Superconductivity
Global Alliance
ScGA

Superconductivity Global Alliance (ScGA)

for

Greener, Healthier, Prosperous and Sustainable Future

Special Session – 3LOr2B

Professor Ziad Melhem

Founder and CEO

Oxford Quantum Solutions Ltd., Oxford, UK

Date: 4th Sep 2023

IEEE-CSC, ESAS and CSSJ SUPERCONDUCTIVITY NEWS FORUM (global edition), Issue No. 57, Oct 2024. Presentation given at ASC 2024, Sept 2024, Salt Lake City, Utah, USA.

Agenda

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Chairs of the Special Plenary Session

- Prof. Ziad Melhem (Oxford Quantum Solutions Ltd, Oxford, UK))
- Dr. Joe Minervini (Novum-Industria, MIT, IEEE-CSC/USA)

Presentations

- ScGA Overview – Prof. Ziad Melhem (20 min)
- ScGA - Strategic Roadmap of Grand Challenges - Prof. Sastry Pamidi (FSU- Florida State University)

Fusion, Energy, Power, and Transport - (20min)

- ScGA -Strategic Roadmap of Grand Challenges in Healthcare – Dr. Kathleen Amm (15 min)
- ScGA -Strategic Roadmap of Grand Challenges in Electronics and QIP – Dr. D. Scott Holmes (15 min)
- ScGA -Strategic Roadmap of Grand Challenges in Science Discovery – Dr. Mark Bird (15 min)

Panel Discussion

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Panel Members

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1. Prof. Sastry Pamidi (FSU- Florida State University)
2. Dr. Kathleen Amm (FSU- Florida State University)
3. Dr. D Scott Holmes (IEEE-CSC)
4. Dr. Mark Bird (FSU- Florida State University)
5. Prof. Susannah Speller (The University of Oxford)
6. Dr. Klaus Schlenga (Bruker/Gauss Fusion)
7. Dr. Sergey Samoilenkov (Faraday Japan Factory)

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Drivers – Four primary ones!

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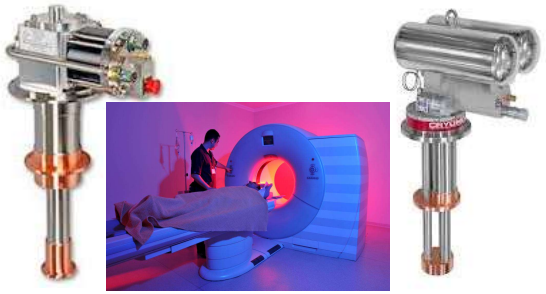
Green Economy
Trend for
Current & Future Economy

UN Sustainable Development Goals
(17 in Total)

LTS with Cryogen Free solutions
LTS for the Future

HTS for the future @ > 4 Kelvin
HTS for the Future



Greener, Healthier, More Prosperous, and Sustainable Future

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Superconductivity Global Alliance (ScGA) initiative

"Superconductivity has already enabled major advances and capabilities such as MRI, NMR, high magnetic field research, and high energy physics accelerators which otherwise would not be possible. In the future, superconductivity will provide a means towards zero-emission targets, for example by enabling fusion power, expanding usage of wind power, and facilitating zero-emission transportation, as well as enabling new technologies such as superconducting classical and quantum computing, water purification, new medical diagnosis and therapy tools, and new scientific breakthrough."

Superconductivity from the Frontier end to Mainstream technologies

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ScGA initiative - The Proposal

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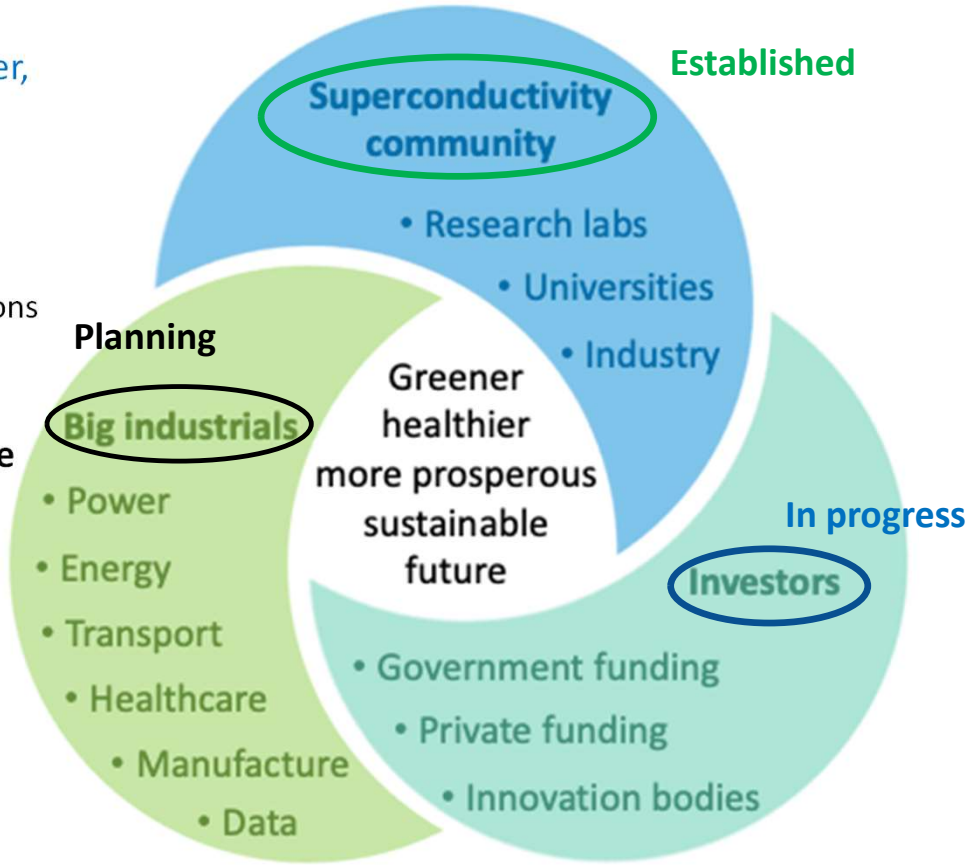
- We wish to catalyse this process and fast-track development through an "Initiative for Superconductivity" towards a greener, healthier, more prosperous, and sustainable future.
- We propose the establishment of public and private partnerships leading to
  - National initiatives and private engagement (Funding and end users) to accelerate the development of superconducting solutions
- We propose to hold a Superconductivity Summit at the senior executive and decision-making level to adopt options for **funding superconducting solutions through public and private partnerships**.
- This ambitious initiative will require setting up formally a **Superconductivity Global Alliance (ScGA)** to
  - Facilitate the delivery of the promise of superconductivity.
  - Guide the development of roadmaps and white papers.
  - Facilitate summit meetings.
  - Development of consortia on agreed grand challenges.
  - Commission impact analysis.



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The ScGA Strategy and status update

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- Stage 1 –
  - Consult with senior experts on Superconductivity
    - Industry, National Labs, R&D at Universities
  - Establish an International Organising Committee
  - Establish conveners for Working groups on
    - **WG1 – Fusion**
    - **WG2 – Industry, Energy, & Power**
    - **WG3 – Transport**
    - **WG4 – Healthcare**
    - **WG5 – Electronics and quantum information processing**
    - **WG6 – Science Discovery**
    - **WG7 – Materials for Applications**
  - Develop whitepapers targeting policymakers, public & and private funders, and big industry.

Zero carbon emission targets by 2050

Stage 2 –

- Launch and publish white papers (EUCAS, MT28, and other events)
- Launch a Website – In Progress
- Engage with stakeholders – **In progress**
- Hold One-day events – UK, EU, USA, **Japan,** South Korea
- **Special session at ICSM – Turkey (April 2024)**
- **Presentation at COST mtg in Belgrade (April 2024)**
- **Special session at ASC 2024 (USA)**

Stage 3

- **Develop options for public and private funding**
- Establish consortia for grand challenges
- **Commission Impact Analysis**
- **Explore funding for Feasibility studies for grand challenges**
- International Summit to Adopt Options

Stage 4

- Funding from public and private partnerships for superconductivity solutions

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ScGA Primary Targets

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- **Target 1 -** Develop Options for public and private partnerships to fund the proposed grand challenges.
- **Target 2 -** Facilitate developing consortia/partnerships between the SC Community, National and Private funding, and Big industrials to address grand challenges.
- **Target 3 -** Superconducting Global Summit at the senior level to facilitate the proposed partnership.
- **Target 4** - Establish a **National Strategy for Superconductivity** towards the **Global Strategy for Superconductivity**
- **Target 5 -** Adoption of identified options with public + private funding at **National Levels for grand challenges ~ > 1 B Euro** over 10 years to deliver on the Strategic Roadmap and the promise of SC for the future.

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ScGA structure

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4 SMART Markets for the Future linked to Grand challenges

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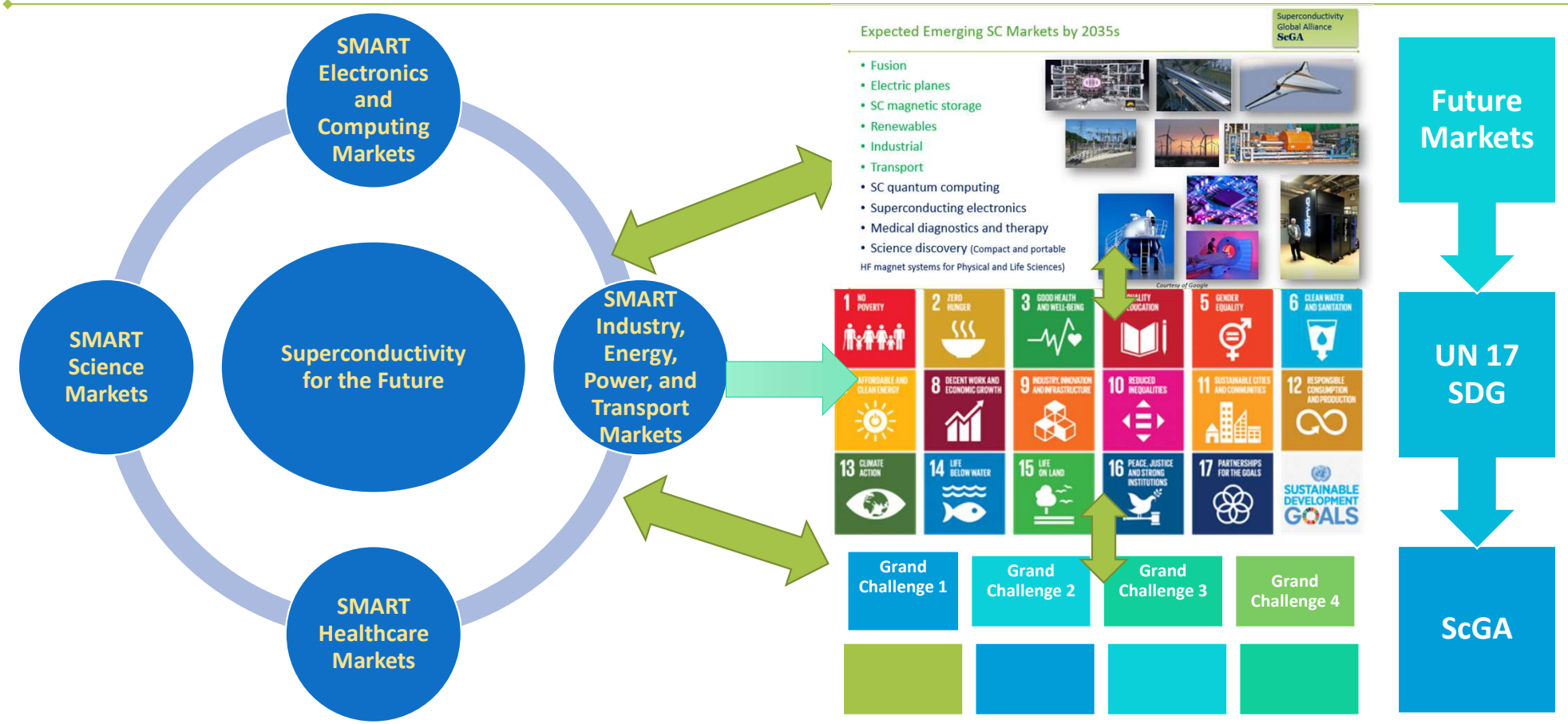

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Current Status

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ScGA initiative Members (> 140) (Research and Industry)

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Industry (45) - Univ (50) - RI (45)

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Grand Challenges and Strategic Roadmap

30 Challenges

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WP1- Fusion- Grand Challenges and strategic Roadmap (1 Challenge with 6 sub-requirements)

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WG theme ambition	<4 Years	<7 Years	<10 Years
The 10 – 100 – 1000 challenge Within 10 years to achieve 100 MW for 1000 seconds	• Design nearing, completion, • Contracting for long lead items (buildings, conductors, vessels) is well underway.	• Buildings complete, • first components being delivered to (or manufactured on) site.	• Start of commissioning.

- This is not a Fusion Power Plant…it's a demonstration that magnetic fusion CAN deliver energy
- It STILL needs significant Tritium and Tritium handling capability

- Two contenders so far, both report being well ahead of the schedule
  - Commonwealth Fusion Systems, HTS SC technology, and innovative magnets
  - BEST (ASIPP China), LTS SC technology and 'conventional' magnets (ITER style)

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WP2 – Power, Energy, and Industry - Grand Challenges and Strategic Roadmap (5 Challenges)

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Overarching Goal	<4 Years	<7 Years	<10 Years
Establish the technical and economic competitiveness, and necessity to achieve Net-Zero Targets of Superconducting Power, Energy, and Industry Applications	• Establish Regional Industry Support Centers to assist businesses to develop SC Power Technologies • Use the Centers to develop trained workforce	• Long-tern demonstration of SC Cables, Wind Generators to retire risks, showcase, and establish confidence	• Operating superconducting substation with integrated multiple SC Devices

Five Grand Challenges of WG2: Superconducting Power and Energy Technologies

1. Regional power and energy centers for supporting the superconducting industry
2. Long-duration tests for superconducting power cables to retire risks
3. Establishing the baseline designs of a 25 MW superconducting wind generator
4. Establishment of standards for superconducting power and energy technologies
5. Showcase integration of power technologies in a superconducting substation

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WP3 - Transport – Grand challenges and Strategic roadmap (7 Challenges)

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Ambition	4 years	7 years	10 years
1. Fully-superconducting motor	Basic technology elements available and demonstrated	Prototype demonstrated in a lab	Ready for commercial use in aviation
2. Fully-superconducting generator	Basic technology elements available and demonstrated	Prototype demonstrated in a lab	Ready for commercial use in aviation
3. DC HTS cable	Demonstrated in lab	Ready for commercial use in aviation	
4. AC HTS cable	Demonstrated in lab	Ready for commercial use in aviation	
5. Cryogenic power electronics	Optimized for cryogenic usage	Required components demonstrated in a lab	Ready for commercial use in aviation
6. Liquid hydrogen storage and distribution	Safety criteria established	The prototype demonstrated in a lab	Ready for commercial use in aviation
7. System level integration	Design refinements based on component performances	Selection of optimal configuration and design	Ready for commercial use in aviation

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WP4- Healthcare – Grand Challenges and Strategic Roadmap (4 Challenges)

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WG Theme Ambition	4 years	7 Years	10 Years
1. Can MRI become ubiquitous for diagnostic imaging? MRI in remote locations with remote diagnosis	Potential for demonstrators with investment	Complete studies in developed world clinical environment	Product deployed globally
2. How can advanced NMR accelerate drug discovery and personalized medicine?	Access to high field NMR 1GHz or above – expand number of systems – how to form a consortium to make it a facility for treatment	Clinical trials progressing	Personalized medicine – diagnosis of disease, personalized drug therapy
3. Ultra-High Field MRI	1st images at Iseult, initiation of various 11.7 and 14 T development programs	More 11.7 T systems deployed. Statement on the feasibility of >14-16T designs. Roadmap for 20 T systems mapped out	More systems being started at 14T and above (cryogenics plant)
4. MRI	NbTi, Nb3Sn, MgB2 Present performance of these conductors is sufficient for applications. Emergence of HTS and cryogen-free systems. Push on cryocoolers	HTS (reliable, quality, length over 1 km, joints), NbTi, Nb3Sn, MgB2 Increased performance at reduced cost desirable achievable for all HTS conductors. Higher perf. Cryocoolers	Fe based? , HTS, NbTi, Nb3Sn, MgB2 Phasing out of cryogen-dependent systems

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WP5 –Electronics and QIP Grand Challenges and Strategic Roadmap (ScE + QIP) (3 Challenges)

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1. Digital computer system
   - 100 EFlop/s performance
   - 200 TFlop/J computational energy efficiency
2. Machine learning system
   - Train on MNIST within 1 second and perform inference with > 90% accuracy
3. Quantum computing support system for 100,000 qubits
   - Provide control, readout, or quantum error correction support

Theme	Unit	4 years	7 years	10 years
High-performance computing (HPC)	EFLOP/s	0.1	20	100
	TFLOP/J	100	100	200
Neuromorphic computing	GSUPS	0.1	0.5	10
Quantum computing support system complexity	M JJ	10	100	1000

SUPS: synaptic updates per second

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Scott Holmes, 2024-08-31T02:19:33.333

WP6 - Discovery Science – Grand Challenges and Strategic Roadmap (9 Challenges)

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(All timelines are best-case scenarios with estimated durations after receipt of funding)

AREA	GOALS	4 years	7 years	10 years
High-Magnetic Field Research	1. 40 T SC Magnet	Design	Construction	Operation
	2. 60 T Hybrid Magnet	Conceptual Design	Preliminary Design	
	3. High field cryogen free magnets	HTS magnets >20T	Cryogen-free HTS magnets >20T	
High-Energy Particle Physics	1. 20 T Dipole Magnets	Design	Short prototype	Long prototype
	2. SC RF cavities		Operational at high gradients	High gradient at high frequencies
	3. 20 T Large bore solenoid for muons	Design and Tests	Prototype	Integrated Coil
	4. 40 T SC for muons	Design and Tests	Prototype	Integrated Prototype
Nuclear Physics	1. 10 T Axion Detector	Design	Prototype	Integrated Prototype
	2. 30 T Axion Detector	Design	Construction	Construction

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WP3-Grand Challenge – HTS DC Cables Securing the Future Energy Grid – In progress

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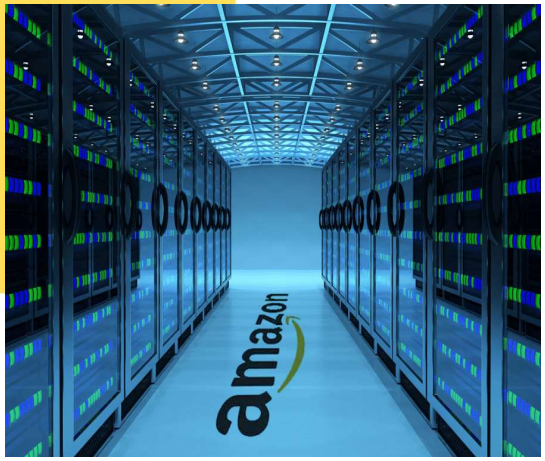

Image Source: Datacenters.com

HTS DIRECT CURRENT CABLES AND CIRCUITS FOR Data Centers

End User

- Solar farms, data centers, fusion nuclear reactors, radiation oncology, & more.

Milestones

- Year 1: Tradeoff study report with a recommendation for specified commercial offering.
- Year 2: Pilot demonstration creation and operational master plan.
- Year 3: Partner commitment agreements.

End User Benefits

- Energy and cost savings

Status –

- Confirming Consortium members
- Engaging with End-users - In progress
- Identifying funding source – In progress
- Contact Ziad in the first instance if you are interested in being a partner

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ScGA Website – To be released soon

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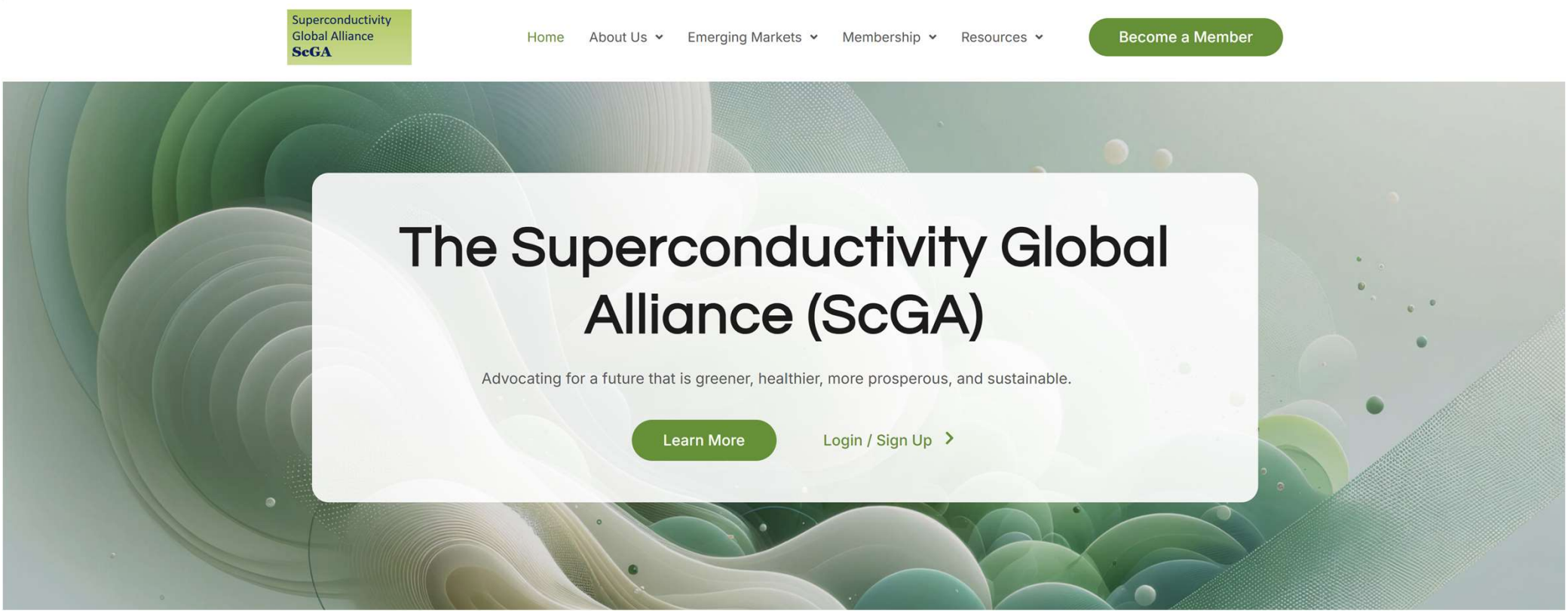

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A shortlist of ScGA Deliverables for 2024-2025

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1. Publish the INWARD version of WP in SUST (Sep 2024)
2. Publish a booklet of the OUTWARD version (Brief copy for reaching out to stakeholders) (Dec 2024)
3. Special session at ICSM 2024 (Turkey) (May 2024)
4. Special Session at ASC 2024 (USA) (Sep 2024)
5. Shortlist of grand challenges for Consortia Development (Sep-Dec 2024)
6. Identify funding for feasibility studies on agreed grand challenges (Dec 2024)
7. Release a website for ScGA (In progress) (Sep 2024)
8. Register the ScGA as a non-profit organization (Dec 2024)
9. Commission an IMPACT analysis (Dec 2024)
10. One-day meeting in Lisbon (Sep 2024 TBC)
11. Plan for the Global Summit (Apr 2025?)

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Concluding remarks

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- 7 WPs are complete – Will be released in the coming weeks!
- We are moving into stage 2 focusing on engagement with stakeholders (Events and 1-to-1 meetings)
  ... And planning for the Global Summit

Join the ScGA initiative

- As we move into an era where sustainability is paramount, superconductivity offers a chance to reshape our future.
- We invite researchers, innovators, policymakers, funders, and passionate individuals to join ScGA in this exciting journey towards a greener, healthier, more prosperous, and sustainable world.

For further details please get in touch with ziad.melhem@oxqsol.com or any member of the ScGA

- Acknowledgments
  - Thanks to ScGA IOC, Editorial Board, WG Conveners, and Members > 150
  - Thanks to IOP, BCC, IEEE-CSC, and ESAS, University of Oxford for sponsoring various activities

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International Organising Committee (IOC) and Editorial Board

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Member	Affiliation	Logo
Prof. Ziad Melhem	Oxford Quantum Solutions Ltd/UK	
Dr. Joe Minervini	Novum-Industria, MIT, IEEE-CSC/USA	
Dr. Luca Bottura	CERN, ESAS/France/Switzerland	
Prof. Susannah Speller	University of Oxford/UK	
Prof. Lance Cooley	Florida State University, IEEE-CSC/USA	
Prof. Venkat Selvamanickam	University of Houston/USA	
Prof. Stephen Gourlay	Fermi National Accelerator Laboratory, USA	
Dr. Anna Herr	Interuniversity Microelectronics Centre (IMEC)	
Dr. Kathleen Amm	Brookhaven National laboratory, IEEE-CSC, USA	
Dr Kazuhiko Hayashi	ISIS Chairman and CSSJ Executive Director	ISIS,
Dr Cathy Foley	Australia's Chief Scientist	Independent

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ScGA Working Groups, Convenors

In total 32 Grand Challenges

Superconductivity Global Alliance **ScGA**

I. Applications			
1. SMART & Sustainable Industry, Energy, Power, and Transport (15 Grand Challenges)			
1a. Fusion (WG1) (5 Grand Challenges)	**Prof. Chris Grovenor** **University of Oxford/UK**	**Dr. Mitchell Neil** **ITER/EU**	
1b. Industry, Energy, Power (WG2) (5 Grand Challenges)	**Dr. Parizh, Michael** **GE Research/ US**	**Prof. Sastry Pamidi** **Florida State Univ./US**	**Dr. Mohammad Yazdani Asrami** **University of Glasgow/UK**
1c. Transport (WG3) (5 Grand Challenges)	**Prof. Marco Breschi** **University of Bologna/Eu**	**Dr. Loïc Quéval** **University of Paris/Eu**	**Dr. Arno Godeke** **Independent Consultant**
2. SMART Healthcare (WG4) (4 Grand Challenges)	**Dr. Amm, Kathleen** **Brookhaven National Lab/US**	**Dr. Joe Minervini** **Novum/MIT/US**	
3. SMART Electronics and quantum information processing (WG5) (4 Grand Challenges)	**Dr. D. Scott Holmes** **IEEE/US**	**Prof. Giampiero Pepe** **ESAS/Eu**	**Dr Anna Lees de Escobar** Founder/CEO of Technology Vector Inc
4. SMART Science discovery (WG6) (9 Grand Challenges) a. HEP/Nuclear science b. HF research & Astrophysics (Dark Matter)	**Dr. Mark Bird** **NHMFL/US**	**Dr. Luca Bottura** **CERN/Eu**	**Prof. Amalia Coldea** **University of Oxford/UK**
II. Materials for the identified applications (WG7)	**Prof. Susannah Speller** **University of Oxford/UK**	**Prof. Selvamanickam, Venkat** **University of Houston/US**	

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Dr. Joe Minervini	Novum-Industria, MIT, IEEE-CSC/USA	
Prof. Susannah Speller	University of Oxford/UK	
Prof. Lance Cooley	Florida State University, IEEE-CSC/USA	
Prof. Stephen Gourlay	Fermi National Accelerator Laboratory, USA	
Dr. Cathy Foley	Australia's Chief Scientist, Australia	
Prof. Ziad Melhem	Oxford Quantum Solutions Ltd/UK	

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ScGA Proposed Activities

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- Develop a Global Superconductivity Strategy to facilitate the development of a National Superconductivity Strategy.
- Develop public and private partnerships with Decision Makers/Funders and Big Industrials
  1. White paper on grand challenges (Delivered by the ScGA)
  2. Strategic roadmap for 10 years directly linked with the SDGs including potential funding required (Delivered by the ScGA)
  3. One-day events (UK, USA, EU, Japan, South Korea, ?)
  4. Global Summit to adopt options.
  5. Mechanisms for Raising Awareness of the Potential of Superconductivity
     1. Aim to present the SC initiative at selected International forums, e.g.
        1. World economic forum – Davos (Jan 2024?)
        2. COP29(Nov 2024 ?)
        3. Doha Forum (Mar 2024 ?)
        4. Others?
     2. Establish regular communication channels
     3. Focused market research on grand challenges
  6. **Establish a mechanism for sustaining the initiative**

Jan 2023 ?

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