28th annual INCOSE international symposium
Washington, DC, USA
July 7 - 12, 2018

Implementing the United Nations Sustainable Development Goals for the Systems Engineering of Multinational Corporations

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Abstract. The United Nations Sustainable Development Goals (SDGs) were adopted in 2015 by 193 countries. They can be characterised as sustainability 'requirements' for the global system. This paper provides a vision of how Multinational Companies (MNCs) are likely to experience the SDGs and their implications for Systems Engineering (SE) of the Enterprise. The SDGs do not have the status of international law and may be implemented differently in different countries over the period to 2030. MNCs will face choices about how they wish to comply today in anticipation of future requirements. Thereby, they also have the opportunity to avoid systems sustainability failures later on. This paper presents an initial approach to implementing the SDGs in the form of business requirements. The research will pave the ground for the development of a systematic framework for the adoption, monitoring and assessment of the SDGs in an SE context.

Introduction

Costs of sustainability failure in Systems Engineering

A Multinational Company (MNC) is a complex environment for Systems Engineering (SE), by virtue of its definition as "A corporation that operates in many different countries" (Financial Times Lexicon 2017). Examples of the very largest MNCs include Apple Inc., Exxon Mobil Corp, Alibaba Group and Nestle (PwC 2017). The failure of MNCs to fully incorporate sustainability requirements into their SE may result in large costs, risks and missed value creation opportunities. Volkswagen provided a 'case study' in this with the 'Dieselgate' scandal. The engine management software, for some of their diesel cars, was engineered to comply with pollution emissions standards when in a test condition but to disregard the standards in normal driving (Volkswagen Aktiengesellschaft 2015). When Volkswagen confirmed this in 2015, the stock market value of Volkswagen dropped by $30 billion (Karian 2015). It has been estimated that around 5000 premature deaths per annum could be avoided in Europe if vehicles in real driving emitted no more than the EU standards (Jonson et al. 2017). A Software Engineer has been sentenced to prison in the United States for his part in this (McCarthy 2017).

Whilst the costs in this case are particularly high, there are many other examples of failure to adequately incorporate sustainability requirements in SE ranging from test-cheating wide-screen televisions (Burgholzer and Dimitrova 2015) to planned obsolescence of software (Hindle and Economist 2008).

The UN SDGs as global sustainability framework

In September 2015, the United Nations Sustainable Development Goals (SDGs) were adopted by all 193 countries (United Nations General Assembly 2015). The 17 goals represent 'the world we want' by 2030 and are shown in figure 1. All the 193 countries have adopted the goals and will be expected to report progress towards meeting these goals. As the culmination of the largest consultation process in human history, they can be said to represent the most widely accepted available global sustainability framework. They hold the potential to define the requirements, which will guide SE to deliver sustainability benefits rather than value destruction.

Figure 1 United Nations Sustainable Development Goals (Global Goals Campaign 2017)

MNC adoption is increasing

An increasing number of MNCs are making public commitments to fulfilment of the SDGs. Leading business figures have made strongly supportive statement such as Paul Polman, CEO of Unilever, "There is no business case for enduring poverty. We have an opportunity to unlock trillions of dollars through new markets, investments and innovation. But to do so, we must challenge our current practices and address poverty, inequality and environmental challenges. Every business will benefit from operating in a more equitable, resilient world if we achieve the Sustainable Development Goals." (Unilever 2017) However, the depth of analysis and impact on business processes varies greatly across companies.

Challenge for Systems Engineering

The challenge for SE in MNCs is to ensure that the SDGs and the corporate commitments are elicited as business requirements and implemented in the business management systems of those MNCs. This paper is an exploration of the nature of the SDGs, how MNCs experience the SDGs and the impacts on SE approaches. It takes an SE perspective at the Enterprise level. It concludes with notes on future work the authors intend to undertake in this area.

The UN SDGs

What are the SDGs?

The 17 SDGs and 169 targets. The 17 SDGs cover a broad scope of environmental, social and economic aims. They were the result of a three year global, participatory process which aimed to include all stakeholders' and peoples' voices (UN Department of Public Information 2015). Each of the 17 goals consists of a number of specific targets. So for example Goal 1 is "End poverty in all its forms everywhere" (United Nations General Assembly 2015:15). Within that are seven targets, including target 1.1 "By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than $1.25 a day" (United Nations General Assembly 2015:15) and target 1.4 "By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance" (United Nations General Assembly 2015:15). The goal titles are inspirational statements but the targets represent a practical agenda for change.

The Millennium Development Goals. The forerunners of the SDGs were the Millennium Development Goals (MDGs) which ran from 2000 to 2015. These were a group of eight goals (see figure 2). The MDGs only applied to less developed countries. The mobilisation behind the MDGs has been described by Ban Ki-Moon as "the most successful anti-poverty movement in history" (United Nations 2015a:3). In 1990, 47% of the population in developing countries lived in extreme poverty, by 2015 that had been reduced to 14%. Similarly, the global number of deaths of children under five had reduced from 12.7 million in 1990 to 6 million in 2015. It was this experience that led to the development of the SDGs with their global coverage and determination that 'no one is left behind" (United Nations General Assembly 2015:1).

Figure 2 Millennium Development Goals (United Nations 2015b)

Adoption of the SDGs by Governments

The SDGs were adopted by 193 governments in the United Nations General Assembly on 25th September 2015. Governments around the world are now putting the SDGs into action. By the end of 2017, 64 governments have already submitted Voluntary National Reviews to document their progress towards the goals (United Nations 2017a) with another 48 scheduled for 2018. However, it is clear that Governments do not have sufficient resources to achieve the SDGs alone. Success will require partnerships with business and Non-Governmental Organisations (NGOs). SDG 17 recognises

this “Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development” (United Nations General Assembly 2015:26).

Adoption of the SDGs by NGOs and Partnerships

The SDGs give NGOs and partnerships a single global taxonomy to describe the areas in which they work and deliver change. Increasingly they are able to identify funders and investors which target specific SDGs. The UN Partnerships for the SDGs online platform documented 3674 partnership projects aligned to the delivery of one or more SDGs by November 2017 (United Nations 2017b).

Adoption of the SDGs by companies

An increasing number of businesses are engaging with the SDGs. The partnership design of the SDGs recognises that businesses are essential to the achievement of the SDGs. Government commitment, supported by NGO programmes, leads to markets being developed which businesses can have greater confidence to invest into. It has been argued that “the SDGS are a critical part of investors’ fiduciary duty” (UNEP Finance Initiative and U N Global Compact 2017:7) because they drive global growth, manage areas of risk and act as a capital allocation guide. Companies are starting to report their activities in alignment with the SDGs. A 2017 survey found that “that 60% of corporate respondents state their businesses are integrating the SDGs into their business strategy”(Dowd 2017). The Global Reporting Initiative, which is the most widely adopted sustainability reporting standard for companies, is working to accelerate corporate reporting in line with the SDGs. Indeed SDG target 12.6 states “Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle” (United Nations General Assembly 2015:22).

Infrastructure for the SDGs

The UN Partnerships for the SDGs online platform is but one example of the infrastructure supporting the delivery of the SDGs. It is a web-based database which enables stakeholders to search for projects and collaborators by SDG. It also supports progress reporting and social media promotion of the projects. There is a growing range of similar infrastructure, for example the United Nations Statistics Division maintains a web database of the reported indicators of progress towards the SDGs (United Nations Statistics Division 2017). There is an increasing set of reports and research on the application of the SDGs in various contexts. The International Telecommunication Union (ITU) maintains a website indicating how information and communication technologies (ICT) can help to deliver the SDGs (ITU 2016) and the ‘Global Goals’ project provides a wide range of digital marketing assets for the SDGs (Global Goals Campaign 2017).

Anticipatory Implementation of the UN SDGs by Multinational Corporations

Reasons for implementing

An increasing number of MNCs are implementing the SDGs and publicising their impacts. As an example, Airbus have made formal commitments towards eight of the SDGs in their Responsibility and Sustainability Charter signed by the Airbus Executive Committee (Airbus 2018). This type of systemic engagement can result in impacts across a wide range of processes and organisations within these companies, including the SE processes and SE organisation within these. So, from an SE perspective, it is important to understand what might be driving this adoption and to identify the probable impacts on the way SE is applied in this context.

Anticipatory Compliance. From an SE point of view, one of the advantages for MNCs from engaging with the SDGs now is anticipatory compliance (Engau and Hoffmann 2011). The SDGs represent a global agenda from 2015 to 2030 and their widespread adoption means that forward looking MNCs will be seeking to anticipate the policy and regulatory implications of the SDGs. This is particularly important for systems with a long lifespan and which must anticipate requirements arising during the

use phase of the system. As all countries will be reporting on their progress towards the SDGs, it can be expected that policy and regulatory initiatives will seek to report and accelerate that progress.

Increase in shareholder value. For many MNCs, the key driver for the implementation of the SDGs will be the pursuit of increase in shareholder value. Investors tend to view strong sustainability credentials as a proxy for good management and may offer favourable access to capital investment. Research has shown that admittance to the Dow Jones Sustainability Index "results in an increase in market value of almost 2.1%" (Robinson et al. 2011:493). For an MNC with a large market capitalisation, that increase in value can be measured in $Billions.

Brand value. Publicising engagement with the SDGs can support MNCs brand positioning. There will be some benefit for MNCs positioning with consumers who are aware of the SDGs. The level of citizen awareness varies quite widely between countries (OECD Development Communication Network 2017). However there will be particular benefit for MNCs engaging with Government clients. MNCs can emphasize how they are supporting the government agenda for sustainable development.

Risk reduction. The comprehensive nature of the SDGs makes them a particularly useful instrument for systems engineers working with MNCs. The SDGs offer a form of risk reduction by providing a challenge to the requirements that might be identified for a project. In a number of projects (not published due to confidentiality conditions) where the authors have worked with MNCs, it has been our experience that the 169 SDG targets have enabled the identification of system requirements with impacts on the system scope, which had not been anticipated by the respective programme teams.

Reporting

Primary reporting responsibility is countries. The primary responsibility for reporting progress toward the SDGs falls on national statistical authorities. The United Kingdom's Office for National Statistics has recently carried out a consultation exercise to identify what data items to report to the United Nations Statistics Division (Office for National Statistics 2017).

Corporate reporting standards. Although it is not primarily their responsibility to report to the UN, companies are beginning to report their contributions towards the SDGs. The Global Reporting Initiative (GRI), which is the sustainability reporting standard most widely adopted by MNCs, has issued a mapping from their indicators to the SDGs (Global Reporting Initiative 2015).

How do MNCs experience SDGs?

Not international law but country implementation. Although the SDGs were adopted by 193 nations, they do not have the status of international law. Thus it is for each country or bloc to develop the policy responses which will lead towards the delivery of the SDGs. This means that there will be a multiplicity of implementation measures.

A range of implementation approaches. An MNC is likely to experience the same SDG target being implemented in different ways across the territories in which it operates. Some countries may legislate for action and compliance, others will introduce incentives and tax advantages to motivate corporate action. This is a particular challenge to MNCs in engaging with the SDGs. MNCs will make a series of choices about the extent of compliance with local measures driving towards the SDGs. They may also choose to go beyond compliance in some territories in order to demonstrate a consistent global approach to selected SDGs where there is benefit to the business in doing so.

Who is responsible for SDGs in an MNC?

The Chief Sustainability Officer? From an SE perspective, it is recommended that a single stakeholder should have the SDGs as their requirements on the system. In some MNCs there will be a Chief Sustainability Officer or board committee who have clear top level responsibility for sustainability. Alternatively, the SDGs related topics may be addressed in the portfolio of the 'Corporate Responsibility' lead in the organisation.

Holistic and pervasive. However, the very broad spectrum covered by the SDGs means that many different owners of requirements may be identified. Goal 8 – 'Decent Work and Economic Growth' includes targets which the Human Resources stakeholder may identify as theirs. Similarly, SDGs 13, 14 and 15 which relate to climate change and terrestrial ecosystems, may well be identified as requirements within the responsibility of the environmental management team. However, in many MNCs the reporting relationships of these functions will align to the Chief Sustainability Officer or the Corporate Responsibility lead.

In many MNCs, SE as a discipline has been increasingly used not only for the development of the systems that companies develop and support during their operational lives, and their enabling systems, but the MNCs themselves and their extended enterprise (e.g. including risk sharing partners, suppliers and sub-contractors) are treated as a system. In other words, Business Management Systems (BMS) are being established, in order to ensure that all mandatory external business requirements (e.g. from regulations, legislation and certain standards), as well as external business requirements that the company choses to comply with voluntarily because they add value, be systematically and properly implemented in the way of working and the organisation of the company at hand. Such an approach enables full traceability of all such external and internal business requirements, and how they have been implemented by which means of compliance in the company's processes and organisations. This means that compliance can be demonstrated both effectively and efficiently, and any non-compliances can be followed up appropriately.

If an MNC with such a BMS wishes to implement specific targets of the SDGs in their processes and organisations, and subsequently demonstrate and report compliance, then the relevant targets have to be fed into this BMS and cascaded appropriately as business requirements into the company and the extended enterprise.

Impacts on the Systems Engineering approach of Corporations

Given the rate of adoption of the SDG's, many working with MNCs will need to understand and incorporate their impact on SE. This will also be the case for those working with governments and NGOs. Looking at the traditional use of SE by MNCs, i.e. for the development of systems that can be sold to customers and serviced during the operational lives, three ways can be identified in which the SDGs and their relevant (as decided by the MNC in question) targets will find their way into the area of SE:

- The SE processes (including applied methods and supporting tools) will receive allocations of SDGs derived business requirements, which the SE processes have to implement by accepted means of compliance;
- The actual systems to be developed or those already in service might receive new system requirements that are based on the SDGs and related technical requirements; and
- The SE organisation of the MNC may receive allocations of SDGs derived business requirements, which the SE organisation has to implement by accepted means of compliance.

However, the third way is not specific to the organisation responsible for SE, but rather all organisations, for example if equal opportunities or gender equality are concerned. Whether the main way the SDGs will impact the domain of SE is via the first or the second way described will depend on whether the MNC is a process-driven company, has a BMS established, and the type of systems the MNC usually develops and supports.

Business choices drive systems requirements

Since the SDGs will be experienced by MNCs through local regulation and incentives as well as through global engagement with investors and activists, there are a large number of choices which businesses will be making with respect to the SDGs. These will have to be documented and incorporated as requirements as described above. These choices will be in a matrix with dimensions of the SDGs (17 goals and 169 targets) and countries in which the MNC has operations. So, potentially there is a significant level of complexity for larger MNCs.

Who are the requirements owners?

As noted above, some MNCs may have a single global requirements owner for the SDGs in the person of a Chief Sustainability Officer. However, it is far more likely that we will find a multiplicity of requirements owners at global, regional and local levels. This will depend on the organisation design model that the MNC has chosen to adopt (Kates and Galbraith 2007) and the extent to which their business process management is formalised.

SDGs as holistic challenge to scope boundaries

The SDGs, because of their holistic and broad nature, make a very useful challenge to the anticipated requirements of projects with a specified scope. In a number of the projects, where we have used the SDGs in developing requirements, we have found that these projects have benefitted from the goals and targets highlighting requirements early in the project which might otherwise have been discovered later or overlooked. Identifying requirements early in the SE process typically saves time and expense (Haskins et al. 2004).

How well formed are the SDG's as requirements?

It must be recognised that the SDG goals and targets are policy documents which resulted from an intensive consultation and negotiation process. They were developed by various negotiating streams and the results are not always well-formed from a requirements engineering perspective. Indeed the style of the targets are not consistent across the full SDG set.

For example, the definition of well-formed requirements is stated in ISO29148:2011 Requirements Engineering:

> A well-formed requirement is a statement that
>
> - can be verified,
>
> - has to be met or possessed by a system to solve a stakeholder problem or to achieve a stakeholder objective,
>
> - is qualified by measurable conditions and bounded by constraints, and
>
> - defines the performance of the system when used by a specific stakeholder or the corresponding capability of the system, but not a capability of the user, operator, or other stakeholder. (International Organization for Standardization 2011:9)

In addition the targets can be compared to the characteristics that ISO29148:2011 expects of requirements

> Each stakeholder, system, and system element requirement shall possess the following characteristics:
>
> - Necessary.
>
> - Implementation Free
>
> - Unambiguous.
>
> - Consistent.
>
> - Complete.
>
> - Singular.
>
> - Feasible.
>
> - Traceable.

- Verifiable (International Organization for Standardization 2011:11).

Some targets are relatively well formed, for example target 3.6 "By 2020, halve the number of global deaths and injuries from road traffic accidents" (United Nations General Assembly 2015:16). This has a clear target date, a quantifiable outcome and a measure which most national statistical organisations will record. There is an implied baseline date. All MNCs will have road traffic operations or staff travelling on roads. So, there is a clear likelihood of an SE requirement arising from this target.

Other targets will require significant work to express as well-formed requirements, for example target 9.5 "Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending" (United Nations General Assembly 2015:20). Many MNCs will have a significant part to play in realising this target but as a requirements statement, it requires decomposition into a series of clearer requirements.

How many requirements?

How many requirements statements will the SDGs generate for an MNC? From the starting point of the 169 targets which make up the 17 goals, we can potentially eliminate a number of the targets which clearly only have application to national governments. However this will require expansion of targets like 9.5 into a series of discrete well-formed statements. This is a research question that the authors have identified and forms part of the future work.

Connecting existing requirements to SDGs

A number of the goals and targets will already be experienced by MNCs as existing national regulations. For example MNCs in many countries will already have requirements which contribute towards target 1.1 "By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than $1.25 a day". These will be experienced in the form of minimum wage legislation and reporting requirements along the lines of the Modern Slavery Act (HM Government 2015).

A mapping exercise to identify the degree to which the goals and targets are covered by existing understood compliance requirements can help MNCs to identify those targets which are less well covered and where the organisation may face a need for anticipatory compliance to be ready for the introduction of new regulations.

Reporting Systems Engineering delivery of the SDGs

Whilst the primary duty to report progress towards the targets rests on national statistical agencies, we can anticipate that many MNCs will want to report their contribution towards the achievement of the SDGs. So, for every SE relevant requirement that arises from the implementation of the SDGs, there is likely to be a parallel reporting requirement to be consolidated at corporate level. This may find expression within the annual Sustainability Report and / or in the annual Financial Report.

A standards based approach

There will be a general benefit to MNCs if the goals and targets are expressed in a manner which is consistent with a standards-based approach to SE such as ISO15288:2015 (International Organization for Standardization 2015). The development of such a requirements set is planned as part of the authors' future work.

Exploring application

The SDGs offer value for Systems Engineering. How do we realise the value?

The SDGs offer systems engineers the opportunity to improve the completeness of system requirements, earlier in the project lifecycle. In the complex web of requirements which is typical of SE in MNC projects, the SDGs offer a comprehensive taxonomy which can assist in the organisation and reporting of sets of requirements. So how can the value of the SDGs in terms of SE be realised for the benefit of the MNCs?

Instantiation of the SDGs as requirements using OntoREM

Working with a Requirements Engineering method. The authors are undertaking research to propose a method for incorporating the SDGs into a formal requirements engineering (RE) method. The SDGs could be used as input to any generally applicable RE method. We have selected OntoREM, an "Ontology-driven Requirements Engineering Methodology" because of its reported time and cost advantages (Kossmann and Odeh 2010). The methodology enables the goal-driven development of detailed requirements based on the targets of the SDGs for a given context. We created an instantiation of the SDGs and their targets in the generic OntoREM domain ontology as a starting point for the development of these SDGs based requirements. Figure 3 shows a mind map of the SDGs as produced using OntoREM.

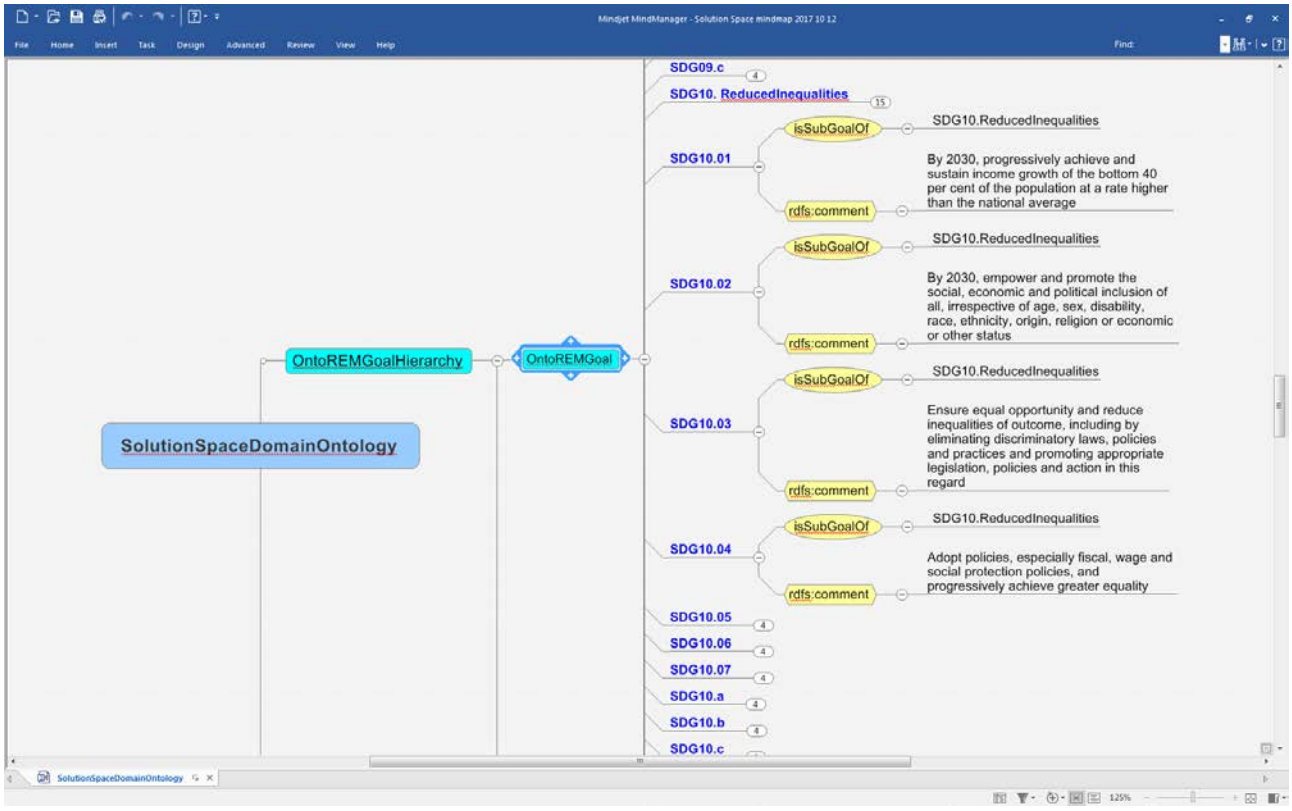

Figure 3 SDGs as OntoREM Mindmap (Authors' work)

Working with the SDGs and Targets.

The team has experience in working with the SDGs in a variety of contexts and sizes of organisation.

High level rapid workshops. The first of these is a rapid SDG delivery workshop during which we work with stakeholders to run through the 17 SDGs in a 90 minute event where we use technology to capture the stakeholders' views. We poll their insights as to which of the SDGs place requirements on the project and how the project will impact on the delivery of the SDGs.

Pre-evaluation and validation. The second is working at the level of the 169 targets. A sustainability expert from the team evaluates the 169 targets in the context of the SE project. They rate each target as high, medium or low relevance to the project. This rating is then adjusted and validated with a senior stakeholder before incorporation into the formal requirements engineering process.

Future work: Resolving the challenges

The SDGs offer value when used in the SE of MNCs however there are some key challenges to resolve and which form the basis of future work.

Expressing the SDGs as well formed requirements

There is a significant amount of work involved in the exercise of expressing the SDGs as well-formed requirements as defined by ISO29148:2011. Some of the targets may not be amenable to expressing as singular, verifiable statements. Indeed some researchers have claimed that 17% of the targets "require significant work" before they could be considered well developed (ICSU and ISSC 2015:6). The authors will work on how the targets can be expressed to be useful for SE.

Cataloguing the experiences of MNCs

The authors will also catalogue the experiences of organisations using the SDGs as requirements in SE through the use of selected case studies.

Bridging the Gap

Expressing the SDGs as requirements in OntoREM is a contribution to bridging the gap between human thinking about sustainability and machine processing for sustainable development, building on the work of (Zayed et al. 2013). The research will pave the ground for the development of a systematic framework for the adoption, monitoring and assessment of the SDGs in an SE context.

Conclusions

Contribution of MNCs to Sustainable Development

The United Nations Sustainable Development Goals are an ambitious programme to set targets for 'the world we want' by 2030. There is significant political commitment to these Global Goals. The goals cannot be achieved by governments alone. Public – Private partnerships are necessary to deliver the scale of change desired. MNCs have a major contribution to make towards achieving the goals through their operations, customers, supply chains and investments.

SDGs, helpful framework, not all well-formed

The 17 goals and 169 targets are a useful and very broad framework which can help MNCs to confirm requirements already identified and to highlight areas where they may need to adopt an anticipatory compliance approach. The targets themselves vary from well-formed to weak.

Unique experiences by MNCs of SDGs

The SDGs do not have the status of international law and different countries can choose different regulatory or incentive approaches appropriate to achievement of the SDGs in their national context. This is a challenge to MNCs which will experience the same SDG target as different requirements in their national operations.

Systems Engineering challenge to turn intention into consistent action

SE can help to deliver the promise of the SDGs in terms of significant social, environmental and financial benefits globally. The challenge is to turn the policy intentions into requirements for consistent delivery through enterprises and practical systems.

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Biographies

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Mario Kossmann (ESEP) is an experienced Systems Engineer and Capability Integrator for Airbus, having previously worked for Blohm & Voss as Program Manager, Systems Engineer, Technical Manager and Consultant in Services Marketing. He has served as a naval officer with the German and French navies, and was awarded an MEng in Aerospace Technology from the University of the Federal Armed Forces in Munich (Germany), an MBA from the University of Warwick (UK) and a Ph.D. in Systems & Software Engineering from the University of the West of England.

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Mohammed Odeh is head of the Software Engineering Research Group in the Faculty of Environment and Technology at UWE Bristol and is Professor of Cancer Care Informatics (first professor awarded this title) at King Hussein Cancer Center in Jordan. He has more than 33 years of research and development experience in the engineering of software systems with an in-depth interest in Systems of Systems software engineering, Knowledge-driven Requirements Engineering and Bridging the Gap between Business Processes and Computer-based Systems. He has supervised 20 PhD students in software engineering and other related disciplines.