Annex M – THRUST 7 – GAPS AND OPERATIONAL READINESS

Note: This Annex appears in its original format.

AVT308 NG-NRMM CDT
TA7 Gaps & Operational Readiness

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Thrust Area 7

Background:

- **DRAFT STANREC is evolving**
- **It should not be assumed that all implementations of NG-NRMM have the same aspirational end state**

Thrust Area 7 considered 3 questions:

1. **Identification:** How do you identify the capability of any given implementation of NG-NRMM?
2. **Use and Users:** Who will use NG-NRMM and what for?
3. **Capability Gaps and Challenges.** What are the perceived capability gaps and challenges?

ET148 Key New Requirements

Category	Sub- Category	Near-Term Priorities for NGN Threshold	Near-Term Priorities for NGN Objective
New System Capabilities	Vehicle Type	Wheeled Tracked	Legged
		Autonomous (simple)	Autonomous (complex)
	Vehicle Scale	Conventional manned vehicles	Lighter, smaller vehicles
	Terrain Scale	Regional, varied resolutions	Global, varied resolutions
New Modelling Capabilities	Suspension Types	Passive Semi-active Active	Active
	Control Types	Driver ABS, TCS, ESC, ABM CTIS	
		Autonomy (simple)	Autonomy (complex)
	Sub-systems	Steering, Powertrain	Human Cognition
		Autonomy (simple)	Autonomy (complex)
	Model Features	Terrain models (e.g. Bekker-Wong)	Terrain models (e.g. DEM, FEM)
		3D Physics based models	Stochastic models
		Multibody dynamic vehicle models	
		Flexible body models	
		Detailed tire and track models	
New Analysis Capabilities	Environment Types	On-road, off-road	
		Urban	Urban
		Soil	
		Snow/ICE	
	Powertrain performance	Grading Turning Fuel-efficiency	Cooling
	Amphibious Operations	Fording Swimming	
	Computations	Efficiency-fidelity trade-off	High fidelity
			High performance
New Output Capabilities	Assessment Types	Performance in operational context	
	Metric Considerations	Verifiable mobility metrics	

Key: Gap areas in:

- Mobility Mapping
- Environmental Modelling
- Intelligent Vehicles
- Stochastics
- Computational Performance
- Verification & Validation

Identification

A system is required such that for a given implementation of NG-NRMM, its capability and configuration can be defined, managed and controlled with reference to the STANREC aspirational NG-NRMM

1. **Validation and Verification**

2. **Context**

3. **Comparing**

Identification: Layers & Levels

Layers: ***"A discrete factor of the mobility of a ground vehicle whose influence can be independently assessed for its impact on terrain accessibility and speed made good, and whose significance is worthy of doing so."***

- **Terramechanics**
- **Roads**
- **Water**
- **Urban**
- **Features**
- **Ride**
- **Control**

DRAFT for Consideration

Levels: ***"A measure of Layer complexity and capability in Next Generation NRMM implementation."***

Identification: Layers & Levels

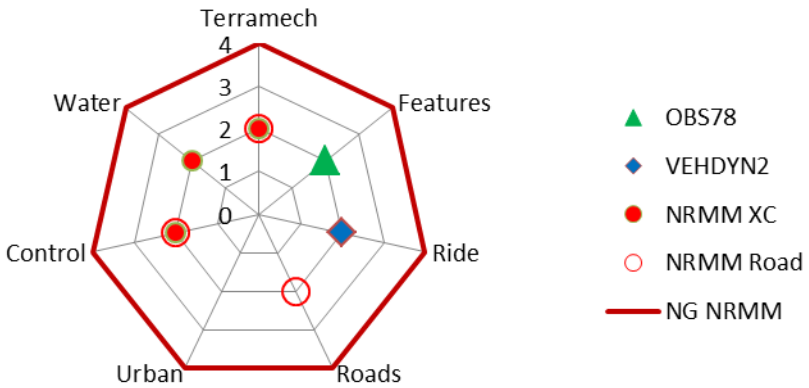
Adopting this approach requires a decision:

- **Use fixed scales**
- **Use variable scales**

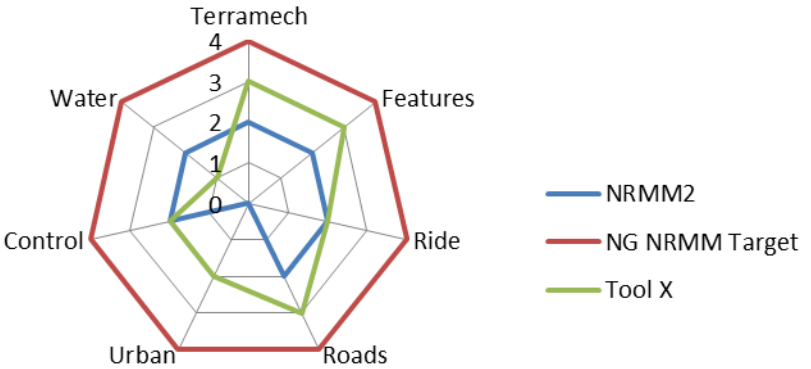
Commonality and ease of recognition

Vs.

Scalability and Adaptability



Example: Current NRMM2 vs. NG-NRMM



Example: New tool vs. NRMM2 and NG-NRMM

Use & Users

Data Set		NRMM2 (current)	NG-NRMM Simple	NG-NRMM Complex
1	Supervised Practitioner	Likely	Likely	Occasional
	Practitioner	Likely	Likely	Likely
	Expert User	Likely	Likely	Likely
	Operational Planner	Unlikely	Unlikely	Likely
2	Supervised Practitioner	Likely	Unlikely	Unlikely
	Practitioner	Likely	Occasional	Unlikely
	Expert User	Likely	Occasional	Occasional
	Operational Planner	Likely	Likely	Occasional
3	Supervised Practitioner	Likely	Likely	Unlikely
	Practitioner	Likely	Likely	Unlikely
	Expert User	Likely	Likely	Unlikely
	Operational Planner	Unlikely	Unlikely	Unlikely
4	Supervised Practitioner	Likely	Likely	Unlikely
	Practitioner	Likely	Likely	Occasional
	Expert User	Likely	Likely	Likely
	Operational Planner	Occasional	Occasional	Unlikely

	NRMM2 (current)	NG-NRMM Simple	NG-NRMM Complex
Research	Occasional	Likely	Likely
Procurement	Occasional	Likely	Likely
Pre-Deployment Advice	Likely	Likely	Likely
General Operational Advice	Likely	Likely	Likely
Specfic Operational Advice	Likely	Likely	Occasional
Research	Likely	Likely	Occasional
Procurement	Occasional	Likely	Likely
Pre-Deployment Advice	Likely	Unlikely	Unlikely
General Operational Advice	Likely	Occasional	Unlikely
Specfic Operational Advice	Likely	Occasional	Occasional
Research	Likely	Likely	Unlikely
Procurement	Likely	Likely	Unlikely
Pre-Deployment Advice	NA	NA	NA
General Operational Advice	NA	NA	NA
Specfic Operational Advice	NA	NA	NA
Research	Unlikely	Occasional	Likely
Procurement	Likely	Likely	Occasional
Pre-Deployment Advice	Occasional	Likely	Occasional
General Operational Advice	Occasional	Occasional	Unlikely
Specfic Operational Advice	Occasional	Occasional	Unlikely

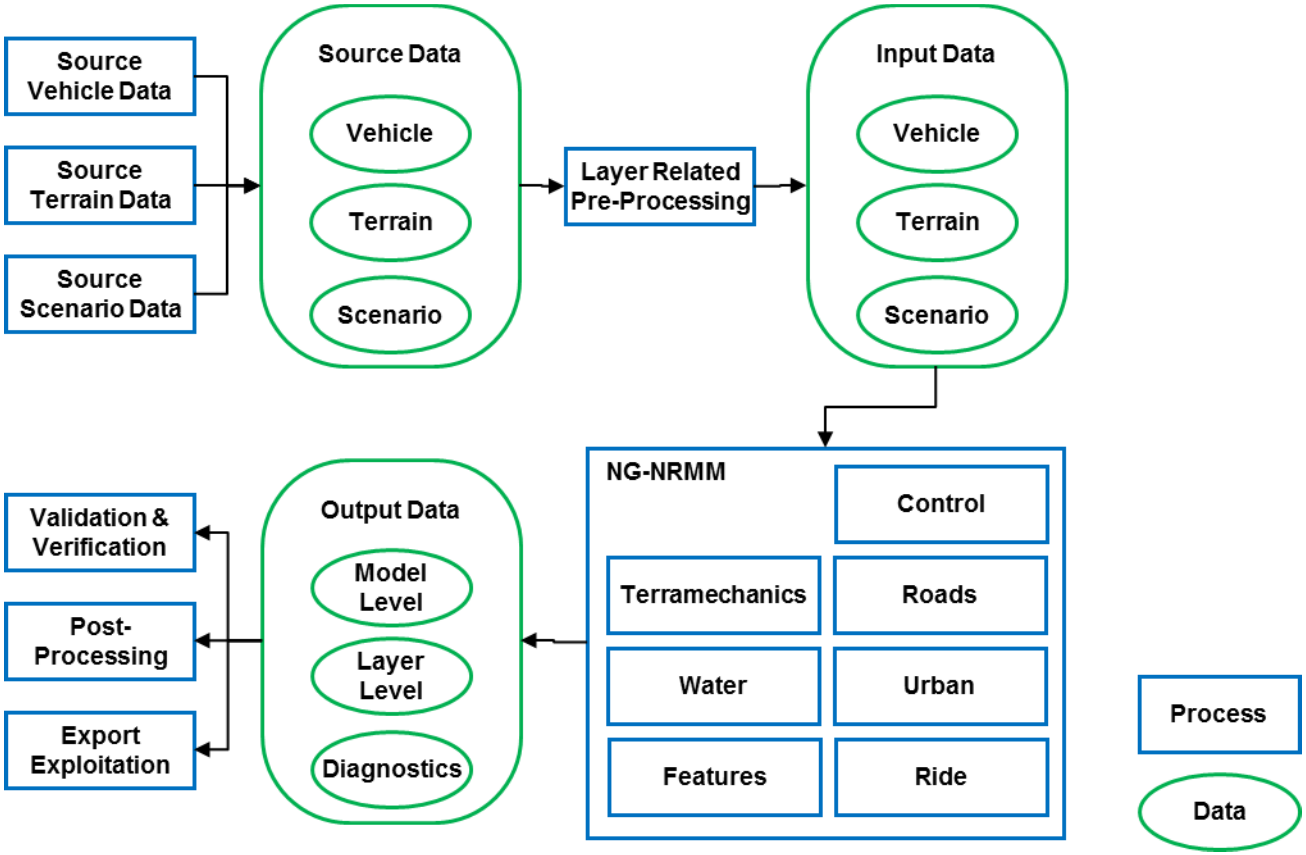
(Example subset of views)

Use & Users

No apparent common overall expectation in terms of who would use the different tools, what for and with what level of expectation (representative of a diverse community) but….

- None of the options are seen as an operational planners' tool by the majority
- Simple NG-NRMM is seen as comparable to current NRMM2 with respect to users
- Complex NG-NRMM is seen as only likely to be utilised by Expert Users, likely R&D rather than operational analysis
- Arguably it can be inferred Simple NG-NRMM has the most potential for exploitation across the potential use cases

Capability Gaps & Challenges



Generic NG-NRMM Methodology

Gaps & Challenges Identified By Other TAs

- **Input:**
  - Data availability (especially soil), resolution
  - Limitations of the MAPTBL format
  - Long term configuration management approach to the database
  - Advancement of the vehicle as a sensor method
- **Modelling:**
  - M&S methods addressing the slope limitations
  - M&S and parameter ID methods addressing slip-sinkage
  - M&S methods addressing bulldozing
  - M&S + experimental methods that address layer effects & load rate effects
  - Leverage Complex Terramechanics developments to extend the Simple Terramechanics database
- **Output:**
  - Validation and Verification challenges

Capability Gaps & Challenges: Inputs

- **Vehicle Data**
  - **Obtaining**, increased complexity, increased challenges
  - **Storing**, implications for adaptability and interoperability
  - **Security**, implications of increased complexity for data handling
- **Legacy Terrain Data**
  - **Data challenges**, e.g. how to enhance obstacle representations
  - **Data gaps**, e.g. how to generate additional soil parameters
  - **Change** over time impact on ability to update and subsequently use
- **Data Confidence**
  - NG-NRMM will need improved methods for capturing data quality and confidence

Capability Gaps & Challenges: Modelling

- **Legged and Small vehicles – ET148 Key New Requirements**
  - There is research that can be drawn on but…
  - Developing NG-NRMM for Legged vehicles may not be viable
  - Developing NG-NRMM for Small vehicles may be able to exploit lab as opposed field work

- **Vehicle Technologies – ET148 Key New Requirements**
  - A shortfall of the current NRMM2 is the breadth of technologies, and their performance impact, it can consider
  - Some technologies can be implemented by data manipulation, e.g. CTIS
  - Some technologies remain gaps to be addressed, e.g. TCS

Capability Gaps & Challenges: Modelling

- **Water**
  - Performance in/around water is integral to freedom of manoeuvre
  - Ingress and Egress is a key gap and challenge for NG-NRMM

- **Features: Obstacles and Vegetation**
  - Improving methods versus impact on go, nogo and speed predictions is an unknown and will be terrain specific
  - 'Can' versus 'Need' to do better, where is the balance?
  - Improvements will require bespoke trials and experimentation, enhancing data models, and increase the data sourcing burden

Capability Gaps & Challenges: Outputs

- **Diagnostic Data**
  - NRMM2 is a procedural model of models, it has the ability for the user to interrogate the inner workings
  - NG-NRMM will require the ability to operate in 'debug mode' for both data and method verification
  - STANREC will need to articulate this requirement

- **Wider Exploitation**
  - NG-NRMM will provide a step-change in mobility performance analysis capability
  - Challenge to understand how to carry that improvement forward, e.g. logistic and combat simulations
  - NG-NRMM alone does not address the 'so what' of improved discrimination between vehicles

Summary

- **Group feedback stresses the fact it should not be assumed that all implementations of NG-NRMM will have the same aspirational end state**
  - Divergent requirements and use cases will impact having a single solution
  - There is still a case for a common, minimum NATO capability
- **If Levels & Layers adopted, Levels will be the focus of STANREC refinement**
- **Simple NG-NRMM has the greatest potential for exploitation across the potential use cases**
- **Different tools and approaches are likely to be required for novel solutions (e.g. walking vehicles) and small UGVs**
  - Should the STANREC hold them to the same standard?
- **The tools considered have demonstrated breadth against the ET148 Key New requirements but significant gaps and challenges remain**