# Industry/University Collaborations
## Different Perspectives Heighten Mutual Opportunities

*In this paper, we present the results of a survey by the SEI Working Group on Software Engineering Education and Training of formal industry/university collaborations. The purpose of these collaborations is to meet the software engineering education and training needs of adult learners through joint ventures such as graduate programs and professional development activities. The Working Group drew on the extensive experience of industry and university collaboration participants to help answer practical questions about the benefits of collaboration, the collaboration process, successful collaboration administration and programming, and lessons learned.*

Universities and industry organizations have traditionally maintained *informal* ways of working together, including student internships, faculty exchanges, and industry capstone projects to complete a degree program. A more recent phenomenon is the *formal* collaboration between a university (or group of universities) and an industry organization (or group of organizations). The purpose is to meet the critical software engineering education and training needs of adult learners through joint ventures such as graduate programs (degree and certificate) and professional development activities (customized classes, seminars, forums, and conferences).

In September 1995, the Software Engineering Institute (SEI) began tracking this phenomenon in its annual *Directory of Industry and University Collaborations with a Focus on Software Engineering Education and Training* [1]. There are now 23 directory entries, representing collaborations formed in the United States, Canada, and Australia. Several of these pioneer efforts are now six to 10 years old.

There is some previously published literature on the topic. In 1994, Neal Coulter and Jim Dammann (1994) published the results of a successful collaboration at Florida Atlantic University [2]. The November/December 1997 *IEEE Software Special Issue on Software Engineering Education and Training* contained the article, "Industry/University Collaboration: Closing the Gap Between Industry and Academia," which described a model for collaborations and featured a close look at three of these efforts **[3].** However, industry/university collaborations for software engineering education and training remain a mystery to many in academia and industry. Commonly asked questions are practical queries such as the following:

- Why collaborate? What are the benefits?
- How would we start, and then operate, a collaboration?
- What makes a collaboration successful?

In other words, what makes an industry/university collaboration "tick"?

The SEI Working Group on Software Engineering Education and Training contacted collaboration practitioners to help answer these practical questions [see sidebar on p. 15]. This paper provides some preliminary answers. It is offered as a service to the software engineering education and training community to assist anyone interested in forming a new collaboration or improving an existing collaboration.

## Survey Methodology

In December 1997, the SEI Working Group surveyed both academic and industry representatives of the 23 collaborations documented in the 1997 Directory, as well as collaborations from Auburn University and Lockheed Martin Corp. The 25-question survey requested:

1. Demographic information.
2. Information on collaboration goals and measures.
3. Overall collaboration process information.
4. Individual collaboration activities and results.
5. Lessons learned.

Fourteen responded. Participating universities and their industry partners are listed below:

- American University with Center for Systems Management
- Applied Information Management Institute at Creighton University with First National Bank of Omaha
- Auburn University [in development]
- Boston University Corporate Education Center with Affiliated Computer Services (ACS) Government Solutions Group (formerly Computer Data Systems Inc.)
- Embry-Riddle Aeronautical University with ACS Government Solutions Group (formerly Computer Data Systems Inc.)
- Florida Atlantic University with Allied Signal, CITRIX, Encore Computer Corporation, Harris, IBM, Motorola, Sensormatic, Siemens Telecom, and United Technologies
- Lockheed Martin Tactical Defense Systems with University of Akron
- Lockheed Martin Idaho Technologies Company with Boise State University, Idaho State University, Montana State University, University of Idaho, and Utah State University
- Software Engineering Forum for Training, California State University/Long Beach (SEFT/CSULB) with The Boeing Co., Northrop Grumman, and TRW
- Software Engineering Research Centre of Royal Melbourne Institute of Technology and University of Melbourne with Ericsson Australia
- Software Quality Institute, University of Texas at Austin with 28 representatives from industry and government
- University of California Santa Cruz with Santa Cruz Operation, Seagate Technologies, and Thuridian
- Texas Tech University with Raytheon Co.
- University of Maryland University College with ACS Government Solutions Group (formerly Computer Data Systems Inc.)

From the respondents, the Working Group selected the following for follow-up phone interviews:

1. American University/Center for Systems Management
2. Florida Atlantic University
3. Software Engineering Forum for Training, California State University/Long Beach (SEFT/CSULB)
4. Texas Tech University

## Summary of Overall Survey Data

### Demographic Information

Responding collaborations generally have been active for one to five years; however, there are instances of collaborations operating for 10 years or more. Table 1 depicts demographic information from the 14 collaborations responding to the survey. The types of software engineering education and training services provided through the collaborations are documented in the column on the right. Graduate programs denote master's degree or graduate certificate programs; professional development signifies noncredit courses, seminars, and conferences.

### Why form an industry/university collaboration?

There are many reasons for forming an industry/university collaboration. These reasons include fulfilling an organization's education mission, accessing education and training resources, gaining competitive advantage, addressing business growth, achieving cost savings, enhancing organizational reputation, increasing revenue, accessing research and tool resources, and providing a staffing source.

Fulfilling the organization's educational mission was selected most often as the respondents' first priority (seven ratings), followed by business growth (three ratings), access to education and training resources (two ratings), and staffing source (two ratings).

### What do industry/university collaborations offer?

Collaborations offer a variety of software engineering education and training activities, including classes, seminars, conferences, workshops, and certificate and degree programs. These activities are typically held on location, either at the university or industry site, although circumstances may vary. The survey revealed a healthy number of participants is served each year by collaboration activities. The surveyed collaborations reported the attendance shown in Table 2.

Courses cover software management topics, integrated product teams, electrical engineering topics, principles of software development, system engineering applications and practices, and simulation models for operations analysis. The various

| Collaboration Name | University(ies) | Industry Partner(s) | Location | Types of Services |
|---|---|---|---|---|
| AU/CSM | American University | Center for Systems Management | Washington, DC | Professional development and graduate program |
| Applied Information Institute (AIM) | Creighton University | Member companies | Omaha, Neb. | Professional development |
| Strategic Occupation Alliance Resources (SOAR) | Auburn University | [in development] | Auburn University, Ala. | Professional development |
| | Boston University Corporate Education Center | ACS (Affiliated Computer Services) Government Solutions Group | Boston, Mass. | Professional development |
| | Embry-Riddle Aeronautical University | ACS Government Solutions Group | Daytona Beach, Fla. | Professional development |
| | Florida Atlantic University | Allied Signal CITRIX Encore Computer Corp. Harris IBM Motorola Sensormatic Siemens Telecom United Technologies | Boca Raton, Fla. | Professional development and graduate program |
| | University of Akron | Lockheed Martin Tactical Defense Systems | Akron, Ohio | Professional development and graduate program |
| | Boise State University (Boise, Idaho) Idaho State University (Pocatello, Idaho) Montana State University (Bozeman, Mont.) University of Idaho (Moscow, Idaho) Utah State University (Logan, Utah) | Lockheed Martin Idaho Technologies Company | Idaho Falls, Idaho | Graduate program |
| Software Engineering Forum for Training (SEFT) | California State University, Long Beach | The Boeing Co. Northrup Grumman Corp. TRW | Costa Mesa, Calif. | Professional development |
| Software Engineering Research Centre (SERC) | Royal Melbourne Institute of Technology, University of Melbourne | Ericsson of Australia | Melbourne, Australia | Professional development |
| Software Quality Institute | University of Texas at Austin | 28 representatives from industry and government | Austin, Texas | Professional development |
| | University of California Santa Cruz | Santa Cruz Operation, Seagate Technologies, and Thuridian | Santa Cruz, Calif. | Professional development and graduate program |
| Systems Engineering Master's Program – with Software Engineering component | Texas Tech University | Raytheon Co. | Lubbock, Texas | Graduate program |
| | University of Maryland University College | ACS Government Solutions Group | College Park, Md. | Professional development |

Table 1. *Summary of Overall Survey Data*

formats of content delivery include practical hands-on seminars, use of distance learning technologies, and formal classroom instruction. For more detailed course offerings, refer to the *Directory of Industry and University Collaborations with a Focus on Software Engineering Education and Training* at http://www.sei.cmu.edu/publications/documents/97.reports/97sr018/97sr018title.htm.

| Software Engineering Education and Training Activity | Attendance (Annual total for responding collaborations) |
|---|---|
| Courses | 593 |
| Seminars | 496 |
| Conferences | 1,500 |
| Workshops | 353 |
| Certificate Programs | 225 |
| Degree Programs | 337 |
| Other: Software Process Improvement Network | 1,000 |

Table 2. Collaboration Attendance Records

### How does a collaboration work?

Collaborations must be initiated. This is crucial and requires a strong champion on both sides. Of all the respondents, 44 percent indicated that they sought out a new contact with industry, university, or government to establish the collaboration, while 26 percent expanded an existing relationship to get started. The remaining collaborations were initiated by faculty who worked for both partners or through a Software Process Improvement Network contact.

The collaborations are funded by multiple sources, including annual membership fees, activity-based fees, grants, or contracts. A full 90 percent of all collaborations surveyed document their collaboration goals, while 70 percent have a formal agreement such as a charter, memorandum of understanding, or contract. Of those surveyed, 79 percent use consensus among collaboration participants to make operational decisions. They use varied organizational structures such as advisory boards, boards of directors, or program managers to steer the collaboration's activities. Two-thirds of the collaborations surveyed employ between one and three paid staff members to support collaboration activities. Figure 1 is the basic collaboration process.

### What are some benefits of collaborations?

Survey respondents were asked to list benefits realized from

**Academia**
- Identify training & education needs of industry
- Identify benefits of cooperation
- Provide resources
- Learn more about industry

**Industry**
- Identify training & education needs
- Identify benefits of cooperation
- Provide resources
- Learn more about academia

**Develop Joint Working Group**
- Share common perspectives
- Identify training needs
- Develop mission statement & charter
- Determine membership and funding
- Identify common goals
- Develop organization chart
- Develop operation/consensus decision process

**Formalize Agreement**
- Prepare written agreement
- Document goals
- Identify success measures

**Develop Collaboration Processes**
- Course proposal requirements
- Registration
- Marketing
- Class evaluation

**Implement Collaboration Activities**
- Courses
- Seminars
- Conferences
- Certificate/degree programs

**Evaluate Collaboration Activities**
- Provide metrics collected about training program effectiveness to industry partners
- Evaluate financial performance and customer satisfaction
- Document lessons learned

**Review & Update the Collaboration Process**
- Revisit goals
- Review governance and communications structure
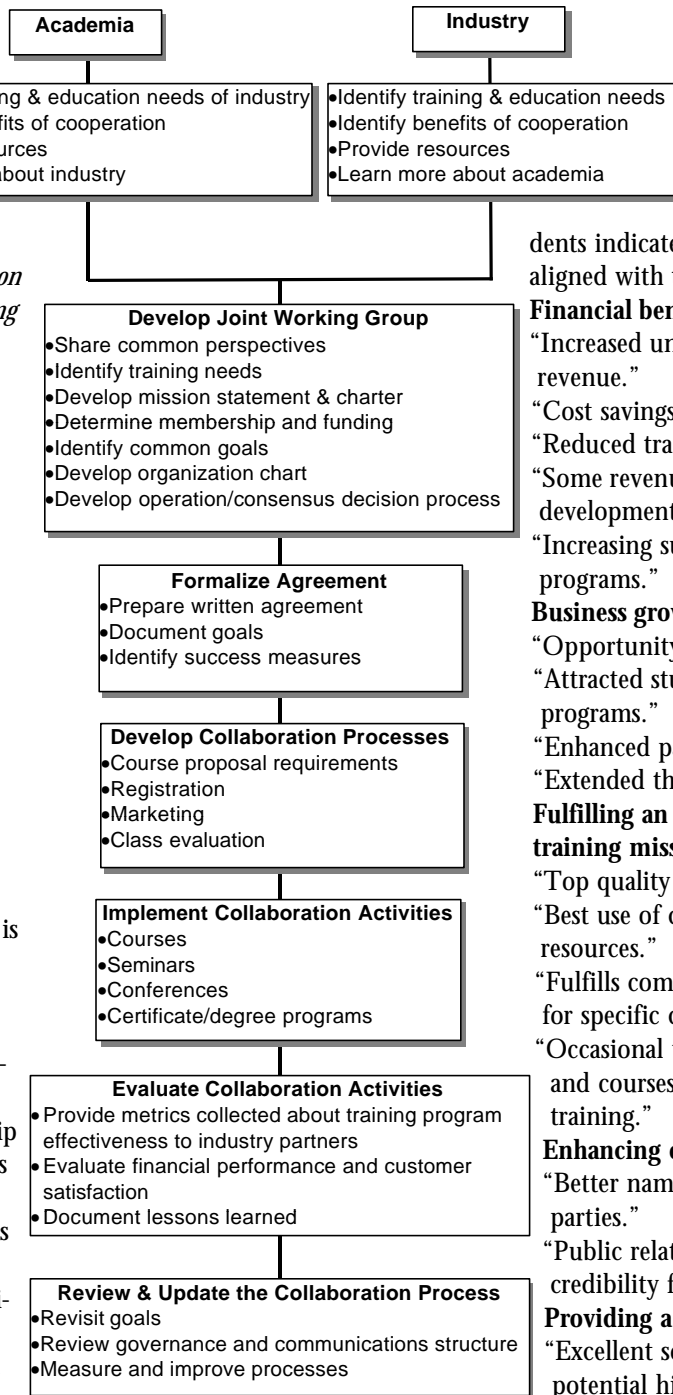- Measure and improve processes

Figure 1. *Academia and Industry Collaboration Process*

their collaborations. The list indicated collaborations could realize their goals and sometimes benefit in ways not previously expected.

Quotes from respondents indicated the following benefits aligned with their stated goals.

**Financial benefits**
"Increased university and partner revenue."
"Cost savings."
"Reduced training costs per employee."
"Some revenue for program development."
"Increasing support for research programs."

**Business growth**
"Opportunity for follow-on business."
"Attracted students for degree programs."
"Enhanced partner's marketing."
"Extended the reach of the university."

**Fulfilling an organization's education/training mission**
"Top quality training."
"Best use of company's training resources."
"Fulfills company training requirements for specific courses."
"Occasional use of academic knowledge and courses to supplement industry training."

**Enhancing organizational reputation**
"Better name recognition for both parties."
"Public relations benefit and local credibility from the partnership."

**Providing a staffing source**
"Excellent sources of interns and potential hires."

Survey respondents also reported important collaboration benefits they did not specifically set out to achieve, such as:

"Knowledge of workings of the opposite sector."
"Sharing of knowledge and experience of member companies."
"Insight into member companies' training programs, issues, problems, and experiments."
"A community of practitioners able to share their expertise as a community of learners rather than as competitors."
"Sharing knowledge and use of emerging technology (distance learning and Web-based training)."

## Results of Follow-Up Interviews

After gathering initial data, the SEI Working Group looked at the collaborations that reported having documented processes and had been active for two years or more. The Working Group conducted follow-up phone interviews with representatives from four of these collaborations: Texas Tech University, Florida Atlantic University, Software Engineering Forum for Training, California State University/Long Beach (SEFT/CSULB), and American University/Center for Systems Management (AU/CSM). Although the collaborations interviewed represented different collaboration models and missions, the data they shared with the Working Group provide useful details on successful collaboration administration and programming.

### Collaboration Models and Missions

Single university/single industry collaboration. Texas Tech in Lubbock, Texas provides a master's degree in systems engineering with software engineering component to Raytheon Co. employees. Single university/multi-industry collaboration. SEFT/CSULB provides tailored training in software process improvement and management practices to employees of three member companies from the aerospace industry—The Boeing Co., Northrop Grumman Corp., and TRW. Florida Atlantic in Boca Raton, Fla. collaborates to deliver graduate software engineering courses to employees of nine research and development firms with headquarters or major plants in southeast Florida: Allied Signal, CITRIX, Encore Computer Corp., Harris, IBM, Motorola, Sensormatic, Siemens Telecom, and United Technologies. University/consultant collaboration. American University, Washington, D.C., and the CSM, San Jose, Calif., jointly market and deliver a 15-credit Graduate Certificate Program in systems and project management, with short courses in these topics.

All four collaborations originated from existing industry/ university/government alliances. They share similar missions (e.g., enhanced institutional reputation, access to affordable training resources, and a source of revenue). Also, SEFT/CSULB and Florida Atlantic view their collaboration as a vehicle for serving the software engineering education and training needs of the regional community. Florida Atlantic established a goal to obtain access to research, training, and educational resources from its industry partners.

### Successful Administration

Industry/university collaborations have a myriad of organizational formats due to the variety of projects encountered and the organizations involved. For the most part, the four collaborations interviewed are formal arrangements with Florida Atlantic the exception. However, Florida Atlantic's informal arrangement involves committee activity, and—as with all of those interviewed—there is mutual planning and review with industry partners. Also, all four organize activities, make operational decisions, and administer their collaborations through joint industry/university responsibilities. Additional joint responsibility of administrative functions was found primarily in marketing activities of the collaborations (e.g., American University/CSM and SEFT/CSULB), in contacting new organizations, expanding existing relationships, or working through industry/professional associations for new members to add to or replace members in their collaborations.

Two governance models were noted. The first was joint university-industry input and evaluation (Texas Tech and Florida Atlantic). American University was similar, as it included its industry partner CSM in program administration planning and decisions. A different governance structure was found in the SEFT/CSULB collaboration, which is administered by CSULB-University College and Extension Services (UCES).

SEFT/CSULB is a partnership between member companies and the university. Each member company has representatives on the executive board, which is the policy-making body, and the technical committee, which develops curriculum and assists the board. Through the technical committee, industry has direct input into course topics and curriculum. The SEFT Program Director, a member of the CSULB-UCES staff, works with the executive board and technical committee to facilitate the development of SEFT activities and manages day-to-day operations.[1]

All four collaborations have well-defined communication structures to aid program administration, which are as follows:
- Florida Atlantic—Joint Advisory Board
- SEFT/CSULB—Executive Board and Technical Committee
- Texas Tech—Industry Advisory Board
- American University/CSM—Department Chair (American University) and CEO (CSM)

Funding arrangements reflect the diversity of missions and organizations involved. Florida Atlantic relies upon industry members and some state funding, while American University garners money from client fees. Texas Tech obtains grants and contracts from its corporate partner, while SEFT/CSULB operates on activity fees from classes and annual membership fees.

### Successful Programming

Table 3 identifies the software engineering education and training programming of the four collaborations.

The four collaborations share common strategies for successful programming. Industry perspectives are heavily emphasized.

| Collaboration | Program(s) | Program Format(s) | Site(s) |
|---|---|---|---|
| Texas Tech University | Master's degree | Classroom<br>Distance education delivery includes video, lecture, and Web-based instruction | University sites |
| SEFT/CSULB | Professional development | Classroom | Client and university sites |
| FAU | Master's degree and professional development | Classroom<br>Videotape and live broadcast over Florida Engineering Educational Delivery System | Client and university sites |
| AU/CSM | Graduate certificate program | Classroom | Client and university sites |

Table 3. *Software Engineering and Training Planning*

Each collaboration bases its programming on an assessment of the industry customer's needs. For example, in the SEFT/CSULB program, courses are often customized vs. being built from the ground up, as the industry customer's perspective is to develop and provide timely, short, and relevant materials and programs. All stress flexibility in program formats to adapt to their industry customers' schedules. For instance, each three-credit American University/CSM course is presented in a compressed format (i.e., five full days of instruction in one week or over three weekends). All quickly adapt their programs based on customer feedback.

Texas Tech approaches its software engineering education and training program for industry practitioners from a systems engineering perspective. The Raytheon Co. designates approximately 12 students per year to begin the 36-credit program, which takes three to four years to complete. The students come to Texas Tech for four weeks each summer for two summers, completing nine credits each summer. The program's other 18 hours are achieved in various ways, by taking courses at Texas Tech or elsewhere via distance education during the fall and spring semesters. The emphasis is on industry input and immediate adaptation, if needed.

American University's offering, like Texas Tech's, is a concentrated format of courses taken over a one- to two-year period on weekends; however, its core topical emphasis is a combination of systems engineering and project management. SEFT/CSULB differs; its curriculum is built around one- to three-day seminars. American University's and Florida Atlantic's offerings add an additional clientele in that their courses are available on both a for-credit (creditable towards a master's degree), and noncredit (certificate of completion) basis.

Several survey respondents noted the importance of appropriate instructor selection for collaboration programming. American University's program emphasizes the instructor's credentials, including both academic and industry experience/credentials, and approval by both the university and industry participants in the collaboration. SEFT/CSULB shares this perspective, as industry experience is critical for instructor credibility with practitioners.

All four collaborations perform evaluation activities. Customer satisfaction and revenues are common evaluation categories. In addition, Florida Atlantic and SEFT/CSULB appraise improved professional performance through post-program evaluations. Florida Atlantic collects metrics on the number of students enrolled, the number of students continuing, and the number of students applying for Florida Atlantic master's programs. SEFT/

CSULB monitors quantitative metrics from their needs assessment and four levels of training program evaluations based on the Kirkpatrick Model.[4] Texas Tech's evaluation process is informal and relies on participant feedback to individual instructors.

## Lessons Learned

While industry and academia are different in many ways, the surveyed collaborations have found ways for industry and academic partners to work together successfully for mutual benefit.

Table 4 documents some of the lessons learned shared by all survey participants.

Table 4. *Lessons Learned*

| **Preliminary Meetings** |
| --- |
| Define goals and needs clearly and candidly. |
| Identify decision-making structures within respective organizations. |
| Gain support of high-profile leaders from all involved organizations. |
| Win commitment to open communication, mutual support, and trust from all involved organizations. |
| Consider collaboration among competitors; it can be productive if approached correctly. |
| Assess organizations' "fit" before committing. |
| **Commitment** |
| Formally document collaboration agreement. |
| Select a governance structure to match joint goals and resources. |
| Dedicate resources. |
| Develop and document collaboration processes. |
| Develop communications structure (e.g., Industry Advisory Board, Technical Committee). |
| **Operations** |
| Adopt a customer-service orientation. |
| Be proactive. |
| Develop metrics to evaluate program success. |
| Consistently evaluate delivery formats and curriculums from industry perspective. |
| Seek feedback often and adapt programs immediately. |
| Focus on delivery time lines (especially university partners). |
| Incorporate "real-life" experiences and practical applications into activities. |
| Be selective of instructional staff. Look for practical industry experience, as well as academic credentials. |
| Facilitate frequent interactions among partners' staffs. |
| Emphasize mutual benefits as often as possible. |
| Assist partners whenever possible. |
| **Growth** |
| Participate in professional networks and organizations to identify potential new collaboration partners and customers. |
| Review existing contacts for potential new collaboration partners. |

## Conclusions

There are significant benefits derived from the interaction of universities and industry to meet the professional development, education, and training requirements of software engineers. All of the collaborations in this study cited increased university/industry appreciation and awareness, which led to better relations and mutual trust. These partnerships also resulted in increased potential revenues among the partners and an expansion of contacts and resources from both sides of the partnerships. Additional benefits included enhanced reputations for all involved and increased business development opportunities with other similar and affiliated type programs. For university faculty, the collaborations provided much-needed exposure to practical applications and industry trends and, in turn, enhanced faculty development, equipment procurement, and other resources for research and consulting. For industry students, the collaborations offered relevant courses in locations, times, and delivery formats that were realistic in the face of their workplace demands.

What makes a collaboration successful? Practitioners identified shared goals, planning, mutual trust, effective communication, and large doses of patience and hard work as necessary

ingredients. As one survey respondent put it, "Software engineering education and training issues require a hybrid type of organization to address and act upon the elements of the situation in a timely fashion. Collaborations offer a structure/dialogue/action format for addressing the dynamic education and training needs of software engineers."

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## Note

1. SEFT recently changed its name to Systems & Software Engineering Forum for Training (SSEFT). The name change resulted from an executive board's request to change the collaboration's mission, reflecting changing needs of members.

As an outgrowth of the National Software Council meeting in October 1994, the SEI invited a volunteer group of professionals from industry and academia to Pittsburgh in June 1995 to form the SEI Working Group on Software Engineering Education and Training. Nancy Mead, SEI, facilitates the group. The Working Group's mission is to improve the state of software engineering education and training practice in professional development by investigating issues, proposing solutions, and publishing state-of-the-practice information. If you are interested in joining the Working Group, contact Nancy Mead at nrm@sei.cmu.edu.

In 1996, members of the Working Group began assisting the SEI in its publication of the *Directory of Industry/University Collaborations with a Focus on Software Engineering Education and Training*. In 1997, the Working Group defined a model of collaborations formed by university and industry to address the education and training needs of software engineering professionals. In 1997-98, the Working Group administered a survey to the 23 collaborations in the United States, Canada, and Australia documented in the *SEI Directory*, version 6.

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