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Original

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Closure to Discussion of "New Resilience Index for Urban Water Distribution Networks"

by G. P. Cimellaro, A. Tinebra, C. Renschler, and M. Fragiadakis.

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The authors are thankful for the in-depth comments provided by the discussers. The following summarizes the authors' opinions on the issues brought up in the discussion of the original paper:

- The use of T_{LC} in equation (6) and (9) instead of T_R allows to compare different scenarios of the same network as well as different networks, by maintaining the control time T_{LC} constant in all cases. The recovery time T_R is not suitable because it will change when different scenarios are compared as shown in Figure 13 of the original paper. This change will affect the values of the resilience indicators R_1 and R_2 . The ranges T_{LC} , T_{NF-I} and T_{NF-II} are dependent each other and are not provided because they are selected by the user based on the problem at hand.

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- 19 • The definition of Resilience that is adopted in this paper is the one provided in Cimellaro
20 et al., (2009), which in similar forms is commonly accepted in the civil engineering
21 community. The proposed index is able to capture the capacity to recover from failure
22 because the higher is the indicator, the faster is the recovery. Furthermore the index
23 proposed in equation (6), which is related to the service availability, is similar to the index
24 proposed by Shinozuka and Chang (2004) to measure resilience in power distribution
25 networks.
- 26 • As clearly stated in the paper both indicators R_1 and R_2 should be considered in the analysis,
27 because the first is related to the *service demand* and the second to the *capacity*. We will
28 show two examples that explain why both are important. Right after the extreme event, if
29 the authorities do not shutdown the system and are not able to identify the pipe breakage
30 on time, there will be a large water loss in the network, while the service is still maintained,
31 even if with lower pressure. In this case R_1 will remain constant while R_2 will capture the
32 loss of resilience in the network. On the other hand, if the service is shutdown to allow
33 repair operations for example for several hours, then R_2 , that is related to the water level in
34 the tank, will remain constant while the index R_1 will drop because there will be different
35 users without service.
- 36 • Although the authors are fully aware of the problem of infrastructure interdependencies as
37 shown in several papers from the same authors (Cimellaro et al. 2014a-b), the problem of
38 infrastructure interdependencies has not been considered in this paper. Authors are already
39 developing further research in that direction.
- 40 • The authors fully agree that the three indicators are dependent each other, because they are
41 monitoring different properties of the same event. However, the indicators are

42 dimensionless quantities defined as ratios, so they are not probabilities. Different options
43 has been compared such as the mean, the weight average, but finally we have decided to
44 use the product because there is no need to define additional weight coefficients.
45 Furthermore, observing the results, we have noticed that when combining different
46 indicators associated to different properties of the network, we obtain a meaningful
47 “average”. In fact a given percentage change in any of the indicators has the same effect
48 on the final global indicator.

- 49 • The authors thank the discussers for identifying the misprint. The parameter Δt should be
50 dimensionless, while Q_e in equation 19 is expressed in m^3/s .

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