

# **ISI Conference paper: Mapping the Contemporary Terrorism Research Domain: Researchers, Publications, and Institutions Analysis**

## **Abstract**

The ability to map the contemporary terrorism research domain involves mining, analyzing, charting, and visualizing a research area according to experts, institutions, topics, publications, and social networks. As the increasing flood of new, diverse, and disorganized digital terrorism studies continues, the application of domain visualization techniques are increasingly critical for understanding the growth of scientific research, tracking the dynamics of the field, discovering potential new areas of research, and creating a big picture of the field's intellectual structure as well as challenges.

In this paper, we present an overview of contemporary terrorism research by applying domain visualization techniques to the literature and author citation data from the years 1965 to 2003. The data were gathered from ten databases such as the ISI Web of Science then analyzed using an integrated knowledge mapping framework that includes selected techniques such as self-organizing map (SOM), content map analysis, and co-citation analysis. The analysis revealed (1) 42 key terrorism researchers and their institutional affiliations; (2) their influential publications; (3) a shift from focusing on terrorism as a low-intensity conflict to an emphasis on it as a strategic threat to world powers with increased focus on Osama Bin Laden; and (4) clusters of terrorism researchers who work in similar research areas as identified by co-citation and block-modeling maps.

## **1 Introduction**

Contemporary terrorism is a form of political violence that evolved in the 1960s and characterized by an increase in terrorist attacks across international boundaries [33]. The recent escalation of contemporary terrorism has attracted many new and non-traditional research communities such as information science and human factors, whose scholars have a desire to do research in this area. This raises questions for new terrorism researchers as they try to adapt to the challenges in this domain “Who are the leading researchers in terrorism?” “What are their relevant publications?” “What are the dominant topics because I want to know if my ideas have already been explored?” “What types of data are used?” “Who should I work with?”

The task of responding to these questions is difficult because of the explosive growth in the volume of terrorism publications, the interdisciplinary and international nature of the field, and the lack of a professional association to nurture the terrorism research area and provide a platform for organizing and providing systematic access to terrorism studies [14;25]. For example, terrorism information is spread across many electronic databases, government and research center's websites, and a large number of journals that deal with various specialized aspects of the phenomenon [15].

With the interest in terrorism increasing, the findings of this study will be immensely useful in understanding the contributions of key terrorism authors in guiding terrorism-related research. This paper presents a brief review of analytical techniques and framework for knowledge mapping. Subsequent sections will describe the research design and results of our contemporary terrorism literature mapping with three types of analysis: basic analysis, content map analysis, and co-citation network analysis. The final section will provide conclusion.

## 2 Related Work

There is extensive literature on knowledge mapping of scholarly literature and patents to analyze the structure, the dynamics, social networks, and development of a field such as medical informatics and information science [5;13;16;31]. Mapping refers to an evolving interdisciplinary area of science aimed at the process of charting, mining, analyzing, sorting, enabling navigation of, and displaying knowledge [30]. Although it is useful to the subject expert for validation of perceptions and means to investigate trends, it provides an entry point into the domain and answers to domain-specific research questions for the non-expert [4].

### *Citation Data*

Maps and snapshots of a field's intellectual space have been generated as a result of the pioneering work of Garfield and Small who stimulated widespread interest in using aggregated citation data to chart the evolution of scientific specialties [9]. By aggregating citation data, it is possible to identify the relative impact of individual authors, publications, institutions, and highlight emerging specialties, new technologies and the structure of a field [12].

The advent of citation databases such as the Institute for Scientific Information (ISI) Social Sciences Citation Index (SSCI) and Science Citation Index (SCI), which track how frequently papers are cited in a publication, and by whom, have created tools for indicating the impact of research papers, institutions, and authors [12]. The web-version of SSCI, SCI, and the Arts and Humanities Citation Index is the Web of Science (WoS). Web-based tools such as Google and ResearchIndex (formerly CiteSeer) have been created to harness the similarities between citation linking and hyperlinking [9;28]. Searching the digital citation indexes have resulted in enormous amounts of citation data that are difficult to analyze, extract meaningful results, and display using traditional techniques.

This was illustrated in earlier citation network studies of terrorism researchers in which the researcher used authors, institutions, and documents as units of analysis and the ISI databases to identify the invisible colleges (informal social networks) of terrorism researchers, key research institutions, and their knowledge discovery patterns. This manual process was labor-intensive and relied on citation data [25;26;27]. While there are limitations in using the ISI citation data such as they are 'lagging indicators' of research that has already been completed and passed through the peer review cycle [12], they are widely used in visualization studies and are the basis for identifying key terrorism researchers, influential publications, and subgroups of terrorism researchers in this study.

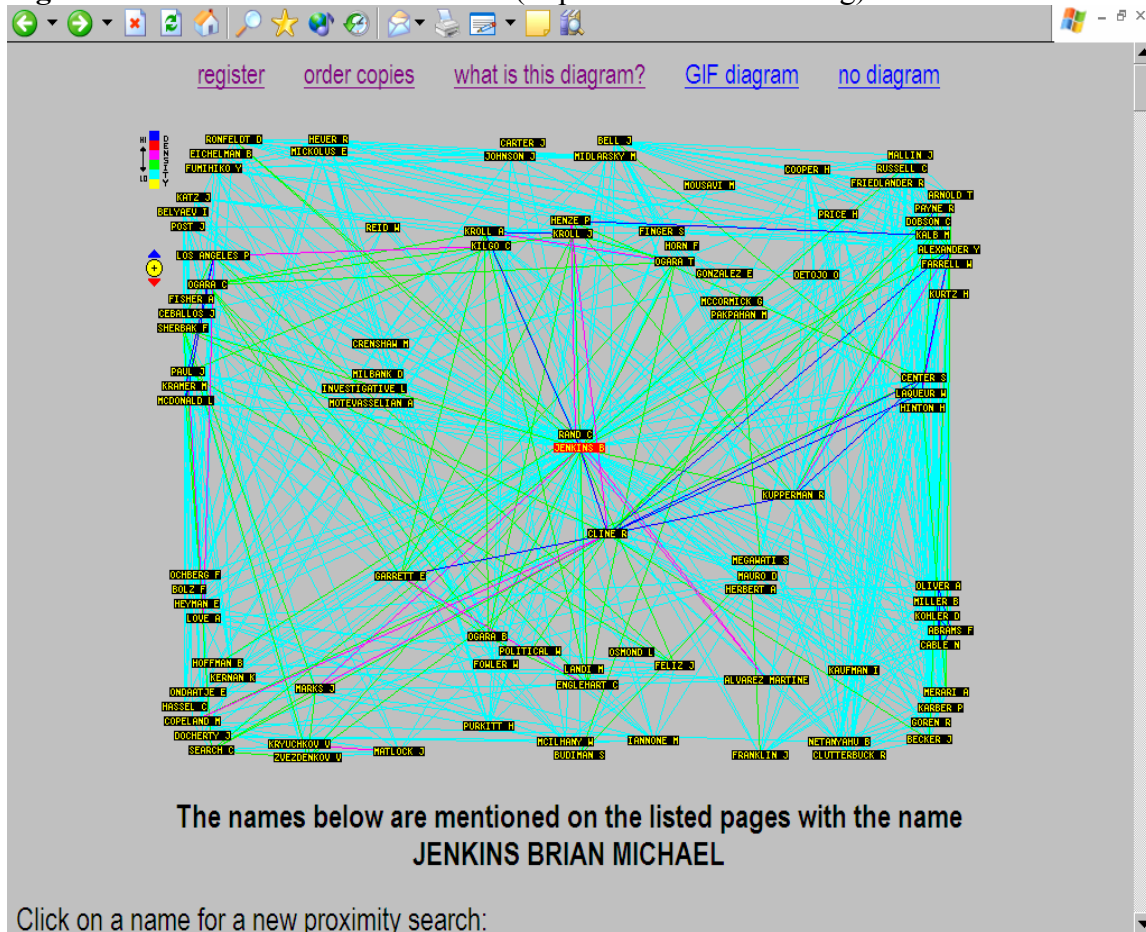
### *Visualization Techniques*

Recent developments in the field of domain visualization attempt to alleviate this "citation information overload problem" by applying information visualization techniques to interact with large-scale citation data [10]. Several techniques have been applied to citation visualization such as Pathfinder network scaling [5], social network analysis, and author co-citation analysis [5;31] which is particularly suited to investigation of intellectual structure because they provide the capability to interact with data and display it from different perspectives. Author co-citation map identifies interrelation among authors by analyzing the counts of the number of articles that cite pairs of authors jointly [32].

Content, or ‘semantic’, analysis is an important branch of domain analysis which relies on natural language processing techniques to analyze large corpora of literature [10]. The content map analysis technique produces content maps of large-scale text collections. The technique uses simple lexical statistics, key phrase co-occurrence analysis, and semantic and linguistic relation parsing. For example, Huang, et.al. [17] uses self-organizing map (SOM) algorithm to generate content maps for visualizing the major technical concepts appearing in the nanotechnology patents and their evolution over time.

Another visualization technique is block-modeling which seeks to cluster units that have substantially similar patterns of relationships with others [11]. It has been applied in criminal network analysis to identify interaction patterns between subgroups of gang members [6]. The application of visualization techniques to citation, content analysis, and author co-citation data provides a foundation for knowledge mapping. The techniques support the users’ visual exploration of a domain to identify emerging topics, key researchers, communities, and other implicit knowledge that is presently known only to domain experts [30]. For example, the Namebase [24], mines names and organizations from terrorism books and periodicals included in its database and links names in a social network. Figure 1 provides an example of a terrorism social network for Brian M. Jenkins (name listed in the center in red), founder of terrorism research at Rand Corporation. It is based on the number of times a name is listed on the same page with Jenkins.

**Fig. 1:** Brian Jenkins’s Social Network (<http://www.namebase.org>)



Although the Namebase visualization does not indicate whether there is a relationship between Jenkins and the other names listed on the page or the context of their relationships, it is the only web-based tool readily available for visualizing social networks of terrorism researchers. Additionally, no systematic study has been conducted that uses citation network, content map analysis, and author co-citation analysis for automatically mapping the terrorism research domain.

### 3 Research Design

This study purports to provide empirically based answers to the research questions (RQs) listed in Table 1. It adopts the integrated knowledge mapping framework proposed by Huang, et. al. [17] for patent analysis and used in Eggers study of medical informatics [10]. The framework includes three types of analysis: basic analysis, content map analysis, and citation network analysis to provide a multifaceted analysis of a research domain.

For the basic analysis, we analyze scientific output measures such as productivity (number of publications produced by a terrorism researcher) and impact (citation counts which allows one to find out how often a publication is cited). By analyzing documents and citation information, we identify key researchers, their influential terrorism publications, and research communities. The content map analysis visualizes the major subtopics and emerging concepts appearing in the publications while the co-citation map measures linkages and similarities among pairs of terrorism researchers as identified by citers. The co-citation data were also used in block-modeling to identify interaction patterns between subgroups of researchers within the terrorism scientific paradigms.

**Table 1:** Knowledge Mapping Framework and Research Questions

Type of Analysis	Unit of Analysis	Measure	Research Questions (RQs)
Basic analysis	Authors Publications Publication's citations	Productivity	Who are key terrorism researchers? What institutions are they affiliated with?
		Impact	What are their influential terrorism publications? What are their collaboration patterns?
Content analysis	Documents Words	Coverage	What are the dominant terrorism topics? What are the new areas of research?
Co-citation analysis	Author's co- citations	Linkage	What groups of authors have papers with related content? What are the communities of researchers?

#### *Basic Analysis*

For the basic analysis, the initial step is to identify a set of key terrorism authors. We compiled a list of authors from several sources: terrorism publications [26;29], active terrorism experts identified by the KnowNet virtual community (organized by the Sandia National Laboratories), and terrorism research center portals identified on the Internet. A total of 131 unique names were identified. Names are for researchers primarily from think tanks, academic institutions, and governments located in 13 countries including UK (18), Israel (7), and France (5). Sixty-four percent are from the United States.

The second step in the basic analysis is to identify the researchers' terrorism publications. A bibliography of English-language terrorism publications was compiled for each researcher using commercial databases. The publications include journal articles, books, book chapters, reviews, notes, newspaper articles, conferences papers, and reports. Table 2 lists the ten commercial databases that were searched using author's name and

terrorism-related keywords such as terrorism, hijacking, bombing, political violence, or bombing. The commercial databases were selected because of subject coverage and availability through our university library.

**Table 2:** Databases Used to Compile Bibliographies

Database	Discipline	Records Exported
ABI/Inform	Business, management, information sciences	164
Academic Search Premier (ASP)	Multi-disciplinary	496
Expanded Academic ASAP (EA)	Multi-disciplinary	439
International Bibliographie der Zeitschriften Literature (IBZ)	International, European	161
ISI Web of Science	Social sciences, science, arts & humanities	360
PAIS International	Public affairs, business, social studies, international relations, economics	588
Political Science Abstracts (PSA)	Political science, international, politics	539
Science Direct	Science, technology, medicine	9
Sociological Abstracts	Sociology, family studies	279
WorldCat (materials cataloged by libraries around the world)	Multi-disciplinary	1,154
Total		4,129

Bibliographical data and abstracts were downloaded, parsed and imported into a database for additional processing. After purging duplicate records, 2,148 bibliographic records were manually reviewed to identify other records that may be duplicates (non-obvious) or non-terrorism publications. Database searches for 22 researchers failed to retrieve any terrorism-related publications while no English publications were retrieved for 21 other recommended researchers. As a result, terrorism publications (bibliographic data and abstracts) were retrieved for only 88 researchers.

The third step is to identify key terrorism researchers from the group of 88 researchers. The publications of the 88 terrorism researchers were analyzed using basic citation analysis to identify how frequently these are cited in the literature. Basic citation counts for each terrorism-related publication for each terrorism researcher were collected from the ISI Web of Science. Citations to each publication from any other article in the ISI dataset are counted, and each indexed author is credited with the full tally of citations to that article [20]. If an author's total number of citations for a publication in our collection is four or more then he is considered a key terrorism researcher. After an author is identified as a key researcher, his terrorism-related publication with the highest citation count is considered as his influential publication

In addition, a coauthorship network was created to identify the collaboration patterns among the authors. The network covered the years 1965-2003. A hierarchical clustering algorithm was used to partition the core researchers who are connected if they coauthored a paper. This allows for visualization of collaboration, research teams, and institutions.

### *Content Map Analysis*

The influential terrorism researchers' bibliographic data and abstracts were used in a content map analysis to identify the dominating themes and terrorism topics in 1965-2003. Since we want to examine more than simple frequency counts, we applied our previous research in large-scale text analysis and visualization for content map

technology to identify and visualize major research topics. The key algorithm of our content mapping program was the self-organizing map (SOM) algorithm [17]. It takes the terrorism titles and abstracts as inputs and provides the hierarchical grouping of the publications, labels of the groups, and regions of the terrorism document groups in the content map. Conceptual closeness was derived from the co-occurrence patterns of the terrorism topics. The sizes of the topic regions also generally corresponded to the number of documents assigned to the topics [22].

#### *Co-citation Analysis*

Author co-citation analysis was used to visualize the similarities among the researchers and their intellectual influence on other authors. It uses authors as the units of analysis and the co-citations of pairs of author (the number of times they are cited together by a third party) as the variable that indicates their distances from each other [1]. It was conducted based on co-citation frequencies for the key terrorism researchers, for the period 1965-2003. The co-citation map was created using a GIS algorithm developed in our lab.

We conducted terrorism keyword searches in the Web of Science to retrieve records related to the topic of terrorism. The records were used to create a terrorism citation collection and included bibliographic records for 7,590 terrorism-related articles that were downloaded. Results were parsed and loaded into a database which was used for the co-citation analysis. Table 3 summarizes the data sets used for this study.

**Table 3: Data Sets Summary**

Data	Web of Science (terrorism keyword searches)	10 Bibliographic Databases (author & keyword searches)
Publications	7,590	4,129
Authors	6,090	1,168
Cited References	67,453	Not retrieved
Cited Authors	32,037	Not retrieved

Program was developed to search the citation field of each bibliographic record and count the number of times two authors (or author pairs) were cited together. The result was the basis of the co-citation analysis portion of this study and offered a mapping of the field of terrorism research and the intellectual influence of the core researchers. Visualization of the relationships among researchers was displayed in a two-dimensional map that identifies their similarities, communities (clusters), and influence on emerging authors.

The co-citation data were also used in block-modeling to identify researchers' roles and positions in the terrorism research network. We used co-occurrence weight to measure the relational strength between two authors by computing how frequently they were identified in the same citing article [4]. We also calculated centrality measures to detect key members in each subgroup, such as the leaders [6]. The block-modeling algorithm is part of the social network analysis program reported in a crime data mining project.

## **4 Results**

### *Basic Analysis*

The basic analysis provides responses to the initial set of questions identified in Table 1. Forty-two authors were identified as key terrorism researchers. A total of 284 researchers (including coauthors) and their 882 publications made up the sample for this study.

Table 4 lists the 42 key researchers, the number of terrorism publications in our dataset, and the number of times the researchers' publications were cited in the ISI databases. They are mainly affiliated with academic institutions (23), think tanks (15), media organizations (3), and the government (1). Their bases of operation are located in nine countries including the US (29), UK (4), and Ireland (1).

**Table 4:** Forty-two Key Terrorism Researchers (based on citation score in ISI)

Author Name	# of Pubs*	# Times Cited	Author Name	# of Pubs*	# Times Cited
1. Wilkinson, Paul	87	<b>229</b>	22. Lesser, Ian O.	5	<b>23</b>
2. Gurr, T.R.	51	<b>214</b>	23. Bassiouni, M.C.	8	<b>22</b>
3. Laqueur, Walter	37	<b>191</b>	24. Carlton, David	1	<b>21</b>
4. Alexander, Yonah	88	<b>169</b>	25. Chalk, Peter	17	<b>20</b>
5. Bell, J.B.	47	<b>138</b>	26. Freedman, Lawrence	14	<b>20</b>
6.. Stohl, M.	30	<b>136</b>	27. Merari, Ariel	25	<b>19</b>
7.. Hoffman, Bruce	121	<b>100</b>	28. Post, Jerrold	12	<b>18</b>
8. Jenkins, Brian M.	38	<b>96</b>	29. Evans, Ernest H.	3	<b>17</b>
9.. Ronfeldt, David	20	<b>95</b>	30. Bergen, Peter	10	<b>16</b>
10. Crenshaw, Martha	40	<b>90</b>	31. Gunaratna, Rohan	14	<b>16</b>
11. Arquilla, John	20	<b>75</b>	32. Cline, R.S.	8	<b>15</b>
12. Mickolus, Edward F.	25	<b>73</b>	33. Friedlander, R.A.	4	<b>14</b>
13. Crelinsten, Ronald	19	<b>62</b>	34. Paust, Jordon J.	11	<b>13</b>
14. Schmid, Alex P.	6	<b>59</b>	35. Ranstorp, Magnus	8	<b>13</b>
15. Wardlaw, G.	25	<b>49</b>	36. Flynn, Stephen E	4	<b>12</b>
16.. Hacker, F.J.	3	<b>38</b>	37. Cooper, H.H.A	10	<b>11</b>
17. Rapoport, David	26	<b>37</b>	38. Wolf, J.B	7	<b>11</b>
18. Sloan, Stephen R	31	<b>30</b>	39. Horgan, John	13	<b>10</b>
19. Dobson, C.	6	<b>25</b>	40. Sterling, C.	5	<b>10</b>
20. Kepel, Gilles	6	<b>25</b>	41. McCauley, Clark	4	<b>8</b>
21. Stern, Jessica E	21	<b>25</b>	42. Merkl, Peter	6	<b>6</b>

\* number of publications in our dataset

The Appendix lists the most influential publication for each researcher which is based on the number of times cited in the ISI Web of Science. Table 5 lists the 12 most influential publications because they were cited more than twenty-five times in ISI databases.

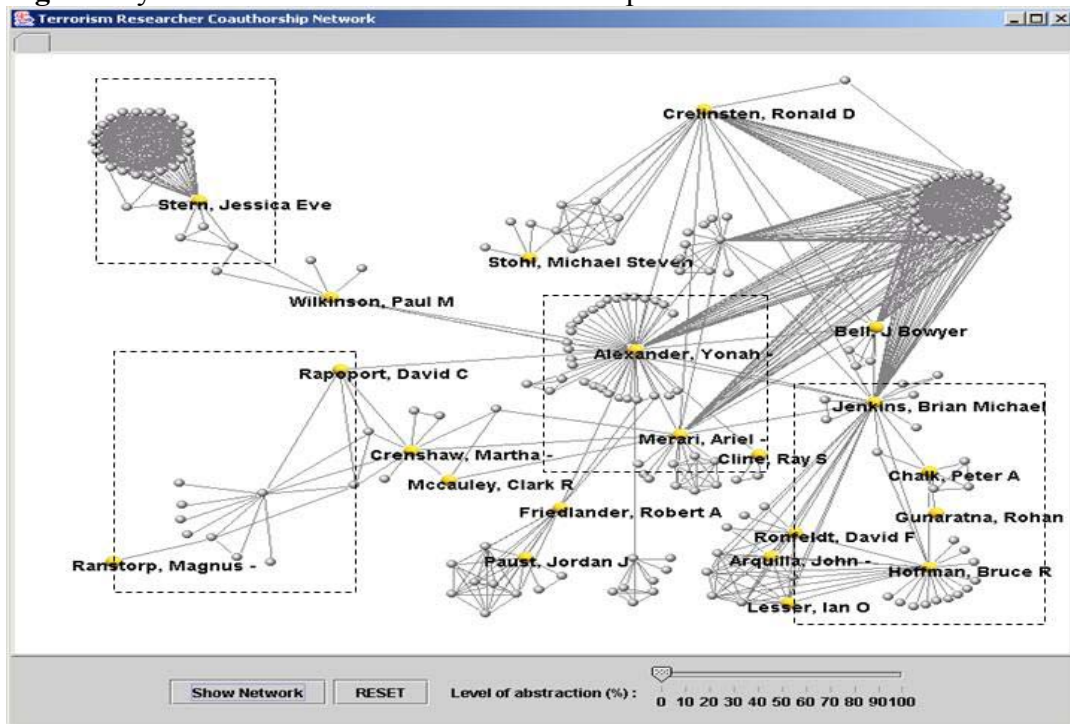
**Table 5:** Most Influential Terrorism Publications

Publication	# Times cited	Topic	Author	Organization
1. <i>Why men rebel</i> , 1970	<b>145</b>	political violence	Gurr, Ted	Univ Maryland
2. <i>Terrorism</i> , 1977	<b>75</b>	terrorism historical aspects	Laqueur, Walter	Center for Strategic & Intl Studies (CSIS)
3. <i>Terrorism &amp; liberal state</i> , 1977	<b>66</b>	terrorism prevention	Wilkinson, Paul	Univ Aberdeen (formerly), CSTPV
4. <i>Inside terrorism</i> , 1998	<b>47</b>	terrorism religious aspects	Hoffman, Bruce	Rand Corporation
5. <i>Trans. Terrorism, a chronology</i> , 1980	<b>41</b>	terrorism incidents	Mickolus, E.	CIA (formerly)
6. <i>Crusaders, criminals</i> , 1976	<b>34</b>	terrorism case study	Hacker, F.J. (deceased)	USC Medical & Law Schools
7. <i>Time of terror</i> , 1978	<b>33</b>	terrorism responses	Bell, J.B. (deceased)	Columbia Univ
8. <i>State as terrorist</i> , 1984	<b>32</b>	state sponsored terrorism	Stohl, M.	Purdue Univ
9. <i>Political terrorism theory, tactics</i> , 1982	<b>31</b>	terrorism prevention	Wardlaw, G	Australian Institute of Criminology

Publication	# Times cited	Topic	Author	Organization
10. <i>Intl. terrorism national regional</i> , 1976	30	terrorism anthology	Alexander, Y.	CSIS; SUNY
11. <i>Political terrorism a new guide</i> , 1988	29	terrorism directory	Schmid, Alex P.	Royal Netherlands Academy of Arts & Science
12. <i>Intl. Terrorism a new mode</i> , 1975	27	terrorism	Jenkins, Brian M.	Rand Corporation

An investigation of the coauthorship patterns provides an understanding of the researchers' social network patterns. Figure 2 exhibits the coauthorship network of key researchers in scientific collaboration networks. The nodes represent researchers who coauthored papers.

**Fig. 2: Key Terrorism Researchers' Coauthorship Network**



In the lower right corner of Figure 2, the Rand research teams led by Jenkins and Hoffman is one of the most active clusters. Except for Gunaratna, all of the researchers in the cluster are Rand's employees. Gunaratna coauthored publications with Chalk and Hoffman, his PhD advisor at St. Andrews University, Scotland, and founded the terrorism research center at the Institute of Defence and Strategic Studies, Singapore. Hoffman founded St. Andrews' Centre for the Study of Terrorism and Political Violence (CSTPV) and created the Rand-St. Andrews terrorism incident database which provides data for their studies [18].

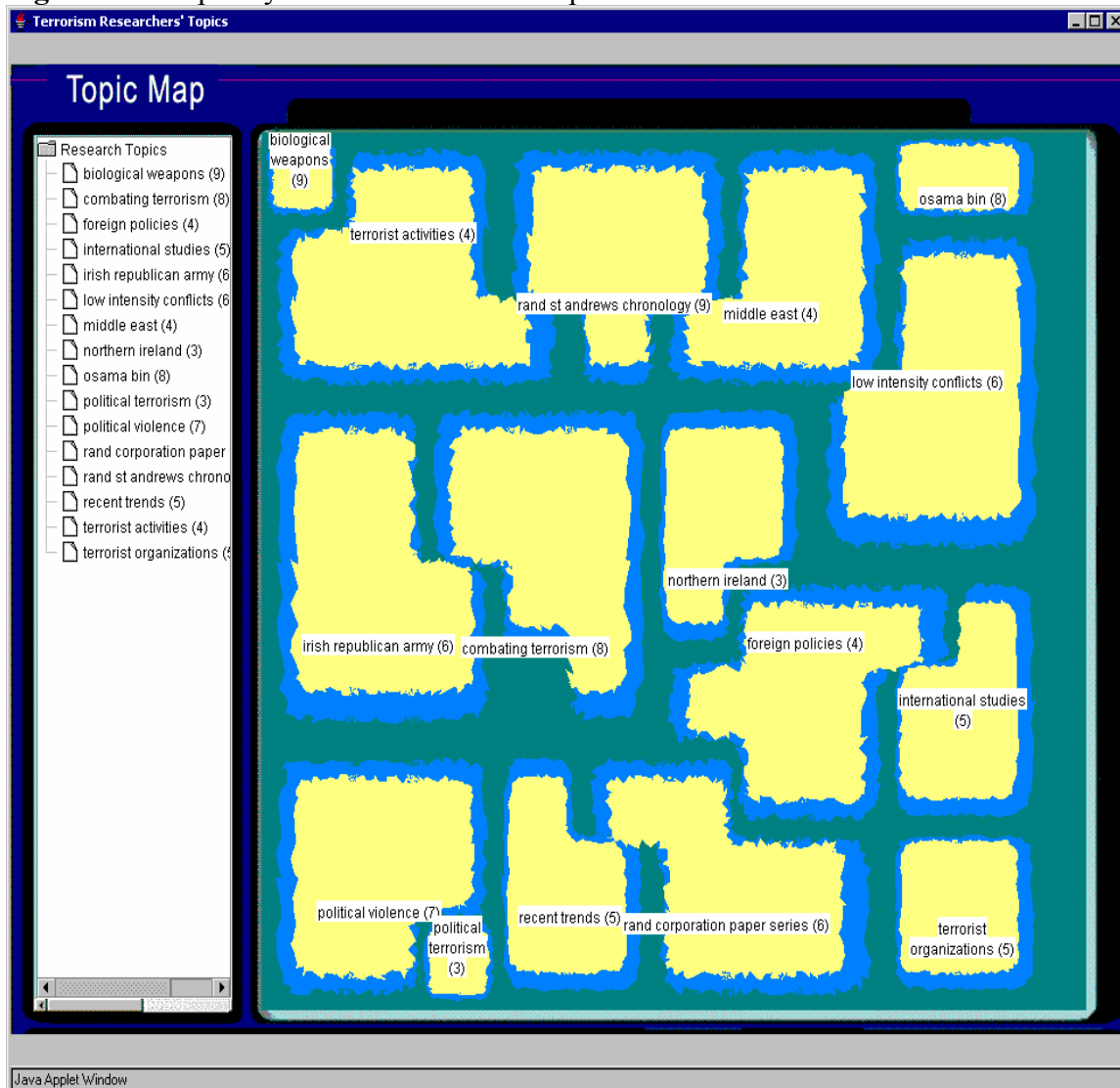
For the cluster in the lower left corner that includes Ranstorp from CSTPV, it is sparse and shares few coauthorships. As chairman of the Advisory Board for CSTPV, Wilkinson has a few collaborations with Alexander but none with researchers at CSTPV who are in this sample. Another cluster includes researchers such as Alexander and Cline at the Center for Strategic and International Studies (CSIS). Since Alexander has 82 coauthors, this cluster displays a pattern of one to many coauthors. We found that coauthorships do

not seem to be sustainable because many authors produce only a single publication with Alexander and did not publish with other terrorism researchers in this sample.

### Content Map Analysis

Regarding the next set of questions identified in Table 1, several dominating terrorism topics have been identified for 1965-2003. Figure 3 displays the contemporary terrorism content map that was generated based on the title and abstracts of the 882 terrorism-related publications in our dataset. The topic map interface contains two components, a folder tree display on the left-hand side and a hierarchical content map on the right-hand side [17]. The terrorism publications are organized under topics that are represented as nodes in the folder tree and colored regions in the content map. These topics were labeled by representative noun phrases identified by our programs. The number of terrorism publications that were assigned to the first-level topics is displayed in parenthesis after the topic labels.

**Fig. 3:** Contemporary Terrorism Content Map: 1965-2003



Major terrorism topics (large regions with depth in the content map) include “low intensity conflicts,” “rand corporation paper series,” “osama bin,” “political violence,” “rand st andrews chronology,” and “irish republican army”. The topics “rand

corporation paper series” and “rand st andrews chronology” highlight the major roles that Brian Jenkins, one of the pioneers of modern terrorism studies [33], and Paul Wilkinson, Chairman of the St. Andrews’ Centre for the Study of Terrorism and Political Violence (CSTPV), Scotland, played. They established terrorism research centers, created databases of terrorism incidents, secured funding for terrorism research projects, produced terrorism studies, and supervised student’s research on terrorism [25].

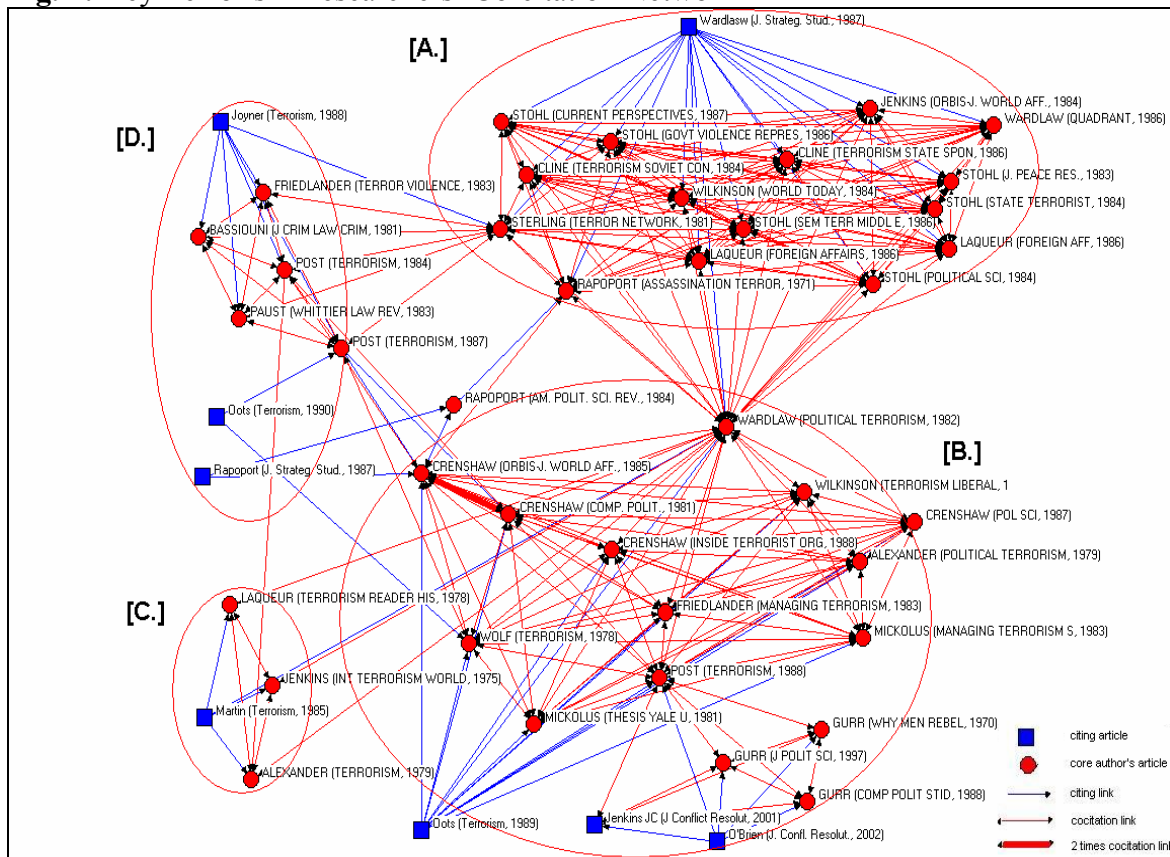
Several interesting shifts in the cognitive structure of contemporary terrorism research are identified. A traditional terrorism topic, “low intensity conflicts,” first appeared in 1991 and appeared seven other times in the 1990s but only one time in 2000s. Prior to 11<sup>th</sup> September, the conventional wisdom was that the use of terrorism was endemic in low intensity conflict but that it rarely, if ever, posed a strategic threat to the security of major international powers [33]. After 1997, there was an increasing appearance of the topic “osama bin” which first emerged in our dataset in 1998 as the subject of an article by Peter Bergen [2]. “Osama bin’ referring to Osama Bin Laden is a new topic of interest.

#### *Co-citation Analysis*

For the final set of questions identified in Table 1, the author co-citation analysis is used to visualize the closeness of research interests among the key terrorism researchers and their intellectual influences on others. The raw co-citation data derived from keyword searches of the ISI Web of Science were used for the analysis conducted in this part of the study. We created author co-citation networks to identify which key researchers in terrorism are often cited together.

Figure 4 shows a sample of pairs of authors (researchers) linked by co-citation counts of 1-3. Authorship nodes are represented either by a square or circle followed by the last name of the first author, publication source, and year. The square node identifies a publication that cites the key terrorism researchers (circular nodes). The width of the arrows connecting authorship nodes have been made proportionate to their co-citation counts in size. The narrow arrow width reflects a count of one co-citation link while a thick one reflects a count of at least two co-citation links.

**Fig. 4: Key Terrorism Researchers' Co-citation Network**



To illustrate the findings represented through the author co-citation map, boundaries were drawn around clusters of researchers. Figure 4 illustrates four groupings of author co-citation patterns.

The groupings provide a way of clustering pairs of researchers who share areas of interests. For example, publications cited in Group A focuses on terrorism and foreign policy (based on terms from the titles and abstracts of their publications). In Group A, Wardlaw’s article on terror as an instrument of foreign-policy is citing several of the most frequent co-cited pairs. The most frequently appearing author co-cited pairs are Laqueur and Wardlaw (13 times), Stohl and Wardlaw (12 times), and Cline and Stohl (12 times). Cline and Stohl specialized in state sponsored terrorism.

Group B emphasizes the organizational perspectives of terrorism. It includes Oots’ publication entitled “Organizational Perspectives on the Formation and Disintegration of Terrorist Groups.” Oots cites seven of the key researchers and identifies almost fifty author co-citation pairs. Group C’s subject deals with historical aspects; while that of Group D is legal aspects of terrorism.

Another way of viewing subgroups and key members in contemporary terrorism research is to analyze their interaction patterns to identify the roles and positions that they play. It was found that, as Figure 5 shows, 18 terrorism researchers from the resulting network were co-cited in ISI.

**Fig 5:** The 18 Key Terrorism Researchers Who Were Co-cited in ISI

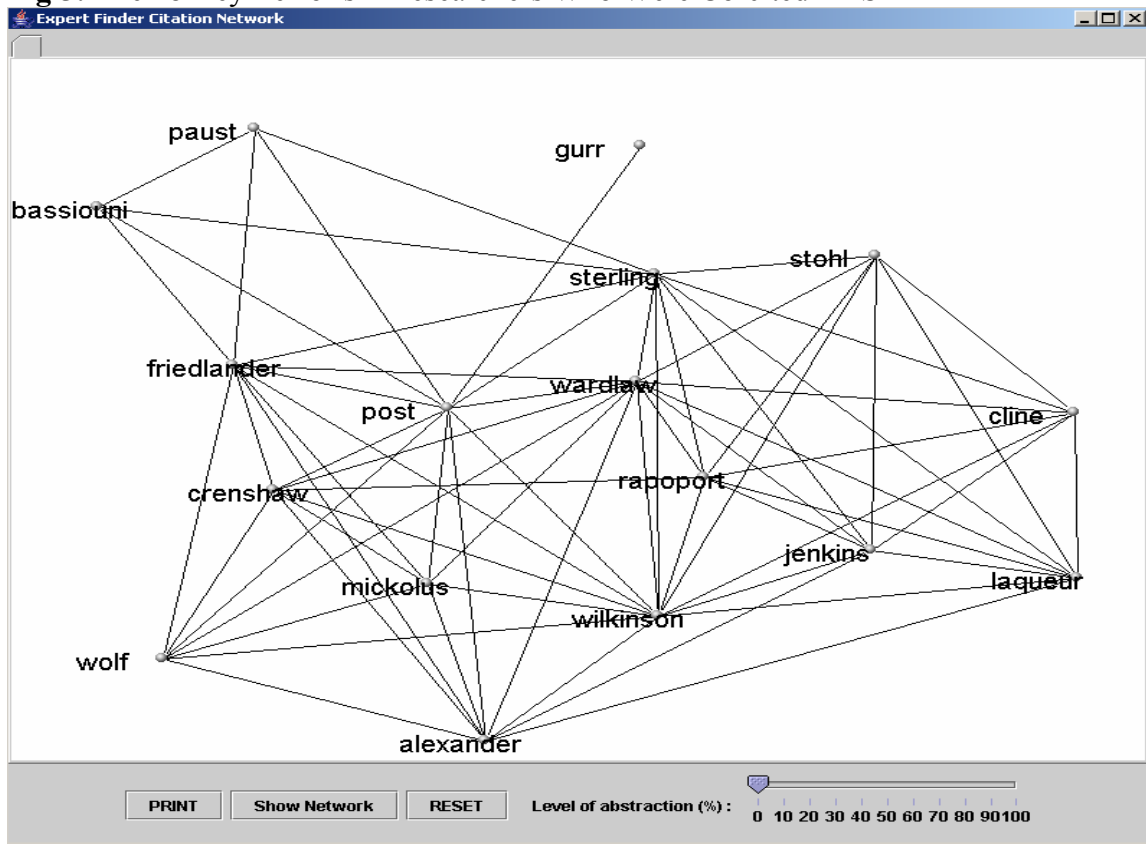
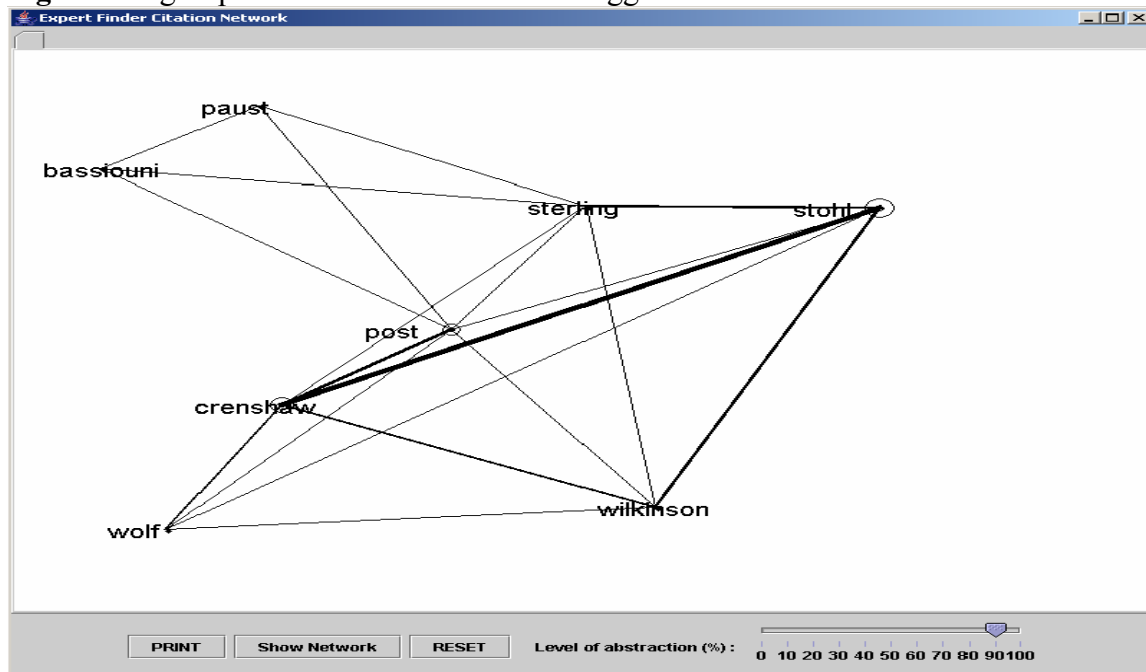


Figure 6 shows the subgroups identified by the system. They have the labels of their leaders' names (Crenshaw, Post, and Stohl). The thickness of the straight lines indicates the strength of relationships between subgroups.

**Fig 6:** Subgroups of Co-cited Authors and Tagged with Leaders' Names



For example, Crenshaw's group consists of Mickolous (cited with Crenshaw eight times), Post (cited with Crenshaw six times), Wolf (cited with Crenshaw six times), etc. Those familiar with terrorism research would not be surprised with the close co-cited relationship between Crenshaw and Post because they focus on the psychological aspects of terrorism with Crenshaw positing that there is no profile of the typical terrorist[8].

## **5 Conclusion**

The mapping of contemporary terrorism research provides a perspective that heretofore has not been afforded. As such, the tools such as content map analysis and co-citation analysis can help individuals visualize scholarly development within the field. For instance, while those familiar with terrorism will already know that, say, Stohl and Cline worked in similar areas and are often cited together, those who are not well oriented with the field, particularly new researchers could find such information relevant.

Although there are benefits of using visualization techniques, visualization is not a substitute for extensive reading and detailed content analysis for understanding the development of a field. For new researchers, it provides an alternative approach for understanding quickly the structure and development of a field. Thus, the knowledge mapping framework and tools provided here, could allow the expanding group of non-traditional terrorism researchers to conduct systematic exploitation of the terrorism field and identify trends and research gaps in a short period of time. This approach helps identify influential researchers in a field, the amount they are cited, the topics that are being investigated, and the frequency of co-citation with other terrorism authors who perhaps work in similar subject areas. With the current challenges in the interdisciplinary and international field of terrorism, new researchers must understand the intellectual structure of the field and how they can better frame their research questions.

We intend to supplement this work with other studies that will use time-series topic maps to present the development trends in terrorism across various periods to further examine the recent evolution and topic changes in the field. We will also include author content map analysis to group individual researchers based on their common research interests. In addition, we will use the results to develop a terrorism expert finder application that supports domain visualization and field test it with new and experienced terrorism researchers.

## **Acknowledgement**

This research was funded by the National Science Foundation (NSF) and the ITR grant. Authors wish to thank the KnowNet Community, Dr. Jerold Post, and Dr. Marc Sageman for their support and assistance.

## **References**

1. Andrews, J.E., Author Co-citation Analysis of Medical Informatics. *Journal of the Medical Library Association*, 2003. 91(1): p. 47-56.
2. Bergen, P., *Holy War, Inc.: Inside the Secret World of Osama Bin Laden*. 2001, New York: Free Press.
3. Borgman, C.L. and J. Furner, *Scholarly Communication and Bibliometrics*, In *Annual Review of Information Science and Technology (ARIST)*. 2002, ASIST.

4. Boyack, K.W., Mapping Knowledge Domains: Characterizing PNAS. Arthur M. Sackler Colloquium of the National Academy of Sciences, N.A.o.S. (NAS), Editor. 2003, NAS: Irvine.
5. Chen, C. and R.J. Paul, Visualizing a Knowledge Domain's Intellectual Structure. IEEE Computer Society, 2001. 34(3): p. 65-71.
6. Chen, H., et al., Crime Data Mining: a General Framework and Some Examples. IEEE Computer Society, 2004: p. 50-56.
7. Chua, C., et al., Measuring Researcher-Production in Information Systems. Journal of the Association for Information Systems, 2002. 2: p. 146-215.
8. Crenshaw, M., Psychology of Terrorism: An Agenda for the 21st Century. Political Psychology, 2000. 21(1): p. 405-420.
9. Cronin, B., High-Fidelity Mapping of Intellectual Space: Early and Recent Insights from Information Science, in Spaces, Spatiality and Technology Workshop. 2002, Napier University, Edinburgh Scotland: Edinburgh.
10. Eggers, S., et al., Mapping Medical Informatics Research, in Medical Informatics: Knowledge Management and Data Mining in Biomedicine. Forthcoming, Springer Science.
11. Ferligoj, A., P. Doreian, and V. Batagelj, Optimizational Approach to Blockmodeling. Journal of Computing and Information Technology, 1996. 4: p. 63-90.
12. Garfield, E. and Welljams-Dorof, Citation Data: their Use as Quantitative Indicators for Science and Technology Evaluation and Policy-making. Science & Public Policy, 1992. 19(5): p. 321-327.
13. Garfield, E., A.I. Pudovkin, and V.S. Istomin, Algorithmic Citation-Linked Historiography: Mapping the Literature of Science, In ASIST 2002 Contributed Paper. 2002.
14. Gordon, A., Terrorism Dissertations and the Evolution of a Specialty: an Analysis of Meta-Information. Terrorism and Political Violence, 1999. 11(2): p. 141-150.
15. Gordon, A., Effect of Database and Website Inconstancy on the Terrorism Field's Delineation. Studies in Conflict & Terrorism, 2004. 27: p. 79-88.
16. Huang, Z., et al., Longitudinal Patent Analysis for Nanoscale Science and Engineering: Country, Institution and Technology Field. Journal of Nanoparticle Research, 2003. 5: p. 333-363.
17. Huang, Z., et al., International Nanotechnology Development in 2003: Country, Institution, and Technology Field Analysis Based on USPTO Patent Database. Journal of Nanoparticle Research, 2004. 6: p. 325-354.
18. Hughes, G., Analyze This, in The Age. 2003.
19. Incites, Citation Thresholds. 2003, Institute for Scientific Information (ISI): Philadelphia.
20. ISI, How Does ISI identify Highly Cited Researchers? 2003, Institute for Scientific Information (ISI): Philadelphia.
21. Kennedy, L.W. and C.M. Lum, Developing a Foundation for Policy Relevant Terrorism Research in Criminology. 2003, Rutgers University: New Brunswick.
22. Lin, X., H.D. White, and J. Buzydowski. AuthorLink: Instant Author Co-citation Mapping for Online Searching. In National Online Proceedings 2001. New York City: Information Today.
23. McCain, K.W., Mapping Authors in Intellectual Space: a Technical Overview. Journal of the American Society of Information Science, 1990. 41(6).
24. NameBase, Public Information Research, Inc.: 2004. San Antonio.

25. Reid, E.O.F., Analysis of Terrorism Literature: a Bibliometric and Content Analysis Study. 1983, University of Southern California: Los Angeles.
26. Reid, E.O.F., Evolution of a Body of Knowledge: an Analysis of Terrorism Research. Information Processing & Management, 1997. 33(1): p. 91-106.
27. Reid, E., et al. Terrorism Knowledge Discovery Project: a Knowledge Discovery Approach to Addressing the Threats of Terrorism. In Second Symposium on Intelligence and Security Informatics, ISI 2004, June 2004 Proceedings. 2004. Tucson, Arizona: Springer-Verlag.
28. Reid, E.O.F. Identifying a Company's Non-Customer Online Communities. in Proceedings of the 36th International Conference on Systems Sciences (HICSS). 2004. Hawaii: HICSS.
29. Schmid, A. and A. Jongman, Political Terrorism: A New Guide to Actors, Authors, Concepts, Data Bases, Theories and Literature. 1988, Oxford: North Holland.
30. Shiffrin, R.M. and K. Borner. Mapping Knowledge Domains. In Arthur M. Sackler Colloquium of the National Academy of Sciences. Held May 9-11, 2003, at the Arnold & Mabel Beckman Center of the National Academies of Sciences & Engineering. 2004. Irvine, CA: NAS.
31. White, H.D. and K.W. McCain, Visualizing a Discipline: an Author Co-citation Analysis of Information Science 1972-1995. Journal of the American Society of Information Science, 1998. 49(4): p. 327-355.
32. White, H.D., X. Lin, and J. Buzydlowski. Co-cited Author Maps as Real-time Interfaces for Web-based Document Retrieval in the Humanities. In Joint International Conference of the Association for Computers and the Humanities and the Association for Literary and Linguistics Computing (ALLC). 2001. New York City: ACH/ALLC.
33. Wilkinson, P. Terrorism: Implications for World Peace. In Westermorland General Meeting Preparing for Peace Initiative. 2003. United Kingdom: Westermorland.

**Appendix:** List of 42 Influential Terrorism Researchers (as of Dec. 2003)

Author Name	No. of Pub.	Active Years	# times cited for pubs in collection	Most Frequently Cited Terrorism Publication	Date	# times cited
1. Alexander, Yonah	88	32	<b>169</b>	Intl. terrorism national regional	1976	30
2. Arquilla, John	20	30	75	Cyberwar is coming	1993	18
3. Bassiouni, M.C.	8	17	22	Intl. terrorism & political ...	1975	16
4. Bell, J.B.	47	35	<b>138</b>	Time of terror	1978	33
5. Bergen, Peter	10	7	16	Holy war inc	2001	15
6. Carlton, David	1	2	21	Terrorism theory & practice	1979	21
7. Chalk, Peter	17	26	20	West European terrorism	1996	7
8. Cline, R.S.	8	14	15	Terrorism the Soviet	1984	14
9. Cooper, H.H.A	10	25	11	Chapter in Terrorism Interdiscip.	1977	7
10. Crelinsten, Ronald	19	28	62	Political terrorism a research guide	1993	22
11. Crenshaw, Martha	40	35	<b>90</b>	Why violence spreads	1980	23
12. Dobson, C.	6	14	25	Black September	1974	8
13. Evans, Ernest H.	3	4	17	Calling a truce	1979	17
14. Flynn, Stephen E	4	4	12	Beyond border	2000	8
15. Freedman, Lawrence Z.	14	21	20	Terrorism & Intl Order	1986	7
16. Friedlander, R.A.	4	10	14	<ul style="list-style-type: none"> <li>• Terror violence</li> <li>• Terrorism documents</li> </ul>	1983 1979	7 7
17. Gunaratna, Rohan	14	8	16	Inside al qaeda	2002	14
18. Gurr, T.R.	51	41	<b>214</b>	Why men rebel	1970	145

Author Name	No. of Pub.	Active Years	# times cited for pubs in collection	Most Frequently Cited Terrorism Publication	Date	# times cited
19. Hacker, F.J.	3	5	38	Crusaders, criminals	1976	34
20. Hoffman, Bruce	121	27	<b>100</b>	Inside terrorism	1998	45
21. Horgan, John	13	18	10	Technology vs terrorism	1986	5
22. Jenkins, Brian M.	38	30	<b>96</b>	Intl. terrorism new mode	1975	27
23. Kepel, Gilles	6	4	25	Jihad expansion	2000	16
24. Laqueur, Walter	37	28	<b>191</b>	Terrorism	1977	75
25. Lesser, Ian O.	5	30	23	Intl. terrorism a chronology	1975	13
26. McCauley, Clark	4	12	8	Terrorism research & public	1991	8
27. Merari, Ariel	25	26	19	Readiness to kill & die	1990	8
28. Merkl, Peter	6	18	6	Political violence & terror	1986	6
29. Mickolus, Edward F.	25	28	73	Trans. terrorism, a chronology	1980	41
30. Paust, Jordon J.	11	30	13	Federal jurisdiction over ...	1983	11
31. Post, Jerrold	12	19	18	Terrorist psycho logic	1990	12
32. Ranstorp, Magnus	8	13	13	Hizb'allah in ...	1997	7
33. Rapoport, David	26	33	37	Assassination & terrorism	1971	20
34. Ronfeldt, David	20	30	<b>95</b>	<ul style="list-style-type: none"> <li>• Cyberway is coming</li> <li>• Networks &amp; netwars</li> </ul>	1993 2001	18 18
35. Schmid, Alex P.	6	7	59	Political terrorism a new guide	1988	29
36. Sloan, Stephen R	31	34	30	Simulating terrorism	1981	10
37. Sterling, C.	5	7	10	Terror network	1981	10
38. Stern, Jessica E	21	13	25	Prospects of domestic bioterrorism	1999	12
39. Stohl, M.	30	28	<b>136</b>	State as terrorist	1984	32
40. Wardlaw, G.	25	23	49	Political terrorism theory, tactics	1982	31
41. Wilkinson, Paul	87	32	<b>229</b>	Terrorism & liberal state	1977	66
42. Wolf, J.B	7	16	11	Fear of fear	1981	5

Bold indicates most influential publications