Summary Report and Recommendations

Working Group 16 – Physics and Industry
International Union of Pure and Applied Physics

BACKGROUND

The 29th General Assembly of the International Union of Pure and Applied Physics (IUPAP) at Sao Paulo, Brazil, passed the following resolution:

- To establish a Working Group on *Physics and Industry* to serve until the close of the 30th General Assembly
- To charge the Working Group on *Physics and Industry* to report to the 30th General Assembly with recommendations on how IUPAP can strengthen its connections with physicists working in industry, and with industries which make strong use of physics to develop and deliver their products.
- To delegate to the Executive Council the responsibility of appointing the Chair and the members of the Working Group on *Physics and Industry*.

In accordance with the above resolution, Working Group 16 was formed with the following members:

- Andranik H. Sarkissian, (Plasmionique Inc., Canada)
- Christophe Rossel (IBM Research-Zurich, Switzerland)
- Didier Roux (Académie des Sciences, France)
- Lawrence Woolf (General Atomics Aeronautical Systems, Inc., USA)
- Nisha Holla (Centre for Cellular and Molecular Platforms, India)
- Pablo Garcia Tello (CERN, Switzerland)
- Tian Feng See (Micron Inc., Singapore)
- **Chair**: K.S. Narayan (Jawaharlal Nehru Centre for Advanced Scientific Research, India)

The Working Group has met virtually on eleven occasions starting March 2020.

OUTLINE

1. Mandates and objectives of IUPAP's Working Group 16 (WG 16)
2. Survey of relevant industry membership programs
3. Physics for society and grand societal challenges
4. Summary of recommendations to IUPAP

1) MANDATES AND OBJECTIVES OF WORKING GROUP 16

The mandates are:

"To assist in the worldwide development of physics, to foster international cooperation in physics amongst academia and industry, and to help in the application of physics toward solving problems of concern to humanity".

"To continue the activity of the WG16 beyond the 30th GA with a specific mandate."

"To identify particular IUPAP Commissions and Working Groups which could benefit from and contribute to close involvement with industry."

The objectives are:

- *To explore expanding involvement of the Physics Community outside Academia, in particular Industry, towards existing or new activities of IUPAP;*
- *To identify mechanisms for the involvement of Multinational Corporations, Small and Medium-Sized Enterprises and Start-ups;*
- *To co-organize/sponsor (in partnership with other commissions and WGs) suitable international meetings, workshops and prizes that could foster the mandate of WG16.*

2) SURVEY OF RELEVANT INDUSTRY MEMBERSHIP PROGRAMS

As part of the first two objectives of Working Group 16, the group explored the membership programs of many international scientific organizations. The mechanisms and programs adopted by these organizations were then analyzed in the context of IUPAP's organizational structures and specific recommendations were made. The group also explored the needs of various industry associations and representative individual companies to ensure the recommendations provided concrete benefits.

(i) International Union of Pure and Applied Chemistry (IUPAC) (https://iupac.org/)

The organizational structure of IUPAC is similar to IUPAP. The IUPAC Committee[1] Chemistry and Industry (COCI) focuses on issues of importance to the global chemical industry. COCI develops new programs and projects on emerging topics. It is also a conduit for communications between IUPAC and National Adhering Organizations (NAOs), Company Associates (CAs), and individual scientists. It provides an essential platform for the chemical industry and for chemists and related professionals from industry through networking, global recognition, and participation in IUPAC projects that span the field of chemistry. The IUPAC Company Associates (CA) program was envisaged as an important link between IUPAC and chemistry-based industries. The IUPAC CA Program has evolved over the last few decades. It was instructive for IUPAP WG-16 to study the progress and changes made in the CA program.

In the initial phases, after introducing the CA program, IUPAC experienced a gradual decrease in the number and participation of Company Associates. There were attempts to attract more CA from countries with a significant chemical industry. Apart from a few isolated successes, there were no major indications of what actions IUPAC and COCI (Committee on Chemistry and Industry) could take to systematically increase the numbers of CAs. An assessment within IUPAC to identify the gaps in the prevailing CA scheme identified a core problem: "*The CA scheme has little financial benefit for IUPAC and, collaterally, little defined benefit for participating organisations. If IUPAC could define the value proposition for the CA scheme, ensure that value proposition is relevant then it could charge a reasonable sum for membership of the scheme and enhance take up since organisations would benefit from membership in a tangible way. So long as IUPAC is unclear what Applied means to it as an organization, it will continue to struggle with the concept of a viable and valuable CA scheme.*"[2]

Based on these surveys and feedback, the CA program of IUPAC was revitalized to make it more relevant to companies and their chemists and engineers employees. The new program was approved at the 49th IUPAC Council meeting in July 2017 and phased in during the 2018-19 biennium. Key points of the CA Program now include:

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[1] IUPAC "Committees" are equivalent to IUPAP "commissions". Information sourced from iupac.org

[2] Extracted from https://iupac.org/projects/project-details/?project_nr=2014-018-2-022

1. Employees of CAs are eligible for Division elections, appointments to Standing Committees, and nominations for IUPAC's Committee on Chemistry and Industry
2. CAs/employees can participate in IUPAC projects, develop project proposals, serve as project task group members, and assume leadership of projects
3. Discounts on IUPAC publications, both print and digital, including 25% on IUPAC's flagship *Pure and Applied Chemistry* journal
4. 10% discount on registration fees for IUPAC-endorsed conferences where two persons per CA are eligible
5. Complimentary access to the digital copy of *Chemistry International*.

Subscription fees for CAs:

1. A 2021 subscription fee target of US$ 2,500 was set in 2017 with a four-year phase-in process.
2. New CAs will be charged the US$ 2,500 subscription fee. Existing CAs as of 2017 will presumably be charged less, though it is unclear how much.
3. IUPAC has a structure of 54 National Adhering Organizations (NAOs), some of whom choose to coordinate the CA program in their country and can charge equal to or greater than US$ 2,500 for new CAs.
4. As of May 1 2020, IUPAC had 31 CA subscriptions across 12 countries.

Other details:

1. Apart from the CA program, IUPAC also has an Affiliate Membership Program (AMP) for individuals from both NAO and non-NAO countries to engage with IUPAC. This provides a second alternative for membership after NAOs and CAs. Chemists from 73 countries participate via the AMP program. Major changes to the AMP program were also driven as part of the 49th IUPAC Council meeting in July 2017. AMP members have the choice of US$ 50 and US$ 75 programs with differing benefits.
2. COCI goals are to hold regional workshops, award prizes including the IUPAC-Solvay Award for Young Chemists and the Hanwha-Total IUPAC Young Scientist Award, develop international safety training programs via the Committee on Chemistry and Industry Safety Training Program and as a provider of science input to the Strategic Approach to International Chemicals Management (SAICM) initiative, develop responsible care project materials via the Committee on Chemistry and Industry Responsible Care, and provide leadership on the role of women in chemistry internationally. IUPAC also sponsors a number of awards in various fields of chemistry. For the Peaceful Uses of Chemistry initiative, IUPAC is showcasing the value of chemistry and chemists to inform the

public how chemistry contributes to the well being of society and the sustainability of the planet.

→ Recommendations and implications for IUPAP:

1. A clear value proposition must be defined by IUPAP for companies to enrol in a program similar to IUPAC's CA program.
2. Accordingly, a cohesive number of benefits that companies will accrue by enrolling must be defined.
3. A tiered system of enrolment may be prudent with varying subscription packages depending on company size. Benefits can vary accordingly.
4. The following benefits can be introduced:
    a. Employees of CAs can be eligible for Division elections, appointments to Standing Committees, and nominations for IUPAP's Commission on *Physics and Industry*.
    b. CAs/employees can participate in IUPAP projects, develop project proposals, serve as project task group members, and assume leadership of projects.
    c. Discounts on IUPAP conferences, 10% discount on registration fees for IUPAP-endorsed conferences where two persons per CA are eligible.
    d. Complimentary access to the newsletters and other forms of information.
5. Showcase the value of physics and physicists to inform the public how physics contributes to the well being of society and the sustainability of the planet.

(ii) American Physical Society (APS) (https://www.aps.org/)

APS has a number of programs involving industry:

- Industrial Physics Advisory Board: Formed in May 2016 with a focus on enhancing interactions between APS and physicists working in the private sector, it complements the work of the APS Forum on Industrial and Applied Physics (FIAP) and seeks to raise the profile within APS of industrial physicists and entrepreneurs. It advises the APS on industrial physics programs, issues, and policies and recently issued a major report: "The Impact of Industrial Physics on the U.S. Economy."
- Director of Industrial Engagement: The APS has a single point of contact for directing its industrial engagement, currently Dan Pisano, Jr.
- APS IMPact: Industrial Mentoring for Physicists: IMPact is a mentoring program intended to connect graduate students and postdocs with physicists who work in industry. Over 400 mentors and mentees are

participating, and many mentees have received invaluable information that will help them chart a course to successful careers.

- APS Forum On Industrial & Applied Physics: APS FIAP is one of the largest APS units with almost 7,000 members. The unit's objective is to enhance the Society's ability to meet the needs of the industrial and applied physics community, and help the Society take advantage of the evolving opportunities in the practice and application of physics. It organizes sessions on industrial physics at national meetings.
- APS led task forces and reports, such as the Phys21 report: Preparing Physics Students for 21st Century Careers
- APS Industry Days at the APS March Meeting
- APS also has a Careers in Physics section that shows physics employment opportunities, sponsors job fairs and provides career workshops.
- APS PIPELINE Project - EPIC Report This report is an outcome of the APS PIPELINE program, an effort to transform the undergraduate physics experience to incorporate the skills, knowledge and mindset that not only leads students to successful employment, but also empowers them to make a positive impact on the world. This approach, called "physics innovation and entrepreneurship (PIE)" education, was incorporated into several curricular approaches by the PIPELINE project team.

(iii) American Institute of Physics (AIP) (https://www.aip.org/)

AIP has 3 main programs of relevance to industrial physics.

- Corporate Affiliates program: Benefits of joining include opportunities for interaction with peers and leaders in industry, including involvement at Physics Leadership Summits, participation in the annual Industrial Physics Forum (IPF), and opportunities for connections with industry at mixers held at major scientific society meetings, and a complimentary registration to the next IPF. Currently they are six corporate associates. *As the last IPF was in 2018 and there are only 6 corporate associates, the program is clearly not thriving and may not be an appropriate model program for IUPAP.*
- AIP Careers Toolbox: The Careers Toolbox focuses on undergraduate physics students entering the workforce after graduation. Many of these tools can be applied to finding internships, research positions, or even entrance into graduate programs.
- Statistical Research Center: The AIP Statistical Research Center develops and disseminates reports and graphics on the employment of physicists and astronomers in the U.S. They discuss the initial employment of recent physics and astronomy degree recipients earning their bachelor's,

master's, or PhD at a U.S. institution. They document sectors and fields of employment, starting salaries, and skills used.

→ **Recommendations and implications for IUPAP:**

1. A corporate affiliates program must demonstrate clear value for the company. This is a challenge for a national physics society and even more so for an international physics society.
2. Include "Industry Day" like sessions at the IUPAP meeting.
3. Set up an international mentoring program so that industrial and applied physicists from more developed countries can mentor physics students and early career physicists from less developed countries with interests in industrial and applied physics.

(iv) European Physical Society (EPS) (https://www.eps.org/)

EPS has an Associate Membership (AM) program that encourages AMs to participate in its proceedings.

The proposed benefits are:

1. Exclusive invitations to EPS award ceremonies
2. EPS recognition and visibility at EPS events and all communications channels
3. Dedicated press releases in e-EPS, EPN, etc.
4. Global exposure at EPS events (conferences, workshops, fairs, etc.)
5. Display Associate Members' promotional material at EPS events
6. Reduced Individual Member fees for Associate Member staff

AMs have the option to participate in a three-tiered system:

1. *The EPS 'Prestige' Sponsorship* for AMs who wish to sponsor the most prestigious prizes of the Society that often recognise potential Nobel Laureates. It is exclusive for major partners. Annual fee is 5,000 €.
2. *The EPS Sponsorship for Societal Challenges* for AMs to support physics and society projects of the EPS. Annual Fee is 2,500 €.
3. *The EPS Supporter Associate Membership* for small and medium-sized organisations seeking global exposure from EPS networks and events. Annual fee 1,500 €.

Today EPS has over 40 AMs and has a running initiative to acquire more of them. For this purpose, a working group 'Reaching Industry' has been created to engage in recruiting actions. It produced a specific survey sent to many organisations and

companies involved in physics-based research or technology to probe their interest and expectations in becoming EPS AMs.

EPS published in 2019 a report by the Centre for Economics and Business Research (Cebr) on the *Importance of Physics to the Economies of Europe* with an exhaustive list of physics-based industries. This study gives statistics for 31 European Countries.

→ **Recommendations and implications for IUPAP:**

1. EPS' tiered system for members of different sizes and objectives is worth examining to offer in IUPAP's program as well. This could help cater to the wide diversity in physics-based industrial companies and enable them to engage in their preferred manner.
2. Their list of physics-based industries is worth being consulted to better focus on interesting potential AM candidates.
3. The idea of a survey or questionnaire to investigate the interest and needs of companies would be a helpful tool.
4. It appears that direct contact to operative executive officers of companies is the best chance to have them participate as corporate members of IUPAP.
5. An amalgamation of the features from IUPAC, APS and EPS is recommended. For example, organization of joint conferences with other commissions or affiliate organizations such as IAPS.

(v) Canadian Association of Physicists (CAP) (https://www.cap.ca)

CAP has a Corporate Membership program dedicated to any corporation or firm that supplies a product or service to physicists, or that uses physical sciences to produce products and offer services. These companies are invited to apply for Corporate Membership in the CAP.

Corporate Membership in the CAP assists an organization to build important connections to the Canadian physics community. This is facilitated through CAP's journal, *Physics in Canada,* the CAP website, participation in joint Industry-Academic working groups, and other CAP initiatives.

Corporate Membership fees are directed entirely to the CAP Foundation, which is a charitable arm that manages/funds for the educational activities of the CAP. The objectives for the broader educational activities of the CAP are to help to enhance the public understanding of the importance of science and scientific education to

the Canadian community. CAP Lecture Tour for undergraduates is supported by CAP Foundation, as well as by participating physics departments.

Corporate Membership fees and services are structured to accommodate the size and scope of individual institutions and their level of commitment to the CAP. Corporate Members of the CAP are represented on the Advisory Council by a Director of Corporate Affairs; Corporate Members may vote and hold office for this position. A directory of current Corporate Members is posted on this web site and is published from time to time in *Physics in Canada.* Applications for Corporate Membership must be accepted by the CAP Board.

Professional Certification (PPhys):

As a measure to elevate the profession of Physicist in the eyes of students and employers alike, the CAP launched its Professional Physicist / designation at the CAP Annual Congress in June 1999. Since then, the Trademark Committee has worked hard towards the implementation of the certification process, including the adoption of a code of ethics for licensees, the striking of a Professional Certification Committee, the filing of a Trademark application, and the development of the Professional Practice Examination (PPE).

The Canadian Association of Physicists (CAP) offers a professional certification program for its members. All CAP members who meet (or will shortly meet) the criteria, including graduate students, are invited to apply.

Career in Physics Orientation:

The CAP Careers website provides a significant amount of information about physicists in industry, as well as gives examples of profiles of physicists from all levels of training (BSc, MSc, PhD) working in a variety of career paths. In May 2017, CAP launched a program to create **video interviews** with a variety of physicists in various careers. CAP also created and distributed the first in a series of careers posters to high schools across Canada.

Joint Membership**:**

The CAP has agreements for reduced membership fees for members of following organisation.

- The Chemical Institute of Canada (CIC)
- The Canadian Organization of Medical Physicists (COMP)
- The Canadian Astronomical Society (CASCA)

→ **Recommendations and implications for IUPAP:**

1. Most of these points overlap with the recommendations suggested earlier (IUPAC, APS, AIP, EPS). Some of the other points like a directory of information, outreach and certification program can be considered. Agreements with other global organizations and publishers can be explored for lower rates and access to journals.

(vi) Agency for Science, Technology and Research (A*STAR), Singapore (https://www.a-star.edu.sg/)

The Agency for Science, Technology and Research (A*STAR) is Singapore's lead public sector R&D agency. They collaborate with partners in both the public and private sectors to benefit the economy and society and bridge the gap between academia and industry.

Their research creates economic growth and jobs for Singapore, and enhances lives by improving societal outcomes in healthcare, urban living, and sustainability. A*STAR plays a key role in nurturing scientific talent and leaders for the wider research community and industry. A*STAR's R&D activities span biomedical sciences to physical sciences and engineering.

Of all the various initiates at A*STAR, the A*STAR Collaborative Commerce Marketplace (ACCM) online platform that is created under the programme for SMEs might be a feature or benefit that can be included in IUPAP's industry membership programme.
This e-portal provides a platform for members to network, learn and collaborate to develop commercial solutions and explore new business opportunities. Membership is currently free for businesses.

It has five major features, namely Partner Search, Interest Groups, Events, Call for Proposals and Marketplace. Partner Search allows businesses to search for a solution provider, distributor or potential collaborator based on their products, services, and their capabilities. The Interest Groups function helps to facilitate learning and sharing of knowledge in a specific field such as Robotics, Advanced Imaging or Machine-Vision. Furthermore, ACCM's members can publicise their events through the Event feature. The Call for Proposals function gives members a platform to publish procurement requests (i.e., Request-for -Quotation, Invitation-to-Tender, Call-for-Proposals, etc.) for free and they could directly respond to procurement requests from other companies and agencies. Finally, the

Marketplace is for members to showcase technology solutions to a wider online audience and attract potential adopters.

→ Recommendations and implications for IUPAP:

1. The ACCM's digital platform and its five specific features catering to different industry interactions could be a good model for IUPAP to emulate. Creating a virtual platform for IUPAP's global CA membership to interact, especially in a post-COVID world, could create immense value for the CA members.

(vii) Feedback from informal discussion with organizations in Asia.

It is important to have a larger presence of IUPAP in the Asian region. The changing demographics with an increasing number of physics related academic and industrial researchers makes a strong case to pursue affiliate-corporate memberships from this region. Future events and IUPAP sponsored conferences in Asian venues will enable interactions. These industries represent many important topical areas of photonics, optics, semiconductors, automotive, and energy materials. Some of the national organizations have a similar associate-supporting-institutional-membership structure, for example, Physical Society of Japan (JPS), Korean Physical Society (KPS), and Institute of Physics Singapore (IPS) where there are benefits and no voting rights. These links can be explored to have a larger involvement of relevant industry.

Useful benefits to companies from membership in physics societies include:

1. Talent recruitment via career fairs organised by the society or advertisement of the company in the society's network.
2. Corporate social responsibility (CSR) with outreach programmes.
3. Setting and regulation of industry practices and standards.

(viii) Association of SME (Small to Medium-sized Enterprises) in IUPAP

SMEs are the driving source of employment in general. However, technology-oriented SMEs also have their unique challenges, which complicates their internationalization process through development of various networks. The challenges vary depending on the size of SME and type of activities; however, financial and human resources are common factors for all. Moreover, association of individual SME in any shape or form to IUPAP may create a significant administrative burden for IUPAP.

Given that most countries have various support programs, one avenue for integration of SMEs into IUPAP should be through an organization that could represent all SMEs in a given country. The international programs connect companies with the funding, advice, export, and innovation services they need to access new markets and global value chains.

It is important to provide a global platform to physics based startups. The option of waiving associate membership for a certain initial period may be considered.

→ **Recommendations and implications for IUPAP**

1. Countries having a seat at IUPAP should provide the support for the involvement and inclusion of their SMEs in IUPAP. The mandate should perhaps be delegated by IUPAP to its member Countries.

3) PHYSICS FOR SOCIETY AND GRAND SOCIETAL CHALLENGES

The mandate of WG16 also explicitly advocates: "to help in the application of physics toward solving problems of concern to humanity". In this sense, the WG 16 aligns with the extensive scholarship recognizing Physics as one of the key enablers for facing the Planetary scale challenges that we, as humankind, face now and in the coming decades[3]. The United Nations under the so-called Sustainable Development Goals (SDGs) has framed those[4].

Physics can only play a role in solving grand societal challenges if working hand in hand with industry (technology development, innovation, job creation, economic growth, etc.), politicians (funding, laws, regulations) and the public in general (taxpayers, communities with citizen-driven actions). Outreach and communication play a very important role. It is expected from researchers to better explain what they work on or discover, to outline the advantages that society gets from the funds allocated to fundamental research and how they maximize the benefits of knowledge. Among the different fields of physics condensed matter physics and material science have played a dominant role in the creation of new technologies and applications, but today the interdisciplinarity of physics is impacting all aspects of our everyday life. Outreach activity and social dialog are not limited to universities or research organisations

[3] Some overarching references, for example, are; *National Research Council. 2001. Physics in a New Era: An Overview. Washington, DC: The National Academies Press. https://doi.org/10.17226/10118 ; United Nations, Global Sustainable Development Report 2016, (Chapter 3, Perspectives of scientists on technology and the SDGs).*

[4] https://sdgs.un.org/goals

but are also part of the industry portfolio in convincing the public of the beneficial impact of their products (bio, sustainable, environment friendly, etc.). In this sense, a IUPAP commission on *Physics and Industry* should play an information and consultation role and nurture the dialog between Industry and the different scientific communities represented in the existing IUPAP commissions.

→ **Recommendations and implications for IUPAP**

1. A commission on *Physics and Industry* could become an incubator by providing services within IUPAP and developing network activities, strategic partnerships, and skill resources with industrial companies. It could also develop an assessment, monitoring and dissemination function, from a scientific point of view, for early detection and identification of various risks and challenges to be addressed by the scientific community.

4) SUMMARY OF RECOMMENDATIONS TO IUPAP

1. Corporate Associates (CA) to IUPAP can be defined as any legal entity, including industry and international research organizations with that status, except particular individuals who instead become IUPAP associate members. CA membership will operate on an annual subscription fee-based model.

2. An annual subscription fee target of nx€2,500 equivalent to n shares but no voting right at the General Assembly would allow n people from the CA in commissions.

3. Employees of CAs could be eligible to join Commissions and Working Groups and for appointments to Standing Committees, similar to members. A commission on *Physics and Industry* can envision eligibility criteria and nomination methodology.

4. CAs/employees can participate in IUPAP projects, develop project proposals, serve as project task group members, and assume leadership of projects.

5. IUPAP can call for CAs to contribute an additional €1000 towards sponsoring a Young Scientific Prize. This will benefit the sponsoring company by giving them access to young talent. IUPAP can involve the International Association of Physics Students (IAPS), an IUPAP affiliate, here.

6. IUPAP can explore avenues to facilitate access to major instrumentation and research capabilities to its CA members.

7. Beyond WG16, a commission on *Physics and Industry* could be created to continue working towards the given mandates. Members can be requested to nominate more physicists connected to the industry. These nominations will add to the visibility of IUPAP member countries. The WG 16 or the future commission *Physics and Industry* could interact with IAPS and other IUPAP affiliates to jointly organize IUPAP sponsored events that encourage greater interaction with physicists in industry. This commission could be an incubator by providing services within IUPAP and developing network activities, strategic partnerships, and skill resources with industrial companies. It could also have a monitoring function for early detection and identification of various risks and threats.

8. Large organizations like CERN, ITER, ILL, SOLEIL, TRIUMF, SKA, ALMA and others can be invited to join IUPAP's CA program.

9. Explore joint inter-institutional activities (example IUPAP-EPS-IAPS) with common online services such as those proposed earlier by the Physnet network (http://www.physnet.de/PhysNet/).

10. Explore setting up an international industrial mentoring program where industry members can mentor university students or early industrial career physicists.

11. Explore the creation of a website that includes worldwide industrial career resources and opportunities that utilize existing national physics organization resources.

12. Explore the creation of a website that shows the value of physics and physicists to inform the worldwide public how physics contributes to the well being of society and the sustainability of the planet.

Conclusion

The Working Group 16 is submitting this report to the IUPAP Executive Council towards fulfilling the group's objectives of exploring better connections and closer interaction of the physics community with industry. As suggested in the IUPAP's Strategic Plan, WG16 has analyzed the prospect of reaching out to a wider community by creating a new corporate associate membership structure. Recommendations are also made to help IUPAP promote physics-based resources that have an impact on the economy and on society. WG 16 will continue working towards broadening these objectives.