

Team Jefferson 2007 DARPA Urban Challenge Debrief Summary

(for a complete debrief, see the [Debrief-Complete-TeamJefferson-DRAFT.pdf](#) document)

Team Jefferson's 2007 DARPA Urban Challenge effort began addressing the shortcomings identified from the team's 2005 DARPA Grand Challenge experience. This included lack of up-front and full-time support for mechanical and electrical engineering. The team addressed such issues this challenge by engaging full-time mechanical and electrical support up front, albeit behind the team's initially planned schedule. The team also raised enough money to buy equipment and fund travel reasonably well in advance of the anticipated need. Finally, the team also addressed many fail-safe features deemed desirable before releasing their bot Tommy Junior into DARPA's safety control.

While the team met the 2007 DARPA Urban Challenge head on addressing concerns from the 2005 DARPA Grand Challenge, the Urban Challenge was an order of magnitude more complex than the 2005 DARPA Grand Challenge. The team understood this entering the challenge and created three plans: 1) an austerity plan of \$90K funding for parts and travel; 2) a 'winning chance' plan of \$400K for parts, travel, and 5 F/T engineers; and 3) a 'slam dunk' plan of \$800K fully funding the team's parts, travel, 8 F/T engineers, and P/T operations and consulting needs. Ultimately, approximately \$47K was applied toward parts and over \$40K was applied toward travel. Labor was largely unfunded but included 2.3 man-years of labor total, of which 10 man-months were spent on software.

The team's primary technical shortcomings entering the race were in an incomplete road and lane detection solution, untested route re-planning, untested low-lying obstacle detection, and non fully tuned turn and speed handling. While the team attempted to address these shortcomings toward the tail end of the project with part-time and over-time labor support, the desired full-time support on such tasks was not achievable at the level of funding and time remaining. Rather, much time was spent on successfully addressing many other critical tasks. The team did produce, in only a year's time, enhanced autonomous steering and speed controls, route planning, lane collision avoidance, moving car following, vehicle passing, intersection handling, merging, parking lot maneuvers, 3-point U-turns, proper turn signaling, dynamic collision avoidance, GPS outage handling, fail-safety and dependability features, development & test enhancements, and operations & marketing enhancements.

Over 100 teams initially applied for participation, only 53 teams were granted site visits (which Team Jefferson aced), and only 35 teams were invited to the national qualification events in California (of which Team Jefferson was one). In the end, DARPA only selected 11 teams to advance to the final event of the 35 invited to the national qualifier events. Of the 11 teams, 7 were Track A teams with \$1M advance funding from DARPA. Team Jefferson (and other national qualifiers) were not granted their two scheduled runs per course (6 runs total) during the national qualification events. What's more, involvement in this challenge's event yielded more insight into the decision making process of DARPA's conduct of grand challenge operations. This challenge's events point to an exclusive body of decision making being wielded by the Chief Judge and DARPA director, Tony Tether. What's more, it's apparent that many rules of engagement were being made on the fly by the Chief Judge at the event itself. The discretionary and last minute decision making on the part of the Chief Judge raised the bar even further for under-capitalized teams like Team Jefferson who relied heavily on rules published by DARPA prior to the race and who designed for race conditions rather than for generalized or unforeseeable conditions.

The issue with designing according to published rules versus generalized conditions was further highlighted when Team Jefferson impacted a low hanging railway crossing arm during one of its runs. DARPA's published city driving challenge rules allude only to ground based obstacles, and California laws prohibit such an obstacle class on California city roads, hence not being something to consider for the race. While many teams had similar issues with the concrete railway crossing arm's obstacle's placement, Team Jefferson's impact led to subtle issues that hampered Tommy Junior's performance during subsequent runs. Finally, while DARPA requires sole control of the safe shutdown of the team's bot during runs, on more than one occasion, DARPA did not safely stop the team's bot (nor did they stop other team's bots)

responsively enough before impact. DARPA does not allow the teams to safely shut their bots down in parallel to officials.

In summary, the team was up against two major challenges during its efforts. The first challenge was time and money. Raising enough money up front to surpass a 'winning chance' prior to involvement is key. Only with such up front capitalization can the team best advance past critical task completion earlier, but also to address more generalized race conditions not explicitly defined by DARPA up front. Furthermore, DARPA's safety procedures have repeatedly demonstrated their difficulty with guaranteeing the safety of the team's primary asset, their robotic vehicle, during the competitions. Thus, unless DARPA will allow a member of each team to safely pause and stop their vehicle in parallel with DARPA officials, more time and money would need to be spent focusing on the design for conditions enabling the vehicle to safely shut itself down before DARPA officials. Regardless, if involved, the team would again petition DARPA to allow team members to also have E-stop control of their vehicles.

The second challenge is getting past the arbitrary and capricious decision making by the Chief Judge that is inherent to the DARPA challenges. While more well defined rules would enable better planning on the part of the teams, after involvement in both 2005 and 2007 DARPA challenges, additional insight provided directly from DARPA personnel as well as from other teams, it is apparent that advancement to the DARPA challenge final events are decisions made almost exclusively by the Chief Judge under wavering conditions. This is opposed to decisions being made by the organization of DARPA and grand challenge program managers, and under well-defined and pre-published selection criteria. Lacking an organizational change to the DARPA grand challenge programs, it is apparent that teams enter the event under conditions involving arbitrary and capricious decision making. Thus, in order to compete in the DARPA run challenges, a team must raise enough money to put it into a 'slam dunk realm fairly early in the game and consider a wide range of generalized conditions as part of its final design. Otherwise, teams enter an event whereby random and last minute decision making by the Chief Judge renders the team's time and money spent, as well as tax payer money spent, wasted and mismanaged.