

floor) with 3-way splices made to provide "T-off" connections to the substations at the 7th, 41st and 75th floors. The transformers fed a common 4000A busbar on the secondary side. Power was then distributed to the relevant locations through a low-voltage switchboard.

The supply of large parts of the structure at a higher voltage does imply that a cable failure, due, for example, to the aircraft impacts, would have necessitated the tripping of the 13.8 kV circuit breaker controlling that entire circuit. Even though each substation obtained a supply from multiple feeders, cables routed in close proximity were all vulnerable simultaneously. However, the practice of splitting the eight circuits into two groups of four does mean that, although damage to the cables would cause connected substations on all levels to lose power, the substations at all levels on the other side of the building could continue to operate. This is discussed further in the context of the aircraft impacts.

A.4 TIME LINE OF CON ED SUBSTATION EVENTS

A.4.1 Tripping Events, Substation #1

Table A-3 provides a record of activity on September 11, 2001, for all the feeders into and out of SS #1, together with the associated circuit breaker designations transcribed from the system diagrams (Con Edison 2005f) . The first number of the circuit ID corresponds to the network being served:

- 37: World Trade Center (all seven buildings, as described above)
- 15: Cortland Network
- 38: In-feed from the transmission switching station (at 138 kV)

Prior to the impact of the first aircraft, all the feeder circuit breakers were closed, and all indications were that the power system was operating normally. The columns on the right of Table A-3 depict the times at which circuit breaker operations took place (either automatically [A] as a result of the operation of the protective relaying, or manually [M] by operations commanded by the control center). This information was transcribed from the Control Center station logs (Con Edison 2005g) and a Con Edison incident report (Con Edison 2005g). Events are given in eastern daylight time.

Of primary interest from Table A-3 is that two of the circuits tripped automatically at 8:46 a.m., as a result of collateral damage caused by the aircraft impact into WTC 1, and a further two were lost at 9:03 a.m. in the same way, when WTC 2 was impacted by an aircraft. Note that for each aircraft impact, all the circuits were not damaged initially, presumably as a result of dividing the power and providing two separate routings to the substations on either side of the towers. At 9:59 a.m., the remaining four circuits feeding the entire WTC complex tripped automatically. As a result, power to all seven of the WTC buildings from the utility was lost. This occurred, as designed, by the operation of the installed protective relays without any utility intervention. No evidence indicated that the faults on the cable system or in the WTC distribution substations were caused by anything other than the collapse of WTC 2.