Proposals of the Renewed Task Group "Advanced Mathematical Tools for Data-Driven Applied System Analysis"

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Co-Chairs

Background: Resilience of Digitized Complex Systems

Today's society has become dependent on complex systems, enabled by increased digitization of our world and the increasing availability of vast amounts of data, that have had a great impact on virtually all facets of our lives and our societies: enabling our financial transactions, running our power grid, underpinning our transportation systems, empowering our health care, supporting the rapid delivery of supplies and materials. Yet these changes have made us vulnerable to natural disasters, deliberate attacks, just plain errors. A challenge is to develop ways to make our complex systems more ***resilient***. We propose to continue the work of the "Task Group Advanced Mathematical Tools for Data-Driven Applied System Analysis" to address this challenge through the development and refinement of a toolkit of advanced mathematical tools.

Mathematical Tools to Enhance Resilience

Modern technological and sociotechnological systems consist of numerous critical infrastructures that are strongly interconnected, which makes them vulnerable to multiple chain or cascading destructive impacts. Vast amounts of data need to be taken into account in understanding the performance of such infrastructures and their interconnections, and understanding how to make them resilient. Mathematical tools can assist with this and in particular the Task Group will study algorithms for responding to a disruption that will enhance resilience, i.e., minimize the departure from a previous state when things settle down after a disruption.

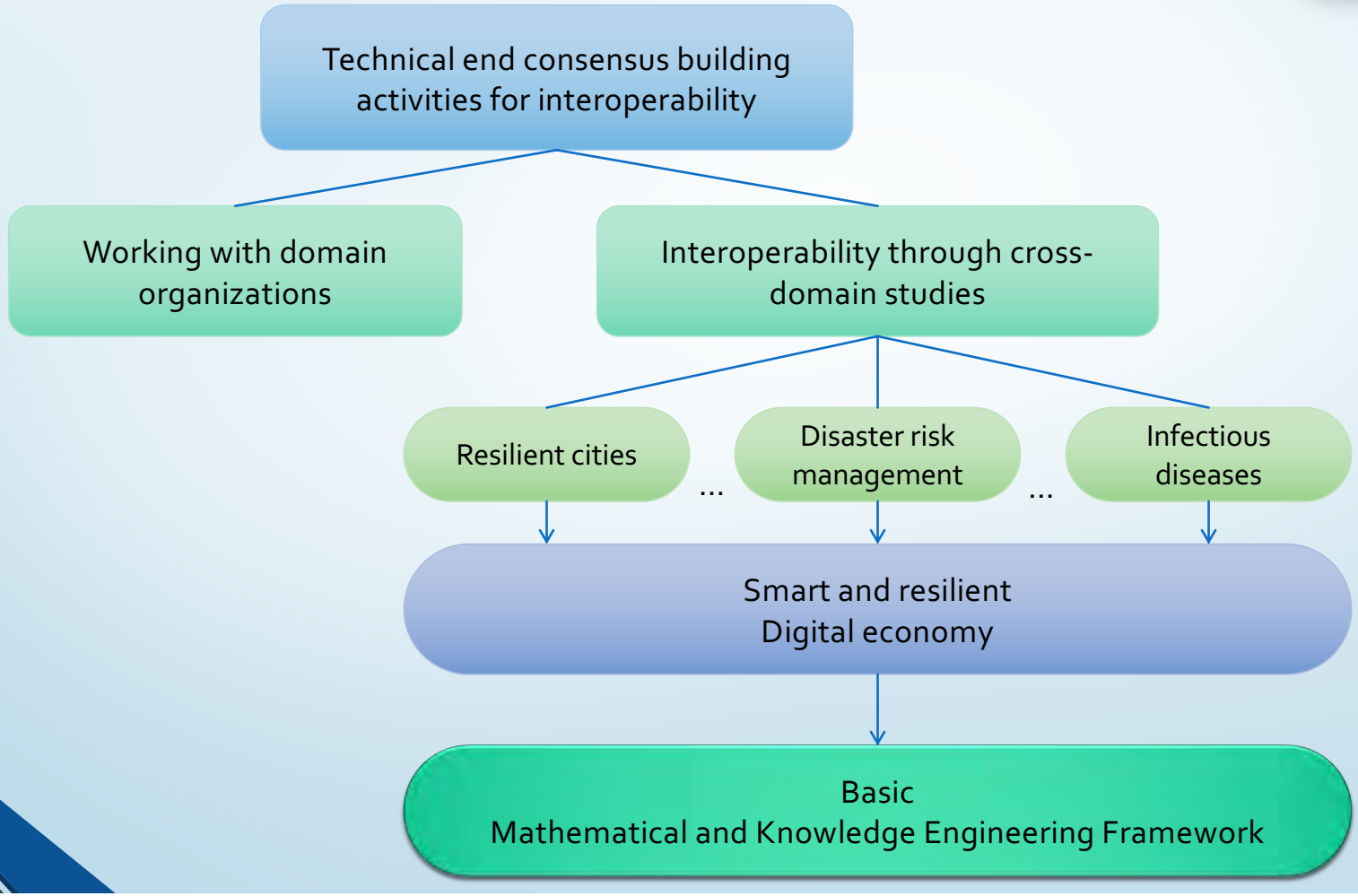
Mathematical Tools to Design Resilient Systems

In addition to helping us understand how to bring a system back to a normal state as rapidly as possible, mathematical methods can aid us in understanding how to design systems so as to make them more resilient in case of disruption. Modern complex systems may include millions of interconnected components (humans, devices, buildings, etc.), so to design a system with a predefined level of resiliency, it is necessary to represent in some formal way a system's structure and logic of operation, and to develop an appropriate mathematical and algorithmic toolkit that can provide for efficient search for solutions over the extra-large volumes of data associated with digitized systems in today's era of Big Data. This is a major goal of our proposed renewed Task Group.

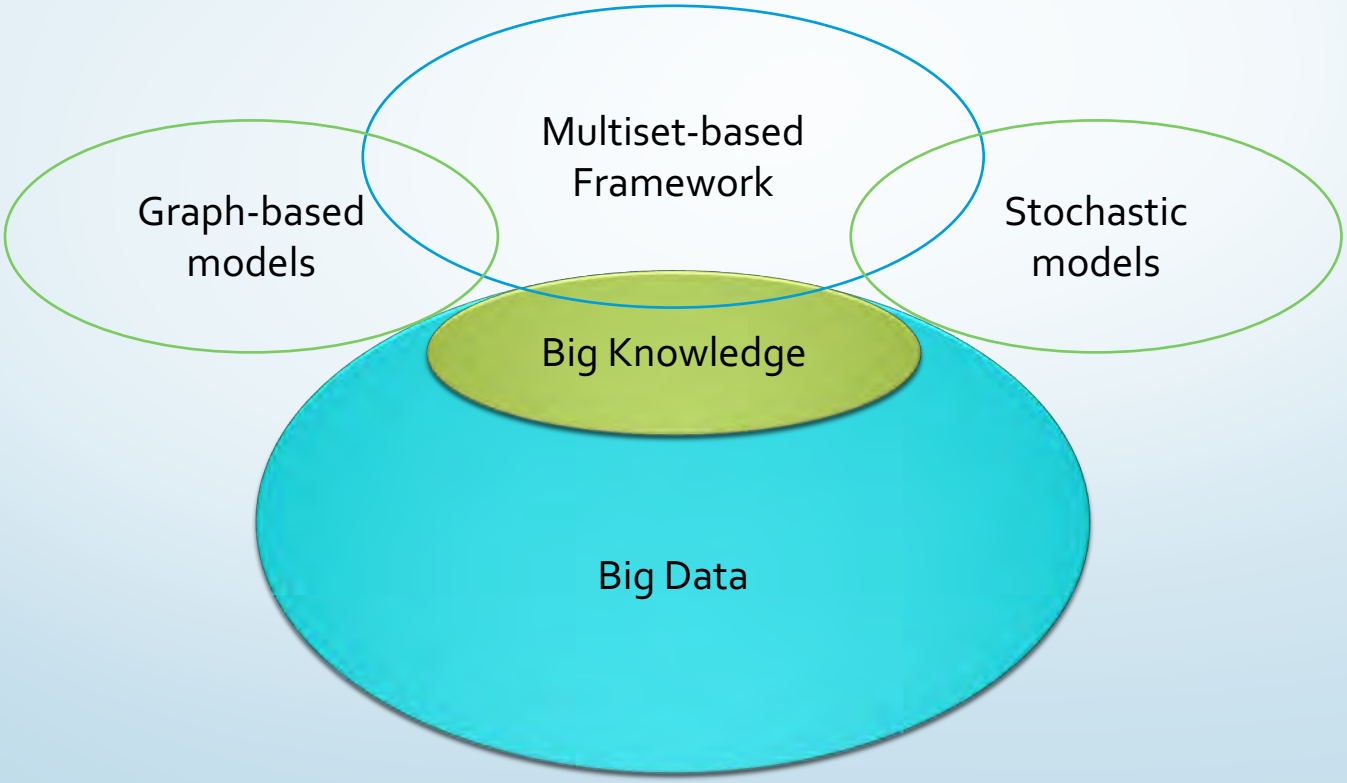
The Task Group's Approach

In the pages that follow, we describe the basic components of our approach. This consists of taking advantage of a multidisciplinary team, each bringing to the dialogue their own mathematical expertise and tools (whether it be graphs and networks, simulation tools, or the theory of algorithmic decision making), developing ways to share the tools, and studying how to relate them to an organizing component designed around a multiset-based (multigrammatical framework). Pilot software for components of the improved mathematical and knowledge engineering framework will be implemented in standard platforms and carefully documented. We also describe the connection to other Task Groups, to the CODATA Decadal Program, and the collaboration with the International Institute for Applied Systems Analysis (IIASA). The plans for the renewed Task Group are modeled after the successes of our first TG, namely webinars, a workshop, scientific papers, and a research monograph.

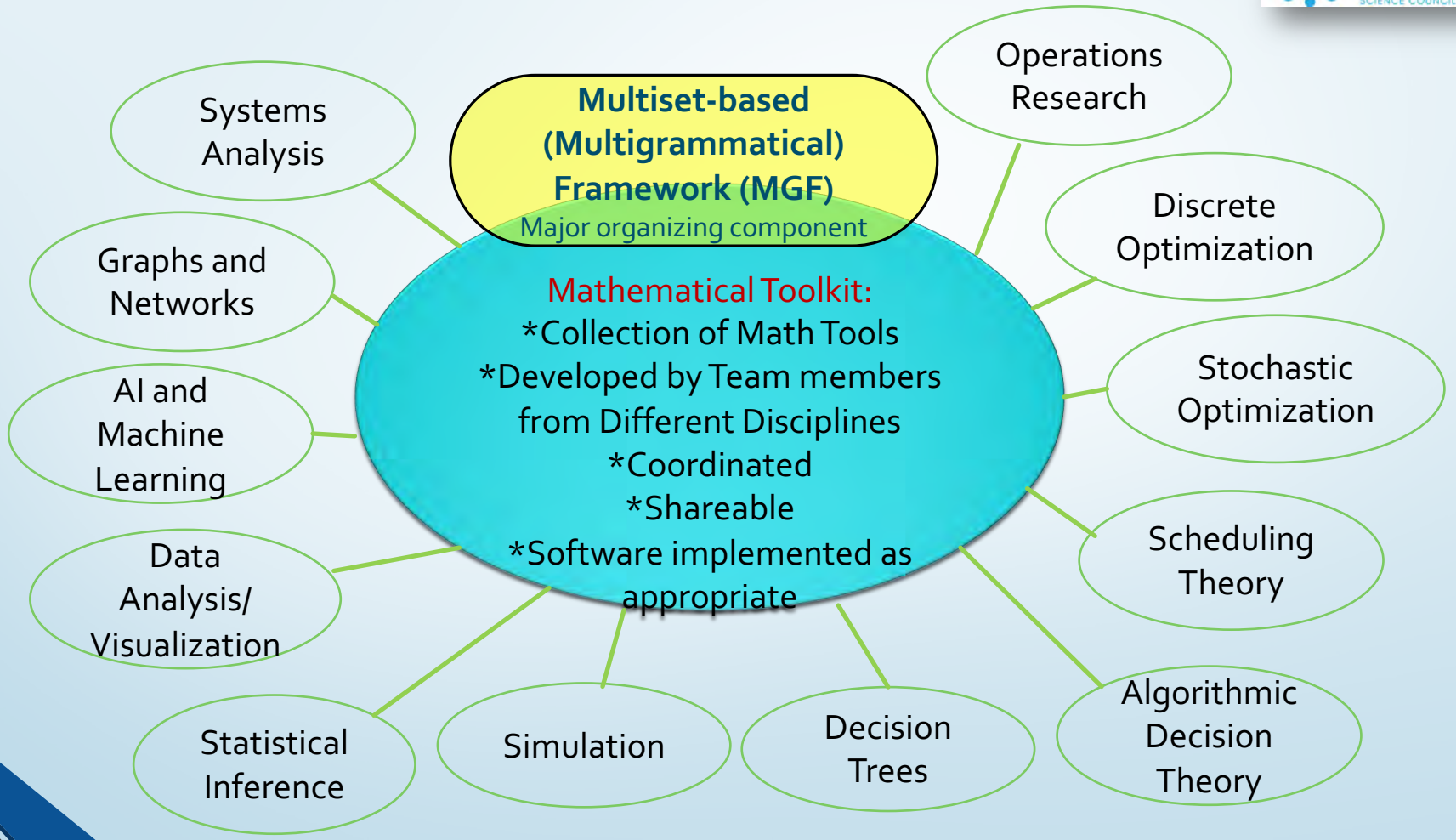
Making Data Work



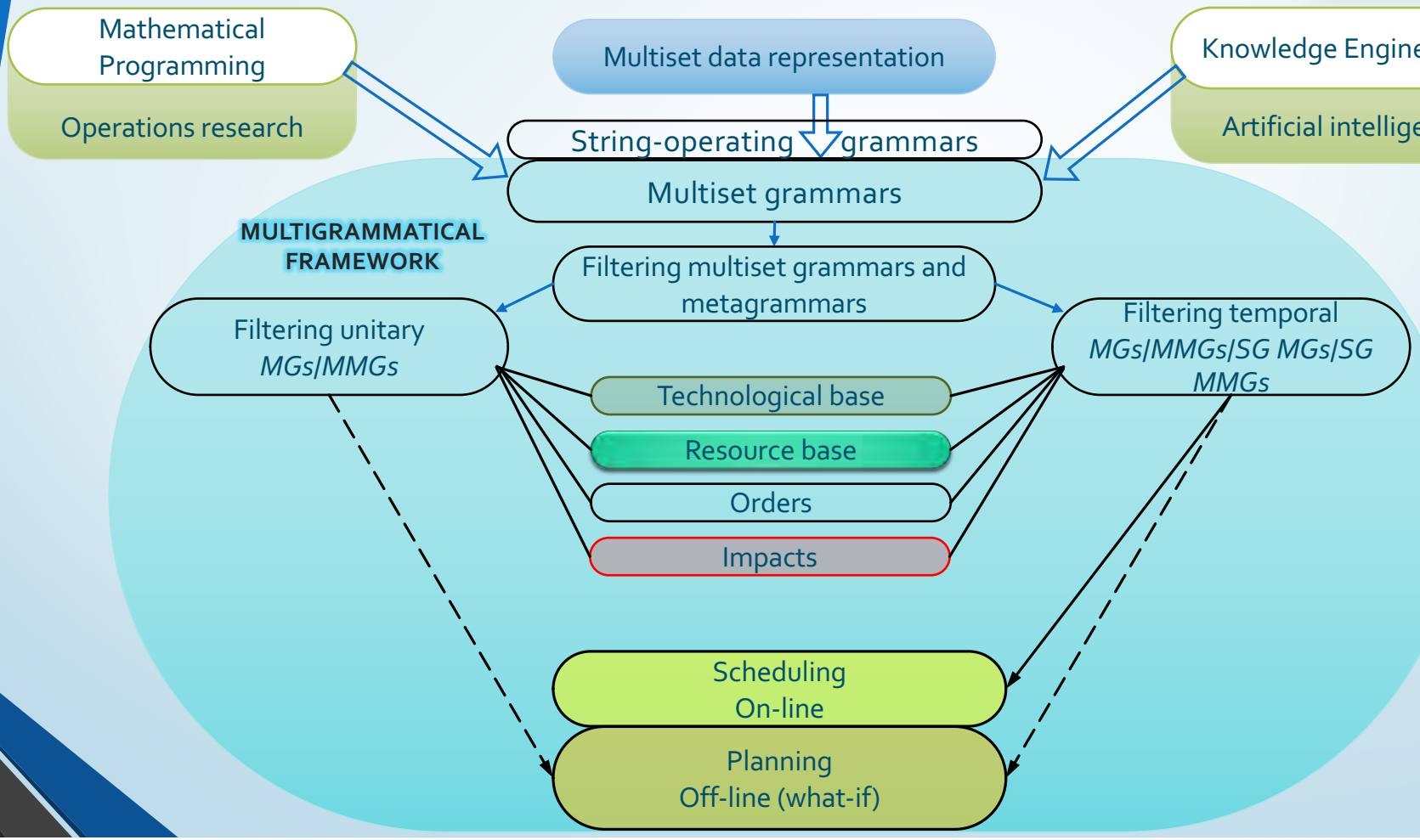
Basic Mathematical and Knowledge Engineering Framework and its Nexus



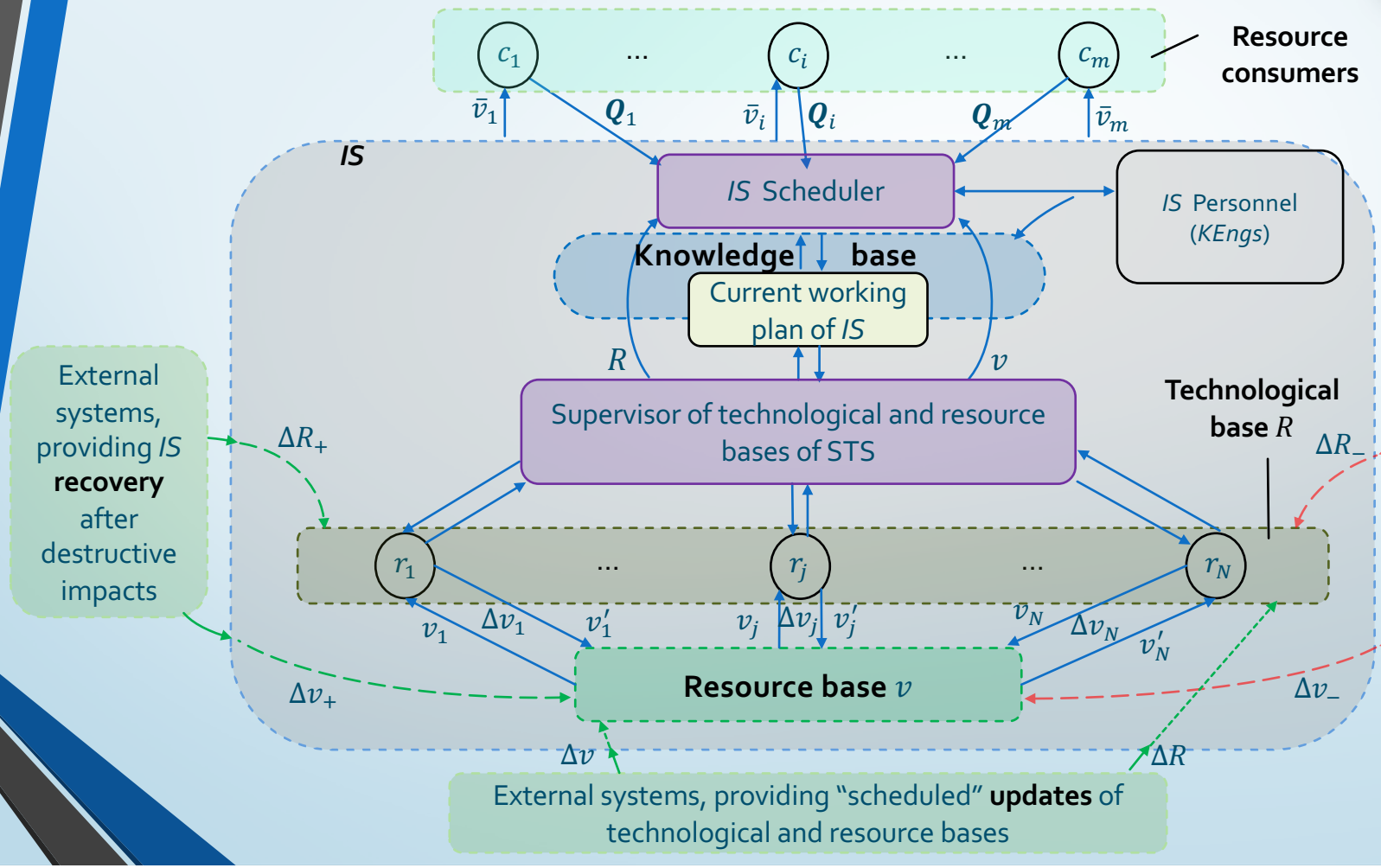
A Mathematical Toolkit: A Set of Tools



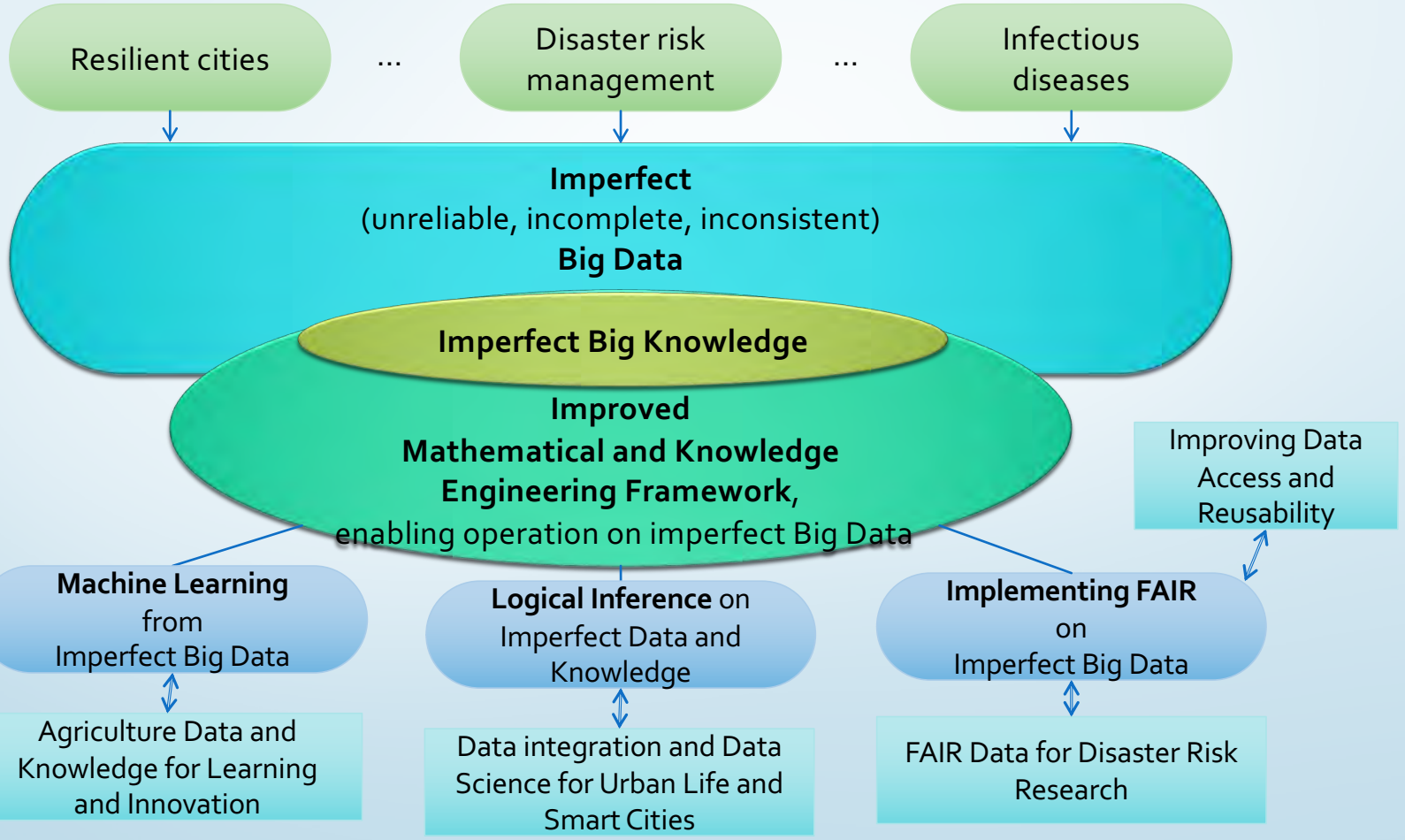
Multiset-based (multigrammatical) Framework



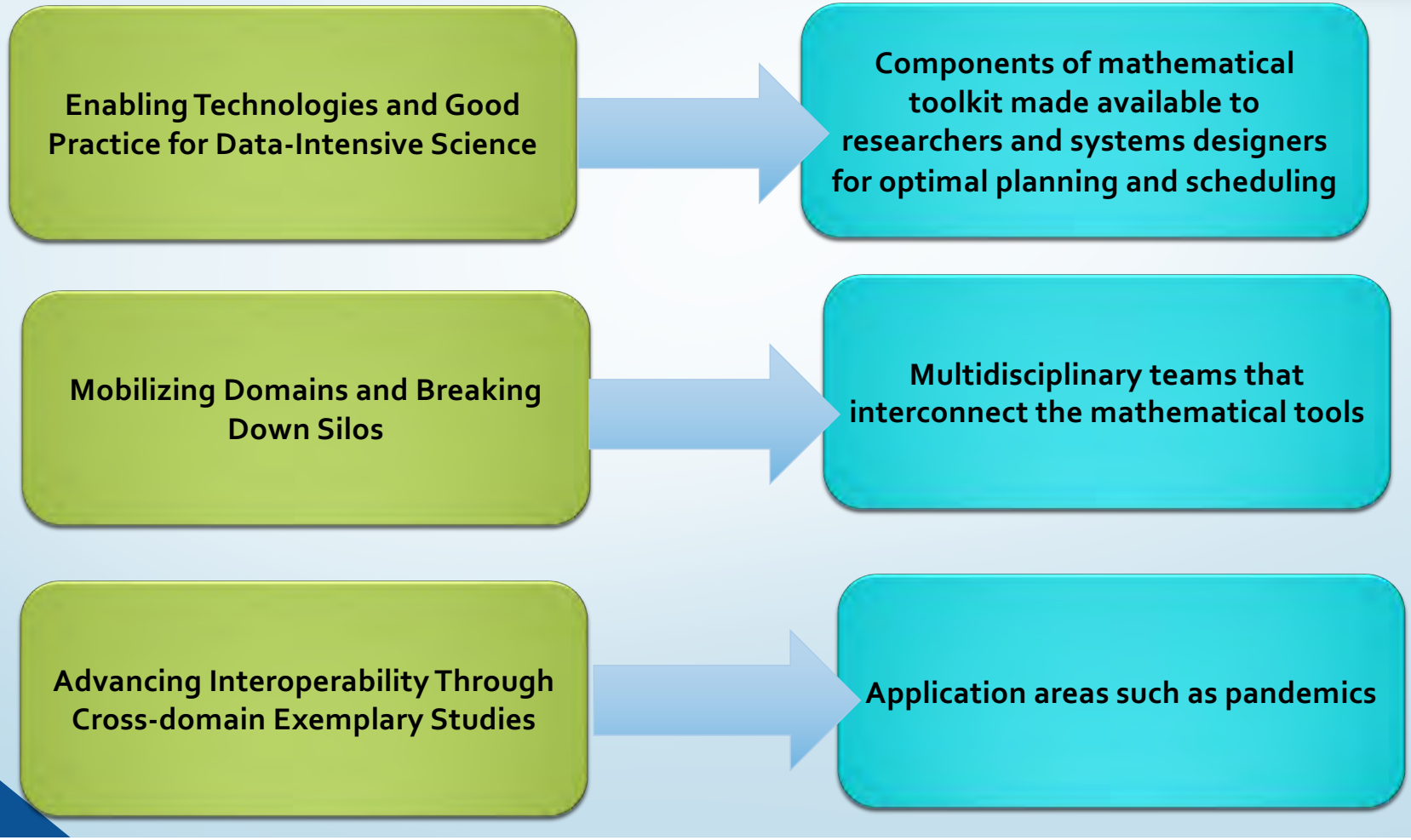
General Model of the MGF-Based Ecosystem



Objectives of the Renewed Task Group and its Nexus with other Task Groups



Connection with CODATA Decadal Program



Connections to International Institute for Applied Systems Analysis (IIASA)

IIASA researchers on Task Group team

IIASA researchers contributed chapters to first TG volume; will be invited to contribute to planned new volume

Cooperation through joint CODATA-IIASA Working Group on Big Data, Open Data and Systems Analysis

Plans of the Renewed Task Group

2022

April
Webinar
"Big Data and Knowledge Engineering: Extending the mathematical background of System Analysis"

October
Webinar
"Imperfect Data and System Analysis"

2023

May
Workshop
"Imperfect Data and Knowledge and CODATA Decadal Programme"
Geophysical Center of Russian Academy of Sciences, Moscow, Russia

November
Monograph
"Big Data and Systems Analysis" publication

Pilot Software Implementation of Components of the Improved Mathematical and Knowledge Engineering Framework –in standard platform, carefully documented, shareable

COMMITTEE ON DATA
CODATA
INTERNATIONAL
SCIENCE COUNCIL

Thank you