes had bent so that the wheel rim was in a nearly vertical plane with the lower portion against the steering column. (See Figure 10.)

California Highway Patrol inspected both vehicles and found no indications of pre-crash failure of safety-related components.^{2/}

The Drivers

Driver of V-1 was a male, aged 26. According to the California Department of Motor Vehicles, he had a record of three moving traffic violations: Illegal left turn, 1968; following too closely, 1969; and running a stop signal, 1969. In the prior two, he was operating a 1968 Mustang, and in the latter, a 1969 Porsche 912. In May 1970, he was the driver of the Porsche 912 when it was totally wrecked in a collision in which he was found not at fault, but suffered a head injury requiring hospital observation.

^{2/} Stanford Research Institute Crash Analysis Team (SRI-CAT) had planned to make detailed examinations of both vehicles, but were unable to do so because the vehicles had not been released by the insurance companies.



Figure 8. Left Front Area of V-2. Note Severe Rearward Crushing of This Area, and Horizontal Bend in Roofline.



Figure 9. Photograph of Right Front Area of V-2, Indicating Severe Rearward Crushing. Note Distortion to Right Door and Bend in Roofline.

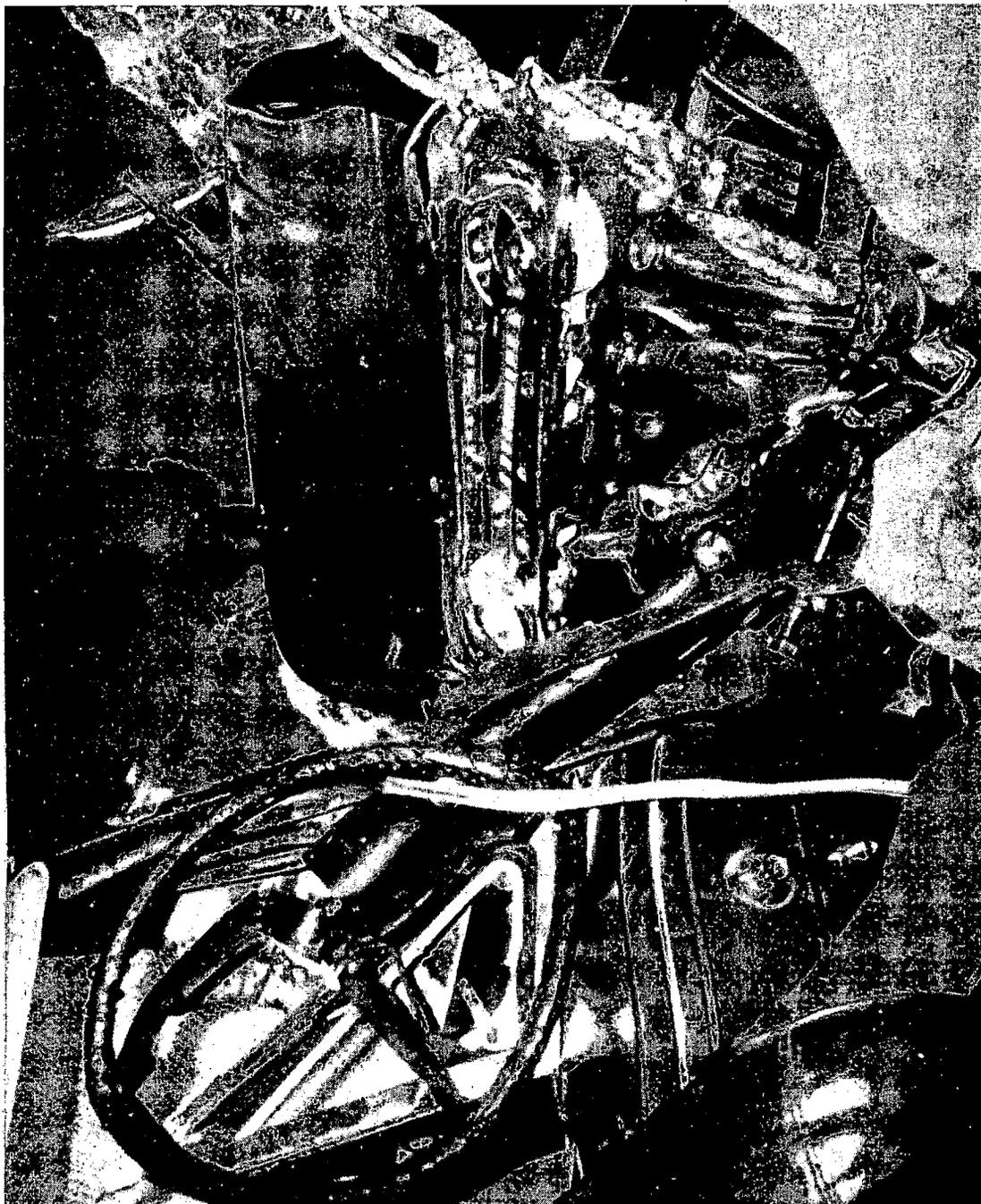


Figure 10. Photograph of Driver's Compartment and Left Instrument Panel Area of V-2. Note Almost Vertical Plane of Steering Wheel, and Forward and Upward Distortion to Dash and Instrument Panel.

One person volunteered information that Driver of V-1 had on more than one occasion driven his 1969 Porsche at speeds of 100 miles an hour when she was with him, and that he enjoyed fast driving. Driver of V-1 acquired the 1970 Porsche Targa on June 13, 1970. Witnesses said he was willing to demonstrate the Porsche to anyone interested.

On the evening of July 10, he had gone to Marin County (north of the Golden Gate) with two girls to a restaurant-bar, where they were joined by another man. The two couples ate dinner separately. The driver of V-1 had several cocktails with dinner. It is not known if he had other drinks prior to dinner or after leaving the restaurant-bar.

Driver of V-1 had a blood-alcohol level of .05 percent at the time of post-mortem analysis when specimens were taken at 9 a.m., July 11. Microscopic brain tissue examinations showed no indications of prior brain injury. The two female occupants showed blood-alcohol levels of .12 and .13 percent, respectively, at time of autopsy.

Driver of V-2 was a male, aged 19. No record of violations or prior accidents could be found. He had a reputation among his friends as a careful driver.

On the evening of July 10, the driver of V-2, in company with several other young males (aged 17 to 19), joined the four female occupants of V-2 (aged 17 and 18) in a neighborhood park known as Sigmund Stern Grove, where a group of 21 young people had gathered. It was decided to go to "North Beach" and "Chinatown," which are night club and tourist centers of attraction in San Francisco. Three of the young people went in one car, nine in another, and nine in the Mustang, V-2. It was on the basis of the V-2 driver's good driving reputation that the girls agreed to go along in that car. This was reportedly not the first time that as many as nine people had traveled in V-2.

In the "North Beach" area, the driver and some of the young men (but none of the girls) drank beer which was purchased in six-packs, and the group had something to eat. About midnight, it was decided to take the girls home, so the nine got into V-2 for the trip home via Doyle Drive and 19th Avenue. The V-2 driver reportedly drove properly. Four persons rode in front, one male and two females in addition to the driver; five rode in back, a male on the left side, a female in the middle, with another female on her lap, and a male on the right with a male on his lap. No one used the four available seat belts.

Immediately after the accident, the V-2 driver was found in the driver's seat with his right arm around the middle occupant and her left arm around him. However, it is not known whether the driver of V-2 had driven this way; since both he and the middle occupant were reportedly conscious for a brief period after the collision, they may have moved into this position after the crash.

The driver of V-2 had a blood-alcohol level of .09 percent at the time of autopsy; one other fatally injured occupant had a blood-alcohol of .23 percent. None of the female occupants of V-2 showed any blood-alcohol. Blood-alcohol tests were not made of the three survivors (including one who died 13 days later). The survivors were male occupants of the right rear seat.

None of the occupants of either vehicle showed any trace of barbiturates, but tests for other drugs or narcotics were not made.

Synopsis of occupant injuries is contained in Attachment 2 of the Appendix.

Witnesses

California Highway Patrol obtained statements from a number of eyewitnesses, who gave the following information:

Witness 1: Northbound in lane N-1 about 35 miles per hour, some distance behind V-2, saw lights coming at her in S-1 lane, and saw a southbound car suddenly spin around. An engine flew out of the wreckage, spun around and around, and almost struck her car. She slammed on brakes and stopped.

Witness 2: While southbound from Sausalito across the Bridge, for about 3 miles she noticed a blue Porsche following her car, within the speed limit. She said that after clearing the toll gate and while she was going 50 to 55 miles per hour, the Porsche passed her in the "fast" lane going "at least 120 miles per hour." As V-1 went into the curve, it appeared to go out of control into the northbound lanes and hit V-2 and "just exploded"--no flames, just flew apart. (Witness 3 was with Witness 2, and verified the account given by 2.)

Witness 4: Northbound in the N-1 lane, about 40 to 45 miles per hour, some 50 or 60 yards ahead of V-2 which was in lane N-2, saw a sports car southbound in lane S-1 going "at least 80 miles per hour." In his rearview mirror he saw the sports car "go wobbly," then cross the divider and hit the Mustang with its right side.

A Bridge employee, first at the scene, was on duty at the toll plaza when directed to respond to an accident on Doyle Drive. When he arrived, the Porsche was on its top, with the arm of a male protruding from the driver's side; he saw three occupants in their respective seats, all of whom appeared to be dead. There were sounds from the Mustang. The driver was alive but dazed, with a female next to him who spoke incoherently to the witness. The witness and others pried open the right door of V-2 and removed the occupants.

Post-Crash Activities

Notification of the accident was made about a minute later by a northbound motorist to the Golden Gate Bridge authority at the toll plaza about 1 mile northwest of the scene. A tow truck dispatched from the toll plaza arrived on the scene approximately 3 minutes after the crash.

California Highway Patrol (CHP) received the accident call approximately 6 minutes after the crash and arrived 3 minutes later.

All occupants of V-1 were believed dead before removal from the car. An attempt to pry open the left door of V-2 failed, so rescue was initiated through the right door.

The first ambulance arrived at the scene about 12 minutes after the crash--5 minutes after receiving call--and took two of the injured from V-2 to Mission Emergency Hospital, San Francisco. A second ambulance, about 20 minutes later, took three other V-2 occupants to Mission Emergency. One occupant was dead on arrival.

All of the victims, except one, were removed from both vehicles at the scene. The rear-seat occupant of V-1 was removed at the Golden Gate Bridge west parking lot, where two tow trucks were required to force up the collapsed rollbar under which the victim was pinned.

California Highway Patrol departed the scene approximately 1 hour and 40 minutes after the crash. During cleanup, traffic was restricted to one lane in each direction.

III. ANALYSIS

Vehicle Kinematics, Pre-Crash

The initial speed of V-2 has been estimated at 40 to 45 miles per hour by eyewitnesses and by analysis of its behavior in the crash event.

The initial speed of V-1 prior to the accident was estimated by eyewitnesses to be over 100 miles per hour. Such eyewitness estimates are frequently unreliable, but here they are supported by analytical estimates:

1. If the initial tiremarks of V-1 were centrifugal, as caused by its exceeding the critical speed^{3/} on the curve, V-1 would have to be traveling in the range of 120 to 130 miles per hour;
2. Using the actual radius of the path described by V-1 as it crossed from lane S-1 into lane N-2, the critical speed would have been in the range of 100 to 110 miles per hour;
3. Estimating (with limited data) the energy dissipated in various events gives an estimated range of 90 to 100 miles per hour;
4. If we assume that V-1 was actually braking throughout the 321-foot mark, and account for the energy required to move V-2 backwards in its tracks (as described above), an initial speed for V-1 of 100 to 105 miles per hour is derived.^{4/}

^{3/} Critical speed is defined as that calculated speed above which a vehicle will no longer adhere to the road and will go off the curve rather than follow around it. The formula for calculating Critical Speed is: $S = 3.9\sqrt{(F - f)R}$, where F is the coefficient of friction, f is the cross-slopesuperelevation, and R is the radius of the curve being traveled by the vehicle. (From Traffic Accident Investigator's Manual for Police, Northwestern University Traffic Institute.)

^{4/} Based on weight differentials, the impact speed of V-1 had to be approximately 30 to 40 percent greater than that of V-2 to produce the final points of rest of vehicles and various components. Using a skid factor for the road of .75, 321 feet of skidmarks gives an estimate of 85 miles per hour initial speed if V-1 skidded to a stop. However, it was still going about 60 miles per hour on impact, and the vector of the two figures is 104-plus miles per hour. If we assume a skid factor of .65 for speeds over 80 (tests could not be made at that speed), the initial minimum speed of V-1 is 100 miles per hour.

The exact speed of V-1 is not known, but all reasoned estimates place it in a range at least double the 45-mile speed limit, and it was probably much greater, so that successful evasive action in an emergency was virtually impossible in this environment.

The initial skid path of V-1 was reported by the California Highway Patrol to be roughly in the center of lane S-1, following the road curvature. If these marks were of true centrifugal sideslip, without braking, as would occur if V-1 were exceeding the critical speed, V-1 would have slid to its right towards the outside of the curve. But the marks initially held to the center of lane S-1, and properly should be interpreted as evidence of moderate braking combined with slight sideslip and corrective steering to the left. Keeping in mind the V-1 driver's experience with Porsche cars at high speeds raises the question of why he would brake and lose control on a curve which was well within the control capabilities of his vehicle.

It can reasonably be assumed that when the driver of V-1 accelerated after clearing the toll gate, the road directly ahead of him was clear of cars. However, any cars entering Doyle Drive eastbound at the 19th Avenue interchange could not have been seen from V-1 until after it rounded the first curve off the Bridge. Most of such cars exit at the Marina, and must cross the paths of vehicles going through on U. S. 101. V-1 was probably going to exit onto Richardson Avenue to follow U. S. 101 into San Francisco-- the most direct route to the hotel where the driver and both occupants resided. Thus, any car which may have been ahead of V-1, intending to exit at the Marina, would have been crossing V-1's path from right to left, and would have posed a potential hazard to V-1, which would have to merge from left to right for its intended exit.

At such point, the V-1 driver might have made his initial braking action, maintaining his course in lane S-1. However, if his rate of closure with a relatively slow-moving car was too great, he would probably have instinctively braked harder. Any evasive steering action would have been to the left, away from the threatened collision, rather than to the right into the source of danger. Excessive brake application could nullify further evasive steering, and the car would be likely to go into a counterclockwise spin and skid in the precise manner identified by the skidmarks found by the Highway Patrol. Any oncoming traffic in the northbound lanes, if observed by the V-1 driver, would have tended only to trigger maximum braking effort, precluding any other evasive action.

Another explanation for the braking-steering maneuver of V-1, compatible with the skidmark evidence, would be that on entering the curve, the V-1 driver was suddenly aware that he was going too fast. In attempting to bring his speed down, and not being altogether familiar with the high-speed handling characteristics of this new car, he could have misjudged the amount

of braking and steering input required, and then applied excessive braking when he found himself heading into the northbound lanes, producing the spin and skid shown in the skidmarks.^{5/}

Interference with his driving by another occupant, or any of a number of minor emergencies, could also have triggered the braking-steering action.

Vehicle In-Crash Kinematics

V-1 first contacted V-2 with the right front corner of V-1, with a direction of force of 1:30 or 2:00, related to V-1, and at a speed of about 60 miles per hour. The counterclockwise rotation of V-1 at impact was accelerated by the force of impact, bringing the right side of V-1 into a position perpendicular to the heading of V-2, allowing full engagement of the frontal area of V-2 with the right side of V-1, where peak deceleration loads were experienced. The loss of V-1's engine and transaxle probably occurred at this time. V-1 rotated around its longitudinal axis in a clockwise direction (viewed from behind), so that the front of V-2 penetrated the right door and body structure. The two right-side occupants of V-1 were thrown into direct contact with V-2 at this point, in the concave distortion of V-1. The rear of V-1 continued its counterclockwise rotation, engaging the left forward side of V-2 as it rotated. The front of V-1 had been elevated by partial vaulting over the front of V-2. As the forward part of V-1 disengaged from V-2, and the rear was still partially engaged with V-2, a vaulting end-over roll resulted, so that V-1 came down almost squarely on its top, coming to rest with little or no sliding. The force of the end-over roll, on impact with the pavement, was sufficient to distort the built-in rollbar severely inward and rearward, pinning the rear-seat occupant between the rollbar and the car body structure.

V-2 was in a straight-ahead position at time of impact, probably slightly nose down in a braking action, and going about 40 miles per hour. As V-2 decelerated on impact, all occupants were thrown forward, upward, and slightly to the left. A strong downward force on the front of V-2, in its maximum engagement with V-1, produced a lifting of V-2's rear portion. Its rear wheels lifted slightly off the pavement. While V-2 was in that position, its counterclockwise rotation received further acceleration from the rotational force of V-1, resulting in an almost in-place pivoting movement, moving V-2 to the position where it was found (Figure 2-A).

Total elapsed time, from impact to final rest of both vehicles, was probably little more than 1 second, except for the sliding of the V-1 engine and transaxle, which took some 5 to 7 seconds.

^{5/} In either postulation, the confining effect of the narrow lanes (10 feet wide) would accentuate a sensation of loss of control on a curve, as a narrow lane demands a much tighter lateral tolerance than does a standard 12-foot lane; generally, the higher the speed, the more confining the narrower lane seems.

IV. CONCLUSIONS

1. The Golden Gate Bridge southern approach, built in 1937 to accommodate some 11,000,000 vehicles per year, is now carrying several times that number under conditions not commensurate with current needs and standards, and thus presents increasing potential for accidents.

2. The narrowness of the highway lanes tended to produce difficulty in driving within lane lines on a curve at higher speeds. This problem was aggravated as vehicle speed was increased.

3. The use of a center divider (median barrier) was not practical on this highway because of the overriding need to obtain maximum capacity during peak hours, requiring the use of reversible lanes. However, had such a barrier been in place, it is likely that V-1 would have been kept from crossing into the northbound lanes.

4. The melding of eastbound traffic on Doyle Drive, entering from 19th Avenue, poses a definite interruption and hazard to through traffic southbound on U. S. 101, and may have been a factor in triggering the evasive action taken by the driver of V-1.

5. The closing of the 19th Avenue interchange to eastbound and westbound intracity traffic would directly enhance the safety of traffic on the southern bridge approach by reducing the vehicle volume on Doyle Drive, by eliminating the constriction now created by the allocation of lane S-3 at the interchange to traffic entering eastbound from 19th Avenue, by providing six full lanes for U. S. 101 and Bridge traffic throughout the southern approach, and by eliminating a serious potential for traffic accidents between the 19th Avenue interchange and the eastern exits of the approach produced by the merging and crossing maneuvers of such intracity traffic. Other good routes are available to intracity traffic if it were denied access to this portion of Doyle Drive.

6. V-1 was moving at approximately 100 miles per hour when it entered the curve where the accident occurred; V-2 was moving at about 45 miles per hour.

7. The tire marks of V-1 in southbound lane S-1 were produced by moderate braking action and slight sideslip, countered by corrective steering to the left, and not by V-1's exceeding the critical speed for the curve.

8. The reasons for the braking and turning action of V-1 are not known, but could reasonably have been the presence of a vehicle (or vehicles) also southbound in the projected path of V-1 which the driver was seeking to avoid.

9. The blood-alcohol level of .05 percent of the driver of V-1, while it may not have impaired his operational capability, could have affected his decision to accelerate to high speed after clearing the Bridge tollgate. Had

he been free of alcohol, it is probable that he would have been restrained by consideration of the hazards of excessive speed at this time and place.

10. V-1 front seat occupants wore three-point harness restraints which kept them in their seats, thus performing their intended function, but which did not protect the occupants from the effects of vehicle intrusion in severe lateral impact.

11. V-1's speed at impact was about 60 miles per hour, having been reduced from about 80 miles per hour when V-1 crossed the centerline, 112 feet west of the impact point. Assuming an average speed of 70-plus, the time lapse would have been approximately 1 second from crossing the centerline to impact with V-2.

12. The opportunity for evasive action on the part of V-2 was extremely limited as to time and distance. However, had an opportunity existed, the blood-alcohol level of .09 percent would probably have delayed the V-2 driver's perception and reaction time. (Under California law, a blood-alcohol level of .10 percent is presumptive of being under the influence.)

13. The overloading of V-2 could have adversely affected any opportunity present for the V-2 driver to take evasive action, by crowding the driver and by adversely affecting performance of the vehicle.

14. The V-2 occupants did not utilize the four seat belts which were available. Their use might have enhanced the chances for survival of some occupants.

15. The use of lap-type seat belts alone might not have enhanced the chances of the driver of V-2 for survival, because of his position in relation to the magnitude and direction of impact forces. Whether the additional use of cross-body (shoulder) restraints would have enhanced his chances is also moot, for the same reason.

16. There is no evidence of improper driving, other than operation with an overloaded vehicle, on the part of the driver of V-2.

17. The front seats of the Mustang, designed for two persons, were carrying a total of four persons. This was in excess of the allowable number of three persons permitted, under Uniform Vehicle Code Section 11-1104, and also in violation of California Vehicle Code in that such loading would interfere with the driver's safe operation and view to the right.

18. The number of occupants between the rear-seat passengers and the impacted components of the front compartment of V-2 may have been the significant mitigating factor which permitted the survival of two rear-seat occupants.

19. The speed of the Porsche, V-1, which was at least 100 miles per hour preceding the crash, and its rated speed capability of 125 to 130 miles per hour, were both far in excess of any legal highway speed limit in the United States.

20. Had the speed capability of V-1 been limited to that of existing maximum speed limits in the United States (80 miles per hour), it is probable that this collision would have been prevented. A speed of 20 miles per hour less than V-1 was traveling would have greatly reduced the probability of loss of control and the excursion of the skid into the northbound lanes; it would have permitted more time for evasive action by the driver of V-2, and any impact which did occur would have been greatly reduced, thus reducing injury and loss of life.

V. PROBABLE CAUSE

The probable cause of this accident was the excessive speed of the Porsche automobile, which led to loss of vehicle control on the curve of a highway which had substandard lane width and no median barrier.

VI. RECOMMENDATIONS

The National Transportation Safety Board recommends that:

1. The California Division of Highways--in concurrence with the Golden Gate Bridge Highway and Transportation District and the City and County of San Francisco--expedite the completion of contract plans to improve the southern approach to the Golden Gate Bridge to bring it up to freeway design standards of the American Association of State Highway Officials and those set forth in the Highway Design Manual of the California Division of Highways, including 12-foot lanes, a permanent median barrier (or divided roadway), and acceleration-deceleration lanes at interchanges.
2. The United States Sixth Army Command, in recognition of the urgent need for safety improvements to the Golden Gate Bridge southern approach, consider reasonable requests by the California Division of Highways and the Golden Gate Bridge Highway and Transportation District for necessary right-of-way through the Presidio of San Francisco.
3. Until the Bridge approach can be brought up to recommended standards, the California Division of Highways consider the feasibility of eliminating access to and from the 19th Avenue interchange for all traffic other than that going to and from the Golden Gate Bridge. This would reduce the internal traffic friction now created by local east-west traffic on Doyle Drive, and thus reduce the accident potential caused (in large part) by the extensive merging and crossing of traffic between the 19th Avenue interchange and the San Francisco exits.
4. The National Highway Traffic Safety Administration's Advance Notice of Proposed Rulemaking, Docket 1-19, published December 1, 1970, on "High Speed Warning and Control" be amended to reduce the maximum speed capability of passenger cars to a speed no greater than the highest fixed legal speed limits of any State, and that the warning devices be set to operate at such maximum allowable speed.
5. That the International Association of Chiefs of Police use its influence and professional resources to direct the attention of law enforcement agencies to the requirements of

Uniform Vehicle Code Section 11-1104, which limits the number of passengers permitted in the front seats of automobiles under certain conditions.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD:

/s/ JOHN H. REED
Chairman

/s/ OSCAR M. LAUREL
Member

/s/ FRANCIS H. McADAMS
Member

/s/ LOUIS M. THAYER
Member

/s/ ISABEL A. BURGESS
Member

February 10, 1971

Page Left Blank

VII. APPENDICES

Page Left Blank

ATTACHMENT 1

DISCUSSION: Effects of .05 to .10 Percent Blood-Alcohol (by wgt.)

"If an individual weighing 150 pounds, drinking between one and two hours after an average meal, were to consume in that one hour at least four and a half ounces of 80 proof liquor (40% by volume), his blood alcohol concentration would probably reach 50 mg. per 100 ml. (0.05% by wgt.) ... ^{1/}

Using the same method by which this was calculated, for a 160-pound person to reach 0.05 percent blood-alcohol after 3 hours, total consumption in that period would be at least 6 to 7 ounces of 80-proof liquor, or its equivalent. A 160-pound person, to reach a BA level of 0.23 percent after 3 hours would require the consumption of 24 ounces of 80-proof liquor, of which the equivalent in beer would be approximately 24 12-ounce bottles or cans. A 135-pound person, to reach a BA level of 0.09 percent after 3 hours would require 10 12-ounce bottles or cans of beer.

"... It is the opinion of this Committee that a blood alcohol concentration of 0.05 % (... by wgt.) will definitely impair the driving ability of some individuals and, as the blood alcohol concentration increases, a progressively higher proportion of such individuals are so affected, until at ... 0.10% ... all individuals are definitely impaired."^{2/}

"Alcohol degrades individual driving performance in many ways, including deteriorations in judgment, ability to concentrate, comprehension, vision, and coordination."^{3/}

"It cannot ... be inferred that a driver is not a menace ... because ... a test of skill revealed no impairment. The decisive feature is not the driver's skill in itself but in relation to what he believes he could do and what he would in fact undertake."^{4/}

All quotations are excerpted from Department of Transportation Report to the Congress, August 1968, titled: "ALCOHOL AND HIGHWAY SAFETY," and the specific references are found as follows:

- ^{1/} on page 4
- ^{2/} on page 13
- ^{3/} on page 40
- ^{4/} on page 41

Page Left Blank

ATTACHMENT 2

SYNOPSIS OF OCCUPANT INJURIES

Driver V-1: Age 26, male, 5'10", 170 pounds, driving experience unknown, trip plan social to home, .05% blood-alcohol, mental condition unknown, upper torso and lap restraint (3-point) used.

Injuries: AMA 7*, dead at scene. Hemorrhage right side of brain, lacerations of lung and liver, fractures of left mandible, right femur, left tibia and fibula.

Occupant, V-1 front seat: Age 22, female 5'5", 122 pounds, .12% blood-alcohol, upper torso and lap restraint used.

Injuries: AMA 9, dead at scene. Partial decapitation, partial absence of scalp and brain, severe multiple skull fracture, lacerations of lungs, spleen, and liver, complete transection of spinal column and partial transection of cord at 2nd lumbar.

Occupant, V-1 rear seat: Age 23, female, 4'10", 120 pounds, .13% blood-alcohol, lap restraint apparently not used.

Injuries: AMA 7, dead at scene. Multiple brain lacerations, brain separated from brain stem, lacerations of lungs, spleen, and liver.

Driver V-2: Age 19, male, 5'6", 135 pounds, 3 1/2 years driving experience, trip plan social to home of occupants, .09% blood-alcohol, mental condition not known, restraints not used.

Injuries: AMA 6, dead at scene. Lacerations of liver, lungs, spleen, left kidney, crush injury of right maxilla, multiple rib fractures.

Occupant, V-2 front center: Age 17, female, 5'3", 145 pounds, negative blood-alcohol, restraints not used (arm around driver's shoulder; driver's right arm around her hip).

Injuries: AMA 6, died in operating room several hours after accident. Lacerated aorta, small amount subarachnoid hemorrhage in brain, hemorrhage in both lungs and right kidney.

Occupant, V-2 right front seat: Age 19, male 6'1", 163 pounds, .23% blood-alcohol, restraints not used.

Injuries: AMA 7, dead at scene. Brain contusions, lung contusions, liver lacerations, fractured left radius and ulna.

* AMA scale of injury is based on a range from 1 to 10 in terms of degree of severity; figures from 6 to 10 are fatal levels.

ATTACHMENT 2 (cont.)

Occupant, V-2 right front lap: Age 17, female, 5'7", 133 pounds, negative blood-alcohol, restraints not used.

Injuries: AMA 8, dead at scene. Brain hemorrhage, contusions of lungs, lacerations of right lobe of liver, fracture of right lower leg.

Occupant, V-2 right rear seat: Age 17, male, height and weight unknown, blood-alcohol unknown, restraints not used.

Injuries: AMA 4, survivor. Brain concussion, some post-traumatic amnesia, forehead laceration, comminuted fracture of upper third of right femur.

Occupant, V-2 right rear lap: Age 18, male height 6'1" (approx.) 200 pounds (approx.), blood-alcohol unknown, restraints not used.

Injuries: AMA 4, survivor. Brain concussion, post-traumatic amnesia, lacerations of diaphragm and hepatic ligament, fractures of left ilium and pubic bone.

Occupant, V-2 left rear seat: Age 19, male 5'8", 124 pounds, blood-alcohol unknown, restraints not used.

Injuries: AMA 5, died 13 days after accident. Contusion of brain, Lafort-III facial fracture, fractured left tibia and fibula, contusion right lung, early broncho-pneumonia (at time of death).

Occupant, V-2 center rear seat: Age 18, female, 5'0", 148 pounds, negative blood-alcohol, restraints not used.

Injuries: AMA 7, dead at scene. Brain lacerations and hemorrhage, lacerations of spleen.

Occupant, V-2 center rear lap: Age 17, female 5'3", 138 pounds, negative blood-alcohol, restraints not used.

Injuries: AMA 8, dead at scene. Brain hemorrhage, concussion and contusions, lacerations of left lung and liver, fracture of left humerus.

ATTACHMENT 3

RESULTS OF SKID TESTS, DRY, MADE BY
CALIFORNIA DIVISION OF HIGHWAYS
OCTOBER 8, 1970

Tests By: California Division of Highways, District 4
Place: Accident Site, Doyle Drive (U. S. 101) approximately 4600 to
4900 feet south and east of Golden Gate Bridge toll gates,
where pavement surface changes from asphaltic concrete to
portland-cement concrete, southbound.

These tests, made at the accident site on request of the National Transportation Safety Board, employed a skid trailer (single-wheel, Moyer model) owned by California Division of Highways. The "skid number"^{1/} which is derived is 100 times the horizontal (braking) force on the trailer wheel divided by the load (vertical) carried by that wheel.

Time permitted only one test skid at each of the speeds shown below. While the discrepancies found are within normal limits for single tests, additional tests would have permitted averaging of the results for confirmation. No tests were run above 50 miles per hour for safety reasons.

The limited results do not permit extrapolation to estimate the skid number for higher speeds. However, experience^{2/} has shown that the skid number usually decreases at speeds over 60 miles per hour, roughly in relation to the increase in speed. This is partly because there is less mechanical engagement of the tire tread with the irregularities of the pavement surface at high speeds.

(table on next page.)

^{1/} "Skid Number" may sometimes be called "skid resistance factor" or "coefficient of friction." The latter two, however, would be the direct ratio between the braking force and the vertical load.

^{2/} Reported in Accident Investigator's Manual For Police, The Traffic Institute, Northwestern University (J. S. Baker, et al). For the highway at this accident site, we have taken the "low speed" skid factor as .75, and the "high speed" skid factor as .65.

ATTACHMENT 3 (cont.)

	<u>SPEED OF SKID TEST (MPH)</u>	<u>OBSERVED SKID NUMBER</u>
Lane S-1, Southbound,)	30	75
On Asphaltic Concrete)	40	79
)	50	78
<hr/>		
Lane S-1, Southbound,)	30	73
on Portland-Cement)	40	77
Concrete)	50	78
<hr/>		
Lane N-2, Northbound)	30	74
on Portland-Cement)	40	74
Concrete)	50	74