PRIORITY
Criminal Justice
NEEDS INITIATIVE

A project of the **RAND Corporation**, the **Police Executive Research Forum**, **RTI International**, and the **University of Denver**

Using Future Internet Technologies to Strengthen Criminal Justice

Appendix

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TECHNICAL APPENDIX

During the in-person workshop, panelists brainstormed needs in small breakout groups. Panelists also were asked to specify the criminal justice communities of practice (law enforcement, courts, and corrections) for which each need was relevant. The result was a total of more than 90 needs.

The electronic panel was developed and implemented as follows: First, following the in-person workshop, RAND researchers reviewed the original set of more than 90 needs generated during the workshop and compressed the set into 45 needs by identifying sets of needs that were highly similar (same technology area, same underlying operational need) and then drafting new needs that captured the content of the needs in each set. RAND researchers also copy edited the language of the needs. The revised list was then circulated to the panelists electronically, and the panel had the chance to review and comment on the consolidated and edited list of needs. RAND then revised the list of needs in response to the panelists' comments. All comments received were administrative; no panelist disagreed with the needs consolidations.

Second, the panelists filled out Excel worksheets to rate the needs. Panelists were asked to rate each need on a scale of 1 to 9 (1 low, 9 high) with respect to the following questions:

- *Questions 1–3*: How important could this need be in supporting each criminal justice community (law enforcement/courts/corrections)?
  - High ratings (7 to 9) mean that the need is critically important to that criminal justice community of practice. Here "critically important" means that—assuming there are no technical or operational barriers to using the solution to the need—the solution to the need would have a *high impact* on furthering criminal justice objectives where it is used, and would be used *pervasively* across the relevant criminal justice communities. We would assign a 9 to the notable "game-changing criminal justice technologies" in recent years, each of which is associated with a 15-percent to 30-percent improvement in performance in a key criminal justice objective where it is used. Examples include the practice of hot spot policing (associated with average crime-reduction effects of more than 15 percent in the meta analysis found in Braga, Papachristos, and Hureau, 2012) and the use of body armor (could reduce officer fatalities by up to 30 percent, per Bir et al., 2011).
  - Medium ratings (4 to 6) mean that the need is important to that criminal justice community.
  - Low ratings (1 to 3) mean that the need is not that important to that criminal justice community.
- *Question 4*: What is the likelihood that this need could be successfully met from a technical perspective?
  - High ratings (7 to 9) mean that a path to overcoming technical barriers is clear and seems achievable (70-percent to 90-percent chance of success)
  - Medium ratings (4 to 6) mean that technical barriers are difficult and success is uncertain (40-percent to 60-percent chance of success)
  - Low ratings (1 to 3) mean that technical barriers are formidable and success requires a breakthrough (10-percent to 30-percent chance of success)
- *Question 5*: What is the likelihood that this need could be successfully met from an operational perspective?
  - High ratings (7 to 9) mean that a path to overcoming operational and deployment barriers is clear and seems achievable (70-percent to 90-percent chance of success).
  - Medium ratings (4 to 6) mean that operational and deployment barriers are difficult and success is uncertain (40-percent to 60-percent chance of success).
  - Low ratings (1 to 3) mean that operational and deployment barriers are formidable and success requires a breakthrough (10-percent to 30-percent chance of success).

Members of the Web 3.0+ Technologies Workshop

- Daniel Castro, Information Technology and Innovation Foundation
- Jason Elder, International Association of Crime Analysts
- Eric Franzon, SemanticWeb.com
- Yolanda Gil, University of Southern California
- Mark Hendershot, American Probation and Parole Association
- Gopal Khanna, The Khanna Group
- Sean Maday, SigActs, Inc.
- Susan Malaika, IBM
- Robert Kasabian, American Jail Association
- Karl Rabke, Cisco Systems, Inc.
- William Raftery, National Center for State Courts
- David Roberts, International Associations of Chiefs of Police
- Joe Russo, National Law Enforcement and Corrections Technology Center, Corrections Technology Center of Excellence (designated by the American Probation and Parole Association to attend the workshop)
- Lee Tien, Electronic Frontier Foundation
- Greg Toth, Internet of Things DC Meetup
- Alan Webber, IDC Global

- Here, “operational and deployment barriers” might include problems related to human factors, affordability, maintainability, organizational acceptance, legal/policy (privacy, civil rights, etc.), and security (hacking risks, etc.).

Panelists also had an opportunity to write comments about why they rated needs as they did. In all, 12 of the 16 panelists completed worksheets.

The ratings were used to construct an *expected value* score from each panelist for each need. Estimating expected value is the baseline approach in decision analysis for assessing the worth of selecting an option under uncertainty (see, for example, de Neufville, 1990, pp. 312–313); it is also the approach used in prior RAND research on criminal justice technology needs, as well as a line of similar research.[1] This is the potential value of the need (as measured by the importance ratings) multiplied by the estimated probabilities that the need could be addressed both technically and operationally. Specifically, the formula for the expected value score, $E(V_i)$, is

$$E(V_i) = \frac{p_{it} p_{id} (V_{il} + V_{ic} + V_{ir})}{3},$$

where P_{it} and P_{id} are the probabilities of success from technical and operational perspectives, respectively, and V_{il}, V_{ic}, and V_{ir} reflect the importance of the need to the law enforcement, courts, and corrections communities, respectively. The 3 in the denominator is used to take the average of the importance of the need across all three communities of practice.

Since it also is important to identify those needs of importance to individual communities of practice, we also calculate expected value scores with respect to individual communities. So, for example, the expected value score with respect to law enforcement is

$$E(V_{il}) = p_{it} p_{id} V_{il}.$$

To create an overall expected value score, we took the median of all the panelists’ individual expected value scores for each need. The median is used as it is robust—it estimates the center of the distribution in a way that is resistant to outliers and atypical distributions. Medians also do not require making any assumptions about the underlying statistical distribution of the scores.

The ratings were done in two rounds. Following the first round, the panelists had an opportunity to see a summary of the results along with the comments on each need. In the second round (the Delphi round), panelists then had an opportunity to re-rate the needs given the summary of ratings and comments from Round 1. (Note that the panelists could choose not to re-rate their needs.)

In presenting the results, we list all needs along with the ratings *tiers* into which they fall. Tiers divide the needs into three categories based on their expected value scores—tier 1 corresponds to comparatively high priority needs, tier 2 corresponds to medium priority needs, and tier 3 corresponds to comparatively low priority needs. Here, we employ the *K*-means clustering algorithm to group the needs into three categories by expected value. *K*-means is a predominant clustering algorithm that iteratively partitions data into *k* subsets in which each element is assigned to the subset with the closest mean. Notably, *k*-means is the only clustering algorithm in the Institute of Electrical and Electronics Engineers (IEEE) International Conference on Data Mining’s “top ten data mining algorithms” (Wu et al., 2007). *K*-means is a heuristic algorithm for solving the following problem: Subdividing data elements into *k* sets such that the total of the squared differences between each data point and its cluster center (i.e., each cluster’s average) is minimized. Mathematically, we want to divide the data points into sets 1, 2, . . . *K* so that the following measure is minimized:

$$\min \sum_{i=1}^{K} \sum_{x_j \text{ in set } i} \|\boldsymbol{x}_j - \boldsymbol{\mu}_i\|^2 .$$

Here, μ_i is the center, or average, of cluster *i*. This measure, also called the *within-cluster sum of squares* or *cluster cohesion*, is one of the most common measures for assessing how effectively the data have been portioned into clusters overall. The reason a heuristic algorithm like *K*-means is used is that minimizing cluster cohesion is known to be hard to solve exactly (mathematically, it is NP-hard). The version of *K*-means used is the StatScicCalc online tool (Ahmed, 2014).

In addition to overall expected value, we specify tiers for expected value with respect to supporting each community of practice (law enforcement, courts, and corrections). *K*-means was used to divide those needs that were relevant to that com-

[1] It is the method used in prior RAND studies on identifying and prioritizing criminal justice needs (Hollywood et al., 2015; Jackson et al., 2015; and Silberglitt et al., 2015). Prior to these studies, expected values were used in a series of related RAND studies to assess portfolios of investment options (Silberglitt and Sherry, 2002; Chow, Silberglitt, and Hiromoto, 2009; Silberglitt et al., 2004; and Landree et al., 2009). In our case, the “investment options” are taking action to address a specific criminal justice technology need.

munity into three tiers, as well. (Needs that are not relevant to a community of practice are assigned to a "not applicable" tier.)

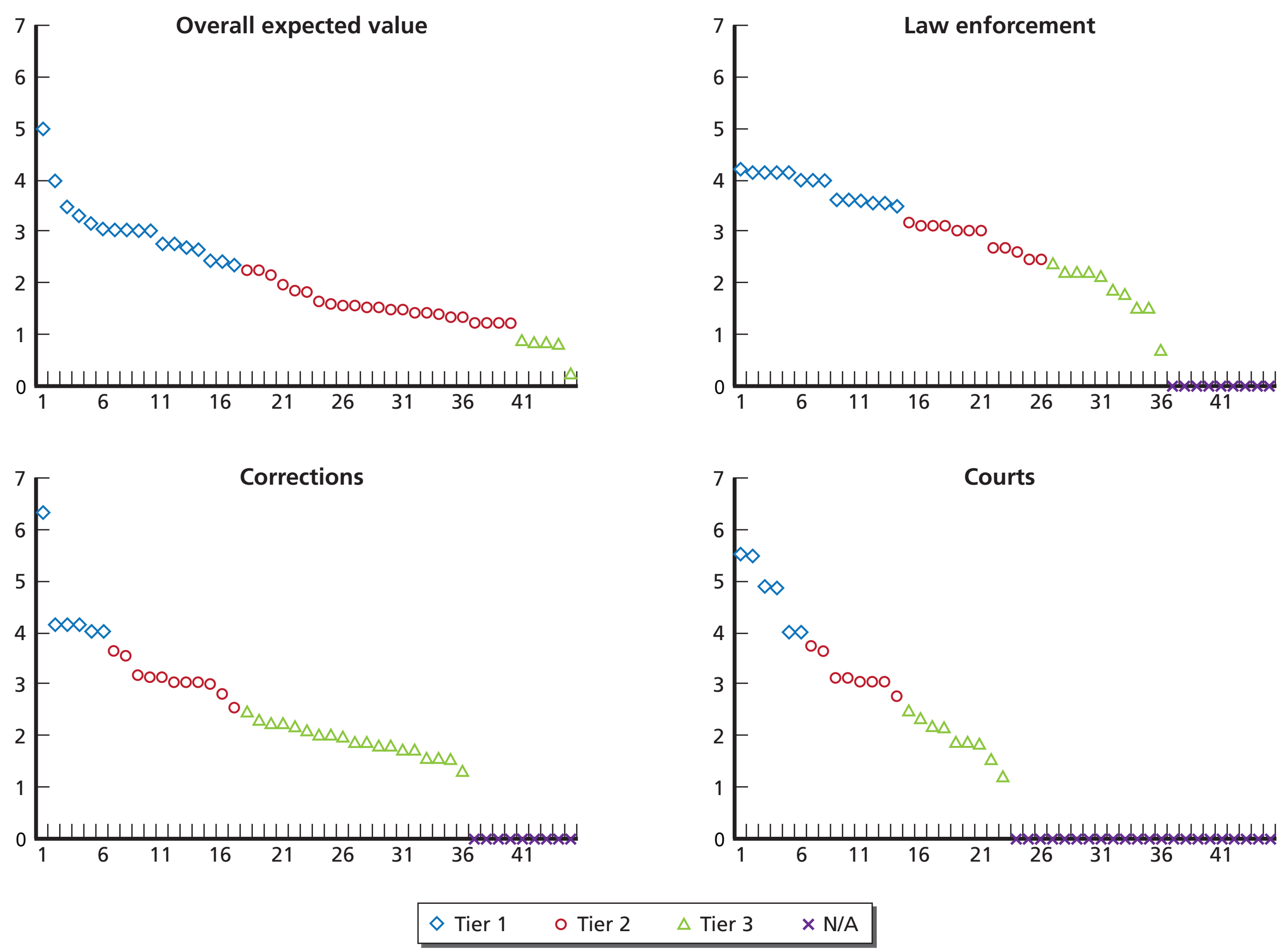
Figure A.1 shows the expected values overall and for each community of interest, along with what tier needs with given expected values are in. Note that *K*-means did find substantially differing numbers of Tier 1 needs for each community of practice. In the case of overall expected value and law enforcement, a good number of needs with similar expected values were clustered at the top, with comparatively few needs with much lower expected values clustered at the bottom. For corrections, however, that pattern was reversed.

The distribution of expected values for courts was between that of law enforcement and corrections. However, there were comparatively few needs that were considered relevant to courts (only 23 of 45).

The body of the report notes that the need to provide video connections to correctional facilities was a "breakout" need. Mathematically, it was an outlier as measured by Grubbs' Test (National Institute of Standards and Technology, undated) for both overall value (p-value < 0.047) and for corrections (p-value = 0.006). The Contchart Software web tool was used to perform Grubbs' Test (Contchart Software, undated).

In addition to computing expected value scores, the panelists frequently flagged particular needs as raising civil rights, privacy rights, or cyber security issues. We tracked which needs were flagged as raising one or more of these issues, as well. Privacy, civil rights, and security risks of the emerging technologies were major topics of discussion at the workshop and in the comments about the needs during the ratings rounds. While panelists did not specifically rate needs by their privacy, civil rights, and security implications, panelists explicitly considered these factors in their operational feasibility ratings.

Figure A.1. Expected Value Scores by Tier



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Bibliography

Ahmed, Alijah, "K-Means Clustering Calculator," *SciStat Calc*, January 24, 2014. As of June 12, 2015:
http://scistatcalc.blogspot.com/2014/01/k-means-clustering-calculator.html

Bir, C., J. Cecconi, A. Dennis, M. McMullen, and C. Sloane, *Behind the Badge: Management Guidelines for Impacts to Body Armor*, National Institute of Justice, Award Number 2004-IJ-CX-K040, 2011. As of June 12, 2015:
https://www.ncjrs.gov/pdffiles1/nij/grants/233645.pdf

Braga, Anthony A., Andrew V. Papachristos, and David M. Hureau, "The Effects of Hot Spots Policing on Crime: An Updated Systematic Review and Meta-Analysis," *Justice Quarterly*, iFirst, 2012, pp. 1–31.

Chow, Brian G., Richard Silberglitt, and Scott Hiromoto, *Toward Affordable Systems: Portfolio Analysis and Management for Army Science and Technology Programs*, Santa Monica, Calif.: RAND Corporation, MG-761-A, 2009. As of November 13, 2014:
http://www.rand.org/pubs/monographs/MG761.html

Contchart Software, "Outlier Tests for the Normal Distribution," ControlFreak: Control Charts for Individual Data Points, undated. As of June 12, 2015:
http://contchart.com/outliers.aspx

deNeufville, Richard, *Applied Systems Analysis: Engineering Planning and Technology Management*, New York: McGraw-Hill, Inc., 1990.

Hollywood, John S., John E. Boon, Jr., Richard Silberglitt, Brian G. Chow, and Brian A. Jackson, *High-Priority Information Technology Needs for Law Enforcement*, Santa Monica, Calif.: RAND Corporation, RR-737-NIJ, 2015. As of June 12, 2015:
http://www.rand.org/pubs/research_reports/RR737.html

Jackson, Brian A., Joe Russo, John S. Hollywood, Dulani Woods, Richard Silberglitt, George B. Drake, John S. Shaffer, Mikhail Zaydman, and Brian G. Chow, *Fostering Innovation in Community and Institutional Corrections: Identifying High Priority Technology and Related Needs for the United States Corrections Sector*, Santa Monica, Calif.: RAND Corporation RR-820-NIJ, 2015. As of June 12, 2015:
http://www.rand.org/pubs/research_reports/RR820.html

Landree, Eric, Richard Silberglitt, Brian G. Chow, Lance Sherry, and Michael S. Tseng, *A Delicate Balance: Portfolio Analysis and Management for Intelligence Information Dissemination Programs*, Santa Monica, Calif.: RAND Corporation, MG-939-NSA, 2009. As of November 13, 2014:
http://www.rand.org/pubs/monographs/MG939.html

National Institute of Standards and Technology, "Grubbs' Test for Outliers," *e-Handbook of Statistical Methods*, undated. As of July 8, 2015:
http://www.itl.nist.gov/div898/handbook/eda/section3/eda35h1.htm

Silberglitt, Richard, Brian G. Chow, John S. Hollywood, Dulani Woods, Mikhail Zaydman, and Brian A. Jackson, *Visions of Law Enforcement Technology in the Period 2024–2034: Report of the Law Enforcement Futuring Workshop*, Santa Monica, Calif.: RAND Corporation, RR-908-NIJ, 2015. As of June 12, 2015:
http://www.rand.org/pubs/research_reports/RR908.html

Silberglitt, Richard, and Lance Sherry, *A Decision Framework for Prioritizing Industrial Materials Research and Development*, Santa Monica, Calif.: RAND Corporation, MR-1558-NREL, 2002. As of July 12, 2015:
http://www.rand.org/pubs/monograph_reports/MR1558.html

Wu, Xindong, Vipin Kumar, J. Ross Quinlan, Joydeep Ghosh, Qiang Yang, Hiroshi Motoda, Geoffrey J. McLachlan, Angus Ng, Bing Liu, Philip S. Yu, Zhi-Hua Zhou, Michael Steinbach, David J. Hand, and Dan Steinberg, "Top 10 Algorithms in Data Mining," *Knowledge and Information Systems*, Volume 14, No. 1, December 2007, pp. 1–37.