UNITED STATES DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
Gaithersburg, Maryland 20899-
OFFICE OF THE DIRECTOR

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Distribution:

This letter summarizes the results of a review and determination conducted as a result of your October 26, 2007 appeal submitted under the National Institute of Standards and Technology (NIST) Guidelines, Information Quality Standards, and Administrative Mechanism. Your appeal requests the reconsideration of NIST's September 27, 2007 denial of your April 12, 2007 request for correction (RFC) that contained multiple assertions and requests under the overall heading "Information in the WTC report violates OMB and NIST information quality standards." Six assertions and requests were: A) NIST's analysis, specifically rejection of the less severe damage estimates, was flawed; B) Request for inclusion of simulations using the less severe damage estimate; C) NIST's interpretation of the necessity of both structural and fire damage for building collapse to occur as a result of computer models was flawed; D) assertion that the conditions used and results of beam sagging obtained through computer simulation and experiments were inconsistent and thus the computer modeling "did not represent physical reality"; E) specimen measurements did not support temperatures used within NIST modeling; F) NIST analyses were insufficient because they presumed that the airplane collisions and ensuing fire were responsible for the failure and only modeled through the inception of failure. NIST was also requested to consider the possibility of explosives contributing to the collapse, and the utility of the report was questioned.

In preparing the response to the appeal, NIST staff who did not participate in the NIST World Trade Center (WTC) Investigation and who did not participate in preparation of the NIST response to your RFC reviewed the appeal and the history of the RFC. This review included reconsideration of the RFC, the NIST response, the appeal itself and referenced WTC investigation documents. Its purpose was to determine whether NIST's response to your RFC fully and appropriately addressed the issues raised and whether additional supporting arguments in your appeal affected the NIST's conclusion that WTC Investigation reports did not need correction.

Using the headings identifying issues in your appeal, the conclusions of the review as well as my resulting decisions are as follows.

Rejection of the Less Severe Damage Estimates

In your appeal, you again requested that NIST address why it rejected the less severe damage estimate. Your appeal focuses on whether a particular item, specifically landing gear, exited WTC 1 on the side opposite the airplane impact in the simulations. You claim that the failure of this particular item to emerge in any of the base, more-severe or less-severe impact simulations, in contrast to what was observed in the actual impact, indicates that no simulation is more valid than the other. The NIST response to your RFC has already noted that the less-severe damage estimates were excluded because "The less severe damage case did not meet a key observable: no aircraft debris was calculated to exit the side opposite to impact and most of the debris was stopped prior to reaching that side, in contradiction to what was observed in photographs and videos of the impact event," the text being a correction that remedied an inconsistency between the statement in NCSTAR 1-2 and NCSTAR 1-6 made in response to your RFC, with appropriate erratum published as noted. Thus, contrary to your assertions, NIST did not exclude the less-severe damage estimate simply because it did not result in building failure; rather NIST relied on the lack of the key observable being met in the less-severe damage simulation.

The NIST NCSTAR report considered the emergence of general "aircraft debris" rather than the emergence of a particular item to be a key observable. The NCSTAR 1 report indicated that factors such as uncertainties in the configuration of the building interior could affect the emergence of a particular item, "Minor modifications to the model (all within the uncertainty of the input data) would have resulted in the engine passing through the north exterior wall of the tower" (NCSTAR 1, p. 116). Using emergence of aircraft debris rather than just one item as a criterion is therefore both logical and reasonable.

Your appeal also contests the use of "shifting of building contents due to the aircraft impact" to support NIST's exclusion of the less-severe damage case. You also claim that this is unreasonable because "NIST had "no visible information" regarding damage to the "interior building contents."" Contrary to your claim, shifting of building contents was visually confirmed: "The two simulations of WTC 2 showed accumulations of furnishings and debris in the northeast corner of the 80th and 81st floors. These piles were observed in photographs and videos." (NCSTAR 1, p. 116)

Based on the reconsideration of the relevant information described above, I find that, with NIST's earlier correction of the error you identified, the NIST WTC Investigation reports need no further correction on this issue.

B. NIST Computer Simulations

This section of your appeal questions elimination (pruning) of the less severe damage case and requests that simulations for this case be provided along with all simulations conducted. The NCSTAR report noted that practical considerations required reduction of the number of simulations "From the component and subassembly simulations, it became apparent that each computation of the full tower and aircraft would take weeks" (NCSTAR 1, p. 109), and "The number of global structural response analyses was prohibitive with this approach." (NCSTAR 1-6, p. 290). As discussed above, the less-severe damage case was eliminated from consideration because of failure to match key observables including the emergence of aircraft debris.

Your appeal suggests that failure to consider the less-severe impact case with all variations of the "factors (or parameters)" before excluding it was inappropriate. However, elimination (pruning) of the intermediate base-case for impact damage (NCSTAR 6, Figure 9-3, p. 292) after variation of parameters at the subsystem level because of superior fitting of key observables by the more severe damage case supports this elimination. Specifically, if the severe-damage case simulations fit the observables better than the base-case simulations, then the fit of the less-severe damage case must be even less satisfactory.

You claim that "the magnitude used for each factor (or parameter) was not consistent in the sub-component analyses." Specifically, you focus on the maximum strain rate associated with engine-core column impacts. You ask why the maximum value corresponds to 1000% of the base-case value (scale factor of 10) while maximum values for the other parameters were set to 190% of the base-case value (scale factor 1.9). The report unambiguously states "At the time of this study, final data were not yet available for strain rate effects in the tower materials, so this large variation was selected." (NCSTAR 1-2B p. 177). The report continues "Subsequent data, as discussed in Chapter 2, was used to reduce this uncertainty to a scale factor of 0.1 to 2.0 in the rest of the uncertainty analysis." This range corresponds to 10% to 200%, which is consistent with the variation of other parameters in the simulations. The wide range of properties considered for strain rate effects of the engine are explained in the same location: "In addition to these material parameter uncertainties, different data sources cited different materials for many of the engine components, so the two different material sets were considered here."

You also question NIST's procedure of variation of parameters: "NIST used a Plackett-Burman design to screen out non-influential factors (or parameters) prior to conducting their global analyses. This was not appropriate for NIST's purposes, because a Plackett-Burman DOE assumes that interactions between factors are negligible." NIST used "an orthogonal factorial design process" to "identify the most influential parameters" (NCSTAR 1-6, p. 290). This process "allowed for identification of influential parameters that reduced the number of analysis runs at the global level." (NCSTAR 1-6, p. 290) This was required by the practical computational concerns noted already in the above section NIST Computer Simulations. NIST's orthogonal factorial design process permitted evaluation of the relative influence of the parameters without examining "interactions", inclusion of which would have increased the number of required simulations to the extent that the analysis was computationally impractical.

With regard to the statement in your appeal that "The public cannot verify NIST's comparison of experimental responses to photographic evidence without access to all the photographic evidence and the logic used", NIST has, wherever possible, made public evidence relevant to the WTC reports. However, due to copyright issues, NIST may not release copies of most of the photographs without permission of the owner. In response to requests for the photographs submitted under the Freedom of Information Act, NIST is currently following Department of Commerce procedures and contacting the photographers to determine whether they will grant such permission.

Based on the reconsideration of the relevant information described above, I find that the NIST WTC Investigation reports need no correction on this issue.

C. Information in Figure 9-3 Violates the OMB and NIST IQS Objectivity Standards

You assert that failure of the isolated cores through impact alone in the more-severe damage simulations, in apparent conflict with the ability of both WTC 1 and WTC 2 to withstand the airplane impacts, raises questions about the more-severe impact damage simulations in the full structure global analyses as well as analysis of this particular building subsystem. You also request "justification for "pruning" a damage estimate which still "informed its global analysis."

The NCSTAR report notes that the World Trade Center towers and the NIST global analyses included a hat-truss structure that redistributed load between the core and the perimeter of each building during and after the impacts. The "isolated core" simulations did not include the hat structure (NCSTAR 1-6, p. 187) being models of the behavior of the isolated core. Thus, the fact that the isolated core did not converge in the more-severe damage case does not indicate that "damage estimates were set too high" as you suggest; rather, "The isolated subsystem models lacked the restraint and load paths to other subsystems found in the global analysis" (NCSTAR 1-6, p. lvii). Whereas the damaged core was able to shed load to the perimeter columns in the actual World Trade Center towers and in the full simulations of the global analysis, such load redistribution was not possible in simulations of the core alone. Failure of the isolated core to converge in simulations immediately upon impact is therefore not inconsistent with the ability of the entire structure to withstand impact, and the use of such results to inform subsequent analysis is reasonable.

With regard to your request for "justification": the NCSTAR documents clearly indicate how comparison of modeling predictions from the behavior of subsystems with key observables was used to limit the range of conditions studied in the global analysis. An example based on aircraft debris is given above in the "Rejection of the Less Severe Damage Estimates" section of this response. Such comparison of prediction and observable to "inform the global analysis" is a central tenet of the scientific method and requires no justification.

Your appeal requests that NIST explain how "significant core weakening" was "**necessary** to initiate building collapse." The NIST report notes that simulations of fires without damage to the core did not result in building failure (NCSTAR 1 p. 147); it also notes a substantial fire that had occurred in WTC 1 prior to September 11, 2001 and testing of modules that both demonstrated the ability of the undamaged structures to withstand fire alone (NCSTAR 1, p. 149). The report also explains that due to the ability of the complete structure to redistribute load between the core and the perimeter columns, damage to both the core and the perimeter columns was necessary for total building failure (NCSTAR 1, p. 322). Furthermore, evolution of the buildings based on data including visual observations of fire progression and structural degradation during the course of the subsequent fires was consistent with the predictions of NIST models. Tables 6-10 and 6-11 in NCSTAR 1 describe some of the significant consistencies during the course of the WTC tower failures including (but not limited to) time, location and extent of perimeter wall bowing, tilt directions prior to collapse, and time to collapse. Taken together, these factors support the NIST conclusion that significant weakening of the core due to both aircraft damage and thermal effects was necessary for structural collapse.

Your appeal further suggests that the "Pruned" entry for the Base Impact Damage: Structural analysis block in Table 9-3 of NCSTAR 1-6 is inconsistent with NIST's presentation of isolated-core structural analyses using base-case impact damage. Table 9-3 includes only the global analyses that were carried out; it does not address the isolated-core, floor and perimeter sub-systems structural analyses that were carried out. "The subsystem analysis results led to the pruning of the **global** structural analysis for the base case impact damage sub-tree, as shown in Fig. 9-3" [bold emphasis added] (NCSTAR 6-1, p. 291).

Your appeal requests "reconciliation" of statements regarding particular details of column buckling/nonbuckling in isolated-core simulations, suggesting that they are inconsistent. Specifically, you claim that because columns in the core of WTC 1 buckled but those in WTC 2 did not "it means that the computer simulations did not predict that WTC 2 would collapse." Your analysis ignores the horizontal restraints for the WTC 2 isolated-core simulation, required because it otherwise was not stable when loaded in the severe-damage impact state (NCSTAR 1-6, p. 186), as well as the previously noted fact that the behavior of a single subsystem is not necessarily indicative of how the entire structure behaves.

Based on the reconsideration of the relevant information described above, I find that the NIST WTC Investigation reports need no correction on this issue.

D. Floor Sagging

Your appeal asserts that differences between computer simulations and experimental ASTM E119 tests of floor sagging and truss deformation during controlled heating exhibit inconsistencies. NIST's response to your RFC noted multiple differences in the conditions of the experiments and simulations, including different thermal profiles and insulation coverage. The details of all are contained within the NCSTAR report, and because of these differences there is no inconsistency.

Regarding the appropriateness of the ASTM E119 tests, your appeal states that "even test specimen 4, with **nearly** [emphasis added] no fireproofing applied, met all test requirements for 58 minutes", i.e., a period longer than available in the actual collapse and therefore "not representative of the real WTC fire condition because it involves longer and more severe fire times." However, comparison of experiment and models shown in Figure 6-44 of NCSTAR 1 demonstrate that a truss with no fireproofing heated to much higher temperatures in just 13 minutes (NCSTAR 1, p. 132) and that NIST models accurately captured such behavior. The reasons behind various test and modeling conditions are described in detail. This includes the reason for modeling with less insulation than the nominal as-built coverage "based on the estimated damage to the fireproofing due to debris impact" consistent with visual observation that is described, e.g., in NCSTAR 1-3, section 6.8.4. Contrary to the assertions in your appeal, the NIST assumptions regarding fire exposure are conservative. Specifically, NIST modeling only assumed fireproofing was removed by direct debris impact; this is supported by observation of 1" concrete removal around reinforced concrete at the Pentagon crash site (NCSTAR 1, section 5.5) as well as experiments on insulated steel bars conducted at NIST using pellets moving at 350 miles per hour (NCSTAR 1, p. 119). Other mechanisms such as fireproofing removal through structural vibrations upon impact, were not included even though "There was photographic evidence that some fraction of the SFRM [insulation] was dislodged from perimeter columns not directly impacted by debris." Details are summarized in NCSTAR 1-6, section 5.6 as well as NCSTAR 1, p. 119. The consistencies between NCSTAR predictions and key observables, for example in Tables 6-10 and 6-11 in NCSTAR 1, support both the significance of the fireproofing damage and the reasonable, conservative, nature of the removal assumptions incorporated into the NCSTAR modeling.

Your appeal also asserts that visual data used by NIST to confirm floor sagging is not valid for this purpose. However, you offer no analysis to support this assertion. The NIST report is based upon quantitative experiments and modeling, described in the NCSTAR reports.

You also ask "Why did NIST perform the floor test if the results were, by design, not going to be used in the subsequent analyses?" The report states that the experiments were conducted specifically because

"NIST found no evidence regarding the technical basis for the selection of insulation material for the floor trusses or for the insulation thickness to achieve a 2 hour rate. Further, NIST has found no evidence that fire resistance tests of the WTC floor system were conducted". The tests were needed "to obtain data regarding the limits of the insulated floors in withstanding the heat from the fires." (NCSTAR 1, p. 141) The experiments thus established the upper limits of their capacities.

Based on the reconsideration of the relevant information described above, I find that the NIST WTC Investigation reports need no correction on this issue.

E. The WTC Steel Temperature

Your appeal requests that NIST redo simulations using the estimated maximum temperature of 250 °C reached by metallurgical specimens of core columns obtained by NIST. However, contrary to your assertions that the number of core column specimens available could represent up to 23 percent of the core columns, the report says "Only two core column specimens had sufficient paint remaining to make such analysis" (NCSTAR 1, p. 90) and "Note that these core columns represent less than 1 percent of the core columns on floors involved with fire and cannot be considered representative of any other core columns" (NCSTAR 1-3, section 6.6.2). It is thus not possible to conclude anything from the recovered core steel concerning the maximum temperatures reached by the core columns. You request that NIST provide "details of the intended extrapolation protocol" because of "NIST's new claim that the test results cannot be extrapolated to provide meaningful information." Knowledge of statistics makes clear that there can be no meaningful protocol for extrapolating from a specimen set that is too small to provide statistically significant conclusions. Rather, the fire growth and spread results of the simulations, consistent with the observable data for the WTC towers, underlie the thermal response results including core column temperatures.

You ask "Why did NIST perform the steel temperature tests, including the paint deformation test and the test of steel microstructure, if the results would not be used in the final analyses?" NIST conducted these tests because such tests could, and did, yield evidence to support the overall analysis "these analyses indicated some zones within WTC 1 where the computer simulations should not, and did not, predict highly elevated steel temperatures." (NCSTAR 1, p. 91).

Your also assert that temperatures predicted in particular locations at a particular time in NIST simulations are inconsistent with predicted failure. This assertion is without basis, as calculations regarding structural evolution and stability at any given moment include consideration of the entire structure as it had evolved to that point in time. Thus, structural failure, such as predicted in the NIST analysis, is a result of the full progression of events to that point in time and includes consideration of failed parts, redistributed loads and weakened structures (including temperature dependent properties). Contrary to your assertions, failure cannot be deduced simply from the temperature distribution on a particular floor at a particular time.

Based on the reconsideration of the relevant information described above, I find that the NIST WTC Investigation reports need no correction on this issue.

F. The Goal of the WTC Report and Its Overall Analysis

Your appeal asserts that NIST should have reported on the full events of the collapse as opposed to stopping at the initiation of collapse as manifest in global instability of the structure. NIST has done so; it explained the likely sequence of events leading to global instability, thus establishing the likely technical cause or causes of the building failure as the towers would not have fallen had instability not been reached. Section 6.14.4 of NCSTAR 1 explained what occurred beyond this point.

Based on the reconsideration of the relevant information described above, I find that the NIST WTC Investigation reports need no correction on this issue.

Alternative cause of collapse

Your appeal asserts that explosives contributed to the building failure based on loud noises described by some first responders. The NCSTAR report describes towers that were undergoing progressive structural failure, with major fires burning on multiple floors and highly combustible jet fuel flowing into elevator shafts and into other parts of the building. Overall evidence includes "nearly 1,200 first-person interviews of building occupants and emergency responders" (NIST NCSTAR 1, xiii), including 116 first responders (NIST NCSTAR 1, 7.2.1). Loud noises and explosions described by some first responders are consistent with the ongoing events and, as part of the larger body of interviews and evidence, are consistent with the NIST report conclusions. Such remarks, taken in the context of all the interviews conducted, as well as the overall fit between observables and NCSTAR model predictions, are not significant and do not provide reason to doubt the conclusions of the NCSTAR report.

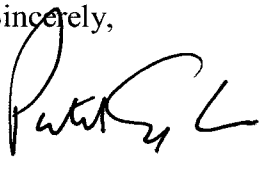
Based on the reconsideration of the relevant information described above, I find that the NIST WTC Investigation reports need no correction on this issue.

Report utility

Your appeal questions the utility of the NIST report. The NIST response to your RFC addresses this issue, noting that "NIST research and in this case the findings of a failure investigation provide the technical basis" for changes to codes and standards by appropriate codes and standards development organizations. The number of code changes based on NIST's recommendations is not a direct measure of the utility of the original NCSTAR report or the appropriateness of NIST's response to your RFC. NIST's findings and recommendations constitute a firm scientific foundation for, and contribute significantly to, the standards setting process.

Based on the results of the review, I have determined that the NIST WTC Investigation as described in NCSTAR 1 and the supporting reports was thorough and based on all available evidence and that the original NIST response to your RFC was appropriate. Therefore, NCSTAR 1 will not be further modified. Thank you for your comments and concern.

Sincerely,



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