The Environment in Network Centric Operations: A Framework for Command and Control

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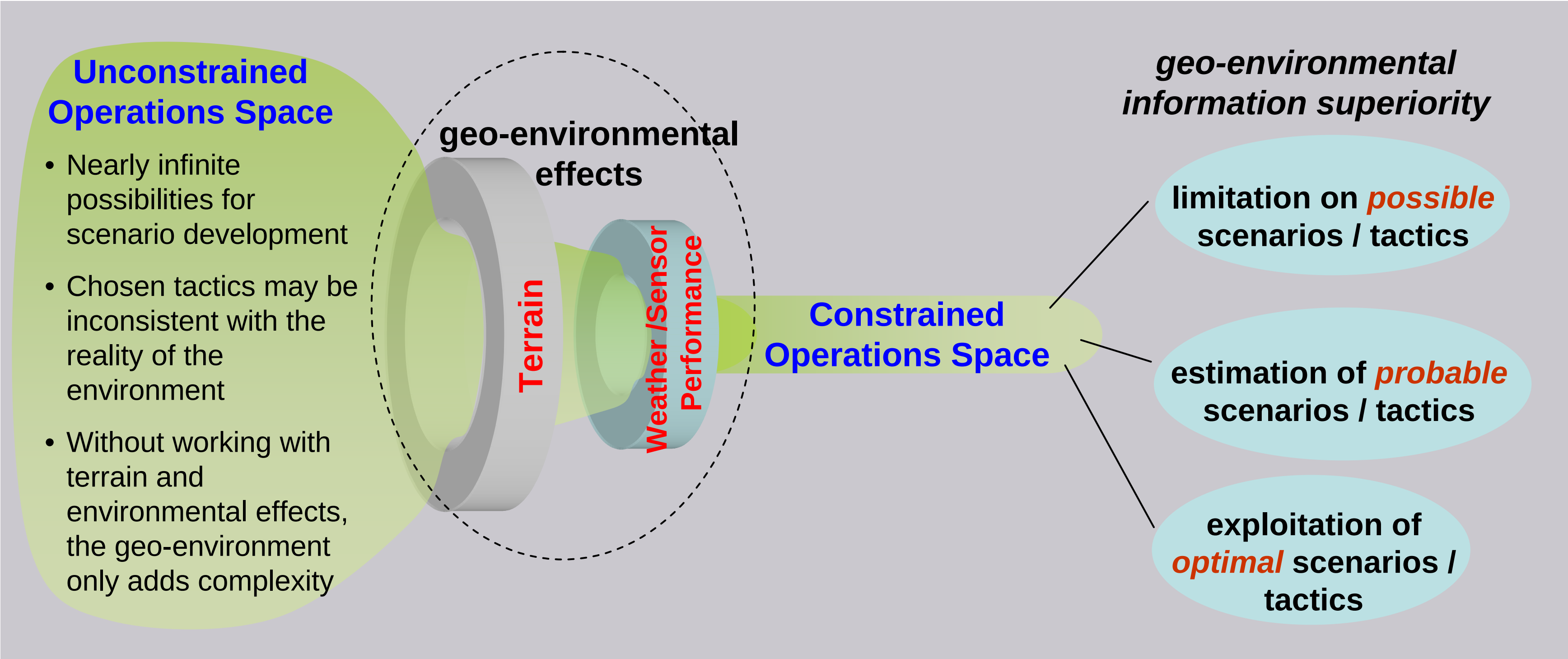
Overview

- Terrain and Weather impact the Environment in which a Mission is performed
- The Network-Centric Paradigm is transforming how Military Operations are conducted, but there is no well-recognized framework to capture the impacts of the physical environment within these processes
- We present a methodology that relates the effects of the Environment to Missions and Tasks
- We use a formalization of Command Intent to represent Missions and develop a framework for a range of physical and information constrains upon missions
- The end result is Actionable Information Products based upon Terrain, Weather and Sensor Effects.

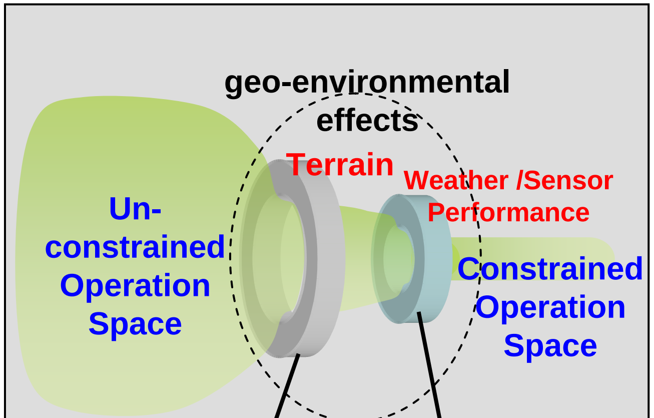
The Geo-environmental Operations Space

Terrain and **Weather (Wx)** effects are ubiquitous and ***constrain*** or ***enable*** mission and unit tactics as well as platform, system, and soldier effectiveness



Understanding and *Exploiting* Terrain and Wx effects allow for the identification and utilization off Procedures that work with the environment for optimal mission success – rather than those that are merely encumbered by the environment once they are put into action

Geo-Environment Analysis



Standard approaches to Terrain, Weather and Sensor Analysis is effective at achieving isolated pieces of geo-environmental knowledge, but is specialized, and lacks a coherent framework for effective employment

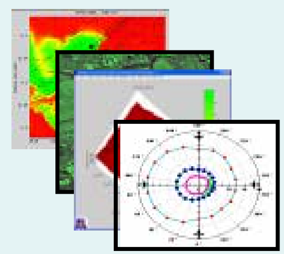
Typical Result

Terrain, Wx, and Sensor analysis products that are reasonably advanced, yet are:

- ***highly specific***
- ***non-standard***
- ***difficult to reuse***
- ***difficult to transfer***

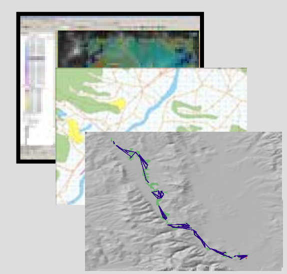
Standard Weather and Sensor Impact Analysis

- **Meteorologist, Terrain analyst, specialized Tactical Decision Aids (TDA) operator, UAV operator**
- **Disparate Wx and Sensor oriented TDA use and sensor employment standards**
- **GIS, standard and non-standard Wx, highly mission driven, "rule of thumb", platform specific TDAs**

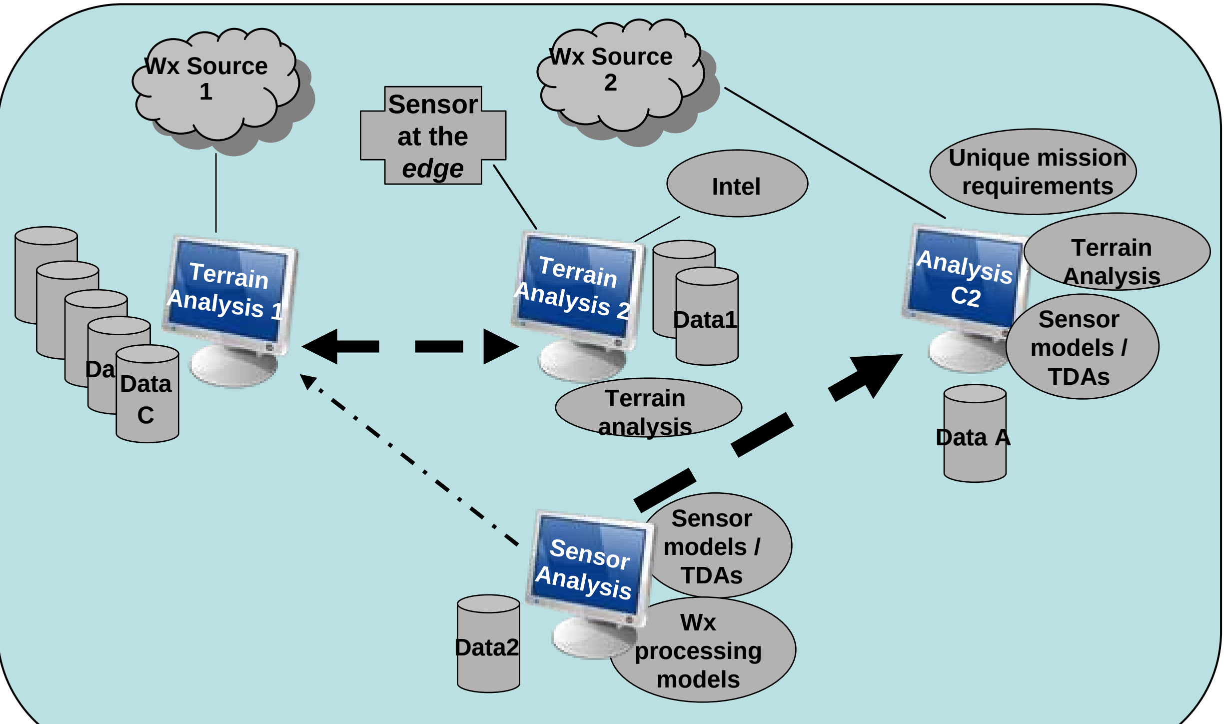


Standard Terrain Analysis

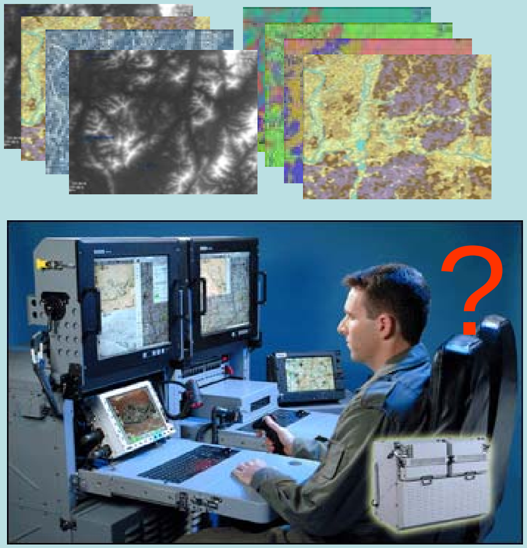
- **Terrain Analyst, Command Staff**
- **OAKOC (Observations and fields of fire, Key terrain, Obstacles, Concealment and cover)**
- **Assist in IPB (Intelligence Preparation of the Battlefield), COA development**
- **Automated or "by hand" map analysis**
- **GIS, standard and non-standard data sources, CADRG, TGD, non-standardized approaches, possibility for the duplication of effort, highly mission driven**



Unstructured Geo-Environmental products in a net-centric paradigm



Unstructured geo-environmental data and product flow in a net-centric environment



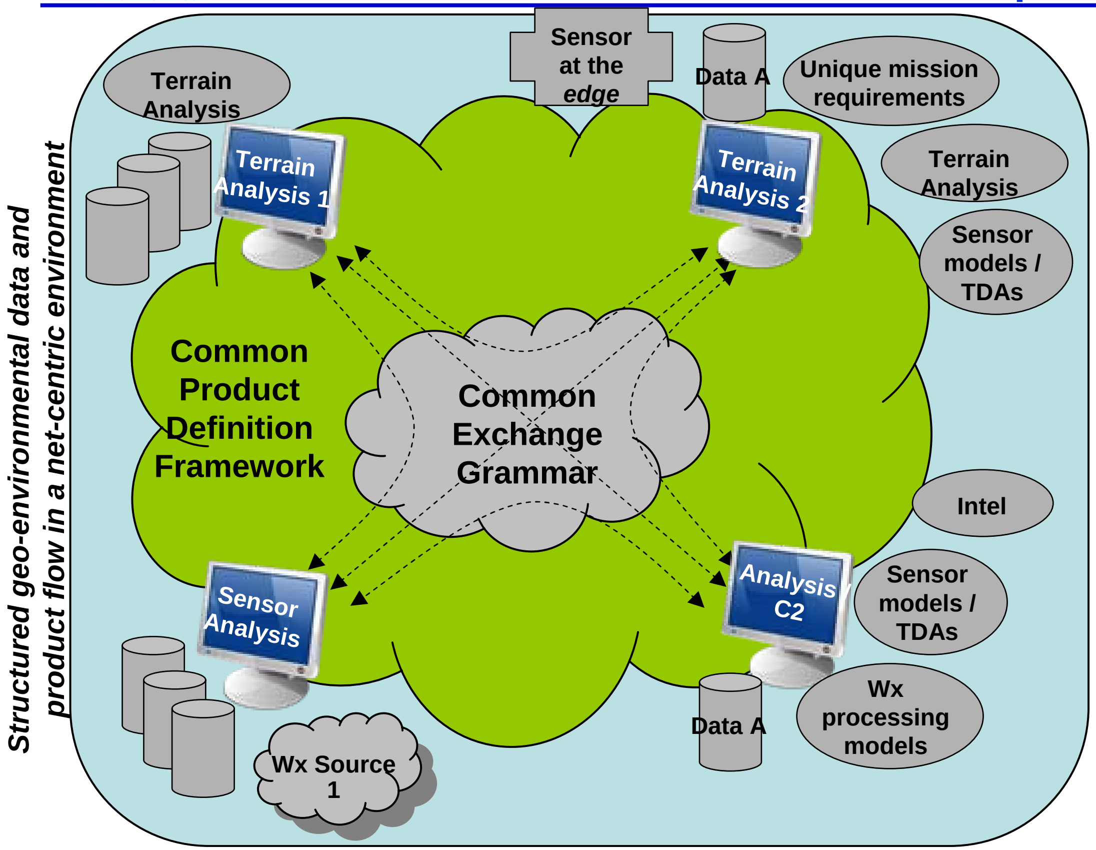
data proliferation at the expense of actionable information

The Net-centric Environment hold the promise of making geo-environmental ***data*** more available. However:

- No solution for the proliferation of data at the expense of actionable Information
- Typically, making more data available exacerbates the problem of identifying and extracting Actionable Information
- Typically, band-width is limited

Therefore, achieving the Net-centric paradigm without a structured mechanism for defining and controlling actionable information exchange may actually make acquiring actionable geo-environmental information more difficult.

Goal: Structured Geo-Environmental products in a Network-Centric paradigm



Benefits of a Framework:

- Favor Actionable Information exchange at the expense of raw data exchange.
- *Target and index the information generated and exchanged to the needs of the mission*
- Reduce the size of the information exchanged through linking to mission parameters
- Enable the interpretation and reuse of actionable information products as opposed to propagating the same data for re-analysis and re-processing

Anatomy of an Effective Framework

Central to incorporating geo-environmental information into Net Centric C2 processes is the realization of information value. This realized value should exhibit two characteristics:

(1) Understood format /syntax to ensure interoperability

(2) Semantic precision to ensure consistency

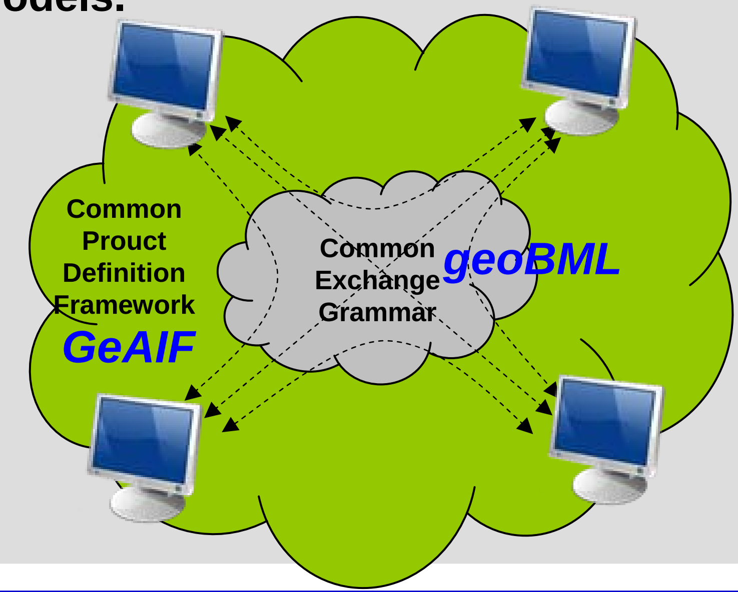
Therefore, Incorporating geo-environmental information into a networked C2 processes and systems requires:

(1) conceptual framework that categorizes Environmental and Sensor information from mission receipt through planning and execution stages

(2) A language capable of defining the appropriate basis of exchange and use of information.

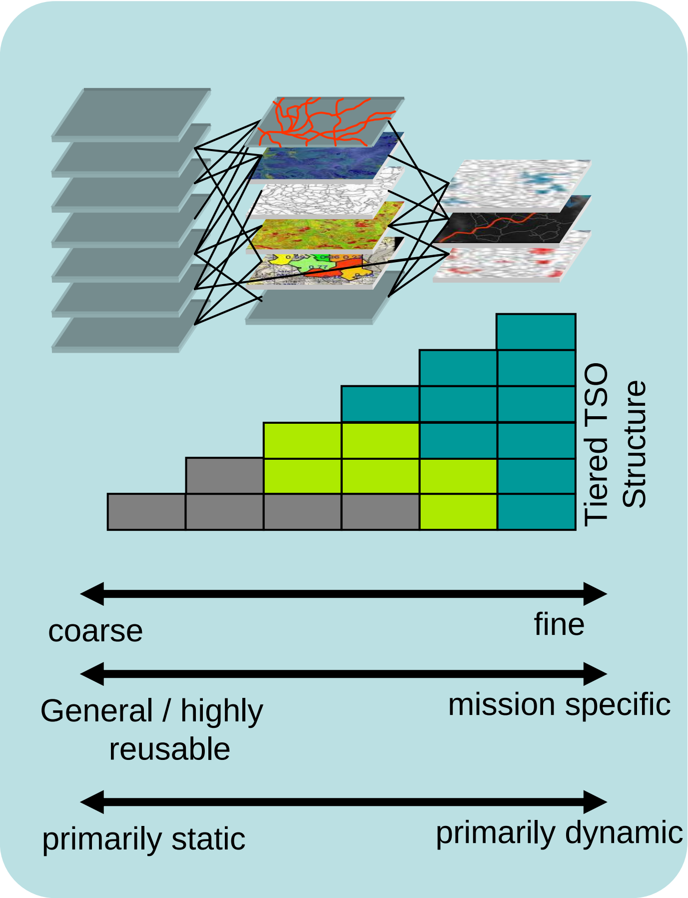
These requirements are addressed through:

- **Evolution of a tiered framework for geo-environmental information – the *GeoEnvironmental Actionable Information Framework (GeAIF)***
- **Development of a *geospatial Battle Management Language (geoBML)***
- **Processes to use geoBML to relate *Actionable geo-information* to mission information within data exchange models.**



GeAIF Structure

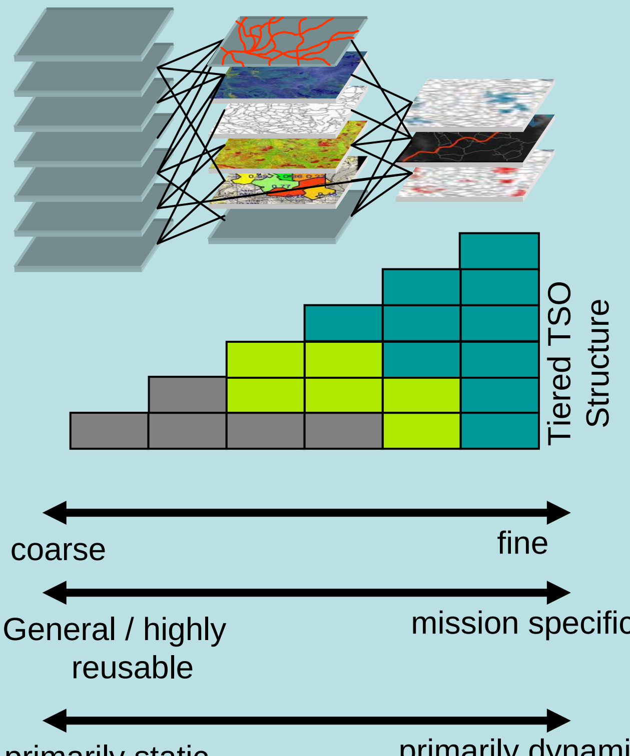
The Geo-environmental Actionable Information Framework (GeAIF) is built upon a tiered structure of of Tactical Spatial Objects



- **Tactical Spatial Object (TSO):** An object developed with topographic support systems/applications that ***directly supports the planning and execution of military operations.***
- In addition to a geospatial component, ***the TSO contains relationships to specific operations, missions and tasks***
- **TSOs** are a operational method for the Warfighter / operator to clearly convey his/her specific geospatial requirements to supporting Environmental Analysis services
- **TSOs** also allow the Environmental Analysis services to return immediately usable products to the operational user

Tiers of Information

- TSOs are of two types and arranged in three tiers:

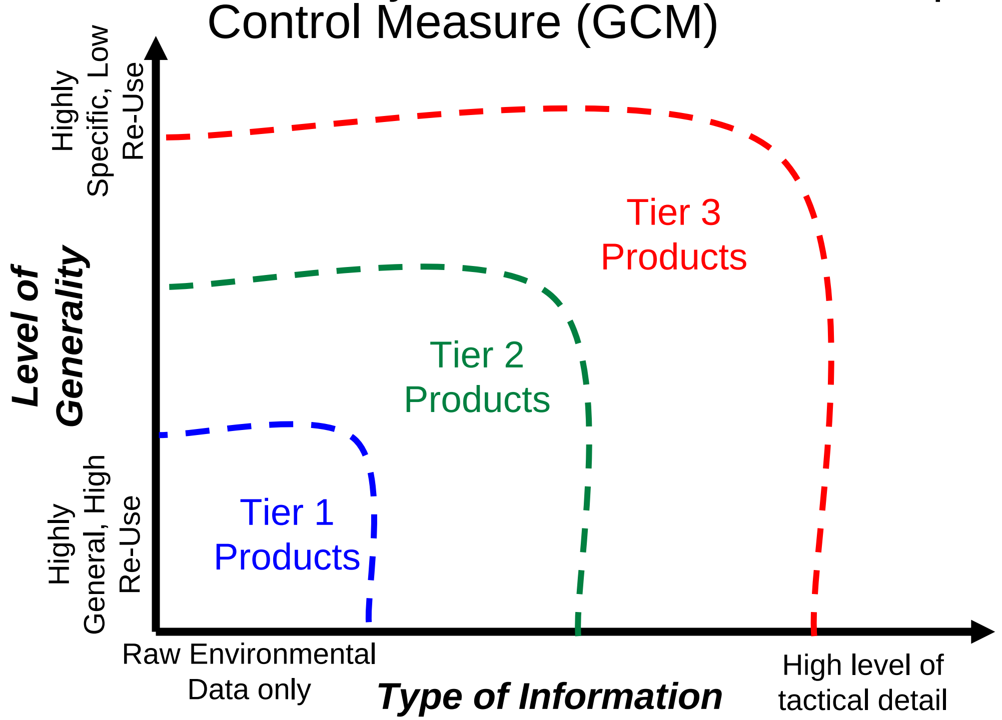


Tier 1s are foundation products

- Are generally computed for relatively large Areas of Interest
- Provide movement solutions
- Used to develop Tier 2/3 TSOs

Tier 2/3s are mission or task specific

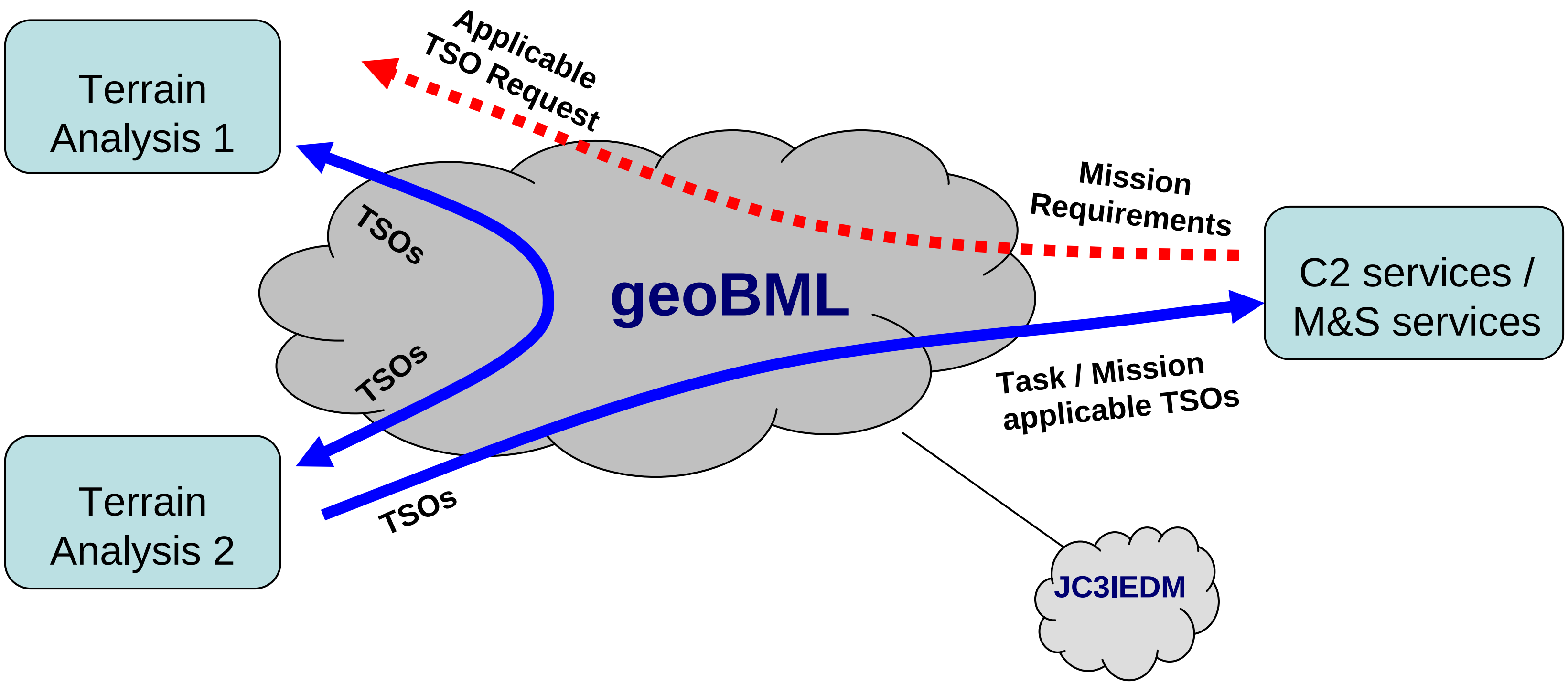
- Are generally computed for relatively small Areas of Analysis
- Generally have an associated Graphic Control Measure (GCM)



geoBML

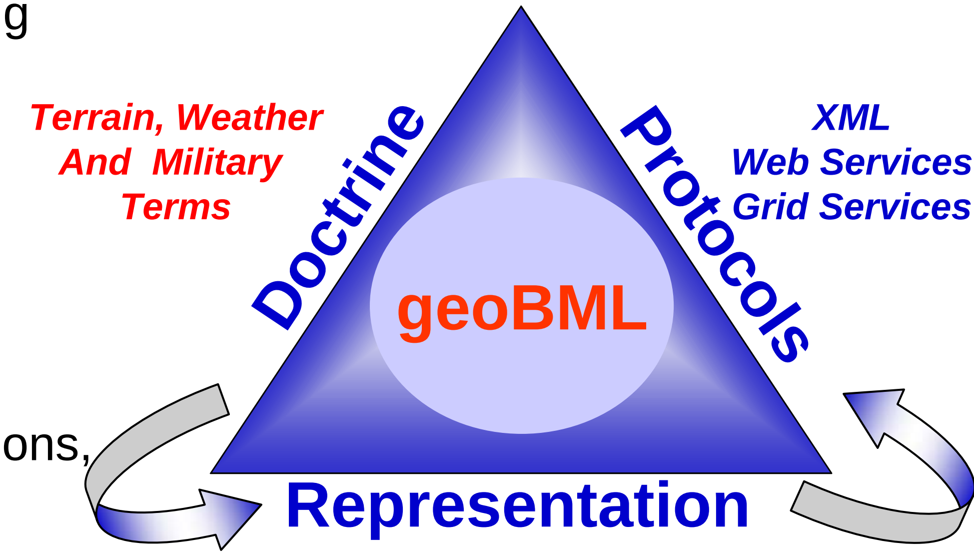
geoBML is the semantic and syntactic bridge between the highly specialized domain of terrain reasoning and analysis and the immediate needs of the operational Warfighter

- geoBML products are **TSOs**
- geoBML is built upon standard C2 Semantics (such as the Joint Consultation Command and Control Information Exchange Data Model – JC3IEDM)



Enabling Interoperability and Product applicability through **geoBML**

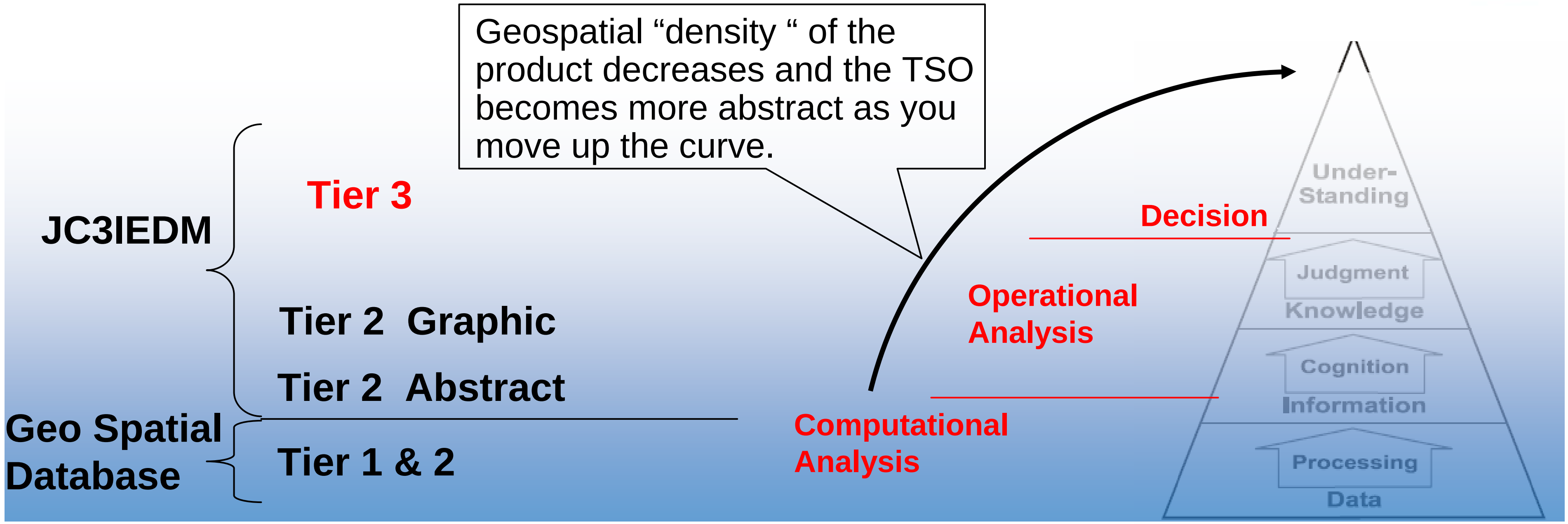
- **geoBML is an Unambiguous Language**
  - Both domain specific and cross-cutting
  - Defined by the role of actionable geo-information in the C2
- **Provides Unification…across**
  - Doctrine and terms
    - Explicit vocabulary and grammar
    - Specific context mapped to operations, missions and tasks – ***Who, What, When, Where***
  - Explicit Representation
    - Consistent extension to the JC3IEDM
    - Computational structure
  - Protocols
    - Explicit structure for transmission / sharing



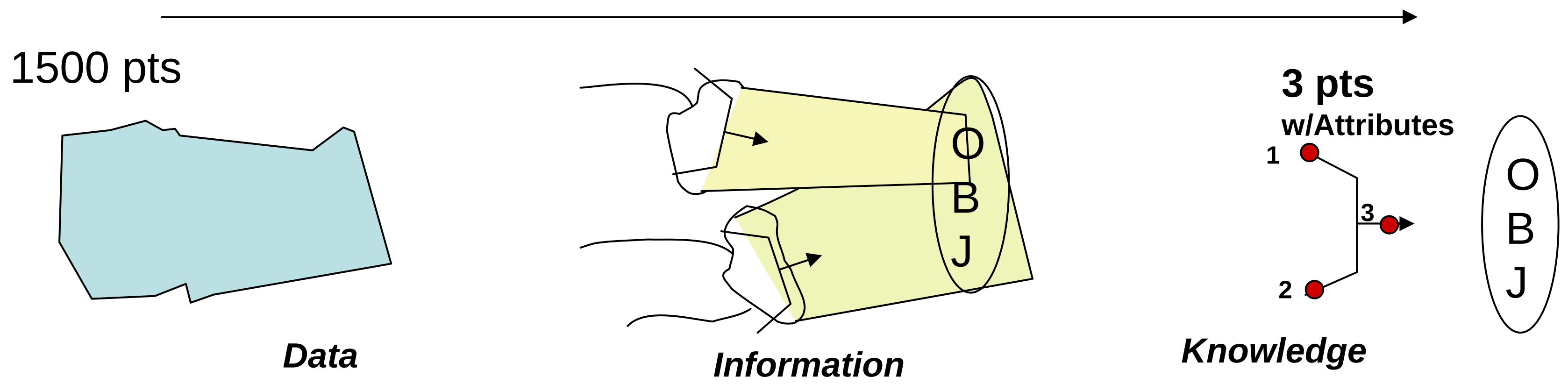
Geo-Environmental Extension to Joint Command Consultation & Control Information Exchange Data Model (JC3IEDM)

Explicit Computational Representation For Actionable Geospatial Information

GeoBML



Tier 2 Representations

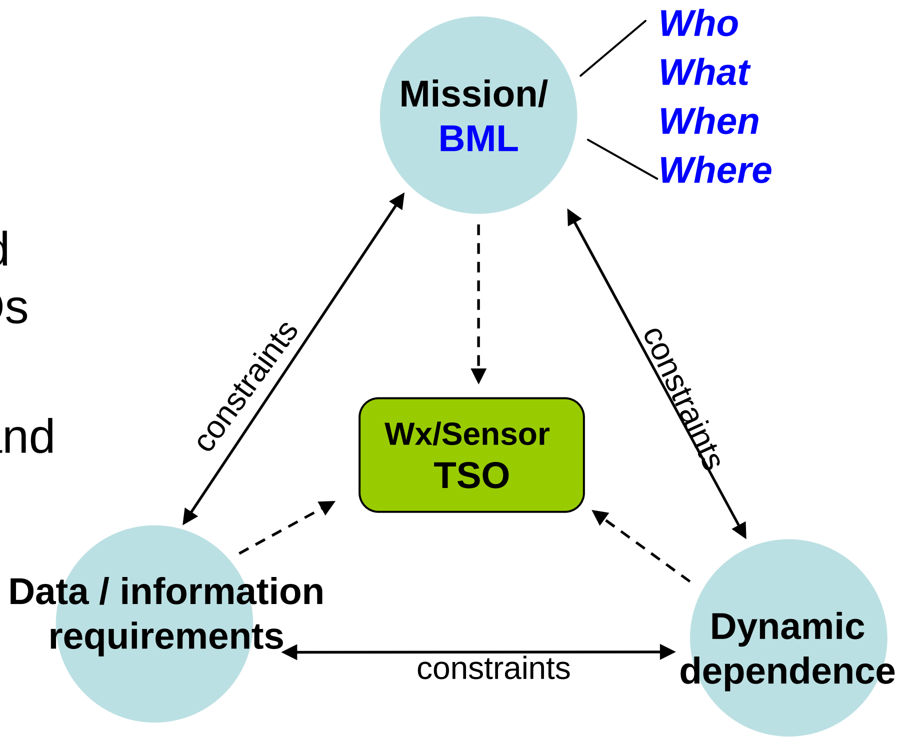


A GeAIF applied to Wx and Sensor Effects

Central Question – *Can a tiered GeAIF and geoBML approach be applied to weather and sensor TDA output products?*

Robust incorporation of more advanced Wx and Sensor performance effects into GeAIF is complicated by several factors

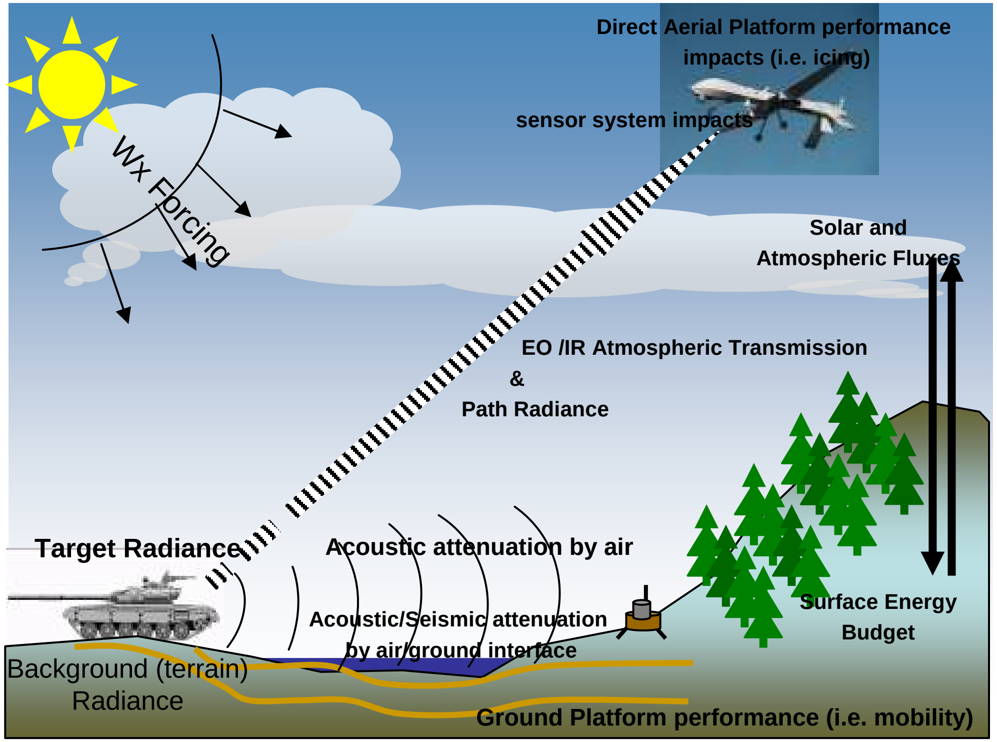
- Weather and Sensor products are highly dynamic
- Temporal quality of a Sensor performance outputs may not equate cleanly to the tiered structure of the terrain analysis based TSOs
- Large number and diversity of sensor modalities, their associated sensor TDAs, and their associated data requirements
- Continuingly Evolving sensor employment Doctrine and mission requirements
- Range of effects from direct impacts on platforms/sensors to the complex interactions between terrain, target, atmosphere and sensor

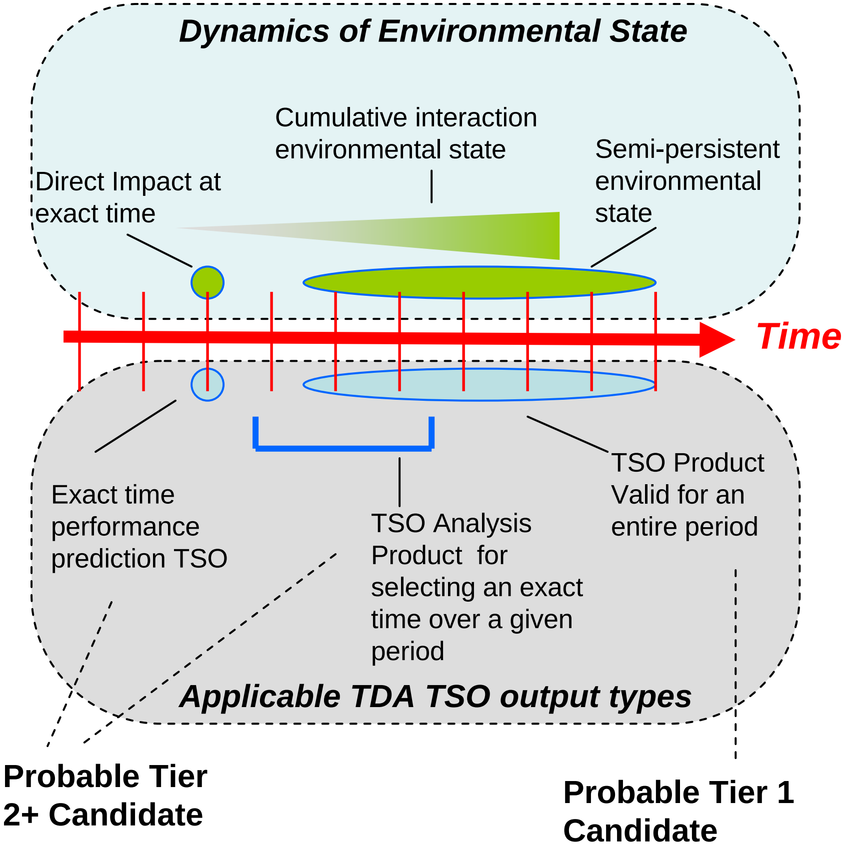


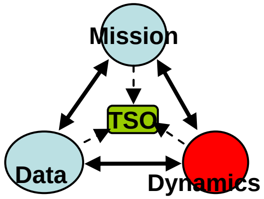
Dynamics of Wx and Sensor effects in the GeAIF

Weather and Sensor effect impacts and their associated TSOs are organized into distinct categories related to their dynamic properties.

These categorizations have a direct impact on the definition of applicable TSOs and their location in the tier structure



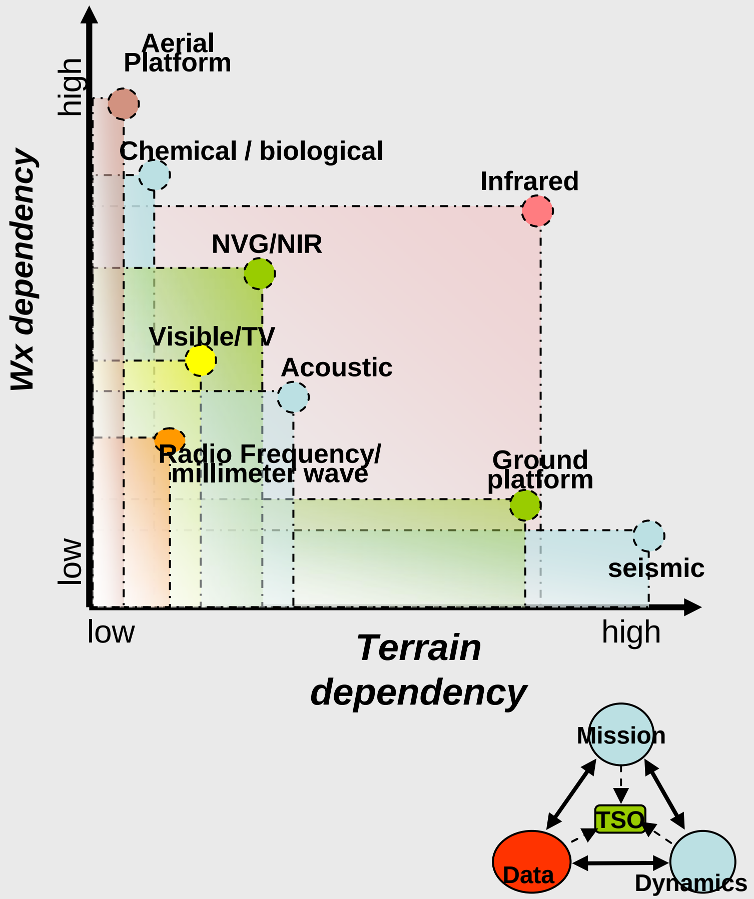




Wx Impacts and Sensor Behavior

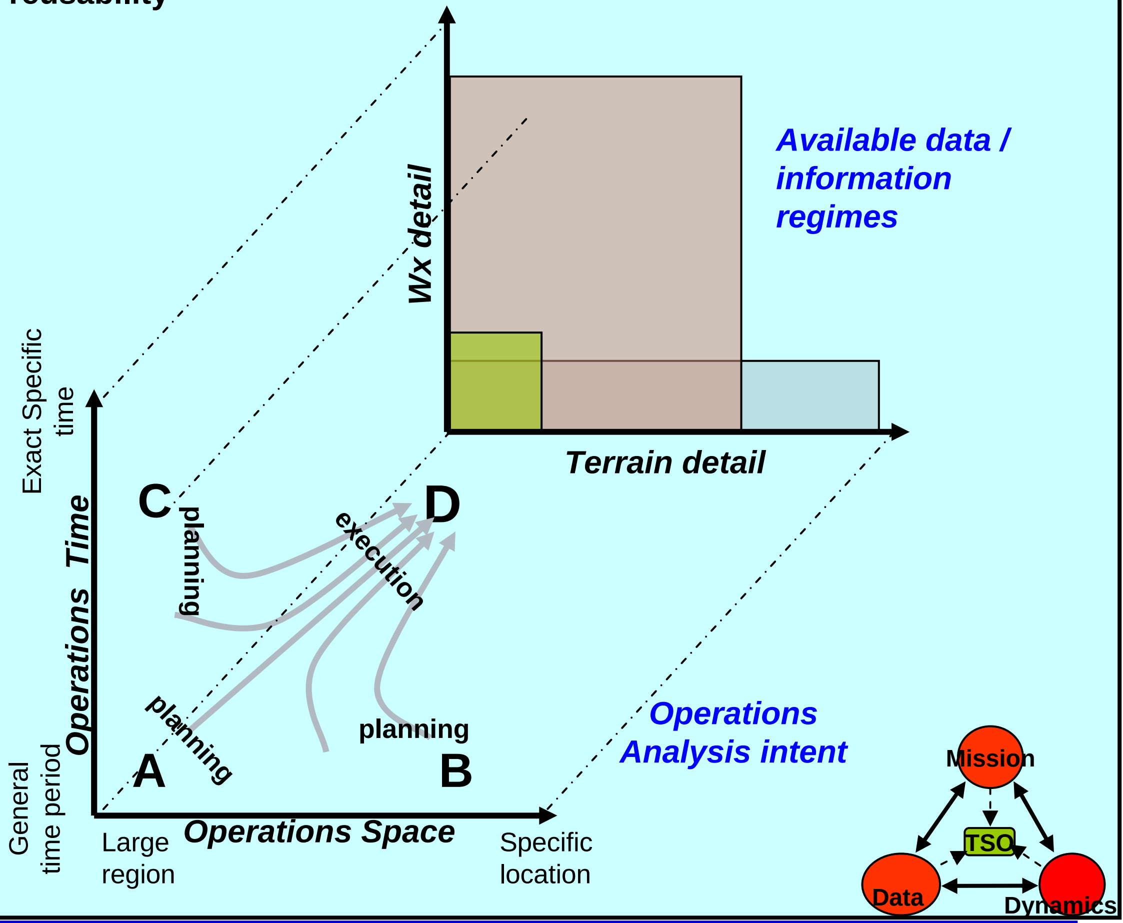
Data Limitations linked to predictive ability

Performance of various Sensor modalities and platform impacts is inherently coupled to terrain and Wx.



Generality and temporal specificity aligned with mission analysis task

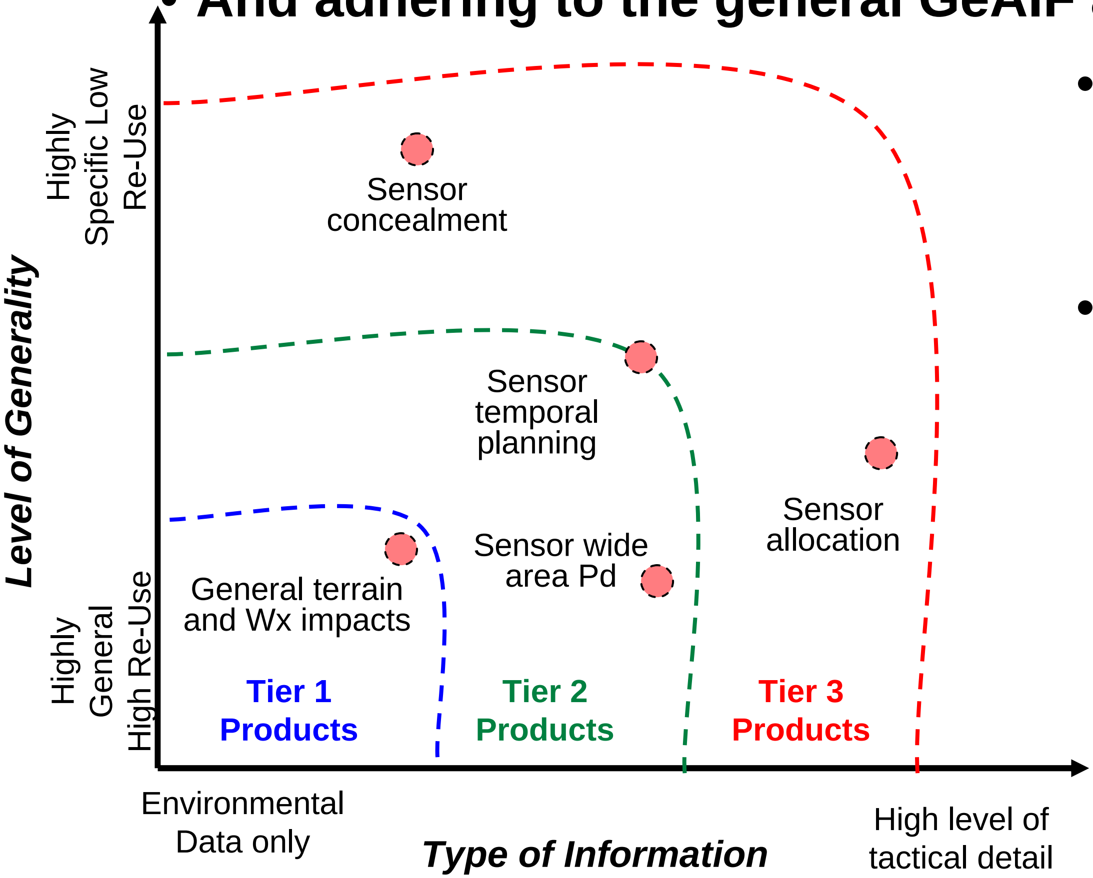
- The level of desired generality in a Wx / SP Decision Aid product is variable throughout the planning-through-execution process
- Generality, in both space and time is linked to specificity and reusability



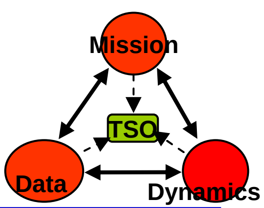
Wx and Sensor effects within a GeAIF

Weather and Sensor effects can be successfully mapped to a GeAIF through incorporating:

- ***a structured interpretation of TSO dynamics related to Sensors and Wx***
- **And adhering to the general GeAIF architecture principals of:**



- *Mapping to the fundamentally coarse-to-fine planning and execution process*
- *Mapping to the general vs. mission specific / persistent vs. dynamic nature of TSO definitions*



Example Wx/Sensor Effects Products

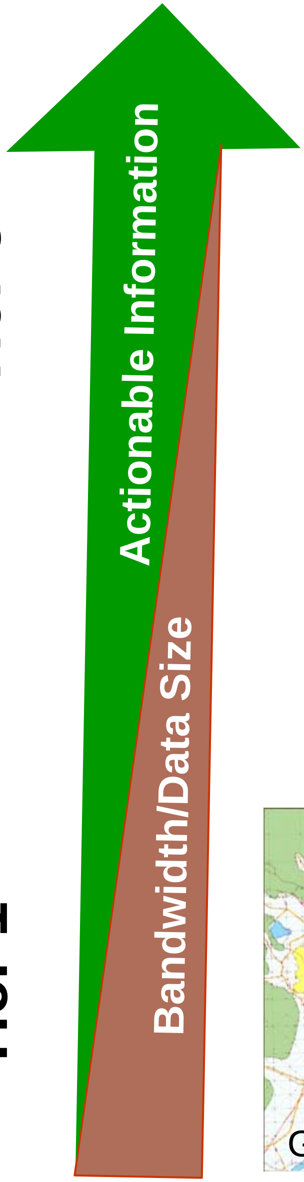
Tier	Category	Sensor Product Type Example	Examples
1	**Foundational information**	Dynamic Terrain Temperature and Moisture Map	Determine a re-usable information construct that provides dynamic physics-realistic information about the state of the terrain.
1	**General in Time and Space**	Tactically Significant Sensor Behavior Regions	For long-term planning purposes, determine the optimal placement of an Observation Point for maximum performance of an IR sensor suite
2	**General in Time, Specific in Space**	Aggregate-Time Sensor Employment Optimization map	Determine the optimal sensor array location and type allocation for a given number of acoustic sensors to cover a specific identified movement corridor.
3	**Specific in Time and Space**	Spatio-Temporal Sensor Performance Map	Determine the optimal Infrared (IR) sensor equipped UAV ingress angle that will result in the earliest detection time of a target at a known location.

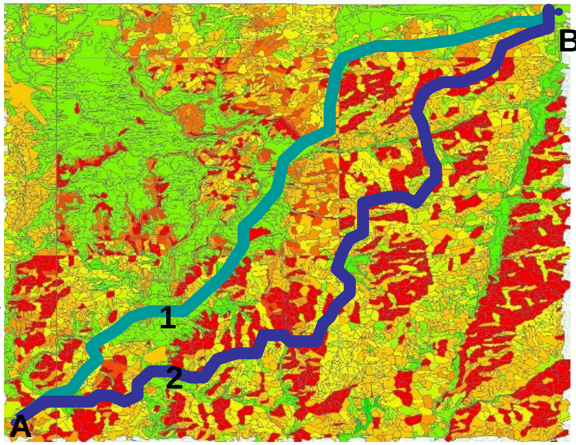
Sensor Analysis Example

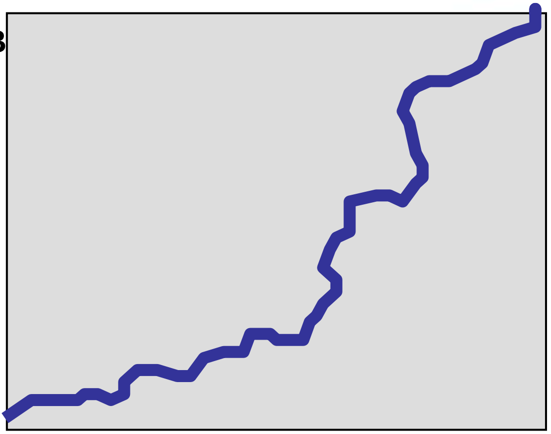
Tier 3

Tier 2

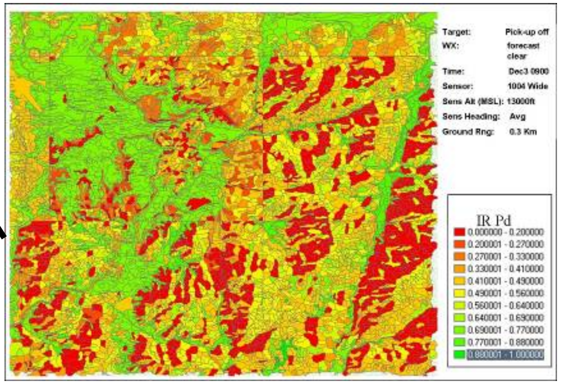
Tier 1



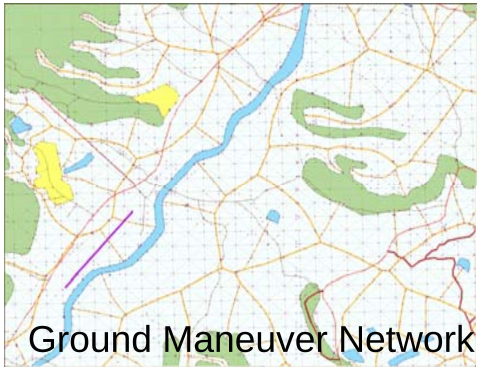


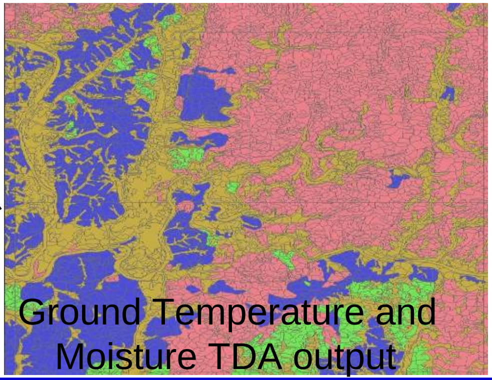


Optimal Selection of ground route based on maximizing IR concealment



Spatio-Temporal Sensor Performance Map showing IR Probability of Detection for a user specified time, sensor ,target and view geometry





Summary and Conclusions

- A framework is needed in order to mitigate the problem of data proliferation at the expense of actionable Information in a net centric geospatial information exchange environment
- The GeAIF, coupled with an information classification and exchange mechanism such as a geoBML, shows promise for organizing and maximizing the actionable information content of geospatial analysis products
- Predicted weather and terrain effects produced by specialized TDAs can be accommodated by this framework. However, complications exist.
- Future work will investigate a robust categorization of Weather and Sensor products into this GeAIF