CLOUD VOLUME STUDIES

By R. J. Bendura*

A time history of cloud growth for the Titan III launch at Cape Canaveral on September 5, 1977, was obtained by using optical data provided by three Askania trackers (position of the cloud) and three Hasselblad cameras (cloud volume). The trackers and the cameras (having 50-millimeter lenses and using 70-millimeter black-and-white film) were located several kilometers north (UCS-9), east (UCS-2), and south (JPL) of the two Titan launch pads so that the cloud could be photographed during its formation, its growth, and its rise. During the September 5 launch, weather conditions were good enough to enable tracking of the cloud for almost 40 minutes. At that time, the cloud was about 15 kilometers away from the nearest camera. The trajectory of the cloud enabled photographing the cloud with the Hasselblad camera from UCS-2 in nearly a downwind direction and from UCS-9 and JPL in a crosswind direction. The cloud was divided into elliptical increments with major and minor axes in the downwind and crosswind directions, respectively, to sum up the volume of the cloud at a particular time. Two quasi-independent measurements of ground cloud volume as a function of time were obtained; they are compared in figure 1. The data represented by the circles use the combination of the Hasselblad cameras of UCS-2 and of the JPL site. No data for the time period around 12 to about 28 minutes are available, however, because ambient clouds passing between the JPL camera and the exhaust cloud prevented the acquisition of any data. Data were acquired using the combination of cameras at the UCS-2 and UCS-9 sites, as represented by the squares. Based on the assumptions made and the quasi-independent camera technique applied, the optical data agree reasonably well, particularly during the early time periods when rapid growth is occurring; but the agreement is less good after 25 minutes. However, at this time, the cloud was 15 kilometers away from the nearest camera site and the cloud image was sufficiently small that a small error in defining the outline of the cloud due to ambient cloud interference or haze could result in a relatively large error in volume.

Aircraft time in the cloud, as measured by the rapid-response nephelometer onboard the aircraft, was also used for determining cloud volume. It was assumed that the cloud formed into a prolate spheroid with the downwind aircraft pass being along the major axis and the crosswind pass being along the minor axis. As shown in figure 1, the cloud volume measured in this manner compares favorably with the optical data after 12 minutes. Cloud volume from aircraft measurements for the entire operation is summarized in figure 2. The aircraft landed and was being refueled in the 1.5 to 3.0 hours after launch time period. The data suggest that the cloud volume may have peaked near 60 ± 10 cubic kilometers and that it remained relatively constant or

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began to decrease slightly soon after 3.5 hours. However, caution should be used in reaching any general conclusions since these measurements are reliable only within a factor of 3 or 4 and are subject to the detectability limits of the nephelometer. In addition, cloud volumes may behave differently for other meteorological conditions.

Cloud volume data from this mission are compared with optical data from prior missions in figure 3 and airborne data from prior missions in figure 4. No attempt has been made to correlate the data based on meteorological conditions.

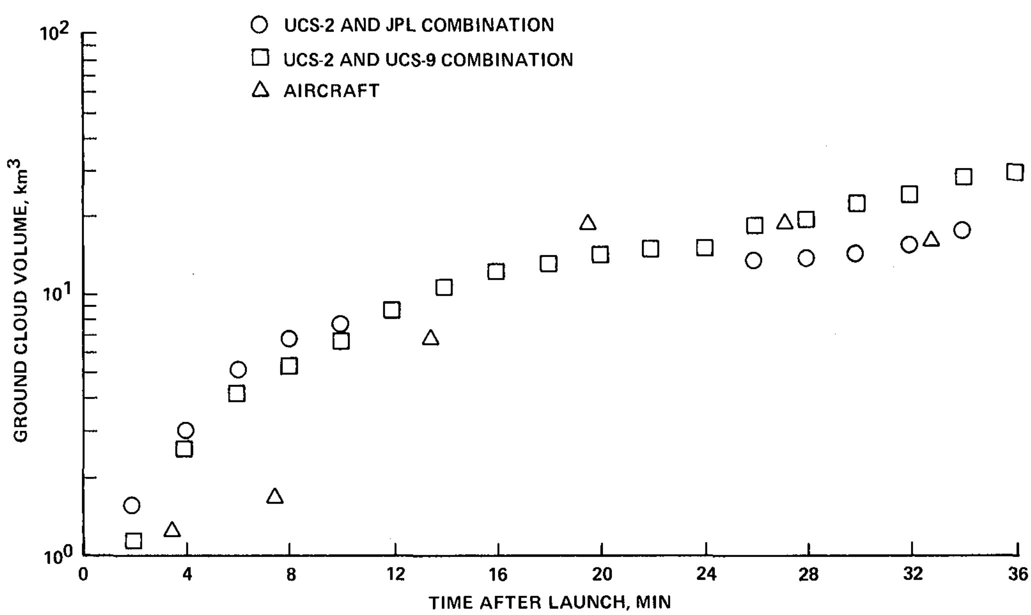

Figure 1.- Optical and airborne measurements of Titan III ground cloud volume as a function of time (September 5, 1977, Voyager I launch).

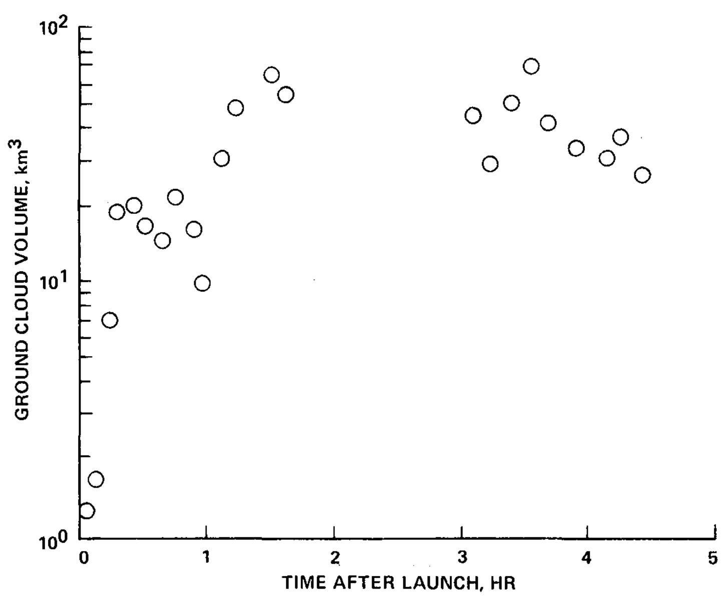

Figure 2.- Airborne measurements of the September 1977 Titan III exhaust cloud growth.

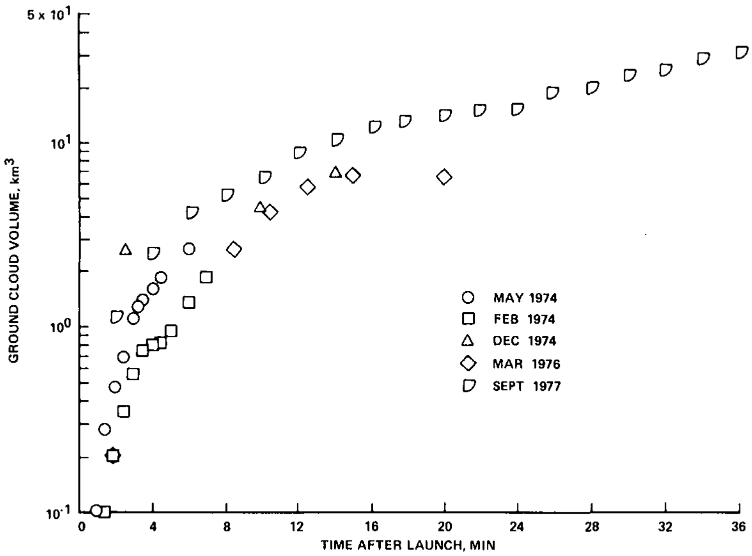

Figure 3.- Summary of exhaust cloud growth from optical measurements of five Titan III launches.

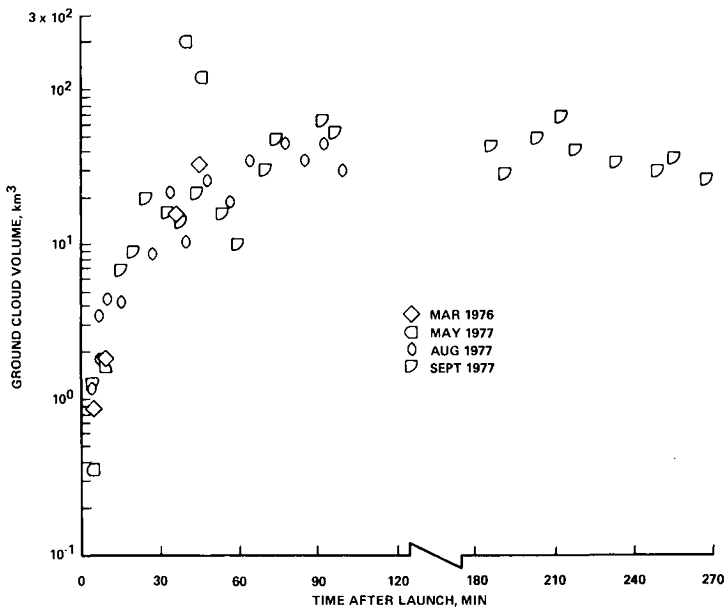

Figure 4.- Summary of exhaust cloud growth from airborne measurements of four Titan III launches.