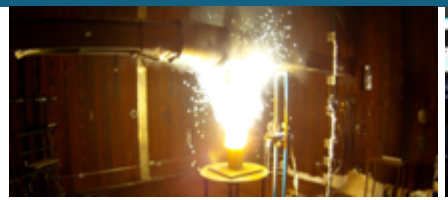
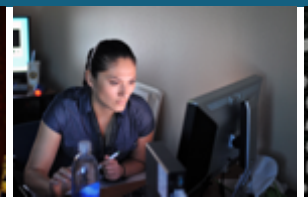
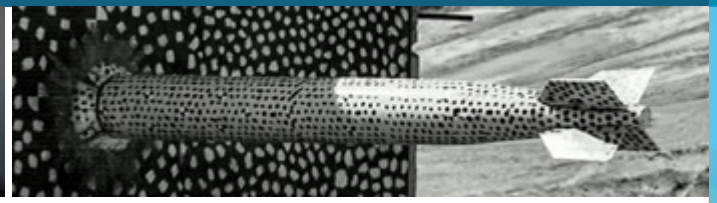
A FRAMEWORK FOR ANALYZING IMPACT OF EMERGING TECHNOLOGIES ON NUCLEAR AND RADIOLOGICAL SECURITY







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Introduction and Motivation

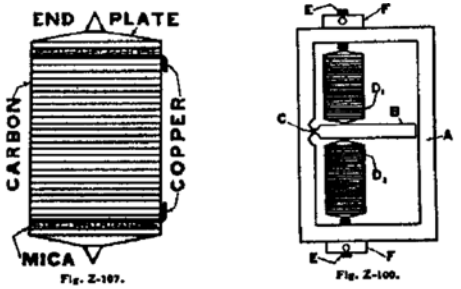
- Rapid advancement in technological development has a profound effect on the world around us
- The research objectives for this work were to develop a systematic understanding of:
  - **How might emerging technologies both create and address current and future risks to security of nuclear and radiological materials around the world?**
- Enable decision makers to evaluate the potential impact of emerging technologies and prioritize investments

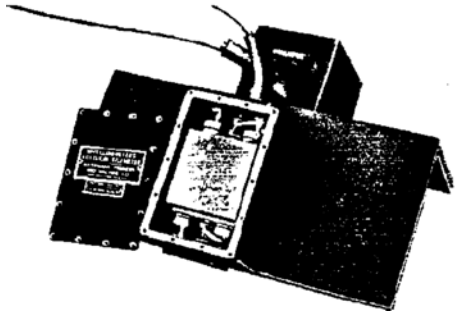
Image source: http://anthillonline.com/technology-headed-two-brilliant-minds-cast-light-onto-shadowy-road/

Image source: https://pressreleases.responsesource.com/news/87678/advanced-reveals-top-eight-technology-threats-of-the-future-for/

How Accelerometer Changed the World

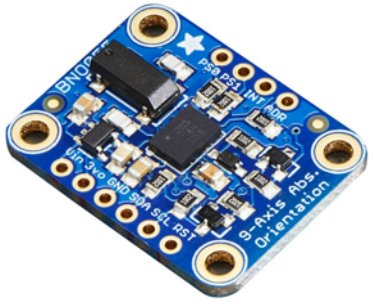
- First created in 1920s
  - to monitor equipment vibrations
- Modern select applications
  - Navigation systems for aircraft and missiles
  - Detection of vibrations of rotating machinery
  - UAS flight stabilization
  - Phones and tablets
  - Gravitational waves detection
  - Building and structure monitoring
  - Sports watches
  - …



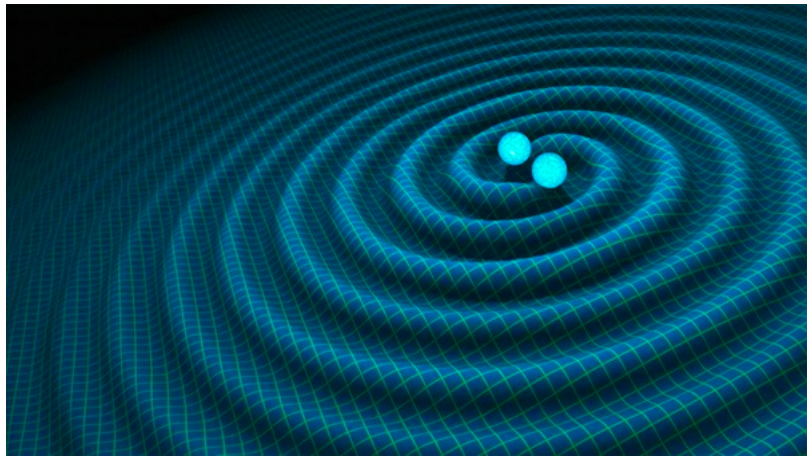


https://www.researchgate.net/figure/The-first-commercial-resistance-bridge-accelerometer-McCollum-and-Peters-photo-date_fig6_275421821

https://en.wikipedia.org/wiki/Military_aircraft#/media/File:1st_Fighter_Wing_hosts_coalition_aerial_exercise_(3).jpg



www.amazon.com

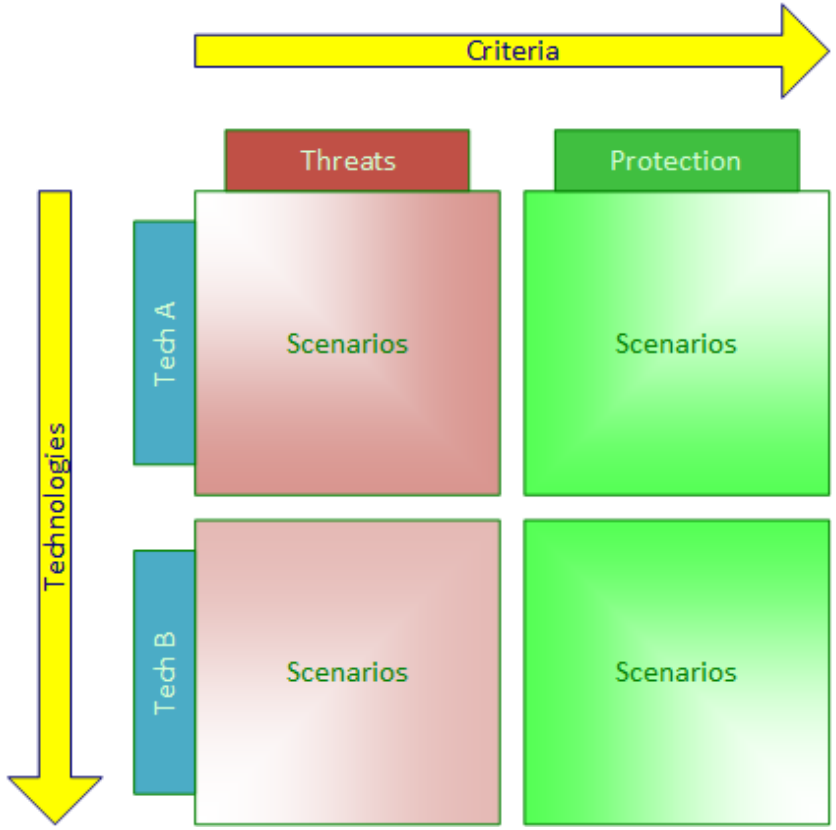


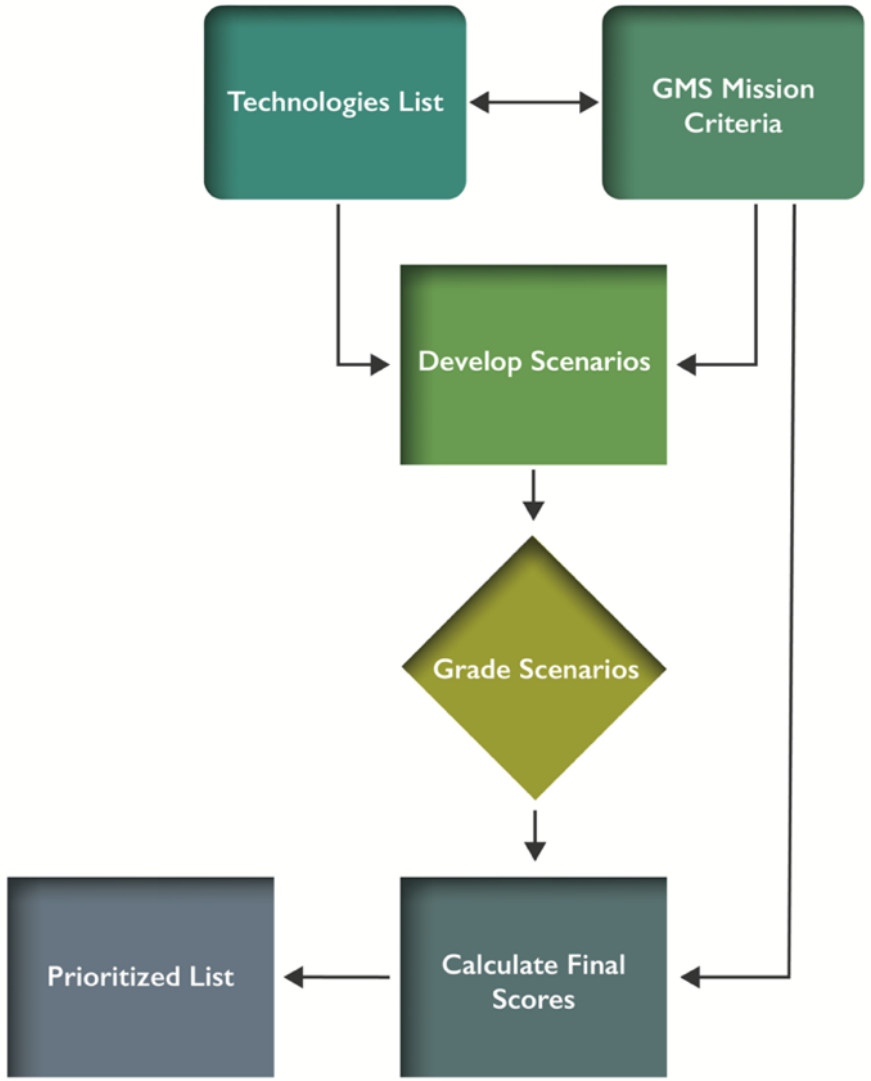
https://astronomy.com/news/2019/07/scientists-start-developing-a-mini-gravitational-wave-detector

https://www.gearhungry.com/best-sports-watch-for-men/

Analysis Framework

- Analysis framework requirements:
  - effectively address specific mission areas
  - be robust
  - be scalable
  - be flexible





Analysis Framework (Cont'd)

- placed each scenario on a *risk analysis* matrix
- as a result each scenario gets assigned a score by SMEs
- for each pair Criteria - Technology pair we kept only the most impactful scenario for further analysis

Protection

		IMPACT			
		T	M	J	C
		TRIVIAL LITTLE TO NO EFFECT	MINOR EFFECTS ARE FELT, BUT NOT CRITICAL TO THE MISSION	MAJOR SERIOUS IMPACT ON THE MISSION	CRITICAL COULD RESULT IN A COMPLETE CHANGE OF APPROACH
	LIKELIHOOD				
I	IMPROBABLE UNLIKELY TO OCCUR	LOW – 1 –	LOW – 2 –	MEDIUM – 6 –	HIGH – 9 –
P	POSSIBLE MAY OCCUR	LOW – 2 –	MEDIUM – 5 –	HIGH – 8 –	EXTREME – 10 –
R	PROBABLE WILL MOST LIKELY OCCUR	MEDIUM – 6 –	HIGH – 8–	HIGH – 9 –	EXTREME – 11 –
H	HIGHLY PROBABLE WILL DEFINITELY OCCUR	HIGH – 8 –	EXTREME – 10 –	EXTREME – 11 –	EXTREME – 12 –

Technology Protection Score (TPS)

$$TPS_i = \sum_{j=1}^{N} d_j \cdot X_j \ ,$$

where i – technology number;
j – protection criteria number
N - total number of protection criteria

Threat

		IMPACT			
		A	T	U	I
		ACCEPTABLE LITTLE TO NO EFFECT ON THE SYSTEM	TOLERABLE EFFECTS ARE FELT, BUT NOT CRITICAL	UNDESIRABLE SERIOUS IMPACT TO THE SYSTEM MISSION	INTOLERABLE COULD RESULT IN DISASTER
	LIKELIHOOD				
I	IMPROBABLE UNLIKELY TO OCCUR	LOW – 1 –	LOW – 2 –	MEDIUM – 6 –	HIGH – 9 –
P	POSSIBLE MAY OCCUR	LOW – 2 –	MEDIUM – 5 –	HIGH – 8 –	EXTREME – 10 –
R	PROBABLE WILL MOST LIKELY OCCUR	MEDIUM – 6 –	HIGH – 8 –	HIGH – 9 –	EXTREME – 11 –
H	HIGHLY PROBABLE WILL DEFINITELY OCCUR	HIGH – 8 –	EXTREME – 10 –	EXTREME – 11 –	EXTREME – 12 –

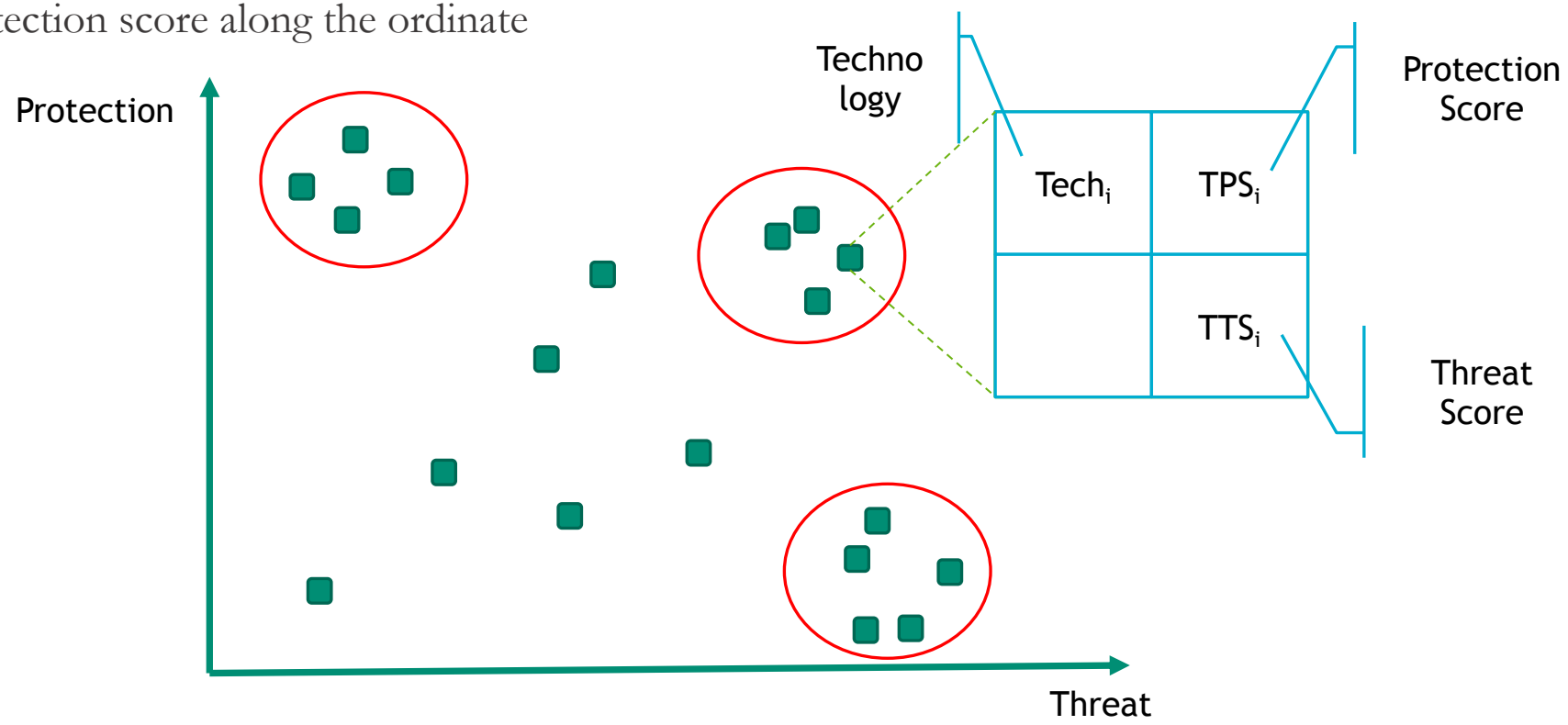
Technology Threat Score (TTS)

$$TTS_i = \sum_{j=1}^{M} t_j \cdot X_j \ ,$$

where i – technology number;
j – threat criteria number
M - total number of threat criteria

Analysis Results: Technology Prioritization

- The last step of the analysis was assembling the final prioritized list of technologies and applications
- the final results were presented in a form a two-dimensional plot:
  - threat score along the abscissa
  - protection score along the ordinate



Sample Analysis (List of Technologies/Applications)

Additive Manufacturing

- low volume production
- counterfeit goods production

Artificial Intelligence

- predictive policing

Autonomy

- assured autonomy
- autonomous weapons

Sample Analysis (Criteria)

Criteria	Weight
Threat	
Theft	0.4
Sabotage	0.6
Protection	
Physical Protection System (PPS)	0.5
Training	0.3
Deterrence	0.2

Sample Analysis (Scenarios)

Counterfeit goods production/Sabotage:

- Building counterfeit parts designed to fail to be supplied to a facility to be sabotaged

Predictive policing/Physical Protection System (PPS):

- Predictive policing would extend the PPS further outside of facility boundaries through early identification of potential threats & adversaries

Assured autonomy/Theft:

- Fully autonomous vehicles may aid in theft of nuclear/radiological materials by providing get away vehicles. This could also reduce the number of human attackers needed, and additional vehicles could be used as a decoy.

Autonomous weapons/Theft:

- Autonomous weapons may be used to distract response forces or lower a response force's probability of neutralization by providing additional fire power for the adversaries. This eliminates tasks that must be completed by a human and makes smaller design-basis threats more effective, as they are able to engage multiple targets using what are essentially tools.

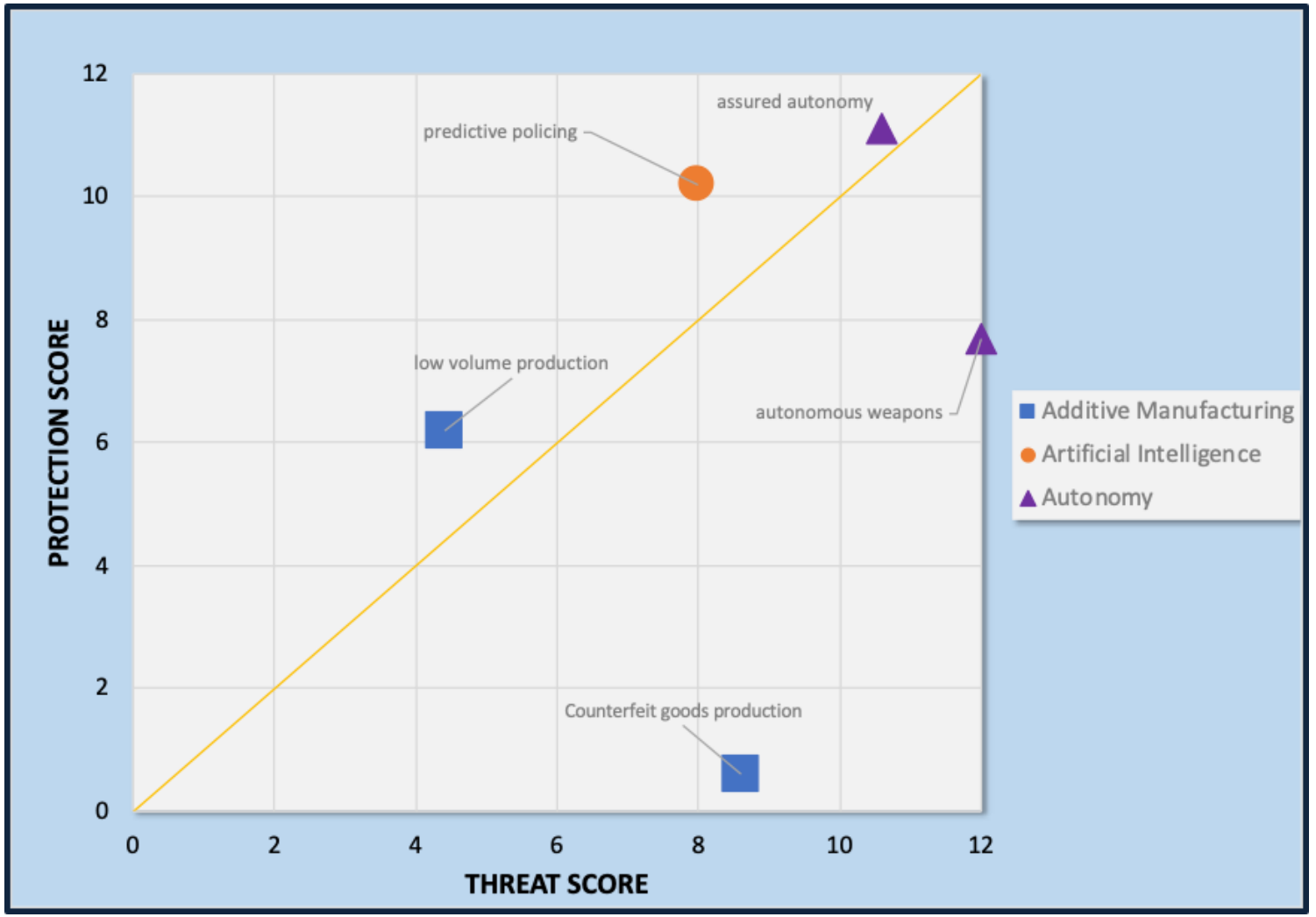
Autonomous weapons/Deterrence:

- Autonomous weapons may serve as a strong deterrence against attacks on a facility.

Sample Analysis (Results)

	Threat			Protection			
Technology\Criteria	Theft	Sabotage	Total	PPS	Training	Deterrence	Total
Additive Manufacturing							
low volume production	8	2	4.4	8	6	2	6.2
counterfeit goods	5	11	8.6	0	2	0	0.6
Artificial Intelligence							
predictive policing	8	8	8	12	8	9	10.2
Autonomy							
assured autonomy	10	11	10.6	12	11	9	11.1
autonomous weapons	12	12	12	10	5	6	7.7

Sample Analysis (Results)



Summary

- Emerging technologies can have a profound impact the field of national security and, in particular, nuclear- and radiological security and detection of materials outside of regulatory control
- The analysis framework developed allows for the comparison of multiple technologies and their effects and prioritization through quantitative analysis
  - While being quantitative, the analysis process relies heavily on SMEs' opinion, adding a degree of subjectivity to the results
  - The effects of subjectivity can be mitigated by increasing the number of SMEs as well as by diversifying the SME group's areas of expertise