System Scenario Selection Method for Faster Analysis

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Introduction

- Systems are often required for multiple purposes
- Either
  - One system with multiple distinct primary functions
- Or
  - One system with a primary purpose but will be used for other purposes because it is available
- Or
  - Users think of additional ‘extension’ uses which they attempt to perform

Impact

- Even a simple system has a very large ‘fan out’ of use cases to account for the range of design uses and the range of conditions under which each may be needed
- And the variety of additional uses need to be included to ensure safety and/or adequate performance under various uses and conditions
- The variety of cases results in considerable effort required for a complete analysis
- Efficiency objectives call for development of a method to truncate the amount of work required to gain the learning of scenario analysis to inform the system specification

Importance of Scenario Analysis

- Scenario analysis defines use situations for the use of the proposed system
- Very important for defining what should be developed
- If scenario analysis is done well system developers have a clear view of what the system should do
  - This leads to developing a sound vision of what the system specification should be – a sound set of requirements
- If scenario analysis is poorly done there is lack of clarity about what the system should do
  - This leads to a poor set of requirements

Project Progress and Cost Impact

- Full scenario analysis for a system could consume substantial effort
  - High cost
- For some systems the cost of doing the scenario analysis work may be high but the risk should errors or omissions be made would be small
  - That is: cost of doing scenario analysis may be higher than is justified
- A method for systematically limiting the cost of scenario analysis would be valuable

Scenario Content and Purpose

- Scenarios are constructed using:
  - What must be done: the transformation or path between the initial state and target event
    - These are the user requirements and express what the system must do
      - What functions
      - Level of performance of the functions
  - The conditions, such as environmental constraints, under which the effect must be achieved
    - These express conditions or constraints under which the required performance must be delivered

Identifying Scenarios

- In many systems, many of the scenarios have a lot of commonality but would be recognised as distinct scenarios in a full scenario analysis
- Each scenario represents the use of the system under particular conditions
- To do one of the functions (or sets of functions) for which the system is developed
- The number of scenarios is potentially large, even for a small ‘simple’ system

Identifying Scenarios (Example)

- A multi-load type vehicle platform to transport loads under defined conditions and quality of transport over types of route
- The load could affect the quality of ‘ride’ required – impacts of this may depend on the transport route environmental conditions
- The load type could affect the platform because of physical, chemical or other properties of the load
- The load type is unlikely to make significant impacts on the transport control interface
- The load type may make significant demands on the loading/unloading processes and personnel
- Conclusion: some parts of the scenarios will be common, some parts distinct
  - Full development of each scenario will add considerable expense to the project

Identifying Scenarios (Challenge)

- How can the large number of scenarios be truncated without loss of value?
  - The risk is that a choice to only investigate scenarios that are considered ‘extreme’ may miss important factors in cases not investigated
- Reducing the workload by truncating the number of scenarios investigated is likely to represent high risk

Construction of Our Approach

- Step 1: Identify the full range of possible scenarios
  - For each identify the task to be performed by the system
  - Identify the sets of conditions under which the system task must be performed

ID	Scenario Name	System Task	Conditions of Scenario
1	Scenario Name 1	System Task 1	Condition set 1
2	Scenario Name 2		Condition set 2
3	Scenario Name 3	System Task 2	Condition set 3
4	Scenario Name 4		Condition set 4
5	…	…	…

- Each set of conditions results in a distinct scenario – something could be different
- System tasks normally would involve the same sequence of actions within the use case

Construction of Our Approach

- Step 2: Itemise the specific actions required to perform the task
- NOTE: The actions must include the specific actions identified in the use case analysis AND the transitions between the actions
  - Transitions are essential elements that must be supported
- The conditions under which the actions are required to be performed must be itemised
  - This step is the secret of our method

ID	System Task	Actions Performed BY or ON the System	Condition Sets for the Action
1	System Task 1	Action 1	Condition sets 1, 2, 4
2		Transition Action 1 to Action 2	…
3		Action 2	…
4		Transition Action 2 to Action 3	…
5		Action 3	…
6		…	…
7	…	…	…

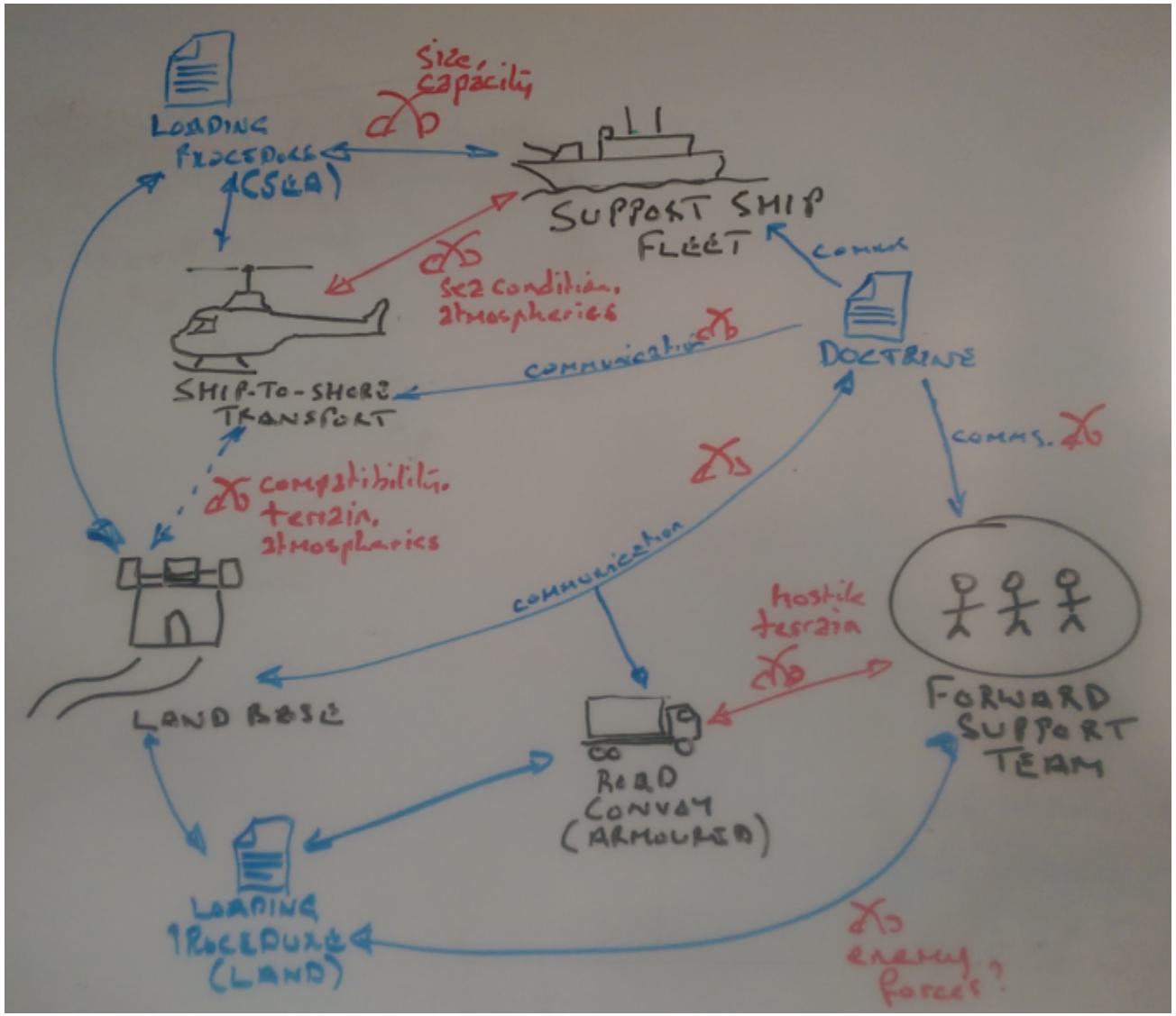
Construction of Our Approach

- The conditions under which the actions are required to be performed must be itemised
  - This step is the secret of our method
- Multiple System Tasks will require the same Actions and Transitions between Action pairs
- The scenario analysis unit is the Action and the Transition (where the set of conditions must each be considered)
  - For one action a particular condition may be the most challenging while for another action a different condition may present the greater challenge (or a different challenge)

A Concrete Example

Rich Picture of the system to ship materiel from the long distance transport to the place of use

The Rich Picture identifies the key decision factors relevant to the system



Concrete Example – Step 2

- This table identifies a list of environmental condition factors relevant to use of the transport solution
  - ‘Conditions’ represent sets of these environmental items
- System States concern the states of the system which may lead to different scenario use patterns – such as item 6 – communications non-functional which may be associated with doctrine for what action would be taken in that state
- Required performance levels for the range of performance measures

Number	Factor Type	Specified Item	Required level of attainment
1	Environment state	Ambient temperature during operation	Normal operation: $x \leq T \leq y$ Extended operation: $T < x$ and $y < T$
2	Environment state	Sea state: WMO Sea State Code	WMO State < 4 full operation, no precautions WMO State < 6 full operation, protection precautions active WMO State > 6 can survive, protection precautions active
3	Environment state	Ground bogginess	This need a measure of the resistance of the ground to vehicle bogging
4	Environment state	Cross-country vegetation penetration	This needs a measure of the density of vegetation which can be driven through
5	System state	All subsystems function	Full operational performance
6	System state	Communications subsystem nonfunctional	Defined autonomous function plan allows safe, partial function
7	Performance	Load carrying capacity	Load described in mass and dimensions
8	Performance	Speed of movement	Described as linear speed at WMO particular sea state measures
9	Protection	Resistance to fire and other attacks	This needs a specification of the types of in-coming that the armor can resist

Concrete Example – Step 3

- In this step the specific scenarios are identified
- The system tasks are listed
- The conditions under which the tasks are to be done are specified

ID	Scenario Name	System Task	Conditions of Scenario
1	Ship sea-land calm	Shipping materiel from ship at sea to land base	Calm sea
2	Ship sea-land rough		Sea state 4
3	Ship land-land clear	Shipping materiel from land base to forward position – on road	No opposition anticipated
4	Ship land-land opposed		Opposition expected
5	Ship land-land cross-country opposed	Shipping materiel from land base to forward position – cross-country	Route includes areas where boggy conditions are expected. Opposition expected.
6	Ship land-land vegetation opposed		Route through thick vegetation. Opposition expected.
...	...	...	...

Concrete Example – Step 4

- One system task is expanded here
- The actions and transitions are listed
- The conditions under which the actions must be performed are listed
  - Sea State 4 is the listed condition – but it is plausible that some actions may be more challenged by a different condition (if so that other condition would lead to the requirements)

ID	System Task	Actions Performed BY or ON the System (in Order)	Condition Sets for the Action
1	Shipping materiel from ship at sea to land base	Open the conveyance 'vehicle' to enable loading	Sea state 4
2		Load the cargo into/onto the conveyance 'vehicle'	Sea state 4
3		Close the conveyance 'vehicle' to enable travel	Sea state 4
4		Initialize the conveyance vehicle for trip	Sea state 4
5		Pilot conveyance vehicle to destination base	Sea state 4
6		Open the conveyance 'vehicle' to enable unloading	Sea state 4
7		Unload the cargo from the conveyance 'vehicle'	Sea state 4
…	…		…

Conclusions

- We have proposed a method to reduce the effort required to perform scenario analysis
- The normal scenario identification method identifies the tasks to be performed by the system and the conditions under which the tasks are to be done
- The key to our contribution is to atomise the tasks into activities and transitions between activities
  - Since the same activities and transitions appear across different scenarios acceleration of the scenario analysis process, without loss of richness, can be achieved through determining the requirements demanded by the need to perform the actions and transitions under the conditions

Questions